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Confocal Review Station
1010 & 1200
Software Version 2.4

User Manual

KLA-Tencor

For Clean-room Use
Software Version 2.4

August 24, 1998

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At the time of this printing, European versions of this system comply with EC Machinery Directive 89/392/EEC, EC Electromagnetic Compatibility Directive 89/336/EEC, and EC Low Voltage Directive 72/23/EEC.

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Contents

Chapter 1 Safety 1

SEMI S2-93 1
Laser Safety 1
High Voltage 2
Emergency Power Off 4
System Components 4
Moving Parts 5
Robot 5
Isolation Table 5
Internal Parts 5
Interlocks 6
Laser Power Interlock 6
Laser Shutter Interlock 6
Robot Cover 7
Cassette Interlock 8
Hazardous Materials 8

Chapter 2 Introduction 11

Confocal Review Station Overview 11
Live Laser Imaging 16
Overview 16
What Is a Live Laser Image 16
Advantages Over White Light 17
Main Applications 18
SUMMARY 20
Principle of Operation 21
Defect Analysis and Classification 25

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Chapter 3 Tutorial 27

Before You Start 27
Requirements 27
Looking Around 28
Your First Session 30
Logging In 30
Loading a Defect File and Wafer 33
Wafer Deskew 34
Reviewing Defects 38
To image a defect 45
Getting Around 50
Optical Controls 50
Making 2D and 3D Images 53
To make a 3D Image 54
To Load 3D Images 55
Experimenting with 3D Images 55
To Zoom in on a Surface Image 55
To Print Images 59
To Save Images to Files 59
Classification 59
Unloading the Wafer 59
Logging Out 59
KLA Tencor CRS Sequence Flowchart 60

Chapter 4 Auto Deskew 63

Overview 64
Manual Deskew 66
Choosing Deskew Points 69
Setting up AutoDeskew 71
Deskew Options 72
AutoDeskew option 72

Chapter 5 Reference 77

Privilege Levels 77
The User Interface 78
Input Devices 78
Mouse 78
Keyboard 78
Stage Joystick 80

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Software Controls 81
Files and Directories 82
Directories 82
File Types 84
Bitmap Files 84
Defect Code Table Files 84
Wafer Map Files 84
Recipe Files 85
Surface and Volume Files 85
TIFF Files 86
Menus 86
File Menu 88
Image File Selection 89
Recipe File Selection 89
SortParams 90
LaserParams 92
Map/Image Save Options 93
Deskew Options 95
WaferMap 97
Defect Code (DefectCodeTable) 97
Map/Image Save 98
Exit 98
Screen Menu 98
Window Panes 99
Pane Sizes 100
Pane Swapping 100
Global and Local Data 100
Defect Map Panes 101
Moving Around the Wafer Map Window 103
Wafer Map Zoom Views 103
Wafer Map Palettes 104
Cassette Pane 104
Status/Defect Pane 106
Status Option 106
Deskew Option 108
DefList 108
DefCode Pane 109
Search Pane 110
Stat Pane 111
Sequence Panes 111
Laser and White Light Controls 114

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White Light Controls 115
Laser Imaging Controls 116
Manual Screen 118
Load Wafer Screen 119
Deskew Screen 119
Review Screen 120
3D Surface and Volume Image Controls 122
Zoom 123
Zoom in with Fixed Magnification Ratio 124
Zoom in with Variable Magnification Ratio 124
Zoom out 124
Translation 124
Color 124
Lighting 125
Z Scale 125
Smoothing 125
Y Width 125
File 125
The 2D Panes 126
2D Slice Image Controls 126
XY - The Top View 128
XY Size Cursor Control 128
XY Cut Cursor Control 128
XZ and YZ VIEWS 129
1st Slice 129
Sections & Spacing 129
New Surface & First Slice 130
XZ and YZ Peaks 130
Z Profile 130
Volume Screen 131
Surface Screen 132
Surface Print 134
4_Library Screen 134
2D/3D/WL Screen 135
Volume Print Screen 136
2D Profiles Screen 137
Large Surface Screen 137
WL 3D Print Screen 138
Setup Menu 139
LaserScan Parms 139
Deskew Options 139
Edit Wafer Map 140
Defect List Sort 141

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Rearranging Map 143
Defect Chart 143
User Menu 144
Login 144
Logout 145
Set Password 145
Config Menu 146
Screen 146
To Create a User Screen 146
To Modify a Sequence Screen 148
Function Keys 148
Misc 152
Maintenance Menu 156
Manual Stage Control 157
Manual Robot Control 158
File Transfer 160
Target Name 162
Actions 162
File selection 162
UserAcct 163
LONDiagnostics 164
PageScan... 168
PMT Amp... 168
FastZ... 169
LON Nodes 170
1 LaserPwrControl LON Node 170
2 CameraFilterWheel LON Node 171
3 LaserLineFilter LON Node 171
4 LaserAttenFilter LON Node 171
5 Bright/DarkField LON Node 171
6 Page Scanner LON Node 171
7 FastZ Ctrl LON Node 172
8 PMT Amp LON Node 173
9 Turret/OpticsCtrl LON Node 174
10 Cassette Switch LON Node 174
11 Solenoid Ctrl LON Node LON Node 174
12 Aperture Ctrl LON Node 174
13 Docking Ctrl LON Node 175
WaferLoadTest 175
Calibration 176
Reset Floppy Drive 177
Reset Network 178

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Stage Flatness Test 178
ImageQuality Test 179
Align Stage/Objectives 180
Test AutoDsk 181
Print Menu 182
Print 183
Queue 183
System Startup and Shutdown 184
System Startup 184
System Shutdown 184
Error Messages 185

Chapter 6 Advanced Operation 193

Recipes 193
To set up a recipe 194
To retrieve a recipe 194
Setting Laser Intensity Values 194
To adjust the laser scan parameters (basic method) 194
To adjust the laser scan parameters (advanced method) 195
Stage Center Offset 196
To determine the Stage Center Offset for patterned wafers 196
To determine the Stage Center Offset for bare wafers 197
Bare Wafer Review 197
Deskewing with Defects 197
Defect Review 198
Defect Coordinate Updating 199
Bare Wafer 3D Imaging 199
Choosing the Objective for 3D imaging 199
To acquire a good 3D image for a small particle 200
Making Wafer Maps 201
Tencor Format Maps 201
Creating a Tencor Map 201
Retrieving the Tencor Map 202
KLA Format Maps 202
Creating a KLA Map 202
Retrieving the KLA Map 203

Chapter 7 Applications 205

Subsurface Imaging 205

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Films and Laser Lines 206
Subsurface Defect Signature 206
Limitations 207
Making Measurements 207
Choosing the Right Objective 208
Resolution 208
Diffraction 208
Scattering 208
Interference 209
General Guidelines 209
Metal or Poly line-space patterns 209
Photoresist line-space patterns 209
Film Thickness Measurements 210
Theory 210
Measurement Procedures 211
Case 1: Film Step 211
Case 2: Blanket Film 212
To find the right wavelength 212
To get the correction factor for a specific film 212
Example 212

Appendix A System Software 215

Introduction 215
Basic UNIX Commands 215
Help 217
User Information 218
System Information 218
Time/Date 221
File Information 222
File Manipulation 224
RCP File Transfer 225
FTP File Transfer 225
Logging on Remotely 226
Directory Manipulation 226
Command Information 228
Process Control 229
Miscellaneous Commands 230
Text Editing using Jot 230
Tapes 231
User Preferences 232

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

.login 232
.cshrc 233
.profile 233
.Xdefaults 234
.sgisessions 234
CRS Command Files 235

Appendix B Preparing for CRS Installation 237
Pre-installation Qualification Checklist 237

Appendix C Preparation for ADC 243
Requirements 243
Scope 244
Items Required 244
Procedure 244
Standard ADC Components for all CRS Systems 244
Items to check that are critical for ADC systems 245
System information 245
Keyfile information 245
Integrated whitelight option 245
Computer Module 245
Primary hard disk 245
UV software version 245
Camera present 246
GEMINI Optics 246
External Optical Drive 246
Objectives in system 246
Automated A-stop mechanism 246
Beamsplitter type 247
RGB output present on interface panel on back of unit 247
Fast-Z PCBA version 247
Stage System 247
Die to die stage accuracy 247
Part number descriptions/definitions 248

Appendix D Specifications 251
CRS 1200 251
Optical System 251

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

General 251
White Light 251
Laser 252
Computer 252
Processor 252
Graphics 253
Communication & Interfaces 253
Storage 253
Other 253
Wafer Transport 254
General 254
Prealigner 254
Robot 254
XYZ Stage 254
XY Axes 254
Coarse Z 255
Fine Z 255
System General 255
External Frame 255
Throughput 255
Reliability 256
Facilities, Environmental, and Shipping 256
Facilities 256
Environmental 256
Physical 256
Shipping 257
Drawings 258
Optical Systems Comparison 262
Terms of Comparison 262
Overview of Laser and White Light Microscopes 264
White Light System 264
White Light Confocal System 265
Laser Confocal System 266

Appendix E Confocal Review Station Options 269

KLA-Tencor CRS 1200 Defect Review Station 269
Standard Equipment and Software 269
Hardware Options 270
Software Options 270
Accessories 270

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Description of Options 270
GEMINI Optics 270
ADC 272
SMIF and Mini-Environment 272
GEM SECS 273
Integrated White Light 274
Light Tower 274

Appendix F Basic Maintenance 277

Troubleshooting 277
Lockup Recovery 277
Restarting the CRS uv Application 278
Executing a Five-Finger Reset 278
Rebooting the Computer 279
Cycling Power 279
Water Removal 279
Wafer Removal Using the Application Software 279
Manual Wafer Removal 280
Preventive Maintenance 281
Safety Precautions 281
The Preventive Maintenance Schedule 281
System Wipe Down 282
Data Backup and Restore 282
To backup the system 282
To restore the system 283
Chuck Cleaning 283
To clean the robot end effector 283
To clean the prealigner chuck 283
To clean the XYZ stage chuck 283
Laser Lifetime 284
To monitor aging of the laser 284
Robot Alignment Check 284
Robot to Cassette Alignment Check 284
Robot to Prealigner Alignment Check 285
Robot to XYZ Stage Alignment Check 285
Robot Safety Interlock Check 285
Changing the Halogen Bulb 286
To change the halogen bulb 286
KLA Tencor Factory PM 288

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Appendix G Configuring NFS 289

Introduction 289
Terminology 289
Configurations 290
Procedure 290
Hardware setup 290
Network address setup 290
To edit the `/etc/hosts` file 291
Testing the Hardware Connection 291
Configuring NFS–Summary 291
Configuring NFS–Detailed Procedure 292
Testing NFS 292
Renaming Remote Directories 293

Appendix H Preparing Optical Disks 295

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List of Figures

Figure 1-1 CRS Wiring Blocks and Color Code 3
Figure 1-2 EPO Button 4
Figure 1-3 CRS Layout 4
Figure 1-4 Schematic Diagram of Laser Interlock 6
Figure 1-5 Schematic Diagram of Laser Shutter Interlock 7
Figure 1-6 Plastic Robot Cover 8
Figure 1-7 Schematic Diagram of Robot Interlock 9
Figure 2-1 Confocal Review Station 12
Figure 2-2 Laser Imaging of Thin Layers 13
Figure 2-3 Laser Imaging of Submicron Particle 14
Figure 2-4 Subsurface Defect in Oxide Layer 14
Figure 2-5 Subsurface Defect Below Metal Lines 15
Figure 2-6 Robot End Effector 16
Figure 2-7 Confocal Microscope Depth of Focus 17
Figure 2-8 CRS Images of a Particle 18
Figure 2-9 CRS Images of a Pit 19
Figure 2-10 Height of Particle 20
Figure 2-11 Principle of Confocal Optics 22
Figure 2-12 CRS Optical System Schematic 23
Figure 3-2 Right Side of CRS with Robot Cover Off 28
Figure 3-3 CRS with SMIF Unit 29
Figure 3-4 CRS Workstation 29
Figure 3-5 CRS Software Startup Screen 30
Figure 3-6 Login Window 31
Figure 3-7 Password Entry 31
Figure 3-8 Hardware Initialization 32
Figure 3-9 Stage and Robot Initialization 32
Figure 3-10 Initial Screen 33
Figure 3-11 Map File Selection Screen 34
Figure 3-12 Deskew Points on Wafer 35
Figure 3-13 Deskew Screen 36
Figure 3-14 Deskew Point at Low Magnification 37

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Figure 3-15 Deskew Point at High Magnification 38
Figure 3-16 Multiple Views of a Defect 39
Figure 3-17 Intensity/Color Mapping in Laser Images 40
Figure 3-18 Laser Image Zoom 41
Figure 3-19 White Light and Laser Image of 0.3µ Feature 42
Figure 3-20 Surface Images of 0.3µ Feature 42
Figure 3-21 Volume Images of 0.3µ feature 43
Figure 3-22 Real or False Defect? 43
Figure 3-23 Light Point Defect Revealed as Particle 44
Figure 3-24 Scratches on Wafer Surface 44
Figure 3-25 Badly Focused Image 45
Figure 3-26 Almost Focused Image 46
Figure 3-27 Well Focused Image 46
Figure 3-28 Adjusting Laser Image Brightness 47
Figure 3-29 Adjusting White Light Brightness 47
Figure 3-30 Laser Image Zoom Sequence 48
Figure 3-31 Zoom Image Areas 48
Figure 3-32 Zoomed Laser Images 49
Figure 3-33 The Relationship Between Focus and Z-position 50
Figure 3-34 White Light Image Controls 50
Figure 3-35 BrightField and DarkField White Light Images 51
Figure 3-36 Laser Image Controls 51
Figure 3-37 Laser Overload Message 52
Figure 3-38 Volume Image Screen 53
Figure 3-39 Surface Image Screen 54
Figure 3-40 Surface Image Before Zoom 56
Figure 3-41 Surface Image with Zoom Box 57
Figure 3-42 Zoomed Surface Image at Low Resolution 58
Figure 3-43 Zoomed Surface Image at High Resolution 58
Figure 3-44 KLA Tencor CRS Basic Operating Sequence Flowchart 61
Figure 4-1 Deskew Sequence Pane 65
Figure 4-2 Manual Deskew Pane 65
Figure 4-3 Deskew Options window 66
Figure 4-4 Wafer Map Window 67
Figure 4-5 System Configuration Window 67
Figure 4-6 Defect Selection Window 69
Figure 4-7 A Poor Deskew Point 70
Figure 4-8 A Better Deskew Point 70
Figure 4-9 Screen Arrangement for Setting Manual Deskew Points 71
Figure 4-10 Confirm Deskew Point Dialogue Box 71
Figure 4-11 AutoDeskew Reference Image Capture 73
Figure 4-12 Testing AutoDeskew 74
Figure 5-1 Error Messages for Unavailable Functions 78
Figure 5-2 CRS Keyboard Layout 79
Figure 5-3 CRS Application Menu Bar 81
Figure 5-4 CRS Menus 87

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Figure 5-5 File Menu 88
Figure 5-6 Image File Dialogue Box 89
Figure 5-7 Recipe File Dialogue Box 90
Figure 5-8 Sort Parameters Window 90
Figure 5-9 Recipe Laser and Imaging Control Window 92
Figure 5-10 Recipe Map/Image Save Options Window 94
Figure 5-11 Recipe Map Image Save Window 94
Figure 5-12 Recipe Deskew Options Window 95
Figure 5-13 MapFile Window 97
Figure 5-14 Create Wafer Map Window 97
Figure 5-15 Defect Code File Window 98
Figure 5-16 Exit Window 98
Figure 5-17 Screen Menu 99
Figure 5-18 Defect Map Panes 101
Figure 5-19 ZoomSize Pane 103
Figure 5-20 Color Palette Panes 104
Figure 5-21 Cassette Pane 105
Figure 5-22 No Map Dialogue Box 106
Figure 5-23 Status Pane 106
Figure 5-24 Edit Defect Window 108
Figure 5-25 Deskew Pane 108
Figure 5-26 Defect List Pane 109
Figure 5-27 Defect Code List Pane 109
Figure 5-28 A Defect Code List 110
Figure 5-29 Search Pane 110
Figure 5-30 Die Jumping in Search Subwindow 111
Figure 5-31 Stat Pane 111
Figure 5-32 Start Sequence Pane 112
Figure 5-33 Load Wafer Sequence Pane 112
Figure 5-34 Deskew Sequence Pane 113
Figure 5-35 Classification Sequence Pane 113
Figure 5-36 Return to Review Sequence Window 113
Figure 5-37 White Light Image Controls 115
Figure 5-38 Laser Image Control Panel 116
Figure 5-39 Manual Screen 118
Figure 5-40 Load Wafer Screen 119
Figure 5-41 Deskew Screen 119
Figure 5-42 Review Screen 120
Figure 5-43 3D Image Controls 122
Figure 5-44 Action of Tilt and Rotate Buttons 123
Figure 5-45 False Color Image Examples 125
Figure 5-46 2D Axis Conventions 126
Figure 5-47 2D View Projections 126
Figure 5-48 2D Image Controls 128
Figure 5-49 Image File History Window 129
Figure 5-50 2D Sections View in 3 x 3 Grid 130

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Figure 5-51 Volume Screen 131
Figure 5-52 Surface Image Screen 133
Figure 5-53 Surface Print Screen Layout 134
Figure 5-54 4_ Library Screen 135
Figure 5-55 2D/3D/WL Screen Layout 136
Figure 5-56 Volume Print Screen Layout 136
Figure 5-57 2D Profiles Screen Layout 137
Figure 5-58 Large Surface Screen Layout 138
Figure 5-59 WL/3D Print Screen Layout 139
Figure 5-60 Setup Menu 139
Figure 5-61 Edit Wafer Map Window 140
Figure 5-62 Defect List Sort Window 142
Figure 5-63 Rearranging Wafer Map Window 143
Figure 5-64 Defect Chart Window 144
Figure 5-65 User Menu 144
Figure 5-66 Set Password Windows 145
Figure 5-67 Config Menu 146
Figure 5-68 Configure Screen Window 146
Figure 5-69 Select Screen Window 147
Figure 5-70 Screen Edit 2D and 3D Option Windows 147
Figure 5-71 Screen Edit Status Window 147
Figure 5-72 Save Screen Changes Window 148
Figure 5-73 Quit Screen Changes Window 148
Figure 5-74 Function Key Window 149
Figure 5-75 Function Key Macro Editing Window 149
Figure 5-76 Config Misc. Window 153
Figure 5-77 Maintenance Menu 157
Figure 5-78 Manual Stage Control Window 157
Figure 5-79 Manual Stage Control with Data Reporting and Input Field. 158
Figure 5-80 Manual Robot Control Window 159
Figure 5-81 Wafer on Robot Error Message 159
Figure 5-82 Wafer Loaded Error Message 160
Figure 5-83 Wafer on Stage Error Message 160
Figure 5-84 Confirm Slot Message 160
Figure 5-85 File Transfer Window 161
Figure 5-86 User Accounting Window 163
Figure 5-87 LON Diagnostics Window 165
Figure 5-88 Page Scan Diagnostics Window 168
Figure 5-89 PMT Amplifier Diagnostics Window 169
Figure 5-90 Fast Z Diagnostics Window 170
Figure 5-91 Wafer Load Test Window 176
Figure 5-92 Calibration Window 177
Figure 5-93 Confirm Saving Configuration File Dialogue Box 177
Figure 5-94 Reset Floppy Drive Window 178
Figure 5-95 Reset Network Window 178
Figure 5-96 Stage Flatness Test Window 179

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Figure 5-97 Image Quality Test Window 180
Figure 5-98 Align Stage/Objectives Window 181
Figure 5-99 Save Stage/Objective Alignment Window 181
Figure 5-100 Test AutoDeskew Window 182
Figure 5-101 Print Menu 182
Figure 5-102 Printer Window 183
Figure 5-103 Print Queue Window 183
Figure 5-104 Hardware Initialization Error 185
Figure 5-105 Robot Not Initialized Error 185
Figure 5-106 Robot Initialization Error 186
Figure 5-107 Microscope Objective Error 186
Figure 5-108 Color Setting Error 186
Figure 5-109 Video Error 186
Figure 5-110 Image Capture Error 187
Figure 5-111 Image Load Error 187
Figure 5-112 Image Save Error 187
Figure 5-113 Surface Image Save Error 188
Figure 5-114 Optical Drive Error 188
Figure 5-115 Cassette Interlock Warning 188
Figure 5-116 Cassette Changed Message Box 189
Figure 5-117 Defect Sort Entry Error 189
Figure 5-118 Key and Function Selection Error 189
Figure 5-119 Key Selection Error 190
Figure 5-120 Network Variable Selection Error 190
Figure 5-121 Paste Error 190
Figure 5-122 Password Error 191
Figure 5-123 List Selection Error 191
Figure 5-124 Sort Criterion Selection Error 191
Figure 5-125 Text Entry Error 191
Figure 6-1 Recipe Window 193
Figure 6-2 Z Peak Shapes 200
Figure 7-1 Defect under Metal Lines 205
Figure 7-2 Defect under Resist 206
Figure 7-3 The Optical Thickness of a Transparent Film 211
Figure 7-4 Linear Fit to Thickness Measurements 213
Figure 7-5 SEM Versus CRS Thickness Measurement Comparison 213
Figure A-1 Toolchest Menu 216
Figure A-2 IRIX Shell Window 216
Figure A-3 Jot Window 231
Figure B-1 CRS Measurements and Floor Layout 239
Figure B-2 CRS Equipment Rack 240
Figure D-1 CRS 3010 Isometric View 258
Figure D-2 CRS Top View 259
Figure D-3 CRS Front View 260
Figure D-4 Power Panel, Right Rear of CRS 261
Figure D-5 Connector Panel, Left Rear of CRS 262

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Figure D-6 Resolution Limit 263
Figure D-7 N.A. and Opening Angle 264
Figure D-8 White Light vs. Laser Confocal Depth of Focus 267
Figure E-1 Effect of Gemini Optics on White Light Images 271
Figure E-2 Effect of GEMINI Optics on Laser Image 272
Figure E-3 CRS with SMIF and Mini-Environment 273
Figure E-4 Light Tower 275
Figure F-1 Shutdown Confirmation 286

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

List of Tables

Table 1-1 SEMI S2-93 Work Types 2
Table 4-1 Setting up AutoDeskew 64
Table 5-1 Account Privilege Levels 77
Table 5-2 Enter Key Functions 79
Table 5-3 CRS Function Key Assignments 80
Table 5-4 Window Controls 81
Table 5-5 CRS Directories 83
Table 5-6 File Extensions 84
Table 5-7 Contents of Wafer Map Files 85
Table 5-8 Recipe File Contents 85
Table 5-9 Menu Functions Requiring Administrator Privilege 87
Table 5-10 Defect Sort Criteria 91
Table 5-11 Standard Wafer Thicknesses 93
Table 5-12 CRS Screen Panes 99
Table 5-13 Window Sizes 100
Table 5-14 Wafer Map Panes 102
Table 5-15 KLA and Tencor Map Colors 102
Table 5-16 Cassette Pane Controls 105
Table 5-17 Status/Defect Display Options 106
Table 5-18 Status Pane Functions 107
Table 5-19 Defect List Format 109
Table 5-20 Mechanical Imaging Controls 114
Table 5-21 Laser Image Screen Controls 116
Table 5-22 3D Image Acquisition Controls 121
Table 5-23 3D Image Controls 123
Table 5-24 False Color Schemes for 3D Images 124
Table 5-25 2D Slice Viewing Options 127
Table 5-26 2D Slice Image Control Functions 128
Table 5-27 Wafer Map Parameters 140
Table 5-28 Functions for Key Bindings 150
Table 5-29 Config Misc. Parameters 153
Table 5-30 Automatic Recipe Load Option Menu 155

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Table 5-31 Obsolete Config Misc. Parameters 156
Table 5-32 File Transfer Window File Type Option Menu 161
Table 5-33 File Transfer Actions 162
Table 5-34 User Account Window Functions 163
Table 5-35 Lon Diagnostics Window Controls 165
Table 5-36 PMT/AMP Diagnostic Window Controls 169
Table 5-37 Laser Power Control Network Variables 170
Table 5-38 Camera Filter Wheel Network Variables 171
Table 5-39 Laser Line Filter Network Variables 171
Table 5-40 Laser Attenuation Filter Network Variables 171
Table 5-41 BrightDarkField Network Variables 171
Table 5-42 Page Scanner Network Variables 172
Table 5-43 Fast Z Control Network Variables 172
Table 5-44 PMT Amplifier Network Variables 173
Table 5-45 Turret/Optics Control Network Variables 174
Table 5-46 Cassette Switch Network Variables 174
Table 5-47 Solenoid Control Network Variables 174
Table 5-48 Aperture Control Network Variables 174
Table 5-49 Docking Control Network Variables 175
Table 5-50 Laser Scan Parameters 177
Table 6-1 Autofocus Performance Versus Laser Intensity 195
Table 7-1 Minimum Required NA for Various CDs 208
Table 7-2 Objective Magnifications and Numerical Apertures 209
Table 7-3 Laser Penetration Depth for Selected Materials 210
Table 7-4 Film Thickness Measurement Comparison 212
Table A-1 UNIX Input and Output Redirection 217
Table A-2 Man Command 217
Table A-3 User Information Commands 218
Table A-4 System Information Commands 218
Table A-5 Time/Date Commands 222
Table A-6 File Contents Commands 222
Table A-7 File Manipulation Commands 224
Table A-8 RCP Command 225
Table A-9 FTP Command and Functions 225
Table A-10 Directory Manipulation Commands 226
Table A-11 Command information 228
Table A-12 Process Control Commands 229
Table A-13 Miscellaneous Commands 230
Table A-14 Tape Commands 231
Table A-15 User Preference Files 232
Table A-16 CRS Application Commands 235
Table B-1 Environment Requirements 237
Table B-2 Vibration Requirements 239
Table C-1 ADC Component Part Numbers and Descriptions 248
Table E-1 Light Tower lamp modes and their codes 274
Table F-1 Lockup Symptoms and Recovery Actions 277

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Table F-2 Preventive Maintenance Schedule 281
Table H-1 Wafer Diameters 307

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1

Safety

The KLA-Tencor CRS has been designed throughout for safety. Every attempt has been made to minimize the hazards presented to the user during normal operation of the instrument. However, as with most semiconductor equipment, operators should always be aware of the machine, its operational status, and its environment. Please read this section carefully and contact KLA-Tencor if you have any questions.

SEMI S2-93

In 1994 an independent organization audited the CRS (at that time the Ultrapointe Laser Imaging System) for compliance with the S2-93 safety standard as defined by SEMI (Semiconductor Equipment Manufacturer's Industry). The CRS passed the audit successfully.

Laser Safety

In accordance with the Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968 (applicable to laser products), a Laser Product Report for this instrument has been forwarded to the Center for Devices and Radiological Health (CDRH). This instrument falls under Class I definitions because there is no user access to laser radiation.



WARNING

Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

The instrument's stainless steel covers should be kept intact during normal operation. Internal to the instrument is a Class IIIb Argon ion laser rated at 25 milliwatts. Removal of any part of the outer

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covers can expose the user unnecessarily to hazardous laser radiation. Danger labels (such as those shown) indicate covers that provide access to hazardous laser light exposure.

DANGER - Laser radiation when open and interlock defeated. AVOID DIRECT EXPOSURE TO BEAM

DANGER - Laser radiation when open. AVOID DIRECT EXPOSURE TO BEAM

To prevent accidental exposure to laser radiation, some of the outside covers of the instrument have interlocks. The interlock switches in the system are on the front and back of the frame and are closed when the top cover is in place. When the top cover of the system is removed, the switches open, causing the laser to shut off. Removal of the top cover is necessary to remove any of the upper side covers. A power cycle of the laser power supply is required to restart the laser.

High Voltage

Internal to the instrument are components using voltages up to 1000 VDC and 240 VAC. Access to and servicing of all internal components is by factory-authorized personnel only. Procedures in this document that require access to components that may be at hazardous voltages will either include warnings or instructions to shutdown, turn off, and lock out the AC input to the machine. In this manner, the customer service personnel will not be exposed to hazardous voltages within the instrument.

The following are the five types of work according to SEMI S2-93. All PM procedures that customer personnel will accomplish will be typed according to this standard.

Type 1	Equipment is fully de-energized (electrically cold)
Type 2	Equipment is energized. Live circuits are covered or insulated. Work is performed at a remote location to preclude accidental shock.
Type 3	Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 Joules. (See NFPA 79-14.3, IEC 204, UL 1950 & 1262, IEC 950)
Type 4	Equipment is energized. Live circuits are exposed and accidental contact is possible. Voltage potentials are greater than 30 volts RMS, 42.2 volts peak, 240 V-A, 20 J, or radio frequency (rf) is present.
Type 5	Equipment is energized and measurements and adjustment require physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes.

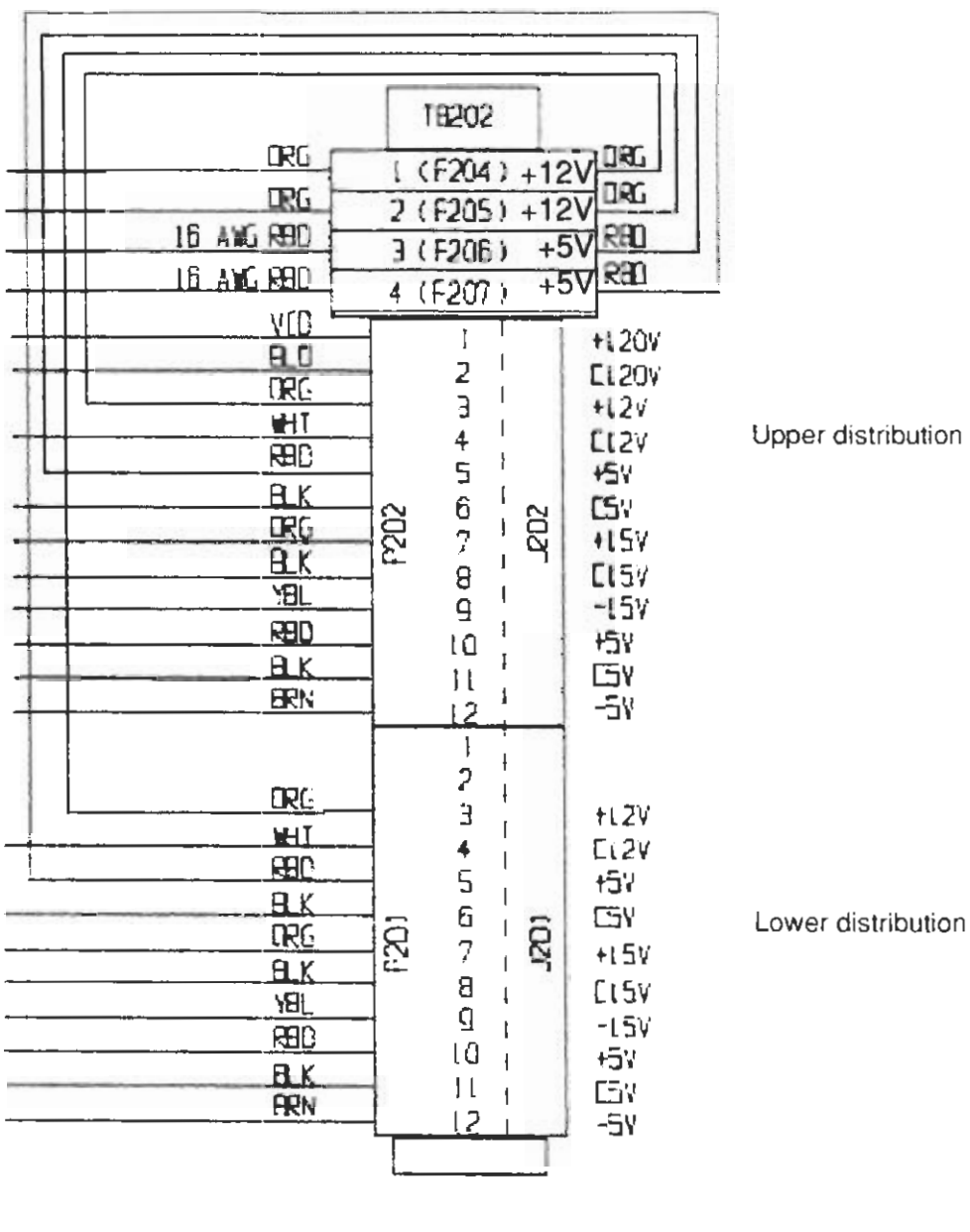
Table 1-1 SEMI S2-93 Work Types

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Whenever possible the system should be fully de-energized (electrically cold) when performing maintenance. To ensure that the system is not energized during maintenance a circuit breaker lockout has been provided.

The wiring in the system is color coded. The color codes are on the wiring diagram in Fig. 1-1.

Figure 1-1 CRS Wiring Blocks and Color Code



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Emergency Power Off

Figure 1-2 EPO Button



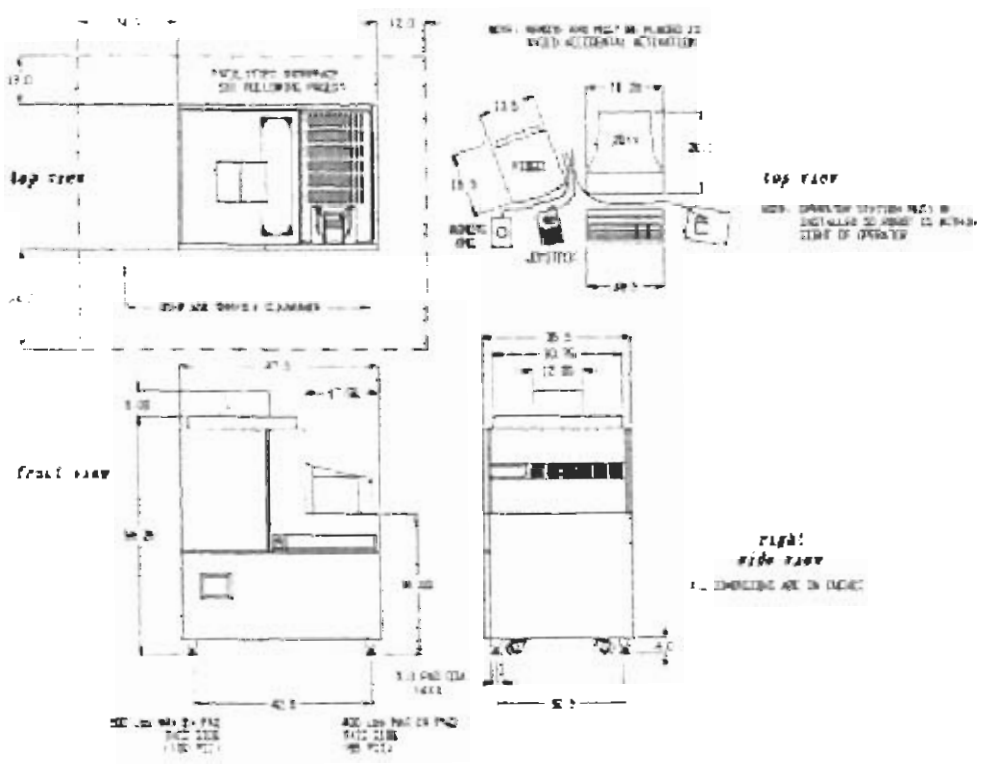
The system is equipped with an Emergency Power Off (EPO) switch to be used when power to the system needs to be removed immediately. This method of shutdown should only be used in an emergency.

The EPO works by removing the 24 VDC from the contactor that opens the contacts, removing all power from the system. The EPO button locks in and will not allow the re-energizing of the system until it is unlocked by rotating the button in a counterclockwise direction.

System Components

The **KLA Tencor** CRS consists of two subsystems: (1) the *main unit* housing the robot, optics, stage, electronics, and laser; and (2) the *operator's console*, with two monitors, keyboard, joystick and mouse. Fig. 1-3 shows a top view of the complete system, together with side and end views of the main unit.

Figure 1-3 CRS Layout



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Control of the main system is done via the operator's console. When setting up your system, be sure that the operator's console is placed so that the robot and its working envelope are clearly visible by the operator during normal operation.

Moving Parts

The following constitute the three classifications of moving parts in the CRS main unit.

Robot

The KLA Tencor CRS is equipped with a robotic handler to move wafers from the machine's exterior (the cassette) to the machine's interior (the XYZ stage) A Plexiglas barrier has been placed around the robot to prevent anyone from coming within close proximity of the robot. If the barrier is opened, then the robot automatically shuts down. Despite this, the user should always take care to keep body parts and clothing away from the robot area. The user should also ensure that all robot operations are complete before adding or removing a cassette from the cassette locator plate.

When operating the robot, the following safety precautions should be observed at all times to avoid personal injury or damage to equipment:

- Remain outside the operating envelope of the robot at all times unless power is off and the power cord is unplugged. The operating envelope is defined as the area under the Plexiglas robot safety cover plus the area of the input/output cassette.
- The robot should never be operated with the safety cover removed.
- Do not place control equipment, such as the host computer or peripherals, within the operating envelope.
- Be sure that the Emergency Power Off (EPO) switch is in a readily accessible position.
- Ensure that all personnel who will operate the equipment are properly trained.
- Adjustments, programming, and calibrations to the robot are to be executed by authorized service personnel only.

Isolation Table

Much of the instrument is attached to an internal frame that is mounted to the external frame (and protective covers) via pneumatic vibration isolators. The floating internal frame can therefore move freely with respect to the covers and creates possible pinch points between floating components and the covers or external frame. Externally accessible floating components (if the robot cover is removed) include the cassette platform, the robot, and the flat finder, all of which have possible pinch points.

Internal Parts

Inside the instrument are many moving parts that could create possible hazards, including motors, shutters, and an XYZ stage. Access to components inside the machine with system power on is restricted to authorized service personnel.

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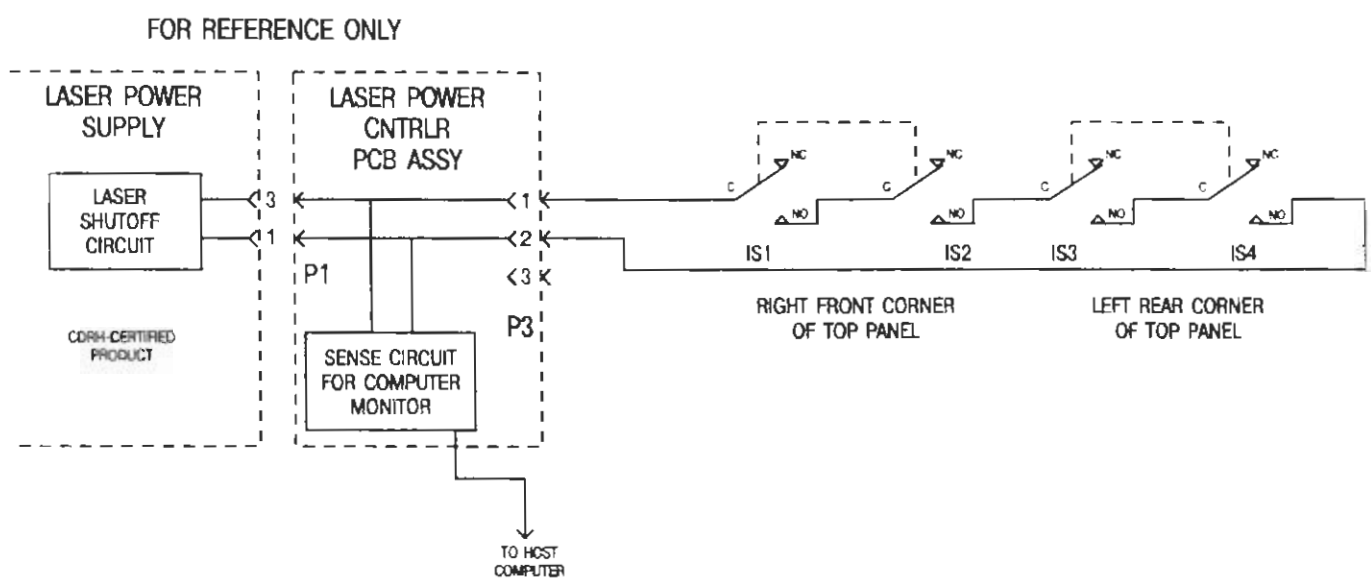
Interlocks

The KLA-Tencor CRS is equipped with interlocks that automatically shut down all or part of the machine when someone violates a safety barrier. ***Do not disable or bypass any of the interlocks under any circumstances.*** The interlocks are described below.

Laser Power Interlock

The upper external panels of the KLA-Tencor CRS are interlocked such that if they are removed at any time, then the laser automatically shuts itself off (see Fig. 1-4). Once the panels have been replaced, the laser must be manually reset by cycling the laser power at the circuit breaker panel.

Figure 1-4 Schematic Diagram of Laser Interlock

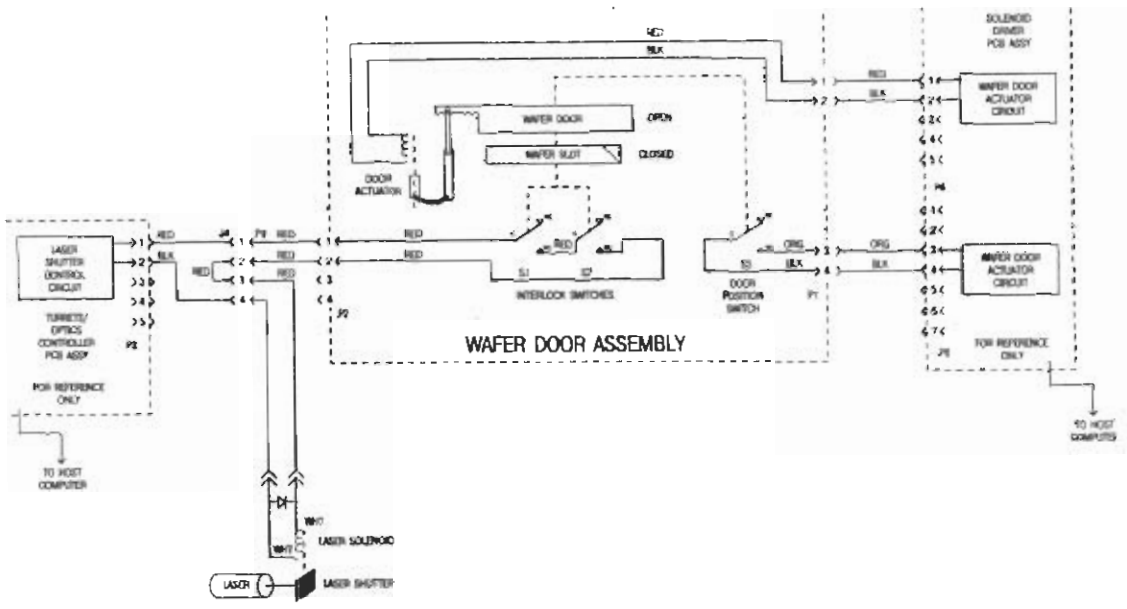


Laser Shutter Interlock

A shutter placed directly in front of the laser minimizes risk of laser exposure. Before a wafer can be inserted into the observation area, a wafer door must be opened to provide access for the robot arm (located outside of the optics area). The wafer door is automatically actuated by the machine and no input is required from the operator. The wafer door is electrically interlocked with the laser shutter so that opening the wafer door automatically causes the shutter to close (thereby blocking the laser beam). In normal operation, once the wafer is loaded and the wafer door has been closed, the shutter is automatically removed from the laser beam path (see Fig. 1-5).

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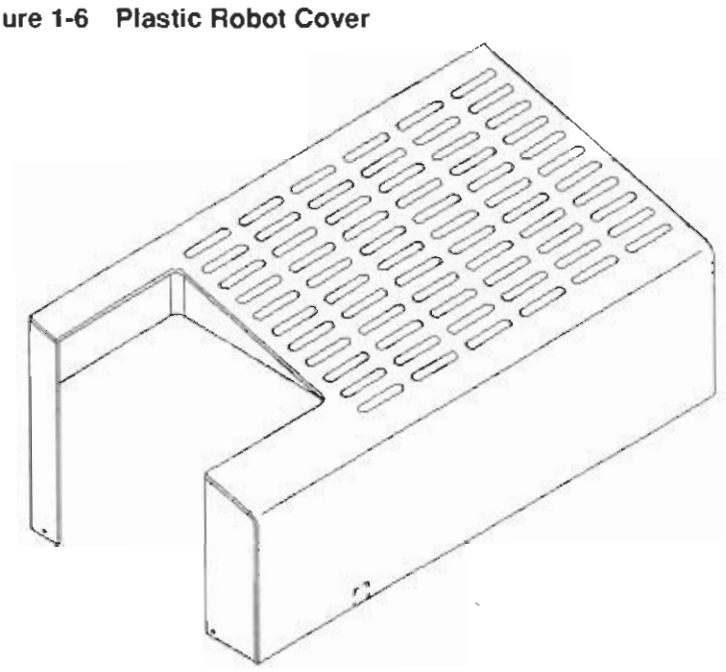
Figure 1-5 Schematic Diagram of Laser Shutter Interlock



Robot Cover

A Plexiglas cover shown in Fig. 1-6 surrounds the robot to prevent anyone from coming into the robot's envelope of operation. If the cover is removed at any time, then the robot is automatically disabled and a warning window appears on the monitor. Once the cover has been replaced, the robot may be enabled for continuation of its sequence after the instructions on the monitor are followed. The robot cover interlock circuit is shown in the diagram in Fig. 1-7.

Figure 1-6 Plastic Robot Cover



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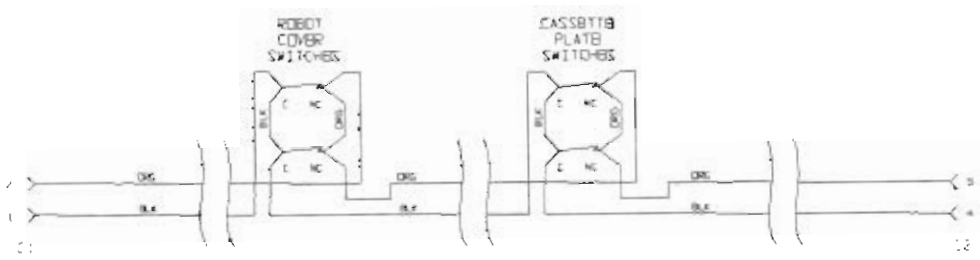
Cassette Interlock

The KLA-Tencor CRS is equipped with a cassette interlock switch which detects whether or not a wafer cassette is properly situated on the cassette platform. Fig. 1-7 shows the cassette interlock circuit. If the cassette is removed during operation, the robot will be disabled and a warning window will appear on the monitor. To resume operation, replace the cassette and follow the instructions on the monitor.

Hazardous Materials

The KLA-Tencor CRS requires only house air, vacuum, and electricity for operation. No other gases, fluids, or chemicals are necessary. However for system wipedown purposes you may elect to use *diluted* isopropyl alcohol. Please exercise care when using alcohol in accordance with your company's Hazardous Materials Safety Regulations.

Figure 1-7 Schematic Diagram of Robot Interlock



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2

Introduction

Confocal Review Station Overview

The KLA Tencor Confocal Review Stations (CRS) such as that shown in Fig. 2-1on the next page are high-performance automated laser/white light microscope systems designed for classification of defects on both bare and patterned wafers, using defect maps generated by a variety of instruments. The Confocal Review Stations combine a bright-field/dark-field white-light microscope with a laser confocal microscope, automated wafer handling, and a powerful image processing computer. The original CRS 500 was designed for manual review, but in later versions Automatic Defect Classification (ADC) was added, making the CRS the first off-line ADC system. ADC is now an option on the current CRS 1200, and is available as an upgrade to the earlier CRS 1010A and to any earlier CRS that can be upgraded to 1010A equivalence.

The argon ion laser used in the CRS has three prominent emission lines, at 515 nm (green), 488 nm (blue), and 458 nm (violet). Any one line can be selected, or all three used together, depending on the structures to be inspected.

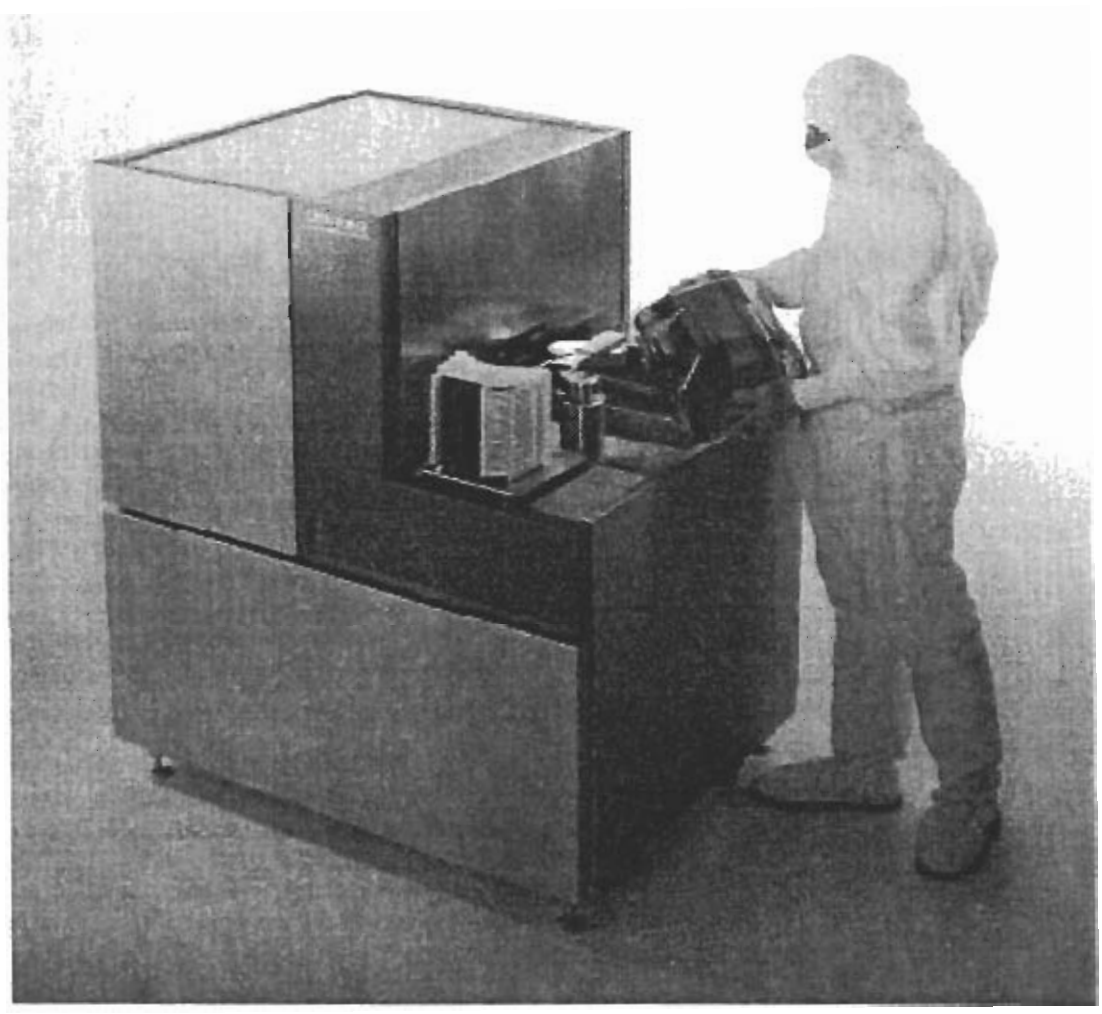
The microscope focusses the laser beam to a diffraction-limited spot on the wafer surface. Vibrating mirrors scan this spot over a square patch on the wafer surface, and the reflected return beam is captured by a photomultiplier tube (PMT) which sends gray-scale signals to a Silicon Graphics Indy computer for conversion to false-color images on the screen. The CRS can display any combination of a 2D focal plane image, a 3D surface image rotated to any orientation, any horizontal slice of a volume image, and vertical 2D cuts through any of the 3D images in XZ or YZ planes. The time to acquire and display a 3D image of 512 × 512 pixels × 64 slices is just 12 seconds. The laser scan amplitude can vary for 1×, 2×, 4×, or 8× zoom within the same magnification of the microscope, providing on-screen magnification up to 25,000× with a 150× objective at Zoom8. One micron on the wafer is magnified up to about one inch in the live laser image at these settings. The software supports measurement directly on the screen, using scales displayed along the edge of images, or rubberband cursors which continuously display their X and Y dimensions while they are moved and resized to fit features of interest.

Both manual review mode and ADC mode are available, under operator or remote computer control following the GEM/SECS protocol. The SMIF option makes possible fully automatic operation in a mini-environment, with sealed wafer cassettes transferred to the CRS from fabrication equipment or other inspection tools, and from the CRS to other stations depending on the results of defect classification. The CRS can save image and defect classification data locally on its own hard drive or to another networked station for later analysis.

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The most important feature of the confocal microscope is its extremely narrow depth of focus in laser light, which makes it possible to image individual layers in semiconductor structures, and to resolve structural and defect features routinely to .15 µ. The depth of focus of the CRS using the 488 nm laser line is about 0.32 µ, an order of magnitude better than a white light microscope. By taking multiple slice images spaced as close together vertically as 12 nm, the resolution of fine Z stage

Figure 2-1 Confocal Review Station



positioning, the CRS can discriminate layers as thin as 25 nm (0.025µ). Fig. 2-2 shows CRS images of stacking faults, with each layer approximately 0.1µ high. The CRS can discriminate between pits and particles which appear point-like and identical in white-light images, and even estimate their sizes, as Fig. 2-3 and illustrates. Fig. 2-4 and Fig. 2-5 show the ability of the CRS to image subsurface defects. The first case is a defect in an oxide layer below resist. The second Note also that the defect's presence caused the metal line above it to bulge. Subsurface defects can frequently be located and classified, even under dielectric layers where the Scanning Electron Microscope (SEM) cannot image.

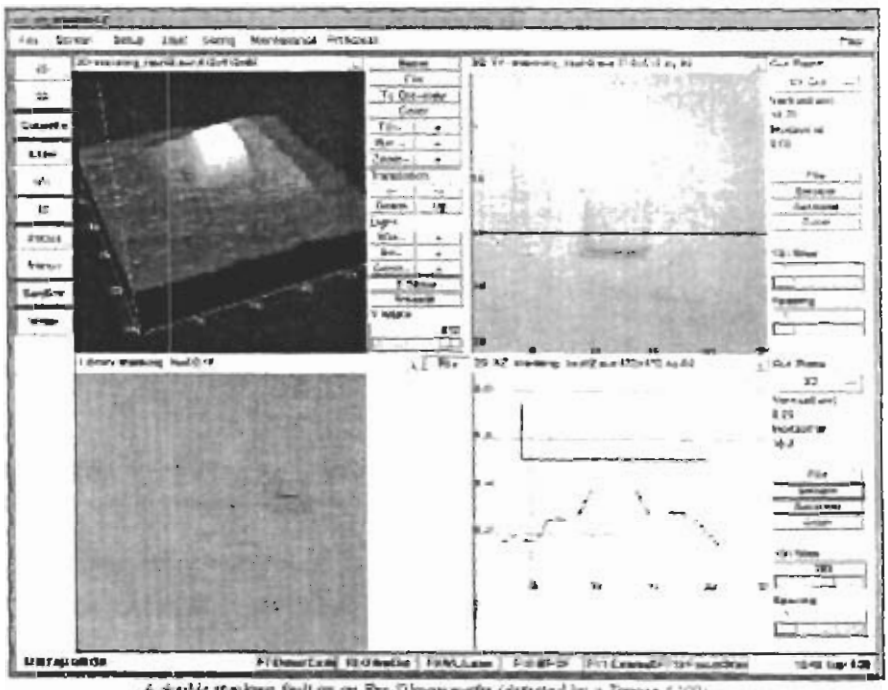
The CRS can be flexibly configured from fully manual operation to fully automated operation. There are manual and automatic options for cassette loading, wafer loading, deskew, defect inspection and

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analysis, image capture, data storage, and communication. The CRS can run automatically using locally stored recipes, or can receive commands and respond to them over the network.

The CRS operates in air with Class 1 cleanroom compatibility. A frequent use of a CRS is in a production line. Cassettes of wafers, from 100 mm to 200 mm in diameter, complete various stages in a process and move to automated inspection tools which examine the entire wafer surfaces. These tools generate wafer map files containing the wafer IDs and the coordinates of each defect along with some other information. Then the wafer cassettes and the map files go to the CRS, and defects are reviewed in the CRS. The CRS can access map files from floppy disks, over serial links, or from the

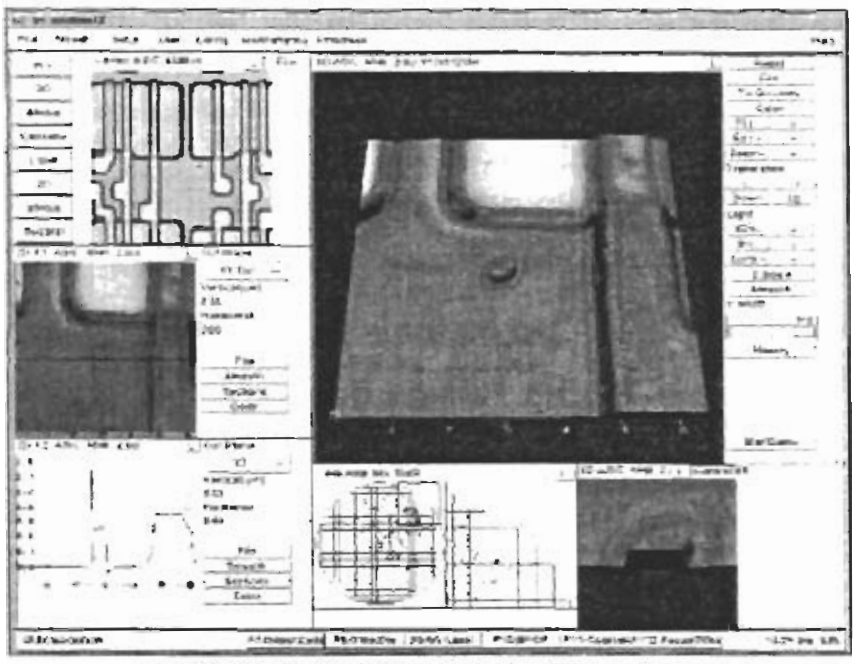
Figure 2-2 Laser Imaging of Thin Layers



A double stacking fault on an Epi-Silicon wafer (detected by a Tencor 8200)
Each "step" of the stacking fault is ~0.3 µm high

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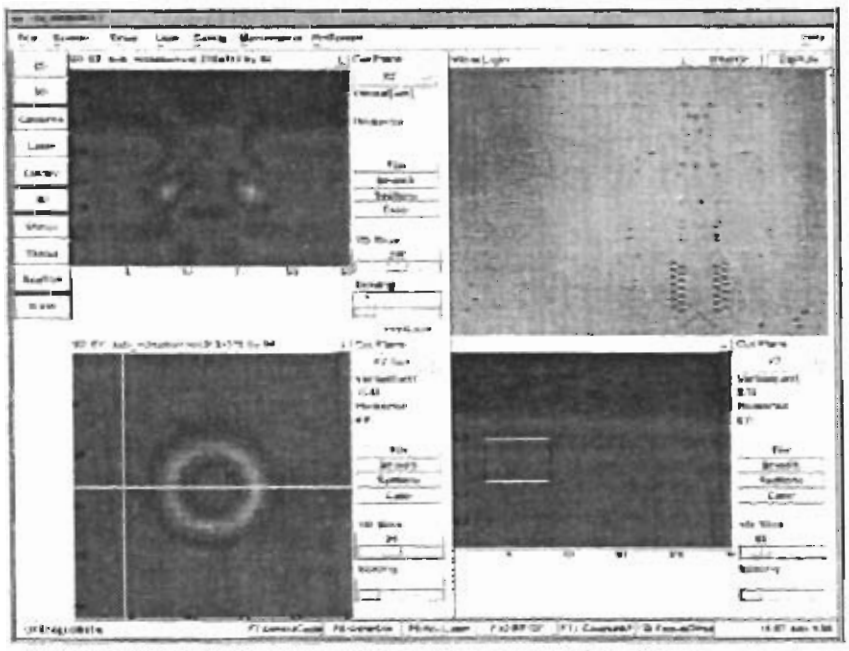
Figure 2-3 Laser Imaging of Submicron Particle



This 0.5µm particle is situated between features of an ASIC device. Its size or layer information can be determined from the white light image while the 3-D image reveals all.

network. Data from the CRS become available to KLA-Tencor yield analysis software to drive process improvements and maintain quality control.

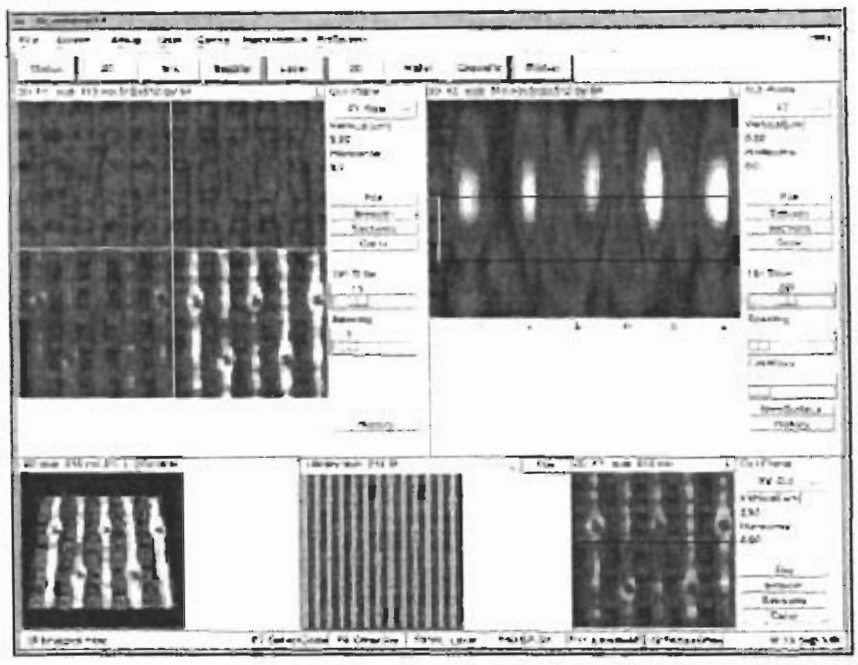
Figure 2-4 Subsurface Defect in Oxide Layer



In white light (upper right) this defect can only be seen at low magnification. The CRS's cross-sectional image shows a ring-shaped defect in the oxide layer above the silicon, below the metal. Consequently the engineer identified this as a "pre-phase nucleation defect" which occurred during oxide deposition.

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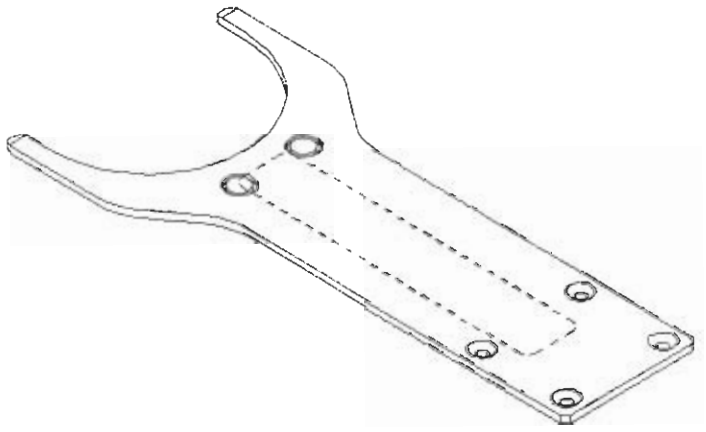
Figure 2-5 Subsurface Defect Below Metal Lines



This application requires a good characterization of the process, especially of the defect types likely to be encountered. Creating that process characterization is another key application of the CRS. Although the SEM has higher resolution than the CRS, the SEM is also slower and much more expensive, both in purchase and operating costs. The CRS can classify defects beyond the capabilities of conventional microscopes, and can select those defects that need to be examined in the SEM, thus supporting much more efficient use of the SEM for analyzing the defects characteristic of a particular stage in a particular process. With this knowledge, engineers can train CRS units with Automatic Defect Classification (ADC) to a level of accuracy higher than most manual operators attain. In particular, the software can recognize low-contrast defects invisible to the eye.

A precision, high reliability robot with a vacuum end effector, shown in Fig. 2-6, picks up the wafers on its fork. The two ring-shaped openings near the fork connect to the vacuum line. The fork fits around the chuck on the prealigner and inside the chuck on the stage, so that the robot can place the wafer in the center of each chuck.

Figure 2-6 Robot End Effector



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The stations within the CRS are the cassette and the optional SMIF for moving wafers between tools, the prealigner, and the XYZ stage which positions the wafers for viewing. The wafer handler removes wafers from the cassette to the prealigner, which centers the wafer and rotates it to orient the notch or flat on the wafer. The robot then moves the wafer to the XYZ stage which secures it to the chuck via vacuum. Locating etched fiducial marks or other pre-specified structures on the wafer surface establishes fine alignment (or *deskew*). The stage can then accurately translate any specified location on the wafer into the field of view with an accuracy and repeatability of a few microns.

Live Laser Imaging

Overview

Live laser imaging is a core feature of the KLA Tencor CRS. Since it is based on a scanning confocal design, it provides higher resolution and higher magnification than white light review stations. In addition, it is live or real time imaging, which makes it ideal for a volume production line where throughput is the name of the game. This note will explain the advantages and applications of the confocal live laser imaging feature.

What Is a Live Laser Image

Unlike white light imaging that uses extended light source and detects return signals from an extended area (i.e. the whole field of view) at the same time, confocal laser imaging is built upon laser light passing through the objective lens, forming a diffraction-limited spot, i.e. the focal point, on the sample surface. The detector collects signals only from that point and with a narrow depth of focus using a spatial filter, in this case a 25 μ pinhole. In essence, a confocal laser microscope is a point illumination and point detection system. To form a image of the sample, the laser beam is scanned across a square patch. The scan has to be fast enough for the images to look live or real time to a user. This is achieved on the CRS by scanning 512 × 512 points in a field of view with scanning rates of 8 kHz in horizontal and 13 frame/second in vertical direction.

Advantages Over White Light

Higher Resolution: The use of a monochromatic light source eliminates chromatic aberration in imaging, thus enhancing the resolution. The point illumination, point detection scheme eliminates the possibility of mixing signals from different parts of the field of view. Thus enhances the contrast and resolution of the image. In addition, the CRS software translates the gray scale image into a false color image, which enhances the contrast and resolution due to the fact that the human eye is more sensitive to color.

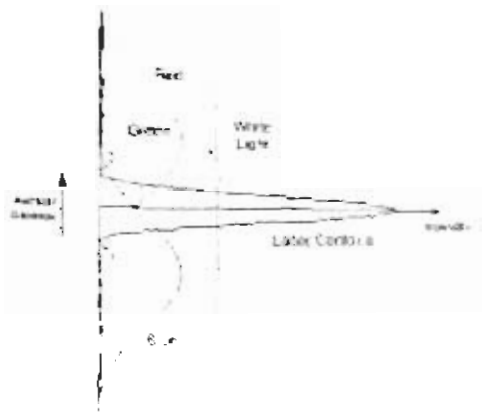
Higher Magnification: For a given objective, the live laser field of view is controlled by the laser beam scanner (zoom). By fixing the sampling at 512×512 points while reducing the laser scan field of view, the magnification of the laser image is increased. A typical laser image magnification of about 25,000× can be achieved with a 100× objective at zoom 8.

Narrow Depth of Focus: The combination of confocal imaging and laser light results in a very narrow range of distances where the surface is in focus. Fig. 2-7 shows the high, narrow peak in the

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amount of light returned for monochromatic laser light compared with the broad shallow peaks for the red, green, and blue portions of the spectrum, and the even broader, flatter peak for white light.

Figure 2-7 Confocal Microscope Depth of Focus



3D Imaging: By taking 64 slice images at different heights, the CRS can construct volume or surface images, and display a number of different views and graphs of the resulting image data. Volume datasets containing all 64 slices can be viewed in any horizontal (XY) or vertical (XZ or YZ) cut plane. Surface datasets are created by choosing the brightest level in each column, and keeping the height and brightness of those points. The reduced dataset is displayed as a relief surface in any orientation, with adjustable zoom, illumination, smoothing, and vertical relief. Vertical cross-sections can be viewed as images in the 3D surface window or as graphs in 2D cut windows. The 3D images are taken with the current setting of laser zoom, so they can also be much higher in resolution than white light images, in addition to showing subsurface features and clearly distinguishing pits from particles.

Main Applications

See more defects: Better contrast and higher XYZ resolution of confocal laser imaging allows it to see more defects. Defects that are very small and very low contrast for a white light microscope are easier to find in the live laser screen. This is critical to minimize the false counts of an in-line defect inspection tool and thus to optimize its inspection recipe.

Pit vs. Particle and Depth vs. Height: Having a much better Z resolution made it possible for a confocal machine to see a very thin slice at a time. By moving the fine Z stage up and down in 0.012 µ steps (i.e. changing the focus levels), the defect height/depth with respect to the substrate is measured, and the pit/particle classification is given. Fig. 2-8 shows a surface image of a particle, which clearly stands out in the laser image and the cross-section graph, even though it is impossible to distinguish in the white light image. Similarly, Fig. 2-9 does the same for a pit.

Height can be measured without taking a 3D image, as Fig. 2-10 illustrates. The fine Z control moves in 12 nm steps over a range of about 50 m, with the current height displayed continuously. The height of a particle can be measured by finding the level of the wafer surface and the level at which the reflection from the top of the particle disappears.

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Figure 2-8 CRS Images of a Particle

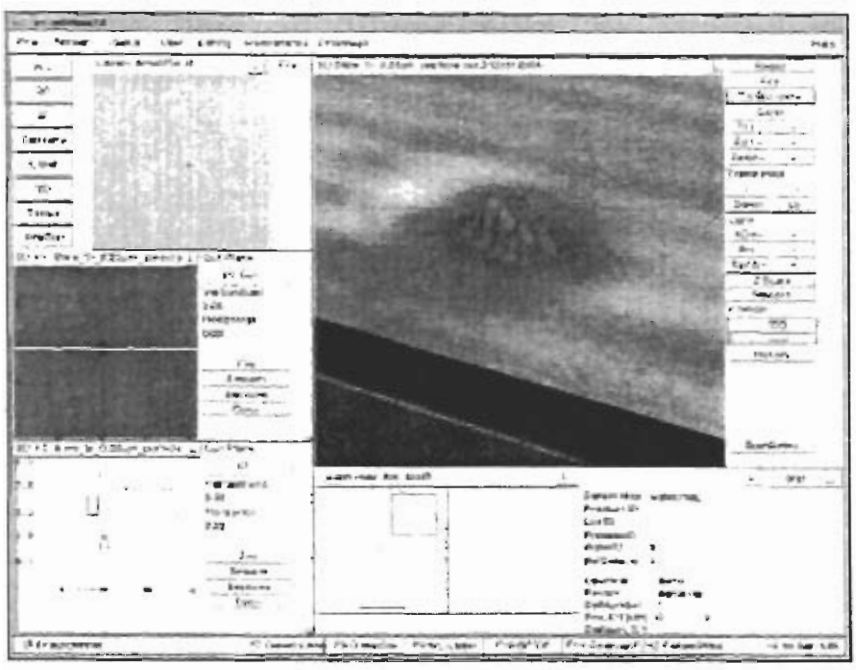
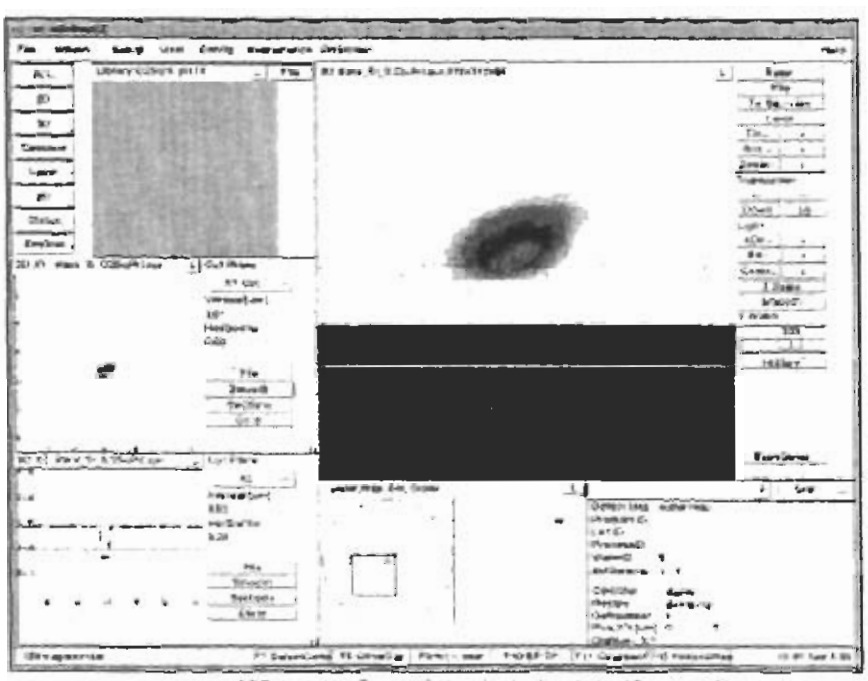
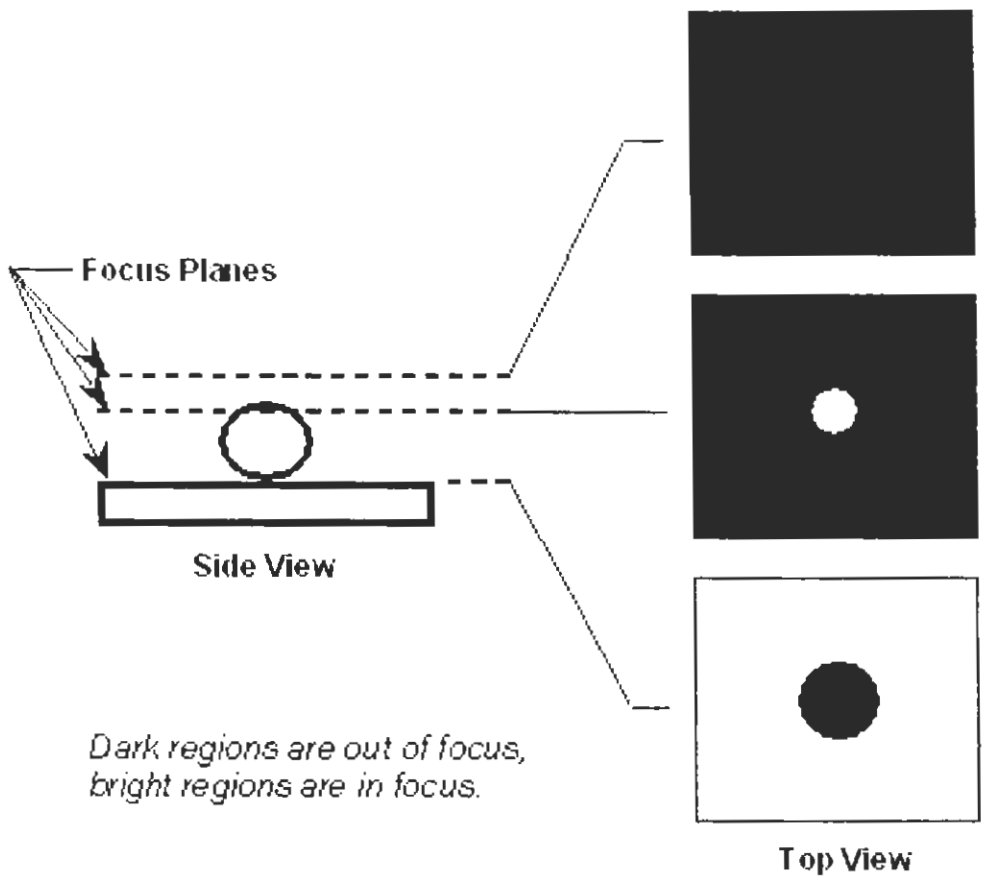


Figure 2-9 CRS Images of a Pit



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Figure 2-10 Height of Particle



Crude material information: The return intensity of the laser light is a function of the sample material, namely its index of refraction and absorption coefficient. On a live laser image, the color of conducting materials such as metal, poly, and silicon is usually golden while that of dielectric materials such as oxide and photoresist is usually dark blue. By comparing the false color (i.e. intensity) of a defect to that of its surrounding area, one could, in many cases, classify the defect.

Quick XY sizing: The live laser screen has ticks on both horizontal and vertical axis in units of microns. The accuracy of the ticks are usually better than 5%, which means one could use the live laser screen to estimate the defect XY size quickly and accurately.

Which process layer the defect resides at: All commonly used dielectric films are transparent to the laser light used by the CRS while conducting materials are usually opaque. By moving the fine Z stage up and down while monitoring the signals from the defect and from each process layer that are transparent to the laser, one can tell which process layer the defect resides at.

SUMMARY

The confocal live laser can see more defects than white light microscopes. It offers higher resolution, higher magnification and better contrast than white light microscopes. The ability of tracking down a defect to its originate process level, quickly sizing a defect and performing crude material

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discrimination has made confocal laser imaging an ideal tool for volume IC production line defect review applications.

You examine each defect image as the tool presents it. **Viewing can be done in white light mode, laser confocal mode, or both modes simultaneously.** You can select from one of several objective lenses, varying effective magnification of the image (the **laser image scales simultaneously** with the white-light image). Optional bright-field/dark-field objectives and illumination can be used to help locate particles and other defects on the wafer surface.

If the defect is not in view, or you wish to examine a larger or different area, a **joystick** controller allows you to manually move about the wafer.

Automatic operation features include **autofocus**, **auto gain**, and **auto ranging** of the vertical scanning. An engineering mode allows **recipe** setup to pre-specify operating parameters for use by operators working on a specific process level and product. **Utilities** are available in pop-up dialogue boxes allowing manual control of the stage, polling of stage variables, plus manual robot control (for example, allowing movement of a wafer from the flat finder or stage after a power failure). **Diagnostics** are called up via a pop-up window displaying all LON (local operating network) nodes and system variables, plus providing direct control of system functions.

With the utilization of ***recipes***, the system can be pre-configured for a specific type of wafer and/or specific process level for that wafer. Both the laser wavelength and laser intensity can be controlled by the operator. Further, both the number and spacing of Z slices can be specified for optimum performance.

A second major use of conventional microscope stations has been the more general inspection function where pre-selected sites on a wafer are inspected for efficacy of a previous process step. The **KLA Tencor** CRS is directly usable in this application, which faces exactly the same dilemma of defect imaging—decreasing size of objects of interest, a lack of resolution, and the need for 3D imaging.

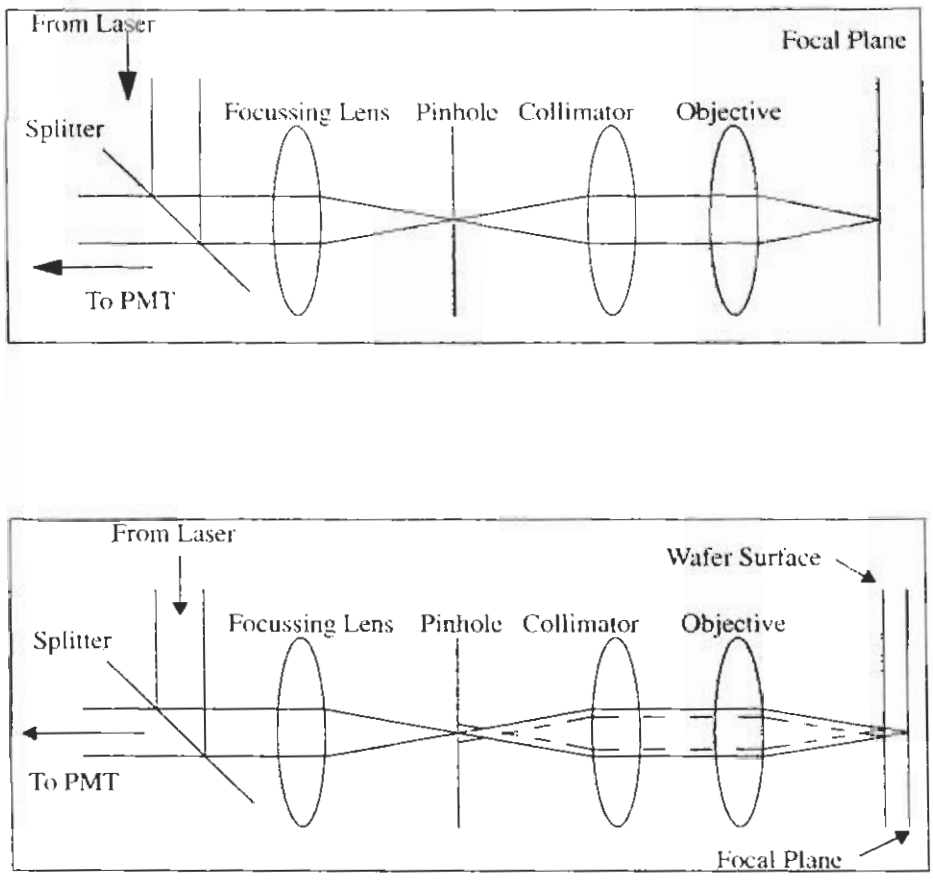
KLA Tencor's CRS Confocal Review Station is a revolutionary new tool in the field of semiconductor microscopy that possesses technological advances that will sustain its usefulness beyond tomorrow's next-generation devices.

Principle of Operation

The **KLA Tencor** CRS utilizes the basic principles of **confocal microscopy**, where the illuminating light passes through a **spatial filter** (pinhole), and the image of this pinhole is then cast on the sample to be viewed, as in Fig. 2-11. The reflected light from the sample returns through the optics to the pinhole. Light reflected from the focal plane of the imaging lens all returns through the pinhole, but reflected light that is out of focus is almost entirely blocked and will not reach the photodetector. Consequently, confocal images give the impression that you are examining narrow slices of the wafer surface.

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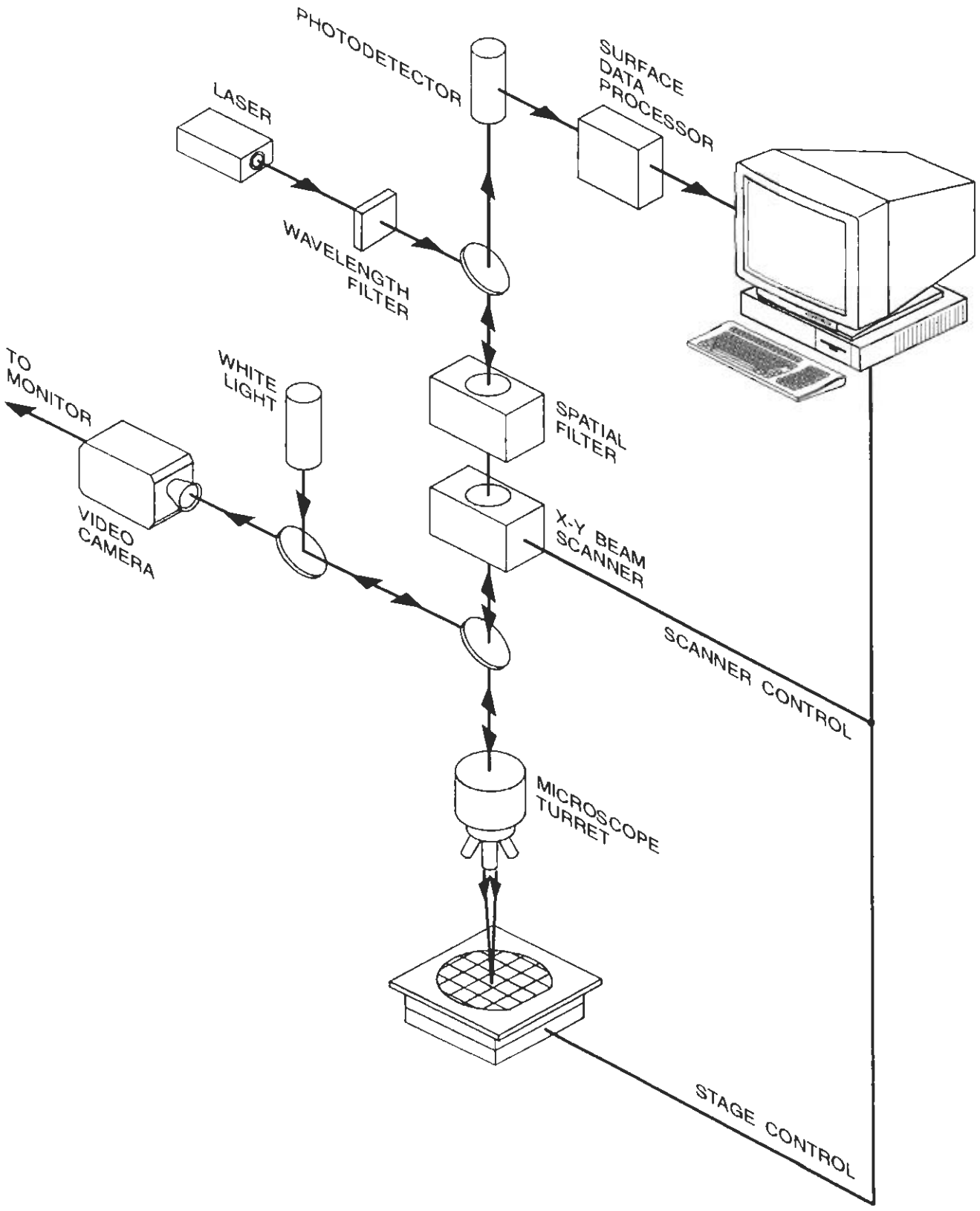
Figure 2-11 Principle of Confocal Optics



The system diagram in Fig. 2-12 depicts the primary components of the CRS. The light source is a multi-line, Argon ion laser that produces polarized light at several discrete wavelengths. The brightest are at 458 nm, 488 nm, and 515 nm. An *optical filter* is used to isolate a single laser line or allow all three lines through. A *polarizing beam splitter* preferentially reflects light only of the proper polarization and directs it to the *spatial filter*. The spatial filter consists of optics that image the laser light on a pinhole whose diameter has been selected to re-image through the downstream optics and objective lens, producing a diffraction-limited spot on the wafer surface. The *XY beam scanner* consists of two mirrors that can oscillate their angle with respect to the beam in a manner that scans a raster pattern in space when operated in conjunction with the scan lens. The raster scanned image of the pinhole is produced between the scan lens and beam splitter cube. The x-axis scanner oscillates at a rate of 8,000 Hz while the y-axis scanner cycles at 13 Hz.

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Figure 2-12 CRS Optical System Schematic



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A *quarter-wave plate* is positioned to convert the linearly polarized laser light to circularly polarized light. The tube lens works with the objective to de-magnify the image of the raster scanned pinhole image and project it on the sample. A portion of this light is reflected back into the objective and returns through the optics train. As it passes through the quarter-wave plate, it is converted to light linearly polarized at right angles to the light emitted by the laser. Thus, when the light reaches the polarizing beam splitter, it passes through and reaches the *photodetector*.

As the raster is scanned, the *surface data processor* keeps track of the returning intensity, and a two-dimensional intensity map of the sample is made. This image passes through the system computer and is produced on the computer monitor as a digital image.

To obtain a three-dimensional image, the height of the sample is incremented in small discrete vertical steps using the *fine Z stage*. At each step, the laser is raster scanned (512 by 512) while the host computer stores the X, Y, and Z location of each image pixel. The surface is then extracted from the data by eliminating all but the brightest pixels for each XY position.

White light (conventional) microscope images are produced (simultaneously with the live laser image) by a *color CCD camera* that views the sample in white light emitted by the illuminator, and inserted in the optical path by the beamsplitter. A filter, which blocks the laser line in use but passes broad bands of light, prevents the laser from saturating the CCD image with reflected laser light.

A *motorized turret* allows for five objectives of different magnifying power. Objective powers range from 5× to 250×.

The optics unit must work in conjunction with a *precision XY stage* and *coarse Z stage*. This module accommodates from 100- to 200-mm diameter semiconductor wafers, working also with the *robotic handler* to load and unload the wafers with high reliability and Class 1-compatible cleanliness.

The electronics package contains all analog and digital electronics, plus power supplies, for complete operation of the tool. The unit operates on 200-240 VAC, 50/60 Hz single phase electric power (or the international equivalents).

The Surface Data Processor (SDP) is a proprietary design that interfaces with the photodetector and is synchronized with the scanner electronics and fine Z stage control, producing an XYZ map of intensity that can either be stored directly in the computer memory or processed to extract a surface image "on the fly."

The system computer is a high-speed, RISC-based, graphics workstation capable of handling concurrent tasks of robot functions, stage motion, operator interface, and optics control, while also performing image processing functions. In addition, it functions with a windowing user interface and high resolution color graphics.

The X, Y, and coarse Z stage controllers communicate with the system computer via an RS-232C interface, as do the robot and prealigner controllers.

The balance of the system's electronic functions communicate through a *Local Operating Network* (LON) interface built on the same interface slot as the RS-232C interface. The LON itself is a network of twisted pair wires that plug into each node serially around the system. Each node contains a local processor and firmware for LON communications, self diagnosis, and local operation of certain functions.

All user interface is via the system monitor, mouse/trackball, joystick/controller, and system keyboard. Through these controls and the windowing software, you can set up, program, and control the complete system. In addition, you can utilize the tool as a microscope, selecting views, translating

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and focusing on details, changing magnification and zooming in on a sample. Image processing and analysis functions can also be performed from the console.

Defect Analysis and Classification

The CRS has a great deal of flexibility in imaging semiconductor structures and defects, combining numerous laser views of surface and subsurface layers with both bright-field and dark-field white-light images at various magnifications and with very high resolution in three dimensions. All of these imaging modes are designed to provide the maximum information about defects on or under the wafer surface. In particular, the CRS is very good at discriminating between pits and particles even at very small sizes, can identify the process layer where a defect occurred, and can measure submicron defect widths with an accuracy of about 5%.

The CRS software provides considerable support for and automation of the process of defect classification. The lowest level is automatic loading and alignment of the wafers for manual review. Full automation includes Automatic Defect Classification (ADC) on wafers in sealed pods transported by robots from station to station, without human contact or intervention. Movement of the pods, loading of wafers with their map files and recipes, capture and analysis of data, and decision-making based on the conclusions of the analysis, can all be carried out under computer control using network communications with the CRS and other instruments.

The first requirement for manual defect classification is a wafer with a defect map file. The map file is created in a surface scanning instrument which records the coordinates of each defect. The CRS takes the operator rapidly from defect to defect, and records the operator's choice of defect category for each. All of the CRS imaging tools are available to the operator for classifying each defect in manual review. The edited wafer map files with the defect classifications entered are then sent automatically to another computer for automated analysis by yield management software such as KLA-Tencor's Intelligent Line Monitor (ILM) products.

Along with the wafer map, the CRS software loads a recipe giving the appropriate system settings for reviewing wafers from a particular level of a particular process. Customer engineers can set up a wide range of parameters to provide the most appropriate initial conditions for viewing defects on each wafer type, depending on the materials used, thickness of layers, and so on. In many cases, the operator has no need to make further adjustments, and can concentrate on reviewing defects.

The CRS was the first instrument with practical ADC. ADC uses advanced image processing algorithms to compare defects on a wafer with a stored knowledge base created by an engineer, using manually classified defects to train the system. The CRS running ADC is faster and more accurate in classifying defects than most operators, and can detect defects too low in contrast to be visible to the human eye.

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3

Tutorial

Training in using the CRS as an operator is a combination of learning specific sequences of commands to carry out standard operations, and trying out the variety of imaging options to see which give the best results on specific structures, materials, and defect types. The following tutorial covers the entire defect review sequence in detail, with every key press and mouse click, and in addition suggests experiments and explorations which you should carry out.

You should keep a personal log of the results of these experiments and explorations. It can include written notes, printed images, and captured files showing, in combination, the best results you have achieved and how to reproduce them. Ask whether the engineers and operators at your facility or elsewhere in your company have logs or libraries of their own, and if so, try out their methods, and examine their captured images and prints.

Make backups of any files that you save. Store the originals and the backups in different places, preferably in different buildings.

Before You Start

Requirements

The following introductory procedure guides you through a simple review session to acquaint you with the ease of use and the power of the KLA Tencor CRS. Whoever is responsible for your training should have the CRS set up for you to try out with the following.

Figure 3-1 200 mm Cassette Plate

- A cassette containing wafers for you to look at. These should be of the same types you will be working with, whether bare or patterned, of the appropriate product types and process levels.

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- 200 mm cassette plate, as in Fig. 3-4, mounted on the CRS, with the cassette correctly positioned on it, or other size if appropriate.
- One or more demonstration accounts with operator privileges, default recipes for the processes you will look at, and access to only the files you need for this tutorial.
- Defect map files of the wafers.
- Defect code lists for the processes involved.

With these in place, you will be able to explore your wafers, their associated files, and the review and imaging functions of the CRS freely, without worrying about damage to files, wafers, or equipment. It is important not to change system settings in the software when you do not know what you are doing, but the system security makes such changes impossible for anyone logged in as an operator. If there is a problem requiring such changes, call for an experienced person with an administrator account to determine what to do.

You will need some assistance in getting started. In particular, someone should put the correct cassette on the CRS and log you in to the correct account with the matching recipe, maps, and defect code file. In addition, someone should be available to answer questions and help you recover from errors.

Looking Around

Before you start, walk around the CRS and look it over. The optics, electronics, and most of the mechanical systems are enclosed. The power controls and removeable media drives are accessible on the front side of the instrument, which is visible in Fig. 3-2.

Figure 3-3 Right Side of CRS with Robot Cover Off



Power, air, vacuum, video, and data connections are on the back. A plastic safety cover at the right end of the CRS gives a view of the wafers in their cassette, the robot wafer handler arm, and behind it the prealigner. The robot can only move with the plastic safety cover on and a wafer cassette in place. This prevents hazards from the robot to the operator and the environment.

Fig. 3-2 shows this area from the rear of the CRS, with the robot cover removed and an operator standing at the front. The prealigner is in the foreground at the back of the CRS, the robot arm is in the center, and the blue wafer cassette is at the front.

Under the cassette is a cassette plate made for a specific size of wafer cassette, like the 200 mm plate in Fig. 3-4 on page 27, which is also visible at the left of Fig. 3-3. The prealigner centers and rotates the wafer for the robot to place on the stage in accurate alignment. This alignment in both position and rotation is essential so that the CRS can place previously found defects in the microscope field of view. There may be a SMIF unit at the far right, which can accept another cassette of wafers in a sealed pod , as shown in Fig. 3-3.

The robot moves up and down, rotates, and moves its arm in and out to pick up, move, and place wafers at the cassette, prealigner, SMIF (if present), and XYZ stage. A door in the side of the instrument opens to allow the robot arm to place wafers on the stage and remove them later. This door is closed whenever the laser shutter is open, to prevent stray laser light from escaping. When the robot is ready to place a wafer on the stage, the laser shutter closes, then the wafer door opens, and then the robot moves the wafer inside. After the robot arm is removed, the wafer door closes, and then the laser shutter is opened.

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Figure 3-4 CRS with SMIF Unit

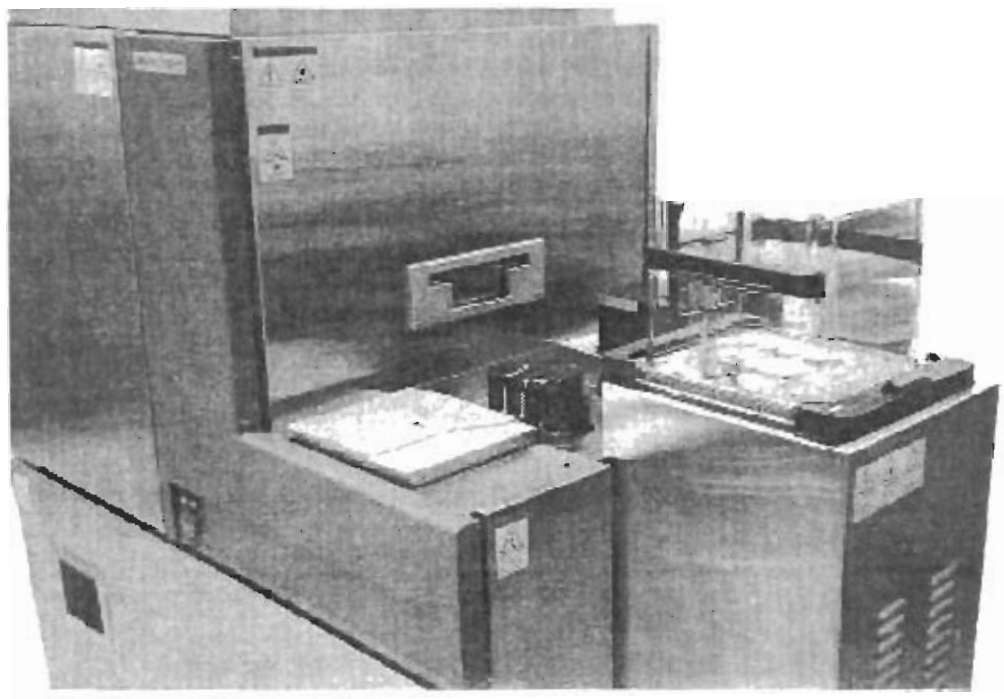


Figure 3-6 CRS-5 Figure Workstation



The CRS is normally controlled from a workstation, as in Fig. 3-4, which can hold two monitors, keyboard, mouse, joystick, and optional printers, with extra space for media, manuals, logbook, etc. An external optical drive is optional. One monitor is connected directly to the video camera on top of the white light microscope, and always shows the white light image of the wafer surface. The other monitor is connected to the graphics computer running the CRS application. This monitor can show a variety of laser images and a digitized version of the white light image, and can also display image files stored in the system.

Most of the functions of the CRS are accessible from pull-down menus and various window controls with the mouse, in the manner which will be familiar to users of Windows on a PC, the Macintosh user interface, or X-Windows on UNIX systems.

There are several methods of navigation on wafers to bring a specific point under the microscope for viewing. The CRS software presents a defect list in the review window, allowing the operator to move sequentially through the list, or to select any defect with the mouse and then click on a button to see it. The operator can also click on a map of the wafer to go to any point. In addition, there is a manual joystick control for moving anywhere on the wafer. Pushing the joystick causes the stage to move in the opposite direction, which means that the image on the screen will seem to move to the same side that the joystick is tilted. For example, if the joystick is pushed to the right, the stage will move in the negative X direction (to the left if viewed from the side of the CRS), and the current image will scroll off the right of the screen.

This is opposite to many other graphics applications, and some users will find that it takes a while to get used to it. The joystick also has a vertical mode for moving the stage up and down in order to image above or below the surface. Moving the joystick forward moves the stage up and the image down to a lower level in the wafer, which again may require some time for the user to adjust to.

The following tutorial tells you at each step what to do and what the result will be. None of the mistakes you can make in the software will damage anything. Usually if you do something in error, you can just correct the error and continue. The account you are logged into should contain only

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copies of demo files. If you mess up a file, someone can copy the original back into your directory and let you try again.

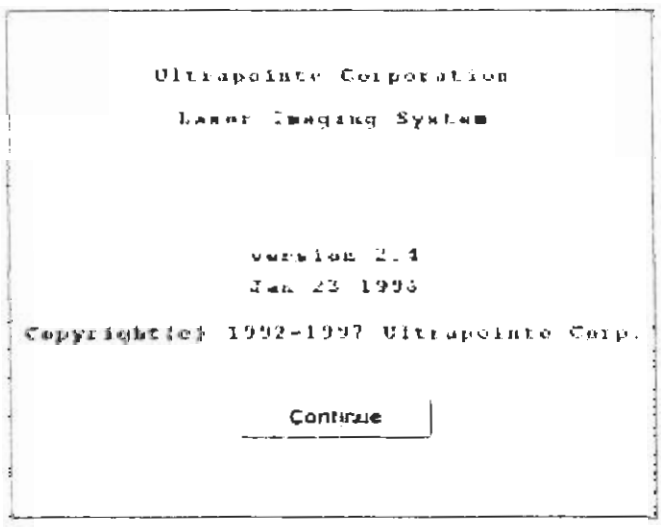
If you get lost, you can always log out and start over. If there is a system problem which prevents you from continuing, you may need assistance to recover from the problem, shut down the system properly, and start up again. Inexperienced users should not turn off the system power unless there is a real emergency. Turning off the CRS while the application is running can damage files.

Your First Session

Logging In

1. Normally the CRS is left running continuously, so you will not have to turn it on. If it is off when you start, check the red Emergency Power Off button, rotating it counterclockwise if you can until it pops out. Then push the green On button. The application starts automatically, loads the default recipe, and presents the following title screen showing the appropriate software version and its date.

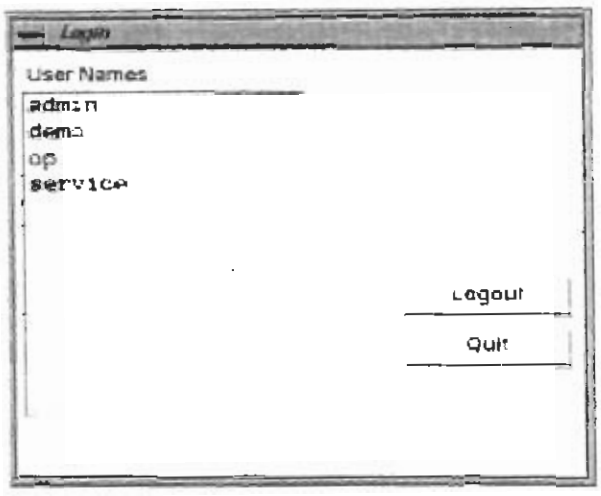
Figure 3-7 CRS Software Startup Screen



2. Click on **Continue** to get to the login window.

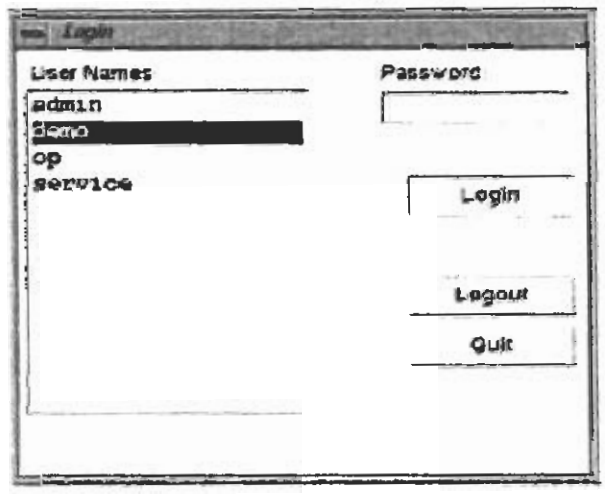
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Figure 3-8 Login Window



3. Highlight the user name for the account you will use in the login window. The password box and the login button will both appear.

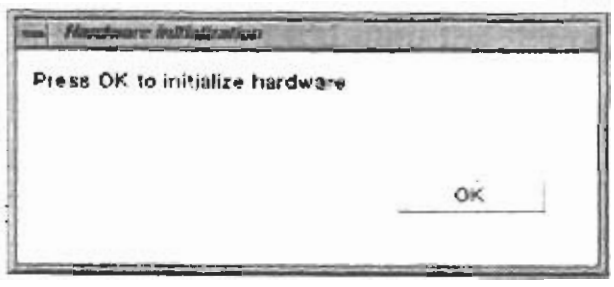
Figure 3-9 Password Entry



4. Click in the password box and enter the password you have been given, which will appear as a line of asterisks. Leave the password box blank if there is no password on your account. Click on Login (or press ENTER).

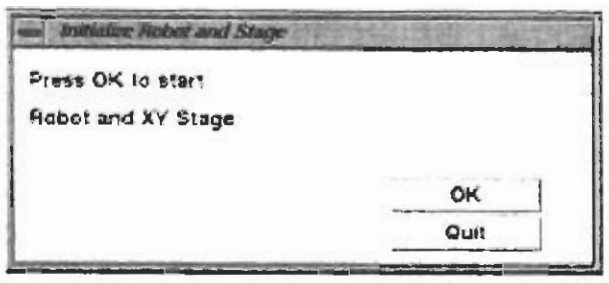
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Figure 3-10 Hardware Initialization



5. The ***Hardware initialization*** dialogue box appears. Click on ***OK***. Internal hardware initialization takes a few minutes.

Figure 3-11 Stage and Robot Initialization



6. The ***Stage and Robot Initialization*** dialogue box appears. Click on ***OK***. After a while, the robot will return slowly to its home position, and then the stage inside the CRS will move to its home position. The stage movement is clearly audible in a quiet room.

7. Next you will see the first screen of the application. Take a moment to look over this screen, which shows the blank wafer panes at the left and the cassette map panes at the right, as in Fig. 3-10.

   There is a menu bar at the top which gives access to the CRS application functions and brings up the appropriate screens and windows for carrying them out. At this point you have the right screen showing, so you don't need any menu commands yet. Below the menu bar in this screen is a line of buttons with labels such as 2D, 3D, W/L, Laser, Library, and Status. These buttons are placeholders for alternate window panes that can be swapped into the screen. There can be more than one of the same type of button. To make a swap, click on a button and drag it into a pane. The pane where you leave the button will take the place of the button, and the button will expand into a new pane of the same size in its place. You can swap panes as much as you like at this point to get the feel of the operation.

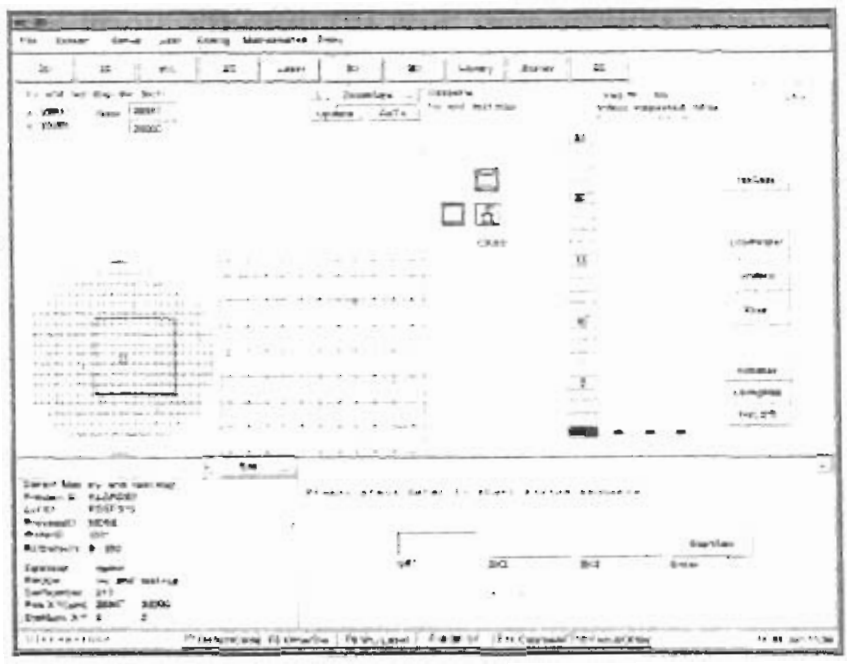
8. The option menu in the pane at the lower left gives you a choice of information to display. When this screen first appears the menu is on the **Stat** selection, but you can choose any of the other options. Have a look at them. Don't worry if you don't understand the information displayed, since you don't need it yet.

9. The wafer outline at the left contains a square zoom box. Clicking on the upper left corner and dragging moves the zoom box. The zoom display just to the right is updated to show the area selected in the zoom box in a larger size. Clicking and dragging on the lower right corner of the zoom box changes its size, and the magnification of the zoomed diagram. Try it.

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10. If the ***Sequence*** pane is in the bottom right of the screen, you can click on the SeqStart button to continue. If you have put the Sequence pane in another, smaller area, you won't be able to see or click on the button at the right end of the pane. You can put it back, or use the **Enter** key instead.

Figure 3-12 Initial Screen



11. Press **Enter** on the numeric keypad, or click on the ***StartSeq*** button on the screen. This begins the Start Sequence, which loads in the files with the cassette and wafer map data, and loads the first wafer. The map associates a wafer with each slot in the cassette, and lists all of the defects found on each wafer along with identification information for each wafer.

Loading a Defect File and Wafer

1. The system automatically brings up the map file selection screen shown in Fig. 3-5, with the ***User*** directory radio button selected, and the current login name highlighted.

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Figure 3-13 Map File Selection Screen



2. Highlight the name of the wafer map for the cassette that is loaded, then click the ***Load*** button. The wafer map diagram updates per the loaded file and the cassette pane displays which wafers are available for review.

3. Press ***Enter*** to load the first wafer and change to the ***Deskew Window***.

   At this point the robot moves to pick up the wafer, first applying vacuum before lifting the wafer, moving it out of its slot, and placing it on the prealigner. The robot arm releases the vacuum as it places the wafer on the prealigner chuck, and the prealigner applies vacuum to hold the wafer in place. The same sequence of applying and releasing vacuum applies to the stage also.

4. The prealigner rotates the wafer and registers the location of its edge with optical sensors. With this information the prealigner moves the wafer to center it. The prealigner rotates the wafer again to register the location of the flat or notch which indicates the proper alignment of the wafer, and presents the wafer to the robot with the flat or notch correctly positioned.

   The robot picks up the wafer from the prealigner and moves to place it on the stage. The stage moves into position inside the CRS to accept the wafer, and the wafer door opens. The robot arm moves in and then down to place the wafer, and then retracts. The wafer door closes, the stage moves the wafer under the microscope, and the software proceeds to the next screen, for deskewing the wafer.

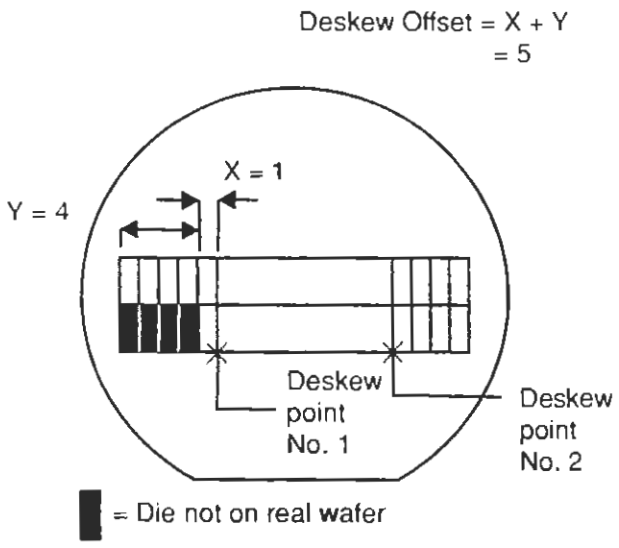
Wafer Deskew

Although the wafer is prealigned, there will still be some small error in placement, within a few microns, and in rotation, within a degree. These errors must be found so that the CRS can calculate the true position of defects and center them under the microscope. The process consists of finding two easily recognizable points at opposite sides of the wafer, and calculating the angle between the line joining them and the X direction of the stage. Immediately on loading the wafer, the stage moves to bring the first deskew point under the microscope, and the surface is automatically brought into focus at 5× magnification, ready for the user to proceed.

All of the deskew calculations are done in the CRS software. The operator only has to align the deskew points with the image crosshairs, and to click on the ***Accept*** button, and the rest is automatic. Some CRS systems are equipped with an AutoDeskew option in which the software finds the deskew points itself, but we will start by going over the manual deskew process. Fig. 3-12 shows

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Figure 3-14 Deskew Points on Wafer



schematically (not to scale) where the deskew points might be located, at die corners, and some of the calculations done in the software to find the right die corners. Trying to locate a corner of a die that does not exist will of course fail. The deskew points do not have to be at die corners. The requirement is to choose features that are easy to recognize and distinctive. In particular there should be no repetitions of the target feature nearby.

The Deskew screen in Fig. 3-13 contains a large laser pane (black at this point, since laser imaging is not turned on) and a smaller white light window to its left. There will also be a white light image on a separate monitor. You should be able to see something on the wafer surface at this point, and in a moment you will be able to explore these structures.

Before you do that, look at the panes in this new screen. Click on the ***WL/Laser*** button, to the right of the laser image pane, to turn on the laser image. You should see on this screen both white light and laser images of your first wafer, showing rather different views of the same area on the wafer, and with a deskew point near the center of the image. You should see crosshairs in both the white light and laser panes on this monitor, but none on the white light monitor. If no crosshairs are visible, click on the button that says **XHairOff**, above the white light image. It will change state to say **XHairOn**, and both pairs of crosshairs will appear.

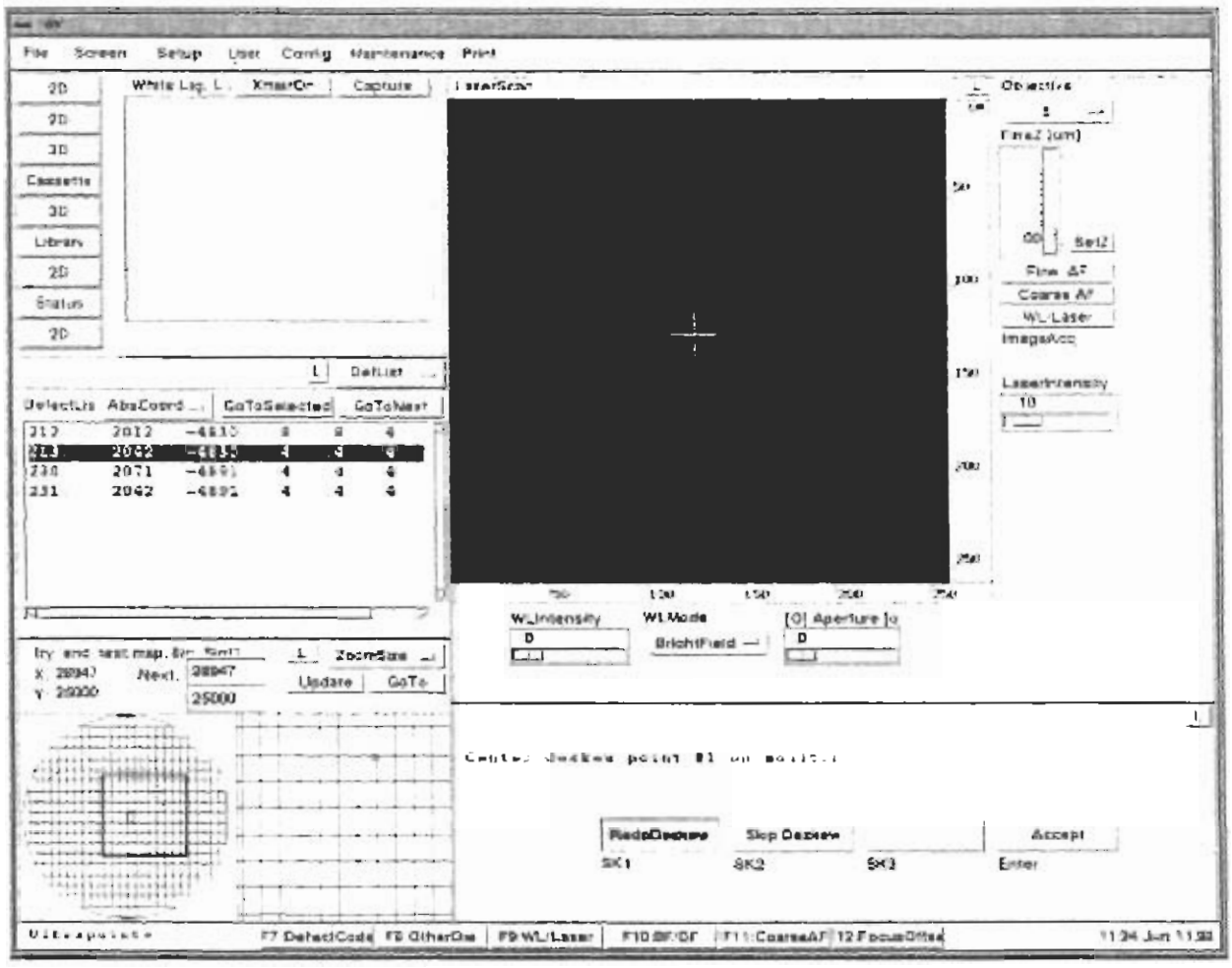
The buttons for swapping panes are now at the upper left. The wafer diagram now contains die edges and colored dots representing defect locations. Many of the die edges do not show up in the figure, which is at relatively low resolution. There is an option menu over the zoom pane, set to ZoomSize. You can set it to three other options for displaying the zoom box area, each with a different color code, and you can view the four color code lists with other options from the same menu. Try them. You will see that defects can be grouped in clusters, and can be coded by severity (**ZoomSize**), whether they have been classified (**ZoomClas**), grouping in clusters (**ZoomClus**), and currently selected cluster (**ZoomCurr**).

The sequence pane offers three choices: ***RedoDeskew***, ***Skip Deskew***, and ***Accept***. ***RedoDeskew*** lets you start over if something goes wrong during deskew. ***Skip Deskew*** would be appropriate for a wafer that has not had deskew points defined, or when performing tasks such as routine maintenance that do not require finding defect locations. For normal review operations, deskew is essential, so we will continue with it. The ***Accept*** button is the most common choice, after locating and centering the first deskew point in the crosshairs on the screen.

1. Restore the settings that this screen started with. If you can remember what you have changed, you can change it back yourself. Otherwise click on ***RedoDeskew***, and the software will start the deskew process over.

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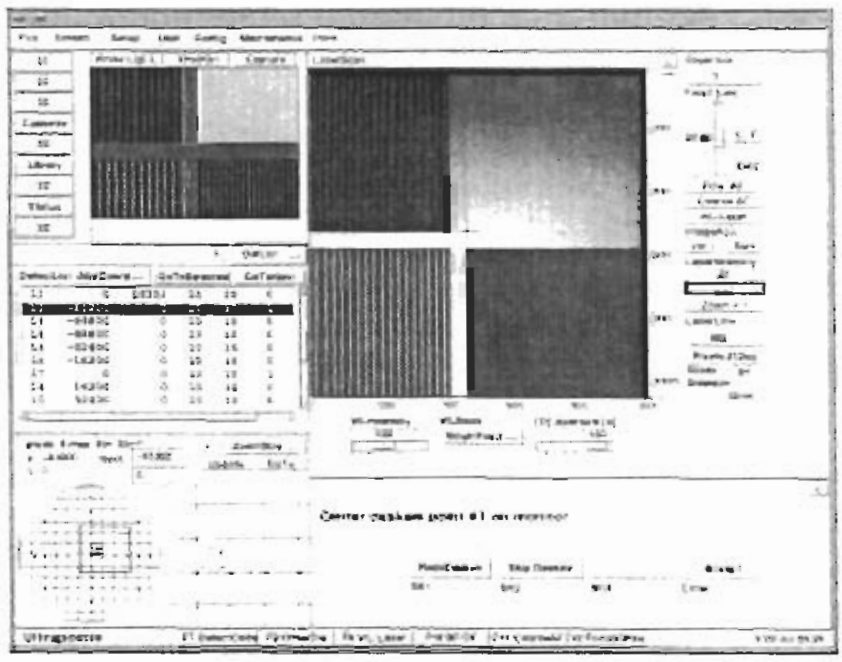
Figure 3-15 Deskew Screen



2. The deskew point should be in the field of view at 5× magnification, like the die corner in Fig. 3-14 that is under the crosshairs. If it is not visible, get help in finding it.

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Figure 3-16 Deskew Point at Low Magnification

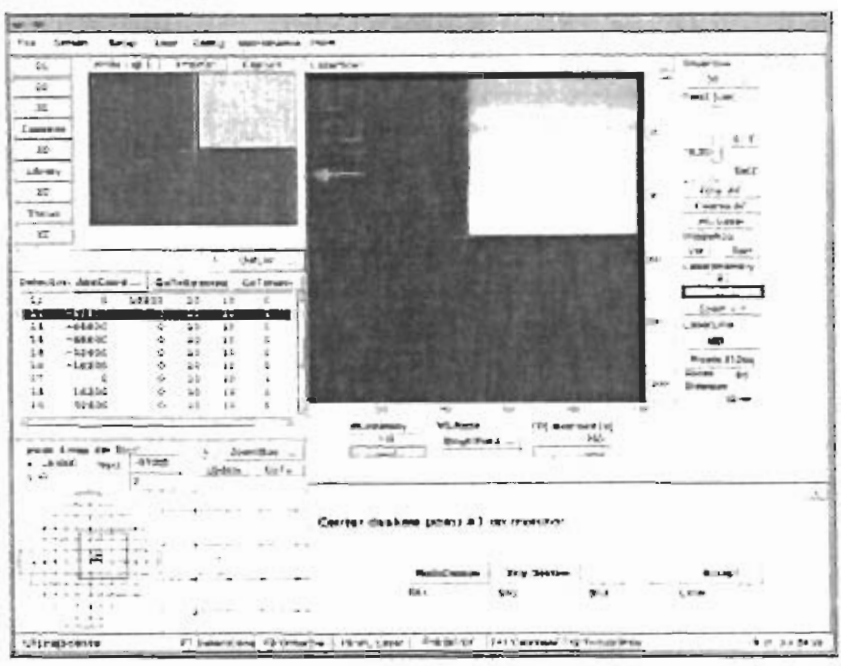


3. You will see the white light image of the wafer on the screen. Put the joystick in XY mode, and use it to move the first deskew point (usually a corner of a die) to the center of the video screen, under the crosshairs. Remember that the screen image moves in the same direction as the joystick.

4. Switch to 50× and center the deskew point again. You can use the **mag**↑ key to increase magnification, and the **mag**↓ key to decrease it. You can also select the magnification you want directly from the **Objective** menu on the screen, at the top of the image controls.

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Figure 3-17 Deskew Point at High Magnification



5. When the defect is centered at high magnification, click on ***Accept*** or press **enter**.
6. The stage automatically moves the wafer to the second deskew point. Move the second deskew point to the center of the video screen, first at 5×, then at 50×, and accept the second point.
7. Repeat the process for the third deskew point.
8. The CRS automatically moves to the first defect and brings up the defect review screen.

NOTE:	**For maximum coordinate accuracy, switch to 50× for each deskew point.**

9. Center the first defect and press the **Map Offset** key.

The deskew operation tells the software the angular error in placing the wafer on the stage, and the map offset value gives the linear error. Using these two values, the software can calculate where to move the stage to bring a defect under the microscope, with an error typically less than one micron.

Reviewing Defects

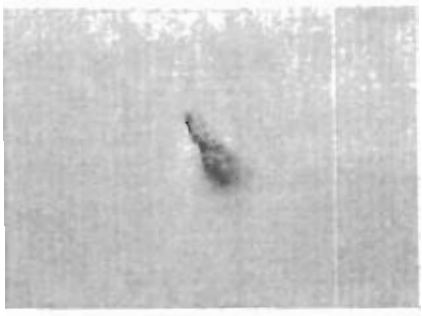
The primary function of the KLA-Tencor CRS is to review defects. For maximum productivity you will utilize both white light and laser confocal images simultaneously to classify defects. Although the laser images might appear unusual at first, you will soon realize that their superior resolution and fine Z discrimination enables you to identify your defects more quickly and accurately. You can also switch to surface and volume views of the same defect.

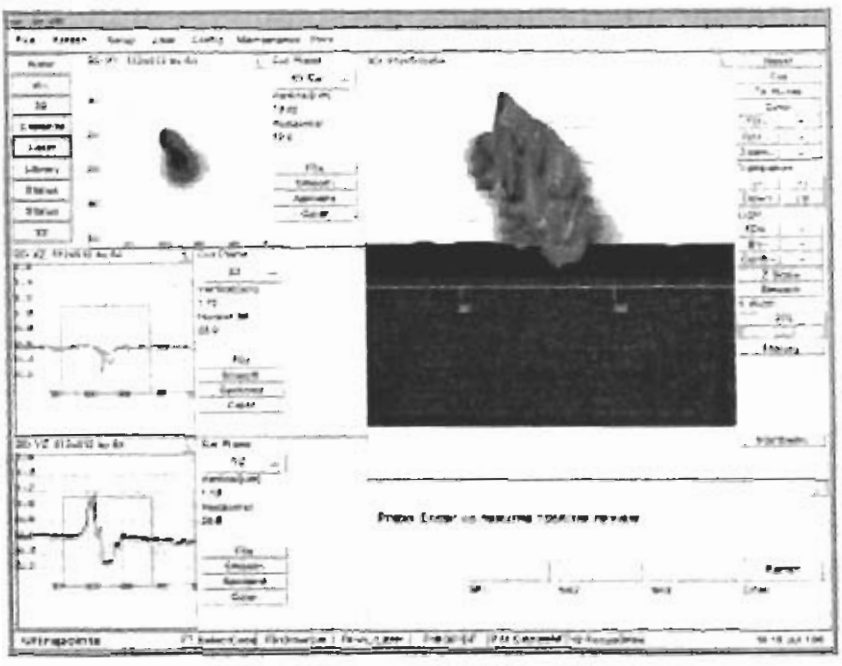
Fig. 3-16 shows the white light image of a defect in the small image at the left, and both the surface and volume screens with 2D laser images, 3D surfaces, and 2D cross-sectional profiles of the same defect. The images in the 2D XY panes in both the surface and volume screens are the same as ordinary laser images in the review screen, but the cross-sectional views are quite different. The 2D

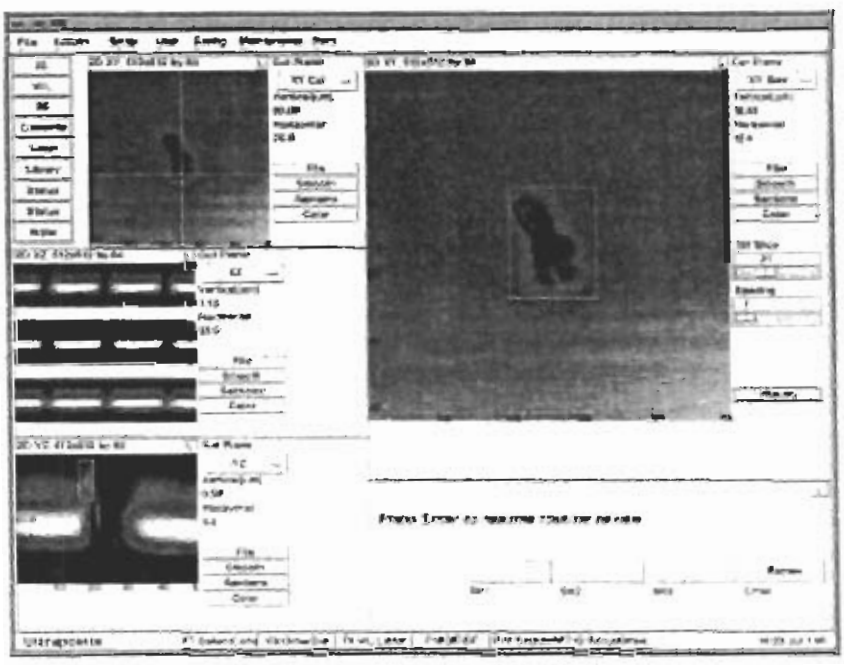
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XZ pane in the volume screen has been divided into 9 sections in a 3 × 3 array, each showing a different slice of the defect near one end. The width of the gap in each slice is slightly different.

Figure 3-18 Multiple Views of a Defect





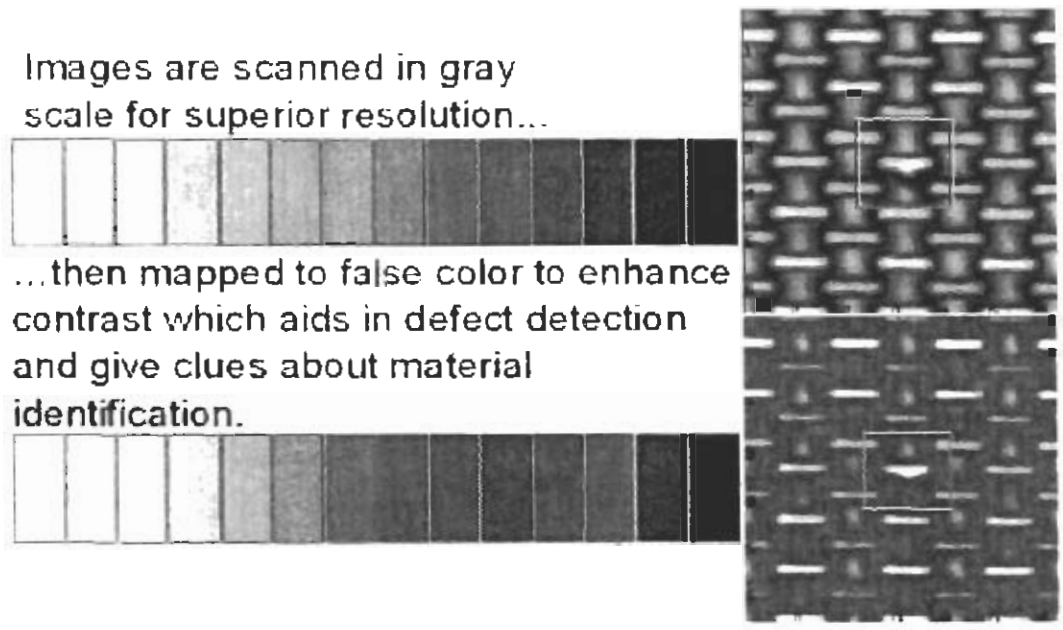


Although the light from the laser is a single color, the laser images are colored on the screen. As Fig. 3-17 shows, colors represent brightness levels, with white the brightest, followed by yellow, orange, purple, green, and black. In addition to the changes in hue, the colors representing bright light are bright, and for progressively darker portions of the image the colors are darker, from bright yellow to dark green. When the image is at its best focus on the wafer surface, with the laser intensity

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adjusted correctly, the parts of the image that are in focus will be a bright gold color. Normally the CRS can focus and adjust the light automatically, but it is necessary sometimes to make adjustments. In viewing defects, it is frequently helpful to adjust the focus above or below the surface some of the time, and it may also be necessary to adjust the laser intensity when doing so.

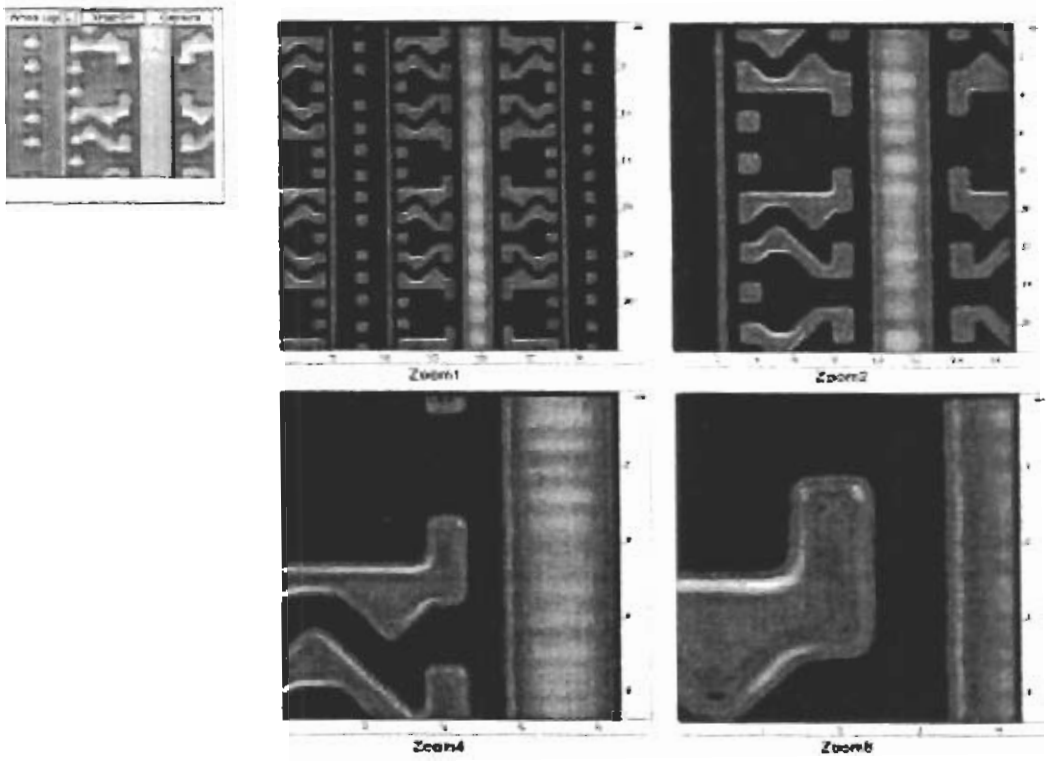
Figure 3-19 Intensity/Color Mapping in Laser Images



The laser image zoom has four settings, produced by changing the scan angles of a pair of mirrors inside the CRS. Decreasing the scan angle decreases the area scanned and increases the resolution in the same proportion. Fig. 3-18 shows a white light image, and four laser images from the same area, each zoomed in to twice the resolution of the one before and showing increasingly fine detail.

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Figure 3-20 Laser Image Zoom



At maximum magnification, 150×, and maximum zoom, 8×, the laser beam scans over a patch approximately 4.2µ on a side. With 512 pixels in each scan line, this gives a nominal resolution of close to 8 nm. In fact, the diffraction-limited laser light spot on the wafer surface is much larger than this, so that the pixels overlap, and usable resolution is about 0.15µ. The following three figures give examples of high resolution laser images showing a feature a third of a micron in diameter. The white light image in Fig. 3-19 shows a square feature on a test wafer with a dot in the center, which is actually a post. The laser image, at ***Zoom8***, shows just the dot. In this image, the surface is out of focus, and only the raised dot is visible.

The surface images in Fig. 3-20 show two views of the same dot, together with profiles cut through the dot in the XY and XZ planes. The upper left image has a pair of cutting cursors that indicate where the profiles are taken. In the profile panes, a rubberband cursor indicates the size of the dot, which is 0.33µ in diameter and 1.0µ high. The surface image at the right has its Z scale set to the minimum, so the post shows up only as colored rings, rather than in relief. The Z scale can be stretched to make the height of the dot clearly visible.

The volume images in Fig. 3-21 give very different views of the same dot. The cutting cursors in the upper left pane are centered on the dot, so that the XZ cut pane shows a clear profile of the dot. Again the rubberband box shows that the feature is 1µ high and 0.33µ wide. Structure smaller than the dot can be made out to some extent. The large pane shows a series of slices through the feature, at 0.1µ vertical intervals (2 slice spaces of 4 steps of 12 nm each). Interference rings are clearly visible in some of the subsurface slice images in the upper part of the pane. The surface is in focus in the slice images with orange backgrounds. Below them are images with the focal plane above the surface. The bright spot in those slices comes from the top of the dot.

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Figure 3-21 White Light and Laser Image of 0.3µ Feature

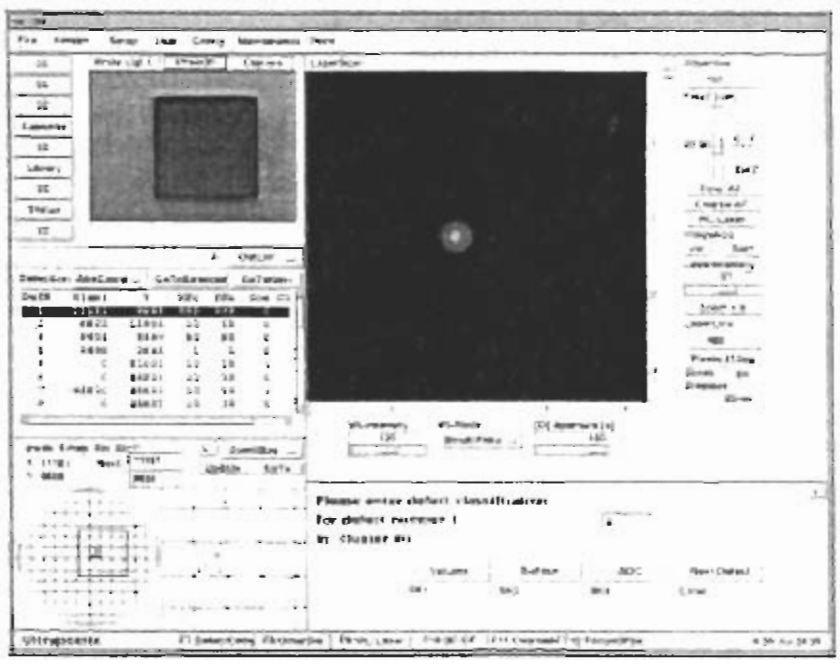
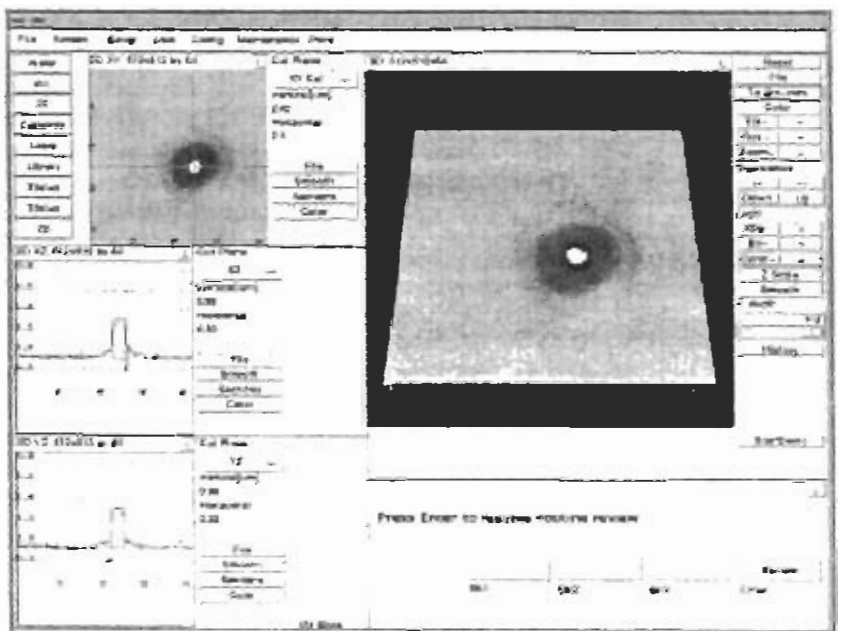


Figure 3-22 Surface Images of 0.3µ Feature



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Figure 3-23 Volume Images of 0.3µ feature

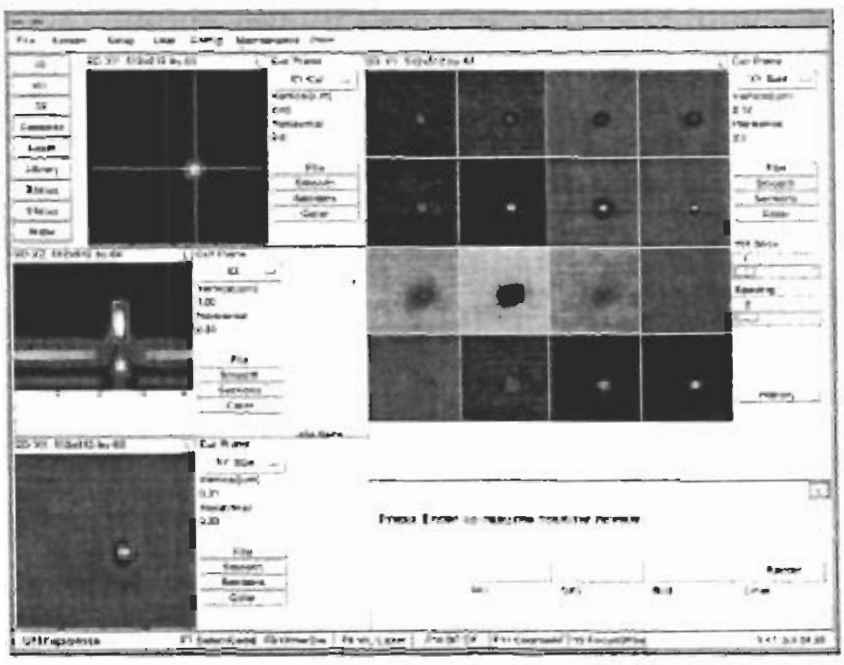
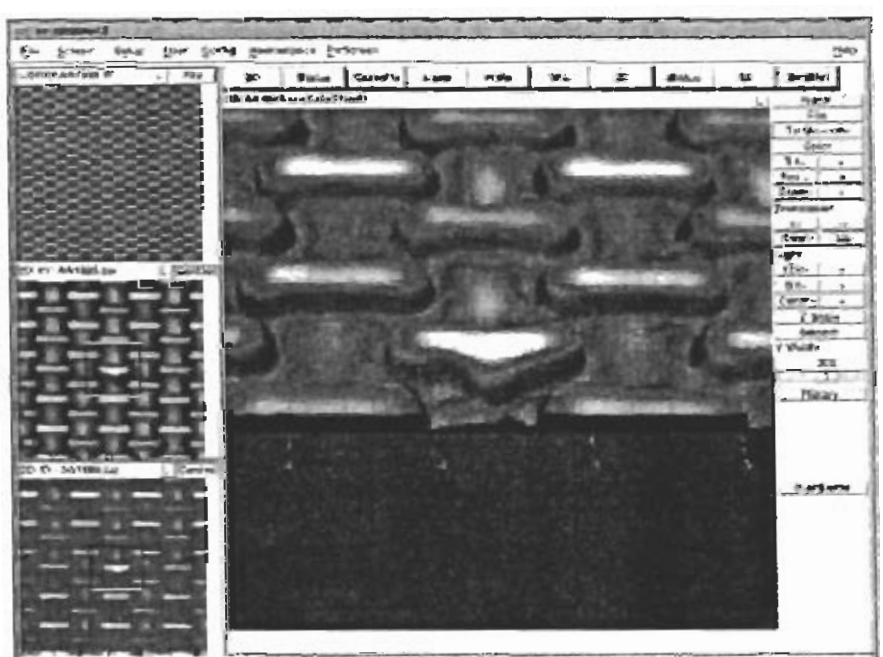


Figure 3-24 Real or False Defect?



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Figure 3-25 Light Point Defect Revealed as Particle

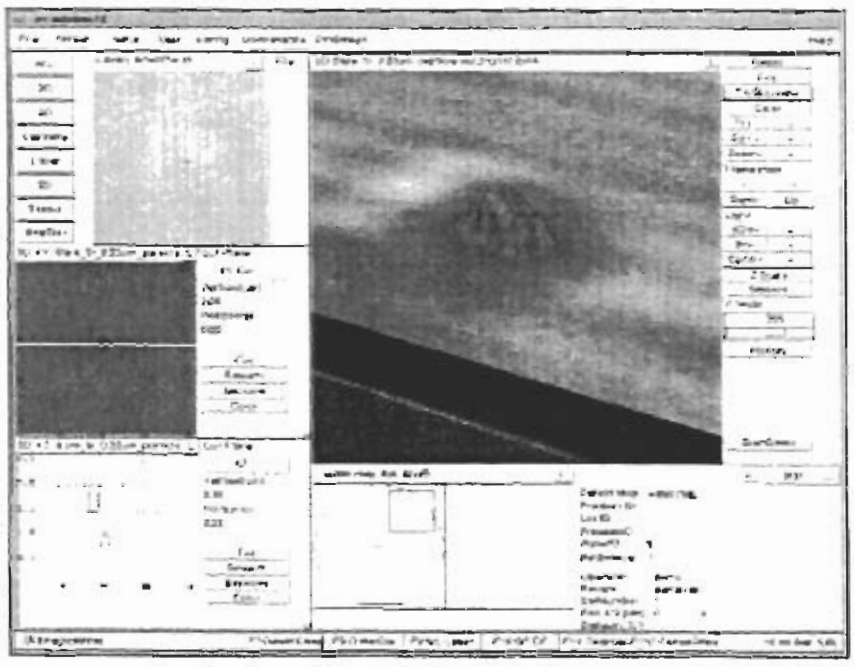
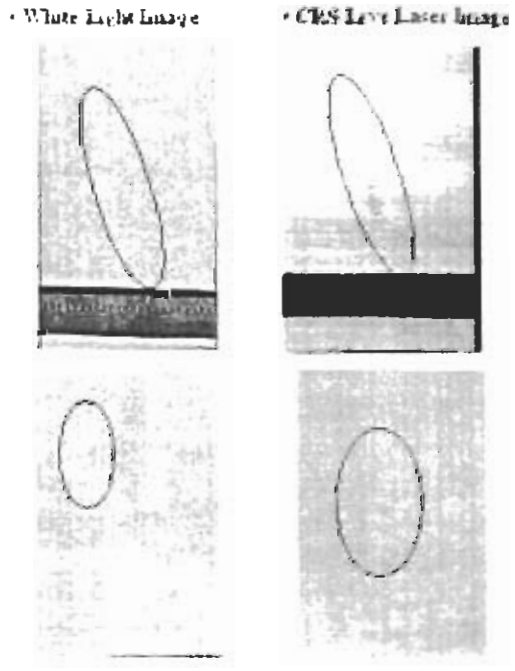


Figure 3-26 Scratches on Wafer Surface

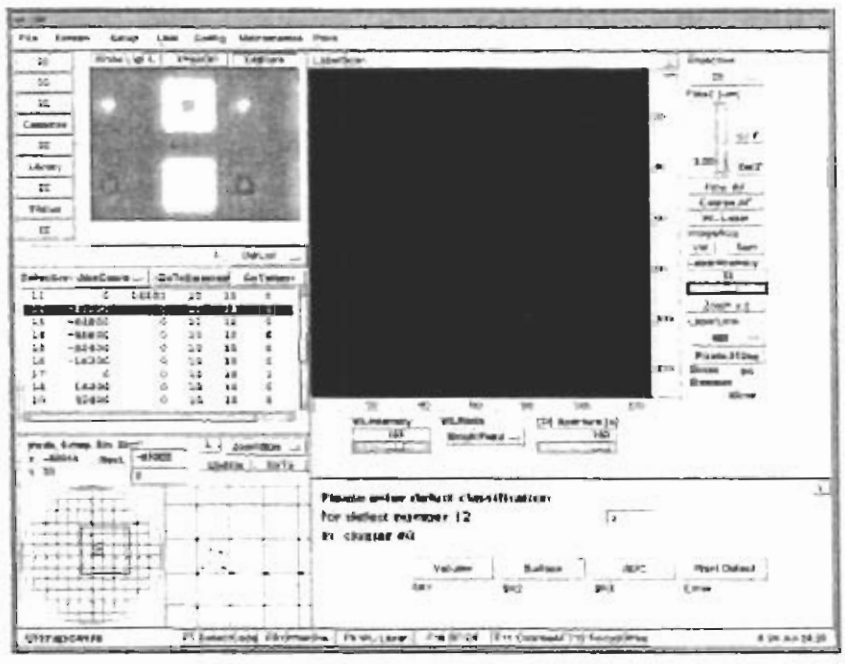


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To image a defect

1. At this point, your wafer is deskewed, you have centered the first defect and you have set the map offset. You will not need to use this key again in this session. You have also seen a few pictures of defects, and now you can look at the live images on your CRS.
2. Check the image focus. The CRS autofocuses, so the image should be fairly good. Sometimes you have to move the wafer out of focus and back again, so you should know how the focusing process works. The sequence of screen images in Fig. 3-25–Fig. 3-27 shows the difference between out-of-focus, near-focus, and at-focus images. The depth of focus of the laser image is much narrower than the white light image, so the white light looks good even when the laser image is obviously not right.

Figure 3-27 Badly Focused Image



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Figure 3-28 Almost Focused Image

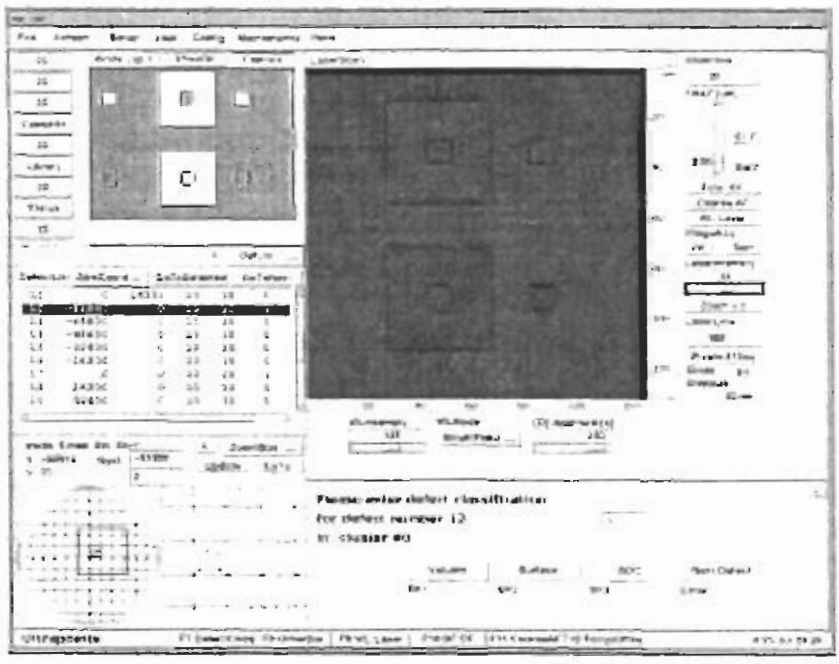
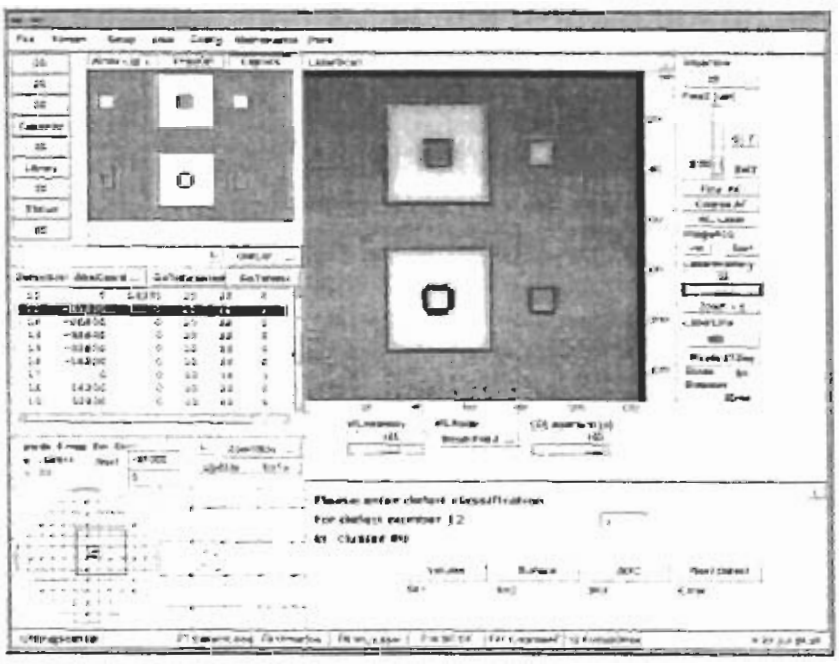


Figure 3-29 Well Focused Image



3. Check the image brightness. The sequence in Fig. 3-28 shows laser images that are too dim, too bright, and just right. Fig. 3-29 does the same for white light images. The best illumination is that which makes features of interest most visible, which usually means the highest contrast between features and background.

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Figure 3-30 Adjusting Laser Image Brightness

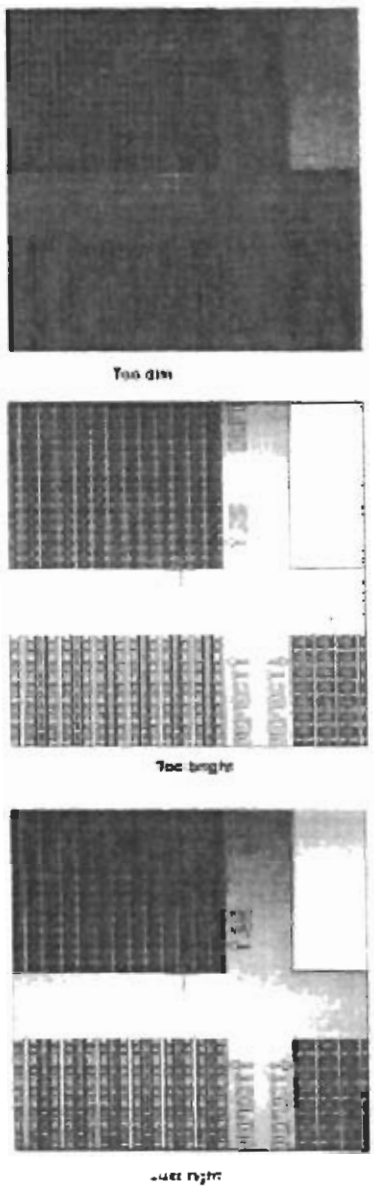
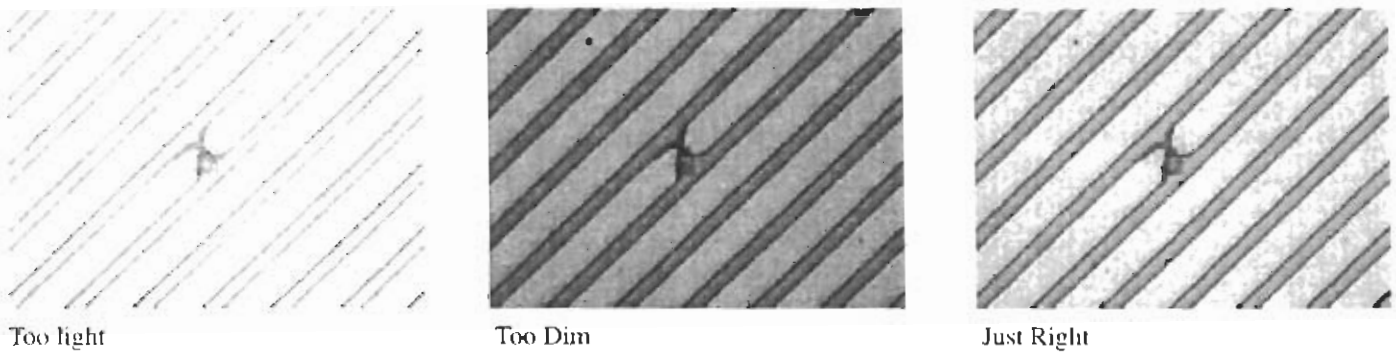


Figure 3-31 Adjusting White Light Brightness



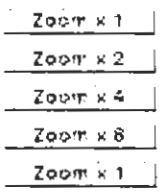
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4. Press the **MAG↑** key to select an objective that is appropriate for the defect, so that it fills half to three-quarters of the image pane, if it is large, or so that you can see the most detail, if it is small. If the magnification goes too high, you can press the **MAG↓** key to go to lower magnification. You can also select an objective directly on the **Objective** menu to the right of the laser image window.

5. Press the **Laser/WL** key or click the ***Laser/WL*** button on the screen if necessary to turn on the laser image. An image appears in the laser window.

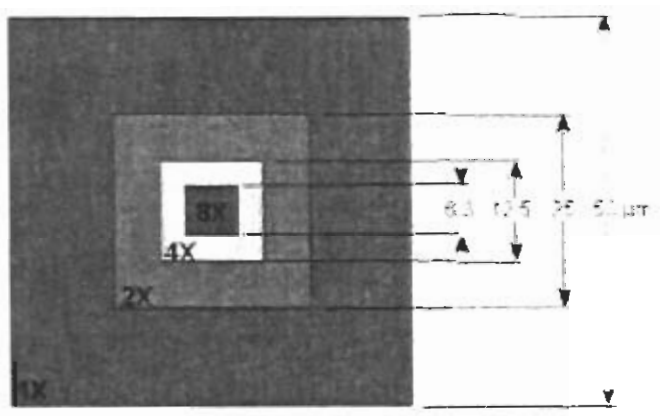
6. If there is no image or the focus seems poor, try pressing the **Coarse AF** key, and then the **Fine AF** key, or click on the corresponding window buttons. You can manually vary focus by pressing the **z↑** or **z↓** keys.

Figure 3-33 Image Zoom Sequence



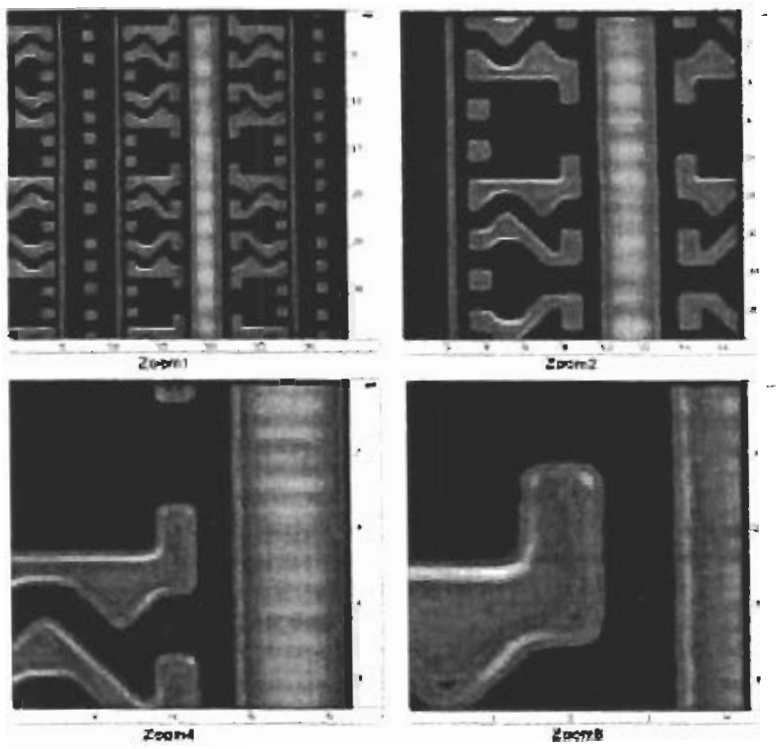
If you wish to increase the magnification of the laser image further, use the **Zoom** key which controls the scan angle of the laser image, or equivalently the ***Zoom*** button on the screen. Each press of the **Zoom** key doubles the magnification of the laser image and changes the value shown on the ***Zoom*** button. On the fourth press, the magnification returns back to the minimum value. The laser window has a scale on both the X and Y axes in units of microns that also updates according to the zoom setting. Fig. 3-30 shows the sequence of zooms produced by repeated pressing of the **Zoom** key. Fig. 3-31 shows the relative areas of zoomed images, and Fig. 3-32 shows the effect on an image.

Figure 3-34 Zoom Image Areas



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Figure 3-35 Zoomed Laser Images



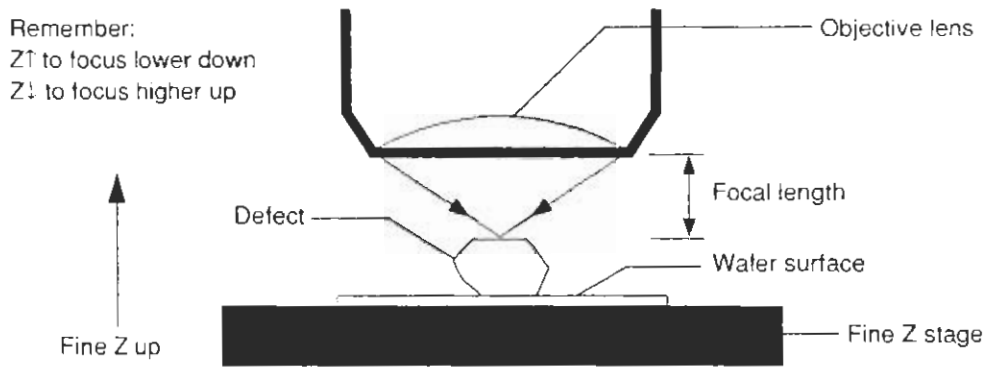
8. Normally the CRS will focus on the wafer surface automatically and supply proper levels of laser and white light illumination. The focus and illumination which are suitable on average may not be good on a particular surface. In that case the user should try for better focus first and better illumination after.

Suppose the machine is focused on a substrate (a uniformly illuminated bright laser image filling the whole laser window). To understand a defect's height information, press the Z↑ or Z↓ key while paying close attention to changes in the laser image. If the defect is a particle, then as the fine Z stage moves down, the strong signal from the substrate decreases, while the signal from the top of the particle increases. Moving the stage up from focus at the surface causes the signal from both surface and particle to decrease. A pit shows exactly the opposite response. As the fine Z stage moves up, the strong signal from the substrate decreases and the signal from the bottom of the pit increases. Moving the stage down from focus at the surface causes both signals to decrease. If there is no signal from the defect above or below the surface, the defect is on the surface. Try moving up and down while viewing a succession of defects.

Fig. 3-33 shows the CRS at the limit of its focus, with the image coming from the top of a defect which is greatly exaggerated in size. Pressing Z↑ moves the stage up, so that the defect moves through the focal plane of the microscope. The image at the focal plane then comes from lower and lower levels in the defect until the surface is reached.

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Figure 3-36 The Relationship Between Focus and Z-position



Getting Around

As mentioned earlier, there are three ways to move to a specific defect location:

- Press ENTER to move to the next defect in the defect list.
- Highlight a defect on the defect list in the status window and click on ***GoToSelected***.
- In the wafer window, click on or near a defect. The stage moves and the number of the nearest defect is highlighted on the defect list. Now click on ***GoToSelected*** in the status window to move the stage to the exact defect coordinate defined by the map.

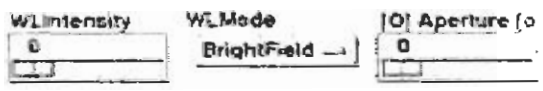
When moving to defects, they might not be seen in the field of view due to inaccuracies of the map data (from the automated inspection system). If that happens, decrease the magnification by switching to a lower power objective whenever you need to find a defect, and increase magnification as needed to view each defect. It should be possible to stay at 50× with a 21XX or AIT map, or 100× with a System 7000.

Try moving around using the three methods of navigation, and at each defect, try focussing and changing objectives to see how they change the defect image.

Optical Controls

There are other ways to change the image of a defect, and in fact to create different types of image. We will look at several methods in turn.

Figure 3-37 White Light Image Controls



The White Light Intensity is set automatically according to the objective you are using, but you can adjust it for particular surfaces. Some reflect more or less light than the average, and need the intensity adjusted in order to give maximum visibility to specific features. It is not necessary to adjust the ***Aperture*** slider in normal use. Most systems without ADC do not have the aperture control installed.

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BrightField illumination, on the **WLMode** menu, is the most familiar. It illuminates the wafer throughout a range of directions, and receives light reflected or scattered at various angles. This is just like ordinary vision, so the image looks normal. **DarkField** illumination gives a less familiar view. It allows light to reach the wafer around the surface of a cone, so that all the rays are at the same angle to the surface. Reflections from level surfaces go off at the same angle, and do not re-enter the microscope. The light that comes back vertically through the microscope to form the image is either reflected from surfaces at a particular angle, or scattered from surfaces that send light in all directions. In DarkField illumination flat surfaces are dark, while edges and particles show up clearly. DarkField is recommended for most CRS use at medium magnification, but does not receive enough light at high magnification to form a usable image.

Try switching between **BrightField** and **DarkField** illumination while viewing several defects, and test the effect of small changes in the ***WLIntensity***.

Figure 3-38 BrightField and DarkField White Light Images

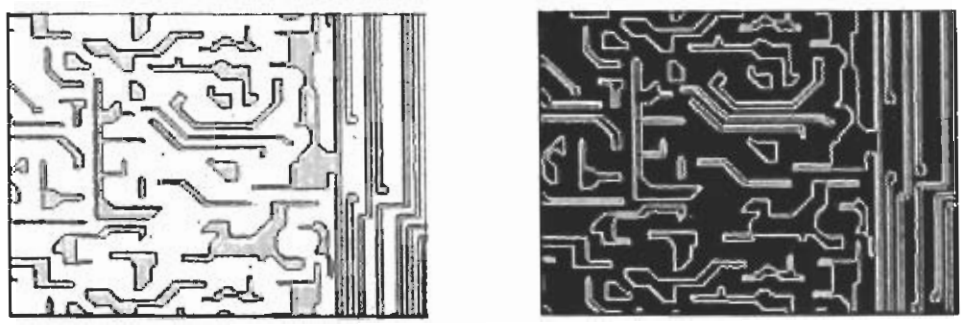


Figure 3-39 Laser Image Controls

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These controls appear at the right of the large laser image panel in the predefined screen layout for defect review. The **Objective** menu is actually for both laser and white light images. It sets any magnification available on the instrument, from up to five objectives on the microscope turret wheel. Magnifications of 5×, 20×, 50×, 100×, and 150× may be available.

The ***FineZ*** slider provides manual control of Fine Z stage movement over a vertical range of a little more than 50µ. Positioning accuracy is in steps of 12 nm, and is given on the slider in increments of 0.01 µ. Dragging is the fastest way to move the slider over its whole range. Clicking on the upper or lower box on the white slider bar moves the stage up or down by 0.1 µ. The ***S***, ***F***, and ***SetZ*** buttons are used for 3D images, and are described later in this chapter.

Autofocus is a two-stage process. The ***Coarse AF*** button moves the coarse Z stage to the position that returns the most light in the laser image, within the accuracy of 0.25µ that the Coarse Z stage is capable of. After a Coarse AutoFocus, the FineAF button can be used to improve the focus further.

Laser illumination is used for both Coarse and Fine AutoFocus operations. If the laser image is not on when the button is selected, it is turned on automatically to measure the focus, and then turned off again immediately afterwards. You will see flashes of light in the laser window during AutoFocus even if you are viewing the surface only in white light.

The ***WL/Laser*** button turns laser imaging on or off. White light images always stay on.

The ***Vol*** and ***Surf*** buttons are for 3D imaging, described below.

The Laser Intensity slider actually adjusts the gain of the light sensor which receives the laser light, not the laser itself. The effect is to change the intensity levels shown on the screen. Try increasing Laser Intensity gradually. This shifts all colors in the laser image to the brighter end of the range. When the image starts to turn white all over, the sensor is shut off to protect it from overload, the laser image window is blacked out, and a red warning message appears above the laser intensity slider, as shown in Fig. 3-37. Adjusting the Laser Intensity downward will restore the image. The exact level at which the PMT overloads depends on the qualities of the wafer surface, the distance from focus, and other factors.

Figure 3-40 Laser Overload Message



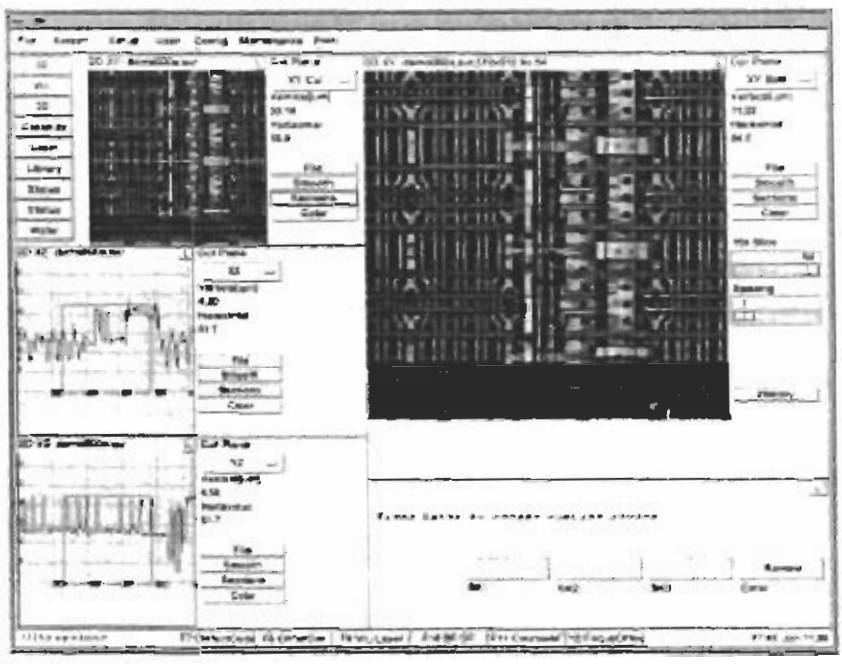
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Making 2D and 3D Images

Once you have a defect in the field of view, you are ready to make 2D and 3D images. The unique images of the KLA Tencor CRS give you the ability to quickly distinguish between pits and particles, and to obtain sizing information at the click of a mouse. The CRS 3D image function captures 64 slices of image data in any range the user desires, and with any spacing in increments of 12 nm. The user can set the start and stop positions, and have the system calculate the spacing. If the start and stop are set at the same point, the spacing is set to the minimum, 12 nm. There is also a button to invoke the entire process automatically, with all parameters set by the system.

Fig. 3-38 shows the screen layout for viewing 2D cross-sections of volume images, with panes showing four different views. The larger color image at the upper right is an ***XY Size*** view. It contains a rectangular rubberband cursor surrounding four repetitions of a pattern. At the right the horizontal and vertical sizes of the area inside the cursor appear. A single pattern repetition is 11.5 µ high and 6.1 µ wide.

Figure 3-41 Volume Image Screen



The smaller color image in the ***XY Cut*** pane at the top left has a pair of cutting cursors, the vertical and horizontal lines crossing the image. Clicking and dragging on either one moves it, while clicking on their intersection moves the both cursors around the image. Below the ***XY Cut*** pane, the ***XZ*** and ***YZ*** panes below show cross sections of the surface, cut along the positions of the cursor lines in the ***XY Cut*** window. These windows have their own rubberband boxes for making measurements.

Volume images contain all of the data from all 64 slices. This allows the user to view subsurface layers which have transparent layers above them. Surface images take the brightest reflection at each XY point out of the 64 values for the different levels. The software then forms a relief image showing the height of those points and their brightness. Both surface and volume images can be rotated in three dimensions. The user can zoom in on any point in the image, and can stretch the image height to make pits and particles stand out.

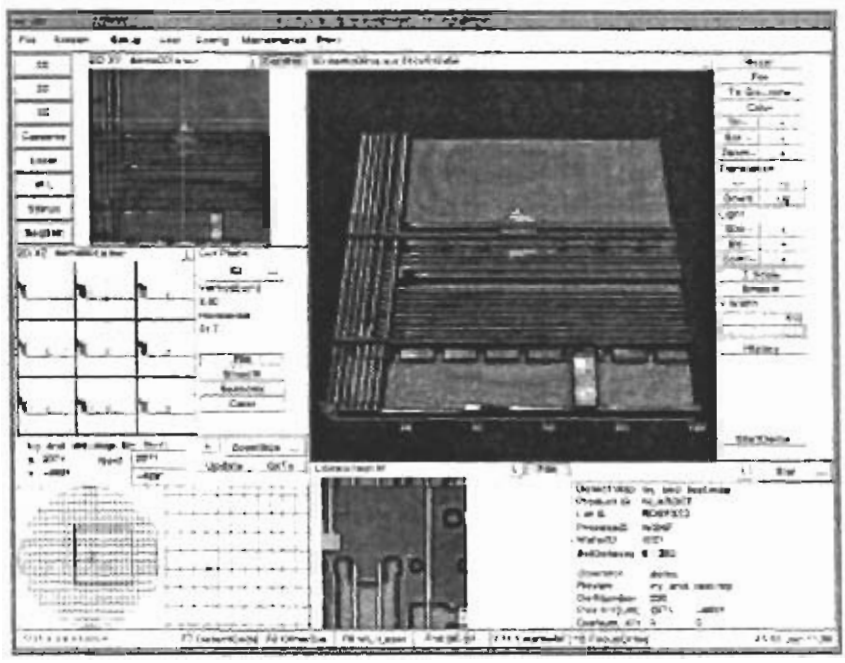
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Surface and volume images can be saved for later review, and brought in via the ***File*** button. Surface images take up about half a megabyte, and volume images 16 M. It is best to save volume images only for recording subsurface defects. Surface images are adequate for viewing most defects.

Fig. 3-39 is an example of a surface image screen with some of the panes rearranged. The main view in the large image pane is the surface of the wafer around a large defect with lines laid down over it. The surface is displayed at an angle. The view from directly above is in the top left window. Below that is an XZ pane divided into nine smaller sections, showing a sequence of slices at the tip of the defect. The upper left section is flat in the middle, while the others show spikes of various heights. It is easy to see in the slice diagrams and in the 3D view that the defect is above the surface but not as tall as the lines. The arrangement of panes in this particular screen has been specified in a user-defined screen layout, and can be modified further by dragging panes from the button bar at the top left.

The image in the bottom center is in a library pane, which lets the user bring in image files from the CRS hard drive, from other networked systems, and from removable media. This image comes from a different wafer.

Figure 3-42 Surface Image Screen



To make a 3D Image

1. In the Review screen, click on the ***Volume*** button or press **sk1** on the numerical keypad for a surface image, or use the ***Surface*** button or the **sk2** key for a volume image. The instrument determines the Z scan range first, does the image acquisition and then changes screens to display the image. The image resolution is initially set low so that image processing and display is quick.
2. For surface images, in the 3D pane, click twice on the ***Smooth*** button to filter out noise.
3. Click on the ***Tilt*** and ***Rotate*** buttons to achieve a desirable orientation.
4. Click on the ***To Hi-res*** button to display the image in full resolution.

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To Load 3D Images

1. Select either the ***Files*** button in an image pane (to load an image only in that pane) or the **Image** command on the **File** menu (to load an image file and display it in all panes). In both cases the same file window appears.
2. You can click on an image type radio button, a directory radio button, a user account name, and a file name, and then on the ***Load*** button to load the selected image.

Experimenting with 3D Images

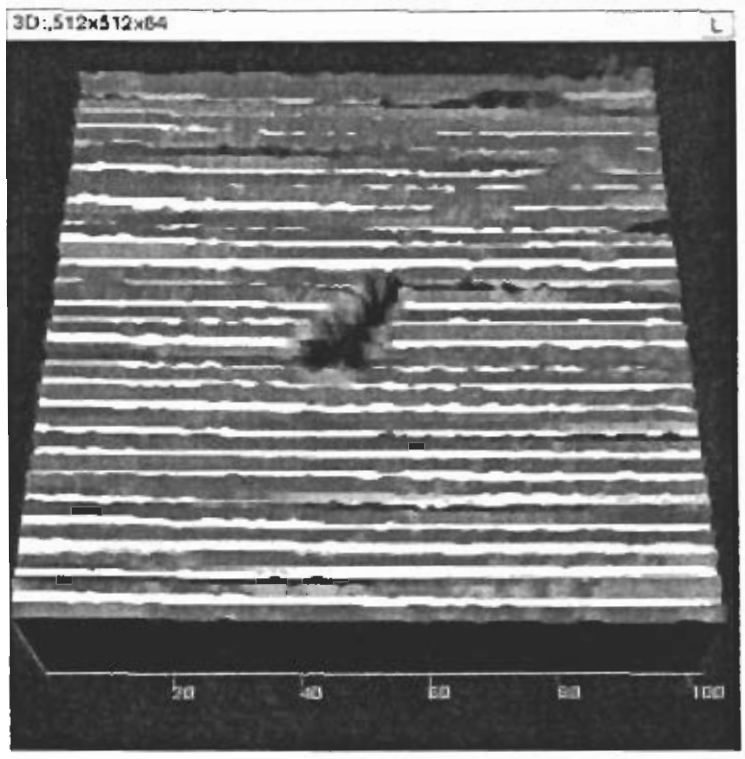
1. Take several 3D images, some surface, some volume, and try out several of the following options with each.
2. Using the mouse, drag the cutting crosshair cursors in a ***2D XY*** pane to the defect location. The ***XZ*** and ***YZ*** panes display the corresponding cross-sectional line profile of the defect (for a surface image) or cross-sectional image (for a volume image) as well as its surrounding area.
3. Now try the rubberband box cursors. Click on the top left corner of the box and drag to move it. Click and drag on the bottom right corner to change the size of the box. Try to enclose the defect precisely in the box. The size of the defect (in microns) is displayed at the right side of the window.
4. Also try the ***Sections*** button, which will give 4, 9, or 16 successive cross-sections in sections of the same pane. The ***Sections*** button is most effective at the edge of features to show how steep they are.
5. With a surface image in a 3D pane, try the rotation and other image manipulation controls, including the ***Zoom*** buttons.

To Zoom in on a Surface Image

1. Bring up a surface view at low resolution, as in Fig. 3-40. Click on the ***QicView*** button, if the image is presently in high resolution.

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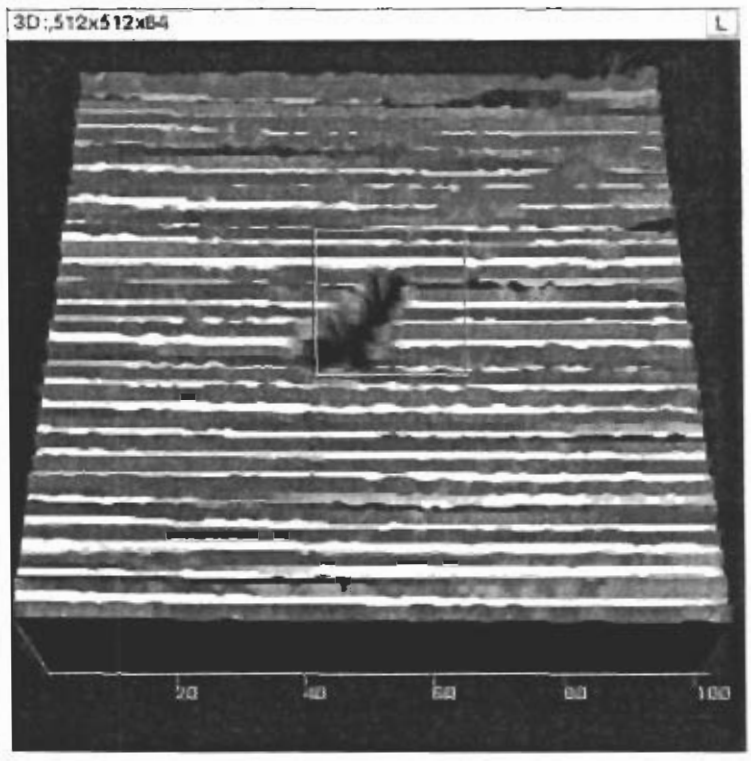
Figure 3-43 Surface Image Before Zoom



2. Click on the ***Zoom+*** button in the 3D image controls, then click in the image. This brings up a square zoom box in the image, centered on the point where the mouse was clicked. Now click and drag in the image. The box is again centered at the new click point. As the mouse moves, the box is resized. Fig. 3-41 shows a defect framed in the default zoom box but not quite centered.

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Figure 3-44 Surface Image with Zoom Box



3. Click on the Zoom button again to accept the selected area for zooming. The image appears, magnified, as in Fig. 3-42.

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Figure 3-45 Zoomed Surface Image at Low Resolution



4. Click on the ***To Hi-Res*** button to display the image at full resolution, as in Fig. 3-43.

Figure 3-46 Zoomed Surface Image at High Resolution



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To Print Images

1. Once you have configured some 2D and 3D images to your liking, click on the **Print** command on the **Screen** menu . Select your printer model and click on ***OK*** to start the printing process.

To Save Images to Files

1. Click on the ***File*** button in the window with the image you want. This brings up a file dialogue box with a ***Save*** button. Note that the **Images** command on the **File** menu only lets you load images, not save them. Enter a name, choose a directory, and click on ***Save***. This saves the image in the pane you are using.
2. Alternatively, select the **Print** command , and click the ***File*** radio button in the ***Print*** dialogue box. Click on the ***OK*** button to bring up the file dialogue box. Enter a name, choose a directory, and click on ***Save***. This saves the entire screen.

Classification

1. Press the **Enter** key or click on the ***Return to Review*** button to return to the review window.
2. Click on the menu in the ***DefectList*** pane and select **DefCode**. This will bring up a list of defect code numbers and names.
3. The classification code of the defect can be typed in the entry box at the lower right of the screen by using the numeric keypad, followed by **ENTER**. Unlike other data entry fields, this is active even when the mouse pointer is not inside it. You can make entries in the wafer map provided for your practice.

Continue moving to defects and viewing them in various modes, including white light and laser at various magnifications, and surface or volume images. See if you can tell what the various controls do, and try them to see how close you came to the way they work. Your instructor may suggest that you look at all of the defects on your first wafer, or tell you to go on to other wafers without looking at everything.

Unloading the Wafer

1. When you are done looking at defects on the first wafer, press **unload wafer** to unload the wafer. The robot returns the wafer to the cassette and the screen configuration returns to the starting layout.
2. You are automatically prompted to save the newly classified data. You can choose to keep the new classifications, or discard them if you wish to leave the original data unchanged.
3. You can continue to load, deskew, and review wafers. When finished, or when taking a break between wafers, log out of the application and leave it ready for someone else.

Logging Out

To log out, click on User on the top menu bar and select the Logout option. The CRS displays the start screen, ready for the next user to click on Continue and log in. You can try logging in and out again, or you can log in and try imaging some more defects.

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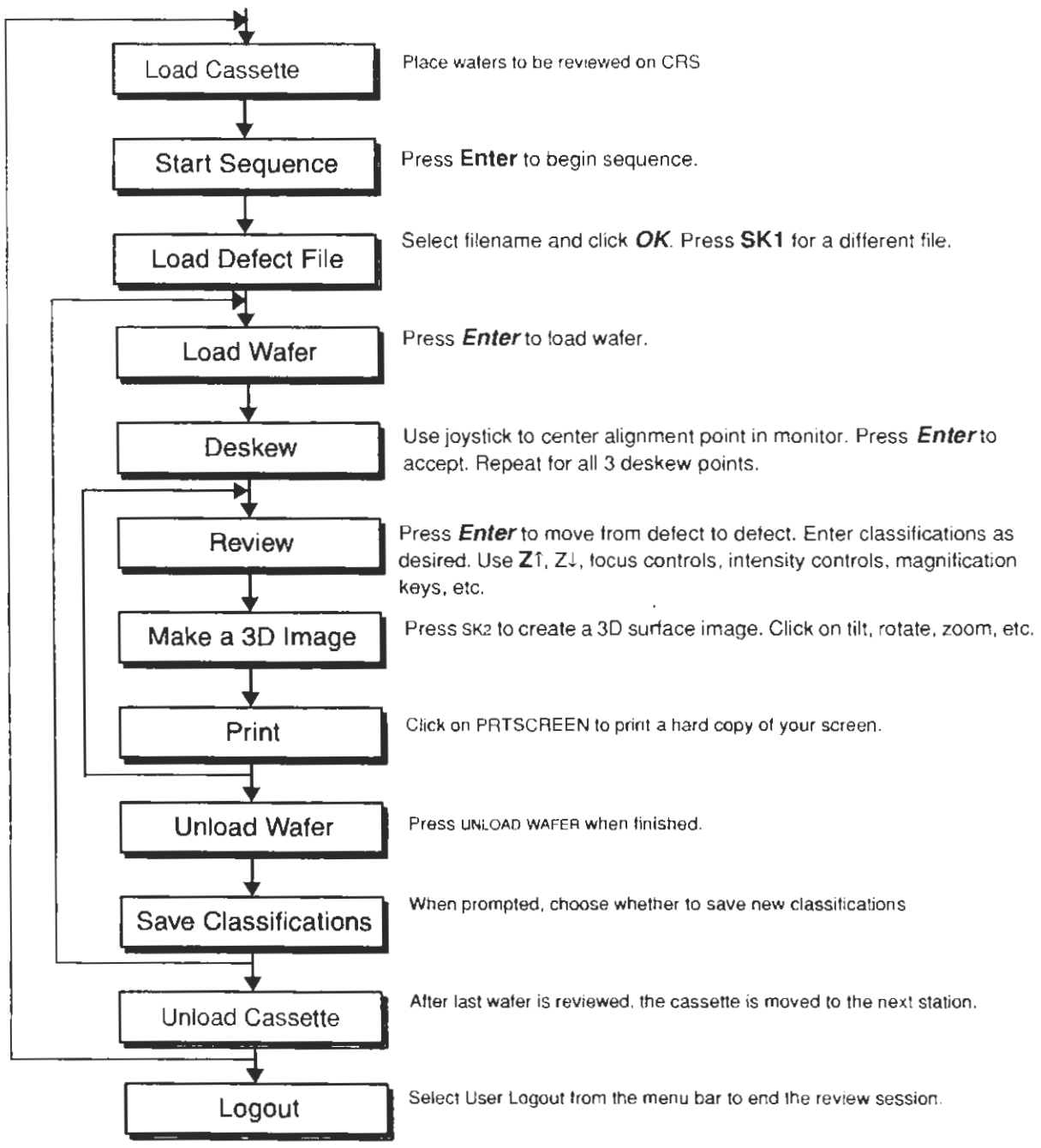
You still have much more to learn about such things as file handling, defect types and codes, and various setup options before you are ready to classify defects. Most of the information you need is specific to your company's processes and products, and cannot be provided here. If you intend to continue further to learn how to administer accounts and set up recipes, you will want to go through the rest of this manual.

KLA Tencor CRS Sequence Flowchart

The flowchart in Fig. 3-44 summarizes the basic steps to using the KLA Tencor CRS.

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Figure 3-47 KLA Tencor CRS Basic Operating Sequence Flowchart



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4

Auto Deskew

Automatic Deskew is a software option for the KLA-Tencor CRS. It uses image processing and pattern recognition techniques to load and align wafers without any user intervention and with consistent accuracy. The alignment precision that can be obtained via automation will insure that all your defects appear in the center of the field of view.

Loading and automatically aligning an 8-inch wafer on our current systems requires just over a minute. Even older generation systems will complete the entire process is under a minute and a half. That's as fast as a highly trained operator, but with accuracy and repeatability that cannot be matched:

- Time to Auto Deskew (150 MHz Indy Computer) 46 sec.
- Time to Auto Deskew (200 MHz Indy Computer) 40 sec.
- Time to Load & Prealign (MECS Robot) 38 sec.
- Time to Load & Prealign (Equipe Robot) 28 sec.
- Deskew Repeatability ±3 µ

These tests were performed on an 8-inch wafer. Performance may vary depending on your system configuration and wafer size.

In order for Auto Deskew to operate properly on your system, you must be using a machine with a Silicon Graphics Indy workstation controller. Older models which used the Indigo workstation cannot run Auto Deskew. Furthermore, you will also need our Integrated White Light option which enables you to capture images from the video camera to the workstation. IWL is standard equipment on the CRS 1200, and an option on earlier systems. If you have any questions about the requirements for Auto Deskew or your tool's configuration, please call KLA-Tencor.

- 5× and 50× Objectives (minimum)
- Either MECS or Equipe Robot
- Optronics DEI-470 or Sony DXC-930/950 Camera
- Integrated White Light Option (8-bit or 24-bit)

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Overview

Matching two plane surfaces in the general case requires a rotation and a translation. In the Deskew process, the rotation between the wafer surface and the focal plane of the microscope is partly corrected by the FlatFinder Angle Offset, and the translation by the Map Offset. The flatfinder, or prealigner, will normally rotate a wafer to within half a degree of the correct rotation. It will also center the wafer fairly accurately.

It is impossible to perform a physical calibration of the prealigner to match the precision of the stage in the CRS, but it is easy to deal with small positioning errors in software. The errors can be measured after a wafer is loaded by taking the offsets from the calculated stage position of a feature to the position with the feature centered in the crosshairs in the image window. Offsets to two points on the same wafer street give the correction for rotation, and offsets at a third point give the corrections for translation in X and Y.

When the application is given a pair of coordinates to move to it can used these measured corrections as parameters to calculate the motion required to bring that spot under the microscope. Using these calculations, the CRS can position wafers with no visible error in rotation and at most a few microns error in translation, so that the feature of interest is well within the field of view of the microscope, even at high magnification.

The manual deskew process is described as part of the Tutorial for the Operator in Chapter 3. Table 4-1 is a step-by-step description of setting up AutoDeskew for the Engineer.

Table 4-1 Setting up AutoDeskew

Start	Load the wafer.
	Manually deskew the wafer.
	Verify defect positions.
	Set the Flatfinder offset.
Set-up AutoDeskew	Unload the wafer.
	Reload the wafer.
	Verify deskew positions.
	Set the Stage Center Offset
	Capture AutoDeskew reference images.
	Test/verify Deskew.
	Correct for Map Offset.

The process makes use of

- Image windows with crosshairs for lining up the deskew points
- The joystick
- The ***Deskew*** sequence pane in the ***Deskew*** screen
- The ***Deskew*** pane for setting deskew points and map offset, accessed from the option menu in the ***Status*** pane
- The ***Deskew Options*** window for other deskew settings, from the **Setup** menu
- The ***Wafer Map*** panes
- The ***System Configuration*** window, accessed as **Misc.** on the **Config** menu.

The ***Deskew*** screen, in Fig. 3-13 on page 36, shows the white light and laser image panes, wafer map and zoom panes, the ***Deskew*** sequence pane, and the ***Status*** pane, which may show wafer information, a defect list, or manual deskew setup functions, depending on the current selection on its

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option menu. The deskew setup functions include setting the location of deskew points and calculating the map offset.

Fig. 4-1 is the ***Deskew*** sequence pane, with buttons to skip or redo deskew, and to accept the current deskew point. It is used for manual deskew, which is necessary to perform before setting up AutoDeskew parameters and capturing AutoDeskew images.

Figure 4-1 Deskew Sequence Pane

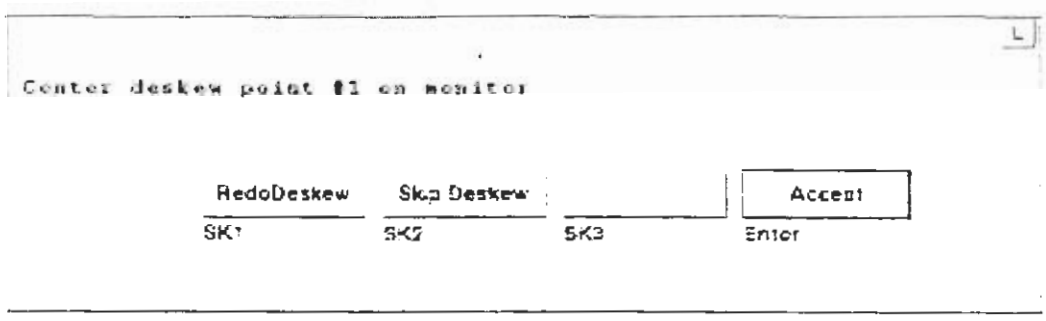
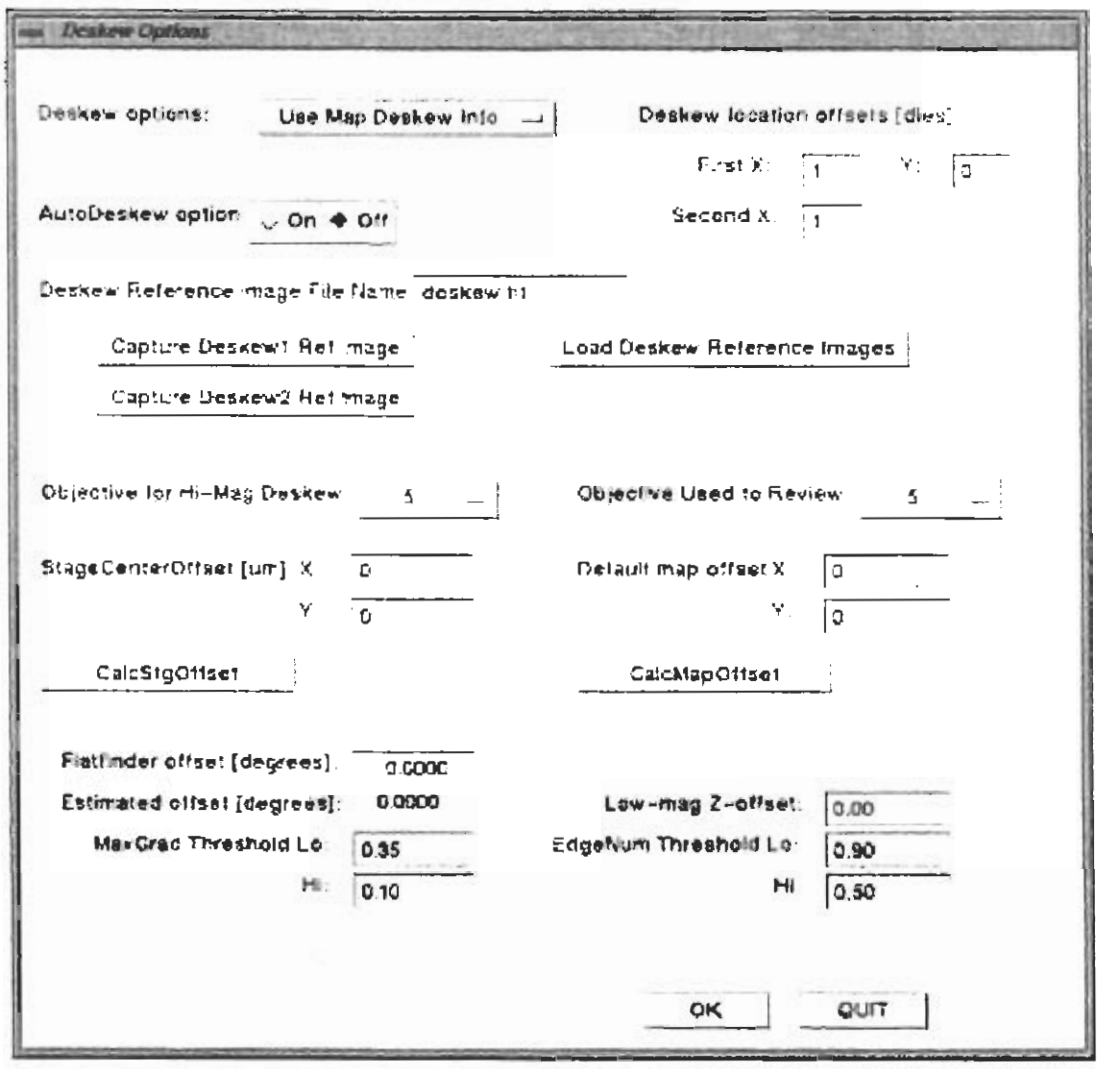


Fig. 4-2 shows the ***Status*** pane at full size with **Deskew** selected from the option menu. The ***Status*** pane is usually displayed in a smaller area which cuts off the rightmost buttons. If necessary, drag the pane to a larger display area, such as the ***Sequence*** pane.

Figure 4-2 Manual Deskew Pane

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Figure 4-3 *Deskew Options* window

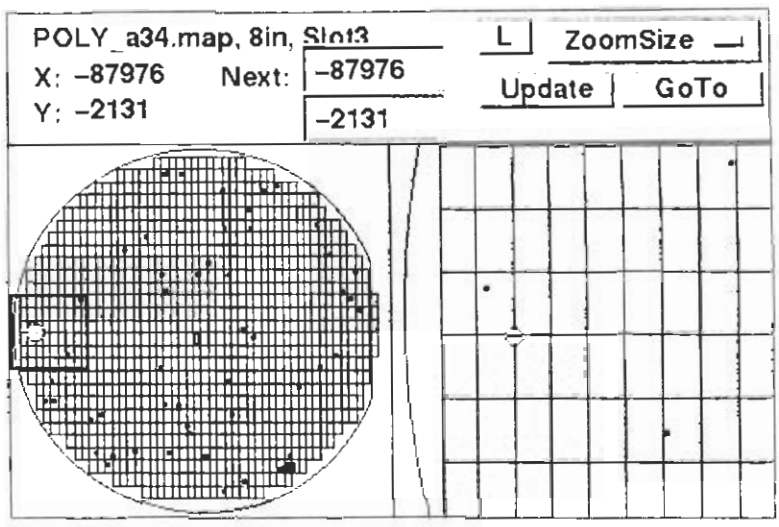


Manual Deskew

From the Review screen, carefully look at the Wafer window and make sure that the deskew point is correct. Fig. 4-4 is an example of what you might see. The blue square in the wafer map at the left is the zoom box. The zoom window on the right side gives a magnified view of the portion of the map in the zoom box. The current defect position will be circled in blue in both views.

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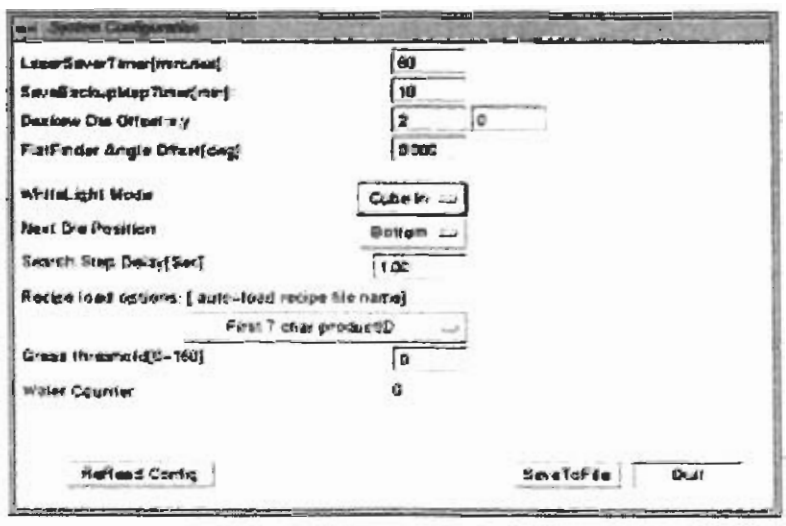
Figure 4-4 Wafer Map Window



The system should have driven to the first deskew point. Check that the die offset shown in the Wafer window is correct. Drive the wafer position around with the joystick to verify that the physical die position that you are looking at is the same as what the computer is telling you. Make sure that the wafer run number you are looking at matches the wafer run number of the map.

Select **Config/Misc** from the pull down menu to view the ***System Configuration*** window:

Figure 4-5 System Configuration Window



Check the values set for the ***Deskew Die Offset:xy*** are the correct number of dies from the edge of the wafer. Next check for the correct wafer orientation, in the ***FlatFinder Angle Offset[deg]*** field.

Set the Deskew options from **Setup/Deskew Options** pull down menu by clicking on the ***Options*** button.

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1. Use **Map Deskew Info** for Pattern Wafers
2. Use **Defects as Deskew pts** for Bare Wafers
3. Turn the AutoDeskew option ***Off***
4. Select ***OK*** button or ***QUIT*** to exit

Center the first deskew point. Turn on the cross hairs by bringing up the ***White Light*** pane (***W/L*** icon) and clicking on the toggle button ***XHairOn/Off***. Align the first deskew point with the crosshairs at 5× and then 50×. When you are satisfied select ***Accept*** with the mouse or **Enter** on the keyboard.

Observe the movement of the stage to the second deskew point. This will help you determine the location of the reference point if it moves off screen. Center the second deskew point with the crosshairs at the same objective magnification that you will be doing ADC with. When you are satisfied select ***Accept*** with the mouse or **Enter** on the keyboard.

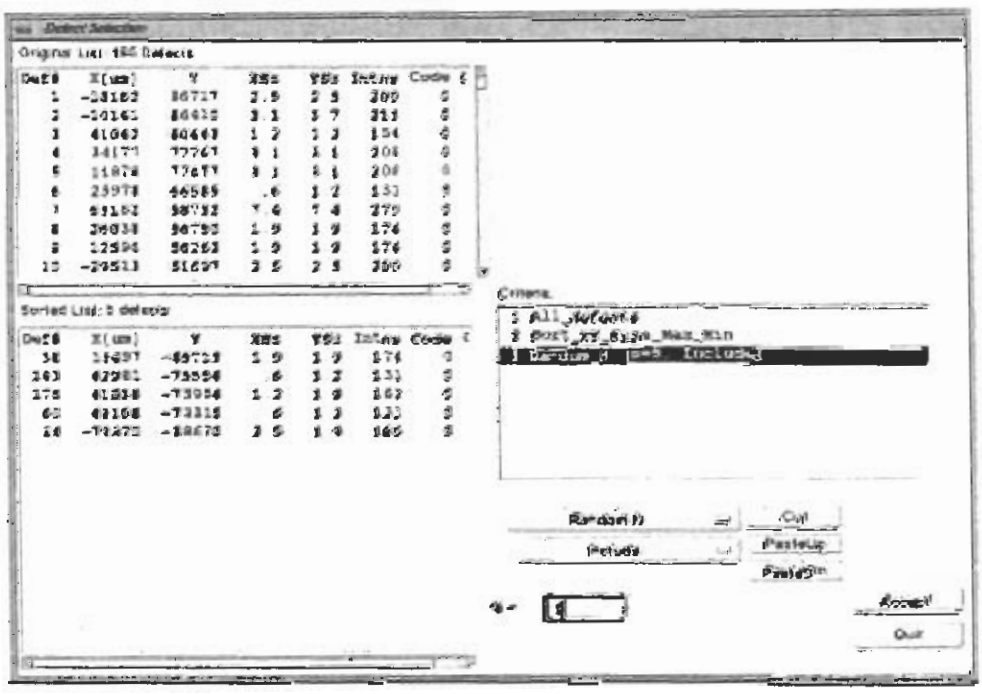
Align the third deskew point with the crosshairs. When you are satisfied select ***Accept*** with the mouse or **Enter** on the keyboard. It will now automatically move to the first defect on the ***DefectList*** pane.

You need to verify the deskew by finding defects. A good technique is to pick a few large defects to see if you can find them. You can perform a sort on the defect list by selecting **Setup/DefectList Sort** from the pull down menus. Fig. 4-6 shows this window with a selection specified and the sort carried out. The original list of 185 points for this wafer is shown in the upper left pane. The right pane displays the current sort criteria, allowing entry and editing. The bottom left pane shows the results of the most recent sort.

Click on the option menu that shows the selection **All** and drag to select sort criteria from the pop-up list. For this purpose select ***Sort_XY_Size_Max_Min***. Click on your selected sort criterion in the ***Criteria:*** list window, then click on ***PasteDn*** to add it to the active list. It is the second criterion selected in , which shows the selection for a random choice of 5 points next. The sort criteria are applied in their order of appearance in this list. When you are have finished selecting sort criteria, click on the ***Accept*** button with the mouse. When you return to the ***Review*** screen, notice that the ***DefectList*** pane now shows a defect list sorted by size, with the largest defects at the top.

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Figure 4-6 Defect Selection Window



Select a defect in the center of the wafer by clicking in the ***Wafer*** window. The nearest defect is highlighted in the ***DefectList*** pane. Then click on the ***GoToSelected*** button. Verify that the defect is in your field of view. Center the defect in your crosshairs and click on the **MapOffset** key on the keyboard. Try a few more defects and adjust the offset so that you can find the mapped defects with consistency. If you are not having good success, you may need to redo your deskew. Select the ***RedoDeskew*** button with the mouse or the **SK1** key on the keyboard.

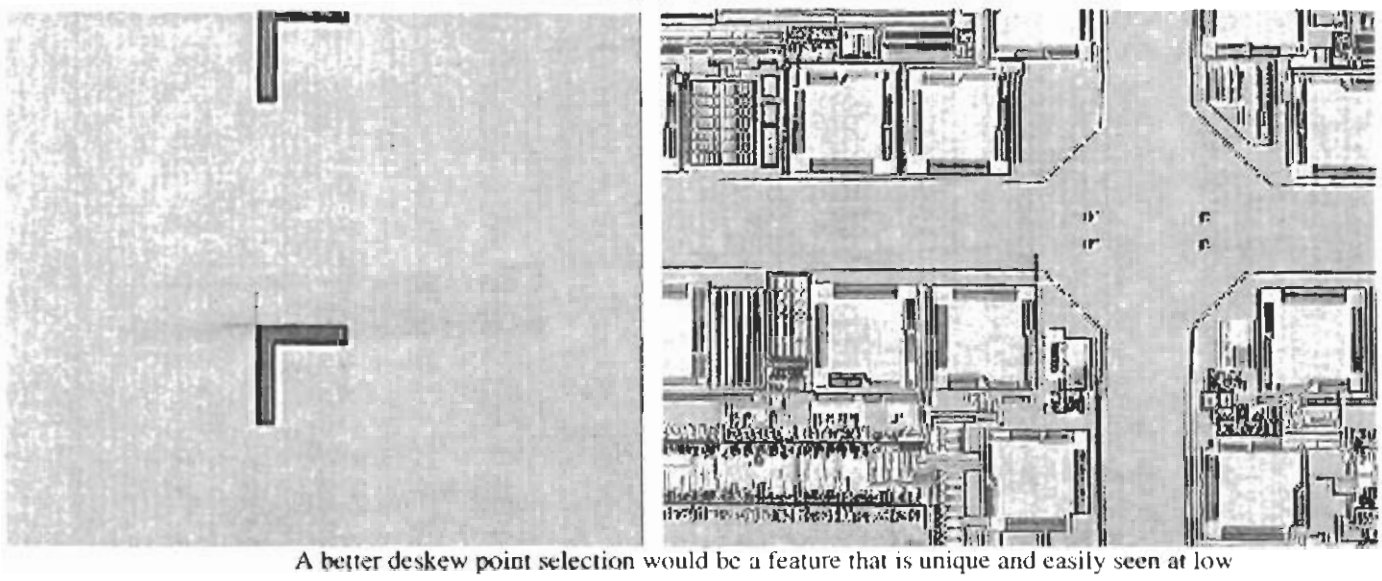
Choosing Deskew Points

Care needs to be taken in selecting AutoDeskew points. The crosshairs in the image on the left in Fig. 4-7 are perfectly centered on a feature which could be used as a manual deskew point. However, this is not a good deskew point for AutoDeskew since there is an identical feature with the same orientation nearby. Repeating, highly symmetric features on multiple axes are poor choices for deskew points. Since the software relies solely on image matching, and has no other information about the location of the deskew point, it cannot tell if the correct feature has been selected.

Deskew points such as these inverted "L" features may appear to be good "human" deskew points at low magnification, as in the image on the right in Fig. 4-7. It is easy to tell where each feature fits in the larger pattern when all of them are visible, but at high magnification they can confuse the system, which may mistakenly align to the wrong feature if the right feature is out of the field of view. In fact, there is no way to tell from these images whether the high magnification view was taken at the lefthand pair of features, or the righthand pair.

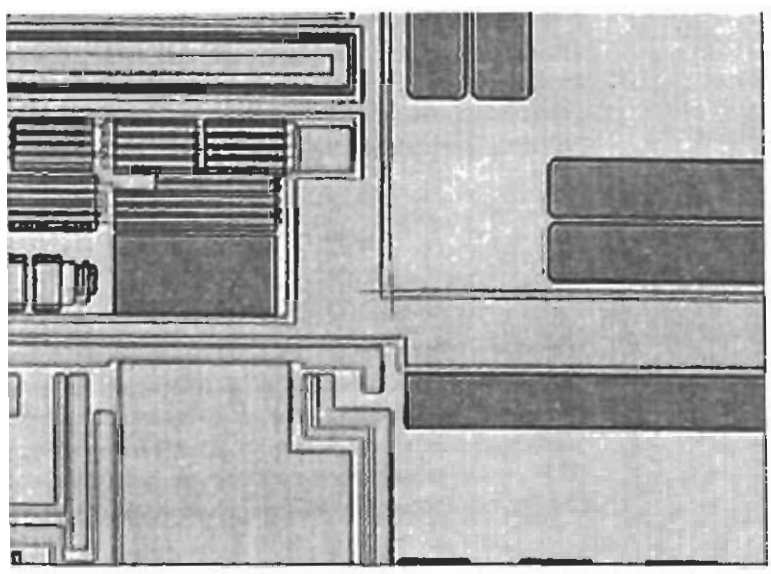
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Figure 4-7 A Poor Deskew Point



A better deskew point selection would be a feature that is unique and easily seen at low magnification, as in Fig. 4-8. This is a good deskew point because features around it are different on both axes and have high contrast. Die corners are among the best choices for deskew points.

Figure 4-8 A Better Deskew Point

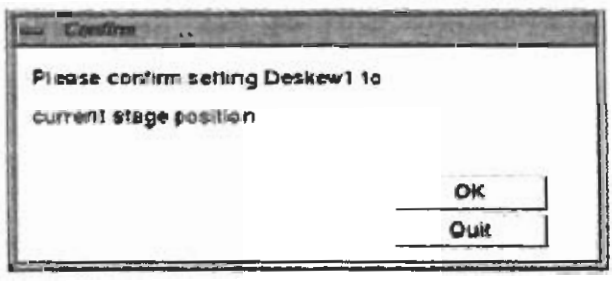


When setting up deskew points for manual deskew, swap the ***Status*** pane with the ***Sequence*** pane, so that all the controls will be visible, and select **Deskew** from the option menu. Select the desired deskew point at low magnification, then center it at high magnification. Click on the ***SetDeskew1*** or ***SetDeskew2*** button, as appropriate. A dialogue box will appear, asking for confirmation, as in Fig. 4-10.

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Figure 4-9 Screen Arrangement for Setting Manual Deskew Points

Figure 4-10 Confirm Deskew Point Dialogue Box



Setting up AutoDeskew

AutoDeskew gives you the ability to automate the deskew process. For a fresh setup, it is good to verify your deskew points by first performing a manual deskew before attempting AutoDeskew. Typically you will be able to setup a recipe with AutoDeskew for a process layer and modify it for use on other layers of the same product. If you choose a feature such as a die corner that is visible on all succeeding layers, it will only be necessary to capture new images of the deskew points after each process step that is to be reviewed.

Select **Setup/Deskew Options** from the menu bar. You will be presented with the window shown in Fig. 4-3 on page 66.

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Deskew Options

This option menu is used to select the way deskew points are chosen. There are two choices that will appear when this button is selected:

- Use Map Deskew Info
- Defects as Deskew Pts

For pattern wafers, you will use map deskew information, which remains the same from wafer to wafer. Please note that AutoDeskew does not work on bare wafers, which necessarily use non-repeating defects as deskew points.

AutoDeskew option

Click on a radio button to turn AutoDeskew ***On*** or ***Off***. Leave it off during setup.

The ***Deskew Reference Image File Name:*** field is a text entry box for the image file name that you wish to use. The CRS application will modify this name for the four deskew image files it needs to capture. A name identifying the process and level is usually appropriate.

Low magnification deskew is done at 5×. The **Objective for Hi-Mag Deskew** option menu offers the list of available objectives. A good choice is 50×.

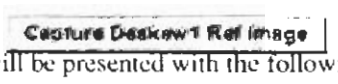
The **Objective Used to Review:** option menu also lists all of the objectives. Select an objective from this list for performing review. A good choice here would typically be 100×.

There are two text entry boxes for setting up the X and Y map offsets. These offset numbers are the position difference between the map and the system. It is used to center the defect in the field of view. For ease of setup, enter zeros for both the X and Y map offsets at this time. Enter 0 into the ***FlatFinder Offset[degrees]*** entry field.

Close the window by selecting ***OK***, and perform a manual deskew. Then select **Setup/Deskew Options** again from the menu. The system will automatically calculate and display an estimated flatfinder augle offset in the ***Deskew Options*** window. Enter the number shown as the ***Estimated offset [degrees]:*** into the ***Flatfinder offset [degrees]:*** text box. Click OK to exit this window. At this point you have changed your recipe settings in memory but not on disk. Select **File/Recipe** from the menu bar, and save the recipe to a file. Enter the name of the recipe in the ***Selection*** text box and click on the ***SaveRecipe*** button.

Unload the wafer and reload it to test the new flatfinder offset. Verify that the wafer street runs true and horizontally flat on screen when performing a deskew operation. Center the deskew point and set the stage offset using the ***CalcStgOffset*** button. Save the recipe again at this point.

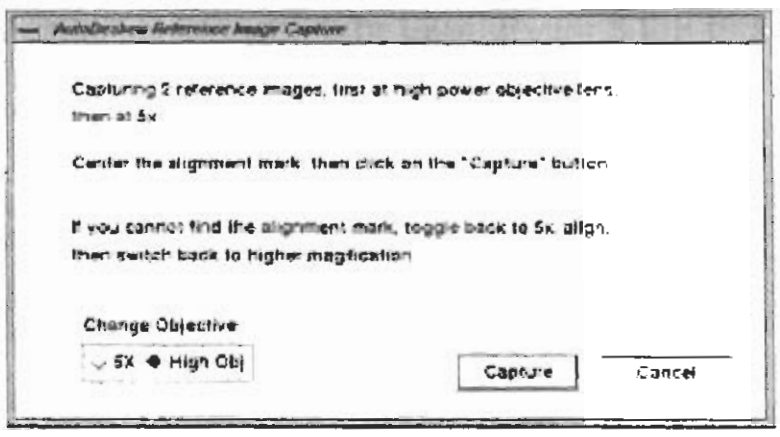
You may verify your selected deskew points for AutoDeskew in the ***AutoDeskew Testing*** window. Please refer to the menu item description section on **Maintenance/TestAutoDsk** in Chapter 5 for further information on using this function.

Click on this button 

to capture two reference images for the first deskew point. You will be presented with the following instructions:

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Figure 4-11 AutoDeskew Reference Image Capture



The system will switch objectives to the high-magnification objective selected in the ***Deskew Options*** window. Use the joystick to center the deskew point on the crosshairs. Capture the two images by selecting the **<Capture>** button, then select **<OK>** in the ***Deskew Options*** window. Next, accept the first deskew point by clicking on the **<Accept>** button with the mouse in the **SeqStat** window or selecting the **<Enter>** key on the keyboard. Select **Setup/DeskewOptions** again to continue.

Select this button **Capture Deskew2 Ref Image** to capture the second set of two reference images for the second reference point. Follow the same procedure as for the first set of reference images. The system will again switch objectives to the high-magnification objective selected in the ***Deskew Options*** window.

The system will store the reference images in the system data directory `/usr/uv/data` named with the user entered deskew image name appended with `1`, `Hi1`, `2` and `Hi2`:

***deskew*`1.tif`**

***deskew*`Hi1.tif`**

***deskew*`2.tif`**

***deskew*`Hi2.tif`**

Load the four deskew reference images that you have captured into memory by clicking on the ***Load Deskew Reference Images*** button. Turn on the AutoDeskew option by clicking on the ***On*** radio button. Close the ***Deskew Options*** window by clicking the ***OK*** button. Now select ***Redo Deskew*** from the keyboard or the screen. If you have carried out all the steps correctly in the proper order, the system will AutoDeskew your wafer and drive to the first defect location.

AutoDeskew option: ◆ On ◇ Off

Center the first defect point on the crosshairs and push the **Map Offset** key on the keyboard. Next find several defects at the far ends of the wafer and readjust the map offset as necessary to keep the defects well centered in the field of view.

When you are satisfied with your map offset, open the ***Deskew Options*** window from the **Setup/DeskewOptions** menu. Click on the ***CalcMapOffset*** button and enter the offset numbers

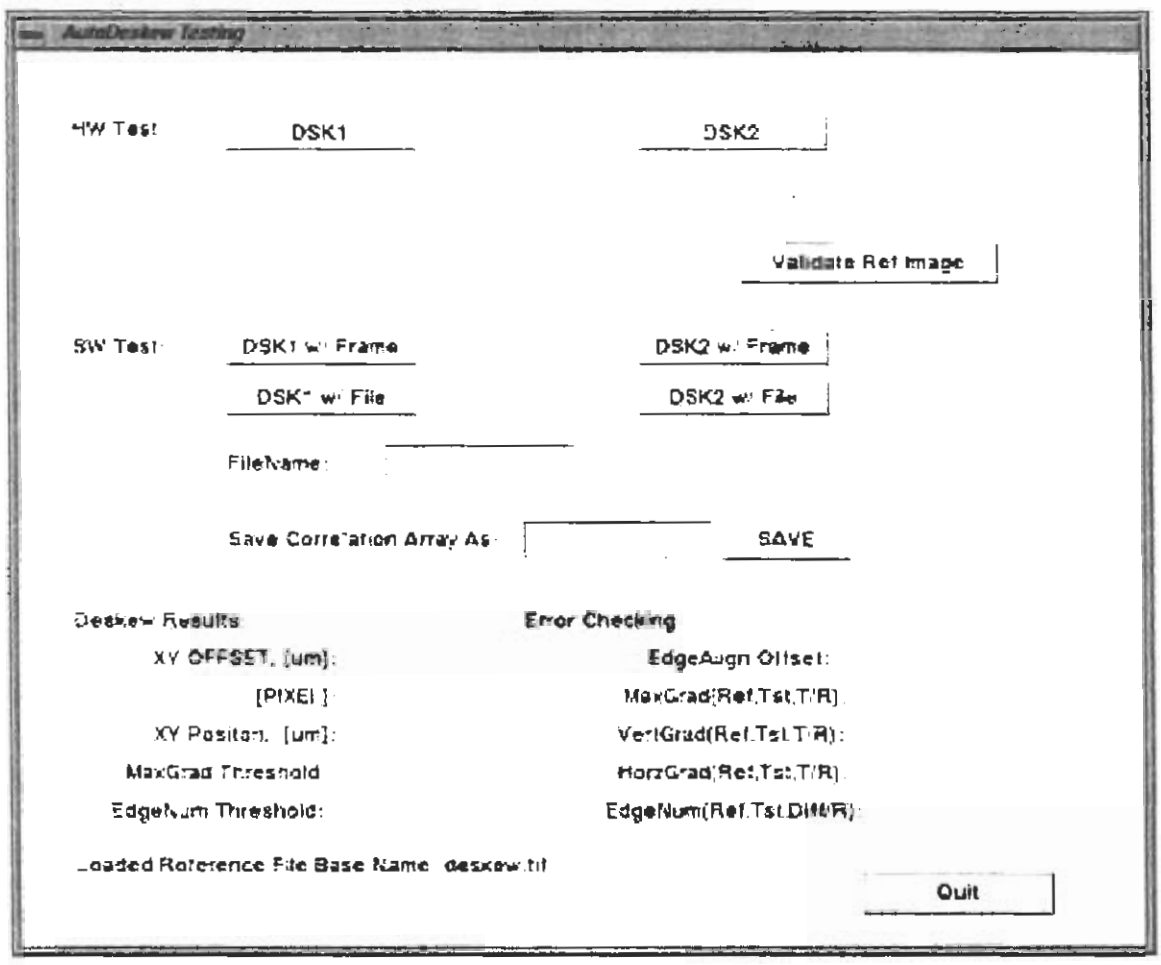
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for the X and Y axes. If you did not previously zero out the values in these boxes you will have to sum the offset numbers with those already in the edit boxes and then enter the new values in the X and Y edit boxes. When you are done, click on ***OK*** with the mouse.

After this has been done, retest the AutoDeskew function to make sure that it works well by selecting ***Redo Deskew*** from the keyboard. AutoDeskew will align the wafer and go to the first defect site. The first defect should now be in the center of the screen.

A further test has been added to the version 2.4 software. Select **Test AutoDeskew** from the **Maintenance** menu to get the window in Fig. 4-12. Click on the ***HW Test*** buttons to drive to the deskew points, and on the ***SW Test*** buttons to check matching between the screen image and the stored image files. The window will report results for the deskew operation in microns and in pixels, and will give values of the error-checking parameters which can be used by service personnel for diagnostics.

Figure 4-12 Testing AutoDeskew



AutoDeskew is set up for this process level and product type. Save the recipe with an appropriate name for this process level.

There are some additional features in the ***Autodeskew*** window that were not touched upon in this section. Please refer to Chapter 5, Reference, for a detailed description of each window item.

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5

Reference

This chapter contains a systematic review of CRS hardware and software functions accessible to the user, with the exception of Automatic Defect Classification (ADC), the subject of a separate manual. Functions covered here include all controls in windows and panes (subwindows) in the CRS software, the joystick controls, and all menu and keyboard commands. Your CRS may not have all of the features described here, depending on which options are installed.

Privilege Levels

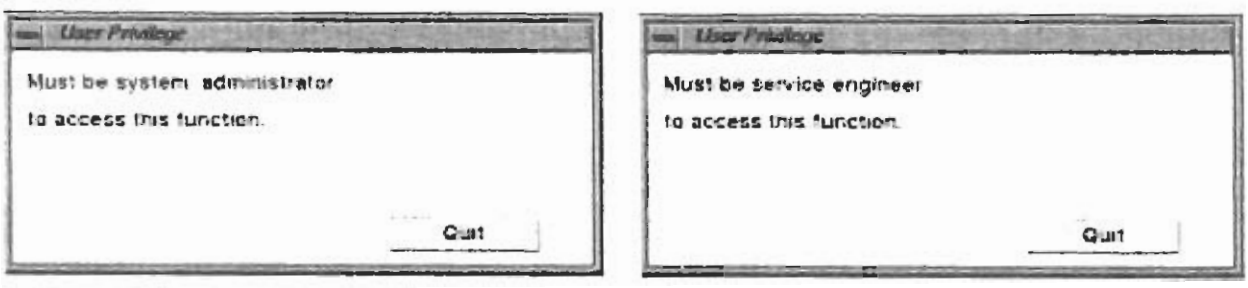
Access to KLA Tencor CRS functions depends on the level of privileges assigned to a login account. The KLA Tencor CRS software supports three levels of users, listed in Table 5-1. Selecting a command which requires a higher permission level than the current account has brings up one of the messages shown in Fig. 5-1.

Table 5-1 Account Privilege Levels

Operator	Functions: Operation. Cannot exit from application. Directories and Files: System directory (shared files) and individual user account UNIX: Shutdown only
Administrator	Functions: Operation, configuration, recipes, some maintenance Directories and Files: All application and user files UNIX: shell, with user restrictions
Service Engineer	Functions: All Directories and Files: All UNIX: shell, superuser

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Figure 5-1 Error Messages for Unavailable Functions



The User Interface

The KLA-Tencor CRS application software has a graphical user interface with mouse and function key control. The interface uses X Windows, which implements the window metaphor on the UNIX platform, much like the Apple Macintosh and Microsoft Windows operating systems.

A window is a rectangular area on the screen for interacting with a particular application. It has a border and a title bar, and may also contain a menu bar and controls and display areas. The user points with the mouse and clicks on various menus or graphical controls to interact with the software application. Each window groups functions for some part of the application's purpose, and the top menu bar provides access to a variety of windows and some other functions. For faster throughput, many of the more commonly-used functions are also duplicated on the keyboard.

Input Devices

To control the KLA-Tencor CRS, you have three input devices at your disposal:

- The mouse accesses all functions graphically. Its motion controls the position of the pointer on the display screen and the buttons allow selection by clicking, double-clicking, or clicking and dragging.
- The keyboard allows entering information (for example, a new filename or a defect code number) to the operating software. It is also set up with the most commonly used functions for high throughput single-keystroke operation.
- The joystick is linked directly to the XYZ stage controller for manual stage movement.

Mouse

The CRS workstation has a standard three-button mouse used for clicking, double-clicking, and click-and-drag. The left button is used for almost all operations. The right button sometimes invokes a pop-up menu. The CRS software makes no use of the middle button.

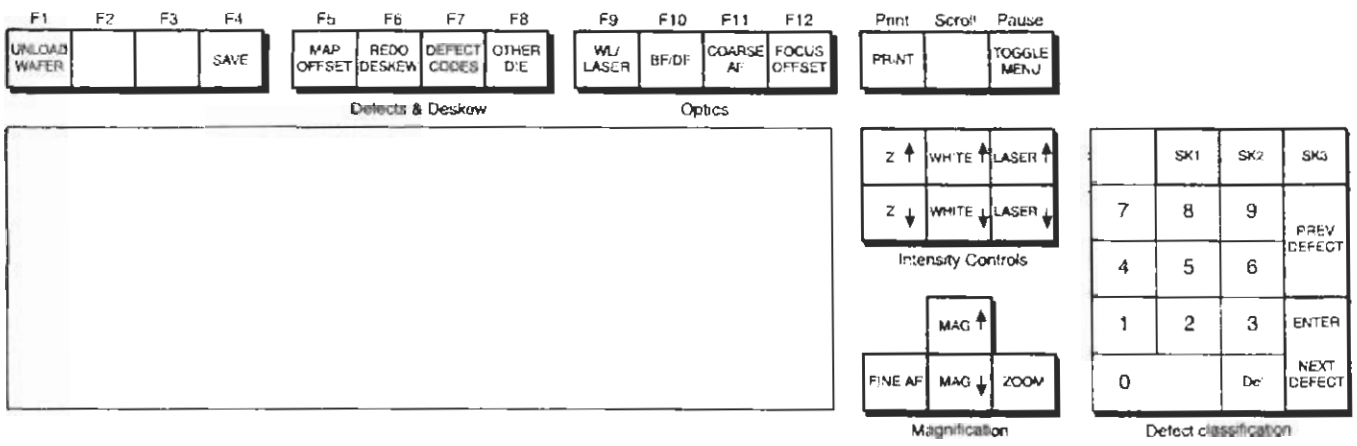
Keyboard

The KLA-Tencor CRS keyboard is a standard 101-key keyboard with custom functions incorporated for maximum efficiency. Functions for defect classification are grouped on the numeric keypad, and

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image control functions are right next to them. Other frequently used functions are provided on the row of function keys, F1–F12, at the top of the keyboard. Fig. 5-2 shows the keycaps for the special functions.

Figure 5-2 CRS Keyboard Layout



For high throughput defect classification, the numeric keypad on the right side of the keyboard is the focal point of operation. The top row of keys on the keypad, labeled SK1, SK2, and SK3, are softkeys whose functions change in different screens. The sequence pane in the lower right corner of the Start, Load Wafer, Deskew, and Review screens shows the current functions of these keys and also of the Enter/Next Defect key. The function of the **Enter** key in each screen is listed in Table 5-2. In the Start, Load Wafer, Deskew and Review screens pressing Enter moves to the next screen, or to the next step in the current screen. In the Review screen, it moves to the next defect in the current list according to the selection and sort parameters that are active.Just above the Enter key is the Previous defect key.

Table 5-2 Enter Key Functions

Screen	Label
Start	StartSeq
Load Wafer	Load Wafer
Deskew	Accept
Review	Next Defect

Just left of the numeric keypad are the keys that control the focus, illumination, and magnification functions. There are keys to increase or decrease stage Z height (Z↑ Z↓), white light illumination (WHITE↑ WHITE↓), laser light gain (LASER↑ LASER↓), and objective magnification (MAG↑ MAG↓). The ZOOM button cycles through the four levels of laser zoom. The Fine AF button invokes a fine autofocus operation. It can be used either after a coarse autofocus, or when previous operations have left the CRS near but not at fine focus.

The actions of the top row of keys (often referred to as function keys) are user-definable, as described in "Function Keys" on page 145. They have been factory-configured for your convenience and it is recommended that you do not change them unless you have had extensive training and experience with the KLA-Tencor CRS. Table 5-3 lists the key labels on the standard keyboard and the CRS

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keycaps. Six of the function keys are displayed at the bottom of the CRS window. The **Toggle Menu** key switches to the other six.

Table 5-3 CRS Function Key Assignments

Key	CRS Name
F1	Unload Wafer
F2	
F3	NoAfOffset
F4	Save
F5	Map Offset
F6	Redo Deskew
F7	Defect Codes
F8	Other Die
F9	WL/Laser
F10	BF/DF
F11	Coarse AF
F12	Focus Offset
Print Screen	Print
Scroll Lock	
Pause	Toggle Menu

Stage Joystick

The stage joystick is linked directly to the XYZ stage controller, bypassing the KLA Tencor CRS software. Manual movement of the stage via the joystick does not affect the position and coordinate display shown on the screen. They are synchronized with the actual stage position the next time a positioning function is activated from the screen. To update the position in the software without moving the stage, use the ***Update*** button in the ***Defect List*** pane.

A toggle switch on the joystick allows the user to alternate between two modes: XY mode and Z mode. In XY mode, tilting the joystick to the left or right moves the stage along the X axis in the direction opposite to joystick motion, so that the image on the screen appears to move in the direction of joystick motion. Tilting the joystick forward or back moves the stage along the Y axis, also in the same direction as the joystick, and also opposite to screen motion.

In Z mode, tilting the joystick forward or back moves the Z stage up or down, so that the focal plane is lower or higher. Again the user must move up to see lower down, and down to see higher up. Left or right movements of the joystick in Z mode have no effect on the stage.

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Most graphics editing applications and simulations move the image in the direction opposite to the joystick or mouse, so that the user's point of view moves with the pointing device. Users who have worked with this oppposite convention will need some time to adjust to the CRS controls, but with experience this method will become perfectly natural.

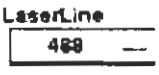
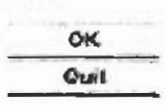
Software Controls

Via the mouse, a variety of controls are at your disposal on the screen. The types of controls are described in Table 5-4, starting with the menu bar in Fig. 5-3.

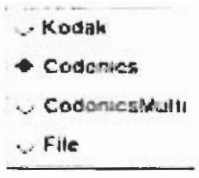
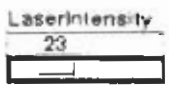
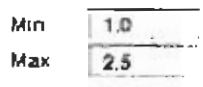
Figure 5-3 CRS Application Menu Bar



Table 5-4 Window Controls

Control	Description
Menu Bars (above, Fig. 5-3)	By clicking on a menu bar item, an associated pull-down menu appears. Then you can activate one of the pull-down menu items by clicking on it. Alternatively, you can press down on a menu bar item and drag to the desired menu item.
Option Menus 	An option menu is similar to a menu bar item, but it does not appear along the top of the screen, and the last selected item remains displayed, rather than a menu title. CRS option menus are distinguished by the small bar at the right-hand end. Clicking on an option menu opens the menu display. Selection is the same as in the main menu bar.
Push Buttons 	By clicking on a push-button, you invoke its associated action. A ***Quit*** button always cancels the current selection and closes the current window. When you are trying to quit a function or the application, you have to click on OK in order to quit. Clicking on Quit cancels the quit operation.
Toggle Buttons 	Each click of a toggle button changes its status, from on to off or off to on. In this case the green button is on, or enabled, and the white button is off, or disabled.

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Control	Description
Radio Buttons 	Radio buttons allow a single selection from several alternatives. Clicking on one selects it and deselects the last one active.
Slider Bars 	You can move the slider button within a bar in two ways: (1) by clicking on and dragging the slider button to the desired value, or (2) clicking on the gray area outside the button. This will increment/decrement the slider bar by a fixed amount. Many scales have 10 as the increment. ***LaserIntensity*** moves by 1, and ***FineZ*** by 0.1
Entry Field 	An entry field is a rectangular area where you can enter text and numbers. An entry field normally accepts keyboard input only if it has the input focus (if it does, the border of the entry field has a thick, dark frame). Clicking within the entry field allows it to have input focus. The only exception to this rule is the ***Classification Code*** entry field located just above the soft key display in the ***Review*** screen. This entry field is always tied directly to the numeric keypad.
Window drag buttons 	Clicking on the ***L*** button in a pane and dragging to another pane interchanges the two panes. There are also named pane drag buttons in a bar at the top or left of the screen. Dragging one of them to a pane brings up the display associated with the button, and replaces the button with one for the pane that was replaced.

Files and Directories

Directories

Files on the KLA-Tencor CRS are located in a variety of local directories, and also in directories on other computers. Table 5-5 describes the various directories accessible from the application. Note that depending on your particular configuration, some of these directories may or may not be available. Moreover, directory names can vary somewhat from system to system. In particular, the

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IMPORT, REMOTE, and REMOTE2 directories can be renamed, and more REMOTE directories (REMOTE3, REMOTE4, and so on) can be created and named.

Table 5-5 CRS Directories

Directory	Description
SYSTEM	Accessible by all users
USER	A private directory corresponding to the operator's login name. Users with operator privileges cannot access files in another user's directory. Users with administrator or service privileges can access any user's directory
FLOPPY	Accesses the 3.5-in. floppy drive located on the front of the main system
OPTICAL	Accesses the 5.25-in. magneto-optical drive (optional)
IMPORT	Usually a local directory that is linked via NFS to a remote computer. Primarily used as a destination for Inspection Systems to deposit their unreviewed wafer maps
REMOTE	A directory on a remote computer that is accessible via NFS. Primarily used as a destination for the KLA Tencor CRS to deposit reviewed wafer maps.
REMOTE2	Same as REMOTE but for a different directory.
REMOTE n	Other remote directories can be defined for communication with multiple instruments and computers

A directory is created for each user, and this is the default directory where all data is stored for that user. An operator can access just this assigned user directory and the shared system directory on the hard drive, while an administrator can access all user directories. The SYSTEM, FLOPPY, OPTICAL, IMPORT, REMOTE, and REMOTE2 directories can be accessed by all users.

All filenames used with the CRS software are keyed with a file extension. For example: all surface filenames end with `.sur` and all volume files have names ending with `.vol`. A directory listing on most media shows only those filenames with an extension that matches the file type selected, unless display of all files is selected.

The FLOPPY directory allows reading from and writing to MS-DOS formatted 3.5- in. floppies. Normally, the FLOPPY directory lists only those filenames that match file type selected. However, if the wafer map type is selected, all filenames in the FLOPPY directory are listed.

The REMOTE, REMOTE2 and IMPORT directories are designed for interfacing to a database host computer, for example, a KLA Tencor Quest system. Some host computers require two directories for file transfer. In this case the KLA Tencor CRS receives a map file in the IMPORT directory and sends the reviewed map file back to the host computer in the REMOTE directory. Other host computers need only one directory for both sending and receiving, and this directory is usually located in the host computer and accessed from the KLA Tencor CRS as the REMOTE directory. Generally, the IMPORT and REMOTE directories list only those filenames that match the file type selected. If the wafer map type is selected, however, all filenames in the IMPORT, REMOTE or REMOTE2 directory are listed. (As part of the installation, the REMOTE, REMOTE2 and IMPORT directories are configured to the correct network addresses.)

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File Types

File types can be distinguished by a three letter extension appended to the filename. The file extensions and their associated file types are listed in Table 5-6.

Table 5-6 File Extensions

Extension	File Type	Description
.bmp .rgb	Bitmap file	A captured image file using SGI RGB format.
.cod	Defect code file	Stores defect codes and their descriptions
.map	Wafer map file	Describes a wafer and its associated defects
.rcp	Recipe file	User-defined system settings
.sur	Surface file	A KLA Tencor CRS image file of the 3D surface.
.tif	TIFF file	A captured image file using TIFF format
.vol	Volume file	A KLA Tencor CRS image file of the volume scan

Bitmap Files

Bitmap images can be loaded and displayed in the library window. These are intended as reference images for defect classification.

A bitmap is any image file that describes the state of every pixel on the display screen at a given moment. There are many different bitmap formats. On the KLA Tencor CRS, bitmap images with a .bmp or .rgb extension are stored in SGI's RGB format; bitmap images with a .tif extension are stored in TIFF format.

Defect Code Table Files

The user-defined descriptions of defect codes are stored in Defect Code Table files. You can edit, create, save and load these files.

Wafer Map Files

A wafer map file contains information about an entire lot of wafers. Generally a wafer map file can handle a lot of two cassettes, and each cassette can have up to 25 wafers. The KLA Tencor CRS supports many standard wafer map formats, including Tencor File Format (.tff) and KLA Results File Format (.map or .001). Typical contents of wafer map files are described in Table 5-7.

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Table 5-7 Contents of Wafer Map Files

Information	Description
Defect information	Each defect is specified in defect size (KLA), intensity (Tencor), location, and classification code (initially 0, unclassified). Defect information is displayed in text format in the defect list pane and graphically in the wafer map pane.
Wafer information	Wafer size, die size, flat orientation and deskew points are displayed graphically in the wafer map pane.
Identification	Product ID, lot ID and process ID are displayed in the status pane.

Recipe Files

Recipe files are used to customize and automate many of the instrument's functions. By loading a properly specified recipe, you can set up the tool's scan parameters and defect sort criteria without any user input. When you log in, the system searches your directory for a recipe with your name. If the recipe is found, it is loaded automatically. The contents of the recipe are described in Table 5-8. Due to the complexity of these parameters, users with operator privileges cannot create recipes.

Table 5-8 Recipe File Contents

Information	Description
Defect Sort Criteria	Defects from a wafer map file can be filtered or sorted with a set of sort criterion so that only the desired defects are reviewed. The sort criterion can be specified in a recipe.
Laser scan parameters	Many of the optics parameters can be specified in the recipe. Configurable parameters include: camera intensity, laser intensity, number of slices, scan dimensions, laser scan xy resolution, laser line, sample thickness, laser display color option, stage autofocus intensities, and stage center offsets. The system is automatically configured when a recipe is loaded.
File Save Options	What type of image file to save with a defect map, where to store map files, and ADC image save options.
Deskew Options	For patterned and bare wafers. Type of deskew information, where stored, optical settings, wafer alignment.
ADC Parameters	See ADC manual.

Surface and Volume Files

The basic image from laser scanning is a two-dimensional image at the focal plane. A volume data set is a series of 2D images taken at regular vertical intervals (or slices). From the volume data set, the system constructs a 3D image of the surface.

The KLA Tencor CRS allows you to view, manipulate, and store the surface as well as the volume data sets. The volume data set size is large (512 by 512 by 64 slices equals 16 megabytes), and the

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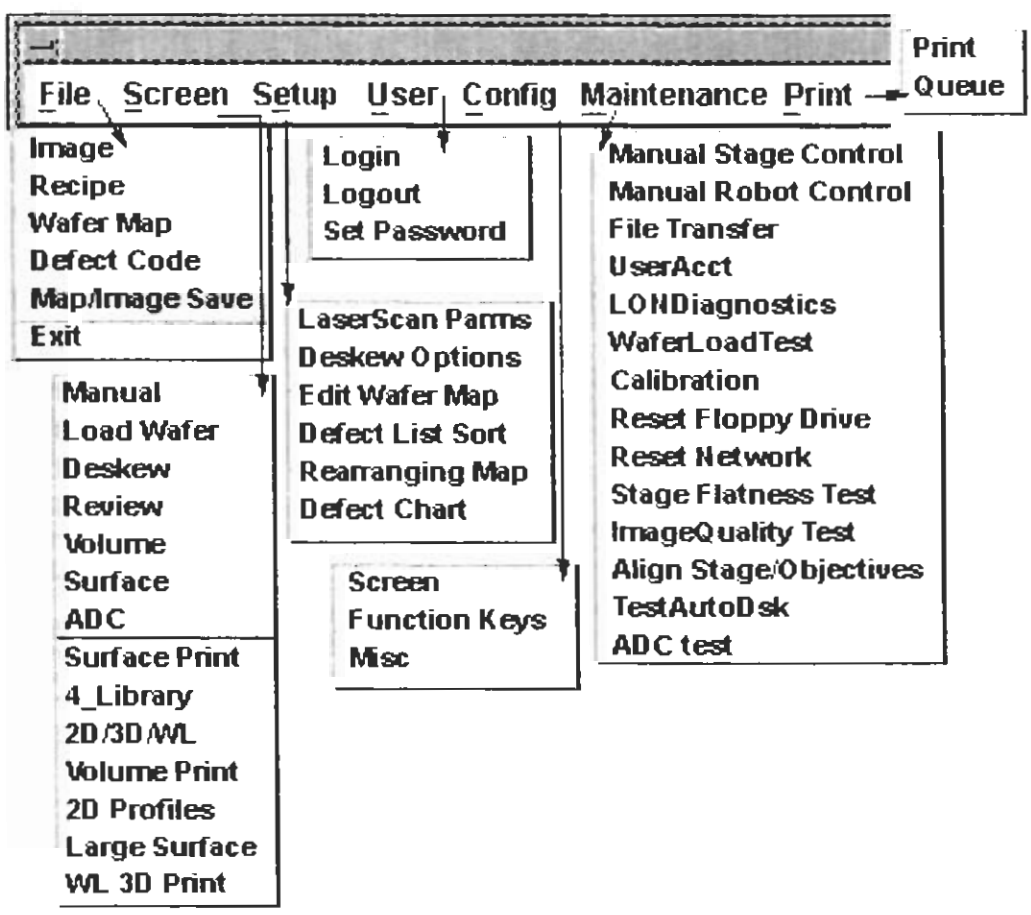
corresponding surface data is much smaller (512 by 512 by 2 bytes = 512 kilobytes). Both volume and surface files are stored with their history records: date and time of image, wafer map used, operator, product ID, wafer slot, wavelength, and defect number.

If you load the image file from the top menu bar, the associated wafer map is also loaded. Note that you must first unload the wafer from the stage in order to load an image file from the top menu bar. Loading images into individual 2D or 3D panes does not update the wafer map, nor does it require removing the wafer from the stage.

Menus

Fig. 5-4 shows the contents of each of the menus in the CRS software, version 2.4. The options on the **Screen** menu change the contents of the main application screen. Other menu selections bring up smaller windows with further options, in many cases including further menus to select from.

Figure 5-4 CRS Menus



Maintenance/UserAcct and **Maintenance/Calibration** are accessible only from accounts with Service privilege. shows the commands available to Administrator accounts but not to Operators. The rest are available to all users, whether Operator, Administrator, or Service.

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Table 5-9 Menu Functions Requiring Administrator Privilege

Menu	Function
File	Exit
Setup	Laser Scan Parameters
	Edit Wafer Map
Config	Function Keys
	Miscellaneous
Maintenance	Manual Stage Control
	Manual Robot Control
	File Transfer
	LON Diagnostics
	Wafer Load Test
	Stage Flatness Test
	Image Quality Test
	Align Stage with Objectives
	Test AutoDeskew
	ADC Test

Clicking on a menu name in the menu bar at the top of the application window opens the menu. It is not necessary to hold down the mouse button while making a selection. The user can click on a menu name and release the mouse button before moving to make a selection, or clicking elsewhere to close the menu. The alternative is to click on the menu name and drag to the desired selection. Releasing the mouse button while pointing to a menu option activates the option. Dragging the mouse off the menu and releasing the mouse button closes the menu without making a selection. Dragging to a different menu name closes the first menn and opens the new one.

There are also keyboard commands for selecting menu items. The key to use for each selection is shown by an underlined letter in the command name, for example, the F key for the File menu. In this manual the keyboard alternates are shown in both menu illustrations and in using menu and menu item names in headings.

When a menu is open, pressing a letter key which does not stand for a command on that menu but does stand for another menu switches to that menu. For example, with the **File** menu open, the U key switches to the **User** menu.

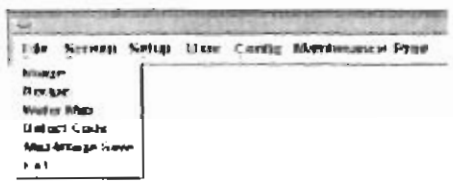
File Menu

Fig. 5-5 shows the File menu, which contains commands for loading and saving files of several types, and also the Exit command for terminating the CRS application. Each file type has a different set of options, accessed from buttons or menus on the right hand side of the dialogue box. Except for

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image files, there are editing functions and a button for saving the edited file in each file dialogue box.

Figure 5-5 File Menu

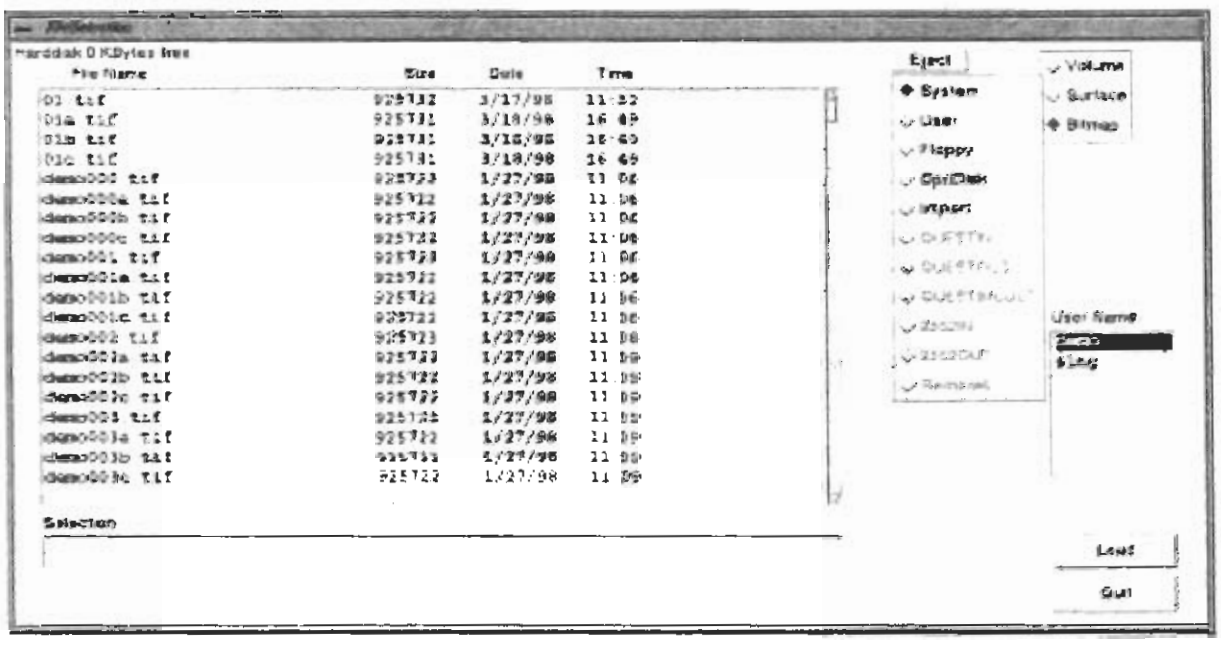


In each file dialogue box, the user selects radio buttons for file type and location. Authorized users (those with an Administrator or Service account) can select from a menu of user accounts when accessing user directories. A user with an Operator account can access the user directory for that account, but not for any other. Files of the specified type are listed in the main scrolling pane, along with size, date, and time for each file. The user can select a file with the mouse or type a name in the text entry box at the bottom. Double-clicking on a file name, or selecting a file and then clicking on the Load button, loads the image file into the designated pane or panes.

Image File Selection

The Image File dialogue box shown in Fig. 5-6 contains navigation and selection controls for loading volume, surface and bitmap files from the directories accessible from the application.

Figure 5-6 Image File Dialogue Box

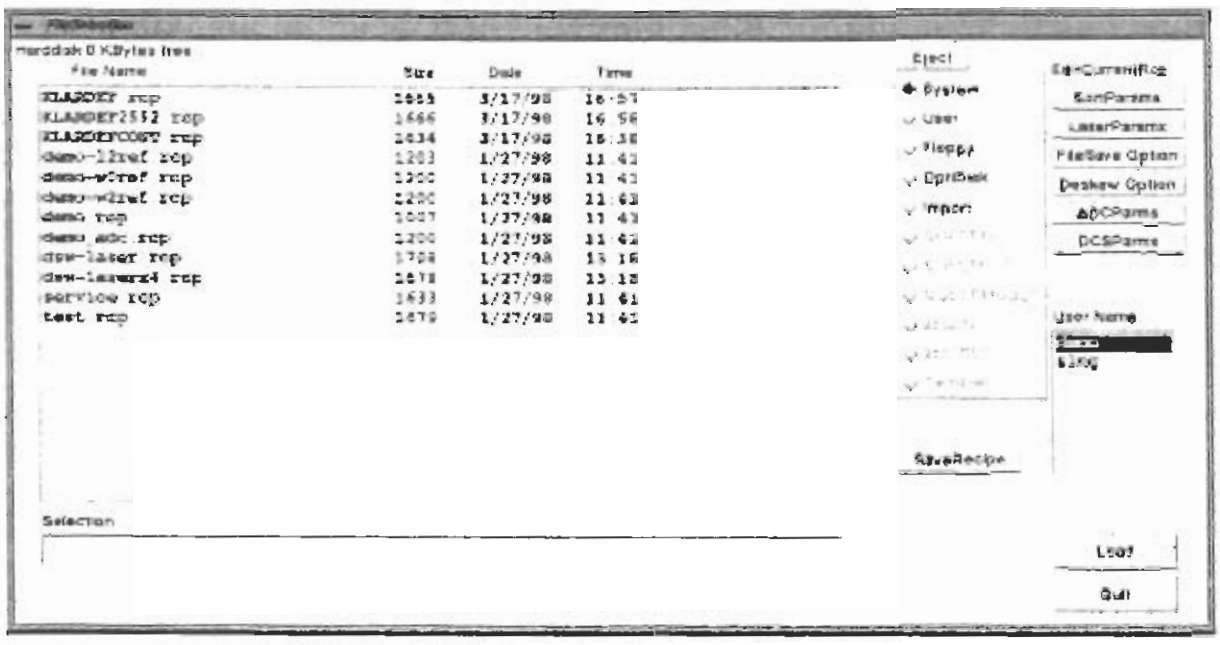


Recipe File Selection

In addition to loading and saving recipe files, the file dialogue for recipe files in Fig. 5-7 includes extensive options for editing the recipe parameters. The buttons at the right bring up windows for editing sort criteria, laser settings, file saving options, and deskew parameters. After a recipe has been edited and saved, it must be reloaded to take effect.

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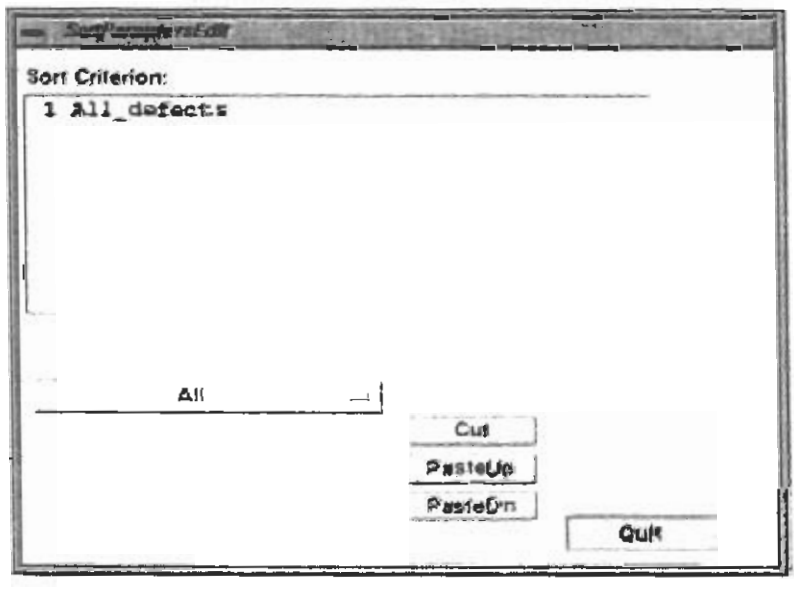
Figure 5-7 Recipe File Dialogue Box



SortParams

Fig. 5-8 shows the default state of the sort parameters, with All Defects included as the sole criterion shown in the list.

Figure 5-8 Sort Parameters Window



The menu at the bottom left of this window offers the selection and sort criteria listed in Table 5-10, with the option to include or exclude defects by each selection criterion. Clicking on a criterion from the menu brings up its parameter entry fields, and for selection criteria other than **All**, the

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Include/Exclude button. There should be at least one selection criterion, usually **All**. If no sort criterion is specified, **Sort DefNum MinMax** is the default. Selecting a criterion in the list at the top and clicking on the ***Cut*** button removes that criterion.

Table 5-10 Defect Sort Criteria

Criterion	Parameters	Comments
All		Select
First N	N	Select N
Random N	N	Select N
XSize	Min, Max	Select range
YSize	Min, Max	Select range
Intensity	Min, Max	Select range. For Tencor maps
DefectCode	Min, Max	Select range. Can be used more than once
X Location	Min, Max	Select range
Y Location	Min, Max	Select range
Every N	N	Select at intervals of N
Min Separation	N	Select by distance between defects
Edge Exclusion	Min, Max	Select by distance from the wafer edge.
Sort Size MinMax		Sort in ascending order by defect size
Sort Size MaxMin		Sort in descending order by defect size
Sort Defnum MinMax		Sort in ascending order by defect number
Sort Defnum MaxMin		Sort in descending order by defect number
Random Percent	N	Select N%.
N per Cluster	N	Select N times number of clusters
ADC Code		Select (see ADC manual)

Some of these criteria naturally go together, like **XSize** and **YSize** or **X Location** and **Y Location**. Others are mutually exclusive, like **Sort Size MinMax** and **Sort Size MaxMin**. The software will allow you to choose any combination, even if it doesn't make sense, and even if it results in no defects being selected. When selecting, the software simply goes through and applies the criteria in order. This flexibility is allowed so that various useful combinations can be made. For example, the sort criteria

```
1 Sort_DefNum_Max_Min
2 First_N: N=50, Included
3 Sort_DefNum_Min_Max
```

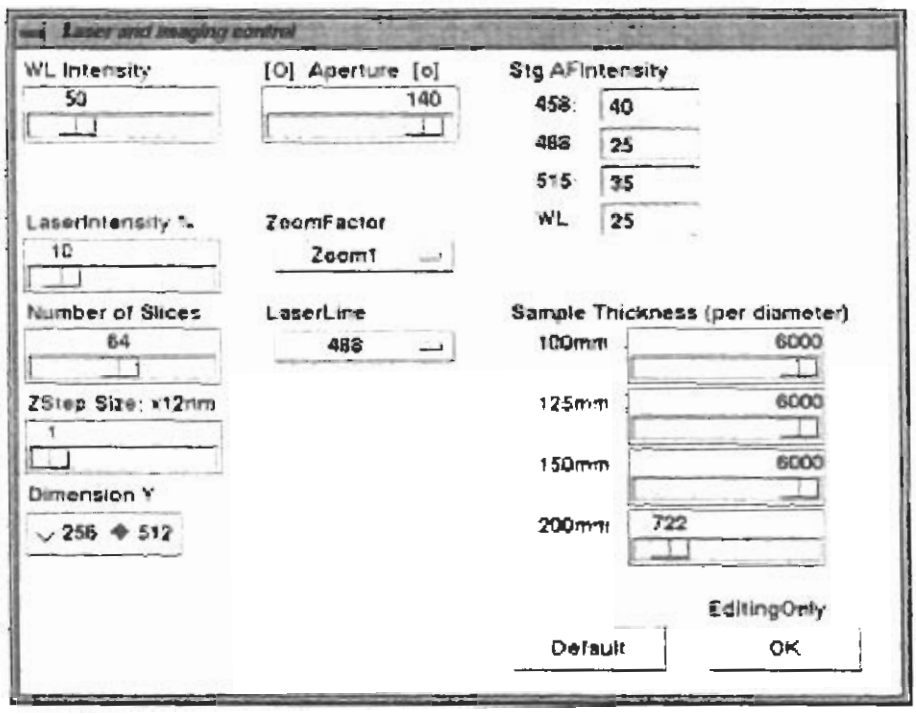
result in selecting the last 50 defects and showing them in ascending numeric order when the recipe is saved and reloaded. Many other combinations are useful, such as selecting the N largest or smallest defects.

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LaserParams

The ***LaserParams*** button brings up the **Laser and Imaging control** window shown in Fig. 5-9. It contains controls for laser and white light image settings, and also wafer thickness.

Figure 5-9 Recipe Laser and Imaging Control Window



The ***White Light Intensity*** slider bar goes from 0 to 255, with a corresponding change in the range of white light power. The ***Aperture*** slider bar goes from 0 (wide open) to 150 (minimum aperture). It is active only on systems with ADC. Reducing the aperture size by increasing this setting can improve resolution in some circumstances. The ***LaserIntensity %*** slider bar sets the light sensor gain, rather than changing the laser output. Nevertheless, it has the expected result, that increasing this setting makes the image brighter. The ***Number of Slices*** slider bar for 3D images can be set from 1 to 128, but should not normally be changed from 64. The ***ZStepSize*** slider bar sets the number of 12 nm steps between slices in a 3D image. It is normally calculated by the system, not set manually. It is possible to change the ***Dimension Y*** value with the ***256*** radio button, but not recommended.

There are two option menus in this window, for the default ***ZoomFactor***, with choices

- **Zoom1**
- **Zoom2**
- **Zoom4**
- **Zoom8**

and for the default ***LaserLine*** selection, which can be set to any one of the three available lines or all three in combination, with the choices

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- 458
- 488
- 515
- ALL

The ***StageAF Intensity*** entry boxes set the laser light sensor gain for autofocus operations. This should be checked by service engineers and not changed by users.

The ***Sample Thickness (per diameter)*** sliders are normally set for the standard wafer thicknesses used in a fab. These settings determine the minimum spacing between the stage and the microscope objective, and must be at least the thickness of any object placed on the stage. For any diameter of wafer not used at the site of the CRS, the sliders can be left at 6000. Setting wafer thickness correctly is critical. If the number entered is too small, the high power objectives can crash into the wafer surface, damaging the microscope and the XYZ stage in addition to breaking the wafer. The standard values for wafer thicknesses recommended by Sematech are shown in Table 5-11, but there is great variation in the industry. For example, 150mm diameter wafers range in thickness from from 600–800 µ and beyond. If there is any doubt about the thickness of the wafers you are using, ask.

Table 5-11 Standard Wafer Thicknesses

Diameter	Thickness
100 mm	550
125 mm	625
150 mm	625 or 675
200 mm	725

The ***Default*** button sets the current values as the new defaults. When the settings have been adjusted as desired, clicking on the ***OK*** button will exit the window, returning to the recipe file window.

Map/Image Save Options

Fig. 5-10 shows the options that can be set in a recipe for saving defect map and image files. In normal use, defect maps are loaded automatically along with the wafer from one directory used for importing files from another instrument. When the wafer has been reviewed and the defects classified, the defect map should be saved automatically in a different directory, where it can be retrieved for analysis. This arrangement prevents confusion between maps that have and have not been reviewed. However, an application engineer can set up the recipe to save map files in any directory accessible from the application.

The ***Bitmap Image Directory*** option menu has the two choices

- Same as map file
- Explicit

The ***Map Image Save Options*** button brings up the window shown in Fig. 5-11, which is also accessible directly from the **File** menu. The window contains three sets of radio buttons.

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Figure 5-10 Recipe Map/Image Save Options Window

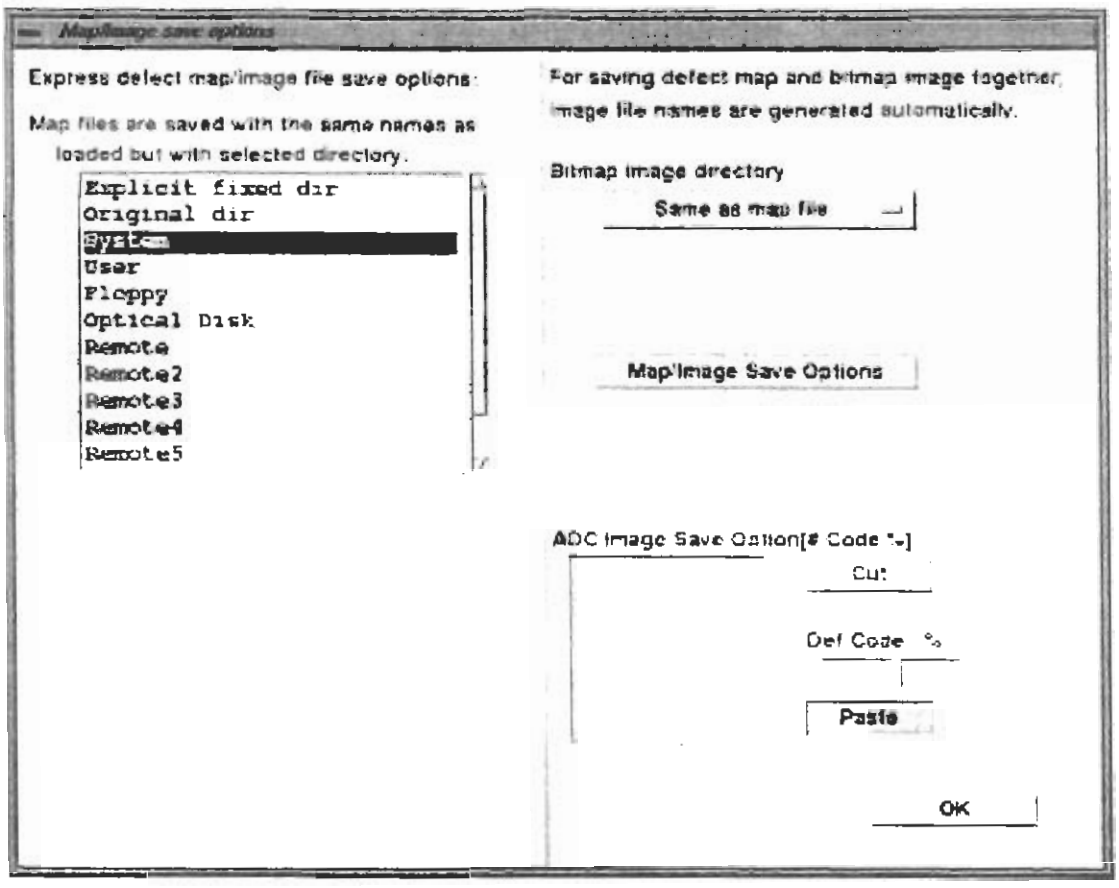


Figure 5-11 Recipe Map Image Save Window

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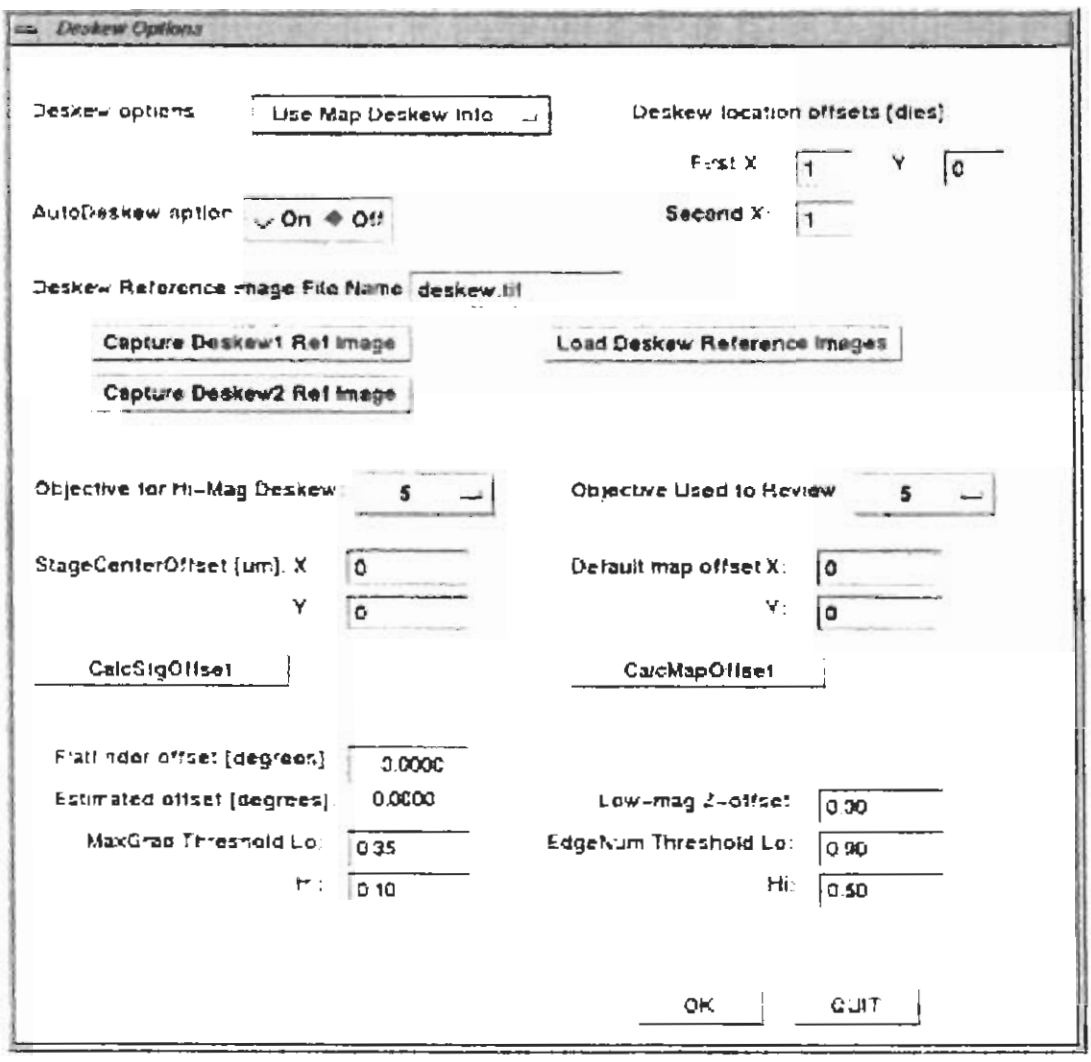
Either or both of the defect map and image can be saved, in either TIFF or JPEG graphics file format. There are nine choices for the image source, including three for white light images, and a selection of laser images and 3D slices. The entire screen, including all of the visible panes, can be saved in a single file. Dentech-compatible data can also be saved. The ***OK*** button saves the user's choices, and the ***Quit*** button discards them.

Deskew Options

Fig. 5-12shows the Deskew Options window for setting parameters in the recipe. The ***Deskew Options*** option menu at the top left of this window gives the choices

- ***Use Map Deskew Info***
- ***Defects as Deskew Pts***

Figure 5-12 Recipe Deskew Options Window



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The first is used for patterned wafers, where a die corner or some other fabricated feature is the natural choice for a deskew point. The second is for bare wafers, which have no features other than defects.

A number of functions in this window are for setting up for automatic deskewing. The deskew process and the steps in setting up AudoDeskew are described in Chapter 4, "Auto Deskew." The ***AutoDeskew Option*** radio buttons turn AutoDeskew on and off on systems where it has been installed. Switching off AutoDeskew leaves all of the parameters in place, so that doing an occasional manual deskew does not disturb the AutoDeskew setup.

The ***Deskew Location Offsets [dies]:*** entry fields can be used in case a deskew die near the edge of the wafer is missing on some wafers. The CRS moves inward from the edge by a multiple of a known die dimension, to bring the same feature on a different die under the microscope. These offsets can be programmed in the ***First X:*** and ***Second X:*** entry fields for the left and right edges of the wafer respectively, and the ***Y:*** entry field in case a Y offset is needed also.

The ***Deskew Reference Image File Name*** entry field contains a file name which is used as the starting point for generating the names for the four image files used in the autodeskew process. In this case the files would be deskew1lo.tff, deskew1hi.tff, deskew2lo.tff, and deskew2hi.tff.

The ***Capture Deskew Ref Image*** buttons each start the process of capturing a low-resolution and high-resolution image of the currently selected point. Low resolution is 5, and high resolution is set by the user on the ***Objective for Hi-Mag Deskew:*** option menu. When autodeskew is completed, the CRS switches to the magnification specified on the ***Objective Used to Review*** option menu.

The ***Load Deskew Reference Images*** button brings the four captured reference images (two per point) into memory.

The ***StageCenterOffset [um], X:*** and ***Y:*** entry fields allow manual entry of a stage offset in both X and Y directions, but normally these numbers are calculated and displayed here by the CRS software. After the CRS displays a deskew point, the user centers it, and then presses the ***Calc-StgOffset*** button to get a display of the X and Y distances which the stage has moved.

The ***Default Map Offset X:*** and ***Y:*** entry fields .

The ***CalcMapOffset*** button is used after a deskew. The user centers a defect in the image pane, then clicks on this button. The numbers displayed can be entered into the ***Default Map Offset*** fields. Usually several such measurements should be made, and an average taken.

The ***Flatfinder Offset [degrees]:*** entry field specifies a rotation, normally less than 0.5°, to be applied in the software to correct for positioning errors in the prealigner. This value can be taken from the ***Estimated Offset [degrees]*** value, which shows the rotation calculated in the CRS software from the deskew results.

The ***MaxGrad Threshold Lo:*** and ***Hi:*** entry fields are used for ADC, and are normally left at the factory-set values, as are the ***Low-mag Z-offset*** entry field and the ***EdgeNum Threshold Lo:***, ***High:*** entry fields. See the ADC manual for further information.

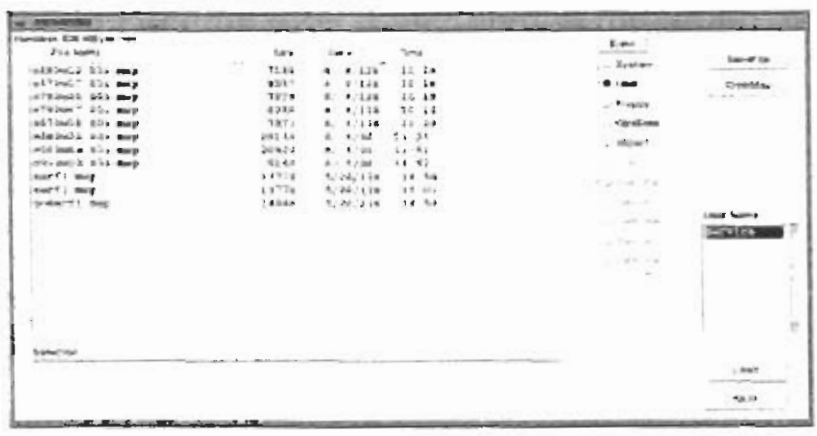
As usual, the ***OK*** button accepts the entered values, and exits the ***Deskew Options*** window, while the ***Quit*** button discards any changes and exits.

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WaferMap

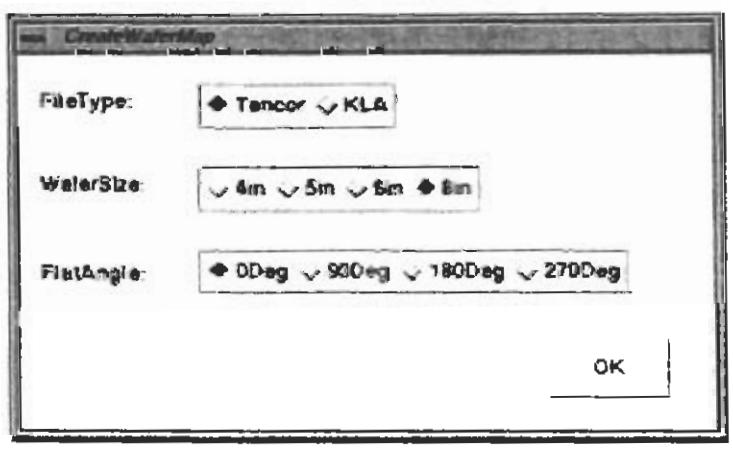
The ***FileSelection*** window in Fig. 5-13 allows the user to select a map file to load, and to save the current wafer map. There is also a button to clear the current map, in order to create and save a new, empty map file.

Figure 5-13 MapFile Window



Clicking on the **ClearMap** button brings up the window in , with three sets of radio buttons for choosing the map file format, wafer size, and wafer alignment. After making these selections and clicking on the ***OK*** button, the user returns to the ***MapFile*** window, where the new map can be saved. It is a good idea to save a newly created map at this point, and then save again after editing other map data.

Figure 5-14 Create Wafer Map Window

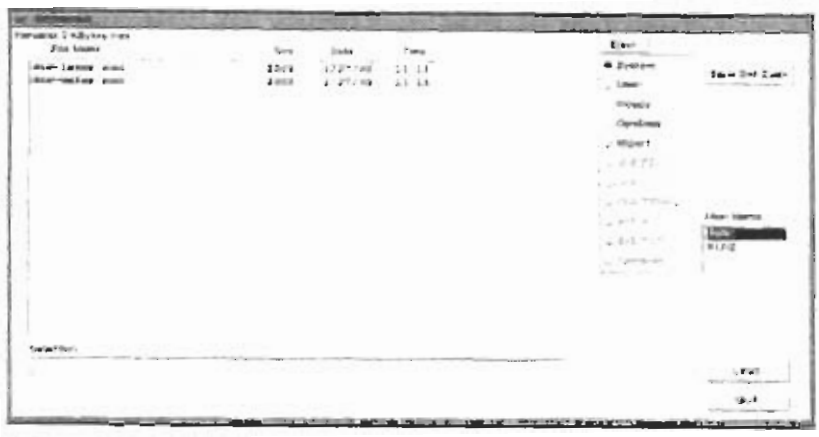


Defect Code (DefectCodeTable)

The file dialogue for defect code files in Fig. 5-15 provides for loading and saving defect code files, containing the number and name of each defect type.

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Figure 5-15 Defect Code File Window



Map/Image Save

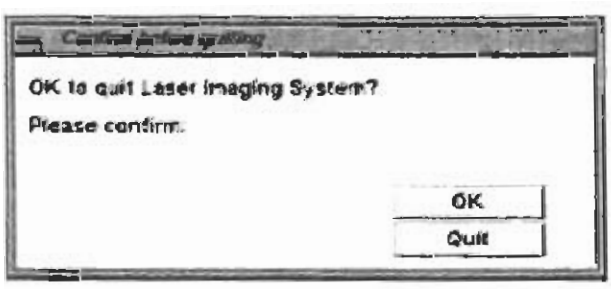
Next on the **File** menu, the ***Map/Image Save Options*** window is also accessible from the Map/Image Save window in Fig. 5-10 on page 93 lets the user select whether to save the defect map and image seperately or together, in either TIFF or JPEG format, with a variety of image options.

There are three choices of resolution for white light images. Options can be set for saving images in a specific window, or for the entire screen including laser, white light, 2D and 3D panes.

Exit

The last item on the **File** menu is **Exit**, with the window in Fig. 5-16. Clicking on ***OK*** quits the application. Clicking on ***Quit*** cancels the function and returns to the application. This is consistent with the effect of the ***Quit*** button in other windows, but can be confusing in this case.

Figure 5-16 Exit Window



Screen Menu

The Screen menu shown in Fig. 5-17 lists all of the available screen layouts for various purposes, including those defined as part of the software system, and also whatever other user-defined layouts have been created using the Screen editor on the **Config** menu.

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Figure 5-17 Screen Menu



The screen layouts above the bar in the middle of the menu are system screens. The first four, Manual, Load Wafer, Deskew, and Review, are invoked automatically in sequence by the software when an operator logs in, and the load, deskew, review sequence is repeated for each wafer when it is loaded. The other screens are available to the user for acquiring and viewing images, and reviewing saved images. ADC (Automatic Defect Classification) is described in a separate manual.

The screens listed below the bar are user screens, which vary from one system to another. The **Screens** command on the **Config** menu allows these screens to be edited, and new user screens to be defined. Several layouts with different sizes, numbers, and arrangements of panes are provided, and within each arrangement, any of the available views and control windows can be placed. See the discussion of the **Config/Screen** command starting on page 143.

Window Panes

The screens are made up by inserting predefined panes into a predefined layout. The layout specifies the size and placement of each pane, and provides buttons for a selection of panes for insertion. This menu of panes is also part of the screen, allowing a user to move panes around during operation. The available panes are listed in Table 5-12.

The Defect Map pane contains a menu with eight selections, showing four versions of a zoom pane and the four color codes used in them. Likewise the Status pane has six options on its own menu.

Table 5-12 CRS Screen Panes

Pane name
DefMap (Defect Map)
Cassette
Status
SeqStat (Sequence Status)
µscope
Laser
2D
3D
ADC

The predefined System screens, which should not be changed, are

- Manual
- Load Wafer
- Deskew
- Review
- Volume
- Surface
- ADC

There are also several predefined user screens which users may rearrange to suit their convenience. These are

- Surface Print
- 4_Library
- 2D/3D/WL
- Volume Print
- 2D Profiles
- Large Surface

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In addition, users can create further layouts within the available templates at will.

Pane Sizes

All window pane types have three distinctive looks, depending on the size of the window, as described in Table 5-13.

Table 5-13 Window Sizes

Window Size	Description
Large	When the size is large enough to show the full functionality of the pane. Typically a large pane is wider than a third of the screen. All controls for a large pane are directly accessible.
Small	When a pane is large enough to show its major functions and a few controls but not large enough for full functionality. A small pane can allow access to its full range of functions indirectly through a control dialogue box.
Button	When a pane is less than 95 pixels wide, a button is displayed with the name of the pane on the button itself. To use the pane, the button must be swapped to a larger location.

Pane Swapping

All screens use the drag and drop method to swap between different panes. Click and hold the mouse on the swap button in one pane and drag it to another pane, then release the mouse button—the two panes interchange positions. The swap button in an active pane is labeled **L**. Inactive panes are shown an named swap buttons.

When switching screens, the contents of a screen's panes carry over to the next *if* there is a corresponding window type in the new screen. It is convenient, therefore, to have use screens containing the same number and types of windows whenever possible. For example, when you switch from a screen with two 2D windows to a different screen that also has two 2D windows, the data in those windows remains the same. If you switch from a screen with three 2D windows to a different screen that has two 2D windows, and switch back again, one of the three 2D window will have lost its image.

Global and Local Data

Operations originated from the top menu bar are global in nature; that is, they affect all windows. Operations originated from within a particular window affect that window only. For example, loading a surface file from the top menu puts the same surface on all 3D and 2D windows, as well as loading the wafer map file for that image. Loading a surface from within a 3D or 2D window updates the surface only in that window and does not update the wafer map.

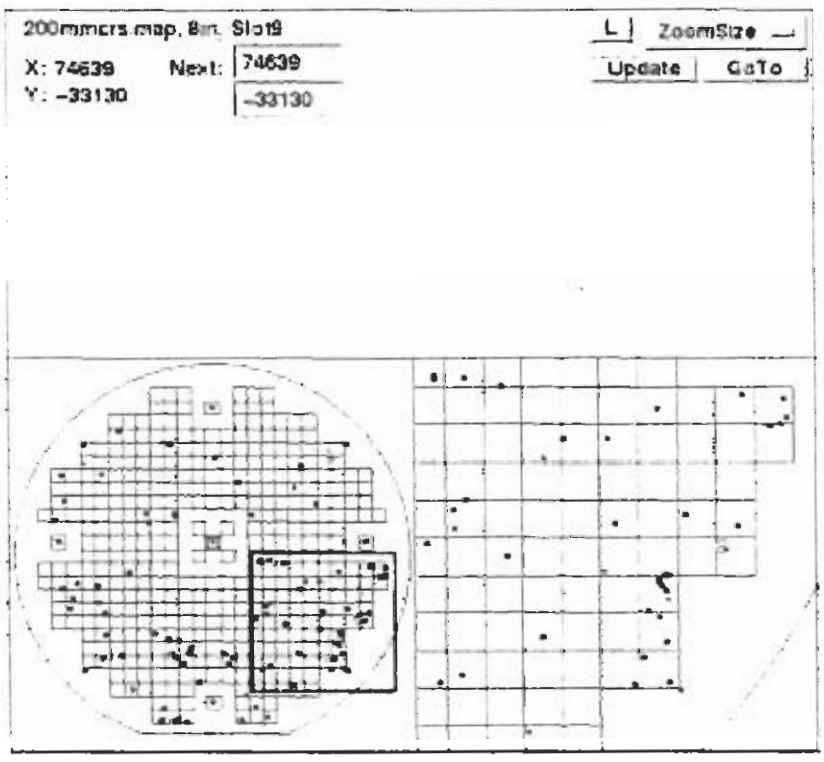
Volume data sets are generally large, and there is a limit of only one volume data set (file) loaded in the system memory at any one time. Therefore, loading a volume file from within a 2D window also updates all 2D windows.

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Defect Map Panes

Fig. 5-18 shows three panes which appear together in the Review screen to display the defect map created by an inspection tool for the currently loaded wafer or image. The three panes are described further in Table 5-14.The option menu in the top pane has eight options, four for different defect color codes, and four for the corresponding color palettes. These options are described below starting with "Wafer Map Zoom Views" on page 102. The lower left pane is a map of the entire wafer in its correct orientation showing the die boundaries, with defects displayed as colored dots. Within this pane is a zoom box that indicates the area to be shown magnified at the lower right. The user can move the zoom box by clicking and dragging on the upper left corner, and can resize the box by clicking and dragging on the lower right corner. As the box moves and changes size, the zoom pane updates continuously. The wafer map pane may also be used for moving about the wafer.

Figure 5-18 Defect Map Panes



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Table 5-14 Wafer Map Panes

Window element	Description
Full Wafer View	The primary view of the Wafer Map window is the left half that depicts the entire wafer. As mentioned above, this view shows all of the defects, all of the dice, and the entire wafer in its proper orientation.
Zoom Pane	The right half of the Wafer Map window is a magnified view of a portion of the wafer. The magnified portion corresponds to the blue zoom box that is depicted in the full wafer view. To move the magnified portion, click and hold on the upper left corner of the blue zoom box with the mouse. The zoom window automatically displays what is enclosed by the blue zoom box. The size of the blue zoom box can be varied to increase or decrease the amount of magnification. To change magnification, click and hold on the lower right corner of the blue zoom box with the mouse. The field of view automatically varies in proportion to your mouse movements.
Defect Colors	Defects in the wafer map appear in different colors. The colors represent different defect sizes (for KLA files) or different defect intensity values (for Tencor files). Defect colors are listed in Table 5-15. They can be viewed by selecting **PalettSize** from the wafer map option menu.
Cursors	There are two different types of cursors on the wafer map: the cross and the circle. The cross represents the current stage position. Note that if you use the joystick to move the stage, the cross does *not* automatically update its position. To update the position, use the mouse to click anywhere in the wafer map window. The circle indicates the *next* position (desired position) of the stage if the operator were to click on the GoTo button.

Table 5-15 lists the colors used in the defect map panes together with the KLA and Tencor values that these colors represent in their respective map files.

NOTE: The KLA Area and Equivalent Length parameters do *not* correspond to specific Tencor intensities.

Table 5-15 KLA and Tencor Map Colors

Defect Color	KLA Area (μm^2)	KLA Equivalent Length (μm)	Tencor Intensity
Red	< 0.06	< 0.25	< 50
Orange	< 0.25	< 0.50	< 100

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Defect Color	KLA Area (μm^2)	KLA Equivalent Length (μm)	Tencor Intensity
Green	< 1.0	< 1.0	< 150
Blue	< 6.3	< 2.5	< 200
Navy	< 25	< 5.0	< 250
Purple	< 75	< 8.7	< 300
Gray	< 2500	< 50	< 350
Black	> 2500	> 50	> 350

Moving Around the Wafer Map Window

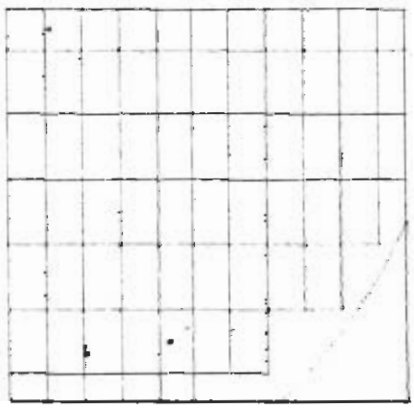
If you click on the wafer map, the stage moves to bring that point under the microscope. At the same time, the nearest defect is highlighted in the defect list. Click on ***GoTo Selected*** to view that defect. If you know the exact wafer coordinates of your destination, you can enter them manually in the text entry field labeled ***Next***. Enter the X- and Y-coordinates of your destination (in microns), and then click on the ***GoTo*** button. The stage moves to the exact coordinates that you specified.

Another useful feature is that the wafer map and the defect list are linked together. The defect list automatically highlights the defect closest to the current stage position after a move to anywhere on the wafer map, either by clicking with the mouse or by entering numerical coordinates. Clicking on the ***GoToSelected*** button in the defect list pane moves the stage to the exact defect position.

Wafer Map Zoom Views

Fig. 5-19 shows the zoom view brought up by the first option on the wafer map option menu, ZoomSize. It is a magnified portion of the wafer map, corresponding to the blue zoom box in the full view, with the same die boundaries, defect dots, and wafer border as in the full view. The defect colors indicate the size (KLA map) or intensity (Tencor map) of the defects.

Figure 5-19 ZoomSize Pane



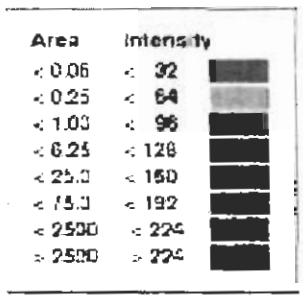
The next three options, ZoomStat, ZoomClus, and ZoomCurr, show the same maps in both the wafer map pane and zoom pane with different color codings, displayed in the following figures, which show the other four selections on the wafer map option menu.

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Wafer Map Palettes

Fig. 5-20 shows the four color palettes used for the wafer map display. The Size palette provides eight colors mapped to specific size ranges. The same eight colors can be used for distinguishing clusters of defects on the Cluster palette. The Class and Current palettes use only two colors, red and blue, to indicate either that defects are classified or not, or that they are in the current cluster or not.

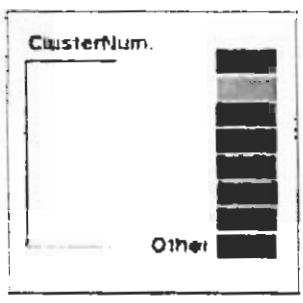
Figure 5-20 Color Palette Panes



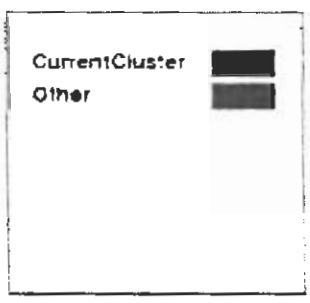
PalettSize Pane



PalettClas Pane



PalettClus Pane



PalettCurr Pane

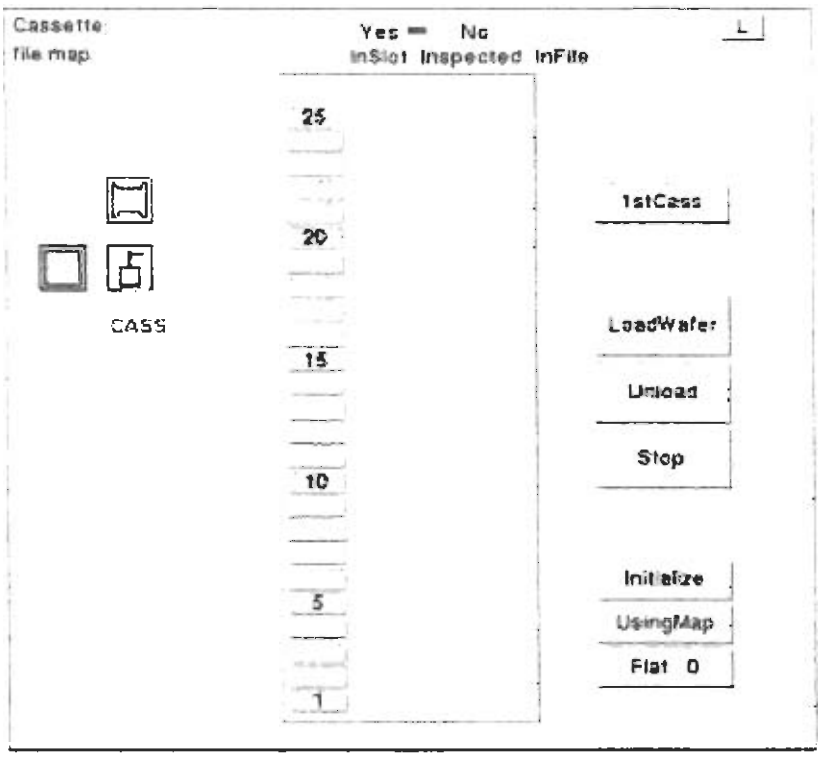
Cassette Pane

The ***Cassette*** pane shown in Fig. 5-21 provides controls for loading and unloading wafers, and indicates which wafers are present. At the left are icons representing the robot arm and the stations where it can pick up and place wafers: the cassette (CASS, at the bottom), the stage (square, left), the prealigner (I-shaped, top), and (if installed) the SMIF (right). During loading and unloading operations the current station is highlighted, and the robot icon changes when it picks up or places a wafer.

For each wafer slot, the display shows whether there is a wafer, whether it has been inspected, and whether there is a map for it. Users can remap the cassette, physically moving a wafer to a particular slot and dragging its representation on the screen to the same slot. The first step in loading a wafer is to click on its slot in the pane to select it.

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Figure 5-21 Cassette Pane



The buttons at the right of the cassette pane control the wafer loading and unloading process. Their names and functions are described in Table 5-16.

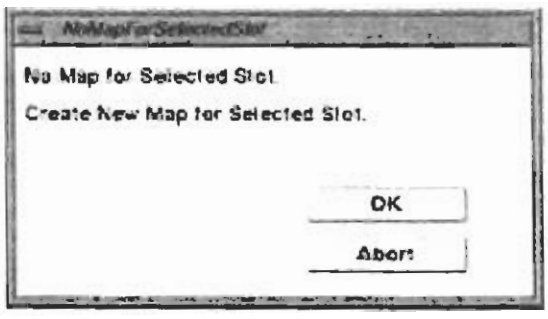
Table 5-16 Cassette Pane Controls

Button Label	Function
1st Cass	Switch between cassettes on cassette plate and SMIF
Load Wafer	Selected wafer is prealigned and then placed on the stage
Unload	Wafer is removed from stage and placed in its slot
Stop	Halt robot, in case of error
Initialize	Robot to home position
UsingMap	Normally on, this can be turned off to review a wafer without a map
Flat 0	The wafer flat or notch position can be set to 0° (down), 90° (left), 180° (up), or 270° (right)

Clicking on a cassette slot for which there is no wafer map brings up the dialogue box in Fig. 5-22, which asks whether to create a new wafer map. If you clicked on the slot in error, you can click on the ***Abort*** button to prevent creation of a new map. Clicking on ***OK*** creates an empty map, which can be edited in the ***Edit Wafer Map*** window, shown in Fig. 5-61 on page 137.

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Figure 5-22 No Map Dialogue Box



Status/Defect Pane

The status pane is usually displayed at small size. For two of its options, Status and Defect, the controls at the right side are cut off. To see these controls and make use of them, it is necessary to drag the pane to a larger display area. The following figures display the complete panes with all of their controls. There are six options for this pane, selected from the option menu at the top right. Table 5-17 lists them and their functions.

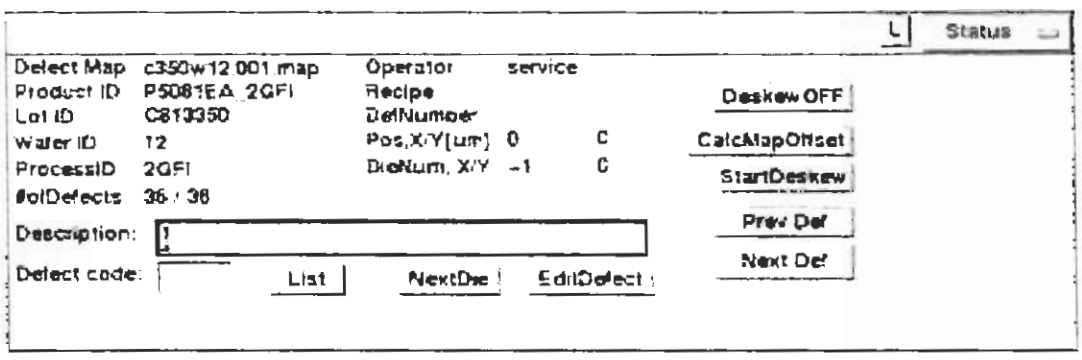
Table 5-17 Status/Defect Display Options

Option Name	Function
Status	Wafer data, controls for deskew and review
Deskew	Deskew point coordinates, stage offset, start deskew
DefList	Selected and sorted list of defects
DefCode	List of defect codes
Search	Search patterns
Stat	Abbreviated wafer data

Status Option

Fig. 5-23shows the status option of this pane. Much of this display is for wafer data, and the rest is controls for the deskew and review processes.

Figure 5-23 Status Pane



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Table 5-18 lists the controls and their functions for the Status Pane.

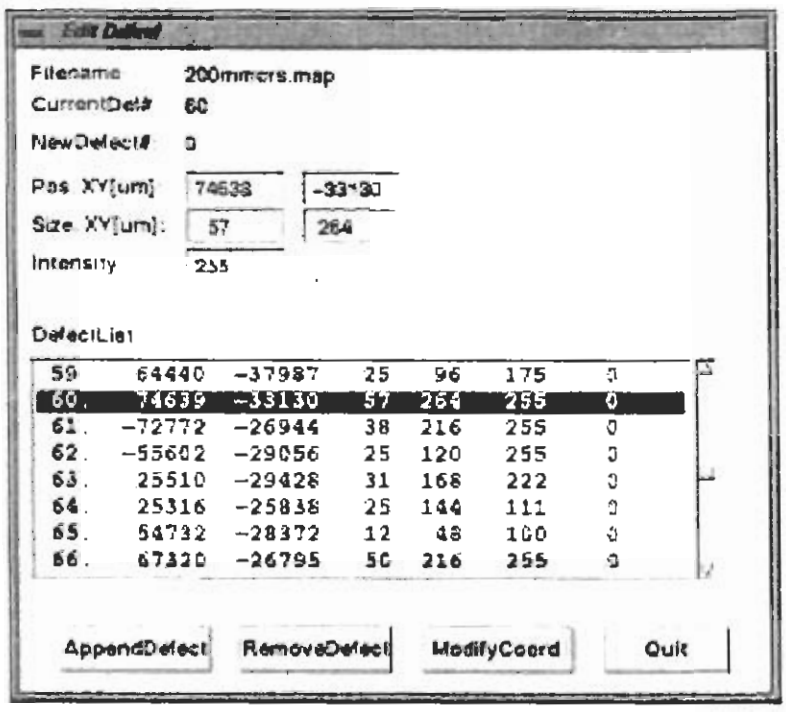
Table 5-18 Status Pane Functions

Function	Description
Start Deskew	Starts the deskew process. This button is not necessary when using sequence mode.
Deskew Off	Shuts off the deskew process and removes all coordinate offset data.
Calculate Map Offset	After deskew, you might find that the defects are continually offset from the center of the field of view by a repetitive amount. If this occurs, manually move the defect to the center of the field of view (via the joystick) and then click on the CalcMapOffset button. All defect positions now include the offset value.
Previous Defect/Next Defect	Move stage to the previous or next defect on the defect list. These buttons have been hard-coded into the rightmost keys of the numeric keypad for faster throughput. (See Fig. 5-2 on page 79.)
Edit Defect	Pops up a special window that enables you to add, modify, or delete defects in the defect list. (See Fig. 5-24.)
List	Brings up a new window that displays defect code numbers and their associated descriptions. These descriptions are defined in defect code files.

Fig. 5-24 is the Edit Defect window. The scrolling list tabulates the parameters of each defect. The information for the selected defect is copied to the data entry fields, where it can be modified. New defects can be appended, existing defects can be removed, and the coordinates of a defect (position, size, and intensity) can be changed, each with a button at the bottom of the window. This window is useful for creating wafer maps for testing purposes. Note that use of this function is an advanced operation. Please contact a KLA Tencor applications engineer for proper training.

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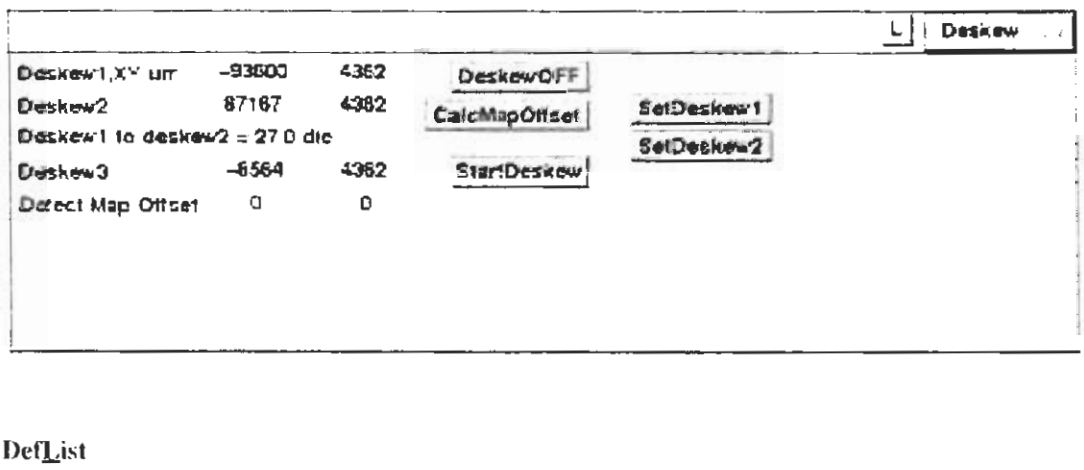
Figure 5-24 Edit Defect Window



Deskew Option

Fig. 5-25 is the deskew option of this pane. It has the same deskew controls as the Status pane plus two more, and displays the deskew data rather than the general wafer data. The two extra controls are for setting the coordinates for deskew points 1 and 2. At the left are the coordinates of the three deskew points, the number of die between points 1 and 2, and the map offsets. The lefthand column contains the X coordinates, and the righthand column the Y coordinates.

Figure 5-25 Deskew Pane



DefList

Defects are displayed in the format described in Table 5-19 for KLA maps with defect size data. The Xsz and Ysz columns are replaced by an Intensity column when reviewing Tencor maps.

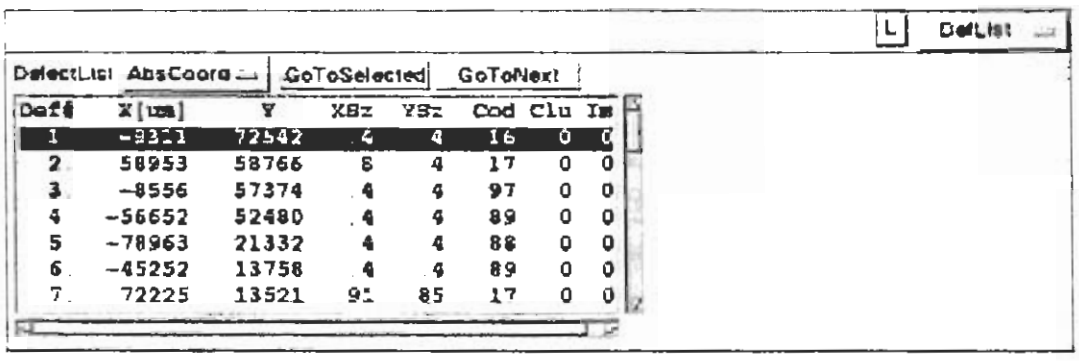
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Table 5-19 Defect List Format

Column Number	Data
Def#	Defect number
X [um]	Defect X position
Y	Defect Y position
Xsz	Defect X size
Ysz	Defect Y size
Cod	Defect classification code
Clu	Cluster
Im	Toggle between Image Auto Save and No Save

Fig. 5-26 is the **Defect List** pane, showing data for a number of defects as well as the headings for a KLA map.

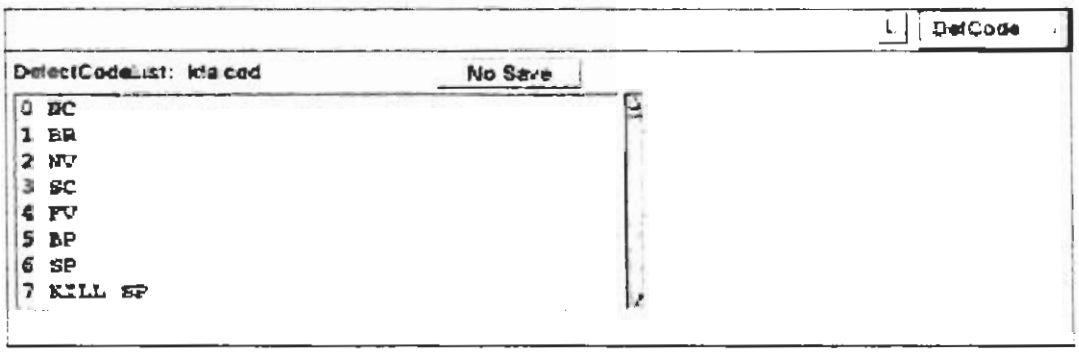
Figure 5-26 Defect List Pane



DefCode Pane

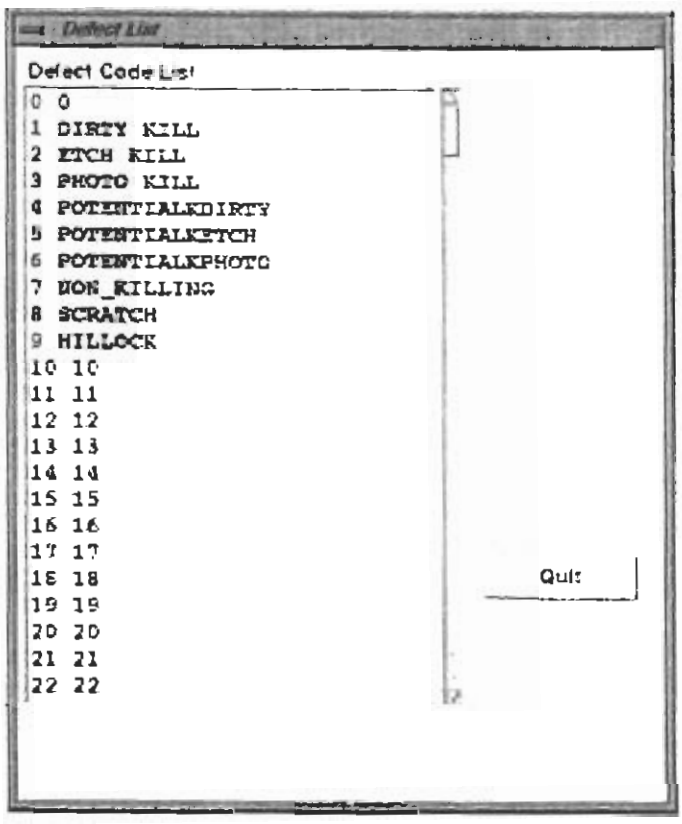
Fig. 5-27 is the Defect Code List pane with a list of abbreviated defect code names. The first item, code 0, is for Not Classified. A more understandable defect code list is shown in Fig. 5-28. The ***No Save*** button toggles between ***Image Auto Save*** or ***No Save***.

Figure 5-27 Defect Code List Pane



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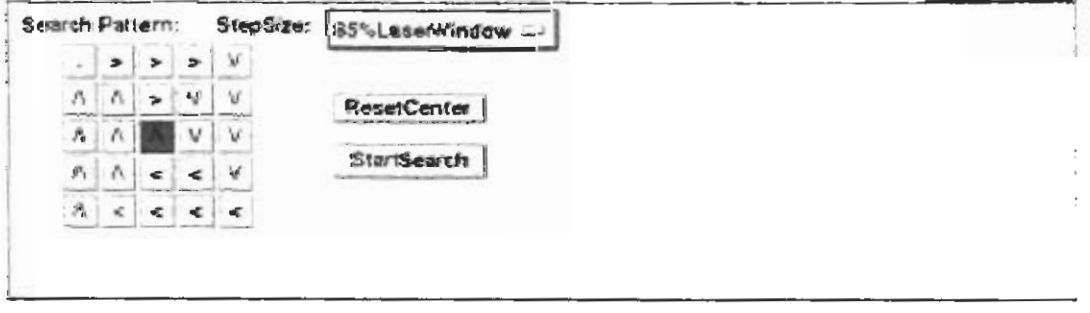
Figure 5-28 A Defect Code List



Search Pane

The Search pane (Fig. 5-29) is a convenient tool for searching systematically for a defect or deskew point that is outside the field of view, or for jumping from die to die. The benefit is that the sequential search pattern prevents the operator from unknowingly skipping an area, as is apt to occur when using a manual joystick. The ***StepSize*** option menu has two choices. The first, ***85%LaserWindow***, moves the stage by 85% of the current laser window width, taking into account the objective magnification as if the laser zoom were set to 1. The overlap between views guarantees complete coverage. The ***Reset Center*** button makes the current position the starting point for a new search pattern.

Figure 5-29 Search Pane

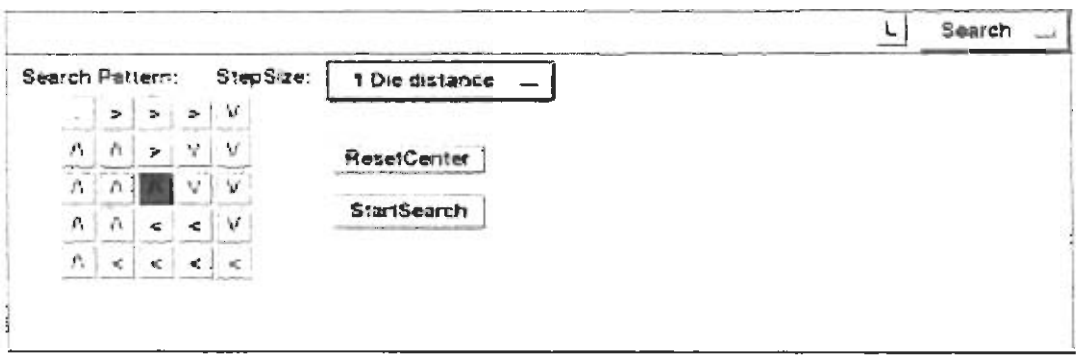


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Clicking on ***StartSearch*** jumps to the next area in the search pattern. The user can click on any square in the pattern and continue from there to the end of the pattern. If the user clicks and *holds* on the StartSearch button, the stage automatically advances after a time delay that is specified in ***Config-Misc***. The search pattern spirals outward, following the direction of the arrowheads in the squares of the pattern, and highlighting the current square at each step—starting in the center, and moving up, right, down, down, left, left, up, and so on. The pattern ends at the top left in the square with the dot. Clicking on StartSearch again from this square brings up the message, "End of search sequence. Reset center or move to another point."

By changing the step size from **85%LaserWindow** to **1 Die Distance**, as in (Fig. 5-30), this same utility may also be used to compare adjacent die, examining the same area, or even the same single feature, regardless of the magnification or zoom.. To jump to the adjacent right die, click on the square just to the right of the highlighted center square. Clicking on any square causes the stage to move to that position in multiple increments of the die pitch.

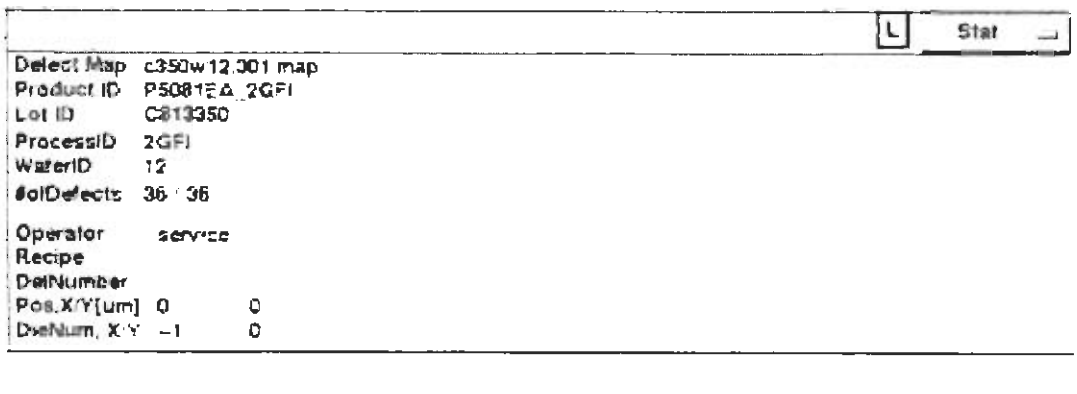
Figure 5-30 Die Jumping in Search Subwindow



Stat Pane

Fig. 5-31 shows the ***Stat*** pane, containing just the wafer data from the ***Status*** pane, without the controls.

Figure 5-31 Stat Pane



Sequence Panes

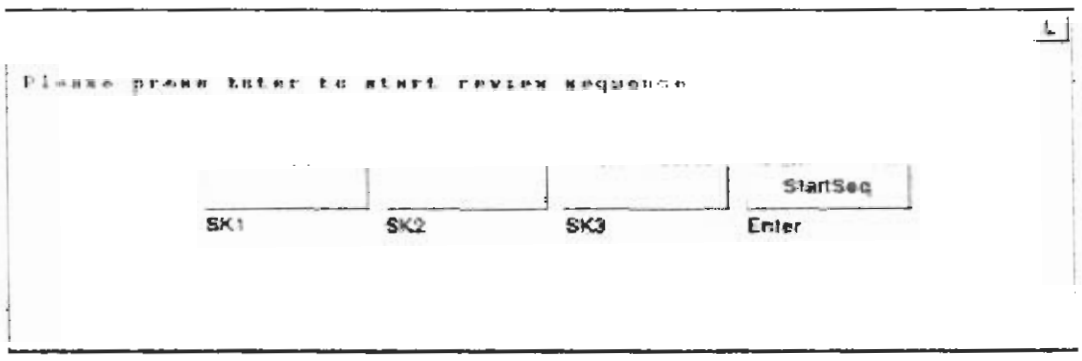
There is a sequence pane in each of the four standard screens, ***Manual***, ***Load Wafer***, ***Deskew***, and ***Review***, and a generic sequence pane in some other screens. Each of these panes shows the current functions of the three soft keys and the **Enter** key, together with an appropriate message. The

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Review screen also has an input field for a defect classification code. The generic sequence pane uses the Enter key to return to the ***Review*** screen.

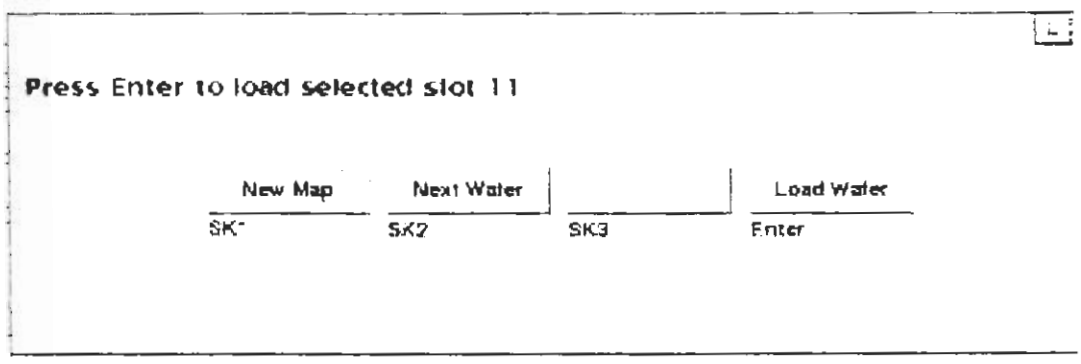
Fig. 5-32 is the ***Start Sequence*** pane, which appears in the ***Manual*** screen. This screen presents the controls for manual operation of the CRS, starting from the cassette pane, where the user may choose any wafer to load. The normal review sequence begins with the single control in the ***Start Sequence*** pane, which is the **Enter** key. Its function is to start the automatic review sequence, by going to the ***Load Wafer*** screen, where wafers will normally be loaded in numerical order by slot number.

Figure 5-32 Start Sequence Pane



There are three functions available in the Load Wafer pane in Fig. 5-33. The user can load a different map (**SK1**), skip to the next wafer (**SK2**), or load the currently selected wafer (**Enter**).

Figure 5-33 Load Wafer Sequence Pane



When the wafer is loaded, the software switches to the ***Deskew*** screen. The ***Deskew*** sequence pane in Fig. 5-34 provides functions for starting deskew over (**SK1**), skipping it (**SK2**), or continuing by accepting the current deskew point (**Enter**).

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Figure 5-34 Deskew Sequence Pane



When deskew is complete, the CRS is ready for defect classification. The Fig. 5-35 is the ***Classification*** sequence pane, which provides a data entry field for the defect code number, and soft keys to go to the ***Volume*** screen (**SK1**), the ***Surface*** screen (**SK2**), ***ADC*** (**SK3**, if ADC is installed), and ***Next Defect*** (**Enter**).

Figure 5-35 Classification Sequence Pane

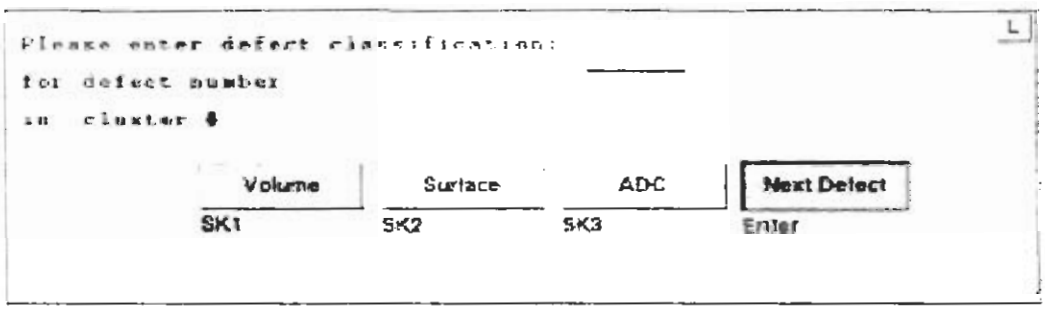
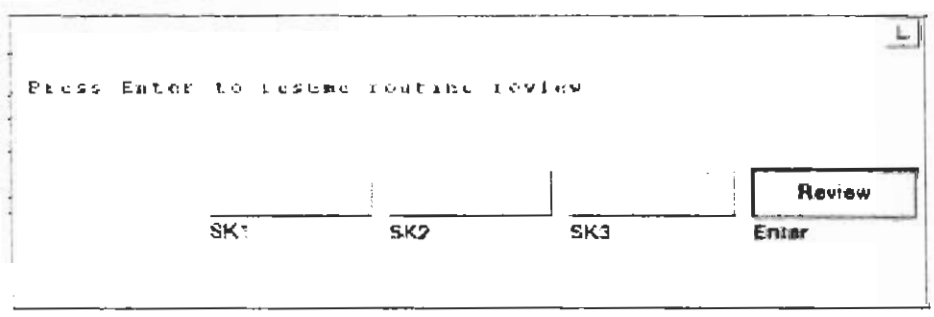


Fig. 5-36 is the sequence pane used in the ***Volume*** and ***Surface*** screens, with the single control to return to the ***Review*** screen (**Enter**) after examining the 3D images for more information about the current defect.

Figure 5-36 Return to Review Sequence Window



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Laser and White Light Controls

The controls described in Table 5-20 appear among the Laser Image Controls in Fig. 5-38 on page 115, but affect both laser imaging and white light imaging. Because they are used frequently, these functions are also accessible directly from the keyboard (Fig. 5-2 on page 79) for faster throughput.

Table 5-20 Mechanical Imaging Controls

Control	Keys	Description
Objective option menu	MAG↑, MAG↓	Several objective magnifications are displayed, depending on which have been installed. The full set is 5×, 20×, 50×, 100×, and 150×.
FineZ slider bar	Z↑, Z↓	The Fine Z stage is a precision piezo-driven stage capable of making 12 nm vertical steps. The maximum travel of the Fine Z stage is 50 µ. A vertical slider bar located in the upper right portion of the Laser Window indicates the current position in microns of the Fine Z stage, with a resolution of 0.01 µ. For finer control of the slider bar, use the mouse to click above or below the bar (in the channel). Each click of the mouse steps the stage in 0.1-µm increments.
FineAF button	FINE AF	Clicking on the FineAF button instructs the system to execute an autofocus routine. If a focus position exists within the range of the Fine Z stage, then the autofocus routine finds it. If the image does not come into focus after an autofocus command, then try the StageAF command.
CoarseAF button	COARSE AF	For large Z translations, there is also a coarse Z stage that allows for movements beyond the range of the Fine Z stage. Consequently, there is a coarse autofocus routine that finds focus positions outside the envelope of the Fine Z realm. To execute a coarse autofocus routine, click on the CoarseAF button (located just below the FineAF button). The system automatically finds the proper focus position. If, after a coarse autofocus command you find that the focus is good, but not great, try a subsequent click on the FineAF button.

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Control	Keys	Description
Focus Offset button	FOCUS OFFSET	The Focus Offset feature allows the user to add or subtract an offset value to or from the focus position that was calculated by the autofocus algorithm. This is useful when you wish to examine a specific layer of a multiple layer wafer. If you find that the layer of interest is consistently out of focus after pressing the **FineAF** button because an alternate layer is coming into focus, then you should use the Focus Offset feature. Use the **Z up/down** keys to bring your layer of interest into focus, then press the **Focus Offset** key. The system calculates the difference between the autofocus position and your new position, and subsequently adds that value every time the autofocus command is executed. No matter where you move to on the wafer, your chosen layer will appear in focus automatically.
Laser/WL Toggle	WL/ LASER	As discussed before, the **KLA Tencor** CRS is equipped with two modes of imaging: white light and laser confocal. The user has the choice of turning the laser image on or off. The white light image remains on at all times. The Laser/WL button (see) is a toggle switch that alternates between either white light mode only, or simultaneous laser and white light mode. It is apparent when you are in white light only mode because the laser window appears blank. Moreover, in white light mode, those control buttons that are dedicated to laser use are hidden from the screen.

In laser mode, when using laser lines other than 488 nm, the white light image has a yellowish tint to it. Do not be alarmed by the tint. A wideband yellow filter is automatically inserted in front of the CCD camera to prevent damage from the laser when either the 458 nm or 515 nm line is selected, or when all three lines are used simultaneously. The unit automatically removes the filter when white light only mode is selected, and uses a colorless notch filter when the 488 nm line is selected by itself. Earlier models did not have the notch filter, and used the yellow filter for all simultaneous laser/white light imaging. See "GEMINI Optics" on page 270 for more details.

Figure 5-37 White Light Image Controls



White Light Controls

Fig. 5-37 displays the white light imaging controls which appear on the screen under the laser image pane. White light intensity can be adjusted with a slider to improve contrast in some situations, but

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Figure 5-38 Laser Image Control Panel



in normal use the white light intensity is adjusted automatically for the current objective, or set by the recipe. The **WL Mode** option menu chooses between bright field and dark field illumination. Dark field is better for finding edges and particles, and is recommended for most defect classification. Systems with ADC have the ***Aperture*** slider activated for use under software control, and some other systems also have this option installed. Although the aperture can be set manually, this is not necessary for normal operation.

Laser Imaging Controls

The controls described in Table 5-21 and pictured in Fig. 5-38 allow adjustment of parameters in live laser imaging and for 3D laser image capture, but do not affect the white light image. The controls for surface, volume, and slice image manipulation are described starting in "Volume Screen" on page 130. If some of the laser imaging controls are not visible on the screen, the system is in white light viewing mode. The ***WL/Laser*** screen button or keyboard key toggles the laser view on and off. When the laser view is on, these extra controls appear.

The default laser line is 488 nm, which is appropriate for 95% of applications. There are circumstances where an alternative wavelength is more desirable, particularly for subsurface imaging, as described in Chapter 7, "Applications." Contact your ***KLA-Tencor*** applications engineer for more information.

Table 5-21 Laser Image Screen Controls

Control	Description
Objective option menu	Choose from up to five objective magnifications.
FineZ slider	Move the stage up and down within a range of 50 µ.
S, ***F***, and ***SetZ*** buttons	Set start position to current height, set finish position to current height, and calculate Z slice height from start and finish positions, rounded to a multiple of the 12 nm stage height step. If S and F are set to be the same, the start position is set to the S value, the Z step is set to 12 nm, and the finish position is calculated.
FineAF button	Fine AutoFocus
CoarseAF button	Coarse AutoFocus
WL/Laser button	Toggle laser image on or off

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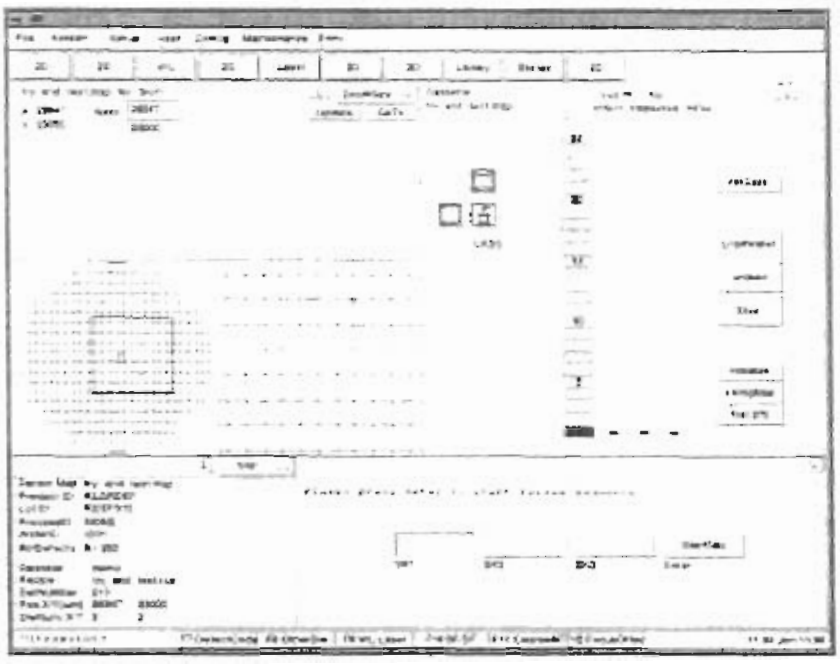
Control	Description
ImageAcq: ***Vol*** and ***Surf*** buttons	Capture volume or surface image
Laser Intensity slider	The ***laser intensity*** slider adjusts the illumination level of the laser image by changing the sensor gain rather than the light level. The brightest region in the image should be a bright golden yellow, verging on white. Any region that is white in color means that the laser photodetector is saturated. Photodetector Saturation Protector: When most of the image is white (oversaturated), the computer shuts the photodetector down and the image goes black. At the same time, the laser intensity slider bar turns red, as in Fig. 3-37 on page 52, warning that oversaturation has occurred. This prevents damage to the sensor. Lowering the laser intensity below the saturation level automatically brings the photodetector back on line.
Zoom button	The ***Zoom*** button cycles through four settings of the scan mirrors, giving 1×, 2×, 4×, and 8× magnification, and then returning to 1×. There is no effect on the white light image.
Laser Line option menu	The Argon ion laser has three lines: 458 nm, 488 nm, and 515 nm. In addition to the individual lines, there is the **ALL** option, which combines all three at the same time.
Pixels toggle button	Sets the horizontal resolution for 3D images to 512×512 or 256×256. Default is 512, which should normally not be changed.
Slices display	Displays the number of slices in 3D images. This value is set in the ***Laser Parameters*** window, accessed from the ***Recipe*** file window (see Table 5-8 on page 85 and Fig. 5-9 on page 91). The default value is 64. It can be set as high as 128, but should normally not be changed from the default.
StepSize display	Distance between image slices. A multiple of the 12 nm stage step size, with 12 nm as the minimum. Normally calculated by the software. This value is set in the ***Laser Parameters*** window, accessed from the ***Recipe*** file window (see Table 5-8 on page 85 and Fig. 5-9 on page 91). It should normally not be changed.

Unlike the white light image, the laser image has the benefit of zooming the magnification without changing the objectives. This is accomplished by varying the scan angle of the X and Y laser scanning mirrors. The **Zoom** key located just to the left of the numeric keypad has the same function as the on-screen ***Zoom*** button.

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Manual Screen

Figure 5-39 Manual Screen

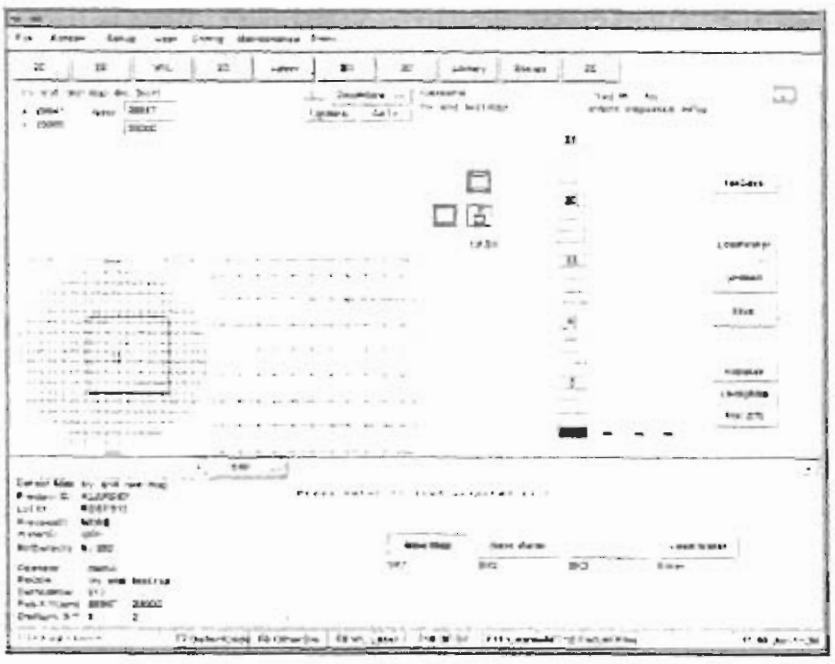


After logging in and initializing the hardware, the first screen the user sees is the starting screen for manual review, shown in Fig. 5-39. The bar of screen buttons for dragging to panes is at the top. The screen panes include a wafer map (middle and upper left, three panes), a cassette map (upper right), and the Stat pane (lower left). The Sequence pane at the bottom right has one active button, ***StartSeq***, linked to the **Enter** key, which invokes the ***Load Wafer*** screen to begin manual review. The user also has the option to make use of any functions of the software in addition to the preprogrammed review sequence which goes sequentially through the wafers in the cassette. The options include using any of the menu functions, rearranging panes on the screen by dragging or selecting from option menus, loading any wafer in the cassette, or switching cassette stations (if the SMIF is installed).

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Load Wafer Screen

Figure 5-40 Load Wafer Screen

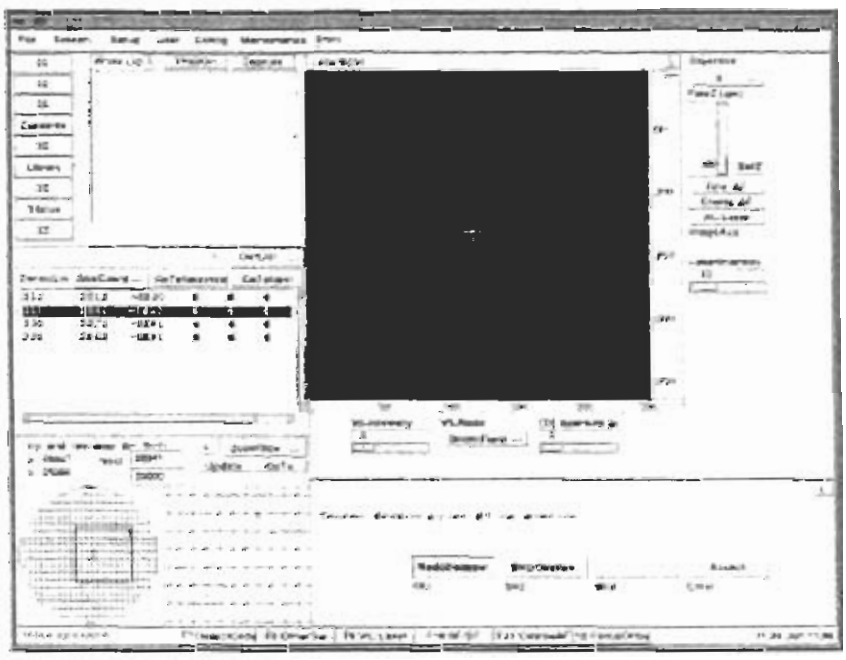


.The ***Load Wafer*** screen in Fig. 5-40 is identical to the ***Manual*** screen, except for the sequence pane. The soft keys load a new map, go to the next wafer (skipping the current selection), and load the selected wafer. After a wafer is loaded with the ***Load Wafer*** button or the **Enter** key, the ***Deskew*** screen appears.

In normal operation, when reviewing a cassette of wafers, the user will simply load the selected wafer at this point.For other purposes the full power of the CRS software is available from the menus.

Deskew Screen

Figure 5-41 Deskew Screen



The Deskew screen shown in Fig. 5-41 is quite different from the preceding screens. The screen button bar is at the left, rather than the top. There are two image panes at the top of the screen, a large laser image screen at the right, and a smaller white light image screen to its left. The white light image also appears on a separate monitor.

At the middle left is a list of defects, above the wafer map panes which include the

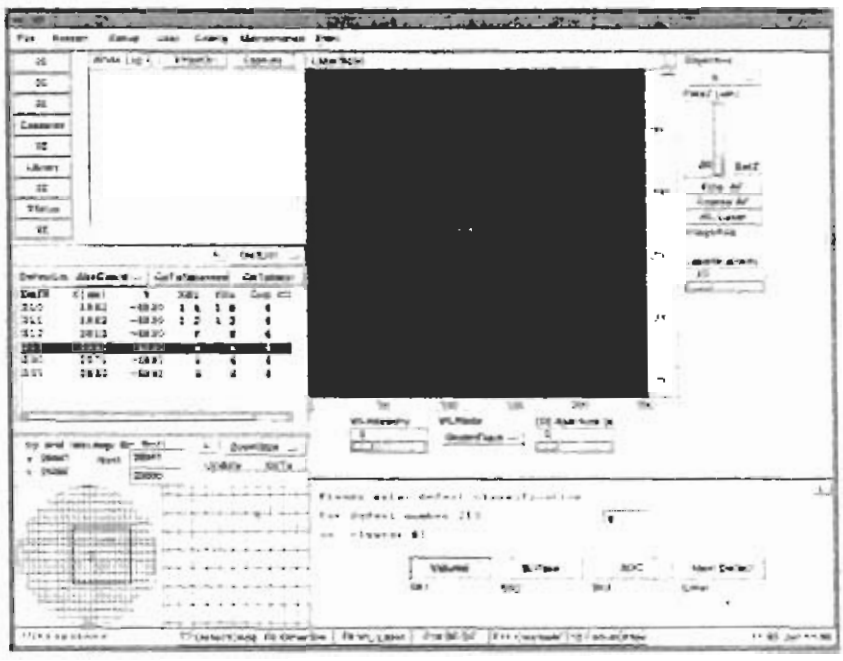
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navigation controls and an option menu for the wafer zoom pane. The navigation controls are described in the section "Moving Around the Wafer Map Window" on page 102. The bottom left pane shows a small representation of the whole wafer. To its right is the zoom pane, which can also show any of four color palettes, depending on the option menu in the pane above. Both the wafer map and the zoom window have four options for color coding, described in the sections "Wafer Map Zoom Views" and "Wafer Map Palettes" on page 103. The ***Deskew*** sequence pane has three soft keys, ***RedoDeskew*** (start deskew over), ***Skip Deskew***, and ***Accept***.

The user normally begins by turning on the laser image. The deskew process consists of moving three consecutive deskew points under the crosshairs with the joystick, and accepting their positions when they are ready. From the first two points the CRS calculates the angular correction needed for accurate positioning. At the third point, the user can also set the stage offset from the keyboard. These two corrections make it possible for the CRS to locate defects with an accuracy of a few microns over the entire surface of the wafer. Accepting the third point brings up the ***Review*** screen.

Review Screen

Figure 5-42 Review Screen



With the preliminaries out of the way, the process of defect review and classification can begin. The ***Review*** screen in Fig. 5-42 keeps the same arrangement of panes as the deskew screen, but changes the sequence pane. The controls here are the data entry field for entering defect codes, the soft keys to go to the volume and surface image screens, and the ***Next Defect*** button, linked to the **Enter** key. The defect code entry field is linked to the numeric keypad even when the cursor is not pointing at it. This is unlike all other data entry fields, which only have keyboard focus when the cursor is within them.

Normally the recipe in use will determine the selection and order of defects to be reviewed. The operator can view the white light and laser images in this screen at various magnifications, move the stage up and down to view features above or below the surface, or change to the ***Volume*** or ***Surface*** screen to get different views of the defect. From the ***Volume*** and ***Surface*** screens the **Enter** key returns the user to the ***Review*** screen to enter the defect code number and proceed to the next defect. The usual options are available for selecting pane options or rearranging panes as needed within the screen layout, and numerous other functions are available from the menus. A very convenient feature is changing from the ***DefList*** option to ***DefCode***, the list of defect names and codes (see Fig. 5-27 on page 108), in case it is necessary to look up one of the more unusual defect

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types. Dragging in a library pane or switching to a library screen to look at images of previously classified defects is also useful sometimes.

The laser image pane contains the controls for setting up and capturing a 3D volume or surface image. They are visible only when the laser image is on. (See Fig. 5-38 on page 118.) Table 5-22explains the individual controls for 3D imaging.

Table 5-22 3D Image Acquisition Controls

Control	Description
Set Z	Clicking on this button instructs the computer to calculate a start and finish position for either a surface or volume image, covering the entire volume in which a significant signal is returned. That is, the software finds the heights of the lowest and highest surfaces in the field of view. The software also calculates an appropriate laser intensity value that does not saturate the photodetector during the image acquisition sequence. Note that while clicking on this button *sets up* the appropriate scan values, it does not *execute* an actual image acquisition function. To complete the image acquisition process, click either the ***Surf*** or ***Vol*** button.
Start & Finish	When in Laser mode, note two small buttons situated just to the right of the Z position slider bar - one labeled ***S*** and the other ***F***. These buttons are used to manually select the Start and Finish position for either a surface or volume image scan.
Surface	The ***Surf*** button instructs the system to begin acquiring an image using the Surface image algorithm. This button is not to be confused with the automatic surface image acquisition button associated with **SK2** (Soft Key 2) or the ***Surface*** button in the sequence pane during Review sequence mode. When the ***Surf*** button in the laser image controls is clicked, the system begins a laser scan based on the parameters that were manually set up by the operator using the ***S***, ***F***, and ***Set Z*** buttons, while **SK2** and the ***Surface*** button set the image parameters automatically.
Pixels	The normal laser window dimensions are 512 pixels in X (horizontal) by 512 pixels in Y (vertical). Click on the ***Pixels*** button to change the window size to 256 x 256.
Volume	Like the ***Surf*** button, the ***Vol*** button instructs the system to begin acquiring an image, in this case using the Volume image algorithm. This button is not to be confused with the automatic ***Volume*** button associated with **SK1** (Soft Key 1) in the sequence panel during Review sequence mode. When the ***Vol*** button in the laser image controls is clicked, the system begins a laser scan based on the parameters that were manually set up by the operator using the ***S***, ***F***, and ***Set Z*** buttons, while **SK1** and the ***Volume*** button set the image parameters automatically.

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Control	Description
Slices & Stepsize	The ***Slices*** readout displays the number of Z steps that are used during a surface or volume image scan. This value can be changed in the ***Laser Scan Parameters*** configuration window. The ***Stepsize*** readout displays the slice thickness calculated by the computer. This value is the Z finish position minus the Z start position divided by the number of spaces between slices (rounded to the nearest 12-nm multiple): $$Stepsize = \frac{Z\ Finish\ Position - Z\ Start\ Position}{Number\ of\ slices - 1}$$

Figure 5-43 3D Image Controls



The first step in acquiring a 3D image, either volume or surface, is to move the stage *up* to the starting height, so that the focal plane is at the *bottom* of the image volume, and click on the ***S*** button in the laser image controls. Then move the stage *down* to the finish position at the top of the image volume, and click on ***F***. The CRS software calculates the height of the slices to fill that distance. It is possible to click on both ***S*** and ***F*** at the same height, which sets the minimum slice height of 12 nm. This gives the minimum total height for 64 slices of 756 nm, or 0.756 µ.

When the three parameters are set, click on either the ***Vol*** or ***Surf*** button to acquire the image data and display the image in the ***Volume*** or ***Surface*** screen, respectively. The CRS steps to the specified slice positions and records the laser light intensity in a 512×512 grid for each, calculates the initial image to display in each pane, and then switches screens. The process of acquiring 64 slices of data and processing them into the initial images takes 12 seconds.

The volume image occupies 16 megabytes, so only one volume image can be held in memory. Surface images discard most of the volume data after extracting the surface data. They occupy half a megabyte, allowing views of several to be displayed in different panes at the same time.

Both ***Volume*** and ***Surface*** screens, as well as other 3D image screens, contain 2D slice panes and 3D panes. There are two sets of controls for manipulating them, shown in Fig. 5-43 for 3D image panes, and Fig. 5-48 on page 127 for 2D slice panes.

3D Surface and Volume Image Controls

The 3D image controls pictured above are summarized in Table 5-23, with further comments following. These controls are used for manipulating 3D images of surfaces. The CRS software calculates views of these 3D data sets as if they were moved around in space, with changing lighting and variable zoom. Images can be viewed in false color or gray scale in several encodings, shown in Fig. 5-45 on page 124. The Z height can be expanded to bring out features in relief better. For quick manipulation, the image can be viewed at low resolution, allowing the computer to calculate the new views faster. When a satisfactory view is reached, toggling to high resolution gives the full detail collected in the imaging process. Since the laser images can be somewhat noisy, a smoothing function is included to produce a better approximation of the true surface. Some of these functions are illustrated in Fig. 3-40 on page 56 and the three figures following.

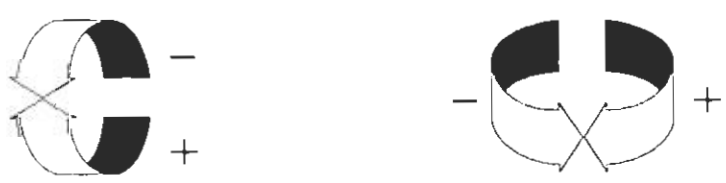
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Table 5-23 3D Image Controls

Control	Function
Reset button	Return to default view, restoring all parameters
File button	Load and save volume (`.vol`) or surface (`.sur`) files
To Hi-Res button	Toggle between low resolution and high resolution display.
Tilt - ***+*** buttons	Rotate around X axis. Raising front edge is positive.
Rot - ***+*** buttons	Rotate around Z axis. Clockwise is positive.
Zoom - ***+*** buttons	Center at a selected point, and magnify or demagnify image.
Translation	
<- -> buttons	Move left or right within image, without rotation. Apparent image motion is opposite to arrow.
Down ***Up*** buttons	Move down or up within image, without rotation. Apparent image motion is opposite to arrow.
Light	
XDir - ***+*** buttons	Change direction of virtual illumination along X axis of frame. The apparent position of the light source remains stationary as the image is rotated, so that the shadows move on the image.
Bright - ***+*** buttons	Decrease or increase image brightness.
Contr - ***+*** buttons	Decrease or increase image contrast.
Z Scale button	Stretch Z axis and increase vertical relief. Use Reset to restore initial value.
Smooth button	Use averaging to reduce image noise.
Y Width slider	Select YZ slice for front of image, from range 4–512. The surface behind the selected slice remains visible, while higher numbered slices are removed from the image.

The action of the the Tilt+ and Tilt– buttons and the Rot+ and Rot– buttons is shown in Fig. 5-44.

Figure 5-44 Action of Tilt and Rotate Buttons



Zoom

Zooming is very frequently used both to achieve higher magnifications and to properly frame the region of interest within the field of view. While ***Zoom+*** and ***Zoom–*** buttons are provided, they must be used in conjunction with the mouse.

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Zoom in with Fixed Magnification Ratio

Move the mouse pointer to the exact center of the defect and click the left mouse button. A small square zoom box appears. This box represents the new field of view that takes effect when you press **Zoom+** button.

If you do not like the location of the defect relative to the zoom box, you can move the cursor arrow to a new location and click the left mouse button again to reposition the box. You can click as many times as you wish to reposition the box without zooming the image. The actual zoom effect does not occur until the **Zoom+** button is clicked.

With this method, the size of the zoom box is always the same. If you want to zoom in to extreme magnifications, you can use the zoom box and **Zoom+** button repetitively. However, there is an alternate way to zoom that allows varying the size of the zoom box, thereby varying the amount of magnification.

Zoom in with Variable Magnification Ratio

1. Move the arrow cursor to the center of the defect.
2. Click and *hold* the left mouse button to display the zoom box. Slowly move the mouse to the left (while the mouse button is depressed) to shrink the zoom box.
3. Release the mouse button and click on the **Zoom+** button.

Zoom out

Click on the **Zoom-** button. Note that pressing the Reset button also zooms out; however, it resets any other orientation information (tilt, rotation, translation, etc.).

Translation

The ←, →, Up, and Down buttons translate your surface image accordingly (relative to the monitor image). However, it is easier and quicker to use the zoom box to reposition the center of your image.

Color

Since a monochromatic light source is used for laser imaging on the **KLA Tencor** CRS , the images are stored in a gray scale representation. To better distinguish between subtle variations of gray, the computer automatically maps a different color to each shade. The colors that you see in both the 2D and 3D laser images are referred to as false color. All 3D surface images are initially displayed in false color; you can change them to gray scale if desired.

There are four color schemes available for 3D images, described in Table 5-24. Each click of the Color button changes the color scheme from one to the next in the following sequence.

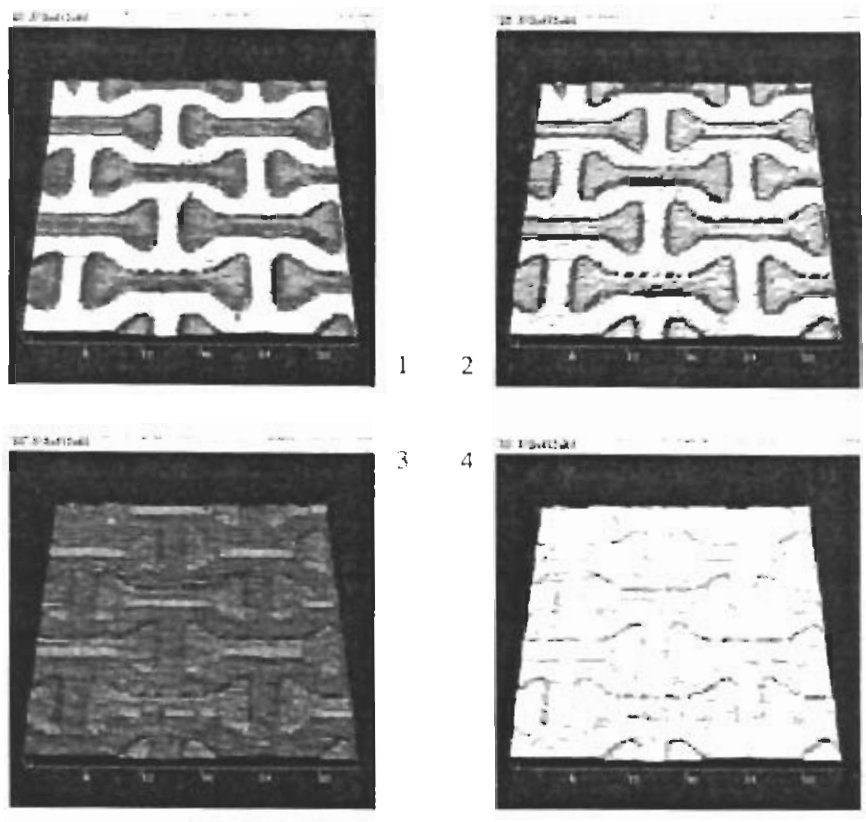
Table 5-24 False Color Schemes for 3D Images

Number	Color Scheme	Description
1	False Color	Color mapped to reflected intensity
2	Gray Scale	Shades of gray mapped to reflected intensity
3	Height Color	Color mapped to Z height
4	No Color	No information on reflected intensity; shadowing allows for observation of surface morphology

Fig. 5-45 gives an example of the same image in each of these color schemes.

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Figure 5-45 False Color Image Examples



Lighting

The ***Bri*** and ***Contr*** buttons adjust the brightness and contrast of the image. The ***Xdir*** button controls the shadowing of the 3D image by changing the angle of the imaginary light source that sits above the image.

Z Scale

To enhance the surface topography of a 3D image, click on the ***Z Scale*** button to increase the scale of the Z axis. This is particularly useful for very thin defects.

Smoothing

Smoothing is always recommended for a more accurate portrayal of a 3D image. Each click of the ***Smooth*** button instructs the computer to mathematically average around each point in the entire surface region. This is eliminates occasional pixel spikes caused by spurious values (noise). Smoothing every 3D image at least 2 or 3 times is recommended. Note that smoothing is the only parameter in the 3D window that cannot be undone with the ***Reset*** button.

Y Width

To cut a 3D surface image in order to examine the cross-sectional topography, use the ***Y Width*** slider. The slider moves along the Y axis from 4 to 512 to represent each XZ cut plane. Drag the bar with the mouse until the image is cut along the desired plane.

File

To save a 3D surface image, click on the ***File*** button, located at the top just below the ***Reset*** button. A file loading/saving dialog box appears. Click in the file name entry field and enter a unique

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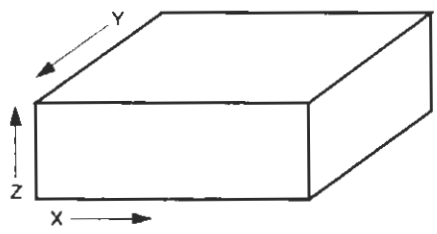
filename. Click on ***Save*** and the image is saved for future retrieval. To load an image file, select a directory and file name, and click on ***Load***.

The 2D Panes

The 2D panes are extremely powerful analytical tools. They not only provide views of images from the top, but also from the front and side, providing both critical topographical and subsurface information. With practice, you will quickly become adept at taking full advantage of their capabilities and will probably use them more than any other window.

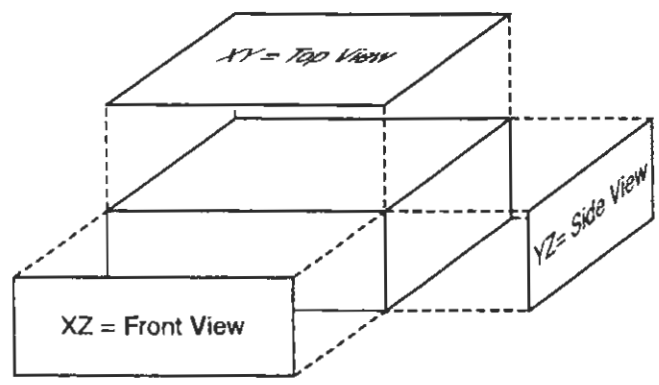
When either a surface or volume image is acquired, the system assigns X, Y, and Z axes to the image to allow for orientation control and axis manipulation. Fig. 5-46 illustrates the conventions used by the ***KLA Tencor*** CRS for 3D images. The block in the figure represents a portion of the wafer viewed from the left end of the CRS. The X axis runs from the back to the front of the instrument. The Y axis has its low end toward the wafer door on the right side of the case, and its high end at the left. When viewed on screen in an XY view, the Y axis runs down the screen.

Figure 5-46 2D Axis Conventions



Moreover, when using the 2D panes, you need to understand the conventions used to represent the various two dimensional view projections. Fig. 5-47 depicts the three different views that are accessible via the 2D window.

Figure 5-47 2D View Projections



The XY cut is equivalent to the top view. This is the same view you would observe with either live laser imaging or via the CCD camera. The XZ and YZ cuts represent cuts in the interior parallel to the front and side views respectively.

2D Slice Image Controls

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Fig. 5-38 on page 127 shows the 2D image controls for viewing slices of 3D images. The first control, the **Cut Plane:** option menu, is summarized in Table 5-25, while the remaining controls are described in Table 5-26 on page 127. The **Cut Plane:** option menu contains seven options—**XY Size**, **XY Cut**, **XZ**, **YZ**, **XZ Peaks**, **YZ Peaks**, and **Z Profile**. Only the first four apply to ;surface images, while all seven apply to volume images. The XY view is the top view. Both the **XY Size** and **XY Cut** options provide the same top view of the image. They differ in that the former provides a cursor box for measuring features, while the latter provides a cutting cursor that defines and controls the XZ and YZ views.

Table 5-25 2D Slice Viewing Options

Function	Surface Images	Volume Images
XY Size	Top view; provides a rubberband cursor for measuring features.	
XY Cut	Top view; provides cutting cross hair cursors that control the XZ and ;YZ views.	
XZ	Front view; surface topography information only; controlled by XY Cut cursor.	Front view; color cross-sectional view of reflected intensity versus depth; controlled by XY Cut cursor.
YZ	Side view; surface topography information only; controlled by XY Cut cursor.	Side view; color cross-sectional view of reflected intensity versus depth; controlled by XY Cut cursor.
XZ Peaks	Not applicable; same view as XZ.	Front view; displays peak reflected intensity pixels versus height; cut-off threshold controlled by slider bar.
YZ Peaks	Not applicable; same view as YZ.	Side view; displays peak reflected intensity pixels versus height; cut-off threshold controlled by slider bar.
Z Profile	Not applicable; same view as YZ.	

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Figure 5-48 2D Image Controls



XY - The Top View

The XY option for a volume image is similar to that of the surface image in that it is a view from the top. However, the two differ in that the volume image shows a selected 2D slice at a time (including those slices inside the image), where the surface image shows a single 3D surface from the outside. Also note that the XY top view of a surface image possesses an infinite depth of focus. This differs from the top view that is associated with a volume image, which is merely a single slice of focus.

A typical volume image is comprised of 64 slices, stacked one on top of the next. The XY view allows you to choose which slice to observe. To control the slice number, use the ***1st Slice*** slider bar, described on page 128.

XY Size Cursor Control

Using the cursor box that is displayed in the XY Size option is identical to that in the Wafer Map window. If you click and hold on the *upper left* corner of the box, you can *move* the entire box. If you click and hold on the *lower right* corner of the box, you can control the *size* of the box. As you vary the size, the numerical dimensions of the box are displayed under the Horizontal and Vertical sections of the 2D window.

XY Cut Cursor Control

If you select the XY Cut option, a pair of crosshair cursors appears. You can define the cutting plane that is displayed in an *XZ* pane if you click and hold anywhere on the *horizontal* cursor in the *XY* view. In other words, the *horizontal* cutting cursor controls any open XZ window. Thus, if you want to measure the height of particle defect, move the horizontal cutting cursor such that it bisects the particle. In the XZ window, a profile appears that represents the protrusion of the particle above the surface. Now you can measure the defect in XZ window by adjusting its cursor box such that is surrounds the defect.

Likewise, the vertical crosshair in the XY Cut view controls the profile that is displayed in the *YZ* view. You can control both the XZ and YZ views simultaneously by clicking and holding on the *intersection point* of the horizontal and vertical crosshairs. Also note that as you move the cursors in the XY Cut view, the Horizontal and Vertical readouts display the actual position of the cursors.

Table 5-26 2D Slice Image Control Functions

Function	Surface Images	Volume Images
File	To load and save images.	
Smooth	Executes an average routine to eliminate spurious noise.	
Sections	Displays multiple slices (1, 4, 9, or 16) in one window; useful to see progression of defect through layers. Only applies to XZ and YZ views.	Displays multiple slices (1, 4, 9, or 16) in one window; useful to see progression of defect through layers. Applicable to all views.
Color	Toggles image between false color and gray scale.	
1st Slice	Identifies which slice is being displayed; linked directly to the XY Cut cursors; not applicable to XY view.	Identifies which slice is being displayed; linked directly to the XY Cut cursors; in section view, identifies upper left slice.

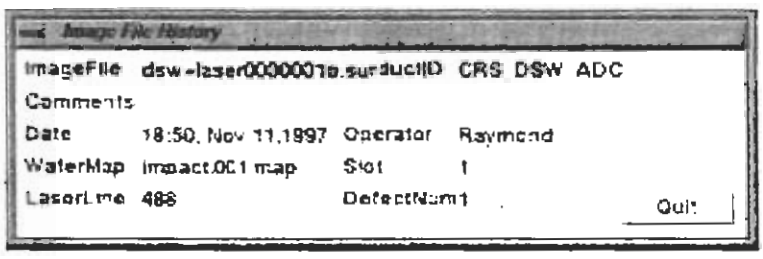
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Table 5-26 2D Slice Image Control Functions

Function	Surface Images	Volume Images
Spacing	For section view only, defines interval of slices between each view.	
First Slice	Not applicable.	Defines lower boundary to be used when the NewSurface function is executed.
New Surface	Not applicable.	Generates a 3D surface image based on the boundaries defined by First Slice.
History	Source data on current image	

The Image File History window in Fig. 5-48 shows information about the current image file and the wafer it came from, including the image file name, product ID, comments, time, date, account, wafer map file name, slot number, laserline wavelength, and defect number.

Figure 5-49 Image File History Window



XZ and YZ VIEWS

The ***XZ*** and ***YZ*** options display front and side views, respectively, of slices from the current surface or volume. The position of the view is defined by the cutting cursors in the ***XY Cut*** view. The ***XZ*** and ***YZ*** options function similarly for volume images as they do for surface images, but the display looks significantly different. Since a surface image is comprised of *surface* data only, its cross-sectional view is a line representing the surface topography. However, a volume image is comprised not only of surface data but also everything below and above the surface. Thus, the cross-sectional view is a map of reflected intensity versus position. The benefit of the volume image is the ability to see defects located below semi-transparent layers such as nitrides and oxides.

1st Slice

A typical volume image is comprised of 512 pixels in X, by 512 pixels in Y, by 64 in Z. When using 2D windows on the **KLA Tencor** CRS 1010, you can (with the 1st Slice slider bar) examine *any* individual slice of pixels in any plane. For example, in the XY view, you are observing the top view of a 512 x 512 image. By moving the 1st Slice slider bar, you can define which of the 64 slices is to be displayed. Note that this is the equivalent of selecting a focus position during live laser imaging. Incidentally, slice number 1 is the bottom-most slice in Z and slice number 64 is the upper-most slice.

The same principle is used for the XZ and YZ views. For example, an XZ side view is comprised of 512 pixels in X and 64 pixels in Z. Further, there are 512 of these slices along the Y axis. Moving the 1st Slice slider bar in the XZ view determines which of the 512 slices you wish to observe.

Sections & Spacing

We just covered how you can observe any single slice of a volume image. However, there are times when you can wish to observe more than one slice at a time. This is the purpose of the ***Sections***

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button. ***Sections*** allows you to observe 4, 9, or 16 slices simultaneously by sectioning the window into a 2×2, 3×3, or 4×4 grid respectively. Click on the Sections button and it instantly splits into a 2×2 grid. Click again and it becomes 3×3; click again for 4×4; and finally click again to bring it back to a single window.

Click on the Sections button until you have a 3×3 grid. The slice of the upper-left square is defined by the ***1st Slice*** slider bar. All subsequent slices are defined by the ***Spacing*** slider bar. The Spacing slider bar tells the computer what the interval shall be between slices. In the example shown in Fig. 5-50, the 1st Slice is set to 7 and the Spacing is set to 3.

Figure 5-50 2D Sections View in 3 x 3 Grid

7*	10	13
16	19	22
25	28	31

* First slice

New Surface & First Slice

3D surface images are a subset of the volume image data set. In other words, a volume image contains all the information necessary to make a 3D surface image. Thus, if you have obtained a volume image and wish to create a 3D surface image, you can do so by clicking on the New Surface button. While this technique is not as fast as clicking on the Surface button during live laser imaging, it does have its advantages.

3D surface images are derived from an algorithm that assumes that the point of brightest reflected intensity for any XY location is the surface. However, there are instances when this assumption is not true. An oxide layer on poly can fool the algorithm into believing that the poly is the surface, since its reflected intensity signal might be stronger than that of the oxide. This phenomena can be overcome by using the ***New Surface*** button in conjunction with the ***FirstSlice*** slider bar (not to be confused with the ***1st Slice*** slider bar). The ***FirstSlice*** slider bar raises the lower boundary so that a new data set can be used to create a subsequent 3D surface image.

The following procedure explains how to create a new 3D surface image depicting the oxide as the true surface (in the above example):

1. Obtain a volume image.
2. Select a screen layout with two open 2D windows and one 3D window. One of the 2D windows should be in the XY Cut mode and the other in the XZ mode.
3. Move the horizontal cutting cursor in the XY view so that the XZ view clearly shows two signals: the stronger poly signal on the bottom and the weaker oxide signal on the top.
4. Slowly move the ***FirstSlice*** slider bar in the XZ view until the lower poly signal is eliminated.
5. Click on the ***NewSurface*** button. Once the data set has been processed, a new 3D surface image appears in the 3D window that should accurately portray the oxide as the true surface.

XZ and YZ Peaks

The ***XZ Peaks*** and ***YZ Peaks*** options are similar to the ***XZ*** and ***YZ*** views except that they present the data in a non-color, pixel format. The peak intensity pixels all appear the same regardless of their intensity value. Therefore, you cannot distinguish between the various intensity levels. However, note that a ***Threshold*** slider bar appears in these views. Any pixels which are brighter than the threshold value appear, while those that fall below the threshold value vanish. Thus, this option provides a more quantitative method of determining the boundaries of multi-layered structures.

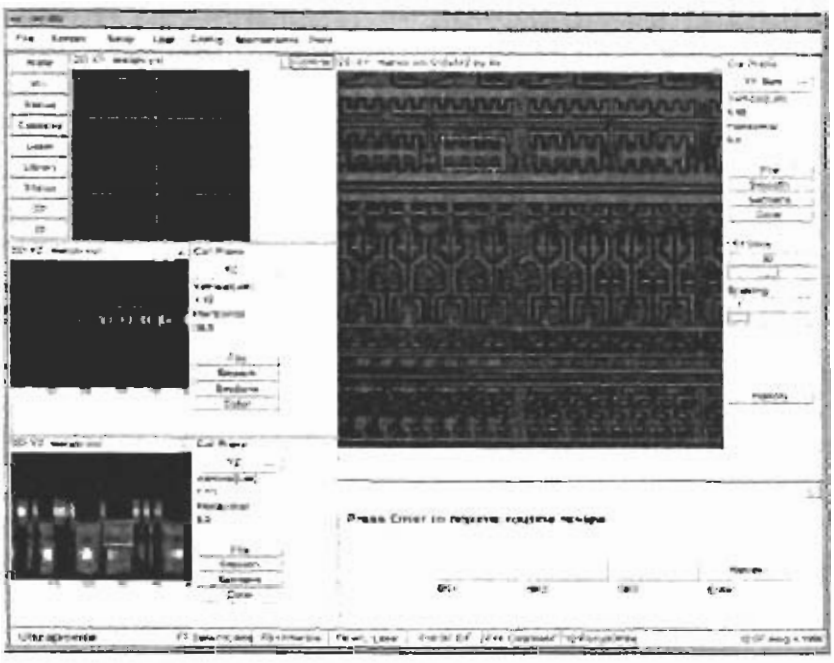
Z Profile

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The ***Z Profile*** view is unlike all the others. Note that the abscissa is a Z position and the ordinate is reflected intensity (on a scale of 1 to 255). Thus this view allows you to see the variation in reflected intensity with Z position (for any single XY location as defined by the XY Cut view). The software displays multiple peaks, which can give complete outline views of layers or defects in cross-section. Contact your ***KLA Tencor*** CRS applications engineer for details on this advanced feature.

Volume Screen

Figure 5-51 Volume Screen



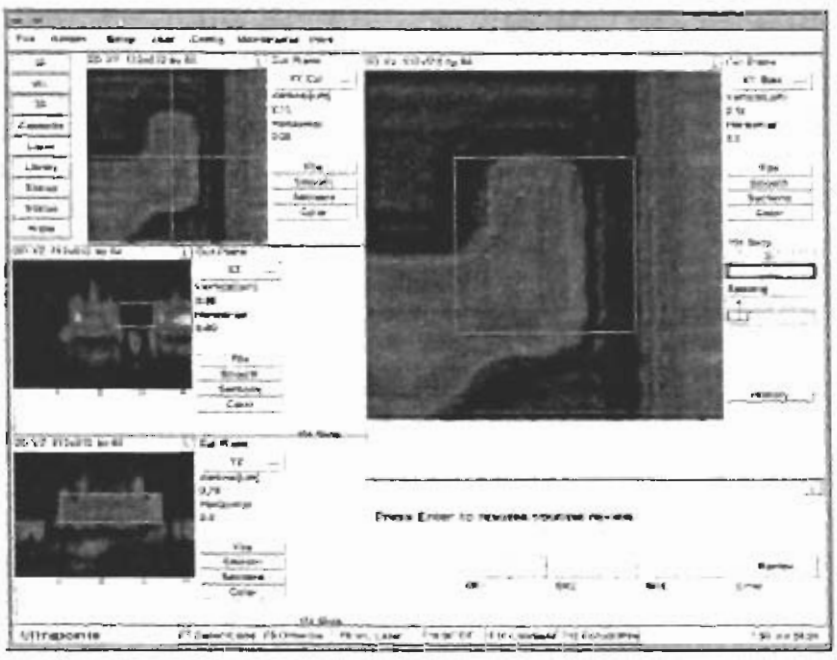


Fig. 5-51 shows two different setsof volume images. The ***Volume*** screen has a large XY image pane containing a rubberband cursor for making measurements, a smaller image with crosshair cutting cursors, and two small cross section panes with rubberband cursors.

The user can replace these views with any of the available views from the option menus, rearrange the panes, or drag in any of the other available panes from the pane bar on the left.

The large 3D pane contains the 3D controls, while the small slice windows have only the Control button, which brings up a menu of 2D controls in a separate window. It is necessary to close this menu before using any other controls in the main screen. It is

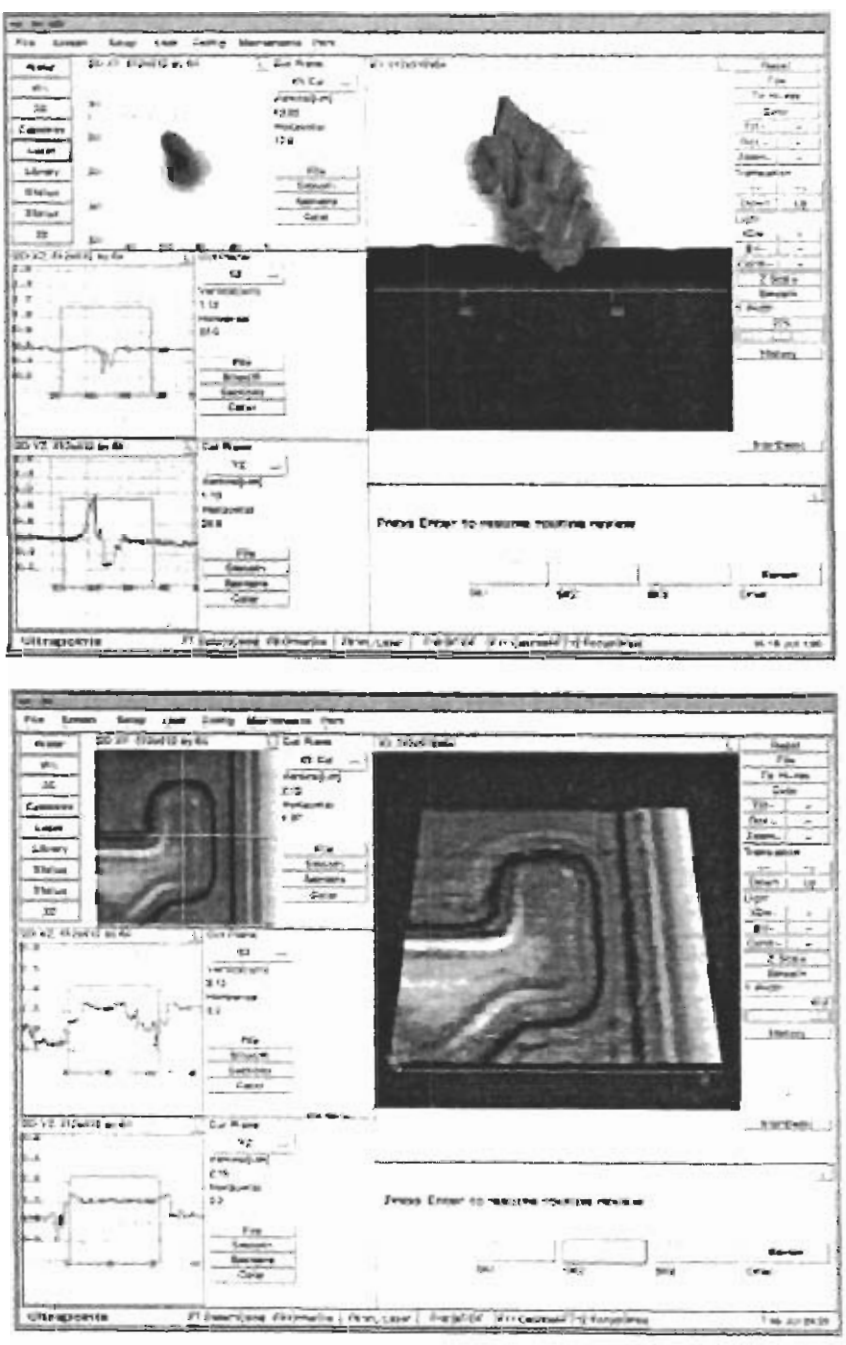
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also possible to swap the 2D pane into the larger space, so that its controls will show up right in the window.

Surface Screen

Fig. 5-52 shows two different sets of surface images. The ***Surface*** screen differs from the ***Volume*** screen in having a 3D surface image displayed in the large pane rather than an XY cut of a volume image, and surface profiles in the XY and XZ panes rather than cross-section images.

Figure 5-52 Surface Image Screen



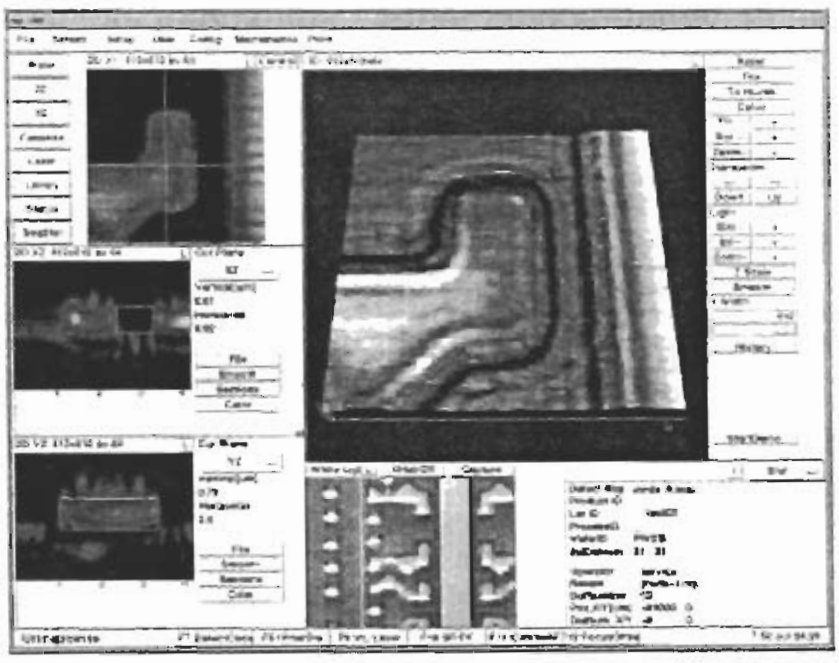
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When a surface image is acquired, all the 3D and 2D windows are updated with the image data. Since surface images are representations of the surface only with nothing underneath, all 2D front and side views only depict a topographical image. If you wish to see subsurface image information, use the Volume image function.

Surface Print

Fig. 5-53 is an example of the Surface Print screen. It gives several views from a surface image data set, together with a white light image.

Figure 5-53 Surface Print Screen Layout

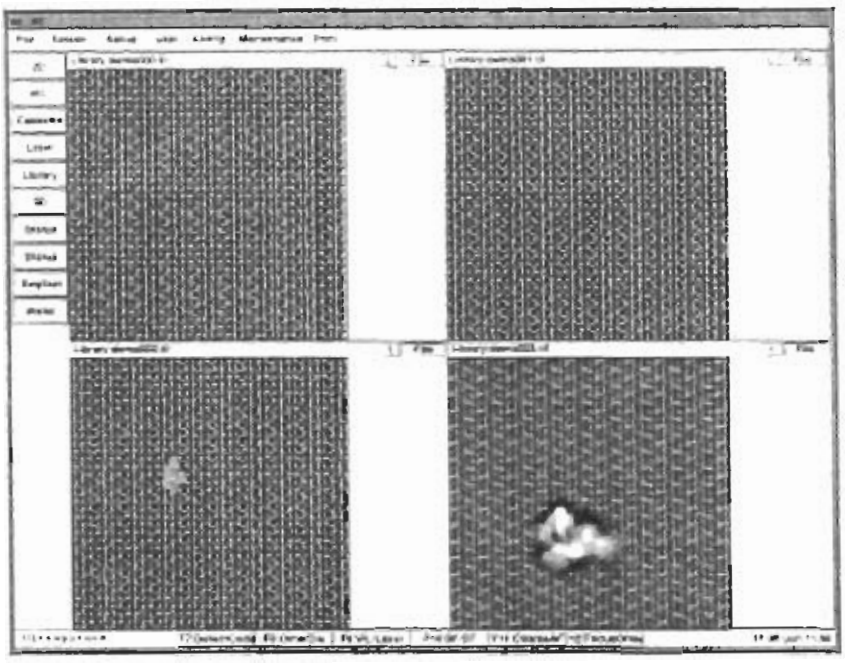


4_Library Screen

Fig. 5-54 shows a 4_Library screen with four different white light images loaded into its library panes. This arrangement is convenient for comparing a captured image with library images of various defects.

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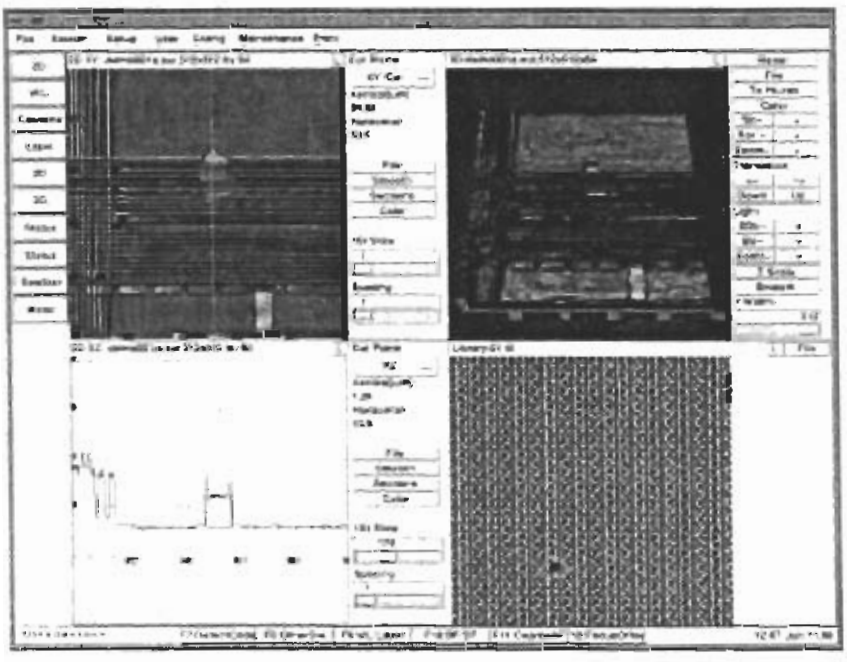
Figure 5-54 4_ Library Screen



2D/3D/WL Screen

The screen layout in Fig. 5-55 combines 2D and 3D laser surface panes with a white light pane. It would normally be used to show several views of the same defect.

Figure 5-55 2D/3D/WL Screen Layout

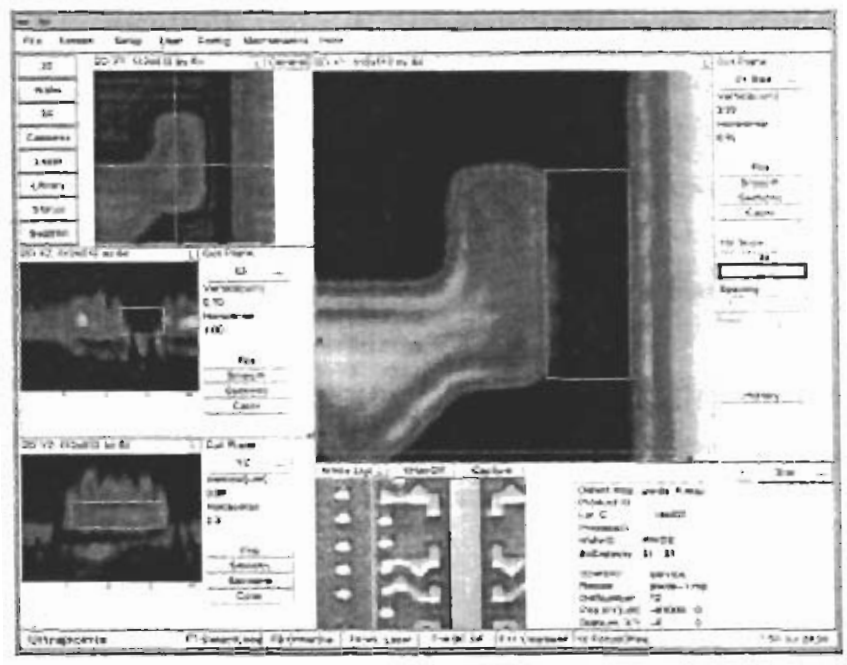


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Volume Print Screen

Fig. 5-56 is an example of the Volume Print screen, which combines four 2D volume slice and cut images with a white light image.

Figure 5-56 Volume Print Screen Layout

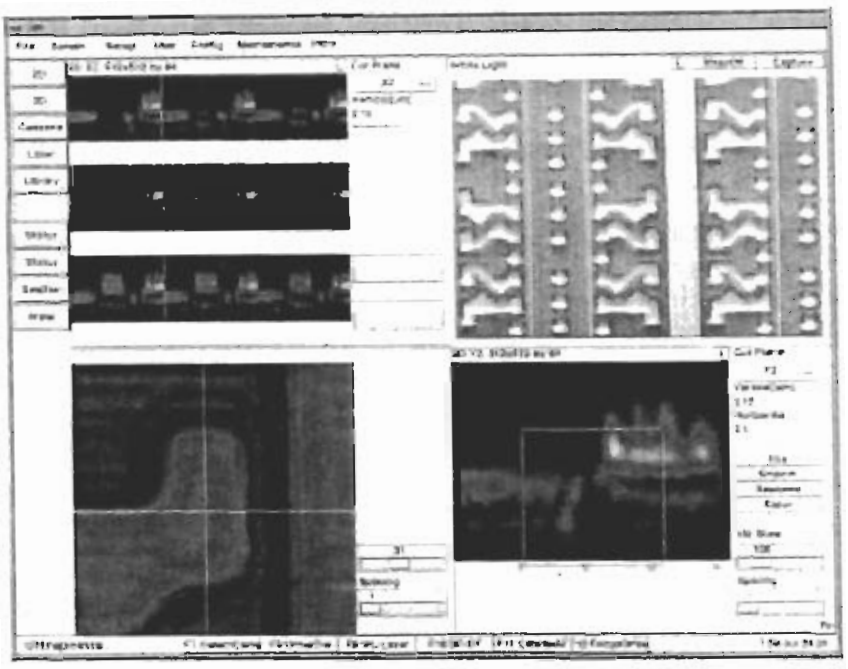


2D Profiles Screen

Fig. 5-57 is similar to the previous screen in combining a white light pane slice with cut panes displaying images from a volume data set.

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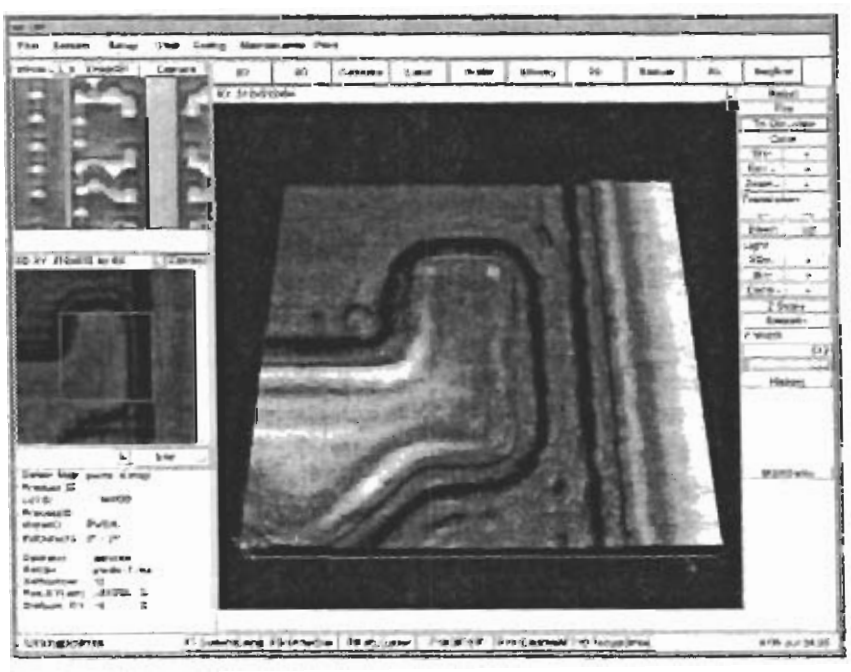
Figure 5-57 2D Profiles Screen Layout



Large Surface Screen

The extra large pane in the Large Surface screen in Fig. 5-58 is useful for examining fine detail in any sort of image. The example shown here is a surface image, but as usual any of the available pane buttons can be swapped into this large pane for viewing white light or laser images, 3D surfaces, 2D slices, or cuts.

Figure 5-58 Large Surface Screen Layout

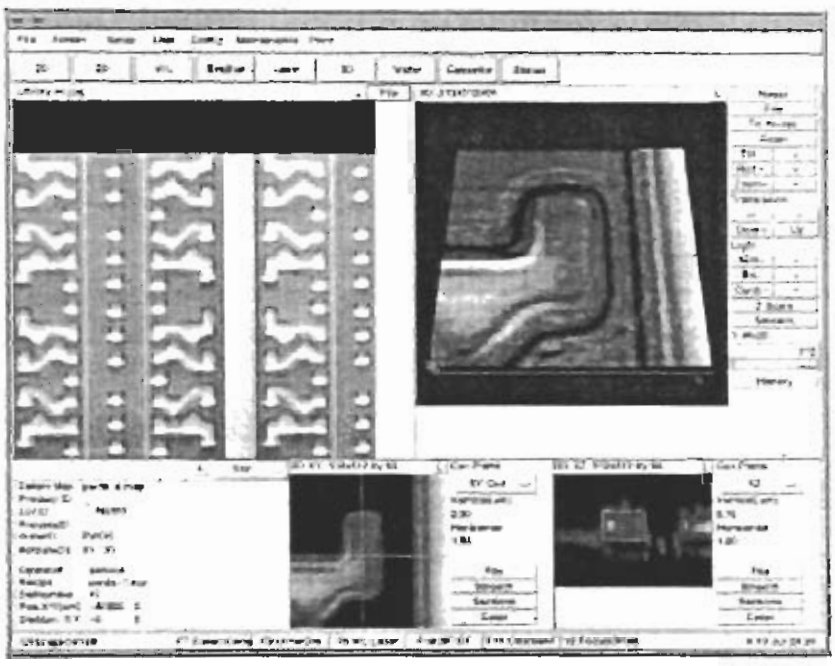


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WL 3D Print Screen

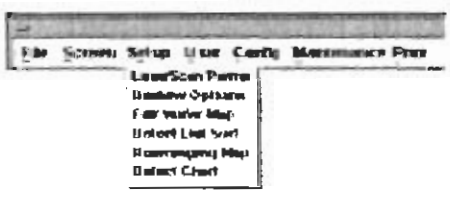
Fig. 5-59 is an example of the White Light/3D Print screen, with a white light image and a surface image taken at laser zoom 8. This combination of panes, with large white light and laser images, plus smaller 2D panes, is convenient for making a printed record of a defect.

Figure 5-59 WL/3D Print Screen Layout



Setup Menu

Figure 5-60 Setup Menu



The Setup menu shown in Fig. 5-60 includes recipe setup functions that are also accessible from the recipe file screen in Fig. 5-7 on page 89. The **LaserScan Parms** and **Deskew Options** windows are identical in both cases, and the **Defect List Sort** is similar. The **Edit Wafer Map** function and the **Rearranging Map** function deal with the current wafer map, and the **Defect Chart** function displays visually the relative numbers of defects classified with each code.

LaserScan Parms

See "LaserParams" on page 91, under "Recipe File Selection". The window brought up by this menu item and that button are identical in function and appearance.

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Deskew Options

See "Deskew Options" on page 94, under "Recipe File Selection". The window brought up by this menu item and that button are identical in function and appearance.

Edit Wafer Map

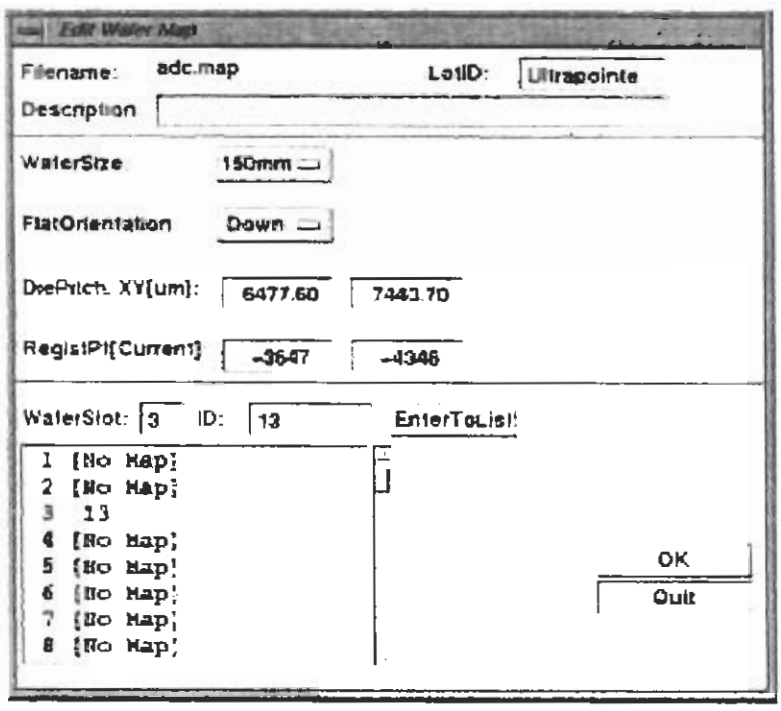
Fig. 5-61 shows the window for editing a wafer map file. It displays the current map file name, and provides data entry fields and menus for entering other information.



WARNING

Bringing a KLARF map file from a 255X to a CRS, changing it on the CRS, and then returning the file from the CRS to the 255X will result in an error when attempting to load the file.

Figure 5-61 Edit Wafer Map Window



This dialog box controls the parameters described in Table 5-27 from the current wafer map file. Changes made here affect the whole file: wafer size, flat orientation, die size, deskew points and wafer IDs. Individual defect editing can be done from the ***Status*** pane.

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Table 5-27 Wafer Map Parameters

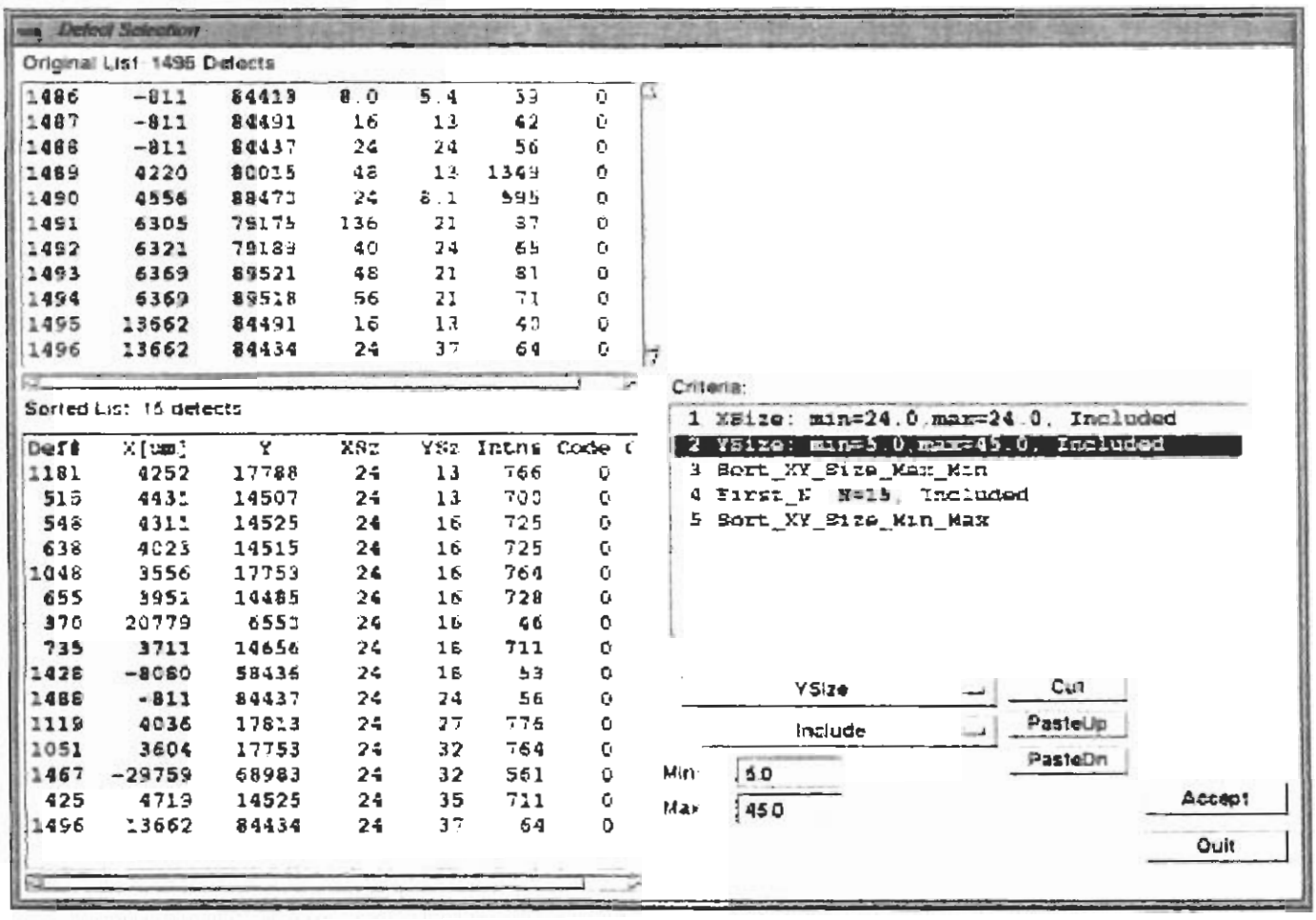
Field	Description
FileName display	Shows the currently loaded wafer map filename.
Lot ID entry field	Allows for editing of the Lot Identification number.
Description entry field	A text string used to describe the file.
Wafer Size option menu	Select 100, 125, 150, or 200 mm.
Flat Orientation option menu	Choose from Down, Left, Up, and Right.
Die Pitch entry fields	X and Y die size in microns; *not* editable for Tencor files.
Deskew1	First deskew location, in microns; *not* editable for KLA files, where it is computed from the die dimensions.
Deskew2	Second deskew location, in microns; *not* editable for KLA files, where it is computed from the die dimensions.
Registration entry fields	Displays the registration location. The registration location should *not* be changed unless you know it is incorrect. Die patterns and defect locations are all relative to the registration point; therefore, changing the location of the registration shifts the overall wafer map.
Wafer Slot and Wafer ID entry fields	Accepts a slot number and a wafer ID for that slot. A valid wafer file must have at least one slot with a wafer ID.
Slot menu	Shows matching of wafer IDs and slots.
EnterToList button	Makes changes to the slot menu, entering the wafer ID for the specified slot.
OK button	Accepts all changes and closes window
Quit button	Discards all changes and closes window

Defect List Sort

Fig. 5-62 shows the expanded ***Defect List Sort*** window available from the **Setup** menu. It should be compared with the window in Fig. 5-8 on page 89, which has the same controls for creating a sort to go in a recipe, but does not display the original and sorted lists, as here in the panes at the left. This sort window is meant for setting up ad hoc sorts, not included in any recipe, when there is some specific reason to change the selection criteria and sort order.

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Figure 5-62 Defect List Sort Window



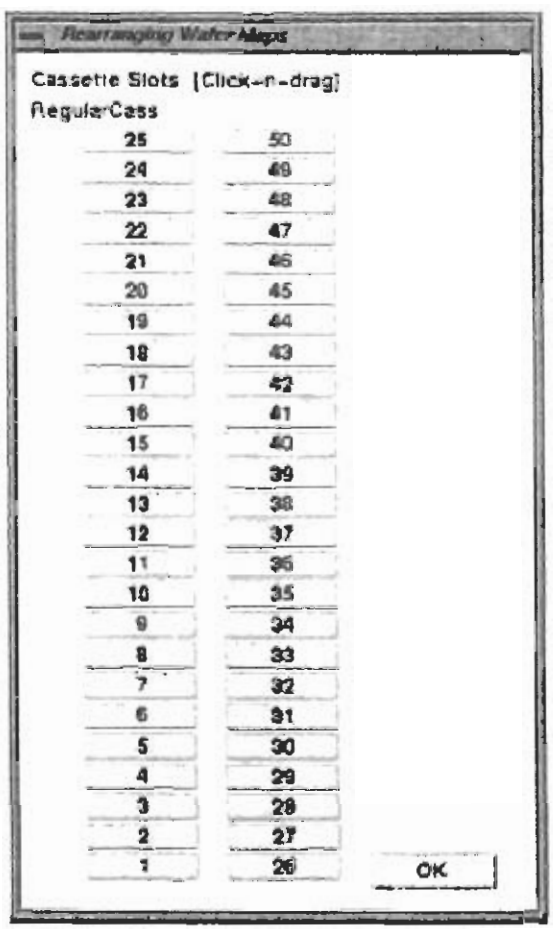
Sorting the defect list allows the operator to review and classify a subset of the original defect list. Sorting can be executed during a review session or saved/loaded as a recipe.

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Rearranging Map

Fig. 5-63 is the window for rearranging a wafer map file. In this dialog box, 50 buttons are provided, so that there is plenty of room to rearrange a full cassette. The slots with wafer maps are displayed in green.

Figure 5-63 Rearranging Wafer Map Window



To move the wafer map from one slot to another

1. Click on the green button which represents the slot with the wafer map.
2. Hold down the mouse button and drag it to an open slot (light color), then release the mouse button. The color of the buttons changes to reflect the slot changes.

This drag and drop operation checks for the follow error conditions:

If the source slot has no map, there is nothing to move. When the destination slot already has a map, it is not overwritten. The user can move the map in the destination cell out of the way, and then bring another map to the newly emptied position.

Click on ***OK*** when done rearranging the map. Use the wafer map function on the **File** menu to save the new map with an appropriate name.

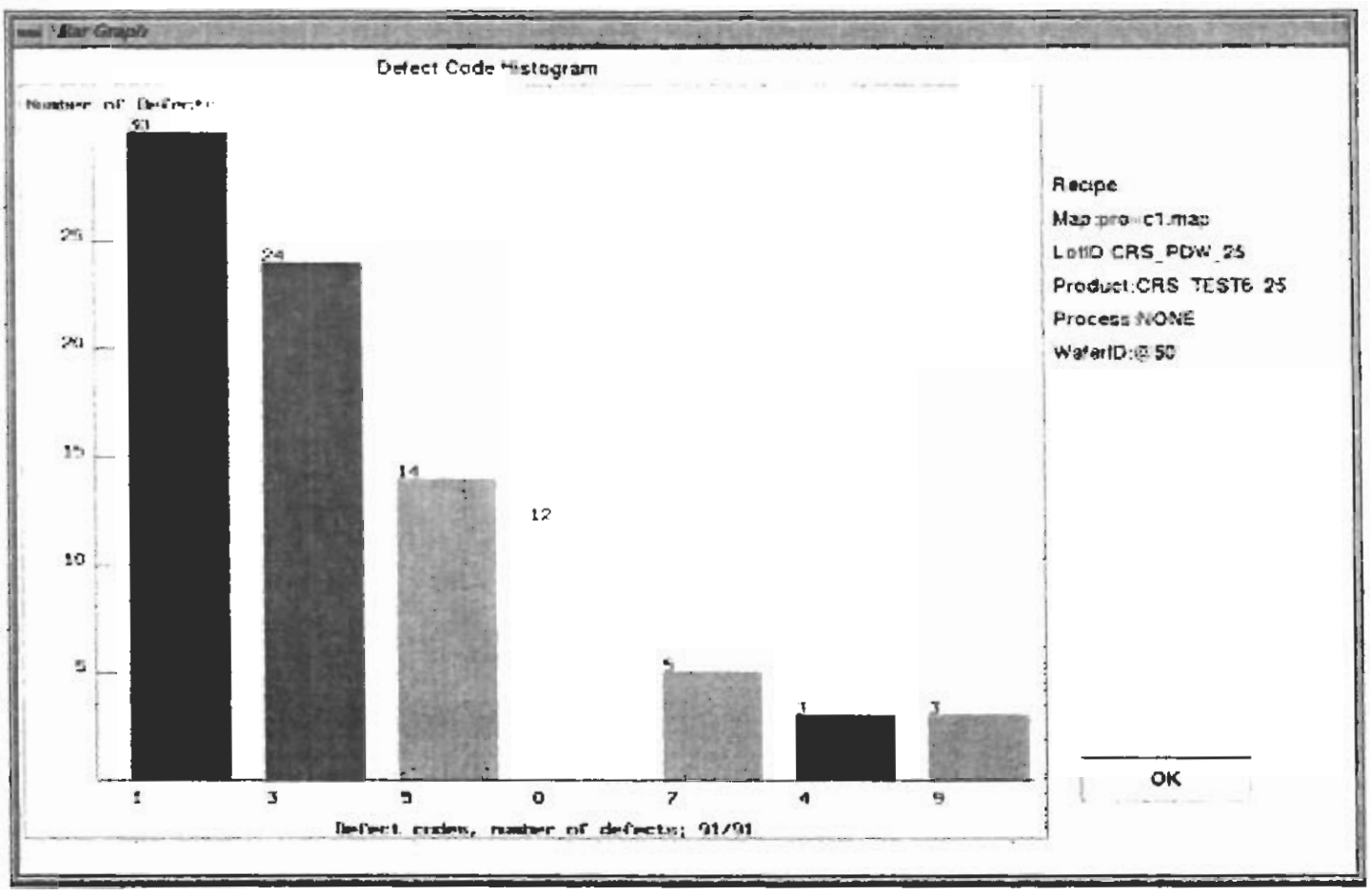
NOTE:	**KLA Users: Do not use this feature if you wish to return the defect map file back to the KLA 255X for analysis. The 255X does not accept defect map files that have had their slot number altered.**

Defect Chart

Fig. 5-64 shows a defect code histogram, that is, a bar chart giving the numbers of defects with each defect code, annotated with the Recipe file name, Map file name, Lot ID, Product description, and process ID. Below the histogram is a line giving the number of defect codes in the current code file, and the number of defects in the current wafer defect map. This window can be printed or captured for inclusion in a document. The only user control in the window is the ***OK*** button to exit.

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Figure 5-64 Defect Chart Window



User Menu

The User menu is displayed in Fig. 5-65. There are three selections, all related to user accounts: **Login**, **Logout**, and **Set Password**.

Figure 5-65 User Menu

Login

The **Login** command returns the user to the ***Login*** window. This is the same as the initial ***Login*** window (see Fig. 3-6 on page 31). It initially contains a menu of user names, and the ***Logout*** and ***Quit*** buttons. When a user name is highlighted, the ***Password:*** entry field and the ***Login*** button appear. From this window the user can log in again on a different account, log out, or quit to return to the current session.

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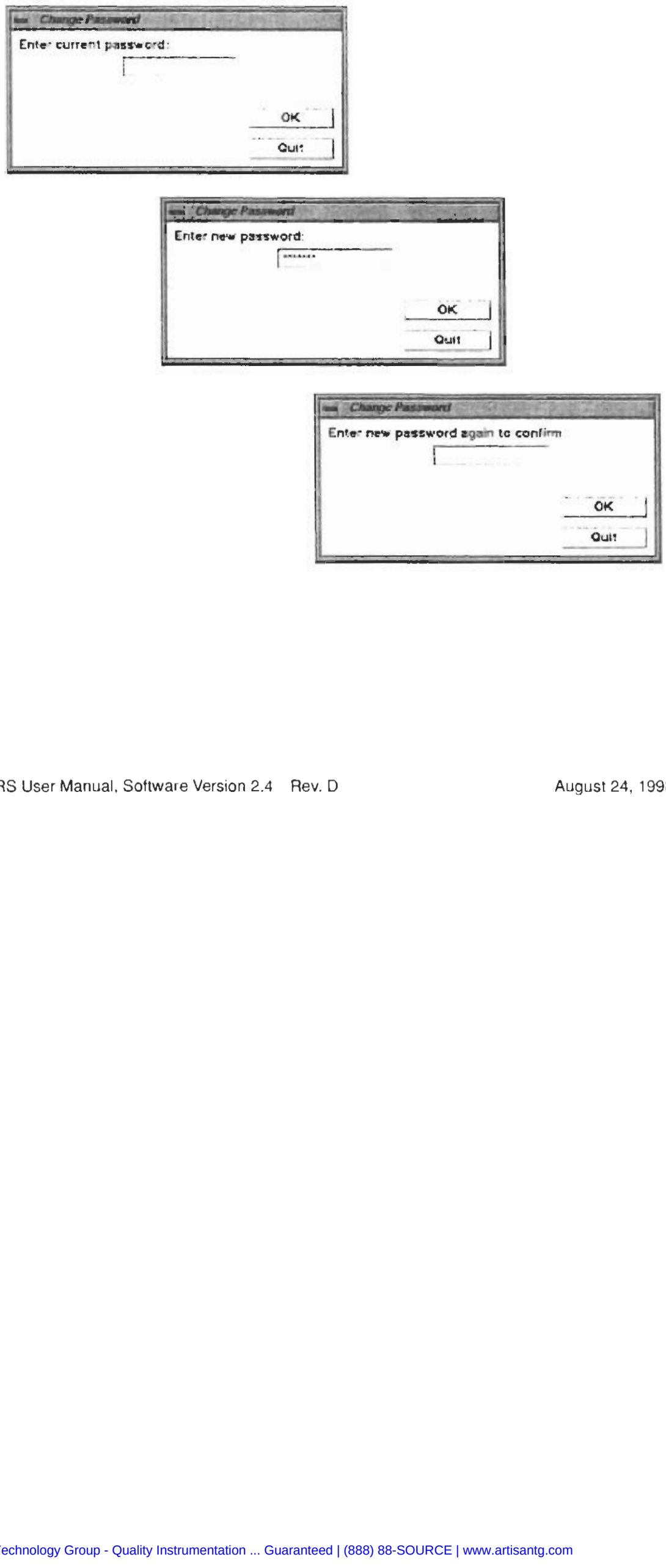
Logout

The Logout function is similar to the Login function. Both end the current user session, but logout returns to the start screen (Fig. 5-10 on page 33) rather than the login screen. The next user must not only log in, but reinitialize the hardware and software.

Set Password

Fig. 5-66 shows the sequence of windows for changing a password. The user is prompted to enter the current password, then the new password. Both appear as a sequence of asterisks, so careful typing is essential. Clicking on ***OK*** proceeds, and clicking on ***Quit*** abandons the process, leaving the previous password intact.

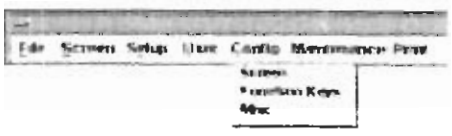
Figure 5-66 Set Password Windows



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Config Menu

Figure 5-67 Config Menu



The **Config** menu shown in Fig. 5-67 allows knowledgeable users to set up custom screen layouts, function key macros, and system parameters. Several predefined screen layouts are provided in the CRS software, specifying the size and placement of panes and the selection of window buttons for dragging. Users can modify screens or create their own with whatever selection of panes is useful, within the set of pane areas provided. Further customization in the form of new pane layouts and selections of pane buttons is possible, but not from inside the CRS software. Consult a ***KLA Tencor*** applications engineer for details and assistance if you have special requirements.

Screen

NOTE:	**Due to the complexity of this option, we recommend that only experienced users of the *KLA Tencor* CRS make any changes to user screens.**

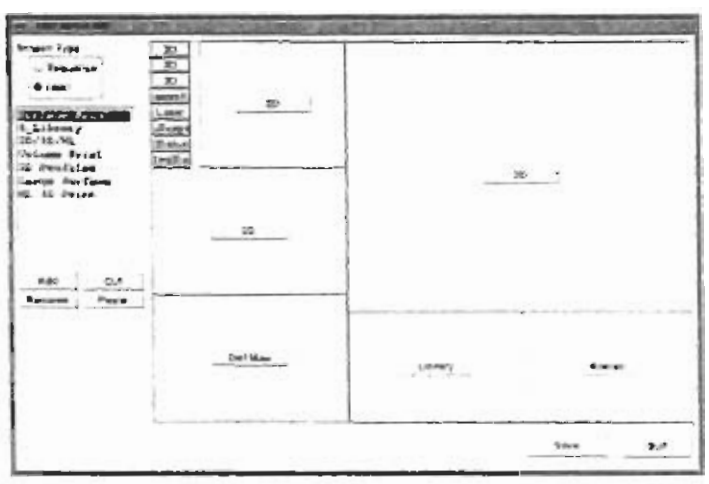
The CRS is configured at the factory with all the necessary screen layouts. Recall that there are two types of screens: Sequence screens and User screens. Sequence screens are used by the computer during the normal progression of those events associated with reviewing wafers (for example, loading a wafer or deskew). There are five sequence screens and you cannot add, delete, or rename them. However, you do have the option of modifying their appearance. User screens may be customized or used as the basis for further screen layouts.

User screens are not employed by the software; however, they are accessible to you by selecting them with the mouse. You may add, delete, rename, and modify User screens as you wish.

To Create a User Screen

1. Select **Screen** from the **Config** menu to bring up the ***User Screen Edit*** window shown in Fig. 5-68.
2. Click on the ***User*** radio button under ***Screen Type***.
3. Click on the ***Add*** button to bring up the ***Select Screen*** window shown in Fig. 5-69.

Figure 5-68 Configure Screen Window



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4. The list box shows the names of various screen layout templates. The names use the descriptors S, M, and L (for small, medium, and large, respectively) to represent the window sizes. For example, a layout with the name 3S + 1L has one large pane on the right, with three small windows to the left, as in the ***Surface Print*** layout in Fig. 5-68 above.

5. Select the desired layout and then enter the name that you wish to assign (such as *Big 3D* or *Report Print*). Click on ***OK*** when completed.

6. A miniaturized version of the layout appears. To rearrange it, drag and drop panes into the mini-layout in the normal manner.

7. The ***2D***, ***3D***, and ***Status*** panes can be individually configured for various display options. Clicking on the ***2D*** pane or button brings up an option menu for selecting the view (***XY***, ***XZ***, or ***YZ***) and cursor type (***Size*** or ***Cut***), shown on the left in Fig. 5-70. Clicking on the ***3D*** pane or button brings up controls for presetting the orientation of a surface image, as shown on the right side in Fig. 5-70. Finally, clicking on the Status pane or button brings up an option menu shown in Fig. 5-71. The menu options are

Figure 5-69 Select Screen Window

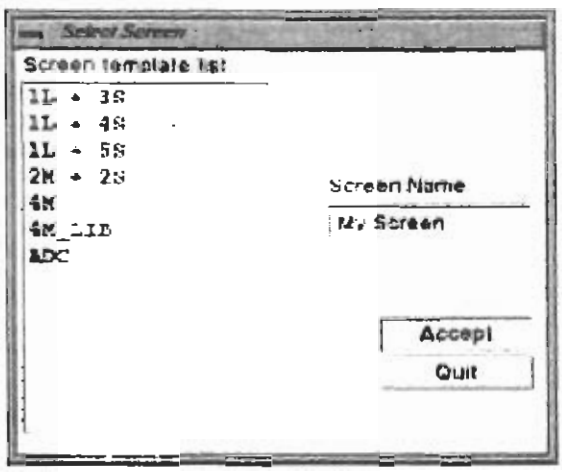
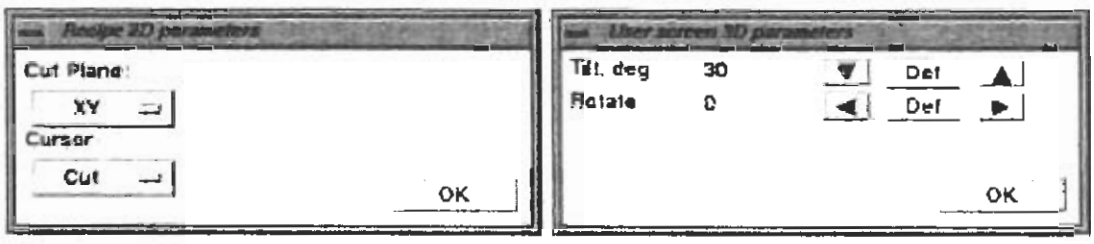


Figure 5-70 Screen Edit 2D and 3D Option Windows



- ***Status***
- ***Deskew***
- ***DefectList***
- ***DefCode***
- ***Search***
- ***Default***
- ***Short Status***

These are almost the same options available in the option menu in the pane (see "Status/Defect Pane" on page 105), although there **Short Status** is called **Stat**. The **Default** option, in this window, resets the pane to the default state, which is the same as **Short Status**.

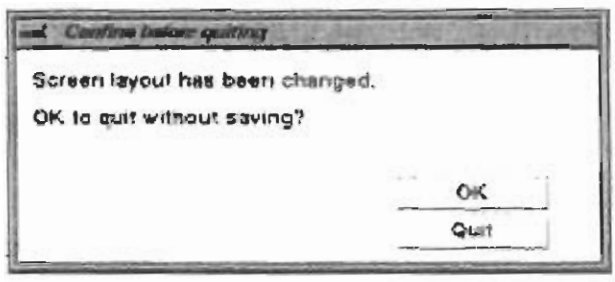
Figure 5-71 Screen Edit Status Window



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8. When you have finished defining your screen layout, click on Save.
9. A window appears, asking you to approve (***OK***) or discard (***Quit***) the changes.

Figure 5-72 Quit Screen Changes Window



If you quit from the ***Configure Screen*** window, and don't want to save any changes, you will see the ***Confirm before quitting*** window shown in Fig. 5-72 at the right, which asks, "OK to quit without saving?" Clicking on ***OK*** quits without saving. Clicking on ***Quit*** does not quit the screen editor. Instead it cancels the quit operation and returns you to screen editing.

To Modify a Sequence Screen

Click on the ***Sequence*** radio button to see the list of available sequence screens. The procedure to change a Sequence screen is very similar to that of a User screen except that you must adhere to the following restrictions:

- You cannot add, delete, or rename sequence screens. You can only modify their appearance.
- You may choose from any available layout template. It is recommended that you always choose one that has a rectangular window in the lower right corner to accommodate the Sequence Status window.
- A sequence screen **must** have the ***SeqStat*** (***Sequence Status***) window as part of its layout. All other windows are open to your choosing from the available set of pane buttons.
- New layout templates with different predefined areas and different selections of panes on the button bar cannot be created within the application. Consult your ***KLA Tencor*** Applications Engineer if you need other screen layouts defined.

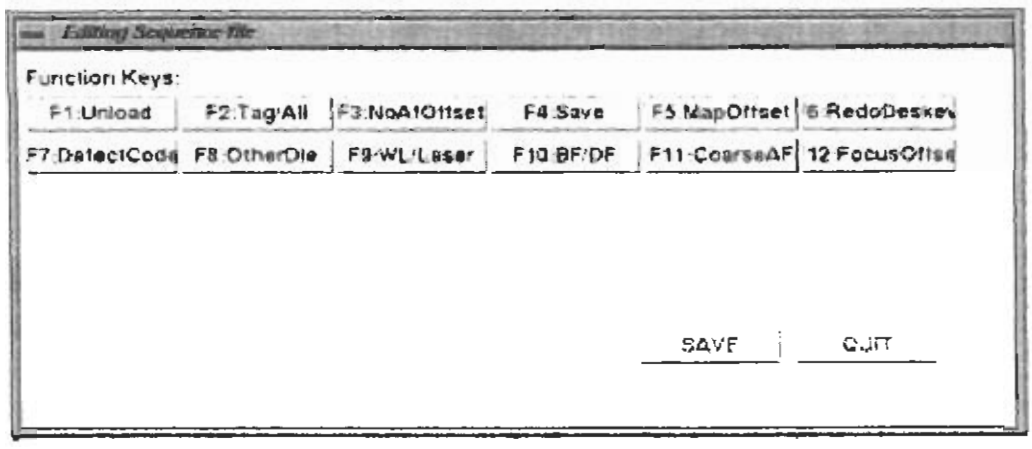
Function Keys

NOTE: Due to the complexity of this option, we recommend that it only be executed by experienced users of the *KLA Tencor* CRS.

The simplest way to use the function keys is to bind a single command to each. The CRS software comes with a predefined binding shown in Fig. 5-73.

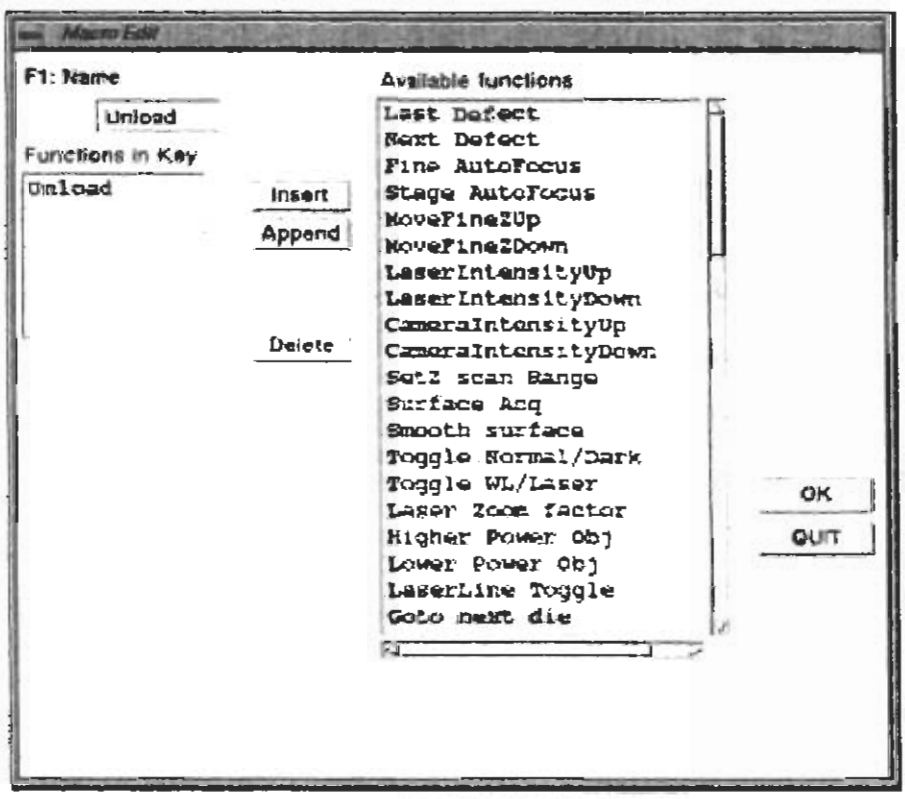
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Figure 5-73 Function Key Window



Clicking on any of these buttons opens the macro editing window for that button, as shown in Fig. 5-74. The top line shows the key being defined (**F1** in this case), with the ***Name*** entry field just below it. Any name up to 10 characters long can be entered, although of course it helps if the name is easily remembered and a good reminder for the operations that the key will invoke. The function sequence bound to the key is shown in the box below the ***Name*** field, one function to a line. If the list of functions is too long to show in the window all at once, a scroll bar appears.

Figure 5-74 Function Key Macro Editing Window



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The list of available functions is also a scrolling menu. Table 5-28 shows the complete list. Clicking on any function name selects it. Then clicking on the ***Insert*** button puts that function before the current selection in the ***Functions in Key*** list, while clicking on ***Append*** puts the function after the current selection. If no line has been selected, the software prompts for a selection. The ***Delete*** button removes the current selection, if any, from the ***Functions in Key*** list.

Table 5-28 Functions for Key Bindings

Name	Abbreviation
Last Defect	LastDef
Next Defect	NextDef
Fine AutoFocus	FineAF
Stage AutoFocus	StageAF
Move FineZ Up	FineZUp
Move FineZ Down	FineZDown
LaserIntensity Up	LaserIUp
LaserIntensity Down	LaserIDn
Camera Intensity Up	CamIntUp
Camera Intensity Down	CamIntDn
SetZ Scan Range	SetZ
Surface Acq	SurfAcq
Smooth Surface	Smooth
Toggle: Normal/Dark	Norm/DarkF
Toggle: WL/Laser	WL/Laser
Laser Zoom Factor	LaserZoom
Higher Power Objective	Obj Up
Lower Power Objective	Obj Down
Laser Line Toggle	LaserLineSw
Goto Next Die	NextDie
ReDo Deskew	RedoDeskew
Calc Map Offset	CalcMapOffset
Load selected Wafer	LoadWafer
Unload Wafer	Unload
Select Next Wafer	Sel Wafer
Volume Acq	Vol Acq
Camera Mode Normal	Cam Norm

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Name	Abbreviation
Camera Mode Dark	Cam Dark
Camera Mode Polarizer	Cam Polar
Objective 1	Obj 1
Objective 2	Obj 2
Objective 3	Obj 3
Objective 4	Obj 4
Objective 5	Obj 5
Laser Line 458	458
Laser Line 488	488
Laser Line 515	515
Laser Line All	All line
White Light Only	WhiteLight
Laser Scan	Laser
Accept Deskew Point	Accept Dsk
Popup Def Code Table	DefCodeTable
Switch to 2D Screen	2D Screen
Switch to 3D Screen	3D Screen
Current Seq Screen	Seq Screen
Screen 1	Scr 1
Screen 2	Scr 2
Screen 3	Scr 3
Screen 4	Scr 4
Screen 5	Scr 5
Screen 6	Scr 6
Screen 7	Scr 7
Screen 8	Scr 8
Screen 9	Scr 9
Screen 10	Scr 10
Load Defect Bitmap	Def library
FineAF Offset	AF offset
SaveMap/Image Popup	SaveMap/Img

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Name	Abbreviation
Classify, SaveMap/Img, Next	Cls,SaveMap/Img, Next
FineAF Offset Reset	AF offset reset
On-Screen Annotation	Caption
Last Cluster	LastCluster
Next Cluster	NextCluster
Release SMIF Pod	ReleaseSmifPod
CrossHair On/Off	XHairOnOff
LPA Tag On/Off	LpaTagOnOff
Manual Deskew	ManualDsk
Save Map Only	SaveMapOnly
Save Image Only	SaveImgOnly
Edit User Tags	Edit User Tags
Print Only	PrintOnly

Keep in mind that you might find it undesirable to change the predefined bindings, since the keycaps have been printed with the factory-defined functions.

Due to space restrictions, only six function key names appear at a time in CRS screens. To see the other six, press the **Toggle Menu** key (**Pause** on standard keyboards).

Misc

An assortment of parameters can be set in the ***Config Misc.*** window shown in Fig. 5-75 for saving in the `.uvconfig` file. The controls in this window are described in Table 5-29, except for recipe autoload options, which are listed in Table 5-30. Also from this window these parameters can be reread to use newly set values. The values do not take effect when set in this window or saved, but only when `.uvconfig` is read in, either at startup or from this window.

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Figure 5-75 Config Misc. Window

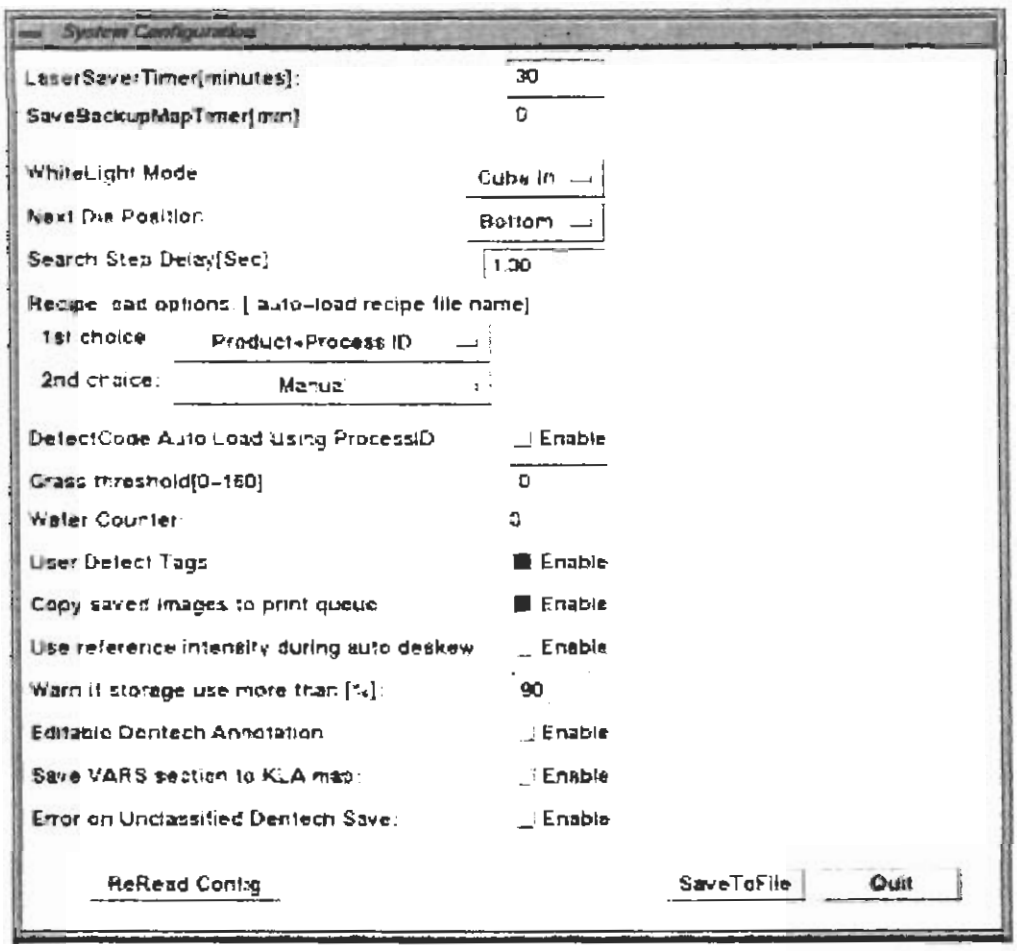


Table 5-29 Config Misc. Parameters

Field	Description
LaserSaverTimer[minutes] entry field	Specifies the number of minutes of mouse or keyboard inaction before the system switches to a standby or idle state. In the laser saver mode, both the laser and white light Halogen lamp are switched to an idle state to prolong longevity.
SaveBackupMapTimer[min] entry field	The time between automatic backups of the current map file. Default is 10 minutes. Setting this value to 0 disables automatic backup.

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Field	Description
WhiteLight Mode option menu	Two white-light-only options are available: with a beam cube in or with the beam cube out. The beam splitter is required in the laser scan mode to get simultaneous white light and laser viewing, as well as in autofocus. However, with the cube in, the white light intensity is cut by 50% (although image quality remains unchanged, and perceived image brightness is down by marginal amount). For very dark samples, one therefore would want to switch out the cube in white-light-only mode. But since the cube has to be *in* in the laser mode, the beam splitter cube switches in and out every time the laser and white-light-only mode is changed. The beam splitter switching is slow and can be a throughput bottleneck. To improve throughput, you have the option of keeping the beam splitter *in* in the white-light-only mode. • Cube Out—Brightest white light image, but switching between white-light and laser can be slow. • Cube In—Slightly dimmer image for the same camera intensity, but otherwise no changes in image quality. Significantly better throughput and reliability.
Next die position option menu	When viewing a defect, sometimes it is useful to compare the image with that of an adjacent die. The KLA Tencor CRS has a button that allows you to go to the same location on the next die. Use the Next Die Position to specify where the next die is located: Bottom/Left/Top/Right.
Search Step Delay[Sec] entry field	Defines the time interval (in seconds and hundredths) between successive moves when using the Search function (see Section 3.5.5, "Search Subwindow").
Recipe Load Options: [auto-load recipe file name] option menus: 1st choice: and 2nd choice:	See Table 5-30,
DefectCode Auto Load Using ProcessID toggle button	Use the ProcessID information from the defect file header to construct the name of the defect code file to load.
Grass Threshold[0-160] entry field	Grass is low-level noise in wafer surface images. It usually looks somewhat like blades of grass sticking up. This parameter tells the software to suppress grass up to a certain level, which also suppresses any image data buried in the noise.
Wafer Counter display	The number of wafers which have been processed during this session.
User Defect Tags: toggle button	Marks in the leftmost column in defect list displays, indicating defects that have been visited.
Copy saved images to print queue: toggle button	When this is enabled, saved images are printed automatically.
Use reference intensity during autodeskew toggle button	The reference intensity is the WL Intensity value set in the Recipe Laser and Imaging Control Window shown in Fig. 5-9 on page 91. The autodeskew software can be instructed to use this value in comparing images of the deskew points.

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Field	Description
Warn if storage use more than [%] entry field	It is recommended that 25% free space be maintained to allow for generation and storage of volume and surface images on demand. If this option is disabled, users can look in the File Transfer window on the Maintenance menu to see the amount of free space on the hard drive.
Editable Dentech Annotation toggle button	An application note on the use of Dentech equipment and files is available. Consult your application engineer for details on connecting the CRS to Dentech equipment and on the use of these features.
Save Dentech VARS section to KLA map: toggle button	
Error on Unclassified Dentech Save: toggle button	
ReRead Config button	Reads configuration file and sets parameters found in it. Used by service engineers after editing configuration file.
SaveToFile button	Save changes in `.uvconfig` file.
Quit button	Discard changes and exit window.

Click on the option menu **Recipe Load Options** to see the various automatic recipe loading options, which are explained in Table 5-30. The default of Manual requires you to load the recipe by specifying the filename in the File-Recipe menu. If you select an option such as First 4 characters of ..., the system looks for recipe names that match the first 4 characters of the Lot ID, Process ID, etc. (depending on your selection).

Table 5-30 Automatic Recipe Load Option Menu

Manual
First 5 char productID
First 7 char productID
First 5 char lot ID
First 7 char lot ID
First 5 char processID
First 7 char processID
Product ID
Lot ID
Process ID
Product+Lot ID
Product+Process ID

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Lot+Process ID
MapFile Name Match

The two fields described in Table 5-31 were available in the ***Config Misc.*** window in earlier software versions. They are now recipe parameters, so that each recipe can have its own values appropriate to a specific product and process.

Table 5-31 Obsolete Config Misc. Parameters

Deskew Die Offset entry field	For a defect file that contains no deskew information (for example, KLA Results files), the ***KLA Tencor*** CRS generates the three deskew points at the lower left corner of three key dies. The left-most middle die is selected as the first deskew die, the right-most middle die is selected as the second deskew die, while the center "00" die is used as the registration die. Sometimes a wafer may have no pattern on the outer-most die locations and the use of a non-existent die for deskew causes problems. A Deskew Die Offset of 1 makes the die next to the outermost dies the deskew die, an offset of 2 selects the dice 2 die space away from the left and right die. The die offset adjustments applies even to those files that do have deskew information. The deskew points in a Tencor file, for example, can point to an incomplete die, or a test die. In this case, you can use the Deskew Die Offset to move the deskew points to another die.
FlatFinder Angle Offset	If the wafer pattern is slightly skewed with respect to the wafer flat, or if there is an error in the robot teach angle, the wafer pattern on the monitor screen appears to be tilted. A stage movement along the wafer's horizontal street causes the wafer pattern to move vertically. This phenomena can be removed by adjusting the FlatFinder Angle Offset. The adjustment resolution is 0.125° (1/8 of a degree) and a typical value is within ±0.5°.

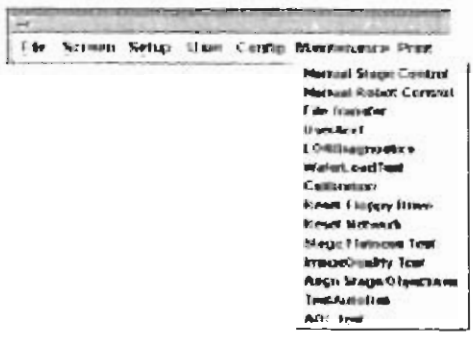
Maintenance Menu

All of the functions for dealing with system problems, configuring the system, and performing calibration procedures that have been automated are on the **Maintenance** menu shown in Fig. 5-76.

WARNING **Maintenance functions should be used only by trained service personnel or customer engineers who are very familiar with operation of the CRS. Functions on the Maintenance menu bypass normal software constraints, creating a variety of possibilities of damage to wafers or equipment, or injury to personnel. Exposure to scattered laser light is also possible.**

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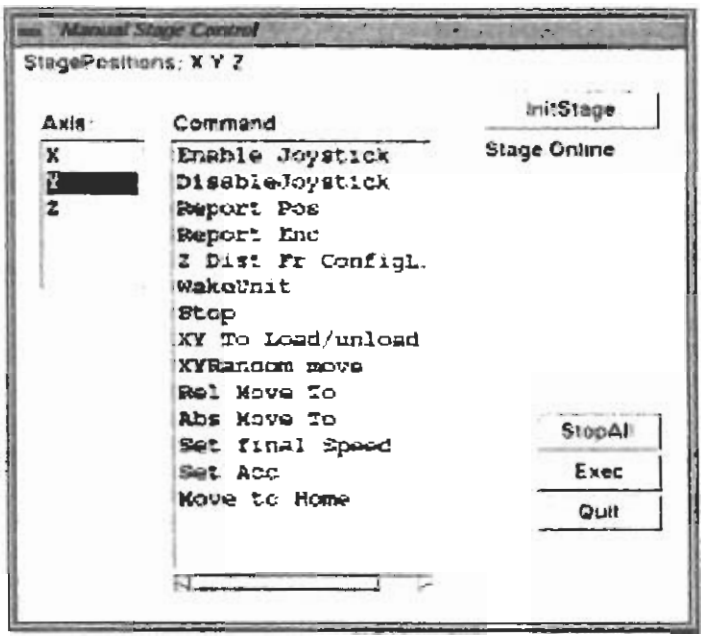
Figure 5-76 Maintenance Menu



Manual Stage Control

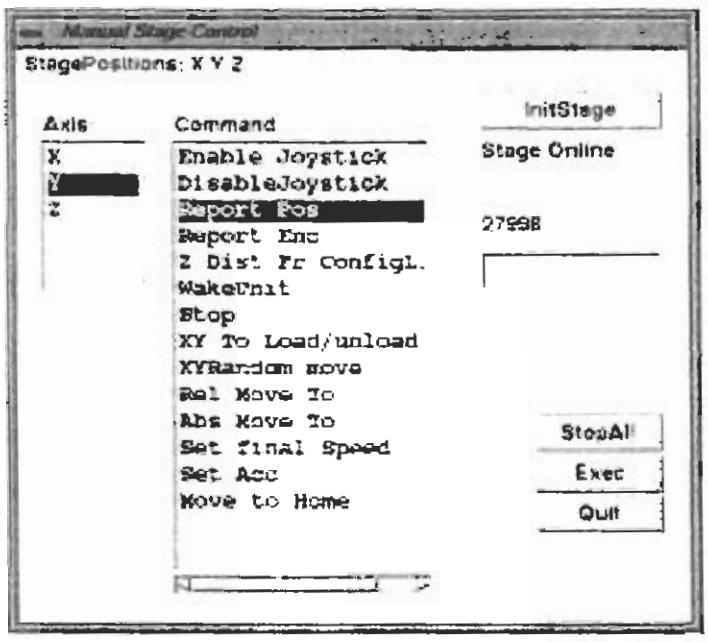
Fig. 5-77 shows how the Manual Stage Control window first appears, before any commands have been executed. There is a menu of commands in the center of the window, allowing control of the stage position and motion parameters, and of the joystick. The menu at the left selects one of the three axes of motion for the next command to apply to. Command buttons are provided to initialize the stage, abort the currently running command, execute the selected command on the selected axis (if applicable), and quit. When a command is selected which requires entry of a parameter or position value, a data entry field appears, as in Fig. 5-78 on page 155.

Figure 5-77 Manual Stage Control Window



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Figure 5-78 Manual Stage Control with Data Reporting and Input Field



Manual Robot Control

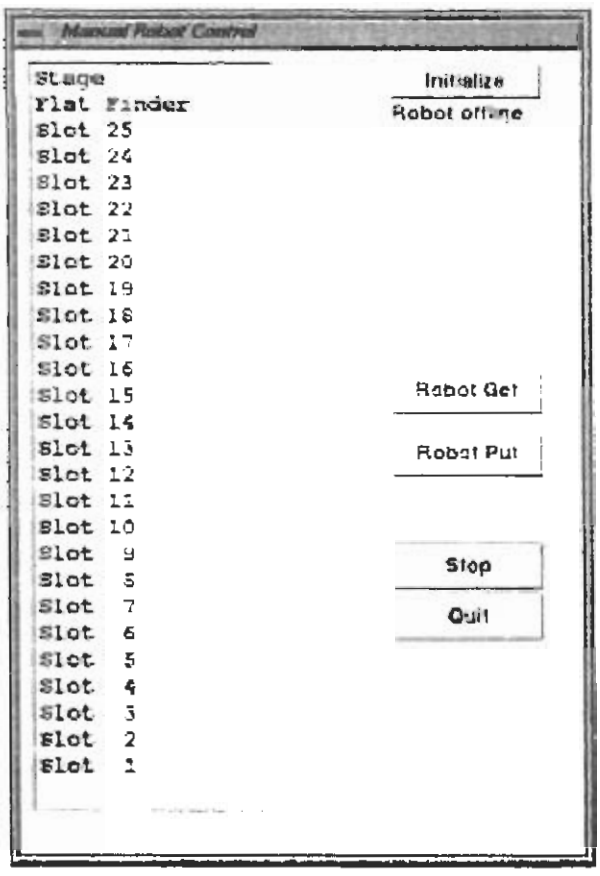
Fig. 5-79 shows the ***Manual Robot Control*** window. At the left is a list of wafer positions, including the stage, the prealigner, and the 25 slots in the current cassette. One of these positions must be highlighted by clicking with the mouse before picking up or placing a wafer. At the right are several control buttons. The ***Initialize*** button returns the robot to its starting state, a function essential during service but not needed in normal operation.

WARNING

Use of these functions is under limited safety controls. Improper usage can break wafers, damage the robot and other components, or injure personnel.

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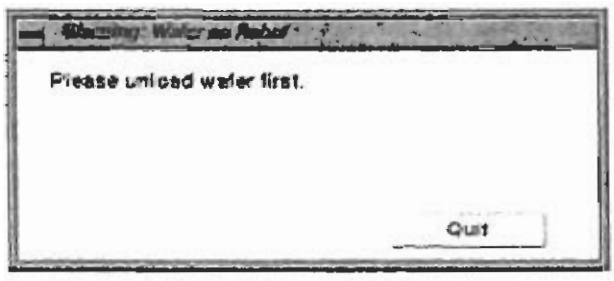
Figure 5-79 Manual Robot Control Window



The ***Robot Get*** button instructs the robot to pick up a wafer from the selected location, following a routine programmed into the robot controller to retract the robot arm, move to the selected position, extend the arm in below the wafer, apply vacuum, raise the arm to pick up the wafer, and retract the arm.

If no location has been selected, or the CRS senses a wafer on the robot arm (by monitoring the vacuum pressure), an error message appears, and the robot does not move. If no wafer is present at the specified location, the robot goes through the motions anyway.

Figure 5-80 Wafer on Robot Error Message



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When a wafer is on the robot arm, selecting a position and clicking on the ***Robot Put*** button causes the robot to place the wafer in that position. If the CRS senses a wafer on the stage or prealigner, or the current wafer map shows that the selected cassette slot has a wafer, an error message appears, an it Fig. 5-81 or Fig. 5-82, and the robot does not move.

Figure 5-81 Wafer Loaded Error Message

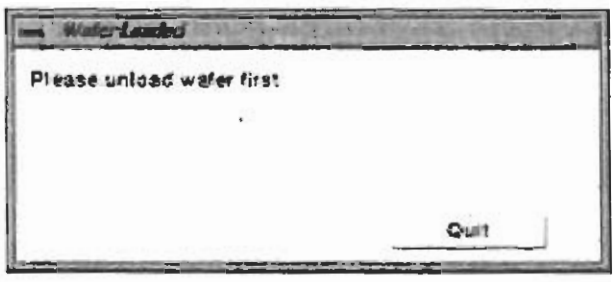
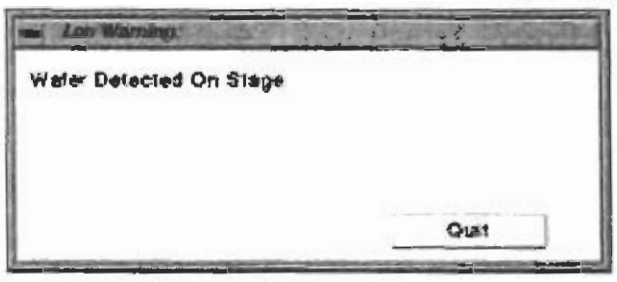
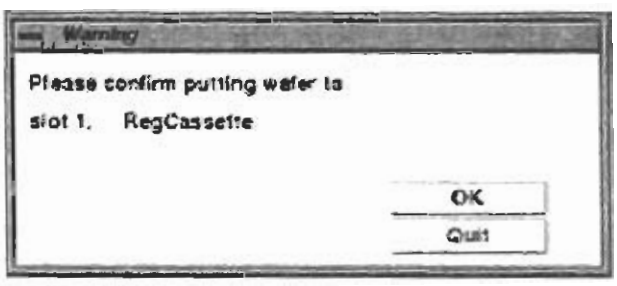


Figure 5-82 Wafer on Stage Error Message



The CRS cannot tell whether there is a wafer in a cassette slot. In Manual Robot Control, when the robot is commanded to put a wafer in a slot not known to have a wafer, the software asks for confirmation of the destination cassette and slot before placing a wafer there. Verify the destination in order to avoid wafer breakage.

Figure 5-83 Confirm Slot Message



If the robot is moving incorrectly, clicking on the ***Stop*** button will freeze it. The ***Quit*** button exits the window as usual.

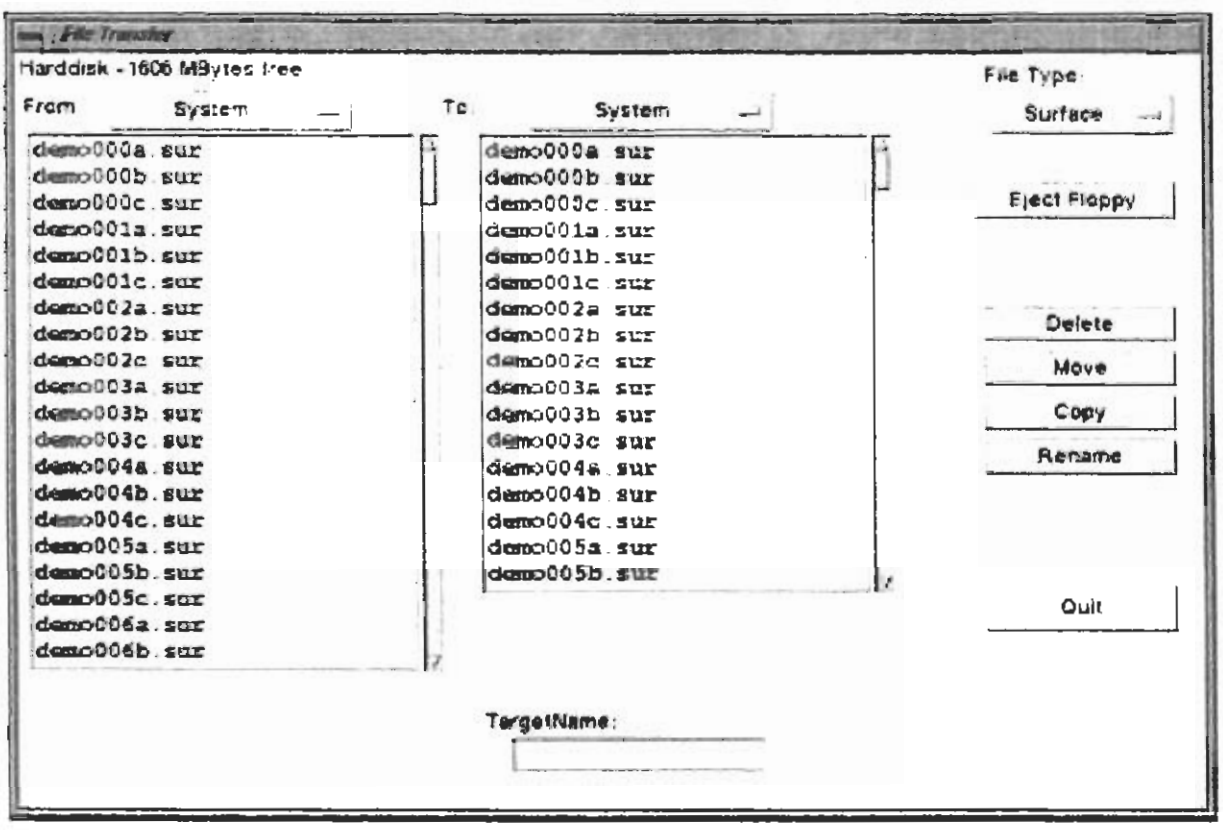
File Transfer

The ***File Transfer*** window shown in Fig. 5-84 has controls for managing files outside the normal routine of CRS operation. Files are displayed in two panes, the source on the left (marked ***From:***), and the destination on the right (marked ***To:***). There are buttons to delete and rename files in the

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source pane, and to move or copy files from the source pane to the destination pane. Option menus allow the user to select from the available directories and file types. There is a button to eject a floppy disk. The ***Target Name:*** entry field displays the name of any file selected from the source pane. Entering a new name here and clicking on the ***Rename*** button renames the selected file. Entering a new name and clicking on either the ***Move*** button or the ***Copy*** button creates a copy of the file with the new name in the destination directory. The difference is that ***Copy*** leaves the original file, while ***Move*** deletes it.

Figure 5-84 File Transfer Window



The file type option menu is shown in Table 5-32. ADC KnowledgeBase files and ADC files are described in the CRS ADC manual.

Table 5-32 File Transfer Window File Type Option Menu

Surface
Volume
Wafer Map
Bit Map
Recipe
Defect Code
All

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ADC KBase
ADC Files

The file type of a file is generally indicated by its filename extension, the portion of the filename after the dot. The extension for CRS files is the last three characters. CRS file types and extensions are listed in Table 5-6 in the section "File Types" on page 84. The ***File Transfer*** dialog box usually lists only one file type at a time. When the **All** option is selected, all files in the directory are listed together. When the Wafer Map file type is selected along with the FLOPPY, IMPORT, REMOTE or REMOTE2 directory, then all filenames are listed.

Target Name

Clicking on a file from the ***From:*** directory selects that file for later deleting, moving, copying, or renaming. The name of the selected file is also copied to the ***TargetName*** entry field. The name in the entry field is used as the new filename when renaming, and as the target name when copying or moving. You can edit the name in the entry field for the different name desired.

Actions

The actions described in Table 5-33 can be performed in the File Transfer dialog box:

Table 5-33 File Transfer Actions

Action	Description
Delete	The selected file from the From directory is deleted.
Move	The selected file from the From directory is moved to the To directory with a filename from the TargetName entry field. That is, the selected file is copied to the new directory and deleted from its original location.
Copy	The selected file from the From directory is copied to the To directory with a filename from the TargetName entry field.
Rename	The selected file from the From directory is renamed to be the name from the TargetName entry field.

File selection

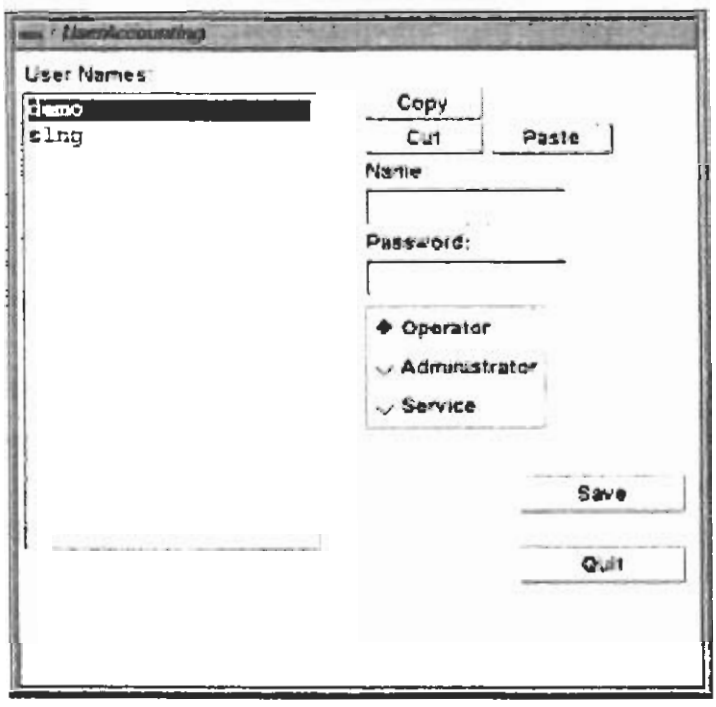
- To select a single file from the ***From:*** filename list box, click on the desired filename.
- Clicking and dragging selects a range of files.
- Holding down the shift key and clicking with the mouse on two different file names also selects a range.
- Holding down the control key and clicking selects or deselects individual files without disturbing the rest of the selection, so it can be used to select scattered files.
- Holding down control, and then clicking and dragging, adds a range to a selection.
- Holding down control and shift, and then clicking, also adds a range to a selection.
- A warning message is displayed for deleting, coping, or moving multiple files. Only one file can be selected at a time for Rename.

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UserAcct

The ***UserAccounting*** window shown in Fig. 5-85 provides functions for creating, deleting, and editing user accounts and privileges. It is only available to accounts with Service privileges. Each user account has a name and password set in the entry fields, and a privilege level, set with the radio buttons. The password may be blank. The privilege levels are described in Table 5-1 on page 77.

Figure 5-85 User Accounting Window



The ***User Names*** list box displays the list of current user accounts. After setting up the information for a new user account, the information must be pasted into the ***User*** list in order to create the account, and the ***User*** list must be saved. The ***User Account*** window buttons and functions are described in Table 5-34.

Table 5-34 User Account Window Functions

Action	Description
Copy	Copies the information for the selected account to the name and password fields and the privilege radio buttons.
Cut	Copies the information for the selected account to the name and password fields and the privilege radio buttons. The selected user account is deleted from the User list.
Paste	Create a new user and puts information into the User list, from the name, password and privilege displayed. Paste can make multiple user accounts with the same name.

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Action	Description
Save	Opens a window to ask whether the changes should be saved. Clicking on OK saves the changed user account information and closes the User Account window.
Quit	Discards changes and closes the window

- To create a new account: Enter name and password, and select privilege level. Then click on Paste.
- To create a new account based on an existing account: Select existing account, click on Copy, make changes including a new name, and click on Paste.
- To delete an account: Select account to delete, and click on Cut.
- To change an account: Select account, click on Cut, make changes but leave the current name, and click on Paste.
- When adding, changing, or deleting accounts, remember that the changes must be saved in order to take effect.

LONDiagnostics

The LON (Local Operating Network) is completely contained within the CRS unit, connecting the SGI workstation to the nodes which control various optical and mechanical systems. Each node is a board with its own processor and two network connections. The boards are daisy-chained in a linear network topology. This means that if any board or connector fails, the rest of the network beyond that point is also out of communication. The NEAT stage controller and the Equipe robot controller are not on the LON, but have their own communications links and their own protocols, which are beyond the scope of this manual.

The CRS application software can communicate with each node individually, setting parameter values in network node variables or reading the current variable values back. Each node has its own list of variables, shown below.

In normal operation, there is no need to test or set network variables. LON Diagnostics functions should be used only by trained service personnel for troubleshooting, configuration, and calibration of the CRS. These functions are available to Administrator accounts, but not to Operator accounts.

Fig. 5-86 shows the ***Lon Diagnostics*** window. It contains a large number of controls, which are summarized in Table 5-35.

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Figure 5-86 LON Diagnostics Window

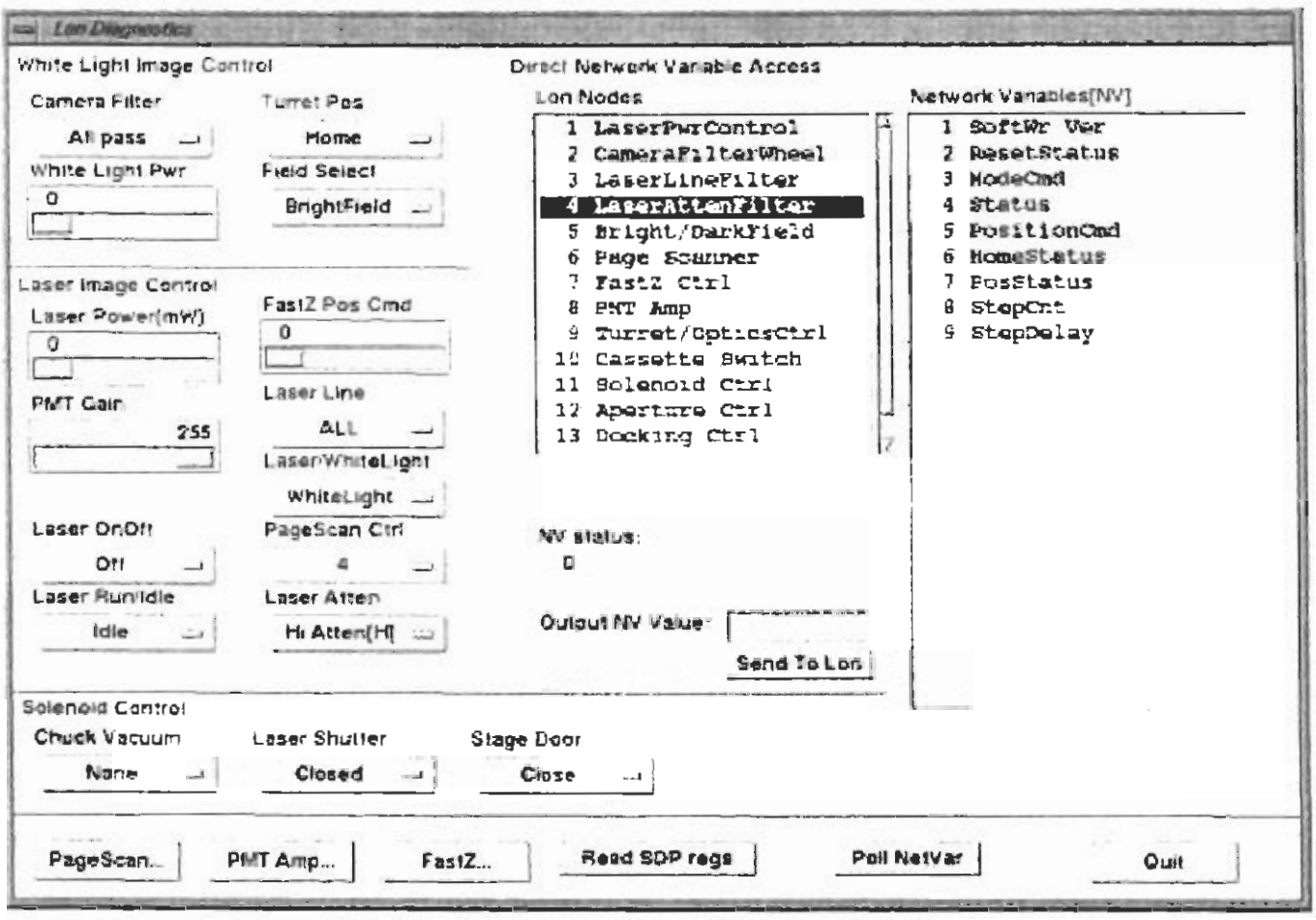


Table 5-35 Lon Diagnostics Window Controls

Control	Function	Comments
White Light Image Control		
Camera Filter option menu	• Polar • 2ndPos • Dim • Yellow • All Pass • Reset[H]	• Polarizing filter • 488 nm notch filter • Neutral filter • Wide band, for laser • No filter • Home position (All Pass) after full turn

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Control	Function	Comments
Turret Position option menu	• 5 • 20 • 50 • 100 • 150 • Home	 • To 5×
White Light Power slider	• 0–255	
Field Select option menu	• BrightField • DarkField	
	Laser Image Control	
Laser Power(mw) slider	• 0–25	
PMT Gain slider	• 0–255	
Laser On/Off option menu	• On • Off	
Laser Run/Idle option menu	• Run • Idle	
Fast Z Pos Command	• 0–4095	• In 12 nm steps
Laser Line option menu	• 458 • 2nd Pos • 488 • 4thPos • 515 • ALL	• No filters in 2nd Pos and 4thPos
Laser/WhiteLight option menu	• White Light • Laser	• White light only • Laser and white light
Page Scan Ctrl	• 0 • 4 • 8 • 12	• 1× • 2× • 4× • 8×

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Control	Function	Comments
Laser Atten	• 1stPos • Low Atten • 3rdPos • Med Atten • Max Atten • Hi Atten[H]	1 2 not used 3 5 4
Solenoid Control		
Chuck Vacuum	• None • 4in • 6in • 8in	
Laser Shutter	• Closed • Open	
Stage Door	• Close • Open	
Direct Network Variable Access		
LON Nodes list box	• See headings following "LON Nodes" on page 167	
Network Variables list box	• See lists following "LON Nodes" on page 167	
NV Status	• Readout of Network Variable value	
NV entry field	• Enter values to send to LON	
Send to LON button	• Sends value in NV entry field to selected variable at selected LON node	
Misc.		
Page Scan...	• See Fig. 5-87	
PMT Preamp...	• See Fig. 5-88	
FastZ...	• See Fig. 5-89	
Read SDP Regs	• Register values from frame grabber	

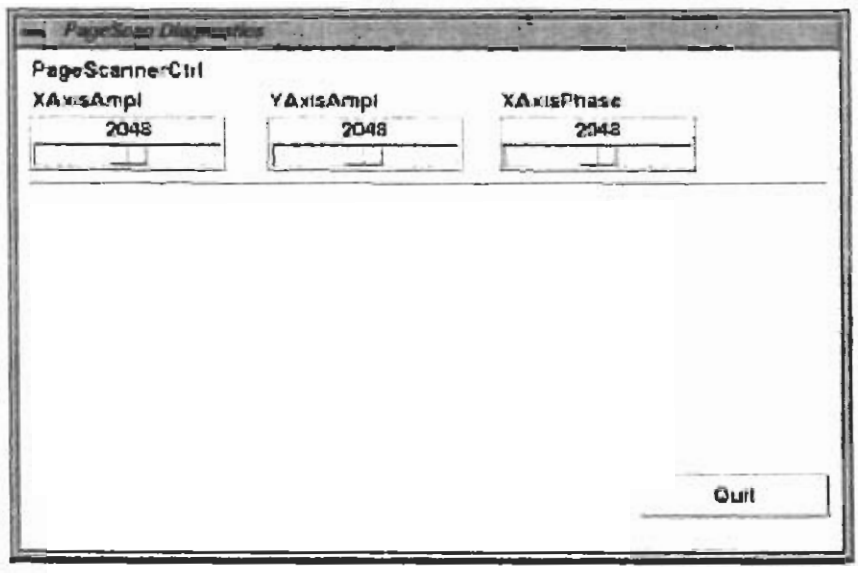
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Control	Function	Comments
Poll NetVars	• Read all LON variables, and report an error for missing values	
Quit	• Close window	

PageScan...

The ***PageScan...*** button brings up the ***Page Scan Diagnostics*** window shown in Fig. 5-87, with slider controls for the mirror assembly that scans the laser beam. In normal use the amplitude in the X and Y directions is not set manually. The phase, which relates the timing of the beam scan to the timing of image acquisition, is normally not adjusted at all. The ***Quit*** button closes the window.

Figure 5-87 Page Scan Diagnostics Window



PMT Amp...

The ***PMT Amp...*** button brings up the ***PMT Amplifier Diagnostics*** window shown in Fig. 5-88. It provides several adjnstments to PMT control parameters for adjusting the PMT response to

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returned laser light. These controls are set at the factory, and not adjusted in normal operation or routine maintenance.

Figure 5-88 PMT Amplifier Diagnostics Window

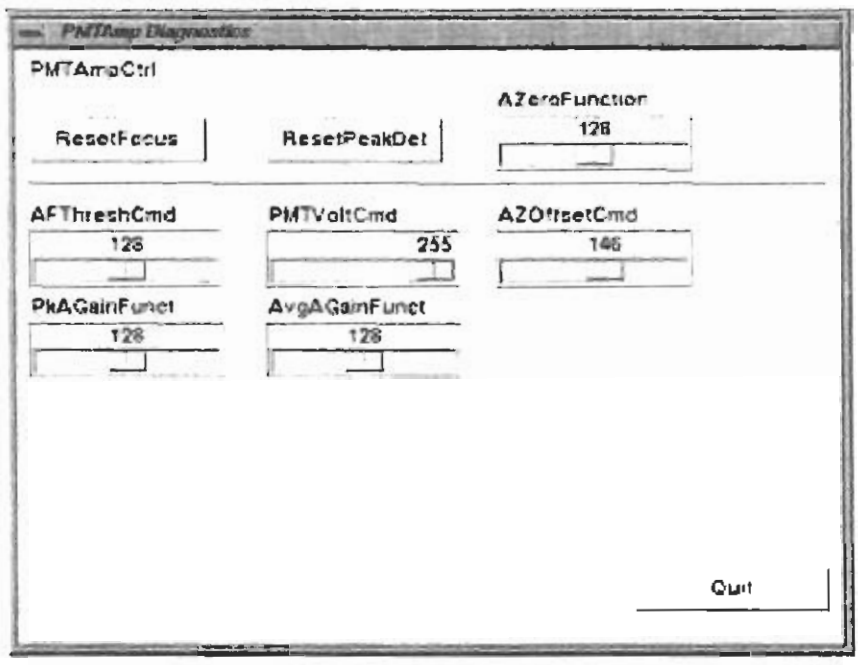


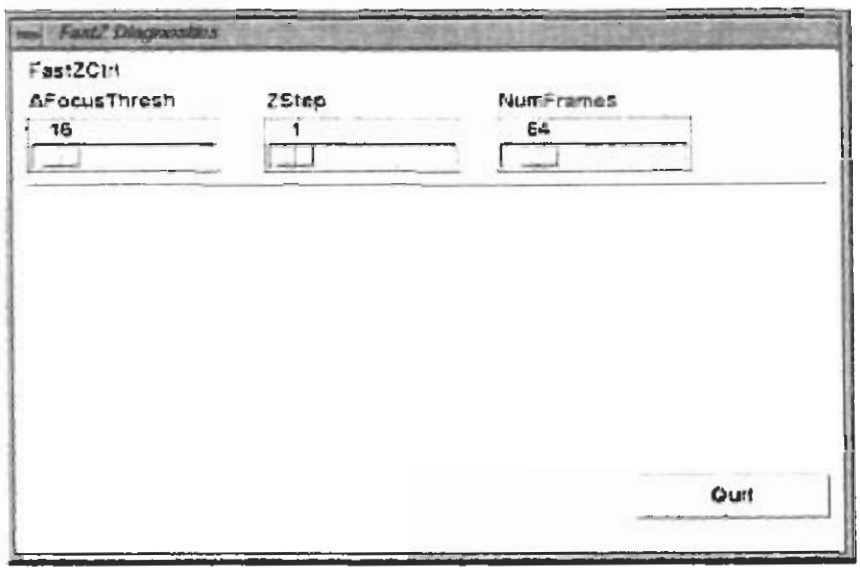
Table 5-36 PMT/AMP Diagnostic Window Controls

FastZ...

The ***FastZ...*** button brings up the ***Fast Z Diagnostics*** window shown in Fig. 5-89. These controls are not adjusted in normal operation or routine maintenance. The autofocus threshold is a parameter used by the autofocus algorithm. The ZStep is set in increments of 12 nm. The number of frames for volume imaging defaults to 64.

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Figure 5-89 Fast Z Diagnostics Window



LON Nodes

Each of the LON nodes has its own set of variables for controlling its specific function within the CRS. The ability to read and set individual LON variables is a powerful diagnostic tool for service engineers, but there is no reason to use this function in normal operation. The following 13 tables list the variables for each of the nodes, including those for options which are not included with every system.

1 LaserPwrControl LON Node

Table 5-37 Laser Power Control Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	LaserStatus
5	LaserOn/Off
6	Run/Idle
7	Light/Curr
8	CurrentCmd
9	PowerCmd
10	WhiteLtPwr
11	SpareCmd
12	InterLock
13	CurrCheck
14	PwrCheck
15	WLPwrCheck
16	SpareCheck
17	HeadTempMon
18	WlPwrSupMon
19	LaserPwrMon
20	CurrMonitor

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2 CameraFilterWheel LON Node

Table 5-38 Camera Filter Wheel Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	PositionCmd
6	HomeStatus
7	PosStatus
8	StepCnt
9	StepDelay

3 LaserLineFilter LON Node

Table 5-39 Laser Line Filter Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	PositionCmd
6	HomeStatus
7	PosStatus
8	StepCnt
9	StepDelay

4 LaserAttenFilter LON Node

Table 5-40 Laser Attenuation Filter Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	PositionCmd
6	HomeStatus
7	PosStatus
8	StepCnt
9	StepDelay

5 Bright/DarkField LON Node

Table 5-41 Bright/DarkField Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	PositionCmd
6	PosStatus
7	Sw1Status
8	Sw2Status
9	StepCnt

6 Page Scanner LON Node

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Table 5-42 Page Scanner Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	VertSync
6	TraceTiming
7	RetraceTime
8	StartAmpOff
9	Increment
10	Decrement
11	CtlRegValue
12	XAxisAmpl
13	YAxisAmpl
14	XAxisPhase

7 FastZ Ctrl LON Node

Table 5-43 Fast Z Control Network Variables

1	SoftWr Ver
2	ResetStatus
3	OpMode
4	OpStatus
5	OpParArr1
6	OpParArr2
7	OpStsArr1
8	OpStsArr2
9	AFocusThresh
10	ZPositionCmd
11	ZControl
12	MuxSelect
13	ZStep
14	NumFrames
15	ZStatus
16	PosStatus
17	Intensity0
18	Intensity1
19	Intensity2
20	Intensity3
21	Intensity4
22	Intensity5
23	Intensity6
24	Intensity7
25	Intensity8
26	Intensity9
27	Intensity10
28	Intensity11
29	Intensity12
30	Intensity13
31	Intensity14
32	Intensity15
33	SelfTest
34	AutoFocus

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35 ReadVideo
36 ReadFeedBk
37 ReadHV
38 SetForVol
39 MonitorFoc
40 Abort
41 ReadStatus
42 AutoFocus0
43 AutoFocus1
44 AutoFocus2
45 AutoFocus3
46 AutoFocus4
47 AutoFocus5
48 Rd Intensity
49 StartContiAF
50 StopContiAF

8 PMT Amp LON Node

Table 5-44 PMT Amplifier Network Variables

1 SoftWr Ver
2 ResetStatus
3 ModeCmd
4 Status
5 OpParArr1
6 OpParArr2
7 OpStsArr1
8 OpStsArr2
9 ResetFocus
10 ResetPeakDet
11 FocThresStat
12 PMTOverLoaded
13 PMTClamped
14 AFThresCmd
15 PMTVoltCmd
16 AutoZeroCmd
17 AZeroGainK1
18 AZeroGainK2
19 AZeroGainK3
20 AvgAutoGainK1
21 AvgAutoGainK2
22 AvgAutoGainK3
23 SelfTest
24 AutoZero
25 PkAutoGain
26 AvgAutoGain
27 ReadAvgVideo
28 ReadPkVideo
29 ReadPMTHV
30 ReadLaserPwr
31 ReadVideoZero
32 ReadFocus
33 ReadPmtOvld

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9 Turret/OpticsCtrl LON Node

Table 5-45 Turret/Optics Control Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	PositionCmd
6	WL/Laser Sw
7	Shuttor O/C
8	StepDelay
9	ObjStatus
10	ClickStatus
11	HomeStatus
12	TurrPosStat

10 Cassette Switch LON Node

Table 5-46 Cassette Switch Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	CassPresent
6	SizeStatus
7	InterlockStat

11 Solenoid Ctrl LON Node LON Node

Table 5-47 Solenoid Control Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	DoorComd
6	ChuckVacCmd
7	DoorStat
8	CheckVacStat
9	HouseVacStat

12 Aperture Ctrl LON Node

Table 5-48 Aperture Control Network Variables

1	SoftWr Ver
2	ResetStatus
3	ModeCmd
4	Status
5	Position Cmd
6	Pos status
7	Home Status

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```
8 Step Count
9 Travel Lim
```

13 Docking Ctrl LON Node

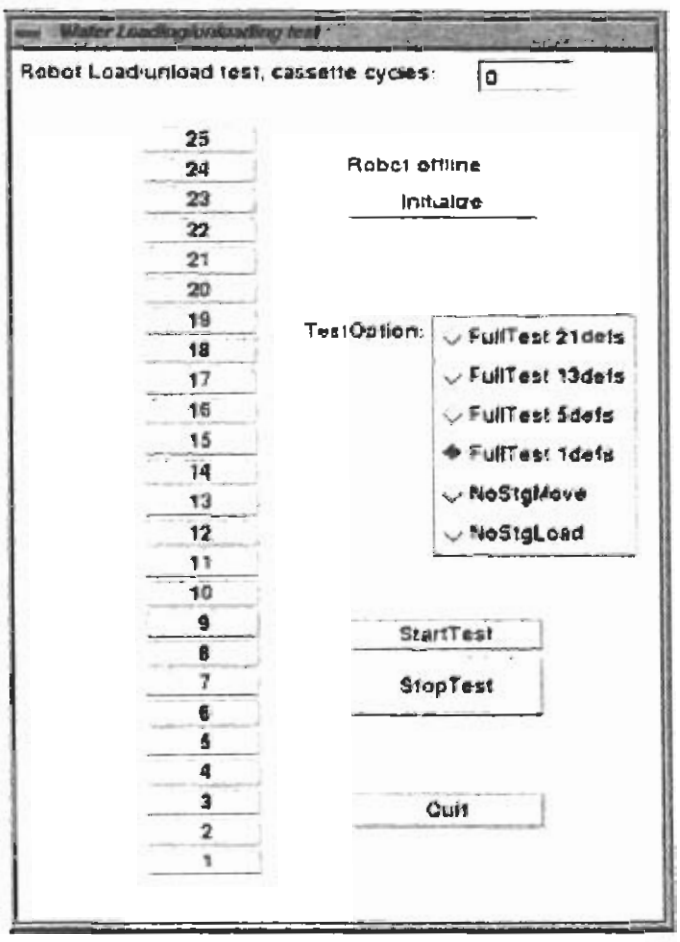
Table 5-49 Docking Control Network Variables

```
1 SoftWr Ver
2 ResetStatus
3 ModeCmd
4 Status
5 Docking Cmd
6 Sol3 Cmd
7 Sol4 Cmd
8 Dock Status
9 Sw 4 status18
```

WaferLoadTest

Fig. 5-90 shows the window for the wafer loading test. The user can set the number of test cycles to execute, has the option of initializing the robot before running a test, and has several options for testing accuracy of wafer placement, ranging from a 21-point defect location test to a simple pick up and replace without even loading the wafer to the stage. The test can be stopped at any point.

Figure 5-90 Wafer Load Test Window



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Calibration

Fig. 5-91 shows the ***LaserScan Calibration*** window. It shows laser scan parameters for each of the four zoom levels. The default values are listed in Table 5-50. Clicking on a laser resolution value, corresponding to one of the four zoom levels, brings up the corresponding display of scan amplitude in both the X and Y directions. These values should not be changed.

Figure 5-91 Calibration Window

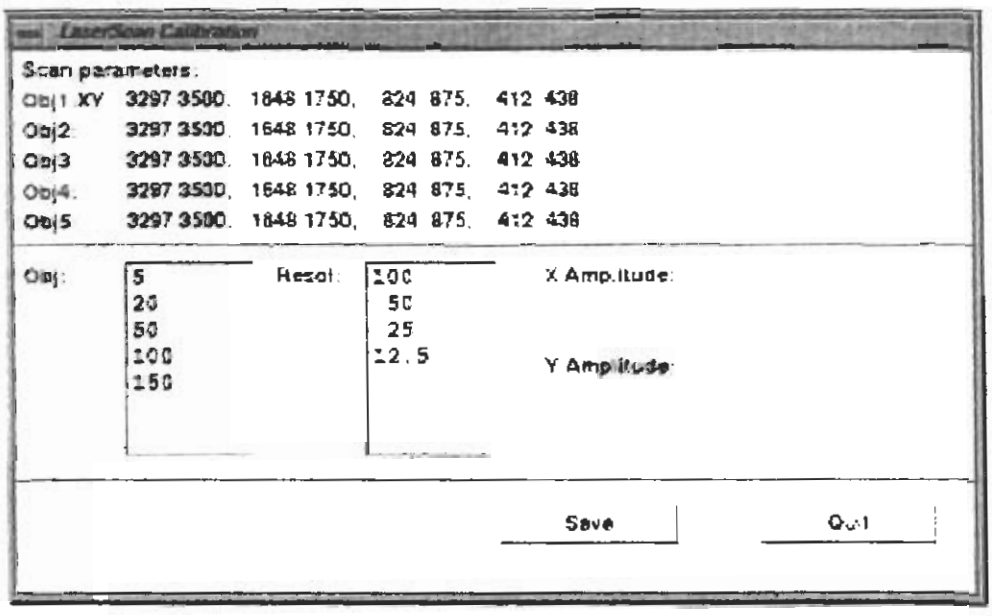


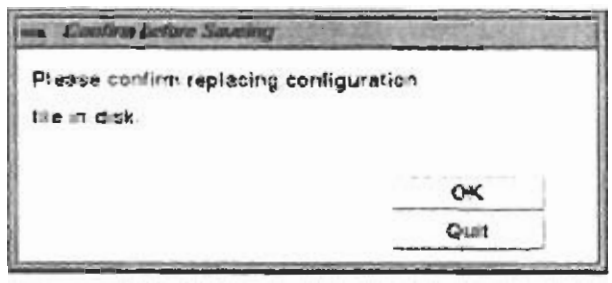
Table 5-50 Laser Scan Parameters

Resolution	Amplitude
100	3400
50	1700
25	850
12.5	425

Clicking on ***Save*** in the ***LaserScan Configuration*** window brings up the dialogue box in Fig. 5-92. Click on ***OK*** to save the new zoom amplitudes for the selected objective and zoom level to `lsvconfig`, or ***Quit*** to abandon changes.

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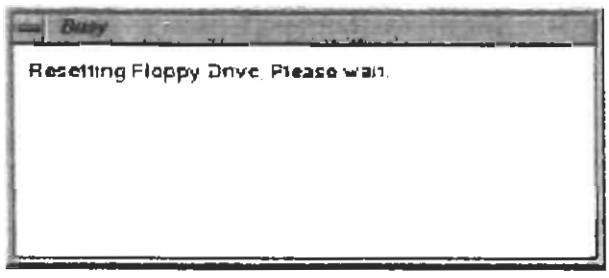
Figure 5-92 Confirm Saving Configuration File Dialogue Box



Reset Floppy Drive

If a problem develops with access to the floppy drive, this command will reset and remount the drive. A message window, shown in Fig. 5-93, appears during the process. A reset will take care of most software problems with accessing the drive. Rebooting is rarely necessary, but is required if the reset command does not cure the problem. See "Lockup Recovery" on page 277 for further details of recovery procedures. If neither a reset nor a system reboot solves the problem, the configuration files and hardware should be checked by a Field Service Engineer.

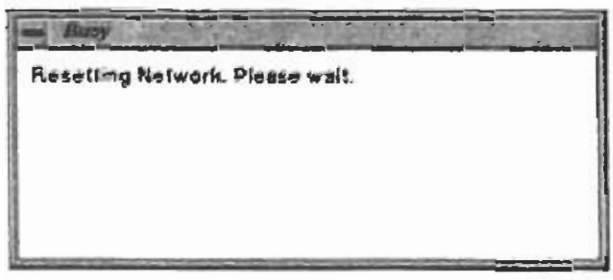
Figure 5-93 Reset Floppy Drive Window



Reset Network

If a problem develops with access to the network, this command will reset and remount the network and network drives assigned to REMOTE directories. A message window, shown in Fig. 5-94, appears during the process. A reset will take care of most software problems with access to the network. Rebooting is rarely necessary. If neither a reset nor a system reboot solves the problem, the configuration files and hardware should be checked by a Field Service Engineer.

Figure 5-94 Reset Network Window

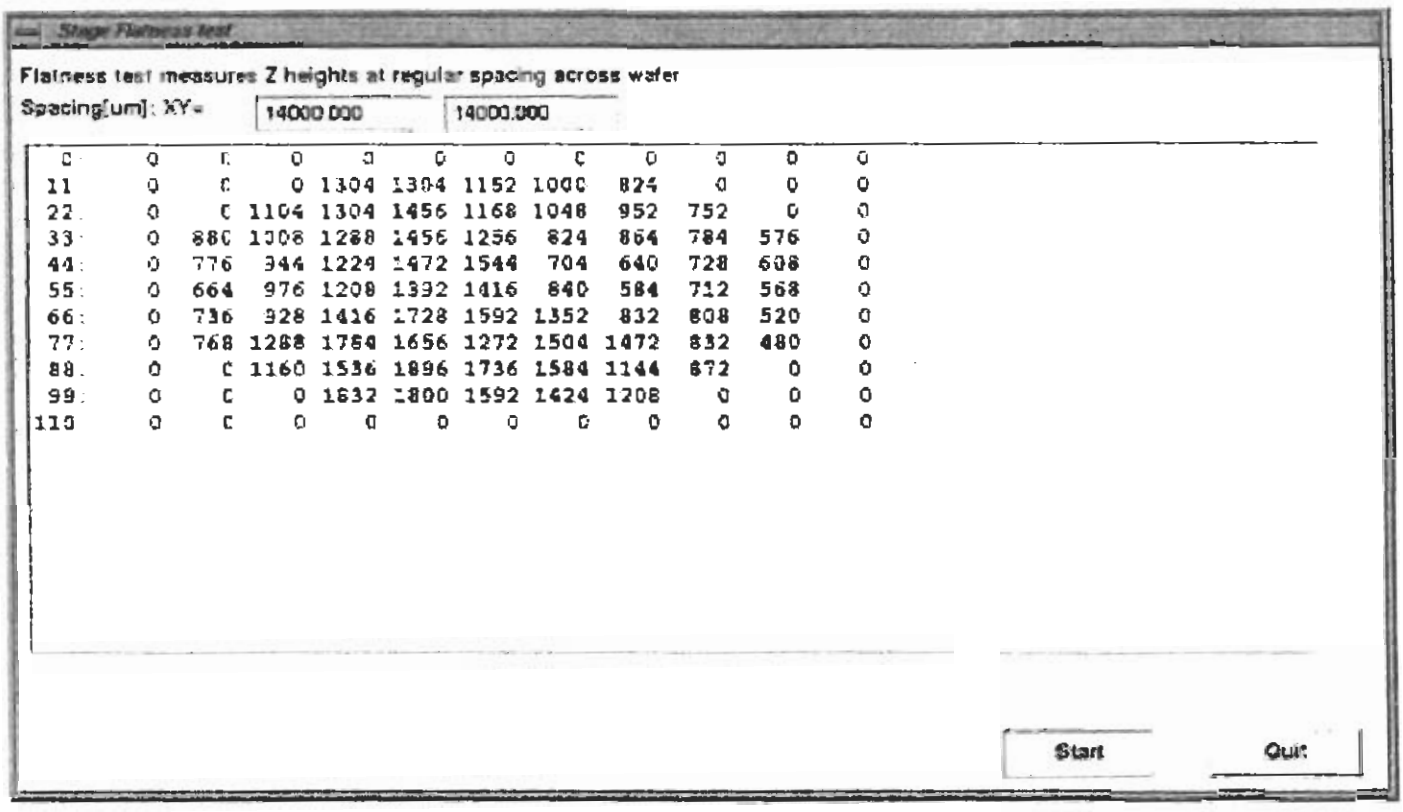


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StageFlatnessTest

Fig. 5-95 shows the results of a Stage Flatness Test. The numbers represent heights above the nominal chuck surface, with 0 representing points off the edge of the wafer. The range of the numbers apart from the 0 values should be within 10µ. In the example, it is over 1000µ. When the window comes up, the large results area is blank, and the default values for the current wafer size are entered in the ***Spacing*** fields. These numbers should normally not be changed. Clicking on ***Start*** begins the process of scanning at intervals across the surface, finding the focus at each XY location, and recording the stage height at that point.

Figure 5-95 Stage Flatness Test Window

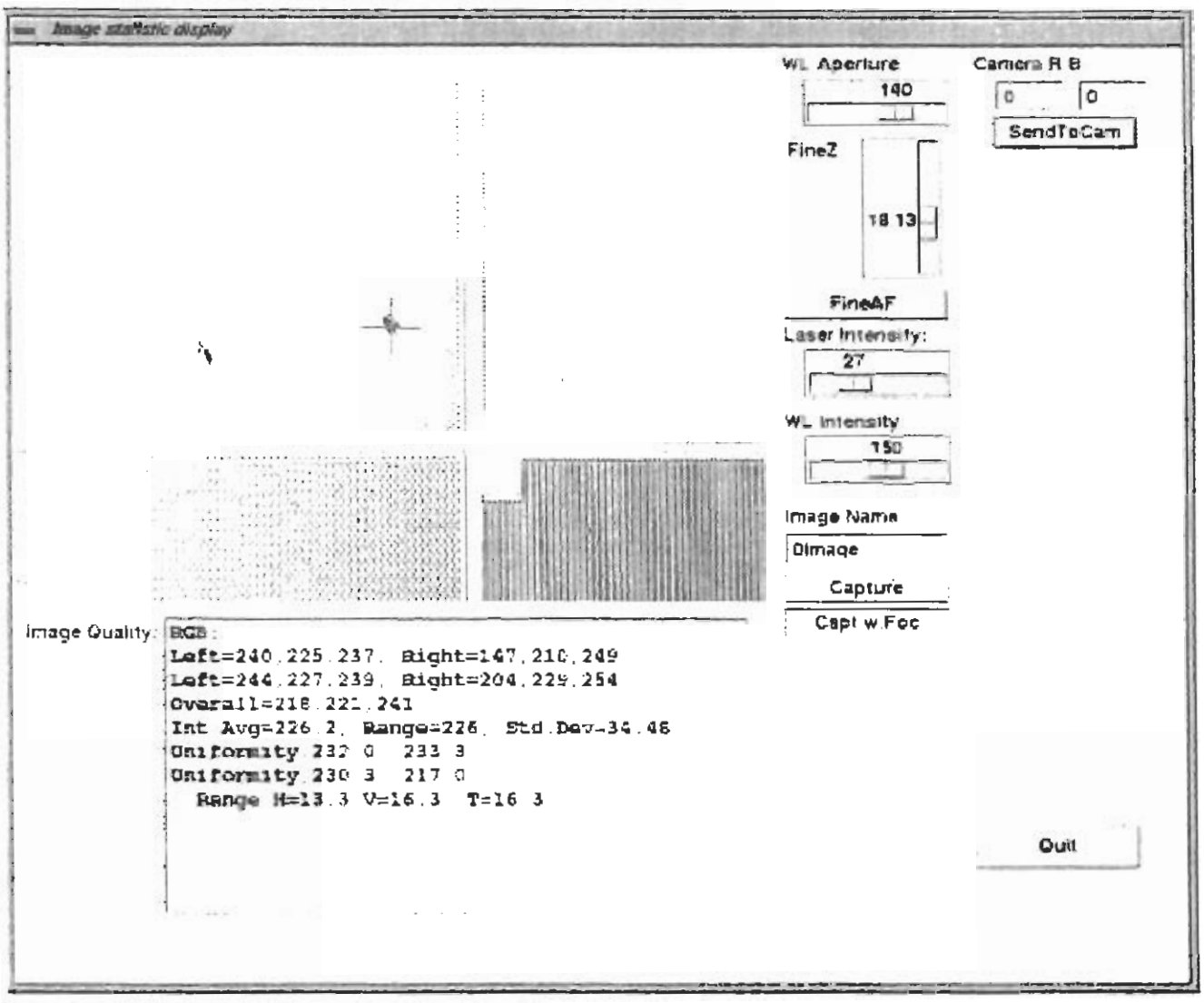


ImageQuality Test

Fig. 5-96 shows the results of an Image Quality Test. These results depend on ADC setup parameters. See the ADC manual for details.

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Figure 5-96 Image Quality Test Window



Align Stage/Objectives

Fig. 5-97 shows the window for aligning the stage to the 150× objective. A similar window appears for each of the other objectives, in sequence during this test. When the image is aligned, click on the ***Done*** button. The CRS will query the stage controller for the current position, and record the offset for the objective. When all of the objectives have been aligned, the window in Fig. 5-98 appears asking whether to save the new values. In any of the alignment windows the ***Cancel*** button will abort the alignment process without making changes to the system configuration, and will exit. In the last window, clicking on ***OK*** saves the changes, and clicking on ***Quit*** exits the window without saving any changes.

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Figure 5-97 Align Stage/Objectives Window

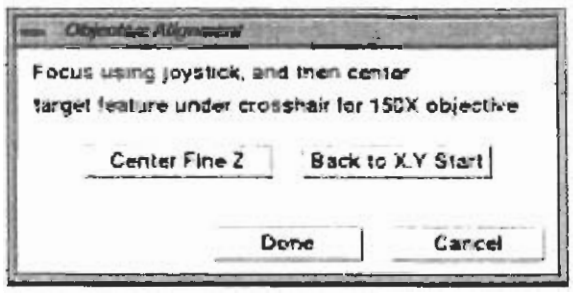
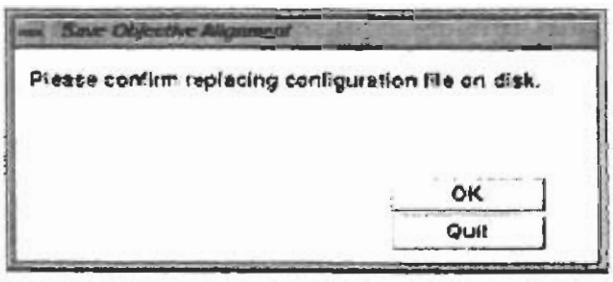


Figure 5-98 Save Stage/Objective Alignment Window

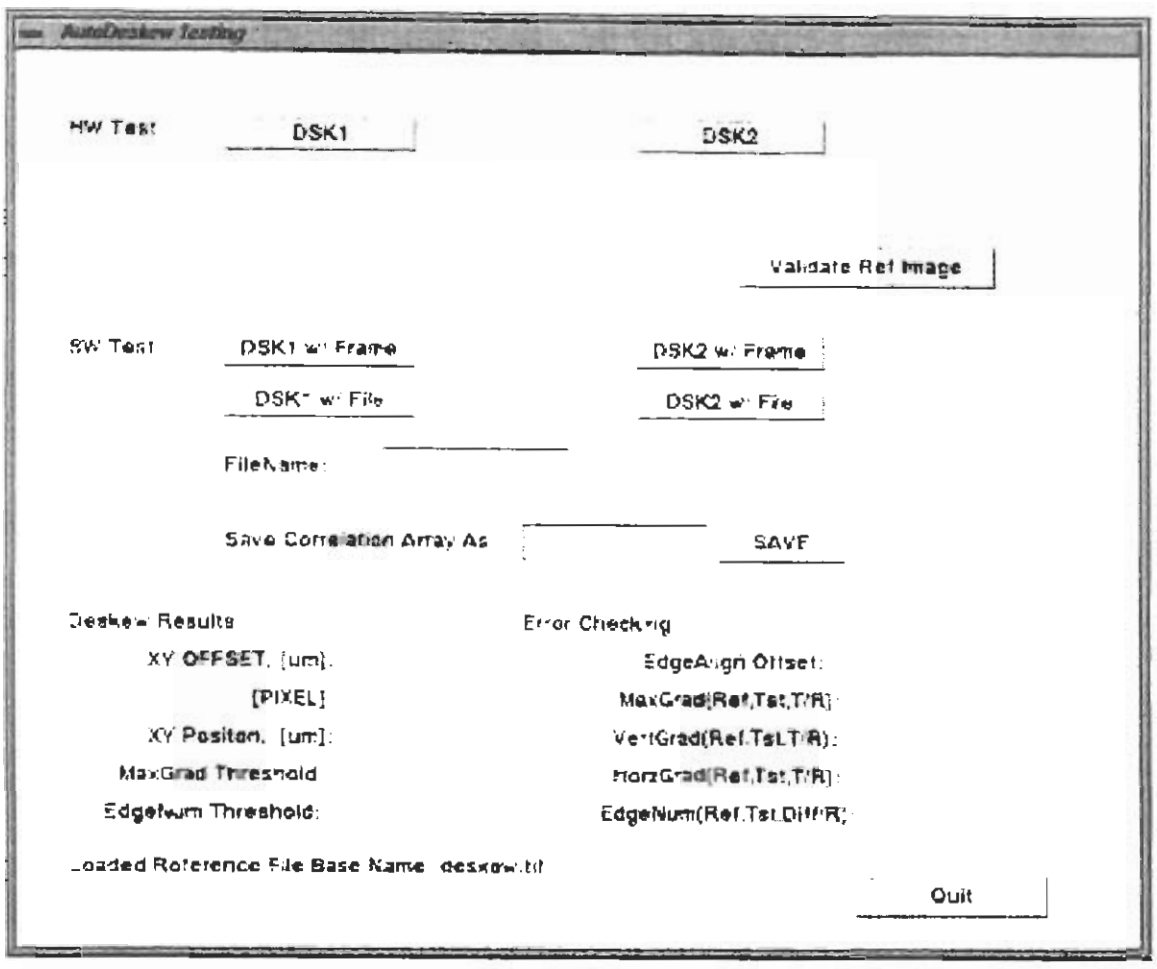


TestAutoDsk

Fig. 5-99 shows the initial state of the Test Auto Deskew window. There are tests of the hardware (for locating the first two deskew points), the software (for comparing the captured image files with the current images), and the image files. The tests return various measurements which an expert can use to evaluate the AutoDeskew process.

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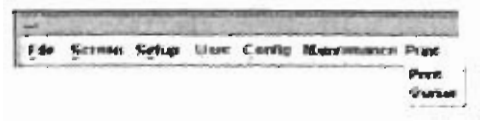
Figure 5-99 Test AutoDeskew Window



Print Menu

The last menu, **Print**, is shown in Fig. 5-100. The **Print** command sends images for printing and also can save images to files, while the **Queue** command reports the status of images sent to the printer but not yet printed.

Figure 5-100 Print Menu

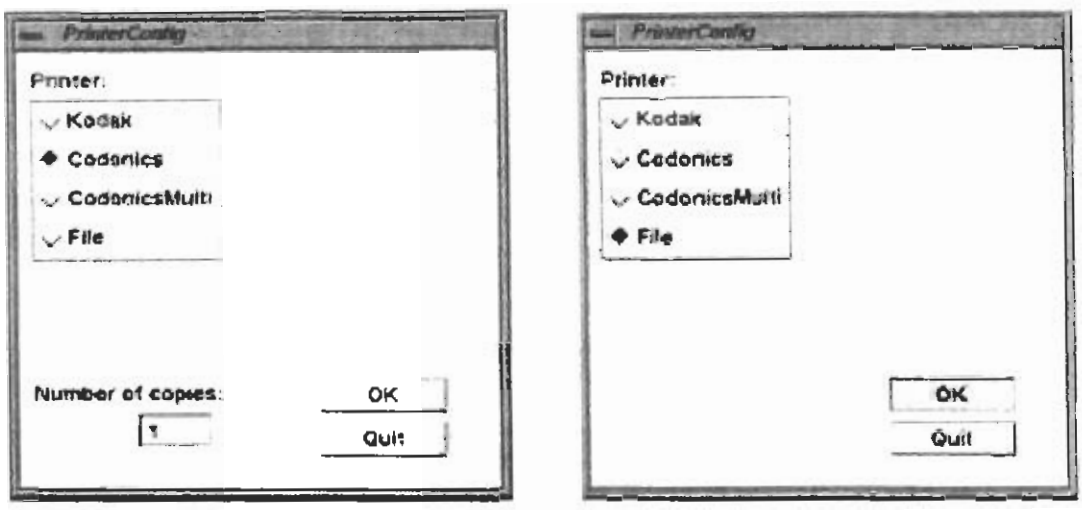


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Print

Fig. 5-101 shows the ***PrinterConfig*** window brought up by the **Print** command on the **Print** menu, with radio buttons for three types of printer and for saving an image to a file. When a printer is selected, a data entry field appears for the number of copies to print. Clicking on ***OK*** sends the image to the printer. When the ***File*** radio button is checked, the entry field does not appear. Clicking on ***OK*** brings up the ***File Save*** window, allowing the user to enter a file name and choose the directory to store it in. The ***Quit*** button has its normal function, abandoning the print process and closing the window. The image file format can be either JPEG or TIFF, selected in the ***Map/Image Save*** window on the **File** menu.

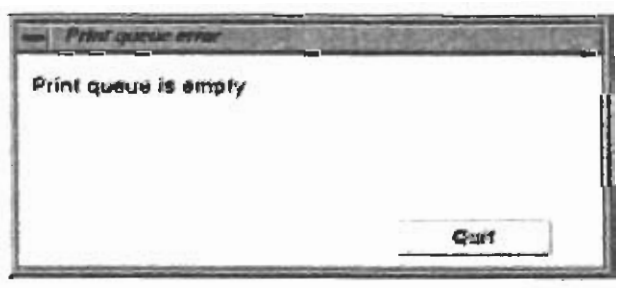
Figure 5-101 Printer Window



Queue

Fig. 5-102 shows the usual state of the Print Queue window, with a message saying that the queue is empty. When several images have been sent for printing in a short time, this window will list those currently waiting to be printed.

Figure 5-102 Print Queue Window



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System Startup and Shutdown

The following two sections describe the proper technique to power up and power down your KLA-Tencor CRS system. Normally the system should remain on at all times so these procedures are rarely necessary.

System Startup

The system is started from a power off condition by pressing the green **On** button at the front of the machine. When the large red emergency off (**EPO**) mushroom button has been pressed, it must be released before power can be applied. Release the emergency off by rotating it counterclockwise until it pops out.

The computer operating system goes through its normal initialization process and finally the KLA-Tencor CRS operating software appears on the screen. A series of initialization and login windows appears. See "Logging In" on page 30 in Chapter 3, "Tutorial" for details, including illustrations of the windows.

System Shutdown

Normally the system should remain on at all times unless you anticipate a unusually long duration of non-operation (2 weeks or more). In this event, you need to properly shut down the system.

> **NOTE:** **The system can be powered off at any time using the red Off button or the large EPO switch on the front panel. However, the file system of the computer's UNIX operating system incurs small amounts of corruption if the system is simply powered down rather than shut down in an orderly manner. This damage is routinely repaired as the computer system boots up at power on. However, if the system is repeatedly turned off without an orderly shutdown, the accumulated damage can be enough to cause the automatic repair process to fail. Therefore, before turning off power to the system, a proper system shutdown process is recommended.**

To perform a system shutdown

1. Lower the KLA-Tencor CRS application by clicking on the small square at the top left corner of the screen, and selecting Lower from the menu that appears.
2. After the CRS application is lowered, a set of buttons appear at the top left of the screen. Click on **System** and another pull-down menu appears. Click on **System Shutdown**.
3. A window appears, asking if you really want to shut the system down; click on ***Yes***.
4. The computer system now begins its shutdown process. After a minute or so, a message appears indicating that the shutdown is complete and that it is OK to turn off the machine. Turn off the machine by pressing the red **Off** button.

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Error Messages

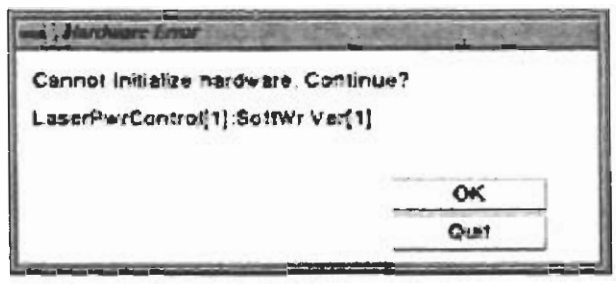
This is not a complete listing of error messages which the CRS software can display, but includes many of the most common varieties, including warnings of hardware faults, software faults, and operator errors.

Attempting to access the menu bar or any controls in a background window while a foreground window is open will result in a beep, and the command selected will not be executed.

Hardware error messages can sometimes be caused by software errors in communicating with the hardware, as well as by faults in the hardware or communications lines. Try restarting the application, rebooting the system, or cycling power. If none of these suffices, service is required to locate and correct the fault.

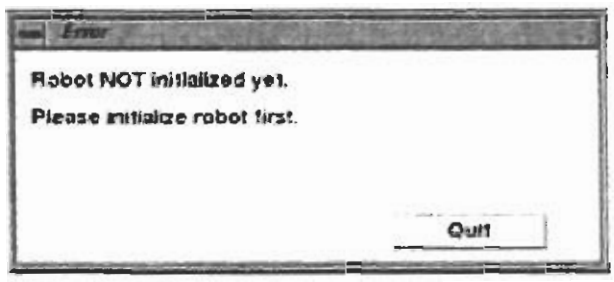
During the startup process, a failure to communicate with a controller, or a failure of the controller to respond correctly, will result in an error message like that in Fig. 5-103.

Figure 5-103 Hardware Initialization Error



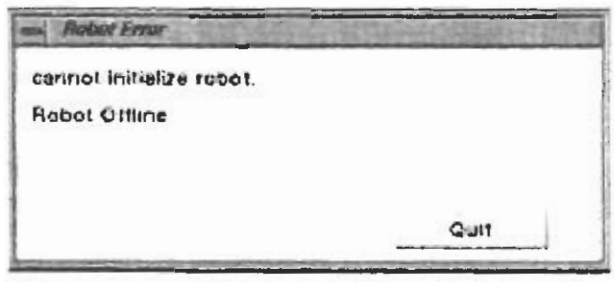
If the robot is not initialized, any command which calls for robot motion will fail. If initialization has not been done at all, the error message in Fig. 5-104 will appear. Restarting the application or rebooting will usually deal with the problem. An administrator can initialize the robot from the Manual Robot Control window. If an attempt to initialize the robot fails, the error message in Fig. 5-105 will appear.

Figure 5-104 Robot Not Initialized Error



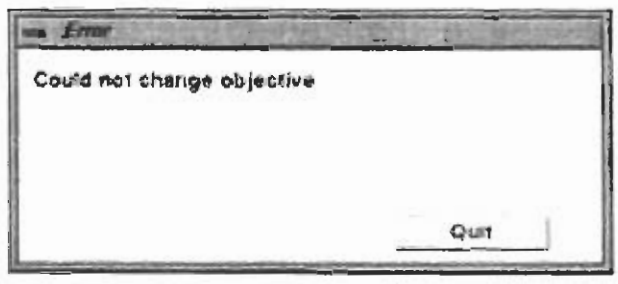
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Figure 5-105 Robot Initialization Error



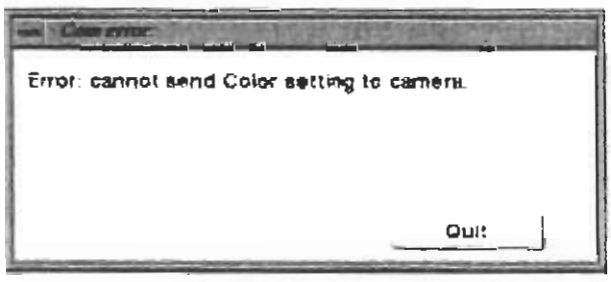
Hardware faults can make it impossible to rotate the microscope turret to a requested objective. The error message in Fig. 5-106 results.

Figure 5-106 Microscope Objective Error



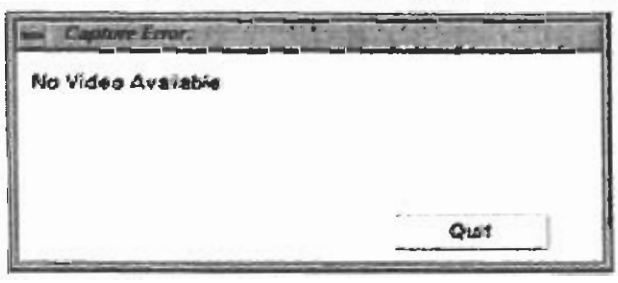
A failure of communication with the white light camera when attempting to send it settings results in an error message like that in Fig. 5-107.

Figure 5-107 Color Setting Error



The message in Fig. 5-108, on the other hand, indicates a loss of video output from the white light camera to the computer, or a fault in the video connection between them.

Figure 5-108 Video Error



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During setup for AutoDeskew it is necessary to capture two images of each deskew point, at low and high magnification. If the computer cannot receive the image data for any reason, it will display the message shown in Fig. 5-109.

Figure 5-109 Image Capture Error



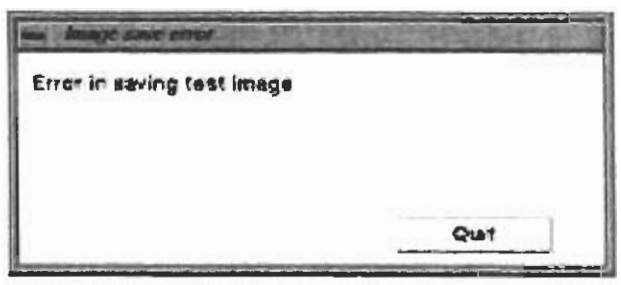
The program will be unable to find and load an image file, as indicated in the message in Fig. 5-110, primarily if the user has entered a non-existent file name.

Figure 5-110 Image Load Error



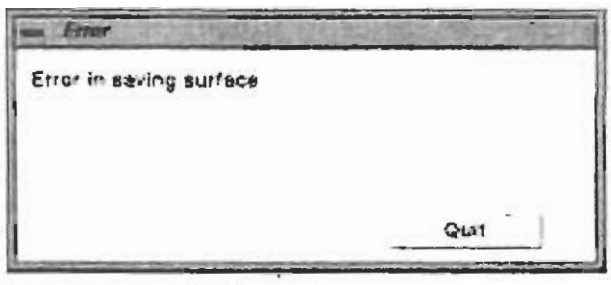
Problems in saving an image as indicated in Fig. 5-111 or Fig. 5-112 may result from a full drive or from a variety of hardware or software problems. It is important to monitor the free space on the hard drive regularly.

Figure 5-111 Image Save Error



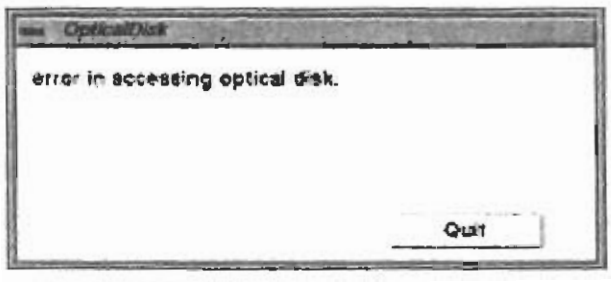
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Figure 5-112 Surface Image Save Error



Problems that can cause an optical drive error as shown in Fig. 5-113 include a missing drive, a drive that is not mounted in the operating system, an empty drive with no data cartridge, an unformatted or damaged cartridge, SCSI cable problems and other hardware faults.

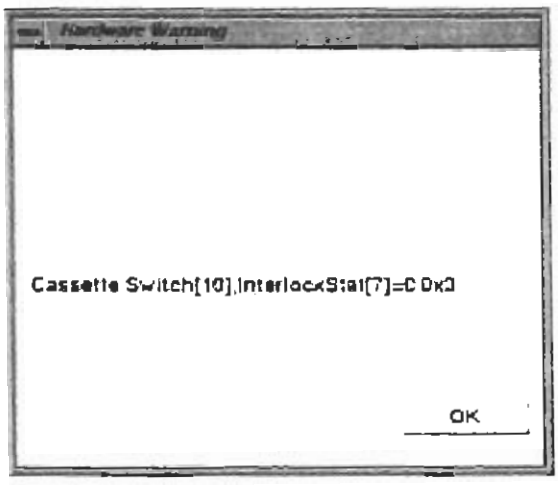
Figure 5-113 Optical Drive Error



Unlike most of the preceding error messages, which usually result from system problems, the remaining messages indicate incorrect procedure by the operator. It is normally possible to exit the window, correct the error, and continue.

Attempting to access a wafer when there is no cassette on the cassette plate results in the message in Fig. 5-114. Click on ***OK***, place the cassette on the plate, and try again.

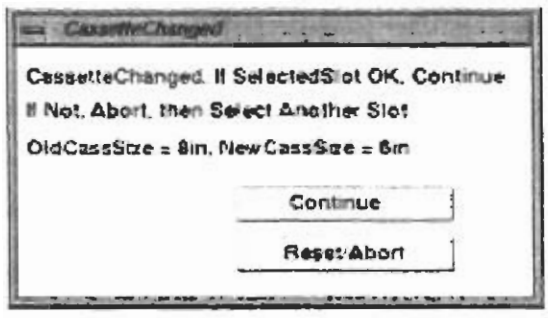
Figure 5-114 Cassette Interlock Warning



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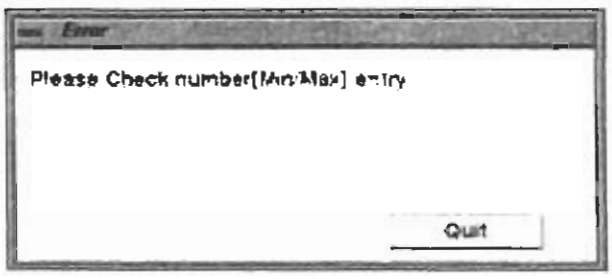
When a new cassette has been placed on the CRS, and especially when a cassette of a different size is put on, its wafer map should be loaded before accessing any wafers. Failure to to this results in a message such as that in Fig. 5-115. In normal operation, the operator should click on ***Reset/Abort***, but during service it may be appropriate to continue.

Figure 5-115 Cassette Changed Message Box



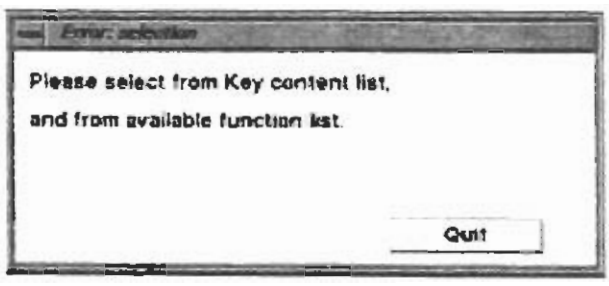
Attempting to enter a defect sort criterion without providing required parameters results in a message like that in Fig. 5-116. The operator can correct the error and continue.

Figure 5-116 Defect Sort Entry Error



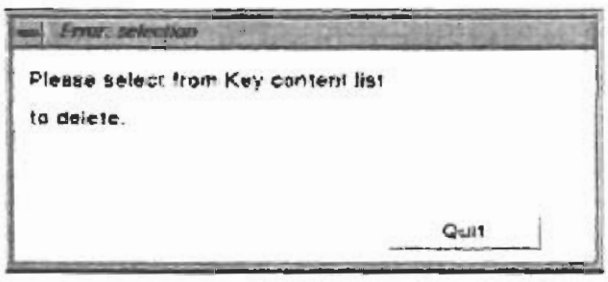
During the function key macro editing process, attempting to perform an editing operation without first making a selection results in an error message like those shown in Fig. 5-117 and Fig. 5-118.

Figure 5-117 Key and Function Selection Error



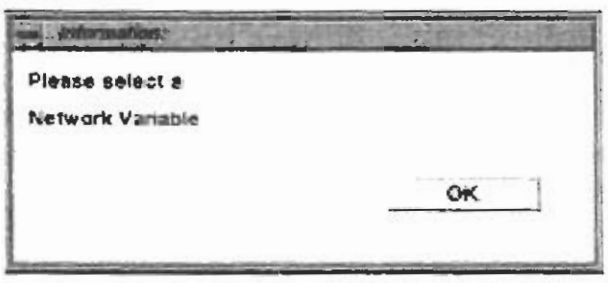
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Figure 5-118 Key Selection Error



In the LON Diagnostics window, attempting to read or set a network variable when no variable has been selected fails with the message shown in Fig. 5-119.

Figure 5-119 Network Variable Selection Error



The message shown in Fig. 5-120 results from trying to paste without cutting or copying anything first. This only happens when the buffer is empty. If some previous cut or copy operation has left the buffer full, then forgetting to cut or copy before pasting results in incorrect data being entered. The error can be corrected before any inappropriate data get saved to a file.

Figure 5-120 Paste Error

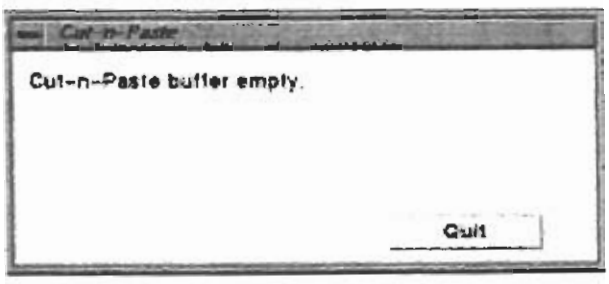


Fig. 5-121 shows the error message resulting from clicking on the ***Delete*** button in the ***Function Key Edit*** window without selecting an item to delete. The two following messages result from similar failures to select an item before acting on it. These and similar messages can arise in a variety of windows, including file windows and those for editing screens, function keys, recipe parameters, and so on.

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Figure 5-121 Password Error



Figure 5-122 List Selection Error

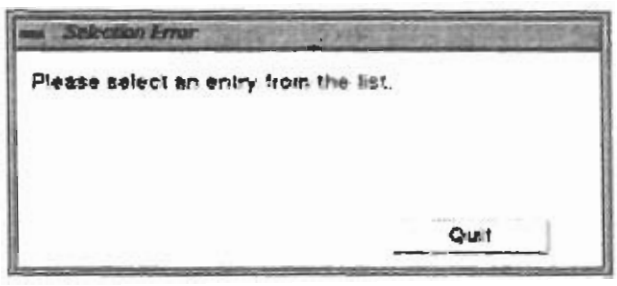
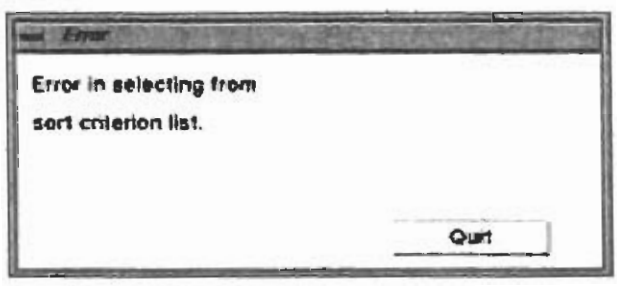
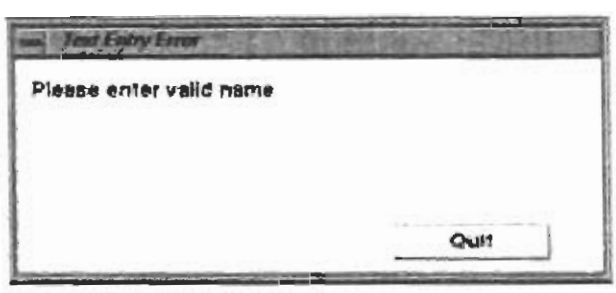


Figure 5-123 Sort Criterion Selection Error



The message in Fig. 5-124 also results from failure to provide an operand to a command, but in this case it is caused by a blank data entry field rather than a list with no selection.

Figure 5-124 Text Entry Error



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6

ADVANCED OPERATION

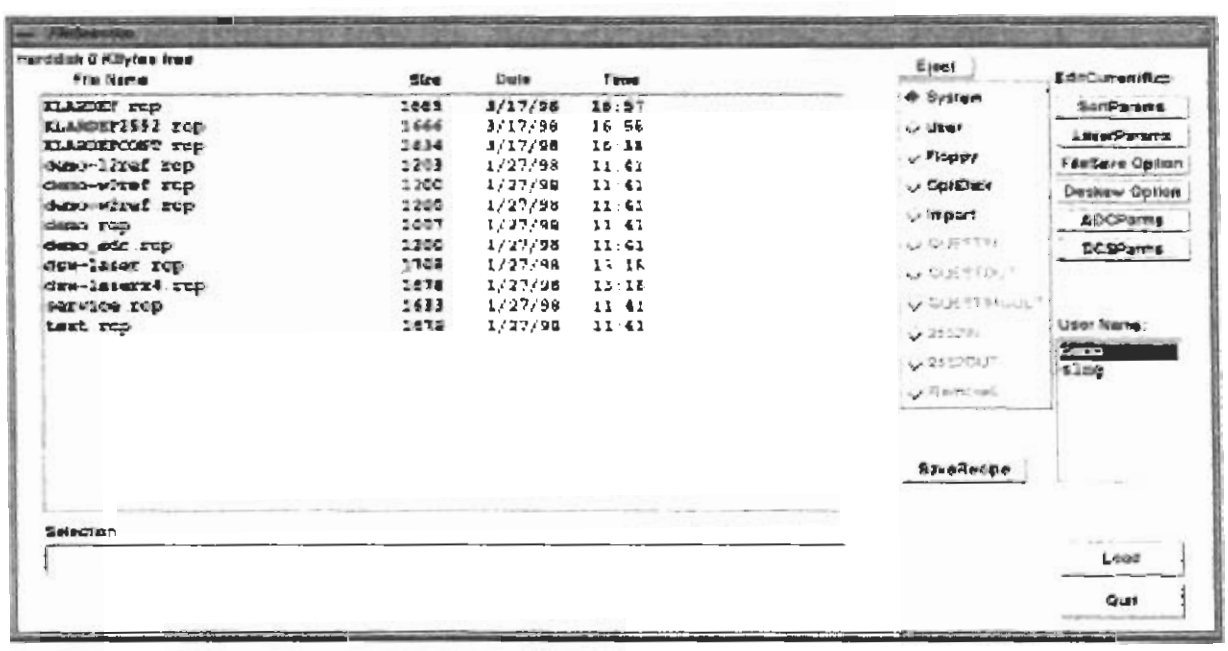
Recipes

A *recipe* allows you to do the following:

- Set the correct laser wavelength and power to let the machine perform autofocus properly on wafers of different process levels.
- Set up different defect sort criteria.
- Set the default white light intensity as well as laser image intensity for the 5× objective.
- Set the stage center offset so that the first deskew point is in the field of view.

Recipe editing functions are in the Recipe window on the File menu, as shown in Fig. 6-1

Figure 6-1 Recipe Window



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To set up a recipe

1. Click on **File** at the top menu bar and select **Recipe**. Click on the ***LaserParams*** button at the bottom of the pop up window. Enter the desired values for ***LaserLine***, ***LaserIntensity%***, ***Stg AFIntensity***, ***StageCenterOffset***, and ***SampleThickness***. Click on OK when done.
2. If you want to set up defect sort criteria, click on the ***SortParms*** button. In the pop up window click on the toggle button All and select the desired criteria. Highlight one and click on ***PasteDn*** (or ***PasteUp***) to enter the new criteria. Quit when done.
3. Save the new recipe by clicking on the ***File*** button at the bottom of the screen, enter a name for the new recipe and click on ***SaveRecipe***. Quit when done.
4. If you wish to have the system automatically load your recipe upon login, then use your login name as the filename for the recipe.

To retrieve a recipe

Click on File at the top menu bar and select Recipe. Click on File at the bottom of the pop up window, highlight the recipe you want and click on Load, then Quit.

If the recipe name is the same as your login name, then it will load automatically upon login. You can also link a recipe to identifying characters of the Lot ID or Process ID to allow for automatic loading. These options are set with the **Config/Misc.** command. See the description of the "Config Misc. Window" on page 150, and Table 5-30, Automatic Recipe Load options, on page 152 in Chapter 5, "Reference."

Setting Laser Intensity Values

The *Laser Scan Parameters* window allows you to control wafer thickness, scan dimensions, autofocus intensities, and a variety of other values. All the values can be saved as a recipe for later retrieval. We strongly recommend that you obtain guidance from an KLA Tencor CRS applications engineer before attempting to adjust these values.

There are two ways to adjust the laser scan parameters:

- The basic method, an easier but not so rigorous approach
- The advanced method, a more rigorous approach

To adjust the laser scan parameters (basic method)

1. Load a wafer, select the ***Review*** screen by clicking on **Screen** and choosing **Review**.
2. Select a 100× or higher objective. Set ***FineZ*** slider bar in the laser window to roughly 26.
3. Use the joystick in Z-mode to bring the image into focus. Adjust the ***LaserIntensity*** slider bar in the laser window until the laser image is comfortably bright (that is, the laser image color is slightly golden). Write down the value.
4. Click on **Maintenance** at the top menu bar and select **Manual Stage Control**. In the small pop up window, highlight ***Z Dist Fr ConfigLim***. Read the number on the right hand side.

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5. Subtract 30 from the number to get the sample thickness parameter. Quit when done.
6. Click on Setup at the top menu bar and select ***LaserScanParms***.
7. Adjust the ***Sample Thickness*** slider bar to the number found in step 5.
8. Select a wavelength by clicking on the ***LaserLine*** toggle button (usually 488). Set the ***LaserIntensity %*** of the selected line to the value found in step 3. Set the ***Stg AFIntensity*** for the corresponding line to 30. Click on ***OK***.
9. Start from a 5× objective and then switch to a 100× or higher. Repeat this practice at a few locations on the wafer. If it autofocus properly then stay at the 100× or 150×, drive to at least 10 defects to test autofocus. If everything is fine, then record the ***LaserLine***, ***LaserIntensity%***, ***Stg AFIntensity*** and ***SampleThickness***.
10. If the autofocus fails, increase the ***Stg AFIntensity*** by 5 and repeat step 9.
11. If it still fails even when the ***Stg AFIntensity*** is very high (>70), try the advanced method described below.

To adjust the laser scan parameters (advanced method)

1. Load a wafer. Switch to a 100× or higher objective. Move the ***FineZ*** slider bar in the laser window to roughly 26. Use the joystick in Z-mode to bring the sample into focus. Adjust the ***LaserIntensity*** slider bar in the laser window until the laser image is comfortably bright.
2. Click on **Maintenance** at the top menu bar and select **Manual Stage Control**.
3. In the pop-up window, highlight ***Z Dist Fr ConfigLim***. Read the number on the right side and subtract 30 from it. This is going to be the sample thickness parameter. Select ***Quit*** when done.
4. Click on **Setup** at the top menu bar and select **LaserScan Parms**.
5. Adjust the thickness slider bar to the number found in step 3. Adjust the ***LaserIntensity%*** to the number found in step 1.
6. Select a wavelength by clicking on the ***LaserLine*** toggle button (usually start with 488).
7. Use the joystick in XY mode to find a spot on the wafer where the reflectivity is minimum, that is, with the sample in focus and with a fixed laser intensity setting, the laser image on that spot appears to be the darkest.
8. Set the ***Stg AFIntensity*** of the selected line to a value around 10. Click on ***OK*** from the pop up window.
9. Do a stage autofocus for different objectives. Write down whether the autofocus failed or not at any objective.
10. Increase the ***Stg AF Intensity*** by 5. Repeat steps 8 and 9. Stop at the highest intensity when autofocus failed.
11. Select another wavelength (for example, 515 nm). Repeat steps 7-11 until all the wavelengths are covered.
12. Summarize the results in a table similar to that shown below:

Table 6-1 Autofocus Performance Versus Laser Intensity

Laser Intensity	Stage Autofocus Performance		
	458 nm	488 nm	515 nm
10	Failed	Failed	Failed

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Table 6-1 Autofocus Performance Versus Laser Intensity

Laser Intensity	Stage Autofocus Performance		
	458 nm	488 nm	515 nm
15	Failed	Failed	Failed
20	Failed	OK	Failed
25	Failed	OK	OK
30	Failed	OK	OK
35	Failed	OK	OK
40	OK	OK	OK
45	OK	OK	OK
50	OK	OK	OK
55	OK	Failed	Failed
60	OK	Failed	Failed
65	OK	Failed	Failed
70	Failed	OK	OK

5. Move to a spot on the wafer where the reflective is moderate. Repeat steps 6, 7 and 9–12 and construct another table (similar to Table 6-1) but for the moderate reflectivity region of the wafer.
6. Move to a spot on the wafer where the reflectivity is the highest (for example, a metal area). Repeat steps 6, 7 and 9–12. Construct a third table for the high reflectivity region.
7. Examine all three tables carefully. For each wavelength, find the laser intensity that allows for the best stage autofocus performance in all three reflectivity regions.
8. Click on **Setup** at the top menu bar. Select **LaserScan Parms**. In the pop up menu, put in the best laser intensity for each wavelength under ***Stg AF Intensity***. Click on ***OK*** when done.

Stage Center Offset

The stage center offset ensures that the first deskew point is in the field of view after the wafer loading. It is very important to set it correctly for bare wafer defect review, because searching for the first deskew point (i.e. a defect in this case) is time consuming. Here is how to figure out this important parameter for patterned and bare wafers:

To determine the Stage Center Offset for patterned wafers

1. Load a map and wafer in the normal fashion.
2. The stage moves to the first deskew point based on the coordinates provided by the map. Switch to the wafer window. Move the cursor onto the wafer and click the mouse.
3. Write down the XY location (X1, Y1).

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4. Use the joystick to center the first deskew point in the field of view. Click on the map to update the XY coordinates. Write down the values as (X2, Y2).
5. Click on ***Setup***, select ***LaserScanParms***, and write down the values currently entered for ***StageCenterOffset***. These are the current X-offset and current Y-offset values.
6. The ***StageCenterOffset (X,Y)*** can be calculated by the formula:

$$X = (\text{current X-offset}) + (X2 - X1)$$
$$Y = (\text{current Y-offset}) - (Y2 - Y1)$$

To determine the Stage Center Offset for bare wafers

1. Load a map and wafer in the normal fashion.
2. The stage moves to the first defect if the bare wafer deskew option has been set properly. Switch to the wafer window. Move the cursor onto the wafer and click the mouse.
3. Write down the XY location (X1, Y1).
4. Use the search pattern in the status window under ***Search*** to find the defect. Center it in the field of view. Click on the map to update the XY coordinates. Write it down as (X2, Y2).
5. Click on ***Setup***, select ***LaserScanParms***, and write down the values currently entered for ***StageCenterOffset***. These are the current X offset and current Y offset values.
6. The stage center offset (X,Y) can be calculated by the formula:

$$X = (\text{current X-offset}) + (X2 - X1)$$
$$Y = (\text{current Y-offset}) - (Y2 - Y1)$$

Bare Wafer Review

The ***KLA Tencor*** CRS can review defects on both patterned and unpatterned wafers. In the latter case, special considerations must be taken into account to maximize your productivity.

Deskewing with Defects

Unlike a patterned wafer where a user can use a corner of a die to deskew, a bare wafer has no pattern but defects. To establish the ***KLA Tencor*** CRS coordinate system, two defects have to be selected as two deskew points. Ideally, they should be isolated defects; that is, no other defects are in the field of view. We also recommend a low power objective (such as 20× or 50×) and darkfield mode to aid in the task of finding defects.

1. After loading a wafer map, click on the top menu bar icon **Setup** and select **Deskew Options**. Click on ***Use Map Deskew Info*** toggle button and select ***Defect as Deskew Pts***. Click ***OK***.
2. Load the wafer. Switch to dark-field mode. If the defect map is from a Tencor or Inspex inspection tool, please display defect intensity instead of size. You can do so by clicking on ***AbsCoord*** and choose ***Intensity*** in the status window under ***DefList***.
3. The machine will automatically drive to the first defect site. In normal cases, the first defect should be in the field of view of 5×. If not, check the defect size (or scattering intensity) from the defect list. If the defect is small, select a bigger one and click on ***GoToSelected***.

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4. If the larger defect still cannot be found, drag open a new status window, click on ***Status*** and select ***Search***. Click on ***Center*** to reset the search path. Press and hold the ***StartSearch*** button until the defect is found. Use the joystick to move the defect to the center of field of view. Click on ***Accept Dsk1***. Click on ***OK*** in the pop up confirmation window.
5. Select the second defect, find it, and move it to the center of field of view, click on ***Accept Dsk2***. Click on ***OK*** in the pop up confirmation window.
6. Select any reasonable size defect and click on ***GoToSelected***. The defect should be in the field of view of 5× or 20× if the deskew is correct. If not, push the ***Redo Deskew*** key to start the deskew process all over again by using two different deskew defects.
7. When deskew has been completed successfully, move the next defect to the center of the field of view and push the **MapOffset** function key.

Defect Review

To begin with, one should examine the defect under 50× (or higher) white light in dark field mode. A particle will look shiny in the whole area it covers. A pit, on the other hand, will usually look bright around its edge but dim at the center. Of course, if the particle or pit is too small, say 0.1 μ, then little dark field information is available. Next, turn on the laser and switch to 100× or higher magnification. Move fine *Z* stage up and down to see if there is unique signature of a particle or pit. The combination of the dark field white light plus the live laser confocal is a very reliable way to classify a defect on a non-patterned wafer. 3D imaging of the bare wafer defects should be done at a 100× or higher objective. Dark field mode is strongly preferred since it will get rid of horizontal fringes seen in the live laser image.

The laser zoom should be set properly (i.e. the defect should fits comfortably inside the laser field of view) before 3D image acquisition. For large size defects, 3D is as easy as hitting the ***Surface*** button.

Here is a recommended procedure for acquiring a good 3D image of a small particle:

1. Take a volume image by pressing the **SK1** key or clicking on ***Volume*** in the ***Review*** screen. Wait until the image is displayed in the volume image screen.
2. Move the horizontal (vertical) cross-hair in the 2D XY pane so that it runs over the defect.
3. Examine carefully the intensity profile in the ***2D XZ*** (***YZ***) pane. If the defect is a particle, a small dark blue peak (could be very faint!!!) is usually present above the strong signal band of the substrate. Look carefully to see whether there is any signal immediately underneath the small dark blue peak. If there is, one should use the slide bar under ***FirstSlice*** to cut out this signal. Be careful not to cut too far. A good rule of thumb is to cut the unwanted while keep a little bit of substrate signal in the scene. Otherwise the particle will be buried in the woods (i.e. noise peaks).
4. Click on ***NewSurface*** to generate a surface base on manipulated volume data set. Pull over a 3D window to view the 3D image of the particle.
5. Save the 3D by clicking on ***File***, typing in a file name in the selection box, and clicking on ***SaveSurface***. This archiving step is necessary for two reasons: 1) the surface image is 0.5MB as compare to 16MB of a volume image. 2) the cross-sectional line profile inherited in the surface image can be used to measure the particle size.

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Defect Coordinate Updating

Due to the limited coordinate accuracy of laser scanning inspection tools, it is often difficult to locate defects during the review process. To aid you in this task, we recommend reviewing in low power objectives (such as 20× and 50×) and dark-field mode. This is easily accomplished on the **KLA Tencor** CRS. However, if you wish to later review your wafer on an SEM, finding defects is even more difficult. Consequently, you might want to take advantage of our coordinate updating feature, which enables you to modify the original wafer map file with the XY stage coordinates of our system. By doing so, you can now use the updated map file on your SEM to reduce the search time associated with poor defect coordinate accuracy.

To Use The Coordinate Updating Feature

1. Load a map file and wafer in the normal fashion.
2. Deskew the wafer as described in "Deskewing with Defects" on page 197
3. Drive to your first defect and use the appropriate techniques to find the defect and center in the monitor's field of view.
4. Drag open a ***Status*** pane and click on the ***EditDefect*** button.
5. Click on the ***Modify Coord*** button. This updates the map file for that particular defect with the XY stage coordinates of the **KLA Tencor** CRS stage. Press ***Quit***.
6. Repeat this process for each defect that you review.
7. When you have gone through all the desired defects, unload the wafer and save the modified map file. You can use the same filename or a different filename.
8. You can now use this new file on your SEM. You will find that there is now much better coordinate correlation between the wafer and your modified map then there was with the original map.

Bare Wafer 3D Imaging

3D imaging of the bare wafer defects should be done at a 100× or higher objective.

Choosing the Objective for 3D imaging

To choose the right objective for 3D imaging is very important for bare wafer defect review.

A1. Confocal Z peaks: Z-peak is an overall indicator of confocal quality. It is determined by the objective numerical aperture, the pinhole size, the laser wavelength, and the overall optics alignment.

A2. Procedure to measure the Z peak:

1. Load a bare Si wafer. Switch to the objective that you used the most in 3D imaging (i.e. 100× or 150×). Turn the laser on and do a fine autofocus.
2. Adjust the laser intensity to an appropriate level, i.e. the laser image should look lightly gold.
3. Manually select the Z scan range. From the focus level, move the fine Z stage up 2 µ and hit the small S button. Move the fine Z stage back to focus level and then move it down by 2 µ, hit the small F button.
4. Acquire a volume image.

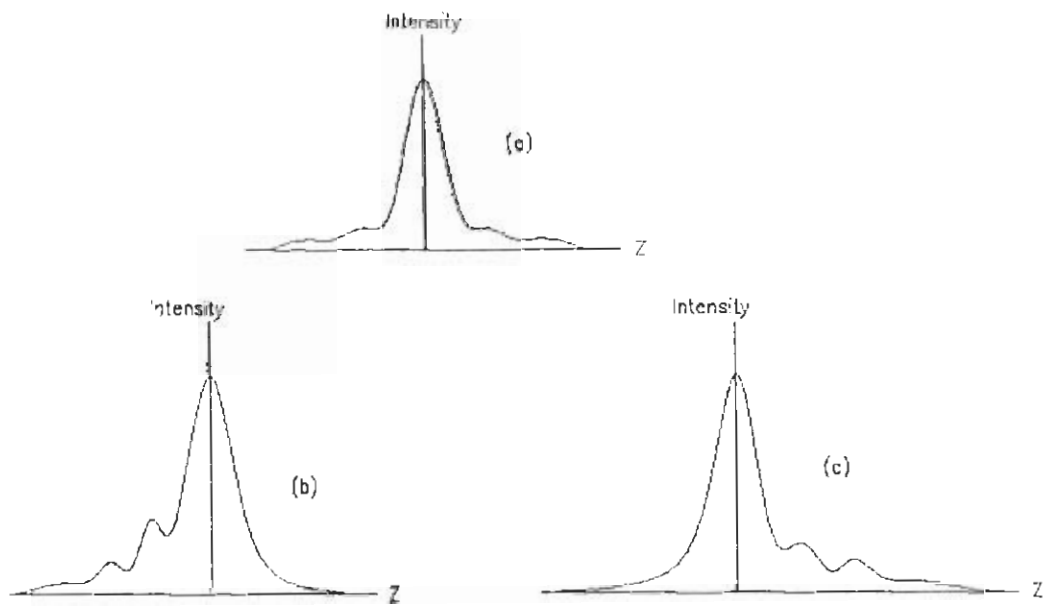
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5. Pull up a 2D XY pane. Click on the icon under Cut Plane and select Z profile.

A3. Characteristics of a Z peak:

Shown below are three most common types of Z peaks. Type (a) is for an ideal system with no geometry aberration. Type (b) and (c) correspond to a system with positive and negative aberrations. It is type (b) that one encounters most often on a CRS system. A good imaging objective should have a narrow FWHM (Full Width at Half Maximum) for its main peak and small side lobes.

Figure 6-2 Z Peak Shapes



A4. Choose the best objective for imaging:

For acceptable confocal imaging performance, a 50× or higher objective is recommended. A user should acquire Z peaks for each objective that is 50× or higher by using a polished bare silicon wafer, measure the FWHM of the main peak, and calculate the ratio of the first side lobe (i.e. the first small peak on the left or right hand side). The best objective for 3D imaging is the one that has narrowest FWHM and smallest side lobes.

Dark-field mode is strongly preferred since it gets rid of horizontal fringes seen in the live laser image. The laser zoom should be set properly (that is, the defect should fit comfortably inside the laser field of view) before the image acquisition. For large defects, 3D imaging is as easy as pressing the Surface button. For small, dark defects, care must be taken to avoid the pit/particle problem.

To acquire a good 3D image for a small particle

1. Press ***SK1*** in the ***Review*** screen to take a volume image. Wait until the image is displayed in the ***volume image display*** screen.
2. Move the horizontal (vertical) crosshair in the ***2D XY*** pane so that it runs over the defect.
3. Examine carefully the intensity profile in the ***2D XZ*** (***YZ***) pane. If the defect is a particle, a small dark blue peak., possibly very faint, is usually present above the strong signal band of the substrate. Look carefully to see whether there is any signal immediately underneath the small dark

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blue peak. If there is, use the slider bar under ***FirstSlice*** to cut out this signal. Be careful not to cut too far. A good rule of thumb is to cut the unwanted signal while keeping a little bit of substrate signal in the display. Otherwise, the particle will be buried in the noise.

4. Click on ***NewSurface*** to generate a surface based on the selected volume data subset. Pull over a 3D window to view the 3D image of the particle.
5. Save the 3D image by clicking on ***File***, typing in a filename in the entry field, and clicking on ***SaveSurface***. This archiving step is necessary for two reasons:
   - The surface image is 0.5 MB as compare to 16 MB for a volume image.
   - The cross-sectional line profile inherited in the surface image can be used to measure the particle size.

Making Wafer Maps

There are a few cases where you might want to generate your own wafer map on the ***KLA Tencor*** CRS instead of on a scanner. For example:

- You might want to visit specific locations on a wafer to monitor repetitive defects caused by a defective mask or some process tools.
- You might want to monitor the uniformity of a process, such as the W-plug etch back or the bonding pad profile at specific sites.

The wafer map creation window is shown in Figure 5-14 on page 96.

Tencor Format Maps

Creating a Tencor Map

1. Select **File** on the top menu bar. Choose **Wafer Map** in the pull down menu.
1. Click on ***ClearMap*** in the file window. The ***Wafer Map Creation*** window appears.
2. Choose Tencor format, put in the right WaferSize and FlatAngle (the flat or notch orientation), and click on ***OK***.
3. Change to the ***Cassette*** screen. Select the slot number and click on ***LoadWafer*** to load the wafer.
4. The stage should stop at coordinate (0,0). Use the joystick to find the first defect (or feature) that is of interest to you.
5. Switch to the ***Status*** window and make sure the **Status** icon is displayed on the option menu in the upper right corner of the window. Click on ***EditDefect***. Click on ***AppendDefect*** and then ***OK***.
6. Repeat steps 4 and 5 until the final defect (feature) has been entered.
7. Select **File** menu and choose **Wafer Map**, enter the filename for the new wafer map and click on ***SaveFile***.

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Retrieving the Tencor Map

1. Load the map file as you normally would.
2. Select **Setup** at the top menu bar and choose **Deskew Options**. In the small pop-up window select ***Defect as Deskew Pts*** instead of ***Use Map Deskew Info***.
3. Load the wafer.
4. Find a defect (or feature) on the left hand side of the wafer. Center it in the white light screen. Press **ENTER** on the numeric keypad or click on ***Accept*** in the Sequence window. Click on ***OK*** in the small pop-up window.
5. Repeat step 4 but for a defect on the right side of the wafer.
6. Revisit other sites just as you do normally.

KLA Format Maps

Creating a KLA Map

1. Select **File** on the top menu bar. Choose **Wafer Map** in the pull-down menu.
2. Click on ***ClearMap*** in the pop-up window. Choose KLA format, put in the right WaferSize and FlatAngle (the flat or notch orientation), and click on ***OK***.
3. In the ***Cassette*** screen, select the slot number and click on ***Load*** to load the wafer.
4. The stage should stop at coordinate (0,0). Use the joystick to center the corner of the origin die (which should be very close to (0,0)) in the field of view.
5. Move the cursor to the wafer map. Click the mouse to read the current XY coordinate. This is going to be the registration point coordinate. Skip steps 5-6 if the XY die pitch is known.
6. Use the joystick to move to a die corner. Record its X position.
7. Move the stage in the X direction for at least 5 dies and record the X position of that die corner. Subtract the two X values and divide by 5. This is the ***X DiePitch***.
8. Use the approach of step 5 to measure the ***Y DiePitch***.
9. Unload the wafer.
10. Click on **Setup** at the top menu bar and select **Edit Wafer Map**. Type in ***Die Pitch*** and ***Registration Coordinate*** in the appropriate box. Enter the ***Slot#*** and ***ID#***. Click on ***EnterToList***. Click on ***OK*** to exit from the window.
11. Click on **File** and choose **Wafer Map**. Type in the filename for the wafer map in the entry field and click on ***SaveFile***.
12. Load the wafer again.
13. Use the joystick to find the first defect (or feature) that is of interest to you. Switch to the ***Status*** window and click on ***EditDefect***. Click on ***AppendDefect*** and ***OK***.
14. Repeat step 11 until the final defect (feature) has been entered.
15. Unload the wafer.
16. Select **File** menu and choose **Wafer Map.** Enter the filename for the new wafer map in the entry field. Click on ***SaveFile***.

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Retrieving the KLA Map

Use the newly-created KLA map the same way you normally would with a KLA map generated by a surface scanner.

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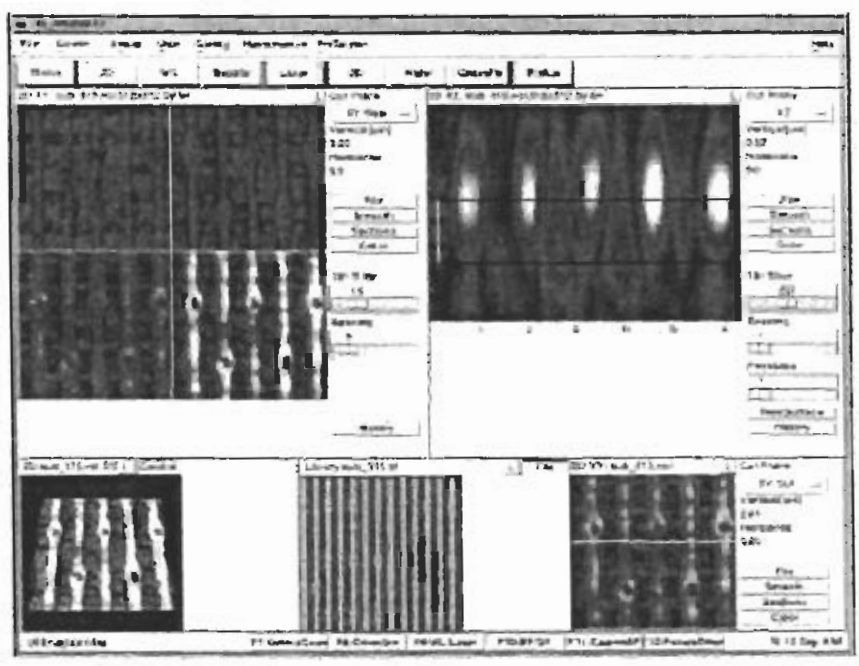
7

Applications

Subsurface Imaging

With IC manufacturing moving to smaller geometries, higher integration and more complex multilevel connections, subsurface defects become more and more important for yield improvement. The **KLA Tencor** CRS system, with its demonstrated ability to identify defects embedded or below a film that is transparent to its laser lines, fits well in this type of application. The next two figures show how clearly subsurface defects show up in CRS volume images under metal or resist.

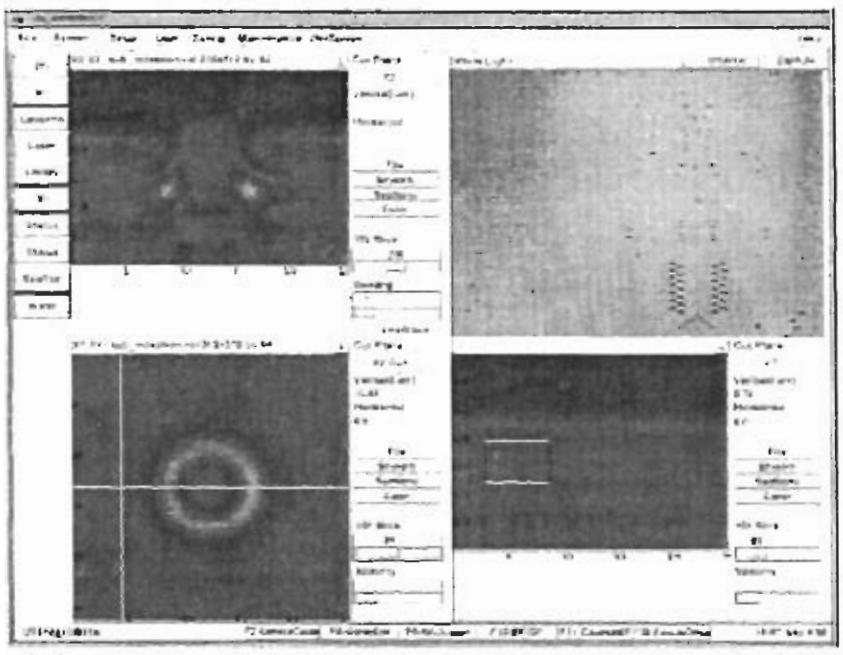
Figure 7-1 Defect under Metal Lines



Invisible in white light (bottom center), this defect can be seen 0.5µm below the metal lines. Note also that the defect's presence caused the metal line above it to bulge.

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Figure 7-2 Defect under Resist



Films and Laser Lines

In principle, the KLA-Tencor CRS can review defects under any dielectric film that is transparent to its three laser lines. For a table of how deep a laser line can penetrate into a specific film and indications of the best wavelength to use in each case, see Table 7-3 on page 210.

Subsurface Defect Signature

Subsurface defects generally have unique signatures, for example:

- A sublayer defect often shows a blurry appearance under white light inspection.
- If the defect is under a flat film, it is usually surrounded by interference rings. In live laser confocal images, the interference patterns (or rings) will change when switching between different wavelengths or moving the Fine Z stage up and down.
- It is easier to spot a subsurface defect by using a low magnification and low NA (numerical aperture) objective, namely 5× or 20× objective.
- If the subsurface defect is located in a complicated pattern area, the best way to find it is to move the Fine Z stage up and down while paying close attention to its intensity variation as compared to the surrounding areas.

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To image subsurface defects

1. Choose the best laser line as to be able to see the weak signal from the top of the dielectric film. Refer to Section , "Film Thickness Measurements," and Section 0.2, Bare Wafer Review, for more information.
2. Carefully choose the ***FineZ*** scan range so that it covers the whole film thickness range.
3. Acquire a volume image. Display it in the ***Volume*** screen layout by clicking on **Screen** and choose **Volume**.
4. Switch to ***2-D XY*** view. Move the crosshair to the defect site. In most cases, one should be able to see the substrate as well as the dielectric film signal in the ***2-D XZ*** or ***YZ*** pane intensity profile.
5. Use the rubberband cursor to roughly measure how deep the defect is with respect to the film surface. Make sure that you measure the depth between the peak of dielectric signal band and the defect signal band.
6. In the large ***2-D XY*** pane, click twice on ***Sections*** to get 9 slices. Adjust the slide bar under ***1st Slice*** and ***Spacing*** so that the slices cover the range between the substrate and the top of the dielectric film.
7. Examine the multi-slices and the 2-D XZ or YZ intensity profile very carefully. In many cases, one can answer two very important questions:

   - Which process level possesses the defect? This is done by comparing the in-focus pattern of the defect to that of the device structure.
   - What is the nature of the defect (that is, metallic, poly, or dielectric)? This is based on a comparison between the defect intensity and that of the surrounding devices.

Limitations

You cannot review defects that are under a metal or poly structure. However, there are certain signs related to the presence of a defect under a metal or poly film that you can use to infer its presence. Talk to your ***KLA Tencor*** CRS applications engineer for more information on this subject.

There are cases when one cannot see any dielectric signal no matter what combination of objective and wavelength one uses. If this happens, check to see if your sample is one of the following:

- The film is less than 500 nm thick, which makes it very hard to separate the film signal band and the substrate signal band.
- There is an anti-reflective coating on the wafer.

Making Measurements

CD measurements in the submicron regime is not an easy task for an optical tool. With a laser confocal system, the performance is generally better, but care must be taken in order to get reliable results.

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Choosing the Right Objective

Generally speaking, there are four factors that one should consider in choosing an appropriate objective:

- Resolution
- Diffraction
- Scattering
- Interference

Resolution

The lateral resolution and the depth resolution of a confocal system is related to the numerical aperture by the following relationships:

$$Lateral\ Resolution = 0.5 \times \frac{\lambda}{NA} \quad \text{(EQ 1)}$$

$$Depth\ Resolution \propto \frac{1}{sin^2\left(\frac{\Theta}{2}\right)} \quad \text{(EQ 2)}$$

where $NA = sin\Theta$. The higher the numerical aperture, the better the resolution.

Diffraction

Line/space structure causes diffraction. It is generally considered appropriate imaging if a lens can capture the first order diffraction wave. The angle between the zeroth and first order lobe is given by

$$sin\alpha = \frac{\lambda}{line\text{-}space\ period}$$

where the *line-space period* is the sum of the line and space widths. It is clear that the NA should be greater than sin α. The following table lists the minimum NA required for various line-space structures by using 488-nm laser line:

Table 7-1 Minimum Required NA for Various CDs

Line-space pitch dimension (µm)	Minimum required NA
1.0	0.5
0.7	0.7
0.5	0.98

Scattering

The higher the NA, the more severe the light scattering from line-space structures. This is because the impinging angle for the incoming ray is bigger.

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Interference

Sometimes the return light from the line and the space can cause interference due to the coherent nature of the laser. If this happens, please switch to a different laser wavelength to see if there is any difference.

The following table summarizes the commonly used objectives:

Table 7-2 Objective Magnifications and Numerical Apertures

Mag.	5×	20×	50×	100×	150×
NA	0.13	0.40	0.70	0.95	0.95

It is clear that for submicron geometry, an objective with 50× or above must be used on the KLA Tencor CRS in order to get good line-space images.

General Guidelines

- Use the 100× objective and 488 nm laser line to start.
- The laser scan zoom should be appropriate; that is, the laser field of view should at least cover a few pitches.
- Use dark-field mode for imaging.
- Use the 2-D XY image to measure CD instead of using 3-D or 2-D line profiles.
- To improve the measurement repeatability and accuracy, the rubberband box in the 2-D XY window should box in at least 2 or more pitches. The box size divided by the enclosed pitch number gives the CD. When drawing the box, the left and right edge of the box should land on a fixed point on the leading/trailing edge of the line or space.

Metal or Poly line-space patterns

The confocal 2D XY image from a metal or poly level wafer is usually very good. A 100× (or greater) objective is recommended. Laser wavelength is not critical and 488 nm is preferred.

Photoresist line-space patterns

Unless coated, photoresist is usually transparent to all three wavelengths. In some cases 3-D imaging is difficult due to strong interference and scattering. A good practice is to try out different wavelengths and different objectives. Choose the combination of objective and wavelength that gives the best 3-D image. Sometimes manual image acquisition setup instead of auto Z range setup will also help. As always, the CDs should be measured by using the 2D XY image instead of the 3D image.

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Film Thickness Measurements

This section explains the basics of multi-layer film analysis on the **KLA Tencor** CRS. A detailed operation procedure is also provided, along with the correction factors that you might have to apply for certain type of films.

NOTE:	**The KLA Tencor CRS system is not a dedicated film thickness measurement tool; therefore, the measurement accuracy is not guaranteed.**

Theory

The **KLA Tencor** CRS system uses the 458-nm, 488-nm and 515-nm lines of the Uniphase air-cooled Argon ion laser. Different wavelengths interact with microelectronics materials differently. The following table summarizes the penetration length of each laser line in microelectronics materials[1]:

Table 7-3 Laser Penetration Depth for Selected Materials

Material	458 nm	488 nm	515 nm	Transparent?
Si	0.061	0.113	0.163	No
Poly	0.016	0.028	0.044	No
SiO_2	•	•	•	Yes
Si_3N_4	•	•	•	Yes
Metal	< 0.01	< 0.01	< 0.01	No
Glass	•	•	•	Yes

Figure 7-3 shows what happens when a ray impinges at an angle upon a film step structure on a Si surface. If the film is opaque to the laser line, all the reflection from the film is from top surface, as such the thickness measured is exact. But if the film is transparent, reflections from both the film surface and the Si substrate will be mixed, with the latter being much stronger. Due to refraction, the focal position will be somewhere in the middle as shown by the intersection point of the incoming and the outgoing ray, and the measured thickness has to be corrected by a factor such that

$$d_{CRS} = (correction\ factor) \times d_{SEM} \qquad \text{(EQ 3)}$$

The correction factor is a function of

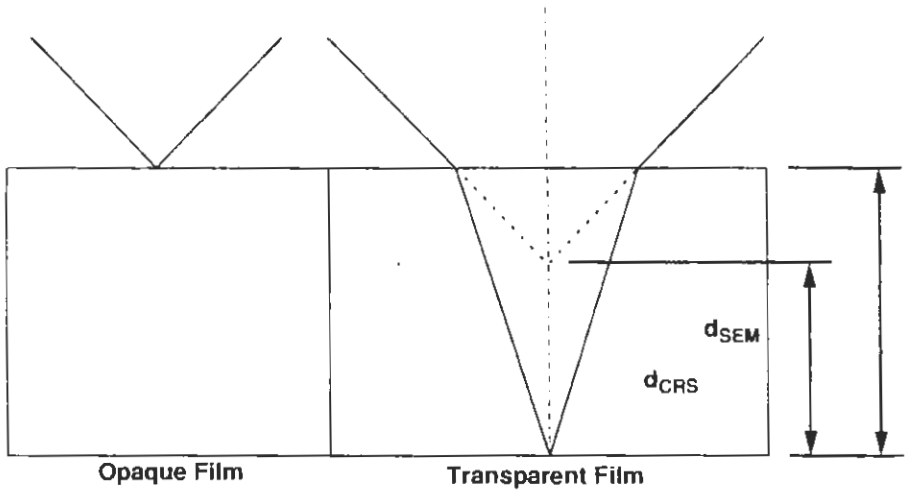
- The index of refraction of the materials involved
- The wavelength used
- The film thickness
- The numerical aperture (NA) of the objective lens.

---

1. H.R. Philipp, "Optical Properties of Materials"

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Figure 7-3 The Optical Thickness of a Transparent Film



Therefore, the correction factor is a complicated non-linear coefficient. The accuracy of the measurement is primarily determined by

- The confocal Z peak of the system
- The uncertainty of the aforementioned correction factor
- The consistency of the operator

Measurement Procedures

Case 1: Film Step

1. Load the wafer. Make sure the wafer surface is in focus.
2. Center the film step in the laser field of view under a 100× objective.
3. Select ***darkfield*** to eliminate the horizontal fringes.
4. Select the appropriate laser line (see "To find the right wavelength" below).
5. Carefully choose the ***Fine Z*** scan range to make sure the Z step size is much smaller than the film thickness.
6. Set the laser intensity appropriately. Try not to use too strong an intensity.
7. Acquire a surface image and measure d_{CRS} from 2D XZ or YZ line profile window. Smooth the profile first if needed.
8. Applied the correction factor to get the real film thickness.

Case 2: Blanket Film

1. Load the wafer. Make sure the wafer surface is in focus.
2. Choose the 100× objective and select ***darkfield***
3. Select the appropriate laser line (see "To find the right wavelength" below).

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4. Carefully choose the ***Fine Z*** scan range to make sure the Z step size is much smaller than the film thickness.
5. Set the laser intensity appropriately, try not to use too strong an intensity.
6. Acquire a volume image. Switch to XZ or YZ intensity profile window. Look carefully for the signal band from the film (note: it could be very faint).
7. In the 2D profile window, Click on XY Size and choose XZ peaks (or YZ peaks) to display the peak signal of the substrate as well as the film. Use the rubberband box to measure the film thickness.
8. Apply the correction factor if necessary.

To find the right wavelength

Acquire a volume image and switch to the 2-D XZ or YZ window. The wavelength that gives the strongest film signal in the 2-D profile is the best one to use.

To get the correction factor for a specific film

1. Prepare many samples (the more, the better) with different film thickness.
2. Measure the film thickness on a SEM or other film thickness measurement tool.
3. Measure the film thickness on the ***KLA Tencor*** CRS.
4. Plot the SEM thickness versus the CRS thickness.
5. Fit data points with a polynomial. This polynomial function provides the right correction factor for different thickness films.

Example

The result of 5 oxide films is used here as an example. The SEM and ***KLA Tencor*** CRS thickness measurements of five samples are summarized in Table 7-4. The XY plot and correction factor calculation are shown in Fig. 7-5.

Table 7-4 Film Thickness Measurement Comparison

SiO_2 nominal thickness (A)	d_{SEM} (A)	d_{CRS} (μm)
500	518	0.03± 0.01
1000	1038	0.05 ± 0.01
3600	3580	0.24 ± 0.02
5500	6988	0.36 ± 0.02
10500	10843	0.46 ± 0.02

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Figure 7-4 Linear Fit to Thickness Measurements

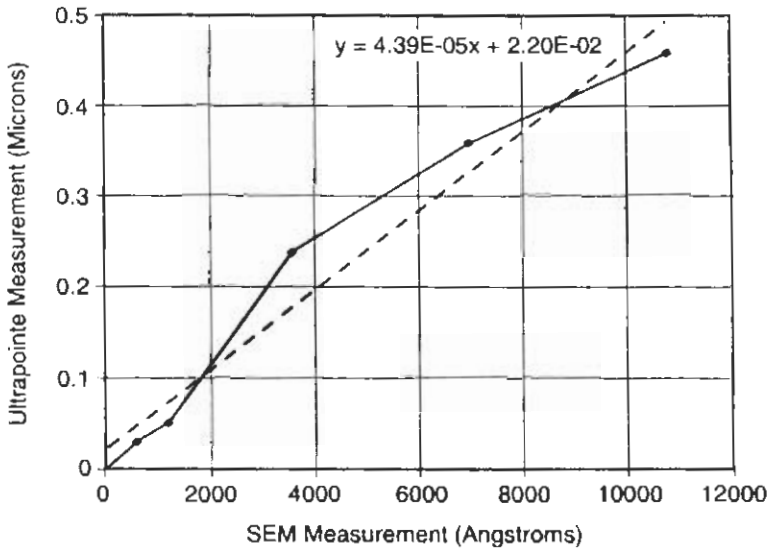


Figure 7-5 SEM Versus CRS Thickness Measurement Comparison

A linear fit is performed and a very rough estimate of the correction factor is made. It is clear that the linear fit is not good enough, indicating that the correction factor is a nonlinear factor. Therefore, one really needs many points to obtain a favorable result.

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A

System Software

Introduction

Each CRS is pre-configured at the factory with all necessary system hardware and software. The system is ready to run after on-site installation by KLA-Tencor. No software installation is required.

For the purposes of system archiving and upgrades, each CRS is supplied with a ¼-inch QIC-150 formatted tape that contains the basic CRS operating software with some sample image files. Refer to the section on "Data Backup and Restore" on page 282 in Appendix F, "Basic Maintenance," for the relevant procedures.

Basic UNIX Commands

The CRS system is controlled by a powerful workstation computer that utilizes a version of the UNIX operating system. Most systems use the IRIX operating system version 5.2, which was developed by Silicon Graphics Computer Systems. A minority of systems may be running on an older version of IRIX with a version number of 4.0.5. Contact your KLA-Tencor service representative if you wish to know which version you are using.

For normal review station operation, it is unnecessary to exit the CRS operating software, and in fact users with Operator privileges cannot leave the application. However, network administrators or advanced computer users might wish to access the UNIX operating environment. The following list of commands will help you navigate through the operating system (regardless of whether your system has IRIX system version 4.0.5 or 5.2). Keep in mind that UNIX is a very powerful and complex operating system that requires training for proper use.

WARNING **Becoming the superuser gives access to all files and directories with no security controls. Careless use can erase files and even make the system inoperable, requiring reinstallation of the operating system.**

UNIX is controlled through a command interpreter called a shell. There are several shells in common use, including the Bourne shell (sh), the Korn shell (ksh), the C shell (csh), and the Bourne-again

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shell (bash). IRIX defaults to the Korn shell. To access a shell window, lower the CRS application by clicking on the small square option menu box in the upper left corner and selecting **Lower**. The toolchest shown in Fig. A-1 will appear. From the **Desktop** menu, you may be able to select **Unix Shell**. When you start a shell, a window titled ***Winterm*** appears, similar to Fig. A-2, but larger. Clicking and dragging on the window border changes the window size. The prompt in the figure shows the path to the current directory. The prompt can be configured by an administrator, so yours may be different.

Figure A-1 Toolchest Menu



If the **Unix Shell** menu selection is not provided in your system configuration, you must exit the CRS application to access a shell. Exiting the application requires Administrator or Service privileges. The next step depends on what tools have been made available on the desktop, and on the user's knowledge of UNIX. Consult your applications engineer if you need assistance in this process.

Each command is illustrated below with a summary of its syntax and purpose. Commands which produce a significant result on the screen are illustrated with an example of the results they return. Responses to some commands are quite long, and in those cases only part of the result is quoted here. Further information about all of these commands and many others is available in on-line documentation (man pages, described below, for text commands, and Help menus in many graphic applications) and in numerous books about how to use UNIX.

Figure A-2 IRIX Shell Window



In command examples, brackets indicate text to be replaced. For example, `cat [filename]` means that you can enter `cat .login`, or `cat guest\.profile`, and so on, with the name or path of some text file supplied as an argument to the `cat` program, which displays the file on the screen.

Subdirectories in UNIX are indicated with the slash character '/', not the backslash '\' which is used in Windows. The root directory is called `/` (read 'slash'). Among the most important directories on the CRS are `/usr/uv` ('slash user slash u-v') and `/usr/people/uv`. There are two special directory names, `.` ('dot') for the current directory, and `..` ('dot-dot') for its parent. Thus in `/usr/people/uv`, `.` stands for `/usr/people/uv` itself, and `..` stands for `/usr/people`.

The UNIX operating system treats devices that read and write data streams in exactly the same manner as files, and allows any device or file to be designated as the standard input or output when invoking a program. The most important case to understand is the console for keyboard input and screen output. Any program that writes to the standard output can have that output displayed on the screen or written to a file, and any program that reads the standard input can accept data from either the keyboard or a file. Furthermore the output of one program can become the input to another program, a process called piping. Many UNIX utilities are intended only for use with redirection. For example, the program `more` sends its input to the screen one screenful at a time. There would be no point in using it for keyboard input.

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The character '>' indicates redirection of output to a file, either creating the file new or erasing its previous contents if it already exists. The output can be appended to a file instead, using the '>>' combination. A program can take its input from a file with the '<' symbol. To take output from one program as input to another, use '|' between the program names. The first program on the line, that is the one to the left, is executed, and as it produces output the second program processes it. Since UNIX is fully multitasking, it is not necessary to wait for the first process to end before starting the next. Table A-1 gives some simple examples.

Table A-1 UNIX Input and Output Redirection

Command	Description
`ls > dir`	Writes a file listing to a file named `dir`.
`ls | more`	Displays the file listing one screen at a time, waiting for a keypress after each
`fn >> log`	Appends the output of `fn` to the `log` file
`fn | tbl | nroff`	Takes the output of `fn`, formats tables, and sends it for printing
`test < script | nroff`	Run a test program with canned input and print the results.

Help

One of the most important help utilities in UNIX systems is `man`, which displays manual page files. These pages are written in a terse style which assumes that the reader has some knowledge of UNIX operating system principles. However, it is not necessary to understand everything in a `man` page in order to use the command. The first few lines always give a brief summary of the command's function and its arguments. For the commands described in this appendix, this is usually sufficient.

Table A-2 Man Command

Command	Description
`man [command]`	Invokes online manual pages for a particular command
`man -k [keyword]`	Search manual pages for a particular keyword

man

```
/usr/people/uv> man man
MAN(1)
NAME
    man - print entries from the on-line reference manuals; find
    manual entries by keyword
SYNOPSIS
man [-cdwWtpr] [-M path] [-T macropackage] [
[section] title ...
    man ]-M path] -k keyword ...
man [-M path] -f filename
DESCRIPTION
```


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```
    man locates and prints the titleed entries from the on-line
reference manuals.  man also prints summaries of manual entries
selected by keyword or by associated filename.
    If a section is given, only that particular section is searched
```
[remainder omitted]

User Information

Table A-3 User Information Commands

Command	Description
`whoami`	Show whose account this is
`who`	Shows who is currently logged on
`finger [user_name]`	Show real name of `[user_name]` and other information associated with that account, including the contents of a `.plan` file, if any, in which users can enter whatever information they want given out.

whoami

```
/usr/people/uv> whoami
uv
```

who

```
/usr/people/uv> who
uv          ttyq0        Jun 10 17:01
```

finger

```
/usr/people/uv> finger root
Login name: root                        In real life: Super-User
Directory: /                            Shell: /bin/csh
Last login at Sat Mar 28 00:15 on :0
No Plan.
```

System Information

Table A-4 System Information Commands

Command	Description
`hostname`	Display the name of the this computer (for example, `irisdemo`)

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Command	Description
`df -k`	Show amount of disk space free (in KB)
`du -k`	Show amount of disk space used for each directory (in KB)
`env`	Show your environment settings, such as PATH, SHELL, TERM, HOME, prompts, etc.
`hinv`	Show hardware configuration, such as CPU type, memory size, serial ports, Ethernet, disk drives, graphics board options, etc.
`versions`	Show versions of installed software
`uptime`	Show how long the system has been up, and the number of users logged on

hostname

```
/usr/people/uv> hostname
adcdemo
```

df

```
/usr/people/uv> df -k
Filesystem            Type  kbytes    use     avail  %use Mounted on
/dev/root               xfs  4253360  1693020  2560340  40  /
```

du

```
/usr/people/uv> du -k
0       ./.web
792     ./Util
0       ./dumpster/A
0       ./dumpster/Cherlin
0       ./dumpster/empty.dir
584     ./dumpster
8       ./.netscape/cache/00
56      ./.netscape/cache/01
44      ./.netscape/cache/02
64      ./.netscape/cache/03
...
484     ./.netscape/cache
704     ./.netscape
0       ./.webcache
0       ./public_html/Miscellaneous
0       ./public_html/Public
12      ./public_html
16      ./.desktop-IRIS/0.0
4       ./.desktop-IRIS/layouts
...
0       ./Desktop
```


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```
732     ./Install/kermit
10372   ./Install
16      ./.ebtpriv
16      ./.desktop-Offline_ADC/0.0
4       ./.desktop-Offline_ADC/layouts
24      ./.desktop-Offline_ADC/configchecks
64      ./.desktop-Offline_ADC
28      ./.desktop-adcdemo/0.0
8       ./.desktop-adcdemo/searchbook
52      ./.desktop-adcdemo/layouts
0       ./.desktop-adcdemo/iconcatalog/pages/Applications
0       ./.desktop-adcdemo/iconcatalog/pages/SupportTools
0       ./.desktop-adcdemo/iconcatalog/pages/O2Demos
...
28      ./.desktop-ADCDemo/configchecks
276     ./.desktop-ADCDemo
0       ./.desktophost/lRIS/Icons
8       ./.desktophost/IRIS
0       ./.desktophost/ADCDemo/Icons
8       ./.desktophost/ADCDemo
...
164120  .
```

env

```
/usr/people/uv> env

_=/sbin/env
LANG=en_US
_SGI_DTLAUNCH_EFFECT=1
PATH=/usr/sbin:/usr/bsd:/sbin:/usr/bin:/etc:/usr/etc:/usr/bin/X11:.
:/usr/people/uv/kermit:/usr/people/uv/Install:/usr/people/uv/Util
SGI_KB_MODEL=indy
NOMSGLABEL=1
WINDOWID=79691780
XUSERFILESEARCHPATH=/usr/people/uv/.desktop-adcdemo/%N:/usr/people/
uv/%N:/usr/people/uv/.desktop-adcdemo/0.0/%N
LOGNAME=uv
MAIL=/usr/mail/uv
SGI_KB_LAYOUT=dvorak
USER=uv
MSGVERB=text:action
LASTLOGIN=Last login: Thu May 28 10:53:39 PDT 1998 on :0
DISPLAY=:0.0
SHELL=/bin/ksh
LAUNCH_EVENT_XY=207:357
HOME=/usr/people/uv
TERM=iris-ansi
PWD=/usr/people/uv
TZ=PST8PDT
WINEDITOR=/usr/sbin/jot -f
NOMSGSEVERITY=1
```


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hinv

```
/usr/people/uv> hinv

Video: MVP unit 0 version 1.2
AV: AV1 Card version 1, Camera not connected.
FLASH PROM version 4.3
On-board serial ports: 2
On-board EPP/ECP parallel port
1 200 MHZ IP32 Processor
FPU: MIPS R5000 Floating Point Coprocessor Revision: 1.0
CPU: MIPS R5000 Processor Chip Revision: 2.1
Data cache size: 32 Kbytes
Instruction cache size: 32 Kbytes
Secondary unified instruction/data cache size: 1 Moyte on Processor
0
Main memory size: 64 Mbytes
Iris Audio Processor: version A3 revision 0
Integral Ethernet: ec0, version 1
 CDROM: unit 4 on SCSI controller 0
 Disk drive: unit 1 on SCSI controller 0
CRM graphics installed
Integral SCSI controller 1: Version ADAPTEC 7880
Integral SCSI controller 0: Version ADAPTEC 7880
Vice: TRE
```

versions

```
/usr/people/uv> versions
I = Installed, R = Removed

   Name                    Date       Description

I  4Dwm                    08/05/97   Desktop Window Manager, 6.3
I  4Dwm.man                08/05/97   Desktop Window Manager Man Pages, 6.3
I  4Dwm.man.4Dwm           08/05/97   Desktop Window Manager Man Pages
I  4Dwm.man.relnotes       08/05/97   Desktop Window Manager Release Notes
I  4Dwm.sw                 08/05/97   Desktop Window Manager, 6.3
```

[remainder omitted]

uptime

```
/usr/people/uv> uptime
5:05pm  up 9 days,  5:36,  1 user,  load average: 0.15, 0.10, 0.01
```

Time/Date

Commands are provided for querying time used on the computer, for reading and setting the time and date, and for generating an ASCII calendar for the current month.

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Table A-5 Time/Date Commands

Command	Description
`date`	Show the current date and time
`date 06091445`	Change date and time to June 9, 2:45 PM
`time [command]`	Show the amount of time it takes to execute `[command]`
`cal`	Show current month's calendar

date

```
/usr/people/uv> date
Wed Jun 10 17:06:26 PDT 1998
```

time

```
/usr/people/uv> time date

real     0m0.02s
user     0m0.00s
sys      0m0.01s
```

cal

```
/usr/people/uv> cal

June 1998
S  M Tu  W Th  F  S
   1  2  3  4  5  6
7  8  9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28 29 30
```

File Information

The commands listed in Table A-6 display all or part of text files, compare files by line or by byte, and count the characters, words, and lines in a file.

Table A-6 File Contents Commands

Command	Description
`more [filename]`	Stop at each page (same as MORE in DOS)
`cat [filename]`	(catenate) Sends the contents of `[filename]` to the screen (same as TYPE in DOS) `cat f1 f2 >f3` makes a new file, `f3`, containing the contents of `f1` followed by `f2`.

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Command	Description
`head [filename]`	Show the first few lines in a file
`tail [filename]`	Show the last few lines in a file
`diff [file1] [file2]`	Show differences between files, line by line
`cmp [file1] [file2]`	Compare two files, byte by byte
`wc [filename]`	Show number of characters, words, and lines in a file

cat

```
/usr/people/uv> cat .profile

Toolchest*horizontal: False
4Dwm*keyboardFocusPolicy: pointer
[remainder omitted]
```

head

```
/usr/people/uv> head .login
#
# This is the default standard .login provided to csh users.
# They are expected to edit it to meet their own needs.
#
# The commands in this file are executed when a csh user first
# logs in.  This file is processed after .cshrc.
#
# $Revision: 1.1 $
#
```

tail

```
/usr/people/uv> tail /usr/uv/.uvconfig

light_tower_alarm_on_time = 10

#Inspex Socket Spec
inspex_socket_spec
inspsock_dbhostname = inspexdb
inspsock_portnum = 2048
inspsock_directorymap = /usr/uv/None
inspsock_directoryimg = /usr/uv/None
inspsock_PastNDaysLotRange = 7 LOT12345*
```


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diff

```
/usr/uv/ADC_Class>diff try_and_test try_and_test-1

1c1
< /usr/uv/ADC_Class/try_and_test
---
> /usr/uv/ADC_Class/try_and_test-1
```

cmp

```
/usr/uv/ADC_Class> cmp try_and_test try_and_test-1

try_and_test try_and_test-1 differ: char 31, line 1
```

wc

```
/usr/uv/ADC_Class> wc try_and_test

             3              15             103 try_and_test
```

File Manipulation

Table A-7 lists the commands for file handling, including move, copy, delete, create link (alias), change access permissions, and change ownership. Access to files depends on the permissions set for the user's account and on the files. For example, ordinary users cannot read the password file, or delete system files by accident.

Table A-7 File Manipulation Commands

Command	Description
`cp [srcfile] [destfile]`	Copy the file named `[srcfile]` to a file named `[destfile]`
`mv [srcfile] [destfile]`	Move or rename a file named `[srcfile]` to a file named `[destfile]`
`rm [filename]`	Remove or delete a file. Can be very destructive, no deleted file recovery in Unix.
`chmod [flags] [filename]`	Change permissions of a file r = read, w = write, x = executable u = user, g = group, o = other, a = all
`chmod a+rw [filename]`	Give read and write permissions to everyone

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Command	Description
`chmod o-x [filename]`	Take away execute permission from others
`chown [NewOwner" [filename`	Change the owner of the file
`ln [srcfile] [destfile]`	Instead of copying files, you can link files, saving space and avoiding redundancy. `[destfile]` becomes a pointer to `[srcfile]`, so whenever you access `[destfile]`, you are actually accessing `[srcfile]`.

RCP File Transfer

In addition to the file management functions described above for a single, system, there is a remote copy command which allows copying between any linked systems.

Table A-8 RCP Command

Command	Description
`rcp [hostname1:/usr/people/user1/filename1] [hostname2:/usr/people/user2/filename2]`	Copy the file `[filename1]` from [hostname1:/usr/people/user1/] and transfer it to [hostname2:/usr/people/user2/] under the name `[filename2]`

NOTE: If you are copying to the remote system, you must have permission to write into the remote directory.

FTP File Transfer

FTP is a file transfer protocol and also the name of the UNIX utility which uses that protocol to transfer files. There are also visual FTP programs which allow the user to click on directories and files, and on icons for downloading, uploading, displaying, and so forth. Such programs issue the standard ftp commands to the other computer, but do not display them to the user. It is possible to ftp files from a CRS using an ftp client or the ftp functions of a Web browser on a Windows or Macintosh computer, as well as from any other UNIX system.

Table A-9 FTP Command and Functions

Command	Description
`ftp [hostname]`	Establish FTP with `[hostname]`
`help`	Provides a list of available commands
`dir`	List directory contents (the command `ls` also works)
`iget [filename]`	Receive the file `[filename]` from remote system
`put [filename]`	Send the file `[filename]` to remote system
`mget [*.c]`	Receive all files with the extension .c from remote system

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Command	Description
`mput [*.h]`	Send all files with the extension .h to remote system
`cd [remote directory]`	Change to the directory [remote directory] on remote system
`cd [local directory]`	Change to the directory [local directory] on local system
`pwd`	Show current directory on remote system
`bye`	Disconnect from remote system

Logging on Remotely

1. Type `rlogin [hostname]` and press **Enter**.
2. Supply a login name and password when prompted.
3. You are now in a UNIX shell on another computer. You can use any commands that are available to your account.

Directory Manipulation

Table A-10 lists the commands for directory manipulation, including navigation between directories, identifying the current directory, getting directory listings in varying amount of detail, and creating and deleting directories. Access to directories depends on the permissions set on the user's account and on the directories. For example, ordinary users cannot delete system directories by accident.

Table A-10 Directory Manipulation Commands

Command	Description
`ls`	List the contents of current directory
`ls -al`	List the contents of current directory, including dotfiles, and showing permissions, ownership, filesizes, dates, times.
`ll`	List the contents of the current directory with detailed information
`pwd`	Print working directory, (show current directory)
`cd [directory]`	Same as CD in DOS world, change to another directory
`cd ..`	Change to parent directory
`cd /`	Change to the root directory
`cd ~`	Change to your home directory
`mkdir [directory]`	Same as MD in DOS world, make a new directory
`rmdir [directory]`	Same as RD in DOS world, remove directory

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ls

```
/usr/people/uv> ls

Desktop
Install
Util
WIN95-root.hdf
demodisk
dumpster
public_html
uv
uv.outbox
uv1000
uv_adcdemo
```

ls -al

```
/usr/people/uv> ls -al

total 301264
drwxr-xr-x   16 1110      user        4096 May 26 10:10 .
drwxr-xr-x    5 root      sys           51 Jan 19 13:26 ..
-rw-r--r--    1 1110      user          62 Jan 27 09:34 .Sgiresources
-rw-rw-rw-    1 root      user         126 Feb 14 23:54 .Xdefaults
-rw-r--r--    1 1110      user         552 Jan 19 13:26 .cshrc
drwxr-xr-x    7 1110      user        4096 May 19 16:03 .desktop-ADCDemo
drwxr-xr-x    6 1110      user        4096 Jan 19 13:28 .desktop-IRIS
drwxr-xr-x    5 1110      user        4096 Jan 27 09:36 .desktop-Offline_ADC
drwxr-xr-x    5 1110      user          58 Jan 27 09:50 .desktophost
drwxr-xr-x    2 root      user          62 May 27 12:17 .ebtpriv
-rw-r--r--    1 root      user           0 May 19 12:16 .expertInsight
-rw-r--r--    1 1110      user         122 May 27 12:14 .infosearchrc
-rw-r--r--    1 root      user        1909 May 19 12:23 .insightrc
-rw-r--r--    1 root      user          64 May 19 12:15 .insighttmp
-rw-r--r--    1 1110      user         631 Jan 19 13:26 .login
drwx------    3 1110      user        4096 May 26 17:48 .netscape
-rw-r--r--    1 1110      user         887 Jan 27 10:20 .profile
-rw-r--r--    1 root      user          30 May 27 12:17 .sgihelprc
-rw-r--r--    1 root      user          64 May 27 11:54 .sgihelptmp
-rw-r--r--    1 root      user       11507 Jan 27 14:08 .sgisession
-rw-------    1 root      user        6622 May 27 12:51 .sh_history
-rw-rw-rw-    1 root      user        3941 Feb 15 00:07 .swinconfig
drwxr--r--    2 1110      user          30 Jan 19 13:32 .web
drwxr-xr-x    2 1110      user           9 Jan 19 13:32 .webcache
drwxr-xr-x    4 root      user          72 May 27 12:43 Cherlin
drwxr-xr-x    2 1110      user         104 Jan 19 13:26 Desktop
drwxrwxrwx    3 root      user        4096 Jan 27 10:25 Install
drwxr-xr-x    2 root      user        4096 Jan 27 10:26 Util
-rw-rw-rw-    1 root      user   150940672 Feb 15 00:07 WIN95-root.hdf
-rwxrwxrwx    1 root      user         332 Jan 27 11:05 demodisk
drwxr-xr-x    3 1110      user          58 May 26 10:10 dumpster
drwxr-xr-x    4 1110      user         148 Jan 27 09:34 public_html
```


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```
-rwxrwxrwx    1 root     user     2581288 Jan 27 10:56 uv
-rw-r--r--    1 1110     user          51 Jan 19 13:26 uv.outbox
-rwxr-xr-x    1 root     user         227 Jan 27 14:07 uv1000
-rwxr-xr-x    1 root     user     2564904 Jan 27 11:38 uv_adcdemo
```

pwd

```
/usr/people/uv> pwd
/usr/people/uv
```

cd

```
/> cd /usr/people/uv
/usr/people/uv>

/usr/people/uv> cd ..
/usr/people>

/usr/people> cd /
/>

/> cd ~
/usr/people/uv>
```

Command Information

It is often necessary in administering a UNIX system to determine what programs are running and where they came from, in case there are multiple versions of a command. The commands in Table A-11 provide these functions.

Table A-11 Command information

Command	Description
`which [command]`	Show exactly which executable will be invoked when `[command]` is typed.
`whereis [command]`	Show where the location of this `[command]` is. This includes its executable, source code, and manual page.
`w`	Show which commands are being executed, and by which users, etc.

which

```
/usr/people/uv> which man
/usr/bin/man
/usr/people/uv> which uv1000
./uv1000
```


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whereis

```
/usr/people/uv> whereis man

man: /bin/man /usr/bin/man /usr/share/catman/u_man/cat1/man.z
```

w

```
/usr/people/uv> w

12:57pm  up  3:10,  1 user,  load average: 0.05, 0.12, 0.15
User     tty from             login@   idle   JCPU   PCPU  what
uv       q0  :0.0           11:51am              1          w
```

Process Control

The most common reason for an administrator on a CRS to invoke process control functions is to dispose of an errant program, including the CRS application, which does not respond to normal exit commands, either its own menu commands or the standard Control-C exit. Methods of dealing with non-responding programs listed in Table A-12 include killing the program, rebooting, or in extreme cases shutting down the CRS. See also "Lockup Recovery" on page 277 in Appendix F, "Basic Maintenance" for other methods of dealing with a program crash.

Table A-12 Process Control Commands

Command	Description
`reboot`	Shutdown system and then Boot up again. No musical tune is played. To power down, choose the [System Shutdown] option on the `[System]` popup menu at the top, left-hand corner of screen.
`CTRL+C`	Kill current process
`ps`	Show the processes running currently, along with their PID (process identification number)
`ps -e`	Show every process on system.
`kill [process_id_number]`	Kill the specified process identified by its PID (process_id_number)
`[command] & [execute]`	Run `[command]` in the background and `[execute]` in the foreground
`fg`	Bring background process back to the foreground.

ps

```
/usr/people/uv> ps
```


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```
 PID TTY      TIME CMD
1165 ttyq0    0:00 ksh
1407 ttyq0    0:00 ps
```

Miscellaneous Commands

There are a few other important commands that do not fit into any of the previous categories, listed in Table A-13

Table A-13 Miscellaneous Commands

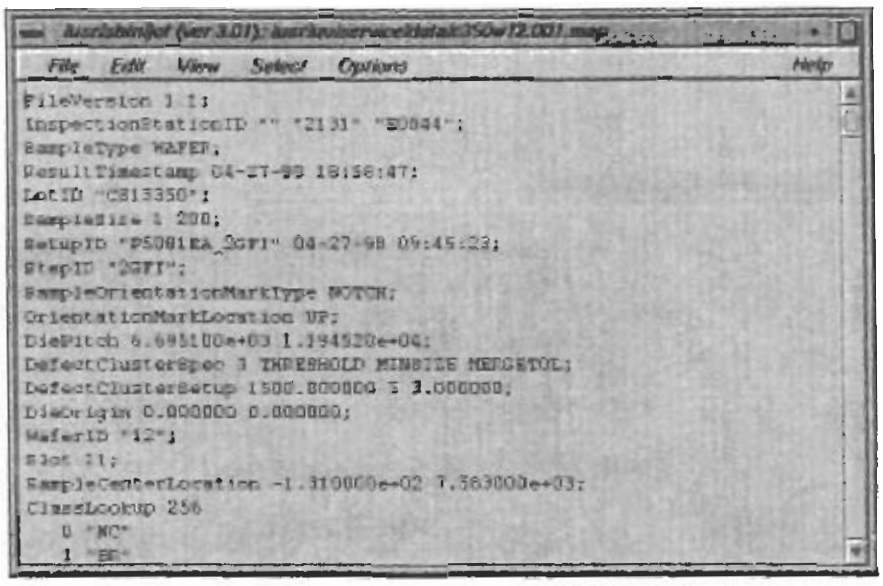
Command	Description
`su`	Become the superuser.
`CTRL+D or exit`	Quit being the super-user; can also be used to destroy a Terminal (BlueScreen).
`Right Mouse Button`	Press the right mouse button when in a BlueScreen (Winterm terminal window or shell window) to bring up a pop-up menu. Options let you change the font, or create another BlueScreen. Press the right mouse button while pointing at the title bar at the top of a window to bring up a pop-up menu with options for window management and exiting the program. Some applications such as the Snapshot screen capture utility and the Jot text editor have other uses for the right mouse button.
`hh`	Show the previous few commands.
`CTRL+P`	Retype the previous command automatically. Repeated pressing brings back earlier commands one at a time.
`eject`	Eject the floppy diskette from the drive.

Text Editing using Jot

Jot is an X Windows visual text-editing application that is simple and easy to use. Jot can open files, cut and paste, undo the most recent editing action, and search for a string.To start jot, type `jot [filename]`. For example, `jot .login` would bring up a window similar to Fig. A-5. To use jot, click and drag using the left mouse button to select regions of text. Use the right mouse button to bring up the pop-up menu, which includes cut, copy, and paste functions.

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Figure A-3 Jot Window



For further information on `jot`, see its man page (`man jot`) and the Help menu at the right of the menu bar.

Tapes

Tar (tape archive) is the most universal type of tape drive format for UNIX systems. You usually copy files from the specified directories onto a tape (backing up or archiving), or extract files from the tape back into their original directories (restoring).

Table A-14 Tape Commands

Command	Description
`tar tv`	List the contents of this tape.
`tar cv [filename1] [filename2]`	Formats the tape to the tar format, then writes the specified files onto the tape.
`tar cv [directory1] [directory2]`	Formats the tape to the tar format, then writes all files from the specified directories and their subdirectories onto the tape.
`tar cv .`	Writes all the files from the current directory and its subdirectories onto the tape.
`tar xv [filename]`	Extracts the file `[filename]` from the tape and copies it back into its original directory.
`tar xv [directory1] [directory2]`	Extracts the contents of the specified directories and their subdirectories from the tape and copies them back into the original directories and subdirectories.

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Command	Description
`tar xv`	Extracts the contents of the tape and copies them back into their original directories and subdirectories.

User Preferences

The home directory is the directory you are placed in upon login. It is usually `/usr/people/` [your_login_name]. For the CRS application, it is `/usr/people/uv`. In the home directory for any login account are some *dotfiles*, configuration files that are executed as part of the login proce.ss. The names of dotfiles begin with a dot (.). Table A-15 lists the most important dotfiles for the CRS. Dotfiles are somewhat similar to `autoexec.bat` and `config.sys` in the DOS world and Preferences files on the Macintosh.

Table A-15 User Preference Files

Dotfile	Description
`.login`	For C shell, configuration file when logging in.
`.cshrc`	For C shell, configuration file when new C shell is started.
`.profile`	For Korn shell, configuration file when logging in.
`.Xdefaults`	Configuration file for X Window applications.
`.sgisession`	Executed each time the user logs in through Pandora screen. For example, sets monitor to 60 Hz and runs uv1000.

.login

```
# This is the default standard .login provided to csh users.
# They are expected to edit it to meet their own needs.
#
# The commands in this file are executed when a csh user first
# logs in.  This file is processed after .cshrc.
#
# $Revision: 1.1 $
#

if (! $?ENVONLY) then
        # Set the interrupt character to Ctrl-c and do clean backspacing.
        if (-t 0) then
            stty intr '^C' echoe
        endif

        # Set the TERM environment variable
        eval `tset -s -Q`
endif

# Set the default X server.
if ($?DISPLAY == 0) then
    if ($?REMOTEHOST) then
```


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```
        setenv DISPLAY ${REMOTEHOST}:0
    else
        setenv DISPLAY :0
    endif
endif
```

.cshrc

```
#
# This is the default standard .cshrc provided to csh users.
# They are expected to edit it to meet their own needs.
#
# The commands in this file are executed each time a new csh shell
# is started.
#
# $Revision: 1.1 $
#

# list directories in columns
alias ls 'ls -C'

# Remember last 100 commands
set history = 100

# For interactive shells, set the prompt to show the host name and event number.
if ( (! $?ENVONLY) && $?prompt ) then
        if ( -o /bin/su ) then
        set prompt="'hostname -s' \!# "
        else
        set prompt="'hostname -s' \!% "
        endif
endif
```

.profile

```
# This is the default standard .profile provided to sh users.
# They are expected to edit it to meet their own needs.
#
# The commands in this file are executed when an sh user first
# logs in.
#
# $Revision: 1.10 $
#

# Set the interrupt character to Ctrl-c and do clean backspacing.
if [ -t 0 ]
then
        stty intr '^C' echoe
fi

# Set the TERM environment variable
eval 'tset -s -Q'
```


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```
# Set the default X server.
if [ ${DISPLAY:-setdisplay} = setdisplay ]
then
    if [ ${REMOTEHOST:-islocal} != islocal ]
    then
        DISPLAY=${REMOTEHOST}:0
    else
        DISPLAY=:0
    fi
    export DISPLAY
fi


# List files in columns if standard out is a terminal.
ls()    { if [ -t ]; then /bin/ls -C $*; else /bin/ls $*; fi }

PATH=$PATH:.:/usr/people/uv/kermit:/usr/people/uv/Install:/usr/people/uv/Util
PS1='$PWD> '
alias ll='ls -al'
alias hh=history
set -o emacs
mousewarp 4 4
umask 000
```

.Xdefaults

```
! For running SoftWindows with 4Dwm
4Dwm*sOftWindows*windowMenu:  SoftWindowsMenu
4Dwm*keyBindings:             SoftWindowsKeys
```

.sgisessions

```
#########################################################################
#
#  NAME
#       /usr/tutor/Customize/example.sgisession - example session script for
#           initializing your environment at login
#
#  DESCRIPTION
#
#    This example.sgisession file shows you how to make the following
#    customizations to your own login account:
#
#       A)  automatically start up applications when you log in,
#       B)  specify an initial window size and location for these
#           applications,
#       C)  specify if these applications should be started as an icon
#           rather than a window,
#
#       D)  set the screen background to a specific color or pattern,
```


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```
#         E)  remap mouse buttons,
#
#         F)  turn off the keyboard bell,
#         G)  change the length of time before an inactive screen goes blank, and
#         H)  turn on keyclicking.
```

[remainder omitted]

CRS Command Files

Table A-16 CRS Application Commands

File	Description
uv1000	Deletes any core dumps, clears the print spooler, kills leftover processes, and then runs uv.
uv	The CRS application program. It should normally be run only from uv1000, and not called on its own.

uv1000

```
/sbin/killall uv
/sbin/killall uv_adc
rm core
rm /usr/people/uv/core
rm /usr/people/uv/WorkSpace/core
rm /var/adm/crash/vmcore.*
rm /var/adm/crash/vmunix*
rm /var/spool/npl/*
rm /var/tmp/core
mousewarp 4 4
/usr/people/uv/uv
```


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B

Preparing for CRS Installation

Pre-installation Qualification Checklist

(U.S.A ONLY)

Your attention to the detailed information found in the **Planning Section** and the **Environment Requirements Section** of the Pre-Installation Documentation will minimize delays and expenses during the installation of your instrument. It is the responsibility of the customer to provide the correct power socket within reach of the CRS's power cord, and also air and vacuum lines of suitable length with the correct connectors for both the CRS and the supply fittings.

Important Notice

The unpacking and installation must be done by a KLA Tencor representative. The following Requirements must be met before a representative will be scheduled. *Please instruct your Receiving department NOT to open the crate upon receipt.*

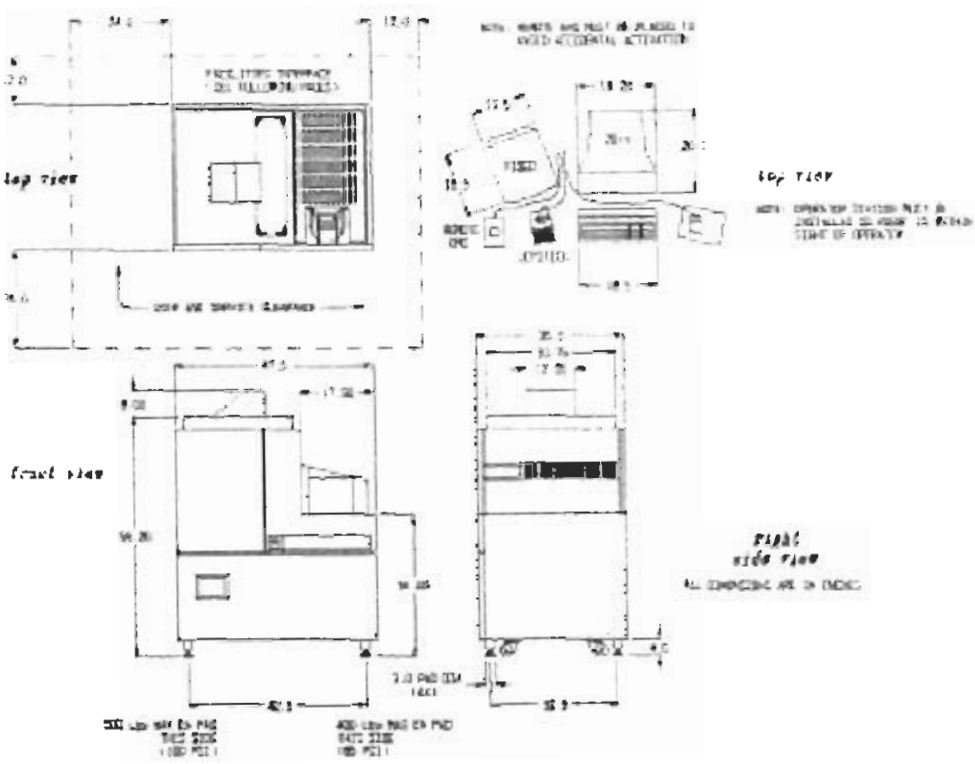
Table B-1 Environment Requirements

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☐	TEMPERATURE	15–24°C (59–75°F)
☐	AIR QUALITY	Clean room, recommended Class 100 or cleaner
☐	AC POWER	Alternating current, single phase. 240/220/208/200 volts (factory configured). Current is 30 amps @ 208 volts. Cord is 3-conductor, 10 gauge, 10 feet long, non-terminated, with locking NEMA plug (U.S.A. only). Safety interlock is optional.
☐	VACUUM	20 inches (508 mm) Hg minimum constant vacuum for the system with a flow rate of 0.5 cfm (14.2 l/min) minimum. Fitting is one ¼-inch female NPT with ¼-inch tube quick disconnect.
☐	PRESSURE	Air or nitrogen, 80 psi minimum with a flow rate of 3 cfm (14.2 l/min). Fitting is one ¼-inch female NPT with ¼-inch tube one-touch.
☐	REMOTE COOLING	Connections are two each, 3.5-inch flexible duct. Flow rate is 400 cfm (11.3 m/min). Heat output is 14,000 BTU/hr (main system only). 10 feet of 3.5 inch ducting is provided.
☐	FLOOR	Must be level and capable of supporting 1255 lbs (570 kg)
☐	SPACE	Requires 24 inches of unobstructed space around the system for user and service clearance. The power input panel at the rear of the machine must be at least 3' from the wall. An 8' × 13' area is suitable for both the CRS instrument and the operator's workstation. Fig. B-.

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Figure B-1 CRS Measurements and Floor Layout



Relative Humidity

35–65 % relative humidity.

Electrical Power

Main System:

Type:	Alternating current, single phase
Voltage:	240/220/208/200 volts (factory configured)
Current	30 amps @ 208 volts
Cord:	3-conductor, 10-gage 10 feet long, non-terminated
Safety Interlock:	Optional

Accessories:

Type:	Alternating Current, single phase
Voltage:	AC 120 volts, 10-15 Amps (depending on options)

External Vibrations

Table B-2 Vibration Requirements

0 < 5 Hz	1 µm p-p
5 < 10 Hz	4 µm p-p
10 < 50 Hz	6 µm p-p
> 50 Hz	2 µm p-p

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Fig. B-1 shows the typical layout of a CRS installation, including the location of the power, exhaust, air, and vacuum connections.

An equipment rack, pictured in Fig. B-2, is designed to hold the two monitors, two printers, keyboard, mouse, joystick, optical drive, and accessories for the CRS in the space shown on this diagram. It is available from **KLA Tencor** (P/N 901-66436-000).

Figure B-2 CRS Equipment Rack



When all requirements are met, please fax the form on the next page to the **KLA Tencor** Product Services Administrative Assistant to arrange for installation.

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CRS 1200 Installation Scheduling Form

We have made all necessary preparations for installing the KLA-Tencor CRS 1200 which we have received. It is in its crate ready for moving to the clean room.

Signature _____

Name _____

Date _____

Company Name _____

Company Address _____

_____

Person to Contact: _____

Telephone No.: _____

Fax No.: _____

E-mail address: _____

Please sign and fax this form to KLA-Tencor Product Services Department at (408) 875-2828. Attention: Product Services Administrative Assistant

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Planning for Installation

Planning

Please review all CRS 1200 system information contained in the pre-installation Documentation before planning your site installation. The installation procedure will take approximately three days from beginning to end, barring any unforeseen disruption. Training takes an additional two days. Please be sure you have the time and work force available at the scheduled time of installation.

Equipment Delivery

Check the shipping crate very carefully for any signs of visible damage at the time of receipt. If there is any damage or if the shock indicators caution of possible damage, note any problems, in writing, before signing for the delivery. **This must be done, with the delivery person on site, at the time of delivery.**

Contact Customer Response Center at 1-800-600-2829 if there is any indication of possible damage.



WARNING

Do NOT unpack the CRS 1200 system until your site is fully prepared and the KLA-Tencor representative is on site.

Note: Save the shipping materials for future transportation of the instrument. The CRS 1200 system must be shipped in the same container to properly protect its mechanical components.

Installation

You will need to meet all of the requirements listed below:

Pre-Installation Qualification Checklist—Found at the beginning of this Installation Guide. Your site must meet all of the requirements listed on this form before the installation will be scheduled. Please have this form, filled out and signed, available to present to the KLA-Tencor Field Service Engineer upon arrival.

Forklift—Capable of transporting the CRS 1200 system from the receiving area to the clean room. Must be able to support the weight of the system, approximately 1255 pounds (570 kg)

Work force—Two or three people, available at the scheduled time of installation, to assist in moving the CRS 1200 system from the receiving area to the clean room.

Training—Provided at the time of installation, requires an additional two days. The recommended class size is four students with a maximum of eight. The training is designed to familiarize your engineers and operators with the basic operation of the CRS system.

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C

Preparation for ADC

Requirements

Automatic Defect Classification requires a CRS set up and maintained to provide uniform, high-quality images to the software for analysis. The following are the minimum requirements for accurate ADC function. These tests and any corrective procedures required can only be performed properly by a trained Field Service Engineer.

- System is parfocal, parcentric, intensity adjusted, and able to autofocus on all objectives.
- ADC software option enabled.
- Laser ADC software option enabled, if ordered.
- Fast Z firmware version 34 or later is installed.
- PMT controller's ZERO offset is set to 128.
- White light and laser parfocality.
- Aperture limit is set to maximum, which is ≤ 150.
- Camera settings.
- White balance.
- WL image quality: skewness, intensity uniformity, dirt, and edge symmetry
- Laser image quality check at 100×.
- Stage XY accuracy test.
- Stage flatness test.
- Autodeskew test.
- Optical drive test.
- Total hard drive capacity of at least 3 GBytes.
- Increase the extra .swap2 file from 30 MBytes to 70 Mbytes.
- ADC test, using standard wafer:

  AutoDeskew.

  After first defect is located, go to ADC screen.

  Select at least 3 different typical defects to build a knowledge base, using the ***Learn*** dialog box.

  Run ***ClassifyAll*** in the ADC screen. All defects should be detected correctly, and classification should be mostly correct.

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WARNING

Audit is to be performed by Service personnel intimately familiar with CRS ONLY.

Scope

This procedure will describe how to identify components on a system in the field that effect ADC functionality and that are not part of the standard list of required components for ADC. This procedure applies primarily to older models 500, 1000, and 1010. If these components are found to be down rev, they will have to be upgraded using the part numbers listed for each area.

Items Required

Standard service kit.

Procedure

Remove panels and use software to verify the following:

Standard ADC Components for all CRS Systems

- Identifier Software with proper keyfile(s) enabled - 001404 is the std software, 001258 is the whitelight only keyfile and 001406 is the laser ADC keyfile.

  Note: 001258 is required for 001406. A new keyfile will need to be generated for system
- Sony camera model 950 (930 acceptable) - 001359.

  Note: this camera is now standard on the CRS 1010A.
- Optics upgrade kit for non-1010A CRS systems - 001355 (does not apply to 1010A or 1200 systems).
- GEMINI Optics Kit - 001412.
- 2GB hard disk - 001354.
- External optical disk drive - 001413.

Note: 1010A systems introduced the Equipe robot (black). All earlier models (non-SMIFed) have a MECS robot (silver).)

There is a possibility that any of the above components could already be present on a system in the field. The procedure to check for presence is also included below.

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Items to check that are critical for ADC systems

System information

CRS Model - _____ CRS Serial Number - _____ -

Keyfile information

Manually record system ID and existing keyfile information by typing "rdkey" in a UNIX shell. If "rdkey" does not work look at the beginning of the window that uv was started from and record the "HardwareID=" numbers and the 1's and 0's listed directly above that line.

Integrated whitelight option

required for ADC video capture.

____Complies

____No Compliance, requires 001251

Computer Module

Computer Model: Indy or Indigo? Indy type with R4400 or R5000 CPU required to run ADC software. To list installed computer hardware type "hinv" in a Unix shell.

____Complies

____No Compliance, requires 001225, 003035, 003037, 000803 (2x), 000852, 000827, 000828, 009059-01, 009059-02 and RGB panel components below

Primary hard disk

Must be 1GB or higher (Does not apply with no compliance above)

____Complies

____No Compliance, requires 014128

UV software version

UV ADC v2.0 (or higher) required.

____Complies

____No Compliance, requires 001404 with 001258 or 001258 and 001406 enabled (requires new keyfile generated for entire system.)

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Camera present

Sony camera model DCX-930 or 950 required for ADC. Earlier systems have a Cohu or Optronics camera.

____Complies

____No Compliance, requires 001359

GEMINI Optics

This is required for "true" simultaneous viewing. These optics are present if while viewing laser image at 488nm line the whitelight image does not use the yellow filter.

____Complies

____No Compliance, requires 001412

External Optical Drive

Required for ADC systems.

____Complies

____No Compliance, requires 001413

(Note: a couple of systems have internal drives, which comply, look under drive bay door.)

Objectives in system

Standard 5X DF, 50X DF and 100X BF (0.95 NA) required.

____Complies

____No Compliance, requires 5X 014018; 50X 000772; 100X 000771 (or partial)

For use with Laser ADC 100X must have less than 10% spherical aberrations side lobe. Check this per separate procedure. (Does not apply with a no compliance above.)

____Complies

____No Compliance, requires 100X 000771

Automated A-stop mechanism

Mechanism which moves A-stop on vertical illuminator must be present. Older systems had this in a fixed position.

____Complies

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____No Compliance, requires 001220

Beamsplitter type

Sliding cube or gimbal mounted plate? Plate assembly required.

____Complies

____No Compliance, requires 001271, 002053, 002052, 002203, 012107

RGB output present on interface panel on back of unit

Required when using above Sony camera. Some older systems had only Y-C output.

____Complies

____No Compliance, requires 003046, 003048, 000803 (2x),

Fast-Z PCBA version

Assy p/n 001003 required for patch scan AF firmware.

____Complies

____No Compliance, requires 001003T

If 001003 is present check the firmware vesion in LON diagnostics. For use with ADC firmware v2.2 is required. This would read as a "34" under LON Diag. FastZ Cntrl/Softwr Ver.

____Complies

____No Compliance, requires 001352, 001353 (These are already part of 001355)

Stage System

Stage controller model 330-UP with single RS-232 port control required. Model silk-screened on front of controller and controller will have only one thumbwheel and one set of start/stop buttons.

____Complies

____No Compliance, requires 014092, 014093, 009082, 009081.

Die to die stage accuracy

must be 6μ or better across entire wafer surface. This is slightly different than our std. accuracy spec. If after recalibration and mapping still does not comply entire stage system may require replacement. This to be determined by the ADC apps engineer.

____Complies

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____No Compliance, requires notification of ADC Apps. Engineer

Part number descriptions/definitions

The part numbers for ADC components in Table C-1 were current at the time of writing this manual. The table summarizes the part number references in the preceding system audit.

Table C-1 ADC Component Part Numbers and Descriptions

Part Number	Description
001251	Integrated Whitelight Option
001225	CPU Module, Indy (includes all PCBAs)
003035	Bracket, Cable Clamp (for clamping keyboard and mouse connectors at interface panel)
003037	Clamp, Keyboard/Mouse Conn. (used with above)
000803	Screw, Button, 6-32x3/8" (used with above, qty-2)
000852	Screw, Cap, 8-32x3/4 (used with above)
000827	Washer, Flat, #8 (used with above)
000828	Washer, Lock, #8 (used with above)
009059-01	Cable, Internal, Keyboard
009059-02	Cable, Internal, Mouse
003046	Panel, Interface (the latest version which has RGB interface)
003048	Cover Plate, Camera Keyboard (used to cover Optronics keyboard port on above panel)
000803	Screw, Button, 6-32x3/8" (used with above, qty-2)
014128	Hard Disk, 1GB Indy
001404	Software, ADC v2.0 (this is basic software no keyfiles enabled)
001258	White Light ADC Option
001406	Laser ADC Option (requires 001258 to be activated to function properly)
001359	Video Option, Sony DXC-950 (also includes many mechanical parts)

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Part Number	Description
001412	Optics Option, GEMINI
001230	Drive Option, 1.3GB External Optical
014018	Objective, 5× Dark-field
000772	Objective, 50× Dark-field
000771	Objective, 100× Bright-field, 0.95NA (Sorted from the Olympus factory)
001220	Assy, A-Stop Upgrade (includes many mechanical parts)
003046	Assy, Beamsplitter Plate
002053	Riser, Video Assy, Front (enhances use of Beamsplitter assy)
002052	Riser, Video Assy, Rear (enhances use of Beamsplitter assy)
002203	Plate, Offset Video Mount (enhances use of Beamsplitter assy)
012107	Screw, Set, 6-32×1/2", Nylon Tip
001003T	PCBA, Fast-Z, Tested
014092	Controller, Neat Stage, UP-330
001352	Programmed IC, Fast-Z Neuron, v2.2
001353	Programmed IC, Fast-Z Logic, v2.2
014093	Joystick, Neat Stage, UP-330
009082	Cable, RS-232, Neat Stage, UP-330
009081	Cable, Internal, Joystick, Neat Stage, UP-330

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D

Specifications

CRS 1200

Optical System

General

Optical Train	Proprietary Design
Objective Turret	Five-position, user-selectable, and motorized
AutoFocus	Proprietary laser-based autofocus with manual override (patent pending)
Objectives - Standard	5×, brightfield / darkfield, 0.13NA, 12.0mm working distance 20×, brightfield / darkfield, 0.40NA, 3.0mm working distance 50×, brightfield / darkfield, 0.70NA, 0.50mm working distance 100×, brightfield, 0.95NA, 0.30mm working distance 150×, brightfield, 0.95NA, 0.80mm working distance

White Light

Illumination Source	100 Watt Halogen
Optical Filters	Neutral Density, Yellow
Camera	Sony : color, three-chip CCD, Model DXC950 , electronic enhancement
Video Monitor	Sony: color, 13-inch diagonal, 600 horizontal lines of resolution
Field of View	Approximately 60 µm × 45 µm (H × V) with 100× objective
White Light Magnification	Approximately 4,400× (with 100× objective on 13-inch monitor)

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Laser

Illumination Source	25 mW, air cooled, multi-line, stabilized Argon-Ion. Class IIIb.
Wavelengths	User selectable: TEM$_{00}$ 458 nm, 488 nm, 515 nm, or combination of all three
Output Power	Variable from 6 to 25 mW
Spatial Filter	25 µm
Spot Size	300 nm (diffraction limited) at image surface (100×, 0.95 NA)
Optical Resolution	XY: ~0.10 µm (based on imaging of certified Polystyrene Latex spheres)

Z: ~0.025 µm (minimum perceptible color variation in false color mode)

Scanning Frequency	X-direction: 8000 Hz Y-direction: 26 Hz
Frame Rate	256 × 256: 26 frames/second 512 × 512: 13 frames/second
Field of View	User Selectable (all at 100×): 6.25 × 6.25 µm 12.5 × 12.5 µm 25 × 25 µm 50 × 50 µm
Pixel Step Size	12.5 nm (at 100× and 6.25 × 6.25 µm field of view)

Computer

Processor

Model	**1200**
Platform	SGI Indy
Processor	mips R4400SC
Clock rate (Mhz)	200
SPEC Marks (integer 92)	122.6
SPEC Marks (floating point 92)	115.5
Random Access Memory (MB)	64

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Graphics

Model	1200
Graphics	24-bit
Colors	16.7 million
Resolution	1280 × 1024
Performance - Tmesh	79K
Performance - 3D Hi Res (sec)	12
Standard Monitor	17-inch

17-inch Monitor	Color, 1280 × 1024, 0.26 mm dot pitch, 50 & 76 Hz refresh rates
20-inch Monitor	Color, 1280 × 1024, 0.31 mm dot pitch, 50 & 76 Hz refresh rates

Communication & Interfaces

File Transfer Methods	Ethernet (1 MB/sec), RS-232 (1 KB/sec), or Floppy diskette
Network Protocols	TCP/IP NFS
Defect Scanner Protocols	KLA 21XX/255X via Ethernet or Floppy (v.1.5 SEM, v.2.0 SEM, v.2.0 Results) Tencor 6XXX/SwiftStation via Ethernet or Floppy 7XXX/SwiftStation via Ethernet or Floppy Surfscan AIT/SwiftAccess via Ethernet or Floppy Inspex TPC-85xx /DMS via Ethernet or Floppy OSI IQ via Ethernet or Floppy Hitachi WI-8XX/AS-2000 via Floppy or Ethernet
Defect Capacity	12,000 defects/wafer
Defect Codes	256, user definable

Storage

Floppy Drive	3.5-inch, 21 MB floptical (compatible with 1.44 MB magnetic)
Hard Disk Drive	2.0 GB
Tape Drive	250 MB, 1/4-inch
Magneto-Optical (optional)	5.25-inch, read-write, magneto-optical disk. 1.3 GB per disk. Removable media.
Image File Size (512 × 512 × 64)	
Surface:	525 Kbytes
Volume:	16.78 Mbytes

Other

Operating System	Silicon Graphics IRIX
Input Devices	101-key Keyboard & Mouse
Access Levels	Service, Administrator, and Operator (password controlled)

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Recipe Parameters	3D View, 2D View, Status View, Cam Intensity, Laser Intensity, BF/DF, Filter, XY Resolution, No.of Z slices, Z step size, Laser Line, Wafer Thickness, Y Dimension, BW/Color, AF Intensity, Stage Center Offset, Sort Parameters

Wafer Transport

General

Cassette Type	SEMI Standard; 3/16" & 1/4" pitch; 25 or 26 slots
Wafer Type	SEMI Standard; Flat or Notch; 0°, 90°, 180°, or 270°
Wafer Size	100 mm, 125 mm, 150 mm, or 200 mm (3-inch optional)
Cleanliness	Class 1

Prealigner

Make & Model	Equipe Technologies PRE 200-B
Detection Type	Non-contact, optical
Drive	DC Servo
Repeatability	
Theta	±0.04°
X/Y alignment	±0.0015 inches
Throughput	9 seconds/wafer

Robot

Make & Model	Equipe Technologies ATM 104-1
Type	Programmable, closed-loop, 3-axis robot
Drive	DC Servo
End Effector	Teflon-impregnated aluminum alloy, vacuum-assisted, backside contact.

Axis Specifications:

	Radial Axis	Theta Axis	Z Axis
Range of Motion	4.45"	345°	7"
Repeatability	±0.001"	±0.005°	±0.001"
Speed	24 in/sec	720°/sec	17 in/sec

XYZ Stage

XY Axes

Range	206 mm (each axis)

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Drive	Stepper Motor (each axis)
Positioning	Closed-loop with Linear Optical Encoders (each axis)
Speed	Variable. 150 mm/sec maximum.
Raw Accuracy	< ± 10 µm
Repeatability	± 2.0 µm, bi-directional, 3σ

Coarse Z

Range	13 mm
Drive	Stepper Motor
Positioning	Open loop, micro-stepping
Repeatability	±10 µm, bi-directional, 3σ

Fine Z

Wafer Chuck	Aluminum alloy, Teflon impregnated; Vacuum assisted
Range	50 µ
Drive	Piezo electric crystal
Positioning	Closed-loop positional sensor
Resolution	12 nm

System General

External Frame

Cleanliness	Class 1
Particle Generation	<0.01 each of >0.3µm added per 1cm^2 per wafer pass in Class 1 environment
External Panels	Stainless Steel
Air Flow	Cleanroom Laminar Air
Vibration Isolation	3-point Active Air Damping & Leveling
Frame	Plated Mild Steel; Inert Gas-welded Construction
Support	Transport: 3-inch Textite Wheels (4); Operation: 2.5-inch Leveling Pads (4)
Controls	On/Off, Emergency Off, Circuit Breakers, Laser Interlock System

Throughput

Load Wafer to 1st Deskew Point	28 seconds
Manual Deskew to 1st Defect	15 seconds
Move & Focus	2.4 seconds (live laser mode, 8 mm travel)
Unload Wafer	13 seconds
Image Acquisition	5.5 seconds (512 × 512 × 64)
Image Display (512 × 512 × 64)	3D Hi Res: 12 sec
Image Storage (512 × 512 × 64)	Surface Image: 0.1 seconds

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Volume Image: 8.0 seconds

Reliability

Halogen Lamp Lifetime	> 4300 hours
Laser Lifetime	> 1 year (covered under initial 1 year system warranty)
System MTBF	>1000 hours
Up Time	> 95%

Facilities, Environmental, and Shipping

Facilities

Electrical - Main System	AC 240/220/208/200 Volts (factory configurable), 1ϕ, 30 Amps @ 208 Volts
Electrical - Options	AC 120 Volts, 1ϕ, 15 Amps (depending on options selected)
Air	80 psi, 3 scfm
Vacuum	20 in. Hg, 0.5 scfm

Environmental

Temperature	15-24 °C; < 2 °C/hour
Humidity	35-65 % relative humidity
Vibrations (pending evaluation)	
0 < 5 Hz	1 µm p-p
5 < 10 Hz	4 µm p-p
10 < 50 Hz	6 µm p-p
50 Hz	2 µm p-p
Cooling	Remote Blower Unit supplied; 400 cfm; to be located 10 ft from system rear panel
Cooling Connections	2 each 3.5-inch flexible duct
Heat Output	14,000 BTU/hr (main system only)

Physical

DIMENSIONS:	
Main System	60.0" × 47.5" × 35.5" (152 × 121 × 90 cm) (H × W × D)
Wafer Plane	900 mm from floor to wafer #1 (SEMI standard)
13-inch Video Monitor	13.5" × 13.6" × 61.3" (34 × 35 × 41 cm) (H × W × D)
17-inch Computer Monitor	16.1" × 15.7" × 17.7" (41 × 40 × 45 cm) (H × W × D)
20-inch Computer Monitor	18.5" × 18.5" × 19.7" (47 × 47 × 50 cm) (H × W × D)
Codonics NP-1600 Printer	12" × 17" × 21"

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	(31 × 43 × 53 cm) (H × W × D)
Sony UP-5500 Printer	6" × 16.8" × 18.8"
	(13 × 42 × 48 cm) (H × W × D)

WEIGHTS:

Main System	1255 lbs (570 kg)
13-inch Video Monitor	37 lbs (17 kg)
17-inch Computer Monitor	55 lbs (25 kg)
20-inch Computer Monitor	81 lbs (37 kg)
Codonics NP-1600 Printer	60 lbs (27 kg)
Sony UP-5500 Printer	23 lbs (10 kg)

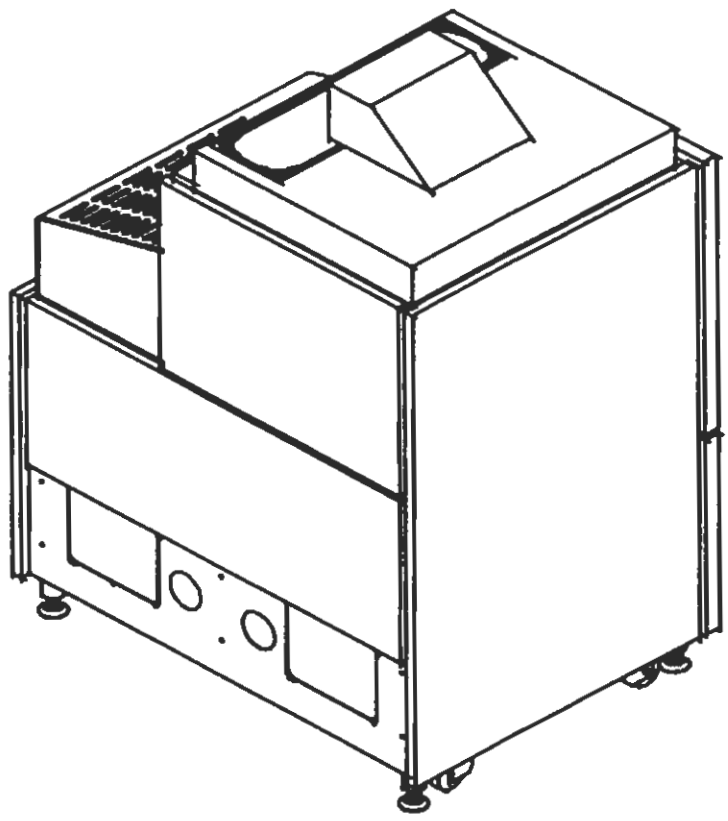
Shipping

Method	Air ride van
Main System Crate Dimensions	48" × 64" × 73"
	(122 × 163 × 185 cm) (W × D × H)
Main System Crate Weight	1852 lbs. (840 kg)
Accessories Crate Dimensions	48" × 48" × 34"
	(122 × 122 × 86 cm) (W × D × H)
Accessories Crate Weight	370 lbs. (168 kg) (will vary with options)

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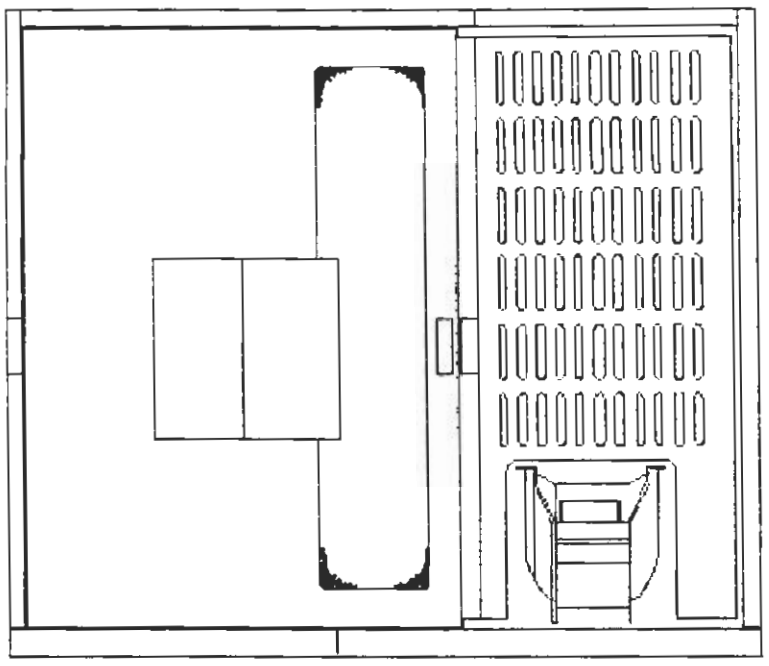
Drawings

Figure D-1 CRS 1010 Isometric View



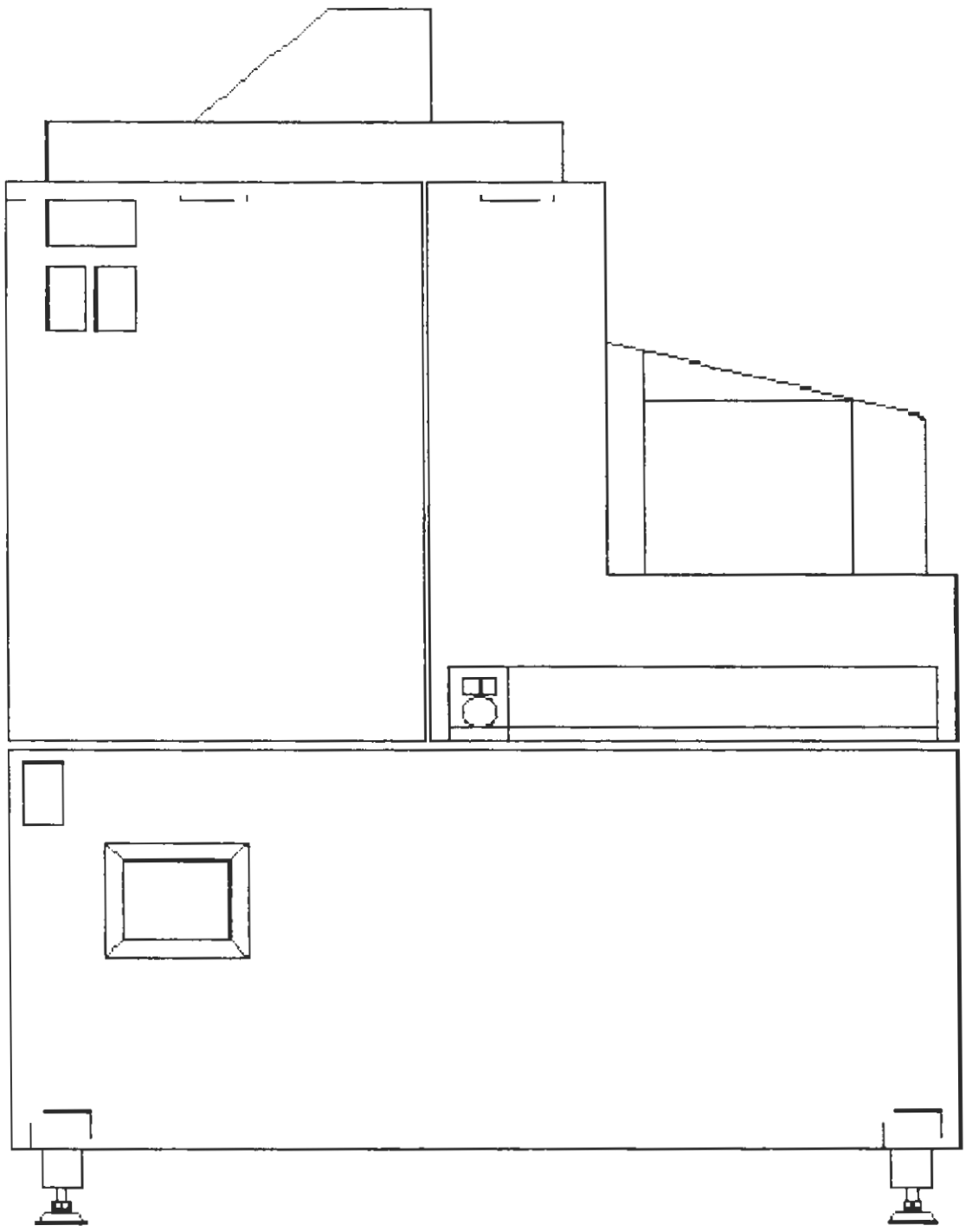
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Figure D-2 CRS Top View



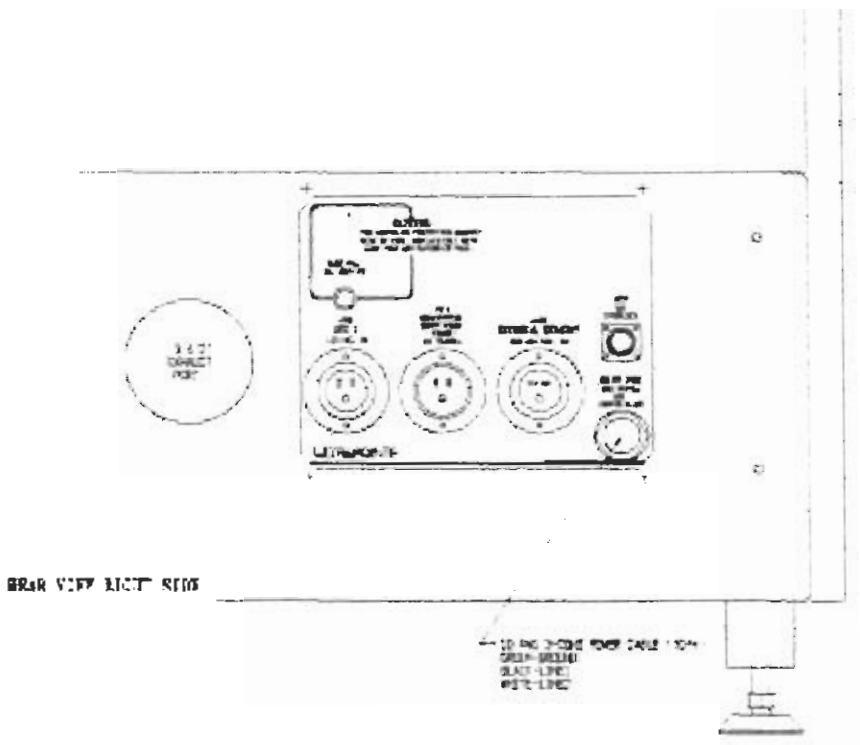
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Figure D-3 CRS Front View



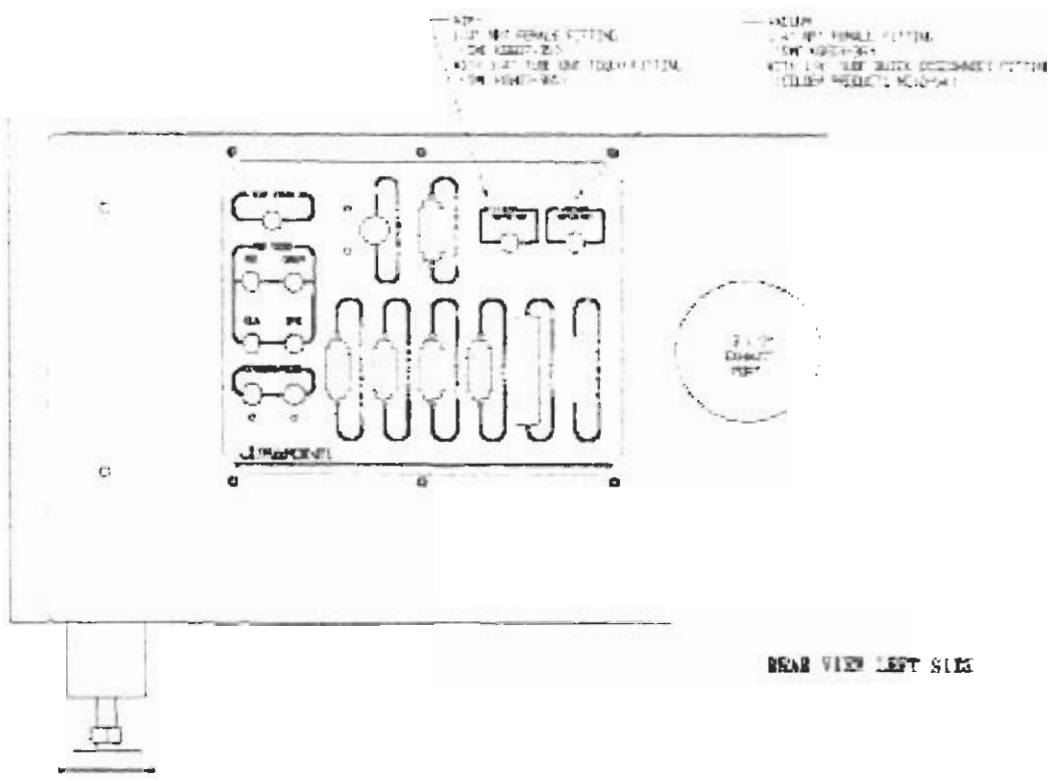
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Figure D-4 Power Panel, Right Rear of CRS



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Figure D-5 Connector Panel, Left Rear of CRS



Optical Systems Comparison

A technical comparison between standard White Light, White Light Confocal and Laser Confocal systems follows. In reading this discussion, it is important to keep in mind the distinction between precision and accuracy, and its application to the distinctions between magnification, resolution, and discrimination.

Terms of Comparison

Precision is defined in terms of the repeatability of measurements. However, it is possible to have a system that repeatably gives the same measurements, all of which are off by the same systematic error. Accuracy refers to the ability to approximate the true answer, where "truth" is defined provisionally as an approximation by the best results attainable by other means in accordance with our best understanding of the underlying physics. In this case the SEM is the usual reference standard.

Under normal circumstances, the accuracy cannot be better than the precision, but can easily be much worse. The CRS has a precision of placement of the XYZ stage to 12 nm vertically and 0.25µ horizontally. Its accuracy is limited by the accuracy of placement of wafers, and of the deskew process for measuring that accuracy, but it is generally able to place features under the microscope with a horizontal accuracy of a few microns. Image processing in software or observation by the operator can then match features and position the stage with an accuracy limited by the size of the

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laser spot, which is comparable to its wavelength. Given wavelengths of 458–515 nm for the CRS, with 488 nm the most often used, this accuracy can be 0.5µ or less.

Magnification is a simple ratio between the size of an image and the size of the original object. Increasing magnification does not always mean a better image, just as increasing precision does not always mean greater accuracy. Magnifying an image that is already at the limit of resolution just produces larger fuzzy spots, without revealing any more detail. The magnification of the CRS optical system is a combination of the variable objective, the variable laser zoom, and fixed optical components, together with the size of the image displayed on the CRT. A distance of 1 micron on the wafer can be translated to about one inch on the screen in the laser image on the review screen, and there are 25,400 µ in an inch. This makes the maximum magnification of the CRS about 25,000.

Resolution in optical systems is commonly defined as the minimum distance at which it is possible to distinguish two different objects in a single image. The basic physical limitations which determine resolution are the spot size and wavelength of light used in imaging, and the optics used, which in the best case are diffraction-limited somewhere in the range of one-half to one-third the wavelength. Diffraction limits the spot size to be at least the wavelength of the light used, so as a first approximation it all comes down to wavelength. This gives a maximum resolution of 0.15µ with 458 nm laser light.

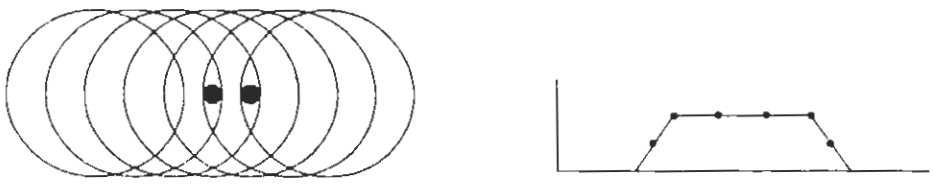
Resolution of a digital image is commonly defined quite differently, by the size of pixels. At maximum magnification pixels in a CRS laser image are spaced on 8 nm (0.008µ) centers. It is better to think of this as addressability rather than resolution, since neighboring spots overlap so much, but current usage is firmly entrenched.

However, there is more. The discrimination of the CRS is better than its resolution. This is a phenomenon well-understood in information theory, where Claude Shannon's basic result is that the information capacity of a channel is proportional to bandwidth multiplied by signal-to-noise ratio (S/N). This is the reason why a 56 Kbps modem can operate on a 3 KHz telephone line if the noise level is low enough. Bandwidth corresponds in the case of CRS images directly to resolution. S/N for the CRS is excellent, based on its ability to move the stage with an accuracy much smaller than the resolution limit, and to take multiple slice images with separations as small as 12 nm. Features as small as 25 nm in vertical dimension and 100 nm in horizontal dimensions can be discriminated.

When the laser spot or the stage is moved by less than the wavelength, neighboring spots overlap. This tends to smear out the image of a feature smaller than the wavelength to about the spot size, as shown schematically in Fig. D-6. The laser light spots are represented by circles, which is not physically realistic. In fact, the intensity of the returned light is a weighted function of reflectivity within the circle, with the center weighted highest, and the weights decreasing outward to nearly 0 at the edge of the circle.

Most of the spots catch both of the small features in this example, or neither, and the image of the feature on the screen would be as wide as the peak in the light response curve, or 4 pixels. This is just about as wide as the spots in this example. This spreading of features in the image is the principal form of noise in well-designed optical systems.

Figure D-6 Resolution Limit



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However, there is a pixel on each side of the feature that captures mainly one spot, resulting in two points in the response curve at half the amplitude of the others. In addition, a physically more realistic model would show that the peak of the curve is not flat. Comparing multiple spots gives us more signal to work with for the same amount of noise, thus improving the S/N ratio, and with it the amount of information that can be extracted. The result is that features significantly smaller than the wavelength can be discriminated.

In this case, the CRS would still not resolve the two features into separate images, but it would show them as a feature that was elongated in one direction. Applying the same process to vertical discrimination gives much better results, both because the precision and accuracy of the stage along the Z axis is much better than along the X and Y axes, and because the CRS can capture 64 closely spaced 2D slice images, or in other words, much more signal.

Overview of Laser and White Light Microscopes

The commercially available optical review stations can be divided into three categories, namely standard white light, white light confocal and laser confocal systems. This note will discuss some of the key features of each system as well as their differences in terms of magnification, lateral resolution and depth resolution.

White Light System

The ordinary white light microscope consists of an objective lens and an eyepiece. The sample under observation is illuminated by an extended incoherent white light source (typically a 100W Halogen lamp). The objective lens forms a real inverted image of the object in a position suitable for viewing with the eyepiece. The eyepiece functions as a simple magnifier producing a virtual image of the object a distance of 25cm from the observer's eye.

Magnification: The overall magnification of a white light microscope is decided by the product of the objective and the eyepiece magnification (e.g. 100× objective × 10× eyepiece = 1000× overall magnification).

Lateral Resolution: The lateral resolution of an objective lens under the Sparrow's criterion is given by the following formula:

$$\text{Resolution} = \lambda/(2 \times \text{N A}) \qquad \textbf{(EQ 4)}$$

where λ is the wavelength of the incoming light and N.A. is the numerical aperture of the lens which, for a non-immersion lens, is defined as the sine of the opening angle formed by the center ray and the extreme edge ray focusing at the focal point, as shown in Fig. D-7.

Figure D-7 N.A. and Opening Angle



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For a non-immersion lens the maximum N.A. achievable is about 0.95. For the white light source the average wavelength is about 0.55 μ. So the best resolution achievable by the white light microscope is about 0.29 μ. An ordinary person's eye can resolve a structure as small as 0.25 mm. This means that the practical magnification limit of a white light microscope is about 0.25 m/0.29 μ = 860×.

Depth of Focus (or Z resolution): The Z discrimination capability (resolution) is determined by the depth of focus. For the white light microscope, the depth of focus (D.O.F.) is given by

$$D.O.F. = \frac{250}{\Gamma} + \frac{250\Psi_{eye}}{\Gamma \cdot N.A.} + \frac{\lambda}{2(N.A.)^2}$$

where Γ is the magnification of the microscope, Ψ_{eye} is the angular resolution limit of the eye, N.A. is the numerical aperture of the lens, and λ is the wavelength of the incoming light. For a microscope with 100× objective, 3.3× eyepiece, 0.95 numerical aperture and average wavelength of 0.55mm, the D.O.F. is about 3.4 μ. In other words, if a object is in focus, an observer can not only see the signal from the focal plane but also the signal 1.7 μ above or below it. This makes the white light microscope unable to discriminate a submicron particle against a pit.

White Light Confocal System

The white light confocal system can be viewed as a standard white light microscope with addition of a spinning Nipkow disk. A Nipkow disk contains many spiral sets of holes at regular angular distances. The incoming light passes through several thousands of tiny pinholes on the Nipkow disk and illuminates an equal number of spots on the sample. The light reflected from each of these spots returns to the same pinhole through which it entered. Due to the small size of the pinhole, the return light from non-focused planes will be blocked by the pinhole, which yields a very short depth-of-focus.

Magnification: The magnification of a white light confocal microscope is the same as that of an ordinary microscope.

Lateral Resolution and Edge Response: Compared to an ordinary microscope, the white light confocal system has 8% - 28% improvement in the lateral resolution (depending on the resolution criterion used). Better lateral resolution results from the fact that the confocal microscope is a point illumination and point detection system (i.e. a coherent imaging system). As such, the effective point spread function (PSF) of the confocal system is given by the square of the PSF of the standard microscope, which cut down the PSF 3dB response (the distance between the half power points of the PSF) by 28%. Furthermore this square property reduces the sidelobe levels of the PSF, yielding better contrast in image. It also enhances the edge response by 13%, resulting in a sharper image when observing edge structures.

Depth Resolution: The depth response d_z of a confocal microscope is given by the following expression:

$$d_z(3dB) = \frac{0.45\lambda}{1 - \cos\theta}$$

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For a 100 × objective with 0.95 N.A., and an average wavelength of 550 nm, the 3dB depth response is about 0.36 µ. This is an order of magnitude smaller than the standard microscope.

Laser Confocal System

The laser confocal system utilizes a single pinhole and a monochromatic light source (the laser itself). Since a point won't make an image of an extended object, a scanner has to be used to translate the laser spot in horizontal and in vertical direction.

Magnification: Since the laser confocal image is a scanning image, the magnification is decided by two factors:

1) the product of the objective and the eyepiece magnification

2) the size of the scanning area, determined by the amplitude of the scan.

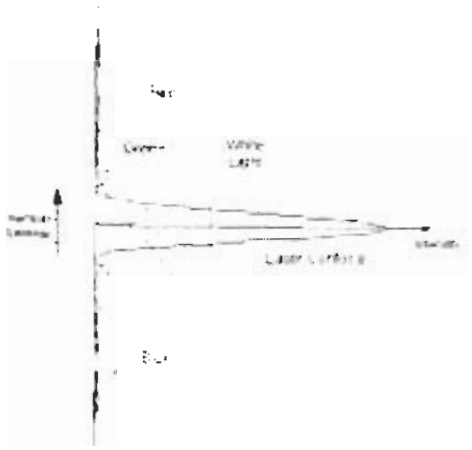
Given an objective and an eyepiece, the magnification of a standard white light or white light confocal microscope is fixed. But a laser confocal system can change the scanner amplitude or field of view of the laser image (i.e. zooming) while keeping the sampling pixel numbers the same, thus a magnification much higher than that of a standard white light or white light confocal microscope can be achieved. For example, with the same set of objectives and eyepieces, the **KLA Tencor** CRS has a maximum magnification of 8 times that of a standard white light or white light confocal microscope.

Lateral Resolution and Edge Response: When the resolution of a standard microscope was calculated earlier, an average wavelength of 0.55 µ was used for the white light. This is not strictly right because the white light is a mixture of many different wavelengths ranging from 0.4 µ to 0.76 µ. Due to the change in the index of refraction of the lens material with wavelength, different color rays will intercept the image plane at different locations even if they all emanate from the same point on the object plane. This phenomenon is known as lateral color. Because of this, the lateral resolution as well as the edge response of a white light confocal system is worse than that of a monochromatic laser confocal system. Strictly speaking, only the monochromatic system can claim the full resolution of what was discussed earlier.

Depth Resolution: Again, due to the fact that the index of refraction is a function of wavelength, the shorter wavelengths are focused closer to the lens than are the longer wavelengths in the case of a positive lens element, a phenomenon called longitudinal chromatic aberration. Because of this, the depth response of a white light confocal system is worse than that of a monochromatic laser confocal system. Fig. D-8 shows clearly the narrow, intense peak in laser focus for confocal optics, compared with the diffuse response of wideband light, whether in red, green, and blue bands, or the full white light range. In short, only the laser confocal system can claim the full depth resolution described earlier. At the wavelength of the most often used laser line, 488 nm, the nominal resolution is 0.3µ. By comparing neighboring slices using the extremely precise vertical step size of the stage, 12 nm, the CRS can discriminate layers as thin as 0.025 µ.

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Figure D-8 White Light vs. Laser Confocal Depth of Focus



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E

Confocal Review Station Options

KLA-Tencor CRS 1200 Defect Review Station

Standard Equipment and Software

- Main System w/Class 1 stainless steel enclosure, robotic wafer handler, non-contact flat finder, precision XYZ stage, laser & white light optical system, electronics

- Cassette Locator Plate 6 inch
- Cassette Locator Plate 8 inch
- Single 25 slot wafer cassette load port
- Surface imaging software package
- Volume imaging software package
- 5 Objectives: 5×, 20×, 50×, BF/DF; 100×, 150× BF
- High resolution Sony camera
- Auxiliary 13-inch video monitor (CE version available)
- 200 Mhz, 64-bit, R4400SC RISC processor
- 20-inch graphics monitor, keyboard, mouse, trackball, joystick & cables
- 4.0 GB hard disk capacity
- Exhaust blower box with interconnecting ducts
- KLARF Interface
- Tencor File Format
- GEMINI Optics Set
- 24-bit Integrated White Light Package
- NFS Software Interface to Ethernet Including Compatibility with

  10 Base 2 Coax

  10 Base T Twisted Pair
- CE compatibility (European destinations require optional CE version SONY video monitor and CE version analog printer if applicable)

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Hardware Options

- Additional Cassette Locator Plate, 4-inch
- Additional Cassette Locator Plate, 5-inch
- 1.3 GB Optical Drive (External - Strongly recommended for ADC)
- SMIF 8" Integrated Indexer (factory configurable only, 6mos ARO)
- Mini-environment for SMIF (subcontracted through BYE/OASIS, 6mos ARO)
- Ergonomically designed cassette rotator
- Operator Console Cable Extension Kit (additional 6 feet for total of 16 feet of cable)
- Signal Tower (factory configurable only)

Software Options

- White light ADC
- Laser ADC
- Automatic Deskew Option—Requires 24-bit Integrated White Light
- Defect file interface to Inspex
- Defect file interface to Hitachi (WI-88X Series)
- Defect file interface to LPA DES
- Interface to Dentech VARS—Scan converter required for VARS to store laser image
- GEM/SECS II Communication interface

Accessories

- Sony Analog Video Printer with interfaces (CE version available)
- Codonics Digital Printer with interfaces
- Operator Console (vertical rack to hold monitors, printers and keyboard)

Description of Options

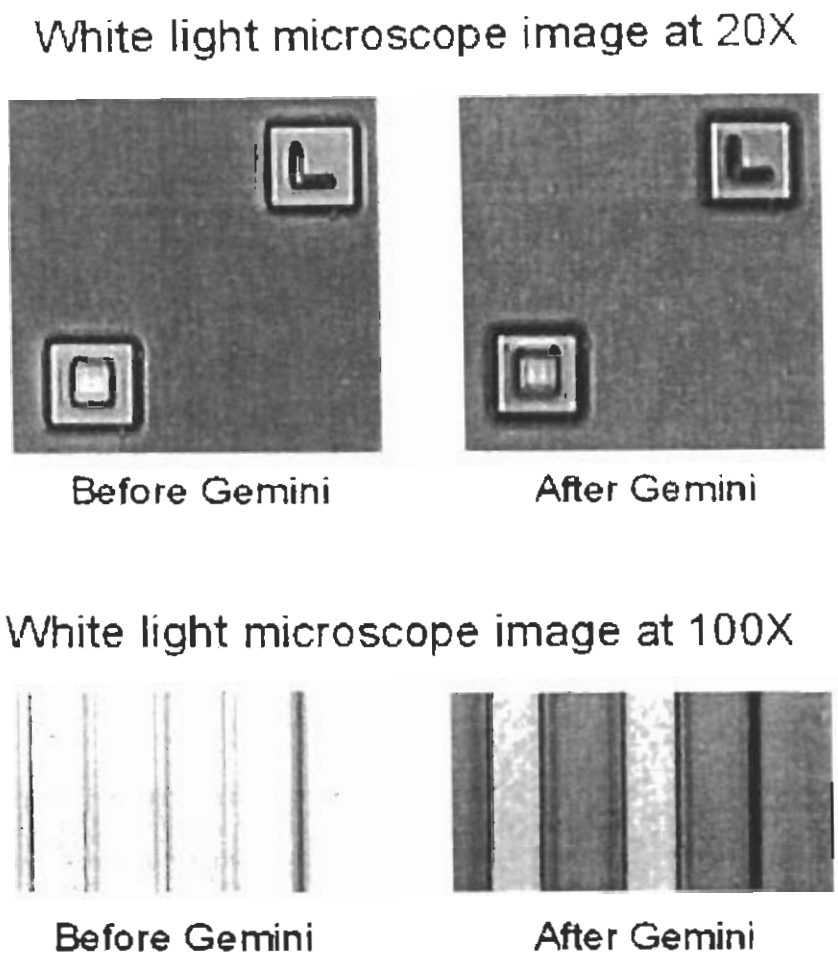
Some of the features which are standard on the CRS 1200 were options on previous models. The most important of these are described below, along with current options.

GEMINI Optics

The CRS provides simultaneous laser and white light viewing of the wafer surface to be inspected. Filters in the laser and white light paths prevent excessive mixing of the white and laser light at their respective sensors, and also prevent damage to the white light camera sensor from concentrated laser light. Originally a yellow filter removed laser light from the white light path to the camera, taking out all three of the laser lines (458 nm, 488 nm, 515 nm). Unfortunately this also meant removing a good deal of the white light at the same time, and changing the color balance of the image considerably. As Fig. E-1 shows, the yellow filter resulted in a very yellow image with greatly reduced contrast. Surface detail is much less visible with the yellow filter.

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Figure E-1 Effect of Gemini Optics on White Light Images



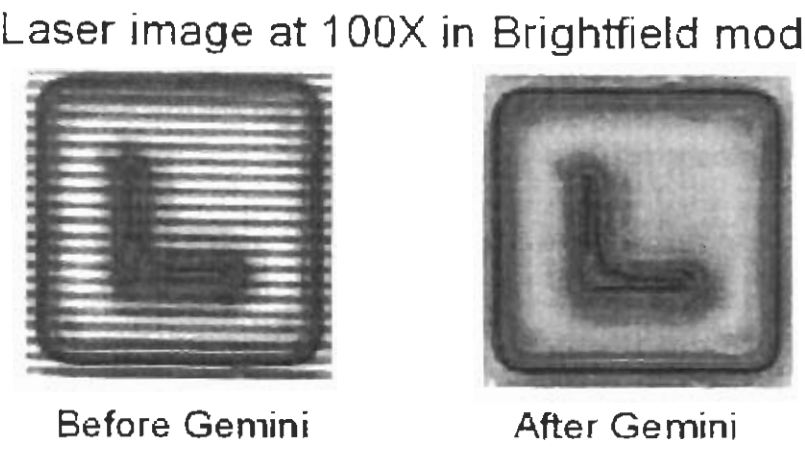
Improved white light images are provided in simultaneous 488 nm laser light and white light with the GEMINI optics option, which includes a holographic 488 nm notch filter in the camera light path. The yellow filter continues to be used for simultaneous viewing using white light along with the 458 nm line alone, the 515 nm line alone, and all three lines together.

Without GEMINI optics, the white light image is always yellowed by the filter in simultaneous viewing. With GEMINI, there is no color change to the white light image when using 488 nm laser light. The only visible effect is a very faint pattern of hazy gray lines.

The GEMINI option also includes a 487nm narrow band filter to select the 488 nm line, and a modified bright field beamsplitter cube. The purpose of the cube is to eliminate interference patterns in the laser image, as Fig. E-2 illustrates.

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Figure E-2 Effect of GEMINI Optics on Laser Image



The GEMINI option changes the light parameters, especially the automatic adjustment of the level of white light illumination in simultaneous viewing when changing objectives. In addition to the physical installation it is necessary for a factory Field Service Engineer to adjust the CRS hardware and its software configuration for best performance.

ADC

Automatic Defect Classification is one of the most important capabilities of the CRS. It is available in both white light and laser versions. The software can be trained to classify defects in a specific process at a higher rate of accuracy than most operators, and to do so consistently at all times in continuous operation. User engineers can set up and train a CRS for any number of steps in any process for which a good sample of defects is available.

In combination with the following options, ADC on a CRS can be completely automated, cassette to cassette. Captured defect data, including wafer maps with classifications and also 2D or 3D images of unrecognized defects, can be passed over a network or other communications link to other systems for data analysis, to engineers for visual review, or to other instruments such as a SEM.

Both White Light and Laser (488 nm) ADC capabilities are available as options in the CRS software. Laser ADC is capable of imaging and identifying subsurface defects in many cases, and can readily distinguish between pits and particles down to 0.15 µ across and 0.025 µ high or deep, well beyond the resolution of white light.

SMIF and Mini-Environment

A SMIF station interface is a factory option with the CRS. There is no retrofit available for field upgrade.The station consists of an Asyst Technologies SMIF-Indexer INX 2150 (for 100 mm/4 inch or 150 mm/6 inch wafers) or INX 2200 (for 200 mm/8 inch wafers). Each of these units includes a laser detection system which determines which slots have wafers in them. The Asyst SMIF-Indexer Series INX 2150/INX 2200 Technical Manual contains full details on configurations and options as well as on operation of these products.

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The CRS with attached Asyst SMIF can be set up within a mini-environment to accept sealed pods of wafers to provide superior cleanroom handling both during processing at the CRS and in transit between machines via an external robot system. In conjunction with the following communications option, the CRS with SMIF supports fully automated handling of wafers with no human intervention or contact.

Figure E-3 CRS with SMIF and Mini-Environment



GEM/SECS

The CRS has external ports for networking and serial communications, which allow control of all CRS functions by computer. The communication protocol for external control is an industry standard, SECS (SEMI Equipment Communication Standard), widely used in semiconductor fabrication and test equipment.

A fully automated multistation system can send pods of wafers from a fabrication step to a surface scanner, and from there to the CRS for ADC, with automatic capture and processing of defect data along with images of defects not classified. Further routing of the wafer pod can be based on the results of the analysis.

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The CRS complies with the full SECS-I standard E4-91, and with the generic portions of the SECS-II standard E5-95. The implementation includes a subset of the SECS-II standard messages appropriate for CRS wafer handling and defect review functions.

SECS defines the communications protocol, and GEM (SEMI Generic Equipment Model for effective factory automation) defines conventions for using that protocol and for designing the communications interfaces on factory equipment units for effective communication with a host computer. The CRS uses a subset of GEM functions, excluding Trace Data Collection, Spooling, and Limits Monitoring, none of which are needed for CRS functions.

Integrated White Light

Integrated White Light permits simultaneous viewing of white light and laser images on the CRS monitor. It was not available on the earliest CRS models, but was added as the available computer power for image processing increased. The first version of Integrated White Light (8-bit) has been superseded by the current version (24-bit).

Simultaneous viewing is possible because the white light and laser illumination share the portion of the optical path through the microscope, both for entering illumination and for the reflected light which forms the images. The beams are joined and then split again on their return at a beamsplitter just above the microscope.

Illuminating the wafer with both laser and white light requires a way to filter out the green, blue, or violet laser light in the white light camera path, in order to avoid damage to the camera sensor. Originally a wideband yellow filter was used for all simultaneous imaging, but now the GEMINI optics package is standard on the CRS 1200.

Light Tower

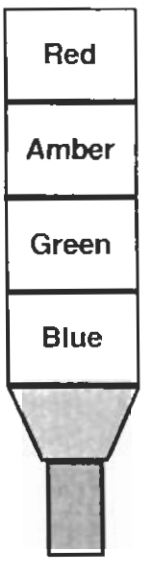
The light tower has four different colored sections with a buzzer mounted at the bottom. Fig. E-4s hows the position of the four different colors: red, amber, green, and blue. Each lamp color can be configured to be on, off, or flashing as defined by the customer. The modes and their associated code numbers are listed in Table 1.

Table E-1 Light Tower lamp modes and their codes

Code	Lamp Mode
0	Off
1	On
2	Flashing; rate defined by SEMI S8-95
3	Flashing - slow; rate defined by user
4	Flashing - fast; rate defined by user
5	No change from previous state

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Figure E-4 Light Tower



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F

Basic Maintenance

Troubleshooting

The following sections describe potential problematic situations that typically do not require a service engineer to rectify. However if you are unsure of your actions in any way, please do not hesitate to contact a KLA-Tencor CRS service engineer.

Lockup Recovery

It is possible for the system to lock up to varying degrees. There have been reports of cases where the system slows down noticeably, of cases where none of the on-screen buttons in the KLA-Tencor CRS application respond to the cursor, and of cases where the mouse and keyboard do not seem to work at all. There is also a special case of lockup that can occur during a volume acquisition. These incidents are rare occurrences and KLA-Tencor is very interested in knowing about and fixing lockups that have any repetitive frequency. The possible recovery actions include

- Restarting the CRS application program
- Rebooting the computer system
- Restarting the XWindows server (five-finger reset)
- Cycling power of the entire instrument.

Whatever the recovery method, the problem and the corrective action should be recorded for maintenance purposes. The following table lists lockup symptoms and their associated recommended recovery actions. For the sake of simplicity, you can attempt to recover from all lockups using the reboot procedure—this takes slightly longer than just restarting the CRS application.

Table F-1 Lockup Symptoms and Recovery Actions

Lockup Symptom	Recovery Action
System slows down	Restart the application
Application does not respond	Restart the application
Mouse does not respond	Five-finger reset
Lockup during volume acquisition	Reboot the computer

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Table F-1 Lockup Symptoms and Recovery Actions

Lockup Symptom	Recovery Action
Cannot lower the application	Five-finger reset
Nothing works	Cycle power

Restarting the CRS uv Application

To Restart the Application

1. Lower the CRS application by clicking on the square at the extreme top left of the screen. A pull-down menu appears.
2. Select **Lower** to lower the application. After the CRS application is lowered,the **Toolchest** menu appears at the top left of the screen
3. Click on **Desktop** and another pull-down menu appears.
4. Click on **Shell** and after a few seconds, the outline of a UNIX shell window appears. Position the window appropriately and click the mouse to create the window.
5. Position the cursor anywhere in the UNIX shell window and type *uv1000* to restart the CRS application.
6. If the application cannot be lowered, see "Executing a Five-Finger Reset" below.

Executing a Five-Finger Reset

If the application cannot be lowered because the box at the extreme top left of the screen does not respond to the mouse, you can try to kill and restart the XWindows server using the keyboard. This involves pressing five keys simultaneously and is referred to as the five-finger reset.

To execute a five-finger reset

1. Press CTRL, SHIFT, ESC, F12, and / simultaneously, where / is on the numeric keypad. (Since your keycaps might have been customized for easy operation, the five reset keys may appear as CTRL, SHIFT, ESC, FOCUS OFFSET, and SK1.) Executing this sequence causes a dramatic change in the display, followed by a recovery to a logon screen called the Pandora screen.
2. The Pandora screen has several icons with user names under them. Double click on the icon labeled ***uv*** and the system restarts normally.

If the lockup occurred during a volume acquisition, you must still reboot the system even though the application has restarted. This procedure is described in "Rebooting the Computer" below.

If the five-finger reset does not work, then you should try cycling the power to the machine. See "Cycling Power" below.

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Rebooting the Computer

1. Lower the CRS application by clicking on the square at the extreme top left of the screen. A pull-down menu appears.
2. Select **Lower** to lower the application. After the CRS application is lowered, a set of buttons appears at the top left of the screen.
3. Click on **System** and another pull-down menu appears.
4. Click on **System Shutdown** to prepare the CRS for powering down, or **Restart System** to reboot without powering down.

If the application cannot be lowered, attempt the five-finger reset as described above in "Executing a Five-Finger Reset," then try the reboot procedure again.

Cycling Power

If none of the above measures is successful in returning the application to normal, the only alternative is to cycle power to the system. Since you will presumably not be able to use the mouse or keyboard, this procedure will be done without a proper shutdown process.

1. Shut off the power by using the red Off button on the front panel.
2. Wait 30 seconds, then power on by pressing the green **On** button. The system should come up normally. Be sure that the **EPO** switch is released by turning it counterclockwise or the **On** switch has no effect.

Wafer Removal

There are two conditions under which a wafer can be left in the instrument. First, the system might lose AC power or the application software might lock up while a wafer is inside the optics chamber or in the prealigner; you therefore have to remove the wafer (using the application software) immediately after restarting the CRS application.

Second, the instrument might become non-functional (due to a component failure) while a wafer is in the optics chamber or in the prealigner, and you might want to remove the wafer manually because the application software cannot be restarted (even by cycling power).

Wafer Removal Using the Application Software

Wafers can be removed from the optics chamber or the prealigner using the Manual Robot Control option, which appears as a menu selection under Maintenance. This menu selection is available only to users with service or administrator permissions. However, if you start the CRS application with a wafer on the XYZ stage (in the optics chamber), the **Manual Robot Control** window appears automatically when you attempt to initialize the robot.

With the **Manual Robot Control** window on the screen, you click on a wafer source or destination in the list at the left of the window, then click on ***Robot Get*** or ***Robot Put*** to command the robot to either retrieve or deposit a wafer at that location. **This window should be used with great care because the usual safeguards in the applications software are not active in this window.** For example, the **Manual Robot Control** menu allows you to attempt to put two wafers in the same slot, or replace a wafer into a cassette of the wrong size.

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To remove a wafer from the XYZ stage

1. Click on the ***Stage*** selection in the source/destination list at the left of the window, then click on ***Robot Get***. The robot enters the optics chamber and retrieves the wafer.
2. To put the wafer back into the cassette, first inspect the cassette to find a slot that is empty, then click on the appropriate slot number in the source/destination list at the left of the window.
3. Click on ***Robot Put*** to deposit the wafer in that slot.


WARNING

Be sure that

the cassette size matches the wafer
the slot in question is empty
the correct slot has been highlighted in the list at the left of the window

before clicking on Robot Put.

The procedure for removing a wafer from the prealigner is similar, except that a ***Robot Get*** operation is performed with the ***Flat Finder*** selection highlighted in the source/destination list.

Manual Wafer Removal

If the CRS application software is inoperable, you can remove a wafer from any of the major components in the system by hand). The default state of the vacuum solenoids in the system is on, so it is highly recommended that you disconnect the vacuum supply at the rear of the instrument before attempting to remove a wafer from the end effector or the chuck.


WARNING

Be aware that you are interacting with mechanical components that move under computer control. It is strongly recommended that the system be shut down before attempting manual wafer removal.

If a wafer is on the robot, it can be easily removed with a vacuum wand. When the system is powered off, you can manually move the robot arm to a more appropriate position to remove the wafer.

The same procedure applies to the prealigner module. A wafer left on the prealigner chuck can be removed manually with a vacuum wand.

If a wafer is to be removed from the XYZ stage in the optics chamber and the system is inoperable, the first step after shutting down the system is to remove the facia plate that surrounds the wafer door. The facia plate is fastened with two screws near its base. Remove these two screws and gently tilt out the bottom of the plate to remove it. Behind the facia plate is the wafer door, which can be

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raised manually. With the wafer door raised, reach into the system with a vacuum wand and remove the wafer from the XYZ chuck.

Preventive Maintenance

These Preventive Maintenance (PM) procedures describe the maintenance operations on the KLA Tencor CRS Confocal Review Station that can be routinely performed by on-site customer personnel (referred to as customer service personnel). The operations are low-risk in the sense that they do not involve delicate adjustments or potential contamination of critical optical components. Furthermore, there is no requirement to bypass or defeat any of the safety interlocks of the machine. At all times, however, the service person is required to observe common safety practices and to avoid altering any adjustments inside the machine that do not pertain to the procedure at hand. These operations are intended to be supplemented by KLA Tencor factory PM operations performed on a less frequent basis.

While every effort has been taken to provide you with the latest revision of the PM procedures, it is recommended that you verify this fact with your KLA Tencor customer service representative.

Safety Precautions

Please be sure to thoroughly read the Safety Section in the front of this manual prior to executing any of these procedures.

The Preventive Maintenance Schedule

The following table outlines the PM procedures listed in this section as well as the time intervals at which they should occur.

Table F-2 Preventive Maintenance Schedule

	Procedure Name	Description	Interval
1	Wipe Down	Wipe down of the exterior of the machine	Daily
2	Backup Data	Procedure to backup critical data to tape	Weekly
3	Chuck Cleaning	Cleaning procedures for the chuck and robot end effector	Weekly
4	Laser Life and Interlock Check	Test procedure for the laser system to determine whether to schedule laser service, and to verify interlock integrity	Monthly
5	Robot Alignment Check	Test to verify that the robot handles wafers and interfaces appropriately to the cassette, prealigner and XYZ stage	3 mos.

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Table F-2 Preventive Maintenance Schedule (continued)

	Procedure Name	Description	Interval
6	Halogen bulb change	Install new Halogen bulb for white light illumination	4 mos.
7	Bi-annual PM	Optics cleaning and alignment, system PM	6 mos.

System Wipe Down

A system wipe down consists of gently cleaning the exterior of the machine with a cleanroom-compatible cleaning cloth and a diluted solution of isopropyl alcohol (with the exception of the plastic robot safety cover which must be cleaned with water only). The user should check with the KLA Tencor factory if other solvents or cleaning solutions are to be used.

DANGER: The solution of isopropyl alcohol is a flammable liquid and must be kept from sparks, flame or heat.

Data Backup and Restore

To avoid loss of data due to a hard disk failure or other disasters, the user should periodically backup critical data. The following procedures describe backup and restore operations.

To backup the system

1. Place a 150 MB, quarter-inch tape into the tape drive within the drive bay and close the door of the tape drive.
2. Lower the CRS application program as follows:

   Click on the small square at the extreme top left of the screen. A pull-down menu appears.

   Click on Lower to lower the application.
3. A set of buttons appears at the top left corner of the screen. Click on System, then System Manager.
4. A window appears with several icons and names above them. Double-click on Backup&Restore.
5. Another window appears for setting up the backup operation. Be sure that QIC150#7 is selected as the tape drive, and Backup as the operation. Click on Accept to accept the setup.
6. Another window appears for specifying the files to backup. Select by Directory as the files to backup
7. Type `/usr/uv` as the directories and files to be backed up.
8. Click on Start Backup. The backup begins, with the "Backup is" indicator displaying "Active." The backup proceeds with the list of files being backed up scrolling through the window until the backup is complete. At this point the "Backup is" status changes to "Inactive."
   Note: This is a typical backup operation; more or less data may be backed up depending on the user's preference. Contact KLA Tencor for recommendations.

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To restore the system

The restore procedure is very similar to that of backup procedure. However, instead of selecting Backup as the operation in the first window, select Restore. When the setup is accepted, a window appears asking you to wait while the tape is being read. A window then appears asking you to specify what files to restore. Be sure to specify that files should be restored to the same directory they came from, then click on Start Restore to begin the restoration process.

Chuck Cleaning

The backsides of wafers come into contact with three components in the KLA-Tencor CRS—the robot end effector, the XYZ stage chuck, and the prealigner chuck. These three surfaces must be cleaned periodically to minimize the risk of backside contamination.

To clean the robot end effector

Cleaning the robot end effector is straightforward. Use a clean-room compatible clean wipe and a cleaning solution of either isopropyl alcohol or water.

To clean the prealigner chuck

Cleaning the prealigner chuck is also straightforward. A special tool is supplied by KLA-Tencor for cleaning the chuck. It should be fitted with a fresh cleaning sleeve and used with alcohol or water to wipe off the surface of both chucks. Do not use acetone with the chuck cleaning tool.

If the robot is initialized, it moves down as far as possible so that it does not interfere with the cleaning process. The chuck is visible through the slot where the wafer enters the prealigner.

To clean the XYZ stage chuck

1. Initialize the robot to get it out of the way using the Initialize button in the cassette window
2. Select a turret position containing no objective (*00* selection from the *Objective* button at top right of LaserScan window). If there is no open position, then select the lowest power objective (usually 5X).
3. Access the LON Diagnostics window by clicking on Maintenance on the top menu bar, and then on LONDiagnostics.
4. A button called WaferDoor appears roughly in the middle of the window; click on it to open or close the wafer door.
5. With the wafer door open, you can reach in with the chuck cleaning tool to clean the surface of the chuck. Be careful not to come into contact with any of the objectives.
6. Close the wafer door using the LON Diagnostics window when the cleaning operation is complete.

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Laser Lifetime

The normal aging process of the laser tube can be monitored by measuring the current required to obtain a given power output. The procedure involves setting the laser power to maximum (25 mW) and measuring the required tube current. With a new laser, this value is typically 6 A. The laser power supply is capable of supplying a maximum of 10.5 A. When the laser tube requires 9.5 A to achieve 25 mW of power, it is close to the end of its life (an estimated 1000 hours remain) and a replacement should be scheduled.

To monitor aging of the laser

1. Click on the Maintenance selection on the menu bar at the top of the screen. Select LONDiagnostics from the resultant pull-down menu.
2. On the right hand side of the LON Diagnostics screen are two columnar lists: the left column (labeled *Nodes*) lists the I/O boards in the instrument, the right column (labeled *NetVariables*) lists the available network variables for the I/O board selected in the left column. Select LaserPwrControl in the left column.
3. Select the PowerCmd network variable in the right column.
4. Click on the text entry box below the left column (labeled *OutputNVValue*) and enter 128, which corresponds to 25 mW of laser power. Click on the SendToLON button to change the current laser power setting to 25 mW.
5. Click on the CurrMonitor network variable in the right column.
6. The result, shown under NV Status, should be between 14 and 22. When the CurrMonitor variable is near the top of this range, the laser tube is close to the end of its life (est. 1000 hours or 40 days remaining) and a replacement should be scheduled.

The wafer door interlock should be tested at the same time as the laser lifetime is inspected. To test the interlocks, load a wafer of any kind into the instrument using routine operating procedures. Focus on the surface of the wafer and obtain a laser image on the workstation screen. The user then opens the wafer door using the LON Diagnostics menu and verifies that the laser image goes away because the wafer door interlock has shuttered the laser. Verify also that the laser image reappears when the door closes.

Robot Alignment Check

Testing robot alignment is a qualitative procedure to ensure that the robot is interfacing properly to the cassette, prealigner, and XYZ stage. The only reason that robot alignment should change is if one of the components in question suffers a mechanical impact of some kind.

Robot to Cassette Alignment Check

1. Bring up the Manual Robot Control window by clicking on Maintenance on the top menu bar, and then on ManualRobotControl.

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2. With a full cassette of wafers on the cassette platform, highlight each of the cassette slots in the source/destination list and use the Robot Get and Robot Put buttons to load and replace wafers from all 25 slots.

CAUTION: Use extreme care with the Manual Robot Control window because the safeguards in the normal operating software are not in effect when using this window.

3. As the robot's end effector goes in and out of the cassette to pick up and replace each wafer, check that the wafers are moved smoothly and that there is no rubbing between the wafer and the cassette.

Robot to Prealigner Alignment Check

1. Use the Manual Robot Control window in the same manner as described above.
2. Execute a Robot Get operation to retrieve a wafer from the cassette, then execute a Robot Put with the Prealigner ***selection*** highlighted in the source/destination list.
3. Observe the motion of the robot as it enters the prealigner and be sure that there is no rubbing between the robot and any parts of the prealigner. Check that the robot places the wafer gently on the prealigner chuck and picks it back up in the same manner.

Robot to XYZ Stage Alignment Check

1. Using the Manual Robot Control window in the same manner as described above.
2. Execute a Robot Get operation to retrieve a wafer from the cassette, then execute a Robot Put with the Stage selection highlighted in the source/destination list.
3. As the robot enters the optics chamber to drop off or retrieve a wafer, be sure that there is no rubbing between the robot or wafer and the wafer door facia plate or the chuck on the XYZ stage.

Robot Safety Interlock Check

To ensure the robot cover and cassette interlocks are working properly the following procedure should be used. The procedure must be followed to avoid possible injury or equipment damage. If any portion of this test fails, power down the system as described below under "Troubleshooting," and contact KLA Tencor Customer Service immediately.

1. Load a test wafer.
2. Remove the cassette from the cassette platform.
3. Press the Unload Wafer key (F1) to unload the wafer.

WARNING: Be sure cassette area is clear of personnel and equipment.

4. The system replies with the prompt

   Please close robot cover and try again.

   Click OK.

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5. Replace Cassette.
6. Press the Unload Wafer key (F1) to unload the wafer.
7. The system unloads the wafer.
8. Reload the test wafer.
9. Remove the robot safety cover.
10. Press the Unload Wafer key (F1) to unload the wafer.

WARNING: Be sure cassette area is clear of personnel and equipment.

11. The system replies with the prompt **Please close robot cover and try again.**
    Click OK.
12. Replace the robot safety cover.
13. Press the Unload Wafer key (F1) to unload the wafer.

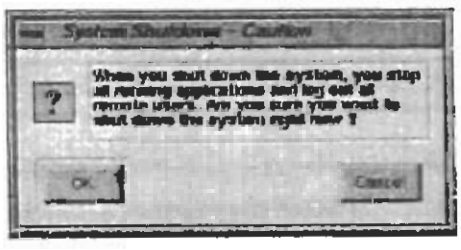
Changing the Halogen Bulb

WARNING! Changing the Halogen bulb requires taking off the top cover of the machine and manipulating the lamp housing on the optics plate. The top cover is interlocked with the laser power supply and should cause the laser to shut off when the cover is removed. It cannot be turned back on until the interlocks are closed and power is cycled. The top cover interlocks are defeatable, but under no circumstances are customer service personnel authorized to defeat the laser interlocks. If at any time, the customer service personnel are aware of laser radiation (intense blue-green light) while the top cover of the instrument is removed, the instrument should be immediately powered off and a service call placed to KLA Tencor service.

To change the halogen bulb

1. Lower the CRS application.
2. On the **System** menu in the **Toolchest**, select **System Shutdown**. A dialogue box, shown in Fig. F-1, appears, asking you to confirm your command.
3. Click on ***OK***.

Figure F-1 Shutdown Confirmation



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4. Wait while the message, "The system is shutting down. Please wait." is displayed. When the next message appears saying, "Okay to power off the system now. Press any key to restart." you can turn off the power with the red **Off** button.
5. Wait 15 minutes for the halogen bulb to cool.
6. Release the top cover of the machine by unscrewing the four quarter-turn captive screws, one at each corner of the top cover. *Carefully* lift off the cover and place it aside in a clean and safe place
7. Wait at least fifteen minutes for the lamp housing to cool down.

WARNING! The Halogen bulb used for white light illumination gets extremely hot during normal operation. Take care before handling the bulb or the lamp housing that sufficient time has been allowed after powering off the system to allow the lamp components to cool.

8. Identify the white light lamp housing—it is a rectangular housing, off-white in color, with black louvers facing up to allow heat to escape. The lamp housing is on the optics plate immediately beneath the top cover. The lamp socket is a cylindrical object that fits into the side of the lamp housing and carries the power cord for the lamp.
9. There are two thumbscrews attached to the lamp socket. One of them protrudes radially from the socket and is used to adjust and lock the angular position of the lamp. The other protrudes axially from the socket and is used to adjust the axial position of the lamp. Loosen the radial thumbscrew and observe that the socket can now be rotated within the lamp housing.
10. Rotate the lamp housing clockwise until it contacts a stop, then pull the socket out axially.
11. The bulb is held in its socket by gold contacts. Press down on the long lever arms of the gold contacts to release the bulb; pull the bulb out of its socket while the levers are depressed.
12. Do not touch a new bulb with your bare fingers. Always use a cloth or wear gloves. Failure to do so will contaminate the bulb, leading to premature failure. Install the new bulb (generic part number: FCR 12V; contact KLA-Tencor Service) by depressing the socket levers while pressing the bulb into the socket.
13. Replace the socket and bulb in the lamp housing.
14. Snug down on the radial thumbscrew to hold the socket in place.
15. Turn on the system with the green **On** button..

WARNING! With the top cover removed and power on, the customer service personnel have access to components that are at a high voltage. There is no danger of contacting high voltage components unless you disassemble components that have nothing to do with the procedure at hand. Use of controls or adjustments, or performance of procedures other than those specified here may result in the customer service personnel being exposed to unnecessary electrical, mechanical, or radiation hazards.

16. Load a patterned wafer into the machine using normal operating procedures. The autofocus operations will not work because the laser interlocks are open.
17. Manually focus on the wafer using the joystick and the lowest power objective available.

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18. Loosen the radial thumbscrew on the lamp socket and rotate the lamp socket to obtain the most uniform illumination of the sample, as indicated by the white light image of the wafer. Snug down again on the radial thumbscrew.
19. Adjust the axial thumbscrew to obtain the most uniform illumination of the sample. These adjustments are moving the position of the lamp filament with respect to the optics train.
20. Repeat steps 13 and 14 until the illumination is optimized. Tighten the radial thumbscrew when completed.
21. Replace the top cover of the machine and screw in the four quarter turn fasteners that hold it to the machine frame. This operation closes the laser interlocks.
22. Do a **System Shutdown** and turn off the power to the machine with the red **Off** button.
23. Restart the machine as previously described. Cycling the power should bring back the laser.

KLA Tencor Factory PM

KLA Tencor factory PM procedures are to be performed *only* by factory authorized personnel. The procedures include cleaning and realignment of the optics train, which is a sensitive process that is critical to the performance of the instrument.

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G

Configuring NFS

The following procedure is provided for system administrators only so that they can activate or change NFS connections between the CRS and other tools, printers, and the like. It is not necessary to have a field service engineer make simple changes to network IP addresses. For more advanced configuration, including adding or changing connections to a KLA-Tencor Quest database system, or to instruments from other manufacturers, including Inspex, Hitachi, LPA/DES, or Dentech, contact KLA-Tencor to make arrangements.



WARNING

This procedure requires the administrator to access UNIIX operating system commands and files. Such access carries with it the danger of damage to system software, and possibly hardware and personnel as well.

Introduction

The KLA-Tencor CRS uses TCP/IP over Ethernet for its basic network communication. With TCP/IP alone, users with some computer skills can access the CRS's files from remote workstations using basic operating system commands such as ftp, as described in Appendix A, "System Software". For ease of network access, KLA-Tencor offers the NFS option, which greatly simplifies network access. With NFS, a remote computer is viewed as if it is one of the KLA-Tencor CRS's directories.

The following procedures should only be executed by a network administrator who is well versed in the UNIX operating system and TCP/IP command protocols.

Terminology

REMOTE: Inside the KLA-Tencor CRS system software, every file access dialog box has a REMOTE directory. When the user select this directory, he is selecting the remote machine. Defect files would be read from and written back to the data hub via this directory.

REMOTE2: You can set up this optional directory to access another directory on the remote host or to access a directory on a different remote host (for example, a second scanner).

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IMPORT: The directory on the KLA-Tencor CRS that you wish to view from the remote machine must be set up to be "exportable." The exportable directory generally is the SYSTEM directory. Files from data hubs can be written here.

Configurations

The CRS could interface with the remote database using any of the following three configurations:

1. CRS could read defect files from the REMOTE directory, and then write back reviewed files to a subdirectory under REMOTE.
2. CRS could read defect files from the REMOTE directory, and then write back reviewed files to the REMOTE2 directory.
3. CRS could read defect files from the IMPORT directory, and then write back reviewed files to the REMOTE directory.

In the first two configurations, the CRS retrieves files stored on a remote system (usually a surface scanner), while in the third configuration, the remote system writes the files to a directory on the CRS hard drive. In all three configurations, the CRS deposits reviewed files in a REMOTE directory on another system for analysis, whether the original scanner, a QUEST database system, or elsewhere.

Typically, Inspex, Hitachi, LPA, and Dentech would use configuration 1, while KLA-Tencor 21XX and AIT would use configuration 2 or 3. Consult your applications engineer if you have questions about setting up connections between the CRS and other tools.

Procedure

Hardware setup

Ask the network administrator to connect the KLA-Tencor CRS and Codonics printer to the same network as the scanner. This can be either 10Base2/ThinNet/BNC/Coaxial cabling or 10BaseT/TwistedPair cabling.

Network address setup

All systems in the network to be accessed must be specified in the file `/etc/hosts`. It is an ASCII file with each line containing the name and the IP address of a system. Obtain the following hostnames and IP addresses from their network system administrator.

- Obtain a hostname and an IP address for the KLA-Tencor CRS.
- (Replace any future reference to `crshostname` in this procedure with the hostname just obtained for the KLA-Tencor CRS.)
- Obtain a hostname and an IP address for the Codonics printer.
  (Replace any future reference to `printerhostname` in this procedure with the hostname just obtained for the Codonics printer.)

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- Obtain the hostname and the IP address for the scanner.
  (Replace any future reference to `scannerhostname` in this procedure with the hostname just obtained for the scanner.)
- Tell the sysadmin that `crshostname:/usr/uv/IMPORT` is the directory for the scanner to mount, and it is where the KLA Tencor CRS will read in map files.
- Obtain the name of the directory to which we should write the reviewed map files. This directory name (referred to here as `OutputDataDir`) will be used in step 2 in the section labeled "Configuring NFS" below.

To edit the `/etc/hosts` file

1. Add the following 3 lines to the **/etc/hosts** file using the jot editor. They should appear similar to the following example but with the valid IP addresses and hostnames obtained above.

```
198.93.209.134     crshostname
198.93.209.135     printerhostname
198.93.209.130     scannerhostname
```

   Save the changes.

2. Change the name in the file `/etc/sys_id` to the `crshostname` given for the KLA Tencor CRS. Save the change.
3. Type `reboot` and press ENTER.

Testing the Hardware Connection

The `ping` command can be used to test network connection. Type `ping [scannerhostname]` and press ENTER. If the connection is good, the data packet transfer will have 0% loss. Type `CTRL+C` to quit.

Configuring NFS–Summary

The basic steps to configure NFS are:

1. Edit the file `/etc/hosts`.
2. Edit the file `/etc/sys_id`.
3. Reboot.
4. Create `/usr/uv/IMPORT` if it doesn't exist (give this directory the correct permissions).
5. Edit `/etc/exports`
6. Enter the command `exportfs -a`.
7. Create `/REMOTE` if it doesn't exist (give this directory the correct permissions and make sure it is empty)

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8. Edit `/etc/fstab`.
9. Reboot.

Configuring NFS–Detailed Procedure

1. Check if the NFS daemon is running by entering the command `ps -e |grep nfsd`. A line similar to the following should appear:

```
123 ?      0.00 nfsd
```

2. IMPORT Directory: The directory `/usr/uv/IMPORT` will be exported to the data hub. Make sure that this directory exists and is given the correct permissions. Use the following commands if needed:

```
mkdir /usr/uv/IMPORT
chmod -R +rwx /usr/uv/IMPORT
```

3. The file `/etc/exports` is an ascii file that contains the local directory to be accessed and the name of the system that is allowed to have the access. Add a line in `/etc/exports` like the following:

```
/usr/uv/IMPORT       kla2550hostname
```

4. After the `/etc/exports` is edited, enter the command `exportfs -a` to update the changes to the system.
5. REMOTE Directory: The directory `/REMOTE` is used as the mount point for the remote directory. Make sure that this directory is created, given the correct permissions, and is empty. Use the following commands if needed:

```
mkdir /REMOTE
chmod +rwx /REMOTE
rm /REMOTE/filename
```

6. The file `/etc/fstab` contains the file system (including remote directories) to be mounted automatically at boot up. Add a line in `/etc/fstab` like the following to make the remote directory appear at `/REMOTE` (the system software expects the remote directory to be there).

```
kla2550hostname:/OutputDataDir /REMOTE nfs rw,intr,soft,bg 0 0
```

where *OutputDataDir* should be replaced with the directory name obtained in step 1.5.

7. Type `reboot` and press ENTER.

Testing NFS

Start up the `uv` program, and access the IMPORT directory to read map files. Review some defects and store the modified map file in the REMOTE directory.

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Renaming Remote Directories

You can modify the label 'IMPORT' to a customized name such as KLA_READ and modify the label 'REMOTE' to customized name such as KLA_WRITE. The two lines to modify are located in /usr/uv/.uvconfig. They are listed as uv_name_for_import and uv_name_for_remote.

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H

Preparing Optical Disks

This procedure describes how to prepare new optical disks which have not been formatted. For more information on UNIX commands, see Appendix A, "System Software"

1. Select **Desktop** in the ***ToolChest*** window at the top lefthand corner of the screen.
2. Select **Unix Shell**.
3. Type `login uv` and press ENTER to login as uv.
4. Make sure the write protect switch on the diskette is in the unprotected mode.
5. Insert the diskette into the drive.
6. Wait until the middle orange light turns off (approximately 10 seconds)
7. Type `umount /OPTICAL` and press ENTER to unmount any optical file system.
8. Type `formatoptics` and press ENTER to set up the diskette.
9. Wait until *both* the left blue light turns off and the computer prompt
   `/usr/people/uv`
   reappears (approximately 40 seconds).
10. Press the eject button on the drive.
11. Flip the diskette around to the second side.
12. Repeat steps 4--10 for the second side.

Notes:

- If you need to install the optical drive, enter the command `InstallOptical`.
- If you need to detach or turn off the optical drive, enter the command `DeInstallOptical`.
- To fix a corrupted a file system on the optical diskette, enter the command `repairoptics`.

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Glossary

µ	Micron, one millionth of a meter (10^{-6} m)
.bmp	Extension for a bitmap graphics file
.cod	Extension for a defect code file, containing defect code numbers and descriptions
.map	Extension for a wafer map file, containing a description of a wafer and its defects
.rcp	Extension for a recipe file, containing user-defined system settings
.rgb	Extension for an RGB file, containing a captured image in SGI RGB format
.sur	Extension for a surface file, containing a 3D CRS surface image
.tif	Extension for a TIFF file, containing a captured image in TIFF format
.vol	Extension for a volume file, containing a 3D CRS volume image
1st slice	Slider bar to choose the slice of a 3D image to view in an XY window Do not confuse with First Slice
absolute coordinates	Locating positions on a wafer in fixed units relative to the wafer center as 0, 0. Contrast with die coordinates.
account	*See* user account
ADC	Automatic Defect Classification
ATM	Equipe Atmospheric robot
autodeskew	Deskew operation performed automatically without operator intervention

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autofocus — An operation of the CRS UV software for finding and setting the height of the stage which gives the brightest return image in laser light. This will normally put the focal plane of the CRS at the surface of the wafer.

beamsplitter — Partially reflecting surface which divides a beam of light into transmitted and reflected beams travelling in different directions

BF/DF — Bright field/dark field

blanket film — In semiconductor fabrication, a thin film covering the entire wafer surface.

bright field — Vertical illumination of the wafer, so that the background of the image is bright from specular reflection. Contrasted with dark-field.

calibration — Measuring and setting parameters to ensure uniform imaging at all settings

cassette — Wafer holder designed for mounting on fabrication and inspection tools in precise alignment for loading and unloading wafers.

cassette rotator — Replacement for cassette plate. The rotator accepts a cassette on its back, with the wafers vertical, and rotates it into position for wafer loading, with the wafers horizontal.

CCD — Charge Coupled Device

CD — Critical Dimension

CDRH — Center for Devices and Radiological Health

CE — Conformité Européenne standard of the European Union

charge coupled device — Electronic light sensor, usually with a square arrangement of pixels. Charge accumulates in each cell in proportion to the light falling on it. Charges are then transferred across the array in parallel for readout, erasing the cells and preparing them to receive the next image.

chuck — Surface for supporting a wafer and holding it in place with vacuum. The CRS has a prealigner chuck and a stage chuck.

Class 1 — Of a cleanroom having fewer than 1 particle per cubic centimeter in the air.

coarse Z stage — Movement of the stage in the vertical direction with an accuracy of 0.25 µ. Contrast with fine Z.

color balance — In white light viewing, adjustment of the red, green, and blue components of the camera image so that they are equal in intensity when viewing a white surface.

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color temperature For an incandescent light source such as the halogen bulb, the temperature of a black body radiator with the closest match to its spectrum. The relative strengths of different frequencies change with temperature.

confocal Of a microscope in which a spatial filter (a pinhole) controls depth of focus. See (diagram)

correction factor In film measurement, the ratio between the actual film thickness determined by an SEM and the thickness measured optically. The difference is due to refraction at the film surface.

CRS KLA Tencor Confocal Review Station

cutting crosshairs Crosshairs in a 2D XY window indicating where the XZ and YZ cut planes should be taken from a 3D image.

daemon An independent software process which carries out a specific function on behalf of applications. The NFS daemon manages the connection between the CRS and its remote directories.

dark field Illumination of the wafer at an angle, so that the image is made up of scattered light. The background wafer surface is dark, since it reflects light well and scatters it very little. Contrasted with bright field.

defect Any structure or object not meant to be on the wafer or within the semiconductor structure on the wafer, or any missing part of a semiconductor structure.

defect classification Assignment of defect codes to defects based on factors such as size, brightness, and location above or below the wafer surface.

defect code Number and name assigned to a set of defects, usually with some common characteristics. 'Unknown' or 'Not classified' are also common defect code names.

defect file File listing the location of all defects found by a surface scanner on a wafer.

defect intensity In Tencor defect maps, a measure of the seriousness of the defect

defect map A file containing the locations of the defects on a wafer, as determined by a surface scanner.

defect signature Properties of a type of defect which can be used to determine whether a specific defect is of that type.

deskew Adjustment in software for angular error in placing a wafer under the microscope. Also, the process of determining the deskew angle from the positional errors in locating specific features at three points on the wafer.

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die coordinates Locating positions on a wafer in units of the dimensions of a die, measured from a specific die chosen as the center of the coordinate system. Contrast with absolute coordinates.

die jumping Using a nearby die as a reference for identifying defects. The CRS software can be set to jump one or more die in any direction.

dielectric Electric insulator

diffraction Changes in the direction of propagation of light due to edge effects and repeating patterns. Diffraction frequently shows up as a pattern of bars or rings produced by interference between diffracted light taking paths of different lengths to arrive at the same point.

diffraction-limited Of an optical system, with the maximum resolution limited only by diffraction rather than the quality of the optical components. In diffraction-limited optics the minimum beam width is the wavelength of the light used, and the resolution can approach a quarter of that wavelength. For example, the 488 nm laser line in the CRS can be used to resolve features down to 150 nm.

end effector The component of a robot wafer handler which contacts the wafer, including the support surface and vacuum outlets. The end effector and chucks are designed together so that the end effector can move to center a wafer on a chuck without coming into contact with the chuck itself.

EPO Emergency Power Off button

ESC Equipe Smart Controller

extension The last portion of a filename, following a '.' (dot), indicating the type of file. Thus `.rcp` for recipe files, or `.map` for wafer map files.

false color In computer imaging, replacement of the original colors or other data in an image with a set of colors designed to make features of interest more visible to the human eye. In the CRS laser images the gray-scale data from the PMT are usually translated to false colors of similar brightness. There is an option in the 3D viewing window to use false color to indicate Z-height.

fast Z Fine Z

fiducial marks Marks engraved on a wafer as aids in alignment

film Thin layer of material deposited on a wafer

film step A sharp edge between a film and another semiconductor layer, or the lateral boundary between two films which have top surfaces at the same height, especially if one is opaque and the other transparent.

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fine Z — Movement of the stage in the vertical direction using piezoelectric drivers monitored by a position sensor, in steps as small as 12 nm over a total travel of 50 µ. Contrast with coarse Z.

FirstSlice — Slider bar used to set the lowest slice included when forming a 3D image. If a reflective subsurface layer returns a brighter reflection than a transparent surface layer above it, the first slice can be set to eliminate the reflection from below the surface and force the higher layer to be used in forming the surface image. Do not confuse with 1st Slice.

five-finger reset — The key combination for recovery from an X Windows lockup on the CRS. The five keys are labelled either

CTRL, SHIFT, ESC, F12, and / (on numeric keypad) or
CTRL, SHIFT, ESC, Focus Offset and SK1

flatfinder — Prealigner

flat orientation — Direction in which a wafer flat or notch is oriented. Down (0°), Left (90°), Up (180°), Right (270°), where Down is toward the wafer door.

focal plane — The surface of best focus in an optical system.

focus offset — A value to be added to the Z position after an autofocus operation. Used when the features of greatest interest are above or below the brightest slice.

Fov — Field of View

FTP — File transfer protocol

FWHM — Full Width at Half Maximum, a measure of the spread of the peak of a distribution.

GEM — Generic Equipment Model of the SECS standard. See SECS/GEM.

GEM/SECS — See SECS/GEM

GEMINI optics — Hardware and software for simultaneous laser/white light viewing. Its principal feature is use of a narrow-pass filter for selecting the 488 nm line from the laser, and a notch filter to protect the white light camera from the laser line, for minimum degradation of the white light image.

halogen bulb — High-intensity light bulb used for white light illumination in the CRS.

Hg — Mercury. The equivalent height of a column of mercury is used as a measure of gas pressure or vacuum

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hologram (1) Recorded interference pattern between a laser image and a laser source, which recreates the laser image when illuminated by a laser beam. (2) Any pattern which produces a desired optical effect through interference with a laser beam.

holographic filter Synthetic hologram designed to filter out a specific frequency band.

ILM KLA Tencor Intelligent Line Monitoring product line for defect detection, defect classification, and yield management.

IMPORT A remote directory accessible by the CRS using NFS. It is usually on a defect scanning system or on a computer which receives data from several scanners.

integrated whitelight The ability of the CRS to display white light images on the computer monitor as well as on the monitor connected to the white light camera. Optional on older models of the CRS, and standard on current models.

interference Addition of field strengths between light arriving at the same point, either from different sources, or from the same source by different paths. If the electric fields of the photons are of the same sign at that point, the total brightness is increased. If they are of opposite sign, the brightness is reduced. Interference is usually seen in the form of alternating bright and dark fringes.

IP address Address used in TCP/IP networking, consisting of four numbers in the range 0-255 separated by dots. For example, 10.38.3.25 or 255.0.0.0.

IRIX SGI version of UNIX

Isolation table A floating internal frame mounted on pneumatic vibration isolaters, which supports the stage, robot, and prealigner

J Joule

jot A visual text editor provided with the IRIX operating system.

Joule A unit of electric energy

keyfile A CRS file which specifies the installed software options.

killer defect Any defect which prevents the IC from performing its intended function.

KLA 255X A surface scanning instrument which creates defect maps usable by the CRS.

KLA map File format and data types developed by KLA for its surface scanning instruments.

KLARITY KLA Tencor software for yield analysis and control

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knowledge base Data on defects specific to a process or process level, used in ADC for defect recognition and classification

laser line The wavelength of highest power emission from a laser. In some cases, multiple laser lines are available—458nm, 488 nm, and 515 nm in the CRS.

library A set of saved image files which can be loaded and viewed within the UV application.

linearity Display of equal-sized images of equal-sized objects in different parts of the view window

lockup A state of a computer program in which it does not respond to normal inputs, whether from keyboard, mouse, joystick, or external devices.

lockup recovery In many cases a CRS can be brought out of lockup using a five-finger reset. In other cases it may be necessary to restart the application, reboot the computer, or cycle power. See Appendix F for details.

LON Local Operating Network connecting control boards within the CRS.

lot ID Identification number for a batch of wafers

lower Put an application in the background, with the other application windows visible on top of it. IRIX has a menu command for lowering any window. Click on the square at the top left of the window to access this menu.

mini-environment An enclosure around a machine to prevent entry of contaminants

N.A. Numerical Aperture

NEAT New England Associated Technologies, manufacturer of the XYZ stage in the CRS

NEMA National Electrical Manufacturers Association

NFS Network File System

nm Nanometer, one billionth of a meter (10^{-9}m)

notch filter A filter which blocks a very narrow range of wavelengths

numerical aperture In an optical system, the sine of the angle within which light enters the objective

offline review Review carried out on a separate instrument, providing superior defect classification and also allowing scanning systems to be used at maximum efficiency

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one-touch — A type of preumatic connector used on the air pressure line into the CRS.

operating envelope — The space which any part of a robot can move through. On the CRS, this is the space enclosed by the Plexiglas robot cover and the wafer cassette.

parcentricity — Alignment of the CRS optics and calibration of the stage so that the fields of view in both laser and white light at any magnification are aligned.

parfocality — Alignment of the CRS optics so that the white light and laser images are both in focus at any magnification.

photomultiplier tube — Extremely sensitive optical amplifier and sensor

photoresist — Photosensitive material coated on a wafer and exposed through a photomask to make patterns for fabrication processes. The process, whether deposition, chemical reaction, or etching, is active only on areas of the wafer not covered by the resist.

PID — Process Identification number in UNIX

pinch point — A point where two mechanical components may come close together, creating a hazard if anything, including any part of a person, is at that point

PMT — Photomultiplier tube

point spread function — In optics, a measure of the spread in the image of a point. A narrower PSF gives better resolution.

polarization — Alignment of the electric vectors in a beam of light

polarizing — Creating a polarized light beam, with the electric vectors in the same plane.

poly — Polycrystalline silicon

p-p — Peak-to-peak

prealigner — Station for centering wafer and aligning its flat or notch in preparation for placement on stage

privilege — Permission for a particular user or group of users to perform certain actions. Privileges are set in the operating system and in the UV application, which sets different privilege levels for Operator, Administrator, and Service Engineer.

prtscreen — Print Screen key

PSF — Point Spread Function

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PWDS SEMATECH Patterned Wafer Defect Standard

quick disconnect A type of pneumatic connector, used on the vacuum line into the CRS.

radio button Visual control, diamond-shaped in the UV application, allowing selection of one out of several choices, like the buttons on a car radio

RCP Remote Copy file transfer utility in UNIX

repeatability Ability to place a wafer accurately in a specified position each time

recipe A file specifying operating parameters for examining wafers of a particular type

REMOTE A remote directory accessible from the CRS using NFS, but located on a drive on another tool or computer system

REMOTE2 A remote directory accessible from the CRS using NFS. REMOTE2 can be located on the same system as REMOTE, or on some other system.

resist Photoresist

resolution The smallest size of feature that can be distinguished in an optical system

review Examine and classify the defects found by a scanning system on a wafer.

rf radio frequency

RGB file SGI image file format

rms Root-mean-square, a formula for average voltage in AC circuits

safety interlock A switch which signals the CRS to halt operation when a safety cover is removed, or to prevent robot motion when there is no wafer cassette on the cassette plate.

scattering Reflection of light in all directions from an irregular surface.

SDP Surface Data Processor

SECS SEMI Equipment Communication Standard. *See* SECS/GEM.

SECS/GEM Communication standard for automation of semiconductor fabrication and inspection equipment. *See also* SECS, GEM.

SEM Scanning Electron Microscope

SEMATECH A non-profit R&D consortium of U.S. semiconductor manufacturers (from SEmiconductor MAnufacturing TECHnology)

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SEMI	Semiconductor Equipment and Materials International
SEMI S2-93	Safety standard created by SEMI
Sequence pane	The portion of the CRS software display which shows the steps which normally follow from the current state, or are commonly-used options in the current state.
SGI	Silicon Graphics, Inc.
shell	UNIX command interpreter
signature	*See* defect signature
SK	Soft Key
slider bar	Visual control allowing a variable to be set anywhere in its range (picture)
SMIF	Standard Machine Interface for handling sealed wafer pods at a fabrication or inspection tool.
smoothing	An image-processing function which takes local averages to produce a smoother representation of a surface.
spatial filter	Pinhole that blocks out-of-focus light in the return beam in a confocal microscope
specular reflection	Mirror-like reflection, in which a beam of light is redirected in a beam
stage	Mechanical system for positioning wafers under the microscope for review. It moves in X,Y, and Z directions using precision hardware and software systems for accurate, repeatable location of wafer features and defects.
stage center offset	An parameter in the CRS software which can be set by the operator and applied to correct for inaccuracies in positioning the wafer on the stage.
stage isolation supports	Pneumatic vibration isolators which support a floating platform bearing the stage, robot, and prealigner
surface data processor	Silicon Graphics Indy computer with frame grabber, which together create 2D and 3D images of the wafer surface
SurfScan™	**KLA Tencor** trademark for surface scanning instruments
swap button	A visual control for dragging a window to another location on the screen. Swap buttons appear in CRS windows as rounded rectangles labelled 'L'.
SWIFT/Station	A Tencor wafer scanning system

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Tencor map A file format originally defined by Tencor for defect data from inspection tools.

TIFF Tagged Image Format File, a standard for image files which permits the addition of descriptive information.

toggle button Visual control in the shape of a square box in the UV application, allowing a selection to be turned on or off independently of other selections.

turret The rotating holder for the various microscope objectives.

UNIX An operating system

user account An association of a logon name, password, and access permissions for an individual CRS user, or for a class of users such as system administrators or field service engineers.

User screen A screen definition in the CRS software which is meant to be redefined by users, or a screen created by a user.

uv CRS application software

uv1000 Shell script (batch file) for starting UV software with the correct state of system processes and communication.

V-A Volt-Ampere, a measure of electric power.

wafer chuck *See* chuck

wafer ID Text string identifying an individual wafer

wafer map *See* defect map

wafer size Diameter of wafer, expressed in millimeters or inches. Standard sizes are

Table H-1 Wafer Diameters

Metric	US
100 mm	4"
125 mm	5"
150 mm	6"
200 mm	8"

wafer thickness Parameter in CRS software for setting the thickness of the wafer or other object to be viewed.

working envelope Operating envelope

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X Windows — User interface providing windows, icons, menus and mouse control for UNIX operating systems.

XY view — The top view in a 3D image

XZ view — A computed image of a vertical slice along the X axis through a 3D image, giving a front view of the cut surface. *See also* XY view, YZ view.

YZ view — A computed image of a vertical slice along the Y axis through a 3D image, giving a side view of the cut surface. *See also* XY view, XZ view.

Z scale — In 3D imaging on the CRS, the height of features can be stretched using the Z scale button to bring out detail that is otherwise difficult to see.

zoom — Magnification of a portion of an image. In a laser image window, there are four physical zoom levels, corresponding to four amplitudes of motion of the scanning mirrors which steer the laser beam, in the ratios 1, 2, 4, 8. In a 3D surface or volume window, the captured image is zoomed by an arbitrary ratio in software.

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Index

Symbols

.bmp 84, 297
.cod 84, 297
.cshrc 232
.login 232
.map 84, 297
.profile 232
.rcp 84, 297
.rgb 84, 297
.sgisession 232
.sur 84, 297
.tif 84, 297
.uvconfig 152, 293
.vol 84, 297
.Xdefaults 232
/etc/exports 291–292
/etc/fstab 292
/etc/hosts 290–291
/etc/sys_id 291
/REMOTE directory 292
/usr/uv/data 73
/usr/uv/IMPORT 291
<emphasis>See also PMT 304
← button 124
→ button 124

Numerics

1 Die Distance 111
1st Slice 129
1st Slice slider 128–129, 297
2D control menu 131
2D images 11, 38, 53, 85, 124, 198, 209
2D pane 55, 86, 100, 126, 133, 200, 207
    1st Slice 129
    New surface & first slice 130
    Sections & spacing (volume image) 129–130
    volume image types 128
    XY cut cursor control (surface image) 128
    XZ & YZ peaks (volume image) 130
    XZ & YZ side views (surface image) 129
    Z profile (volume image) 130
2D projections 126, 128
2D screen command 151
2D swap button 32
3D images 17, 85–86, 133
    acquiring 24, 53
    bare wafer 198
    brightness & contrast 125
    capturing 54, 117
    false color 124, 128
    file types 84
    finish position 121
    gray scale 124
    height color 124
    lighting 125
    loading 55, 100
    no color 124
    Reset button 125
    saving 55, 125
    Set Z 121
    small particle 200–201
    Smoothing 125
    smoothing 125
    start position 121
    step size 117
    surface 130
    translating 124
    Translation 124
    types 11
    Y width 125
    Z height 125
    Z scale 125
    Zoom 123
    zooming 124

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3D pane 133
3D screen 151
3D swap button 32
85%LaserWindow 111

A

abscissa 131
AbsCoord button 109, 197
absolute coordinates 297
absorption coefficient 20
accept 38
Accept button 35, 73
Accept Dsk1 198
Accept Dsk2 198
access, restricted 2, 5
account *See* user account
accuracy
  ADC 25
  coordinate correlation 199
  defect classification 272
  definition 262
  scanner 199
  screen measurement 20
  stage 16, 243, 247, 264
ADC 25, 99, 243–249, 297
  accuracy 15, 25
  Aperture control 116
  automated operation 25
  computer requirement 245
  firmware 247
  KnowledgeBase 161
  Laser 248, 272
  manual 77
  off-line 11
  options 270, 272
  parameters 96
  software option 243
  upgrade 11
  White Light 248, 272
Adjusting laser scan parameters
  advanced method 195
  basic method 194
Administrator 83
air 8, 28
air quality 238
alignment, wafer 25
ALL laser lines 117
Annotation 152
anti-reflective coating 207
AppendDefect 201–202
application, restarting 277
applications engineer 107, 116, 131, 194, 207
argon ion laser 11
A-Stop 249
Asyst Technologies 272–273
ATM robot 297
auto gain 21
auto ranging 21
AutoDeskew 63–75, 96, 270, 297
  not on bare wafers 72
  option 68, 72–73
  Reference Image 96
  reference image capture 73
  reference images 64, 72
  selecting points 69
  setting up 64, 71
  testing 74, 243
  Testing window 72
autofocus 21, 49, 52, 93, 116, 150, 243, 298
  fine 114
  firmware 247
  intensities 194
  performance 195
  setup 193
Automatic Defect Classification *See* ADC
automatic operation 12, 25, 273
axes 126

B

backup 27
bare wafer
  3D image, small particle 200
  defect review 199
  deskew 68, 72, 96, 197
  Stage Center Offset 197
Basic maintenance
  Changing halogen bulb 286
  Chuck cleaning 283
  Cleaning prealigner chuck 283
  Cleaning robot end effector 283
  Cleaning XYZ stage chuck 283
  Cycling power 279
  Data backup & restore 282
  Five-finger reset 278
  Laser lifetime 284
  Lockup recovery 277
  Manual wafer removal 280
  Monitor aging of laser 284
  PM schedule 281
  Preventative maintenance 281
  Rebooting the computer 279
  Restarting CRS application 278
  Robot alignment check 284
  Robot safety interlock check 285

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Robot-cassette alignment check 284
Robot-prealigner alignment check 285
Robot-XYZ stage alignment check 285
Safety precautions 281
System wipe down 282
Tencor factory PM 288
Troubleshooting 277
Wafer removal 279
Wafer removal using software 279
Basic operations
Deskewing 34–38
Getting around 50
Imaging a defect 45
Loading defect file & wafer 33
Logging out 59
Printing 59
Reviewing defects 38
System shutdown 184
System startup 184
Unloading wafer 59
beamsplitter 24, 154, 247, 249, 271, 298
BF/DF 298
bitmap graphics file 161, 297
blanket film 298
bonding pad profile 201
Bri button 125
bright field 11, 21, 25, 51, 116, 249, 298
brightness, adjusting 46–47
button
← 124
→ 124
AbsCoord 109, 197
Accept 35, 73
Bri 125
CalcMapOffset 73, 107, 150
Capture 73
Color 124
Contr 125
Control 131
Down 124
EditDefect 199, 201–202
F (Finish) 121
File 125
FineAF 114
Focus Offset 115
GoToSelected 50, 69, 103
HW Test 74
Laser/WL 115
LaserLine 195
LaserParams 92, 194
Load Deskew Reference Images 73
Modify Coord 199
New Surface 129–130
Pixels 121
RedoDeskew 35, 69
Reset (3D image) 125
Rot- 123
Rot+ 123
S (Start) 121
Sections 39, 128–130
Set Z 121
SetDeskew1 70
SetDeskew2 70
Skip Deskew 35
Smooth 54, 125, 128
SortParms 194
StageAF 114
StartSeq 33
Surf 121
Surface 130, 200
SW Test 74
swap 32, 100
Tilt 54
Tilt- 123
Tilt + 123
Up 124
Vol 121
Xdir 125
Z Scale 125
Zoom 117
Zoom- 123
Zoom+ 123–124

C

CalcMapOffset button 73, 107, 150
CalcStgOffset 72
calendar 222
calibration 5, 298
camera 29, 269
filter 271
for ADC 244, 246
Optronics 63
preventing damage from laser light 115, 270
RGB output 247
settings 243
Sony 63, 248
Y-C output 247
Camera Intensity 150
Capture button 73
cassette 5, 16, 27, 29, 33, 59, 104, 158, 298
interlock 8
loading 12
Cassette pane 34, 104
cassette plate 28, 269–270

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

cassette rotator 270
CCD 298
CD 298
CDRH 298
CE 269–270, 298
charge coupled device 298
Choosing correct objective, factors
  Diffraction 208
  Interference 209
  Resolution 208
  Scattering 208
chromatic aberration 17
chuck 298
  prealigner 15
  stage 15–16
circle cursor 102
circuit breaker 6
circuit breaker lockout 3
classification 12, 38, 59, 142
cleanroom 273
  Class 1 13, 298
  Class 100 238
ClearMap 201–202
Cluster 152
cluster 104
coarse Z stage 114, 298
Codonics printer 270, 290
codonicshostname 290–291
color balance 270, 298
Color button 124
color codes, defect 99
color temperature 299
color, false 11, 17, 20, 39, 124, 128
communication 13
Comparison of CRS and SEM 13
computer
  name 218
  rebooting 277
  requirement for ADC 245
conducting material 20
Config Misc. window 152–156
Configuring NFS
  Detailed procedure 292
  Summary of procedure 291
confocal laser images 16, 38
confocal microscope 11, 16, 265, 299
  comparison 264–267
  depth of focus 12, 17, 267
  principles 21
Confocal Review Station overview 11
connecting CRS to network 290
connectors
  air and vacuum 237
  power, exhaust, air, and vacuum 240
Contr button 125
contrast 17, 20
Control button 131
control dialogue box 103
cooling 238
copy file 162
correction factor 299
cover, robot 5, 7, 28
cover, top 2
create user account 163
creating KLA map 202
creating Tencor map 201
critical dimension 207, 209
cross cursor 102
crosshairs 68, 152
  cutting 55, 128, 299
  in white light and laser image 35
cross-sectional view 55, 127
CRS operating software 215
crshostname 290
cursor
  circle 102
  cross 102
  cutting 127–128
  rubberband 41, 53, 55, 128, 209
  Wafer Map 102
customer acceptance 242
Cut Plane 200
cutting cursors 41, 53, 127–129

D

daemon 299
daemon, NFS 292
damage, shipping 242
dark field 11, 21, 25, 51, 116, 197–200, 209, 249, 299
data connections 28
data storage 13
default wavelength 116
defect 299
  analysis 25
  area (KLA) 102
  classification 11–12, 25, 38, 78–79, 299
  code 59, 161, 299
  code file 84, 107, 297
  code list 28, 59, 106, 151
  code numbers 107
  color codes 101, 103–104
  colors in KLA maps 102
  coordinate 50
  coordinate updating 199

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

descriptions 107
Equivalent Length (KLA) 102
file 33, 299
finding 68
first 38, 73–74
height 49
image 21
intensity (Tencor) 102–103, 197, 299
invisible 25
large 198
list 107
map 35, 93, 102, 299
moving to 50
number 86
parameters 85
repetitive 201
review 18, 21, 27, 38, 199
review, bare wafer 196
second deskew 198
size 18, 20
size (KLA) 102–103, 197
sort criteria 68, 85, 193–194
subsurface 272
types 15
very thin 125
Defect Chart window 143
Defect Map panes 99, 101
Defect Selection window 69
defective mask 201
DefectList pane 29, 50, 68–69
link to wafer map 103
Defects as Deskew Pts 68, 72, 197, 202
DefList 197
delete file 162
delete user account 163
delivery inspection 242
Dentech 95, 270
depth of focus 12, 16–17, 45, 128, 265–266
deskew 12, 16, 71, 106–108, 141, 150–152, 197, 299
automatic 63–75
automatic *See also* AutoDeskew
bare wafer 96
defects as deskew points 72, 197
high magnification 72
manual 66, 72
options 95
reference images 75
Deskew Die Offset 67, 156
Deskew Location Offsets 96
Deskew Options 197, 202
Deskew Options window 64, 66, 72–73
Deskew pane 64
deskew point 35, 37, 64, 66–68, 72, 85, 96, 140, 156, 197
bad 69
first 193, 196
good 70
verifying 71
Deskew Reference Image File Name 72
Deskew screen 35, 64, 99
Deskew sequence pane 64
Desktop menu 278
Diagnostics 21
dice 102
die
incomplete 156
measuring pitch 202
origin 202
size 85, 140
test 156
die coordinates 300
die jumping 111, 300
die offset 67
Die Pitch 141, 202
dielectric 12, 20, 300
no signal 207
dielectric film, weak reflection 207
diffraction 208, 300
diffraction- limited 300
diffraction-limited 16
directories 82–83
directory
change 226
default 83
FLOPPY 83
home 232
IMPORT 83
list contents 226
make 226
REMOTE 83
REMOTE 2 83
remove 226
show current 226
SYSTEM 83
USER 83
user 83
dirt 243
discrimination 262–264
disk space 219
dotfiles 232
Down button 124
drag and drop 100
drive
floppy 83
magneto-optical 29, 83

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formatting disk 295
tape 231
drive capacity 243
ducting 238

E

edge symmetry 243
Edit Defect window 107
Edit Wafer Map 202
EditDefect button 199, 201–202
electricity 8
electronics 8
Emergency Power Off 4–5, 184, 279, 300
emission lines 11
end effector, robot 15–16, 309
engineering mode 21
engineers 272
EnterToList 202
entry field 82
EPO *see* Emergency Power Off
Equipe robot 63, 244
Equipe robot controller 164
equipment rack 29, 246
ESC 300
Ethernet 269, 289
exhaust 240
Exit command 88
extension 84, 162, 297, 300
.bmp 84, 297
.cod 84, 297
.map 84, 297
.rcp 84, 297
.rgb 84, 297
.sur 84, 297
.tif 84, 297
.vol 84, 297

F

F button (Finish) 121, 199
facia plate around wafer door 280
false color 124, 300
in 3D images 124, 128
in laser images 11, 17, 20, 39, 124
fast Z 300
Fast Z Diagnostics window 169–170
Fast Z firmware 243
Fast-Z PCBA 247, 249
fiducial marks 16
field of view 69, 193, 196–198, 209
Field Service Engineer 243, 272
file
bitmap graphics 84, 297
change owner 225
change permissions 224
character, word, and line count 223
copy 162, 224
defect code 84, 107, 297
delete 162, 224
display 222
display beginning 223
display end 223
extension 83
image 93
JPEG 98, 183
move 162
move or rename 224
recipe 84–85, 297
rename 162
RGB 84, 297
selection 162
surface 84–85, 161, 297
tar 231
TIFF 84, 297
TIFF file 86
transfer 225
volume 84, 297
volume file 85
wafer map 84, 297
File button 125
File Transfer window 160, 162
FileName 140
files
compare bytes 223
link with alias 225
show differences by line 223
film 300
dielectric 207
film step 210, 300
Film thickness measurements 210
Example 212
Measurement procedures 211
Theory 210
filter
narrow band 271
notch 115, 271
yellow 115, 270
finding defects 68
Fine autofocus 114
fine Z discrimination 38
fine Z stage 12, 24, 49, 114, 301
FineAF button 114
FineZ slider 114, 116, 194–195
first defect 74
First Slice slider 129

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FirstSlice slider 130, 198, 201, 301
five-finger reset 277–279
flat 16
    See also notch 85
flat orientation 140, 301
Flat Orientation option menu 141
FlatAngle 201–202
flatfinder 301
    See also prealigner
FlatFinder Angle Offset 156
flatfinder angle offset 72
Flatfinder Offset 96
FLOPPY 162
flowchart, CRS sequence 60
focal plane 21, 85, 301
focus 45, 79
focus offset 115, 301
Focus Offset button 115
Focus Offset key 115
forklift 242
formatting optical disks 295
FOV 301
FTP 301
function key macros 146
function keys 79–80
FWHM (Full Width at Half Maximum) 200, 301

G

GEM 274
GEM/SECS II 270
GEMINI Optics 244, 246, 249
GEMINI optics 115, 269, 271, 274
global data 100
GoToSelected button 50, 69, 103
graphical control
    entry field 82
    menu bar 81
    option menu 81
    push button 84
    radio button 82
    slider bar 82
    toggle button 81
graphical user interface 78
gray scale 17, 124, 128

H

halogen bulb 301
halogen lamp, idle state 153
hard disk 244–245, 248
HardwareID numbers 245
hazardous materials 8
Hazardous Materials Safety Regulations 9
height measurement 18
Hg 301
High Voltage 2
Hitachi 270
hologram 302
holographic filter 271, 302
home directory 232
host 83
hostnames 290
humidity 239
HW Test buttons 74

I

ID# 202
Identifier Software 244
idle state 153
illumination 79
ILM 25, 302
image
    2D and 3D 53
    3D 54, 86
    brightness 125
    capture 13
    contrast 125
    controls 37
    file 29, 72, 93
    file size 201
    file, samples 215
    laser 114
    printing 59
    quality, laser 243
    quality, white light 243
    size, pixels 121
    slice 39
    slices 122
    stepsize 122
    subsurface 25
    surface 53, 121, 124, 127, 129
    volume 53, 121, 133
    white light 114
image processing 11, 63
IMPORT 302
IMPORT directory 162, 290, 292
incomplete die 156
index of refraction 20
Indigo computer 63
Indy computer 11, 63
initialize
    hardware 32
    robot 32, 158
    stage 32, 157
inspection 21

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Inspex 197, 220
installation, CRS 237–242
Instrument components
  Coarse Z stage 24
  Color CCD camera 24
  Electronics package 24
  Fine Z stage 24
  LON interface 24
  Motorized turret 24
  Objective 24
  Optical filter 22
  Polarizing beam splitter 22
  Precision XY stage 24
  Quarter-wave plate 24
  Robotic handler 24
  Spatial filter 22
  Surface data processor 24
  System computer 24
  Tube lens 24
  XY beam scanner 22
Integrated White Light option 63, 245, 248, 269–270, 274, 302
Intelligent Line Monitor 25
intensity adjusted 245
intensity profile in 2D pane 207
intensity profile on 2D pane 200
interference 209, 302
interference rings 91, 206
interlock
  cassette 8
  laser 2, 6
  robot 9
  robot cover 8
Internal parts, hazards 5
IP address 290, 302
IRIX 245, 302
  environment settings 219
  File corruption 184
  lower application 184
  Results of mproper shutdown 184
  shell 232
IRIX command
  cal 222
  cat 222
  cd 226
  chmod 224, 292
  cmp 223
  cp 224
  date 222
  df 219
  diff 223
  du 219
  eject 230
  env 219
  exportfs 291–292
  fg 229
  finger 218
  ftp 225
  grep 292
  head 223
  hh 230
  hinv 249, 245
  hostname 218
  jot 230, 302
  kill 229
  ll 226
  ln 225
  ls 226
  man 217
  mkdir 226, 292
  more 222
  mv 224
  ps 229, 292
  pwd 226
  rcp 225
  rdkey 245
  rm 224, 292
  rmdir 226
  su 230
  tail 223
  tar 231
  time 222
  uptime 219
  uv 235
  uv1000 235
  versions 219
  w 228
  wc 223
  whereis 228
  which 228
  who 218
  whoami 218
isolation table 5
isopropyl alcohol 9, 282

J

Joule 302
joystick 4, 21, 29–30, 37, 64, 77–78, 80–81, 102, 157, 202, 249
  XY mode 80
  Z mode 80
JPEG 98, 183

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K

KLA Tencor Field Service Engineer 242
KLA Tencor Product Services Department 241
KLA Tencor Representative 242
KLA Tencor representative 237
key
  Focus Offset 115
  function 78
  Laser/WL 48
  MAG↑ 37, 48
  MAG↓ 37, 48
  Map Offset 73
  MapOffset 69
  numeric keypad 59
  Redo Deskew 74, 198
  SK1 69
  sk1 54
  sk2 54
  Stage AF 48
  Toggle Menu 152
  Z↑ 48
  Z↓ 48
  Zoom 48
keyboard 4, 29, 77–78, 114
keycaps 152
keyfile 244–245, 248, 302
killer defect 302
KLA 255X 143, 302
KLA files 141
KLA map 203, 302
  creating 202
KLA Results File Format 84, 269
KLA Results files 156
kla2550hostname 291
KLARITY 302
KLA-Tencor 21XX 290
KLA-Tencor AIT 290
knowledge base 25, 243, 303

L

laser 1–2, 4, 11, 269
  Argon ion 22
  beam 17
  idle state 153
  intensity 193–194
  interlock 6
  line 92
  reset 6
  scan parameters 194
  zoom 17, 92
Laser ADC 248, 272
Laser and Imaging control window 92
Laser Confocal 262
laser confocal 21, 264
laser Image controls 51
laser image controls 52
laser image zoom 40
laser imaging 16, 114
laser imaging controls 116
laser intensity slider 117
Laser Line 150–151
laser line 115, 117, 303
  depth of penetration 206
laser mode 115
laser overload 52
Laser Power Interlock 6
Laser Product Report 1
Laser Safety 1
laser saver mode 153
Laser Scan Parameters 122
laser scan parameters 85, 195
Laser Scan Parameters window 194
laser scanning inspection tools 199
laser shutter interlock 6
Laser swap button 32
laser wavelength, choosing 209
Laser window
  Laser intensity 117
  Laser/WL toggle 115
  Objective selection 114
  Zoom 117
laser zoom 198
Laser/WL button 115
LaserIntensity 150
LaserIntensity % 195
LaserIntensity slider 194–195
LaserIntensity% 194–195
LaserLine 194
LaserLine button 195
LaserParams button 92, 194
LaserSaverTimer 153
LaserScan Parms 195
LaserScanParms 195, 197
scanner
  oscil 22
layout, typical 240
library 303
library pane 54
Library swap button 32
light tower 274
linearity 303
line-space patterns 209
line-space period 208
line-space structures 208

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live laser imaging 16
Load Deskew Reference Images button 73
load wafer 33–34, 105
Load Wafer screen 99
local data 100
Local Operating Network 164
lockup 277, 279, 303
lockup recovery 303
log 27
Login 30, 144
login 85, 194, 232
Logout 144–145
logout 59
LON 21, 164, 303
LON diagnostics 247
Lon Diagnostics window 164–165
LON nodes 170–175
Lot ID 140, 155
    loading recipe by 195
lot ID 85, 303
Lot Identification 140
lower 303
lower application 184, 278–279
LPA 152, 270

M

MAG↑ key 37, 48
MAG↓ key 37, 48
magnification 17, 20–21, 25, 41, 48, 50, 79, 262–265
Maintenance/TestAutoDsk 72
Making measurements 207
making measurements 207
    choosing correct objective 208
    General guidelines 209
manual deskew 66, 72
manual review 11, 25
manual robot control 21
Manual Robot Control menu 279
Manual Robot Control window 158, 279
Manual screen 99
manual stage control 21
Manual Stage Control window 157, 195
Map Deskew Info 68, 72
map file 28, 33, 199
map offset 64, 72–73, 107, 150
    calculate 107
Map Offset key 38, 45, 73
MapOffset key 69, 198
mask, defective 261
measurement 12, 45, 55
    XY 20
Measurement case study
    Metal or poly line-space patterns 209
    Photoresist line-space patterns 209
measuring features 127
MECS robot 63, 244
menu bar 32, 78, 84, 100
menu, IRIX Desktop 278
menu, IRIX System 184
menus 29, 77, 86–184
    option 81
metal 20
    defects under 207
metal level, imaging 209
mini-environment 11, 270, 272–273
Minimum required NA for various CDs 208
mirrors, scanning 117
Modify Coord button 196
monitor 4, 29, 269
mouse 4, 29, 78, 81, 123
    click and drag 81
Move file 162
Moving parts 5
multi-layered structure, boundaries 130
multiple slices 128

N

N.A. *See* Numerical Aperture 303
narrow band filter 271
navigation 29
NEAT 303
NEAT stage controller 164
NEMA 303
Network
    Address setup 290
    Codonics printer 293
    Configuring NFS (details) 292
    Configuring NFS (summary) 291
    connection 290
    Editing the hosts file 291
    hardware setup 290
    IMPORT directory 290
    Modifying labels in uwconfig 293
    REMOTE directory 289
    REMOTE2 directory 289
    Testing 292
    Testing hardware connection 291
network 13
network administrator 290
network administrators 215
New Surface button 129–130
NewSurface 129, 198, 261
Next die position 154
NFS 83, 269, 289–293

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daemon 292
Nipkow disk 265
Nitrides 129
noise 125, 128, 201
non-operation 184
notch filter 115, 271, 303
notch, wafer 16
NPT 238
numeric keypad 59, 79, 107
numerical aperture 208, 208, 246, 249, 264–265, 303
maximum 265
numerical aperture & objective magnification 209

O

objective 21, 24, 50, 63, 116, 150, 193–195, 199, 206, 243, 249, 269
choosing 208–209
for Hi-Mag Deskew 72
for Review 72
selecting 48
selection 199
objective magnification & numerical aperture 209
Objective menu 37
objectives required for ADC 246
offline review 303
offset
deskew die 67
map 64
prealigner 64
one-touch 238, 304
opaque materials 20
operating envelope 7, 304
operating parameters 21
Operation, principles of 21
operator 86
Operator's Console
See also workstation 4
optical disk
formatting 295
optical disks, formatting 295
Optical Drive 270
optical drive 29, 243–244, 246, 249
optics parameters 85
optics upgrade kit 244
option menu 81
options, CRS 77, 269–275
ordinate 131
origin die 202
OutputDataDir 291
overload, PMT 52
Oxide 130
oxide 20, 129–130

P

Page Scan Diagnostics window 168
Pandora screen 232, 278
pane 77
2D 55, 86, 100, 126, 133, 200, 207
3D 133
Cassette 34, 104
Defect Map 99
DefectList 29, 50, 68, 103
Status 106–107, 140
XY Cut 127
XZ 55, 127–128
YZ 55, 127
Zoom 66, 99, 102
pane swapping 32, 160
panes
Defect Map 101
parameters
camera intensity 85
laser display color option 85
laser intensity 85
laser line 85
laser scan 85
number of slices 85
optics 85
sample thickness 85
scan 85
scan dimensions 85
stage autofocus intensity 85
stage center offsets 85
xy resolution 85
parcentric 243
parcentricity 304
parfocal 243
parfocality 304
part numbers 248
particle 12, 49, 53, 198, 200
size measurement 201
password 31, 163
changing 145
pattern recognition 63
pattern wafer 68, 96, 196
photodetector 24, 117
saturation 117, 121
photomultiplier tube 304
photoresist 20, 209, 304
PID 229
pinch point 304
ping 291
pinhole 16, 21
pit 12, 49, 53, 198, 200
pit/particle 18, 265, 272

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pit/particle problem 35, 203
Pixels button 121
PMT 304
  controller 243
  overload 52
PMT Amplifier Diagnostics window 168–169
point spread function 265, 304
polarization 304
polarized light 22
Poly 130
poly 20, 130, 304
  defects under 207
poly level, imaging 209
positioning 12
power
  connections 28
  controls 28
  cycling 277
  requirements 238
  socket 237
  supplies 24
power cycling 278
power down 184
power loss 279
power up 184
prealigner 5, 16, 28–29, 34, 64, 96, 104, 158, 269, 304
  offset 64
  removing wafer manually 280
precision 262, 264
  difinition 262
preferences 232
Pre-installation Qualification Checklist 237
pressure 238
Preventive Maintenance 2
  Backup Data 281
  Chuck Cleaning 284
  Halogen bulb change 282
  Interlock Check 281
  Laser Life 283
  Wipe Down 281
Principles of operation 21
printer 29, 59
printing images 59
privilege 77, 304
privileges 28, 83, 163–164, 215–216
process
  characterization 15, 272
Process ID 85, 155
  loading recipe by 194
process layer
  See process level
process level 20–21, 25, 27, 71, 74, 193, 207
process step 21
process uniformity 203
Product ID 85–86
Product Services Administrative Assistant 240–241
product type 27, 74
production line 21
Projections, 2-D 124
prtscreen 304
PSF 303
push button 81
PWDS 305

Q

QicView button 55
quality control 14
Quest database 83
quick disconnect 238, 305

R

radiation 2
radio button 82, 305
RCP 305
recipe 13, 21, 25, 28, 71, 74, 85, 156, 161, 193–194, 305
  autoload options 152
  automatic loading 194
  default 30
  laser and imaging control 92
  loading 194
  modifying for other layers 71
  setup 194
recipe file 297
Recipe Load Option 154–155
records, maintenance 277
Redo Deskew key 74, 198
RedoDeskew button 35, 69
reference images, AutoDeskew 72
reference point 68
Registration Coordinate 202
registration die 156
registration location 141
Relationship between focus and z-position 50
reliability 154
REMOTE directory 162, 289
REMOTE2 directory 162, 289, 305
Rename file 162
repeatability 16, 305
  deskew 63
repetitive defects 201
requirements for ADC 243
Reset button for 3D images 125
resist 305
resolution 12, 17–18, 20, 25, 38, 40–41, 262–263, 305

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depth 208
lateral 208, 264–265
review 38, 106, 142, 305
Review screen 38, 52, 66, 99, 194, 200
Review sequence 121
rf 305
RGB file 297, 305
RGB interface 248
RGB output 247
rms 305
robot 4–5, 15, 29, 34, 59, 63, 104, 158, 269
cover 5, 7, 28
cover, cleaning 282
end effector 15–16, 300
Equipe 244
initialization with wafer on stage 279
interlock 5, 9
MECS 244
operating envelope 5
Robot Alignment Check 281
Rot- button 123
Rot+ button 123
Rotate 54
rubberband box 41, 207
rubberband cursor 41, 53, 55, 209
changing sizer 128
measuring dimensions 128
moving 128

S

S button (Start) 121, 199
S2-93 safety standard 1
safety 1–9, 28, 281
Sample Thickness slider 195
SampleThickness 194–195
save 59
SaveRecipe 194
SaveSurface 201
scan dimensions 194
scan parameters 85
scanner 24, 201
Scanning Electron Microscope 12
scanning mirrors 22, 117
scanning rates 17
scattering 208–209, 305
screen 78
2D 151
3D 151
Deskew 99
Load Wafer 99
Manual 99
Review 38, 66, 99, 194, 200
Sequence 99, 146
Surface 132
User 99, 146
Volume 131
Screen editor 98
screen layouts 146
Screens command 99
SDP 305
Search 110
Search Step Delay 154
SECS 273, 305
SECS/GEM 11, 273, 305
section view 129
Sections button 39, 55, 128–130
security 28
SEM 12, 15, 199, 262, 272, 305
comparison to CRS 13
SEMATECH 305
SEMI 1, 273, 306
SEMI S2-93 1–2, 306
semi-transparent layers 129
Seq Screen 151
SeqStat window 73
Sequence screen 99
sequence screen 306
Sequence screens 146
Set Password 144–145
Set Z button 121
SetDeskew1 button 70
SetDeskew2 button 70
setting up AutoDeskew 71
Setting up hostnames & IP addresses 290
Setup/DefectList Sort 68
Setup/Deskew Options 71–72
Setup/DeskewOptions 73
SGI 84, 164, 306
date and time 222
hardware configuration 219
Indigo 63
Indy 63, 248
shadowing 124
Shannon, Claude 263
shell, UNIX 216, 306
shipping crate 237, 241–242
shock indicators 242
shutdown 184
shutter 5–7, 29
Signal Tower 270
silicon 20
Silicon Graphics 11, 215
simultaneous laser and white light mode 115
simultaneous viewing 38

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SK 306
SK1 200
SK1 (Automatic volume image acquisition) 121
SK1 key 69
SK2 (Automatic Surface Image Acquisition) 121
skewness 243
Skip Deskew button 35
slice 85, 128
slice thickness 122
slice, image 86
Slices 122
slices 21
slider
  1st Slice 128–129
  FineZ 114, 194–195
  FirstSlice 130, 201
  laser intensity 117
  LaserIntensity 194–195
  Sample Thickness 195
  Spacing 129–130
  Threshold 130
  Y Width 125
slider bar 82, 306
Slot# 202
SMIF 11, 16, 28–29, 104, 152, 270, 272–273, 306
Smooth button 54, 125, 128
softkeys 79
software 248
  version 219
Sony Analog Video Printer 270
sort criteria, defect 68
SortParms button 194
space around CRS 238
Spacing slider 129–130
Sparrow's criterion 264
spatial filter 16, 21–22, 306
specular reflection 306
spherical aberration 246
stage 4–5, 16, 21, 29, 38, 49, 80, 104, 158, 269, 306
  accuracy 247
  controller 247, 249
  initialize 157
  thumbwheel 247
stage autofocus 114
Stage center offset
  for bare wafers 197
  for patterned wafers 196
  Formula 197
stage center offset 193, 196, 306
stage flatness test 243
stage isolation supports 306
StageAF button 114
StageAF Intensity 93
StageCenterOffset 96, 194, 197
standard wafer 243
standby 153
Start Sequence 33
StartSeq button 33
startup 152, 184
Stat 32
Status pane 64, 106–107, 140
  Deskew off 107
  Previous defect/next defect 107
  Start deskew 107
  swapping with Sequence pane 70
Status swap button 32
step size in 3D images 117
Stepsize 122
Stg AFIntensity 194–195
subsurface defects 205, 272
subsurface image 18, 41, 133, 205
  Films & laser lines 206
  Limitations 207
  Subsurface defect signature 206
subsurface information 126
Surf button 121
Surface button 130, 200
surface file 85, 161, 297
  loading 100
surface image 11, 17, 24, 38, 41–42, 53, 121, 124, 126–127, 129
surface morphology 124
Surface screen 132
surface topography, enhancing 125
SurfScan 306
SW Test buttons 74
swap button 32, 100, 306
swap file 243
swapping panes 32
System Configuration window 64
system ID 245
system parameters 146
System screens 99
system settings 28
System Shutdown 184
system variables 21

T

tape
  format 231
  operating system 215
tape drive 231
tar file format 231
TargetName 162

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

TCP/IP 289
temperature, operating 238
Tencor 197
Tencor File 269
Tencor files 141
Tencor map 307
    creating 201
test die 156
Testing the network hardware connection 291
Testing the network setup 292
Theory of operation 21
threshold 127
Threshold slider 130
throughput 16, 154
TIFF 86
TIFF file 297, 307
Tilt- button 123
Tilt buttons 54
Tilt+ button 123
title bar 78
To Hi-res 54
To Hi-Res button 58
toggle button 81, 307
Toggle Menu key 152
top view *See* XY image
topographical information 126
topography 127, 129
training 107, 242
transparent 20
turret 307

U

ultrahostname 291
uniformity 243
UNIX 78, 289
    access permissions 292
    See IRIX
    shell 216, 245
UNIX Commands
    See IRIX commands
UNIX operating system 215
UNIX shell 278
unload wafer 59, 86, 105
Up button 124
Use Map Deskew Info 197, 202
user account 28, 163–164, 218, 307
    creating 163
user Interface 78
user interface 24
    menu bar 78
    screen 78
user name 31
user preferences 232
User screen 99, 146, 307
UserAccounting window 163
uv 307
    software version 245
uv_name_for_import 293
uv_name_for_remote 293
uv1000 232, 278, 307

V

vacuum 8, 15–16, 28, 34, 238
vacuum wand 280
variables 21
vertical illuminator 246
vibrations 239
video 28
video camera *see* camera
views 126
Vol button 121
volume 85
volume acquisition, lockup during 277–278
volume data set 85
Volume data sets 100
volume file 161, 297
volume image 11, 17, 24, 38, 41, 43, 53, 121, 126, 129–130, 133, 198–199, 207
    capturing 117
    size 85
volume production line 16
Volume screen 131, 207

W

W/L swap button 32
wafer
    alignment 25
    bare 96
    left in the instrument 279
    loading 12, 33–34, 105
    orientation 102
    pattern 96, 196
    size 85, 140, 307
    standard 243
    type 21
    unloading 105
wafer chuck 307
wafer coordinates 103
wafer door 6–7, 29
    opening manually 280
wafer error 159
wafer ID 141, 307
wafer IDs 140
Wafer map

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KLA, creating 202
wafer map 43, 53–54, 83, 86, 161, 201–202, 307
create 105
creating 107, 201
cursor 102
generating 201
link to defect list 103
loading 202–203
reviewed 83
unreviewed 83
wafer map file 100, 140, 199, 297
Wafer Map panes 64
Wafer Map window 101, 128
Wafer map window
Full wafer view 102
Moving around in 103
wafer orientation 67
wafer pattern, tilted 156
wafer removal, manual 270
wafer run number 67
wafer slot 86
wafer thickness 92, 194, 307
standard 93
Wafer window 66–67
WaferSize 201–202
wavelength 21–22, 86, 265
default 116
selection 195
white ligh
t image 24
white light 11, 21, 24, 37, 262
aperture limit 243
A-stop 246
balance 243
confocal 262, 265
default intensity 193
illuminator 24
image 29, 38
image quality 243
imaging controls 115
White Light ADC 272
white light confocal 264
white light image 114
white light microscope 264
white light mode 115
White Light pane 68
white light review stations 16
WhiteLight mode 154
window 77
AutoDeskew Testing 72
Calculate map offset 107
Config Misc. 152–156
Defect Chart 143
Defect Selection 69
Deskew Options 66, 72–73
Edit Defect 107
Edit defect 107
Fast Z Diagnostics 169–170
File Transfer 160
Laser and imaging control 92
Laser Scan Parameters 194
List 107
Lon Diagnostics 164–165
Manual Robot Control 158
Manual Stage Control 157
Page Scan Diagnostics 168
PMT Amplifier Diagnostics 168–169
SeqStat 73
size
Icon 100
Large 100
Small 100
System Configuration 67
UserAccounting 163
Wafer 66–67
Wafer Map 101, 128
window controls 29
Window Panes 99–117
window types 100
wipedown 8
wiring 3
working envelope 307
workstation 29
W-plug etch back 201

X

X DiePitch, measuring 202
X -Windows 230
X Windows 78, 232, 308
restarting 277
Xdir button 125
XHairOn/Off 68
XY Cut cursor 127
XY Cut pane 53, 127
XY measurement 20
XY Size 127
XY slice 126
XY stage coordinates 199
XY view 127–128, 198, 308
XYZ map *see* volume image
XZ 127
XZ and YZ cuts 126
XZ pane 53, 55, 127–128
XZ Peaks 127

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XZ view 308

Y

Y DiePitch, measuring 202
Y Width slider 125
yellow filter 115, 246, 270, 274
yield analysis 14
yield improvement 205
YZ 127
YZ pane 53, 55, 127
YZ Peaks 127
YZ view 128, 308

Z

Z Dist Fr ConfigLim 194–195
Z Profile 127
Z scale 308
Z Scale button 125
Z steps 122
Zoom
    3D 123
zoom 41, 40–41, 308
    choosing 209
    laser 48, 92, 117, 200
    surface 55–58
zoom box 32, 35, 101–103, 124
    move 102
Zoom button 117
Zoom pane 66, 99, 102
Zoom+ button 123–124
Zoom- button 123

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