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# PRELIMINARY CRS 3000
# Confocal Review Station
# User Manual
# Software Version 1.0

Preliminary

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**990-696171-000**
**Software Version 1.0**
**July 2000**

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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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# Revision Log

## Revision History

| Revision | Date | Author or Editor | Comments |
|---|---|---|---|
| AA | July 2000 | Edward Cherlin | Based on CRS 1010 & 1200 User Manual |
| | | | |

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# Safety

The KLA-Tencor Confocal Review Station (CRS) is designed throughout for safety. Every attempt is 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 there are 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.

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## 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.



**LASER**

*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 20 mw. Removal of any part of the outer covers can expose the user unnecessarily to hazardous laser radiation. Danger labels (such as those shown in Fig. S-1) indicate covers that provide access to hazardous laser light exposure.



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**Figure S-1 Laser Hazard Label**




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.

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## 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.

**Table S-1 SEMI S2-93 Work Types**

| | |
|---|---|
| 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 volt peak, 240 volt-amp, and 20 Joule. (See NFPA 79-14.3, IEC 204, UL 1950 & 1262, IEC 950) |



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**Table S-1 SEMI S2-93 Work Types**

| | |
|---|---|
| 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. |

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.

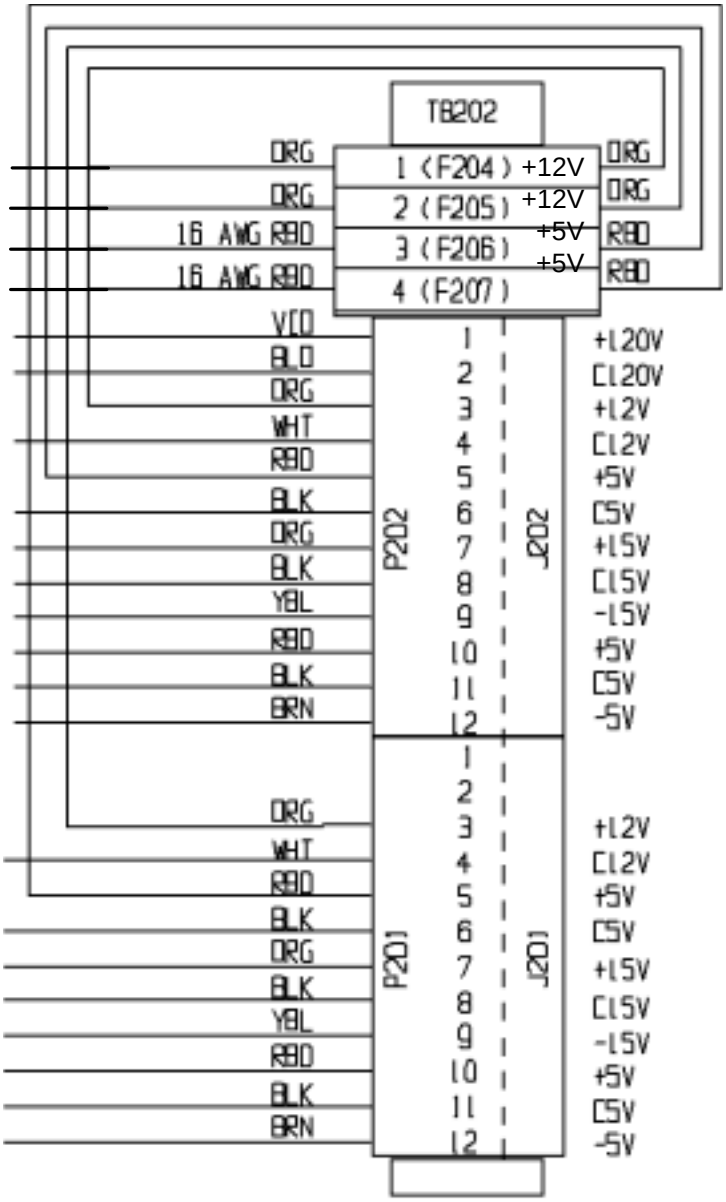
The wiring in the system is color coded. The color codes are on the wiring diagram in Fig. S-2.

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**Figure S-2 CRS Wiring Blocks and Color Code**




Upper distribution

Lower distribution

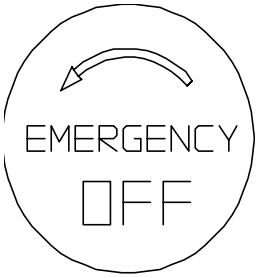
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## Emergency Power Off

**Figure S-3 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

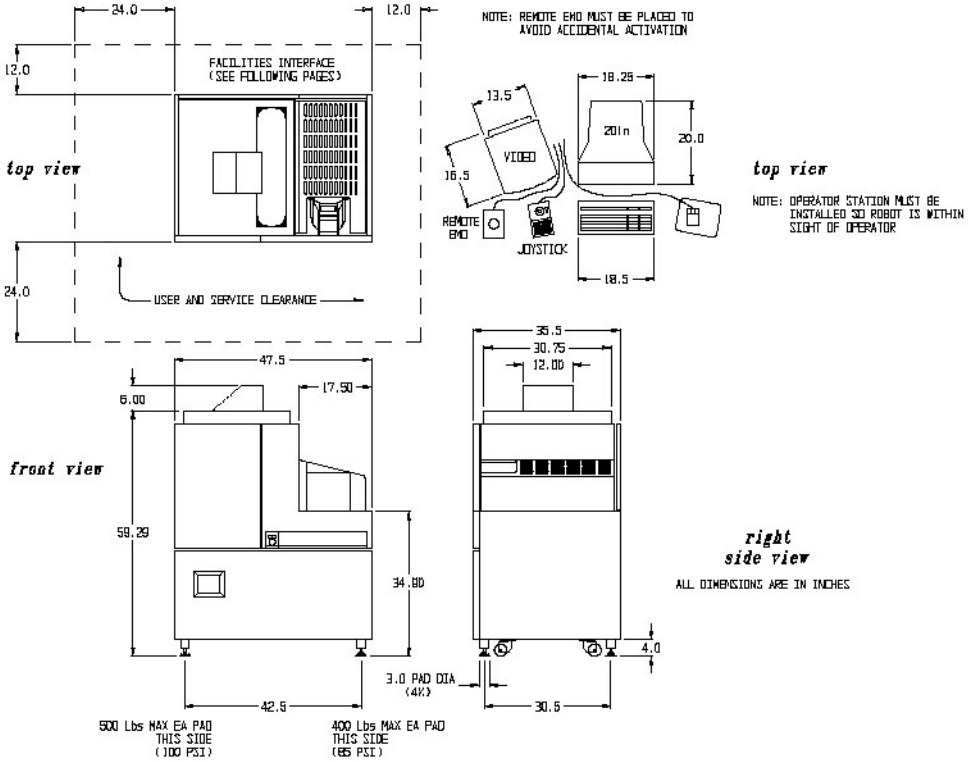
The KLA-Tencor CRS consists of two subsystems: (1) the *main unit* housing the robot, optics, stage, electronics, and laser; and (2) the *operator's console*, with two monitors, keyboard, joystick and mouse. Fig. S-4 shows a top view of the complete system, together with side and end views of the main unit.

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**Figure S-4 CRS Layout**




Control of the main system is done via the operator's console. When setting up the 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 encloses the robot to prevent anyone from coming close to the robot. If the barrier is opened, 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.

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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 prealigner, all of which have possible pinch points.

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### 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.

## 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 in the next sections.

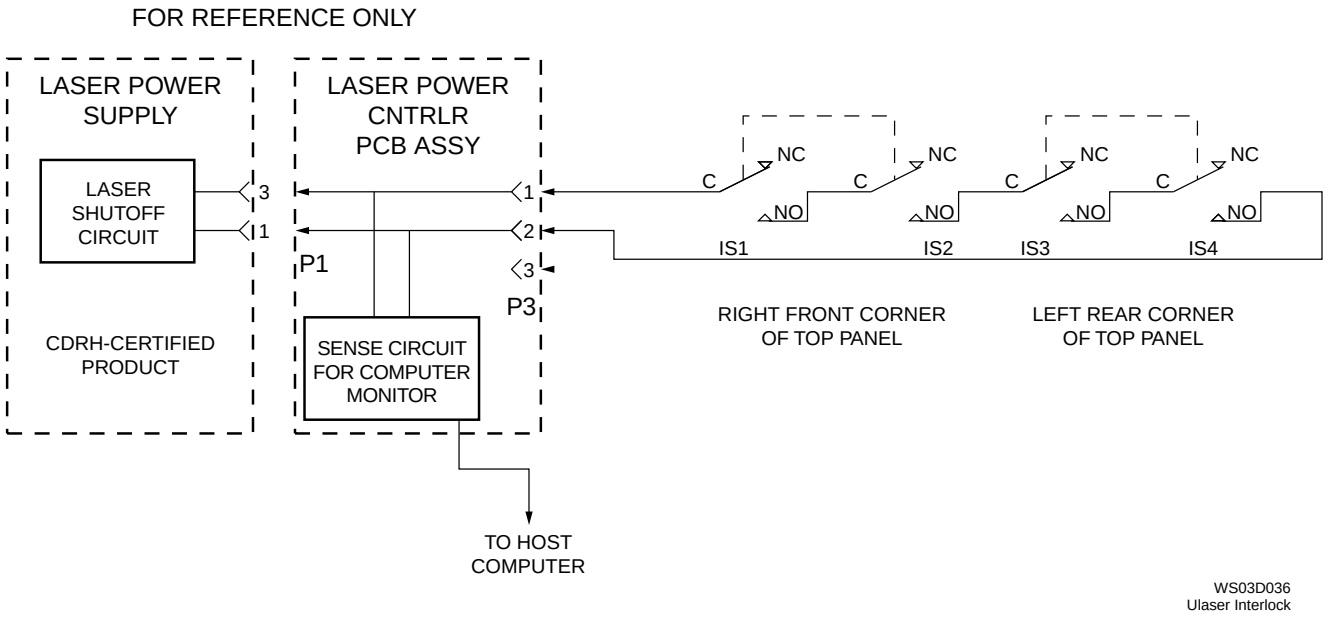


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## Laser Power Interlock

The upper external panels of the KLA-Tencor CRS are interlocked such that if the panels are removed at any time, then the laser power automatically shuts off (see Fig. 5). Once the panels have been replaced, the laser must be manually reset by cycling the laser power at the circuit breaker panel.

**Figure S-5 Schematic Diagram of Laser Power 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. 6).

## Robot Cover

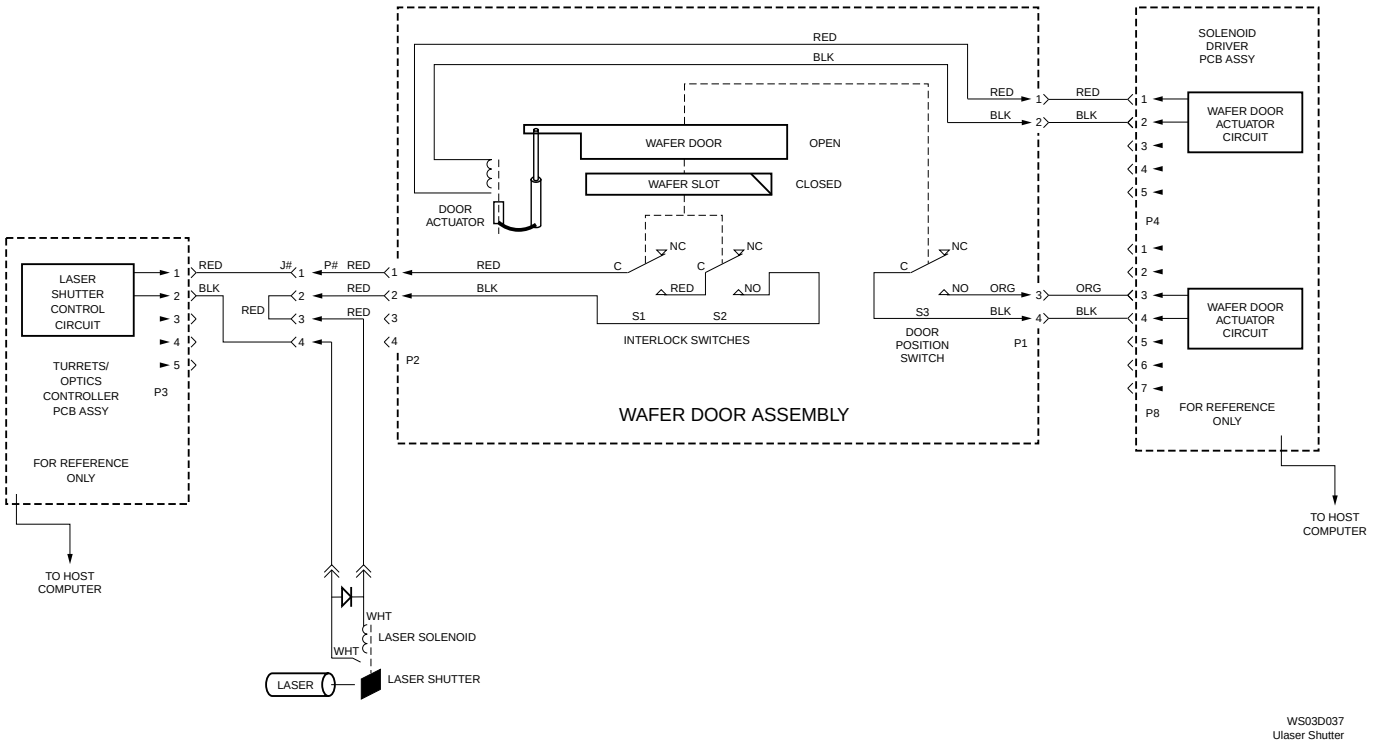
A Plexiglas cover shown in Fig. S-7 surrounds the robot to prevent anyone from coming into the robot's envelope of operation. If the cover is removed at any time, then the robot is automatically disabled and a warning window appears on the monitor. Once the cover has been replaced, the robot may be enabled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

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## Figure S-6 Schematic Diagram of Laser Shutter Interlock



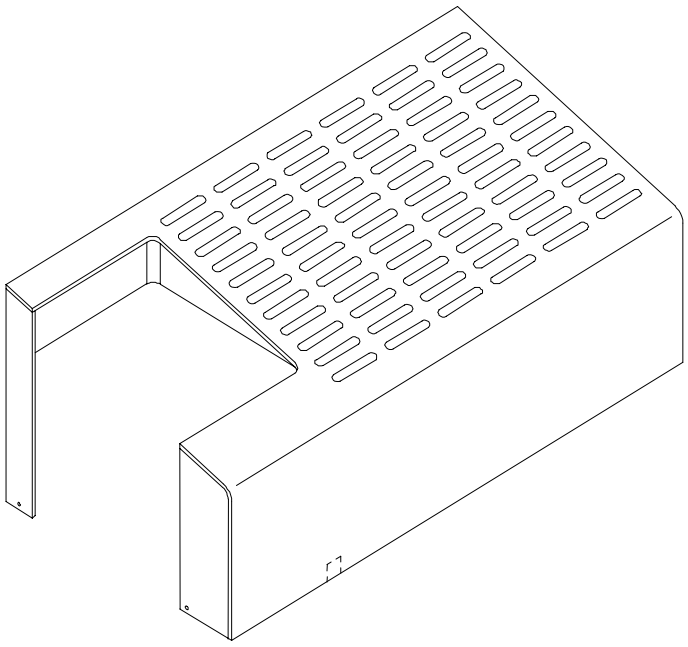

tions on the monitor are followed. The robot cover interlock circuit is shown in the diagram in Fig. S-8.

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**Figure S-7 Plastic Robot Cover**



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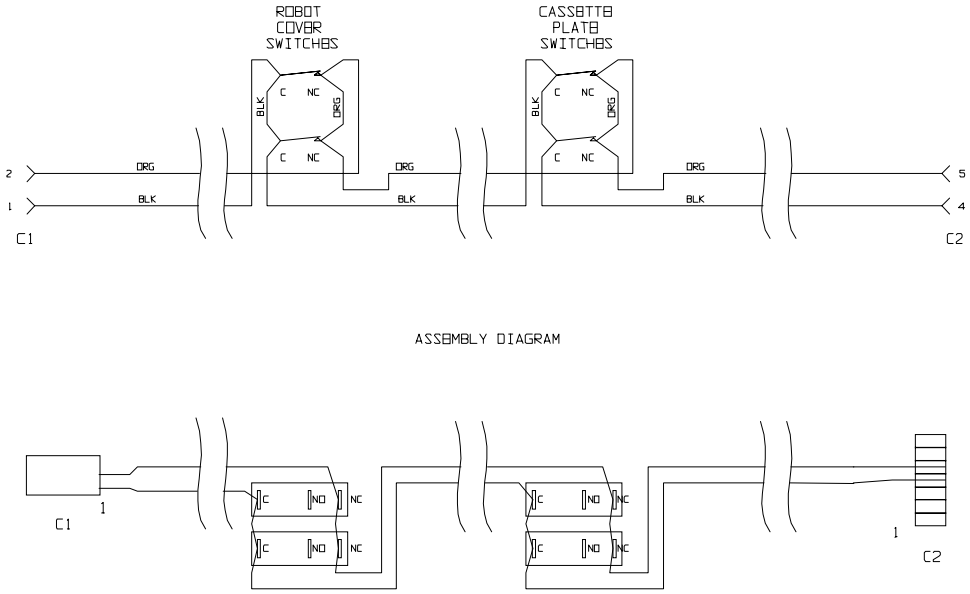
## Cassette Interlock

The KLA-Tencor CRS is equipped with a cassette interlock switch that detects whether or not a wafer cassette is properly situated on the cassette platform. Fig. S-8 shows the cassette interlock circuit. If the cassette is removed during operation, the robot is disabled and a warning window appears on the monitor. To resume operation, replace the cassette and follow the instructions on the monitor.



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**Figure S-8 Schematic Diagram of Robot and Cassette Interlock**




## 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 customers may elect to use *diluted* isopropyl alcohol. Exercise care when using alcohol, in accordance with Hazardous Materials Safety Regulations for this location.

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# How to Use This Manual

## Getting Started

This manual can be used for operator and engineer training and for reference. The soft copy version of this manual is heavily cross-linked, to make information available with a single click from many different places. Cross links are generally shown in color on the screen. The paper version has text cross-references corresponding to the hypertext links wherever they are practical.

The following procedures are for installing the PDF for viewing with Adobe Acrobat Reader on laptop and desktop PCs. The PDF file can also be read on a Macintosh or on various UNIX systems. The installation procedure for Acrobat on UNIX systems with the various XWindows GUIs, and on Macintosh, is similar to that described here for a PC.

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### Installing the PDF File on a Laptop or Desktop Computer

#### From CD-ROM

1. Insert the CD-ROM in the drive.
2. Open ***Windows Explorer*** (Win95) or ***Windows NT Explorer*** (WinNT).
3. Select or create the desired destination directory.
4. To copy the file, drag the icon for the PDF file from the removable drive to the chosen destination directory.
5. If necessary, copy the Acrobat installation file to the hard drive. Then double-click on it and follow Adobe's instructions.

### From the KLA-Tencor Intranet

1. Open a Web browser and go to http://crs.kla-tencor.com/#Documentation.
2. Click and **hold** with the **right** mouse button on the link for any of the documents.



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3. On the popup menu that appears, select **Save Link As…**
4. In the file dialogue box that appears, choose a directory to save into, and click on **Save**.
5. In a file window, click on the icon for the downloaded file. It is a self-extracting archive.
6. Follow Adobe's directions for installation.

   If **Adobe Acrobat Reader 4.0** is not installed, go to the following URL to download it at no charge for any supported computer and operating system from

   `http://www.adobe.com/prodindex/acrobat/readstep.html`

## Testing

1. When the installation of both the documents and the reader is complete, click on the icon for any document. The Acrobat Reader will open and in a moment display the first page, which may be the title page, or a table of links.

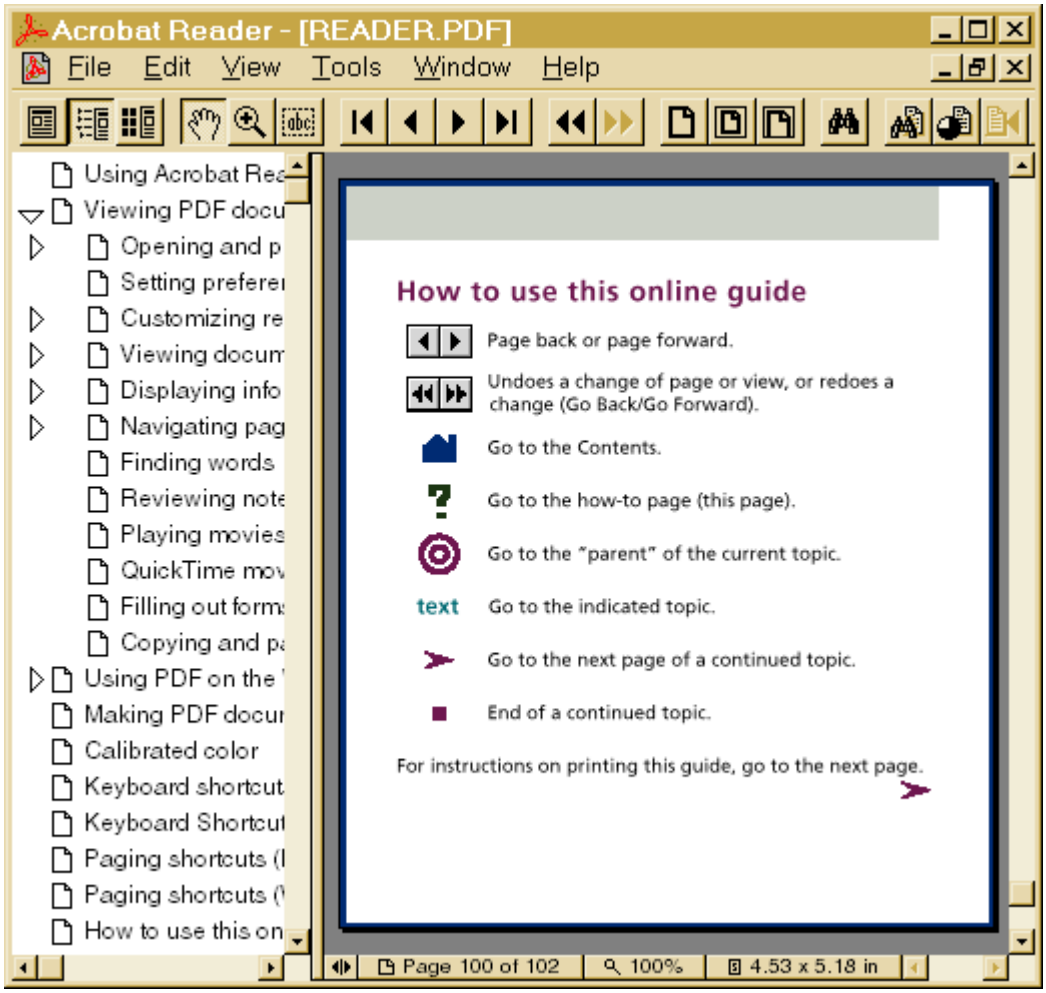
   Acrobat provides a variety of controls for navigation, viewing, and searching, in the menu bar and toolbar above the document window and the popup menus on the status panel at the bottom. In most cases, pointing to a control will bring up a short statement of its function. Help files, also in PDF format, are included in the Acrobat distribution archive, and are accessed from the **Help** menu. Figure 1 shows a page from Adobe's `Guide.pdf` file, explaining the controls used in Adobe's own PDF files.

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**Figure H-1 Acrobat Reader Window**




2. Expand the Acrobat Reader window to full screen, by clicking on the sizing control in the top right of the title bar.
3. Just below the page display, there are several controls, including a zoom menu, which will probably display the setting ***100%***. Click and hold on it, and select ***Fit Visible***.
4. The bar between the panes is movable. In the Windows versions of Acrobat, click anywhere on it and drag it to the right to see more of the ***Table of Contents*** links. In the UNIX and Macintosh versions, there is a small square drag button near the bottom of the bar between the two panes.
5. Try a few links and navigation buttons, and search for anything of interest.

## Manual Conventions

Two sets of conventions are used in this manual to emphasize special information:

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- Tagging with alert icons and italics for Notes, Tips, Important points, and Warnings
- Special formatting of text to indicate its use in the software of the CRS

Special notes, tips, warnings and other information of importance to the reader are emphasized with the following convention.



**NOTE**
*Additional information intended to clarify a process, procedure or concept.*



**TIP**
*Information on additional or alternative ways to effectively use a feature.*



**IMPORTANT**
*Used to highlight information that is important to know or follow to attain optimum performance.*



**WARNING**
*Failure to comply with warning information may result in damage to the system or software.*



**DANGER**
*Failure to comply with warning information may result in injury to personnel.*



**DANGER**
*Failure to comply with warning information about electrical hazards may result in injury to personnel, or even death.*



**LASER**
*Failure to comply with warning information may result in eye injury or blindness.*

Throughout this manual the conventions shown by example in Table 1 are used to identify file names, actions to take, and text to be entered.

**Table H-1 Formatting Conventions**

| Convention | Explanation |
|---|---|
| `Monospaced` | Commands and file names are shown in a monospaced typewriter font. |
| **`Bold monospaced`** | Text to be entered is indicated in a monospaced bold font. Type uppercase and lowercase letters exactly as shown, because some commands are case sensitive. |

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| Convention | Explanation |
|---|---|
| *<file name>* | Text to be replaced, such as a file or directory name, is italicized in caret brackets. |
| **Key** | Press the key on the keyboard with this label. |
| [space bar] | Names of keys that are not labeled on the keyboard are lowercase and in brackets (e.g., space bar). |
| + | Indicates that the keys must be pressed at the same time, then released. For example, **ALT** + **PRTSCRN**. |
| ***Bold italic*** | Text appearing inside a window, including labels on buttons, sliders, etc. |
| **Bold small caps** | Menu items, including names of menus |

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# 1

# PRELIMINARY Introduction to the CRS 3000

## Confocal Review Station Overview

The KLA-Tencor Confocal Review Station (CRS), as shown in Figure 1-1, is an automated laser/white light microscope system used for classification of defects on both bare and patterned wafers, using defect maps generated by a variety of instruments. The CRS combines a brightfield/darkfield white-light microscope with a laser confocal microscope, automated wafer handling, and controlling software. To capture and process images, a digital video camera receives the white light images, and a frame grabber board receives laser image data (one point at a time). The earliest CRS was designed for manual review, but newer versions offer the option of Automatic Defect Classification (ADC). KLA-Tencor Impact® ADC is an option on the CRS 3000.

The argon ion laser used in the CRS is a 20 mW, 488 nm (blue), single-line laser. The output power of the laser can be adjusted between 6 mW and 20 mW. The optics focus the laser beam through a spatial filter (a 25 µm pinhole), and focus it again to a diffraction-limited spot on the wafer surface. Vibrating mirrors scan this spot. The reflected beam returns to the pinhole, which passes only the light reflected from the focal plane. This light is captured by a photomultiplier tube (PMT) that sends gray-scale signals to the frame grabber for conversion to false-color images on the computer 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 8 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 20,000× with a 100× objective at Zoom level 8. One micron on the wafer is magnified up to about 0.8 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 that continuously display their X and Y dimensions while they are moved and resized to fit features of interest.

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**Figure 1-1 Confocal Review Station (CRS) 3000**



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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 view images of individual layers in semiconductor structures, and to resolve structural and defect features as small as 0.15 µm. The depth of focus of the CRS using the 488 nm laser line is about 0.32 µm. By taking multiple slice images spaced as close together vertically as 12 nm, the precision of fine Z stage positioning, the CRS can discriminate layers as thin as 25 nm (0.025 µm). Figure 1-2 shows CRS images of stacking faults, with each layer approximately 0.1 µm high. The CRS can discriminate between pits and particles that appear point-like and identical in white-light images, and estimate their sizes, as Figure 1-3 illustrates. Figure 1-4 and Figure 1-5 show the ability of the CRS to image subsurface defects. The first case is a defect in an oxide layer below resist.

The second case is a defect below metal lines. Note 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 produce an image.

The CRS can be configured from fully manual operation to fully automated operation. There are manual and automatic options for cassette loading, wafer loading, deskew, defect inspection and analysis, image capture, data storage, and communication. The CRS can run

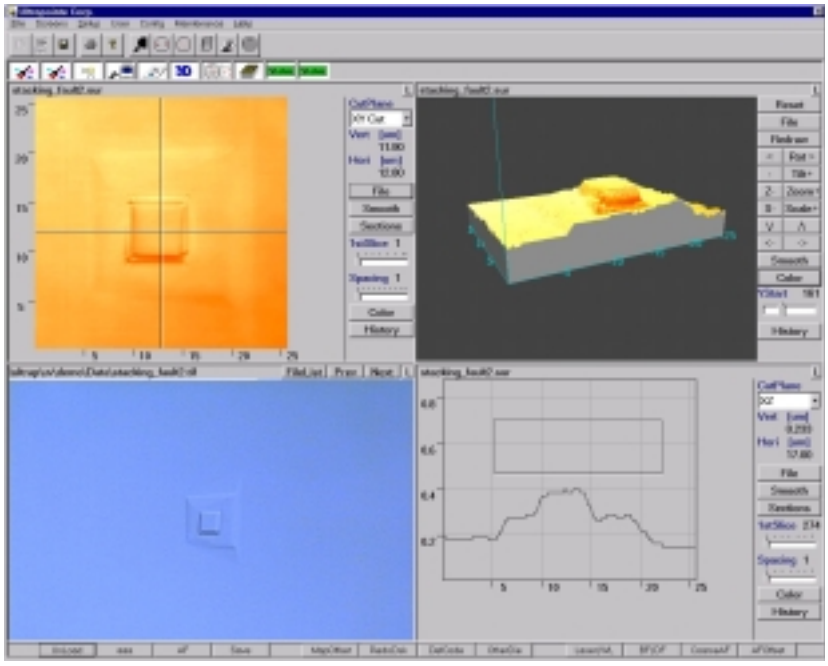


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automatically using locally stored recipes, or can receive commands and respond to them over a network.

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 that examine the entire wafer surfaces. These tools generate wafer map files containing the wafer IDs and the coordinates of each defect along with 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 disks, over serial links, or from a network. Data from the CRS become available to KLA-Tencor yield analysis software to drive process improvements and maintain quality control.

**Figure 1-2 Laser Imaging of Thin Layers**

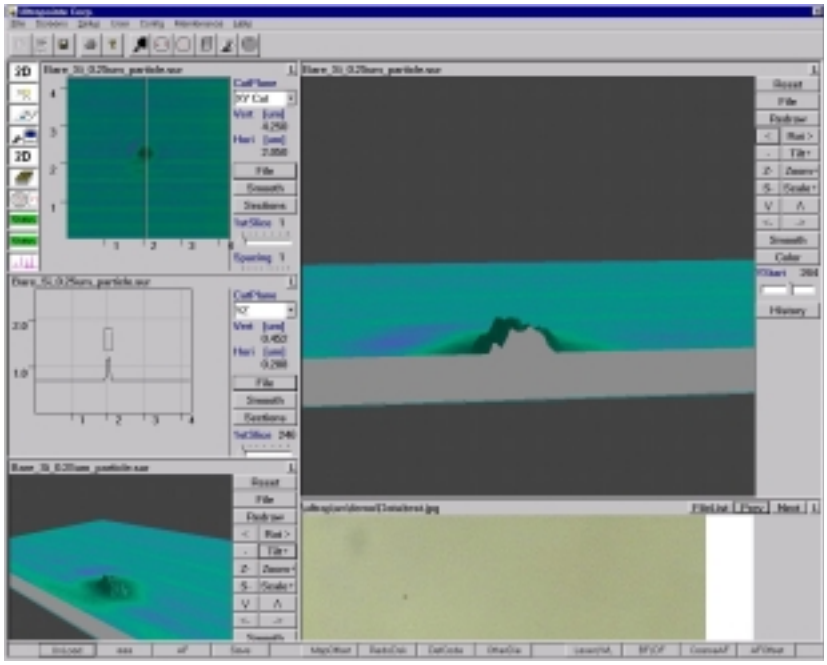


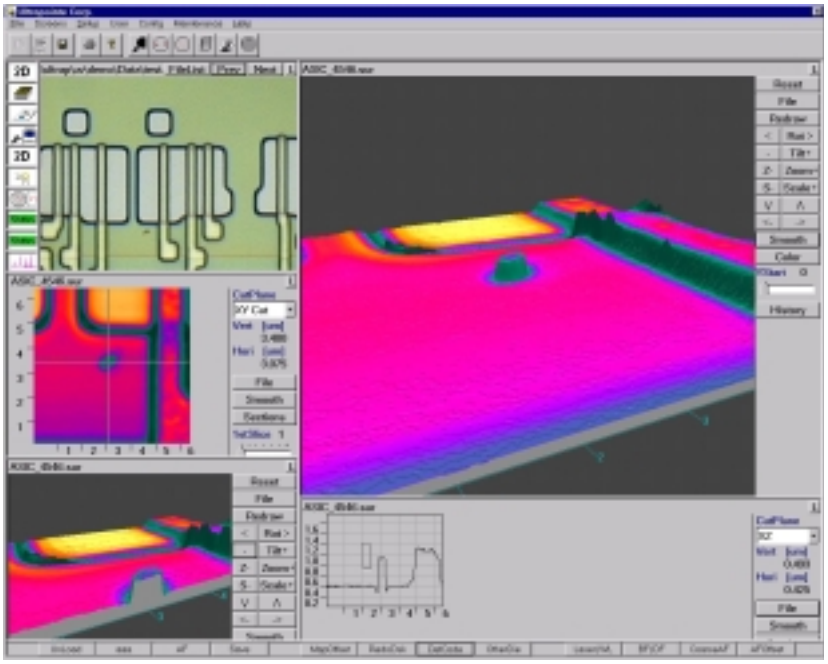
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**Figure 1-3 Laser Imaging of Submicron Particle**





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**Figure 1-4 Subsurface Defect in Oxide Layer**

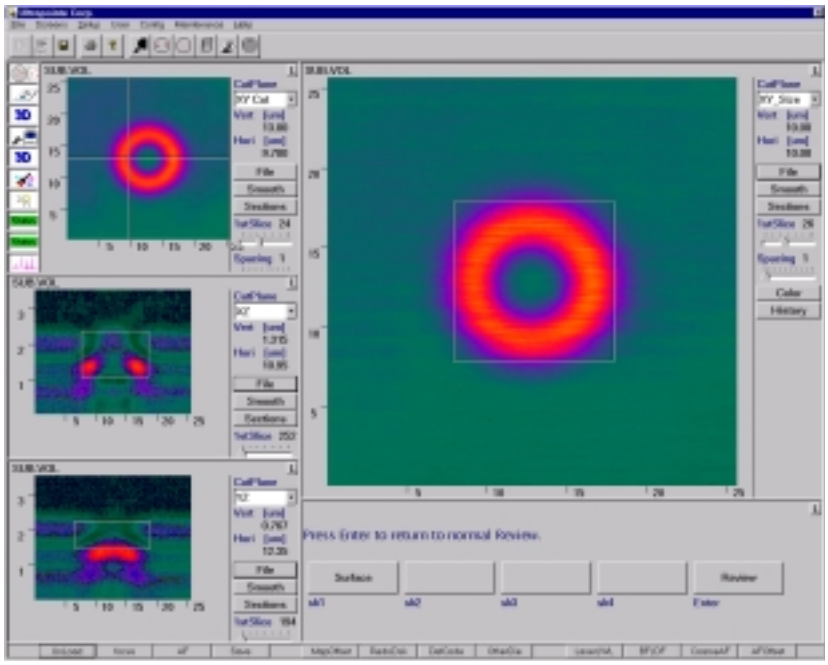
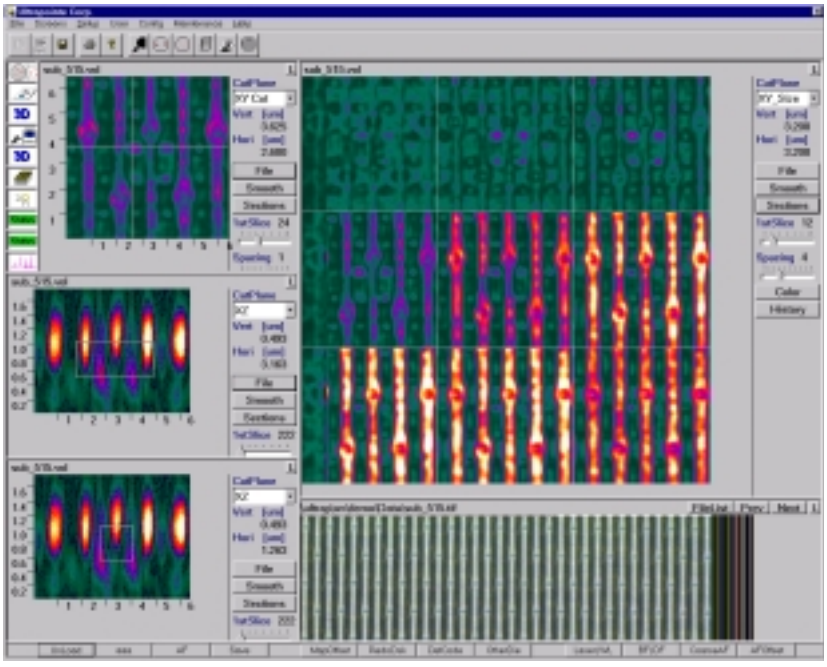


**Figure 1-5 Subsurface Defect Below Metal Lines**



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. The CRS classify defects beyond the capabilities of conventional microscopes, and can select those defects that need to be examined in the SEM, thus supporting

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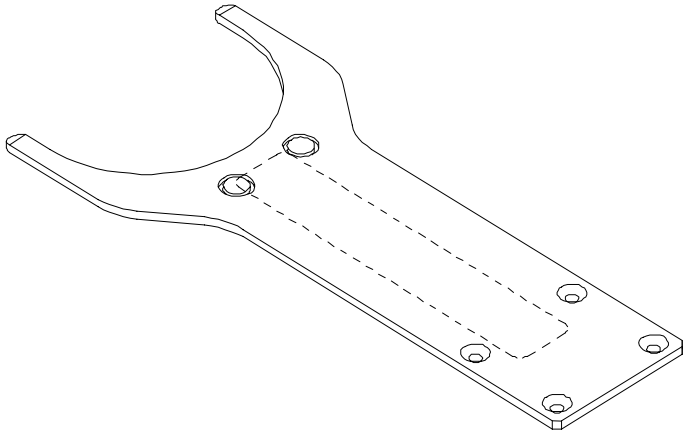


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more efficient use of the SEM for analyzing the defects characteristic of a particular stage in a particular process. With this knowledge, engineers can train CRS units with Automatic Defect Classification (ADC) to a level of accuracy higher than most 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 Figure 1-6, 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 1-6 Robot End Effector**



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The stations within the CRS are the cassette, the prealigner, and the XYZ stage that 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, die corners or other prespecified 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 appropriate for a volume production line.



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## What Is a Live Laser Image?

Unlike white light imaging that uses extended light source and detects return signals from an extended area (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 (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, a 25 µm pinhole. In essence, a confocal laser microscope is a point-illumination and point-detection system. To form an image of the sample, the laser beam is scanned across a square patch by vibrating mirrors. The scan has to be fast enough for the images to look “live” 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 the horizontal and 13 frame/second in the vertical direction.

## Laser Illumination versus 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 it enhances the contrast and resolution of the image. 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 20,000× can be achieved with a 100× objective at zoom level 8.

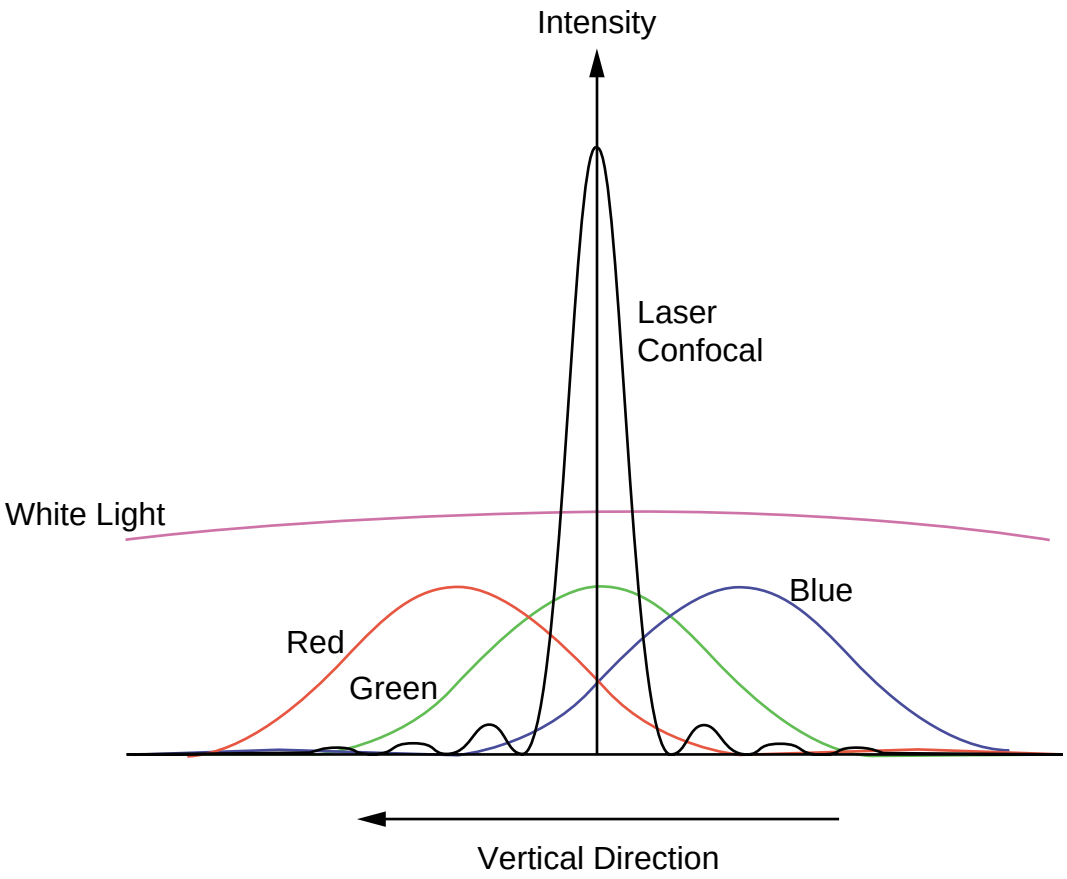
**Narrow Depth of Focus**: The combination of confocal imaging and laser light results in a narrow range of distances where the surface is in focus. Figure 1-7 shows the high, narrow peak in the amount of light returned for monochromatic laser light compared with the broad shallow peaks for the red, green, and blue portions of the spectrum, and the broader, flatter peak for white light, even in a white light confocal system.

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**Figure 1-7 Confocal Microscope Depth of Focus**




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**3D Imaging**: By taking 64 slice images at different heights, the CRS constructs volume or surface images, and displays many 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 finding the level in each column where brightness is greatest, 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**: The contrast and high XYZ resolution of confocal laser imaging allow it to detect more defects than those produced using white light systems. Defects that are small and 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 inline defect inspection tool and thus to optimize its inspection recipe.

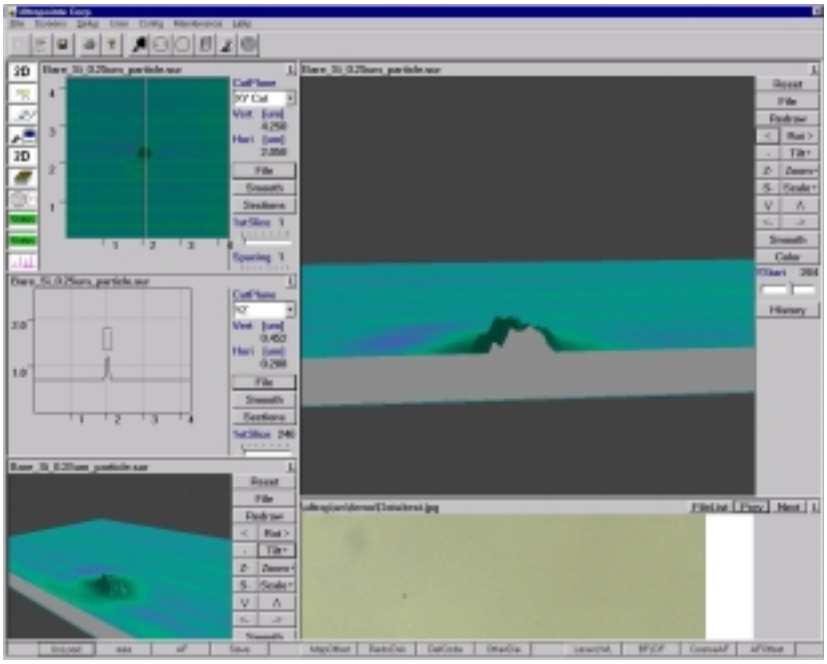


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**Pit vs. Particle and Depth vs. Height**: Having a better Z resolution makes it possible for a confocal machine to see a very thin slice at a time. By moving the fine Z stage up and down in 0.012 µm steps (changing the focus levels), the defect height/depth with respect to the substrate is measured, and the pit/particle classification is given. Figure 1-8 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, Figure 1-9 does the same for a pit.

Height can be measured without taking a 3D image, as Figure 1-10 illustrates. The fine Z control moves in 12 nm steps over a range of about 50 µm, 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 peaks and then disappears.

**Figure 1-8 CRS Images of a Particle**

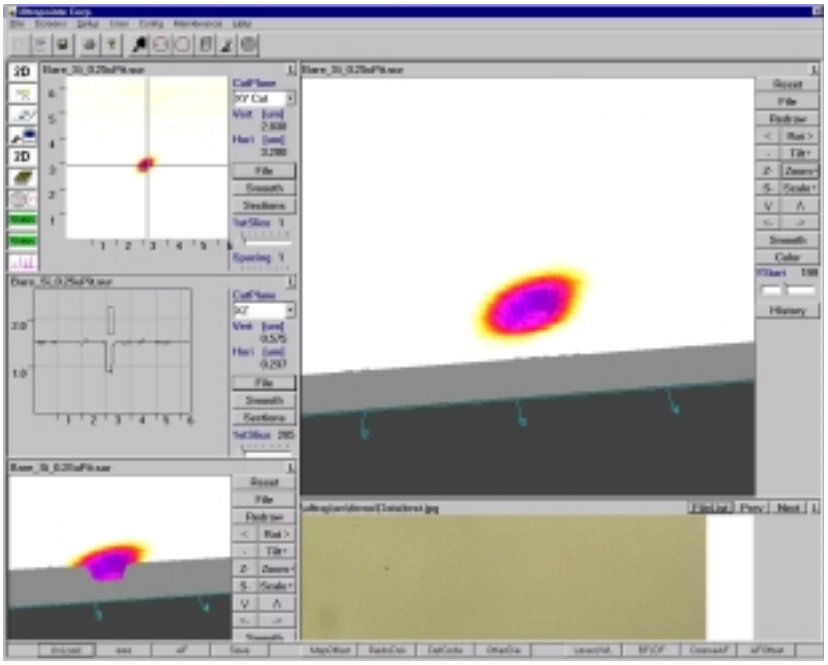


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**Figure 1-9 CRS Images of a Pit**

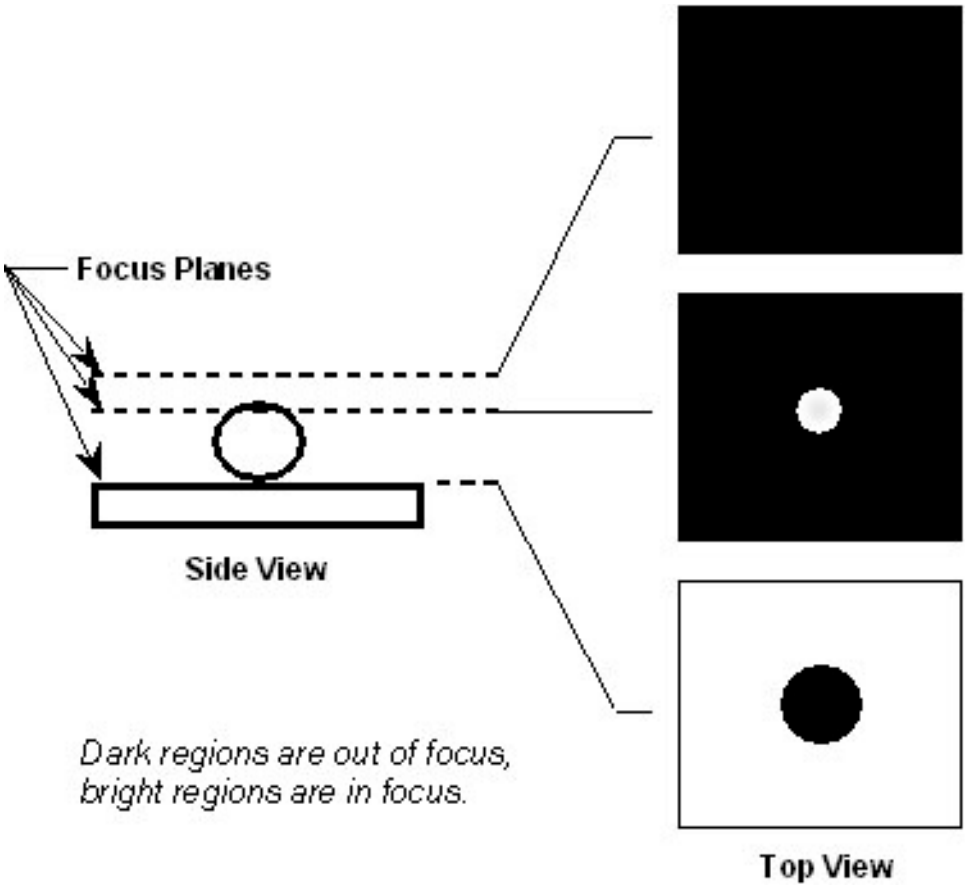


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**Figure 1-10 Height of Particle**




**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 (intensity) of a defect to that of its surrounding area, the user can, in many cases, identify the composition of 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%; thus the operator can use the live laser screen to estimate the defect XY size quickly and accurately.

**Determining the process layer in which the defect is located**: All commonly used dielectric films are transparent to the laser light used by the CRS; 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, the operator can determine in which process layer the defect is located.

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## SUMMARY

The confocal laser detects more defects than white light microscopes. It offers higher resolution, higher magnification and better contrast than white light microscopes. This results in the ability to track down a defect to its originating process level and quickly size a defect and perform crude material discrimination, both of which are critical in volume IC production line defect reviews.

The operator examines each defect image as the tool presents it. Viewing can be done in white light mode, laser confocal mode, or both modes simultaneously. There are several objective lenses of different magnifications. The laser image scales simultaneously with the white light image. Optional brightfield/darkfield objectives and illumination can be used to help locate particles and other defects on the wafer surface. The operator can use the joystick to manually move about the wafer to examine an area not associated with a defect.

Automatic operation features include **autofocus** of the optics, **auto gain** of the laser light sensor, and **auto ranging** of the vertical scanning for 3D image capture. An engineering mode allows **recipe** setup to prespecify 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 prealigner or stage after a power failure). **Diagnostics** are called up via a pop-up window displaying all local operating network (LON) nodes and system variables, plus providing direct control of system functions.

Using ***recipes***, the system can be preconfigured for a specific type of wafer and/or specific process level for that wafer. The laser and white light 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 is inspecting preselected sites on a wafer for the efficacy of a previous process step. The CRS is directly usable in this application, which faces the same dilemma of defect imaging—decreasing size of objects of interest, a lack of resolution, and the need for 3D imaging.

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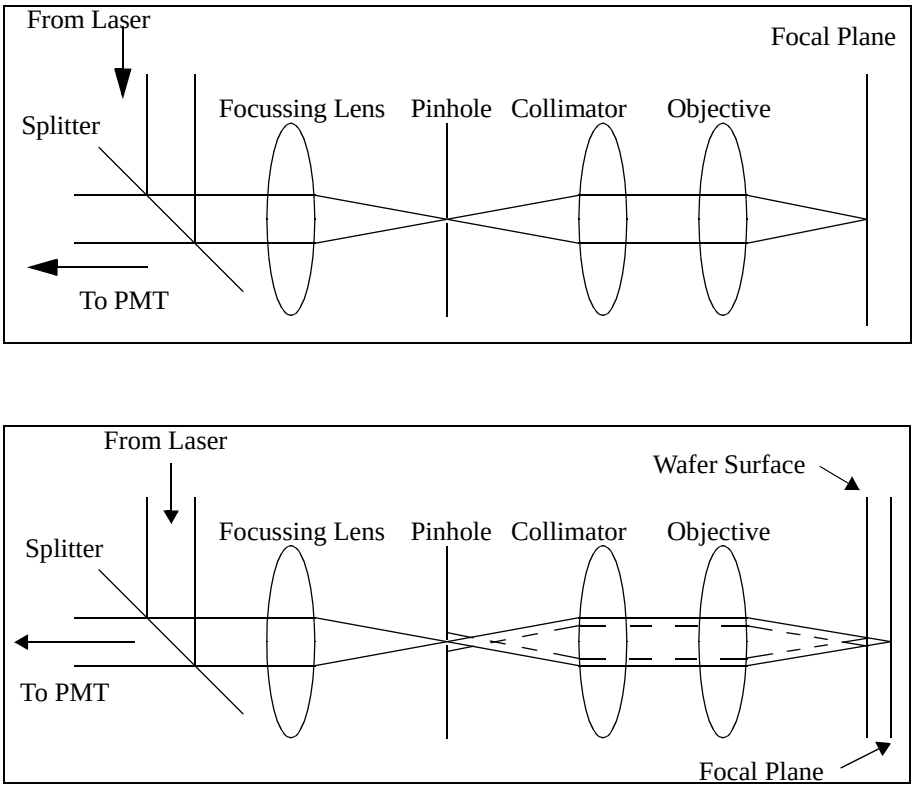
## Principles of Operation

The CRS uses the basic principles of **confocal microscopy**, in which the illuminating light passes through a **spatial filter** (pinhole). The image of this pinhole is then cast on the sample to be viewed, as in Figure 1-11. The reflected light from the sample returns through the optics to the pinhole. Light reflected from the focal plane of the imaging lens returns through the pinhole, but reflected light that is out of focus is almost entirely blocked and does not reach the photodetector. Consequently, confocal images enable the operator to examine thin slices of the wafer.



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**Figure 1-11 Principle of Confocal Optics**



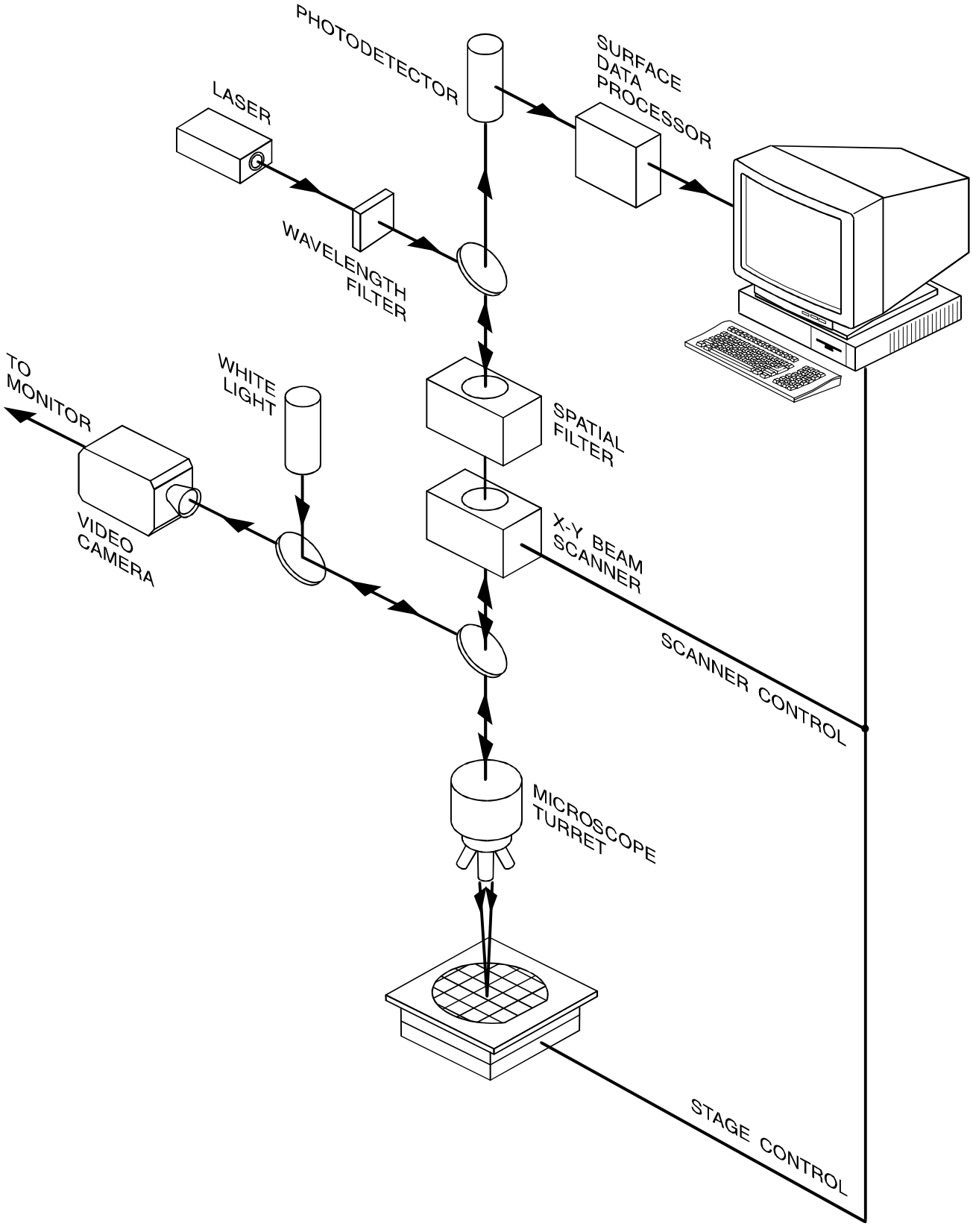

The system diagram in Figure 1-12 depicts the primary components of the CRS. The light source is a single-line argon ion laser that produces linearly polarized light at 488 nm. A *polarizing beam splitter* preferentially reflects light only of the proper polarization and directs it to the *spatial filter*. The spatial filter consists of optics that image the laser light on a pinhole whose diameter has been selected to reimage 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 1-12 CRS Optical System Schematic**




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The tube lens works with the objective to demagnify the image of the raster scanned pinhole image and project it on the sample. A *quarter-wave plate* positioned in a slot in the microscope body converts the linearly polarized laser light to circularly polarized light. A portion of the light is reflected back from the wafer 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 its original orientation so that it can pass through the polarizing beam splitter and reach the *photodetector.* As the raster is scanned, the *surface data processor* turns the photodetector's gray-scale output into a two-dimensional false-color intensity map of the sample, and adds the image of the map to the video signal going to the computer monitor, bypassing the computer.

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 × 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 level 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 *vertical illuminator*, and inserted in the optical path by the beamsplitter. A holographic filter, which blocks a very narrow band including the laser wavelength but passes all other light, prevents the reflected laser light from damaging the CCD sensors in the camera.

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

The optics unit works 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 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), with internal conversion to all required DC and AC voltages.

The Surface Data Processor (SDP) is a Matrox image capture board 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 PC running Windows NT. It is capable of handling concurrent command of robot functions, stage motion, and optics control, management of the operator interface, and image processing functions.

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

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LON 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, the operator or applications engineer can set up, program, and control the system. This includes control of the microscope functions such as selecting views, translating 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 enables flexible imaging of semiconductor structures and defects, combining numerous laser views of surface and subsurface layers with both brightfield and darkfield white-light images at various magnifications and with 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 good at discriminating between pits and particles even at small sizes, can identify the process layer where a defect occurred, and can measure submicron defect widths with an accuracy of about 5%.

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The CRS software provides support for and automation of the process of defect classification. The lowest level is automatic loading and alignment (AutoDeskew) of the wafers for manual review. Automatic Defect Classification (ADC) matches images of wafer surfaces with a Knowledge Base of stored defect images.

The CRS can be integrated into a fully automated production line, where wafers in sealed pods are 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 between 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 that 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 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.



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# 2

# Tutorial

CRS operators need to know command sequences to perform standard operations. Operators benefit from trying imaging options to determine which options yield the best results on specific structures, materials, and defects. This tutorial covers the defect review sequence in detail, and suggests experiments and explorations.

It is helpful to keep a 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 achieved and how to reproduce them. Ask whether other engineers and operators at the same facility or elsewhere in the company have logs or libraries of their own that they can share, and if so, try out their methods, and examine their captured images and prints.

Make backups of saved files. Store the originals and the backups in different places, preferably in different buildings.

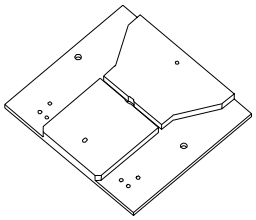
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## Before Starting

### Requirements

This procedure guides the trainee through a demonstration of the KLA-Tencor CRS. The trainer should set up the CRS with the following equipment:

**Figure 2-1 Cassette Plate**



- A cassette containing wafers of the same type the trainees will work with, whether bare or patterned, of the appropriate product types and process levels.
- A cassette plate, as shown in Figure 2-1, mounted on the CRS, with the cassette correctly positioned.
- One or more demonstration accounts with operator privileges, default recipes for the wafers provided, and access to the files needed for this tutorial (only).
- Defect map files of the wafers.
- Defect code lists for the processes involved.



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With these in place, trainees can explore 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 for beginners not to change system settings in the software , but the system security makes such changes impossible for anyone logged in as an operator. If there is a problem requiring such changes, an experienced person with an account at the appropriate level should determine what to do.

Trainees need assistance getting started. In particular, someone should put the correct cassette on the CRS and log each trainee 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 recover from errors.

## Looking Around

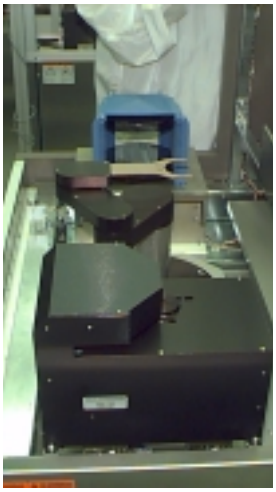
Before starting, walk around the CRS and look it over. The optics, electronics, and most of the mechanical systems are enclosed. The power controls and removable media drives are accessible on the front side of the instrument under a panel that lifts up and locks in place.

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.

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**Figure 2-2 Right Side of CRS with Robot Cover Off**

Figure 2-2 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.



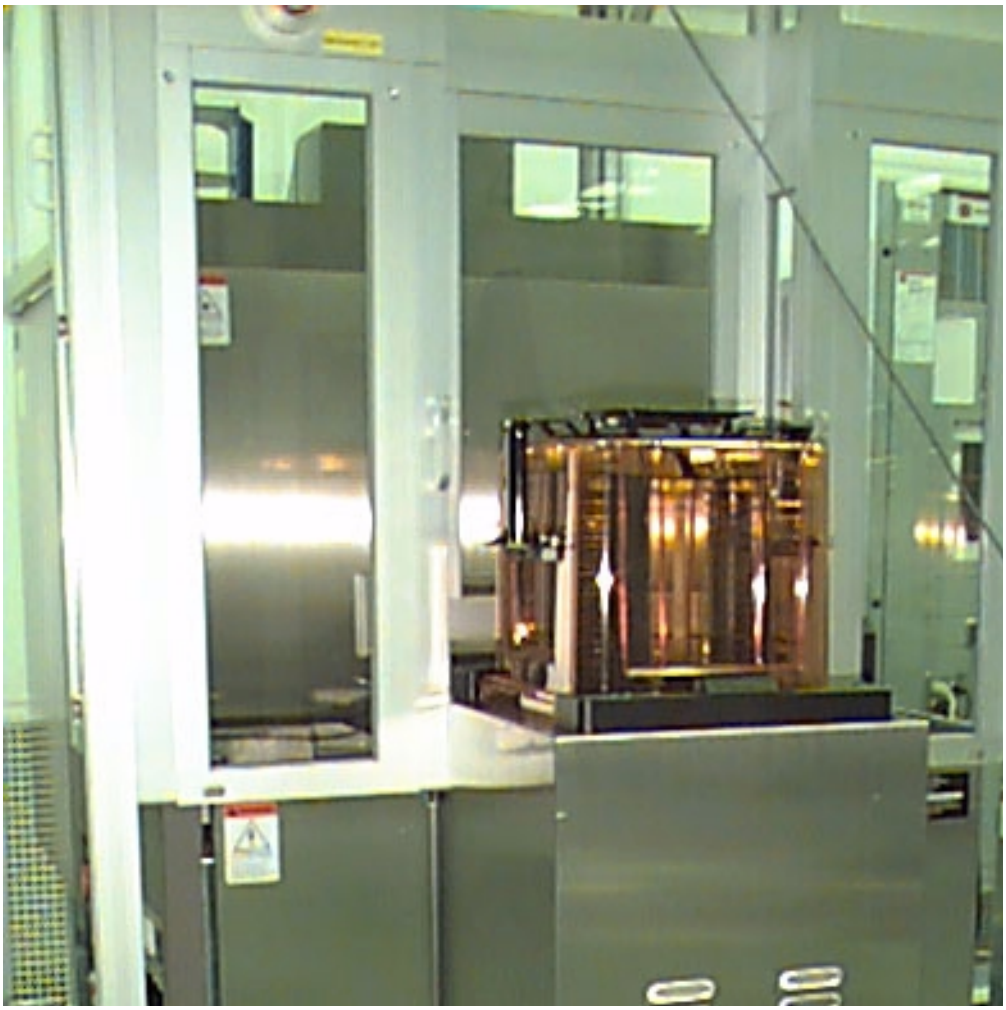
Under the cassette is a cassette plate made for a specific size of wafer cassette, like the 200 mm plate in Figure 2-1 on page 2-1. The prealigner centers and rotates the wafer, so that the robot can place it on the stage in accurate alignment. This alignment in both position and rotation is essential so that the CRS can place previously found defects in the microscope field of view. Depending on the CRS configuration, there might be a Standard Machine Interface (SMIF) unit at the far right. A SMIF accepts wafer cassettes in a sealed pod, as shown in Figure 2-3.

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, 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 opens.



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**Figure 2-3 CRS with SMIF Unit**



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**Figure 2-4 CRS Workstation**



The CRS is normally controlled from a workstation, as in Figure 2-4, which can hold two monitors, keyboard, mouse, joystick, and optional printers, with extra space for media, manuals, logbook, etc. 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 familiar to users of a PC running the Windows operating system, 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. 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. The operator can also click 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



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the opposite direction, so that the image on the screen moves to the same side that the joystick is tilted. For example, if the joystick is pushed to the right, the stage moves in the opposite direction (to the left if viewed from the side of the CRS), and the current image scrolls off the right of the screen.

This tutorial explains what to do and what the result is at each step. None of the mistakes in the software that a beginner can make will damage anything. After most errors, the trainee or an instructor can correct the error and continue. The account that trainees are logged into should contain only copies of demo files. If one of these files is changed or erased during training, someone can copy the original back into the directory.

Trainees who get lost can always log out and start over. If a system problem prevents them from continuing, they may need assistance to recover, 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.

# The First Session

## Logging In

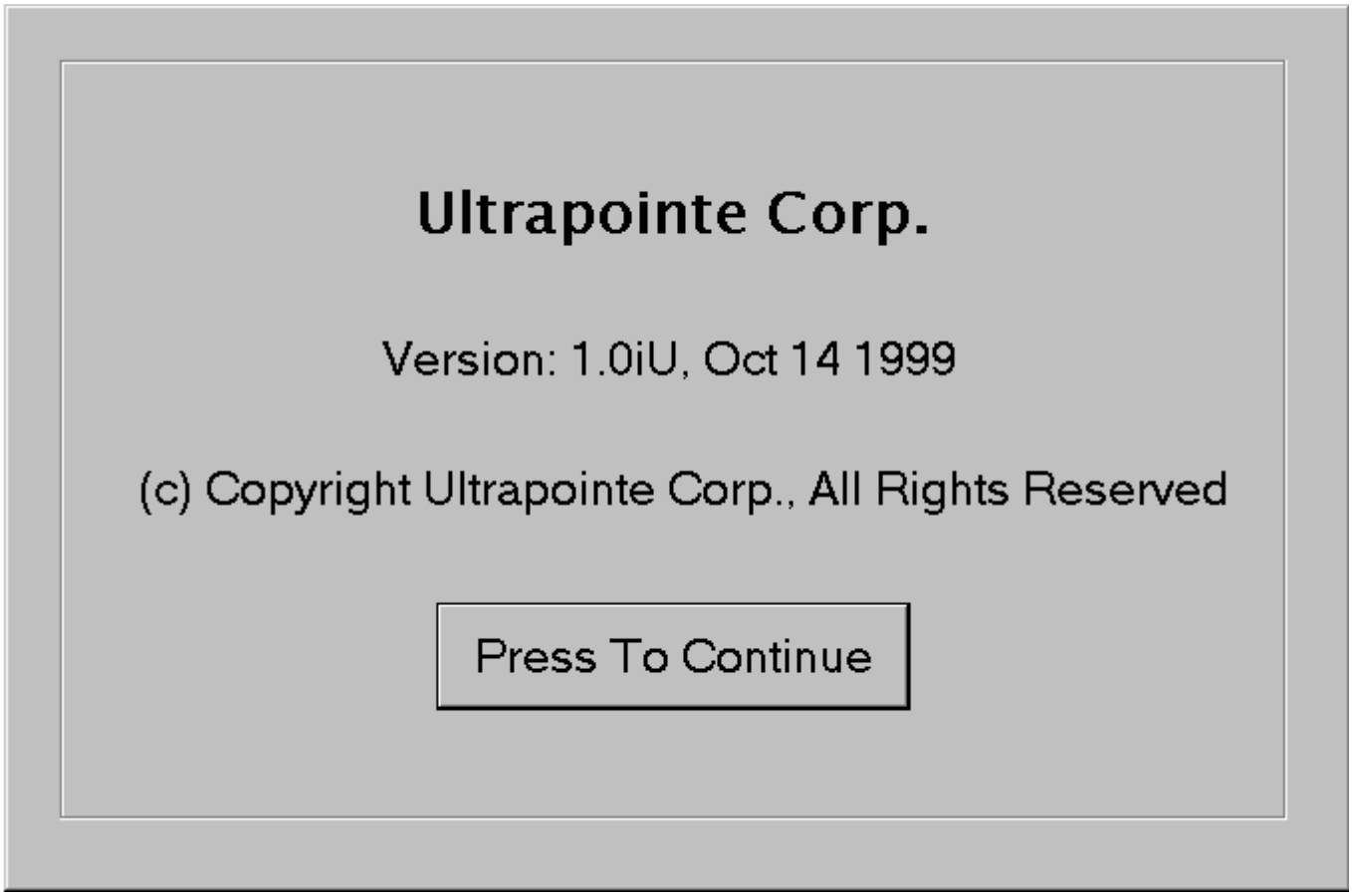
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1. Normally the CRS is left running continuously, so trainees will not have to turn it on. If it is off, check the red **EMERGENCY POWER OFF** button, rotating it counterclockwise if possible until it pops out. Then push the green **ON** button. The application starts automatically and presents the following title screen showing the appropriate software version and its date.



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**Figure 2-5 CRS Software Startup Screen**



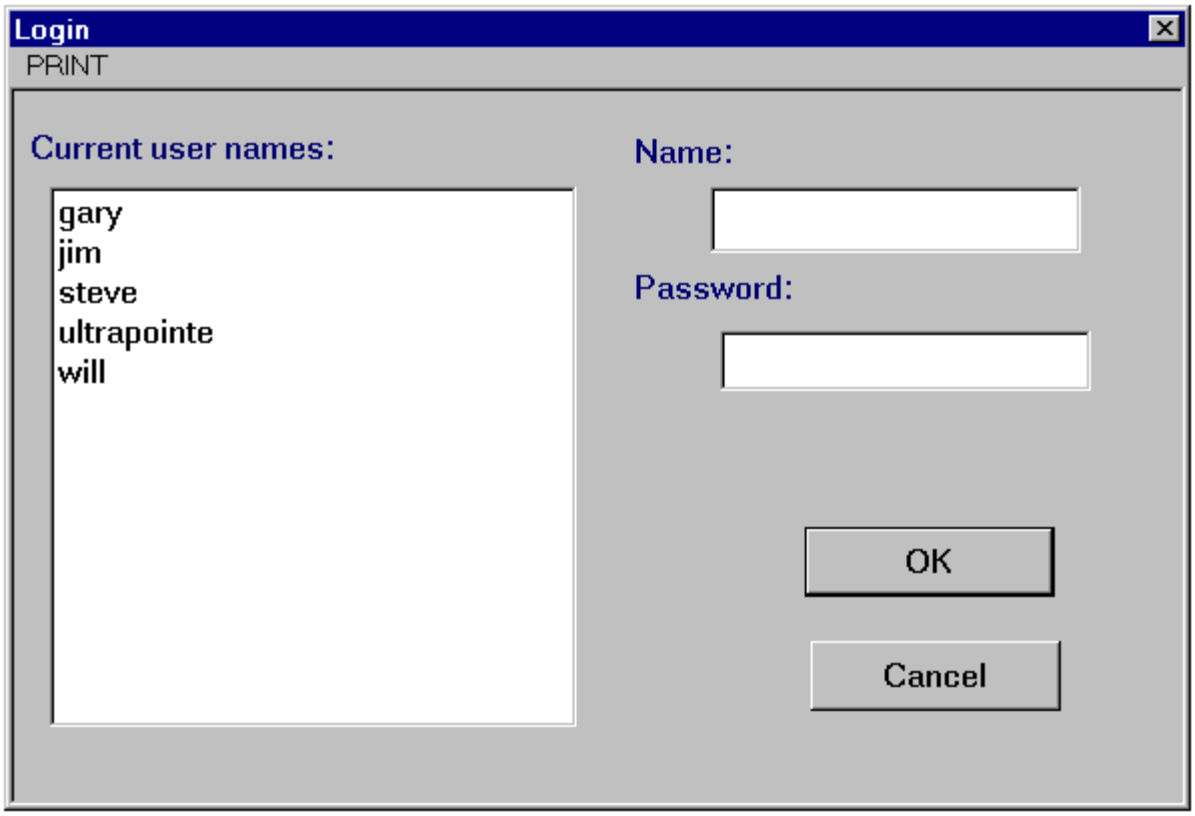

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2. Click ***Press To Continue*** to get to the login window.



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**Figure 2-6 Login Window**



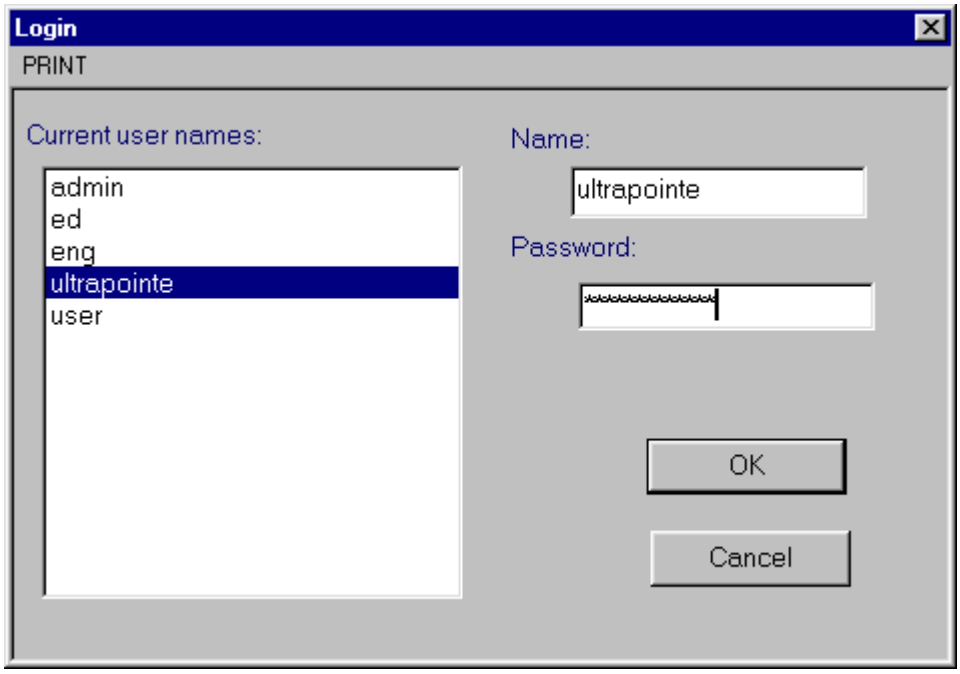

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3. Highlight the user name for the training account in the ***Current User Names:*** list. That name will appear in the ***Name:*** field, as in Figure 2-7.



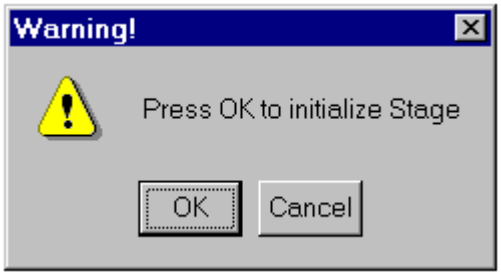
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**Figure 2-7 Password Entry**




4. Click in the password box and enter the password for the account, which will appear as a line of asterisks, as in Figure 2-7. Leave the password box blank if there is no password on this account. Click ***OK*** (or press **ENTER**). The software will load the default recipe for the account, if there is one, and read a number of system settings from it.
5. The ***Stage Initialization*** alert shown in Figure 2-8 appears. Click ***OK***. The stage moves to its home position.

**Figure 2-8 Stage Initialization**



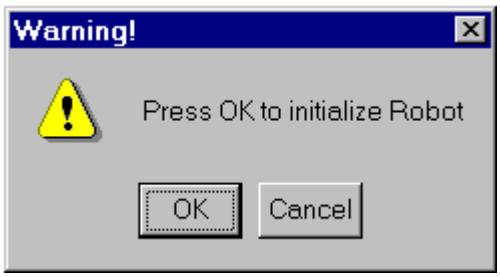

6. The ***Robot initialization*** alert in Figure 2-9 appears. Click ***OK***. The robot retracts its arm and moves to its home position.

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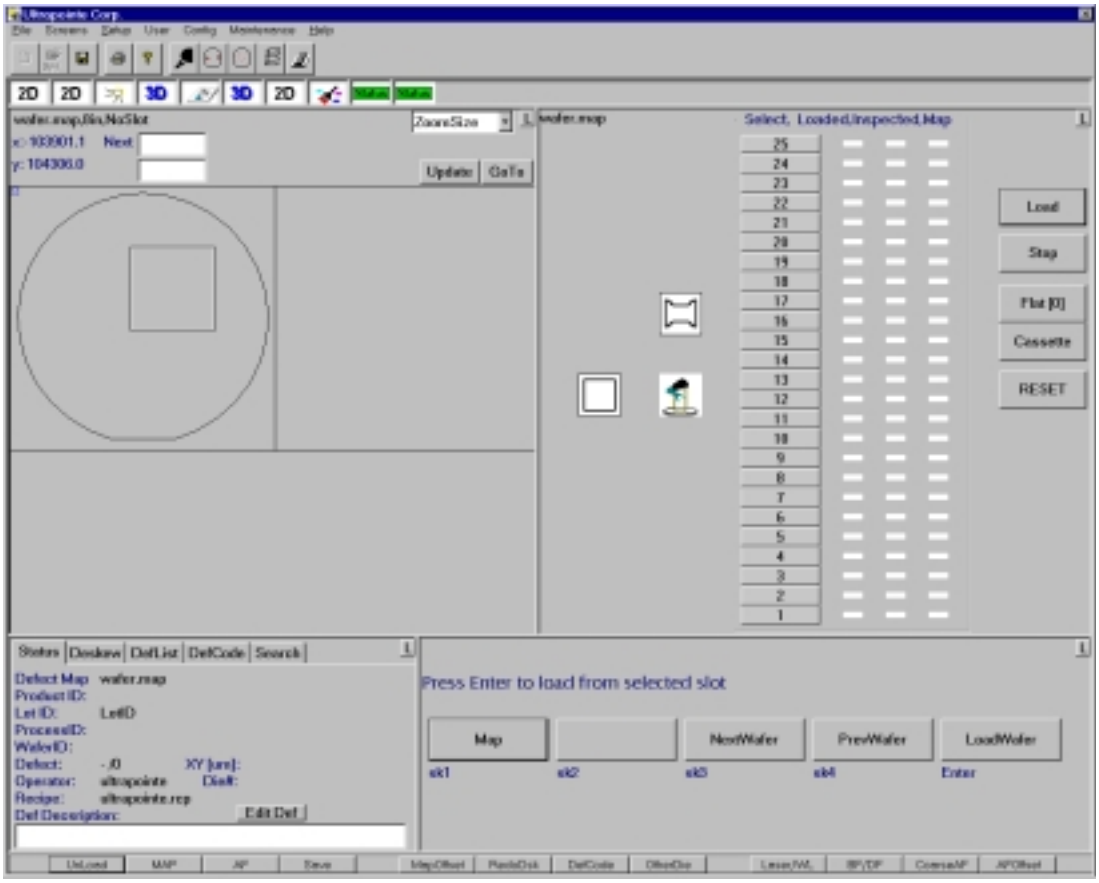
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**Figure 2-9 Robot Initialization**




7. The first screen of the application, as in Figure 2-10, appears. 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.

**Figure 2-10 Initial Screen**




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A menu bar at the top provides access to the CRS application functions and brings up the screens and windows to execute them. At this point the correct screen shows, so there is no need for menu commands.

Below the menu bar in this screen is a line of buttons with labels such as 2D, 3D, and various icons. These buttons are placeholders for alternate window panes that can be swapped into the screen. The buttons are identified in Figure 2-1. There can be more than one of the same type of button.

**Table 2-1 Button Bar Icons**

| | Name | Function of Pane |
|---|---|---|
|  | Microscope | White light image |
|  | RT Slice | Real time laser image |
|  | Slice2D | 2D slice images or contours |
|  | Surface | 3D surface images |
|  | Reference Img | Show images saved in files |
|  | Cassette | Wafer or slot selection |
|  | Seq Status | Soft keys, defect data entry |
|  | Text Status | Tabbed status pane |
|  | DefectMap | Wafer with zoom box |
|  | ADC | Automatic Defect Classification |
|  | Spectra | Not used |

8. To make a swap, click a button and drag it into a pane. The button expands into a new pane of the same size, and the previous pane takes the place of the button. Swap panes freely at this point to get the feel of the operation.
9. The small buttons labeled ***L*** are for swapping visible panes. Click one and drag it to another pane. The panes exchange places and sizes. Dragging an ***L*** button to the button bar exchanges the pane and the button.

   The tab bar in the pane at the lower left offers a choice of information to display. When this screen first appears the **Status** tab is selected, but the user can choose any other tab at any time.

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10. Look at the tabs. At this point, don't worry about the meaning of the information displayed.

    The ***Status*** tab shows the name of the currently loaded defect map file (extension `.map`) and recipe file (extension `.rcp`). Clicking the ***DefCode*** tab shows a list of defect codes and the name of the defect code file (extension `.cod`) from which they were loaded.

    The wafer outline at the left contains a square zoom box. Clicking 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. Dragging the lower right corner of the zoom box changes its size, and the magnification of the zoomed diagram.

11. Try the zoom box controls.

12. If the ***Sequence*** pane is in the lower right of the screen, clicking ***Map*** opens a dialog box for loading the wafer map for the current cassette. Clicking one of the wafer selection buttons, ***NextWafer***, ***PrevWafer***, or (for the wafer selected in the Cassette pane) ***LoadWafer*** loads the wafer selected. If the ***Sequence*** pane has been swapped into another, smaller area, the button at the right end of the pane is not visible. Put the pane back, or use the **ENTER** key instead.

## Loading a Defect File and Wafer

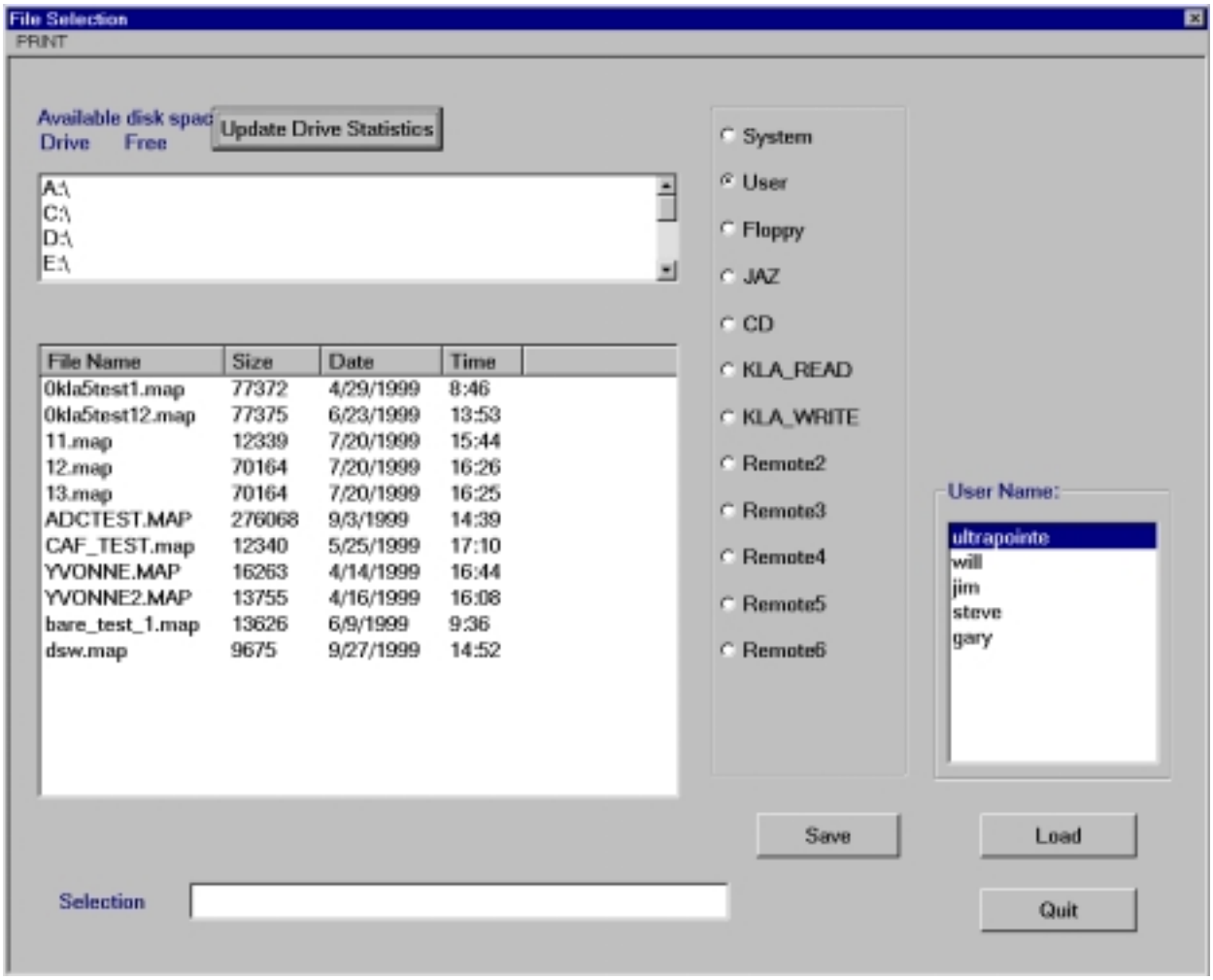
1. Clicking ***Map*** brings up the map file selection window shown in Figure 2-11, with the ***User*** directory radio button selected, the current login name highlighted, and a list of the wafer maps stored for the current user.

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**Figure 2-11 Map File Selection Screen**



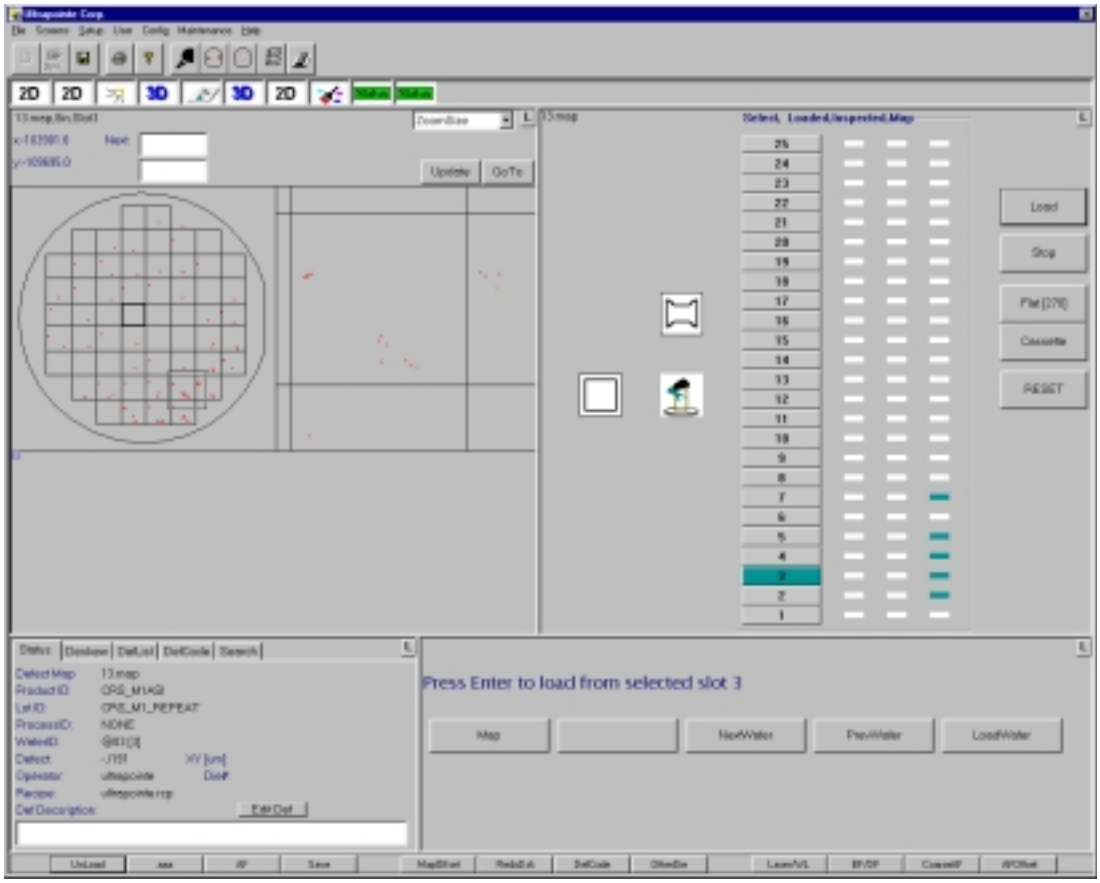

2. Highlight the name of the wafer map for the cassette that is on the CRS, then click ***Load***. The cassette pane highlights the slots in which wafers are available for review, and the wafer map diagram shows the defect map for the currently selected wafer. In normal production, the cassettes have a wafer in each of their 25 slots, but for learning there will probably be only a few wafers in the cassette, as in Figure 2-12.

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**Figure 2-12 Start Screen with Wafer Map Loaded**




3. Press ***Enter*** to load the first wafer.

   At this point the robot moves to pick up the wafer. It first applies vacuum, then moves the wafer out of its slot, and places 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 placing the wafer on the stage.

   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 that indicates the proper alignment of the wafer, and presents the wafer to the robot with the flat or notch positioned as specified in the active recipe.

   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 ***Deskew*** screen.

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## Patterned Wafer Deskew

Although the wafer is prealigned, there is still a small error in placement and in rotation. 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 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 low magnification, ready for the user to proceed.

All of the deskew calculations are done in the CRS software. The operator has only to align the deskew points with the image crosshairs, and click ***Accept***. The rest is automatic. Some CRS systems are equipped with an AutoDeskew option in which the software finds the deskew points itself, and the operator can go directly to defect classification.

The Deskew screen in Figure 2-13 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 is also a white light image on a separate monitor. Something should be visible on the wafer surface at this point. The CRS is ready to explore these structures. But first, look at the panes in this new screen.

1. Click ***WL/Laser***, to the right of the laser image pane, to turn on the laser image. There are panes to show both white light and laser images, with different views of the same area on the wafer. A deskew point (usually a die corner on a patterned wafer, or an isolated defect on a bare wafer) should be visible near the center of the image. The laser and white light panes on the computer monitor have crosshairs for centering features, but there are none in the image from the camera on the white light monitor.

   The icons for closed panes are now lined up vertically at the upper left. 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. There are three other options for displaying the zoom box area, each with a different color, and options to display the four color code lists.

2. Try the **Zoom** options on the menu. 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: buttons for ***RedoCurrDsk***, ***SkipDeskew***, and ***Accept***. ***RedoCurrDsk*** is for starting 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 continue with it. ***Accept*** is the most common choice, after locating and centering the first deskew point in the crosshairs on the screen.

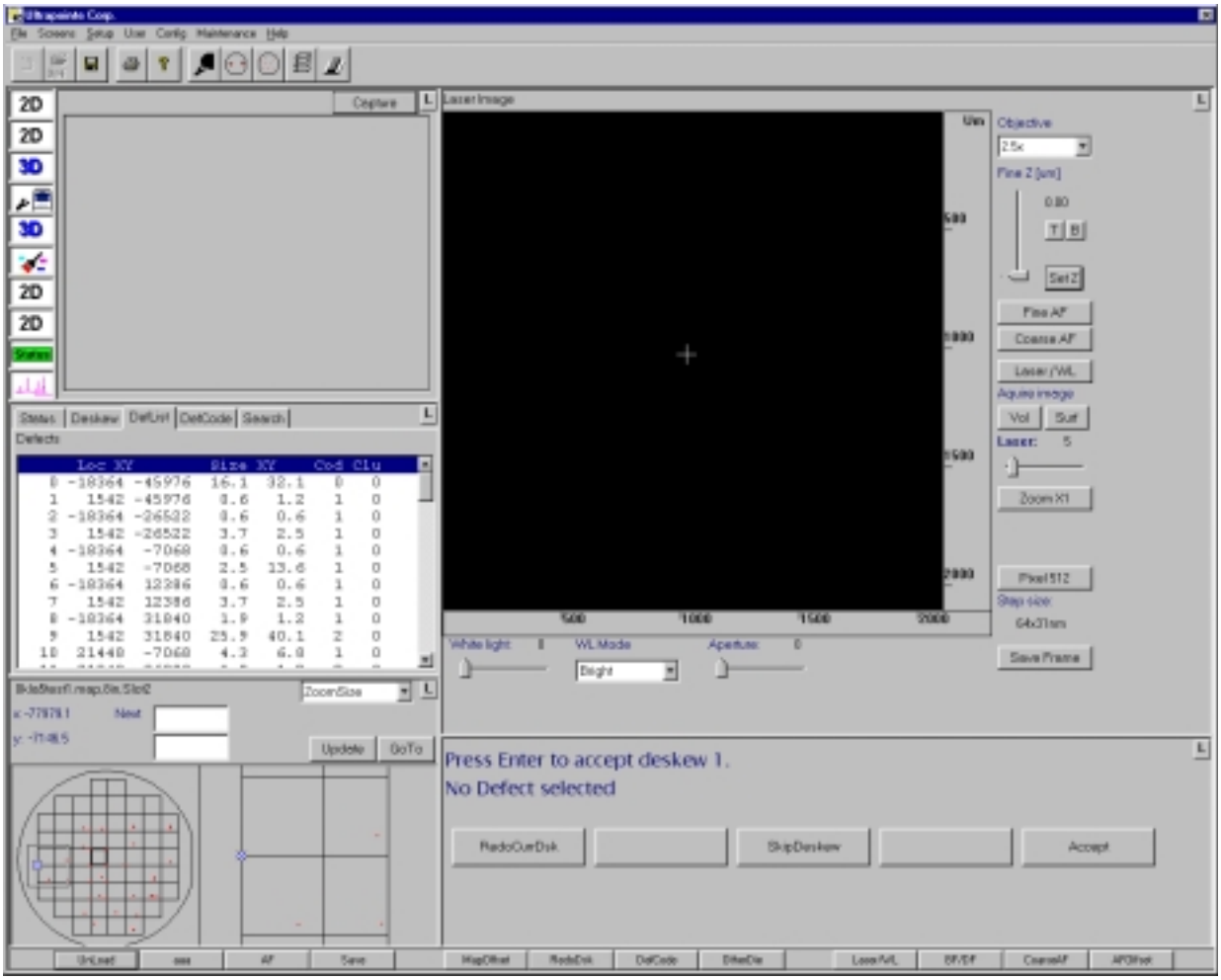
3. Restore the settings that this screen started with by clicking ***RedoDsk***. The software will start the deskew process over.

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**Figure 2-13 Deskew Screen**



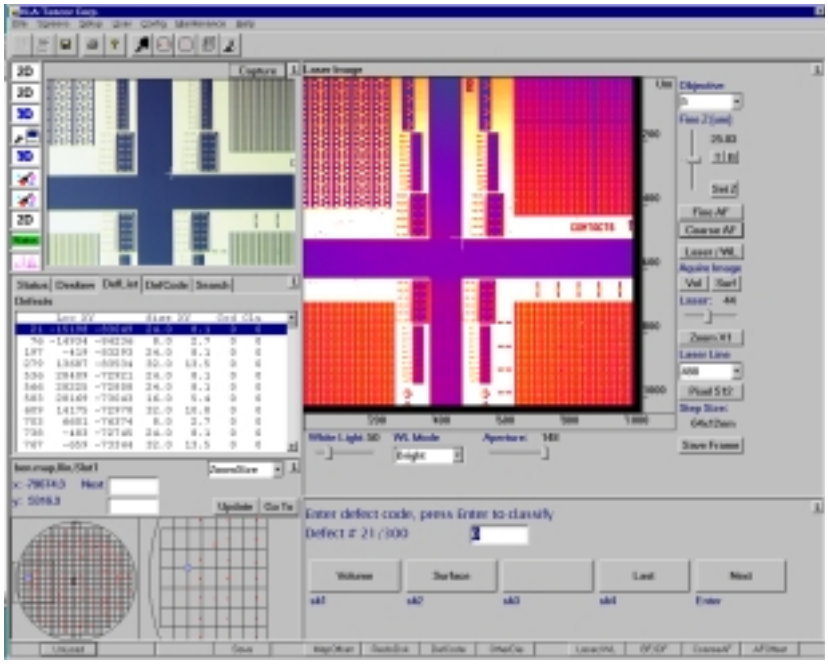

4. The deskew point should be in the field of view at low magnification, like the die corner in Figure 2-14 that is under the crosshairs in the white light image. If the deskew point is not visible, get help in finding it.

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**Figure 2-14 Deskew Point at Low Magnification**



5. Put the joystick in XY mode (toggle switch toward the user), 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.
6. Switch to 50× and center the deskew point again, as in Figure 2-15.

   Note that both the white light and laser cursors are visible in this view, and that the die corner is centered in both images. This alignment of the two images is called parcentricity.

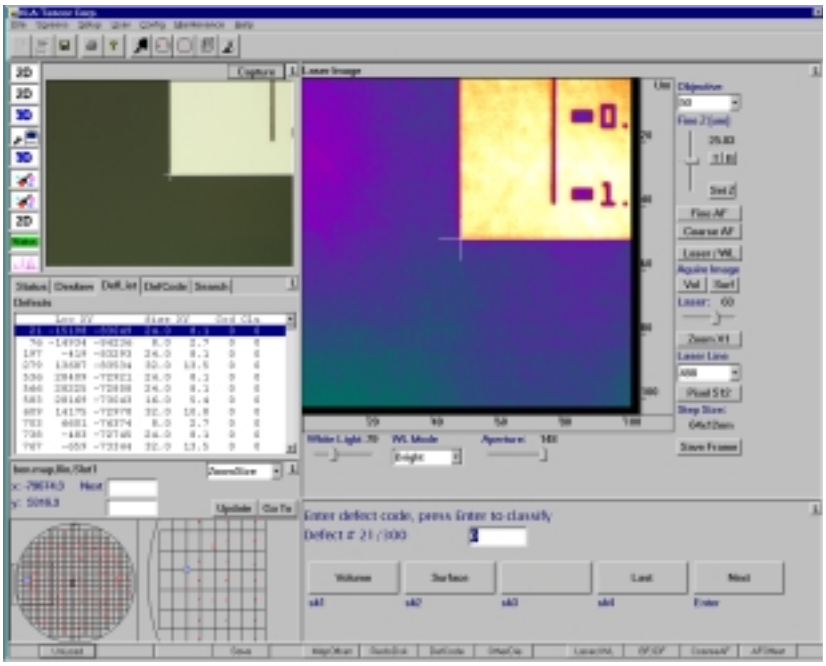
   Pressing the **MAG**↑ key changes the objective to increase magnification, and the **MAG**↓ key decreases magnification. To go directly to a chosen magnification, use the **Objective** menu on the screen, at the top of the image controls.

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**Figure 2-15 Deskew Point at High Magnification**



7. When the deskew point is centered at high magnification, click ***Accept*** or press **ENTER**.

   The stage automatically moves the wafer to the second deskew point.

8. Move the second deskew point to the center of the video screen, first at 5×, then at 50×, and accept the second point.

   The CRS automatically moves to the first defect and brings up the defect review screen.

9. Center the first defect and press the **MAPOFFSET** 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 accurately where to move the stage to bring a defect under the microscope.

10. From the Review screen, carefully look at the Wafer Map pane and make sure that the deskew point is correct.

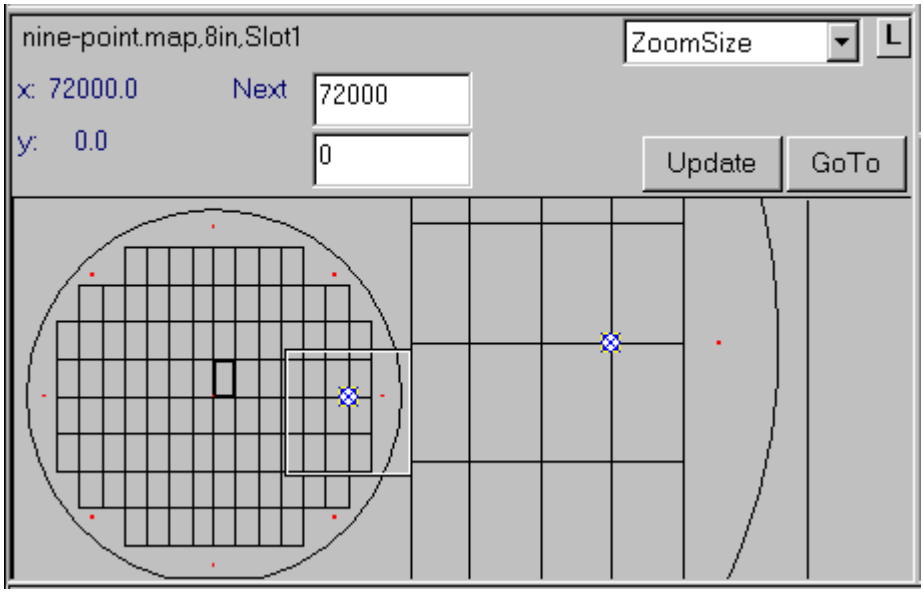
    Figure 2-16 is an example of what the user might see for the second deskew point. The square in the wafer map at the left is the zoom box. The zoom window on the right side gives a magnified view of the portion of the map in the zoom box. The current alignment position will be marked in blue in both views.

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**Figure 2-16 Wafer Map Pane**




The system should have driven to the first deskew point.

11. Check the ***Die Offset*** in the ***Deskew Options*** window.
12. Drive out to the edge of the wafer with the joystick to verify that the physical die position of the deskew point matches the location given.
13. Align the first deskew point with the crosshairs at 5× and then at the higher magnification to be used for defect classification (usually 50× or higher).
14. When satisfied with the alignment, select ***Accept*** with the mouse or **Enter** on the keyboard.
15. An alert appears, asking whether to match the current location with the deskew point coordinates. Click ***OK***.
16. Observe the movement of the stage to the second deskew point. This helps determine the location of the reference point if the wafer street moves off screen.
17. Center the second deskew point with the crosshairs at low and high magnification.
18. When satisfied, select ***Accept*** with the mouse or press **Enter** on the keyboard.

    The stage automatically moves to the first defect, viewable on the ***DefectList*** tab.
19. Center the defect at low and high magnification
20. Press the **MAP OFFSET** key.

To verify the deskew, see how good the system is at finding some easily recognized defects. Large defects are generally good for this purpose. Sorting the defect list from the **Defect Selection Option** window on the **Setup** menu by size is an easy way to find the largest defects. Figure 2-17 shows this window with a selection specified and the sort carried out. The original list of 9 defects of different sizes 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

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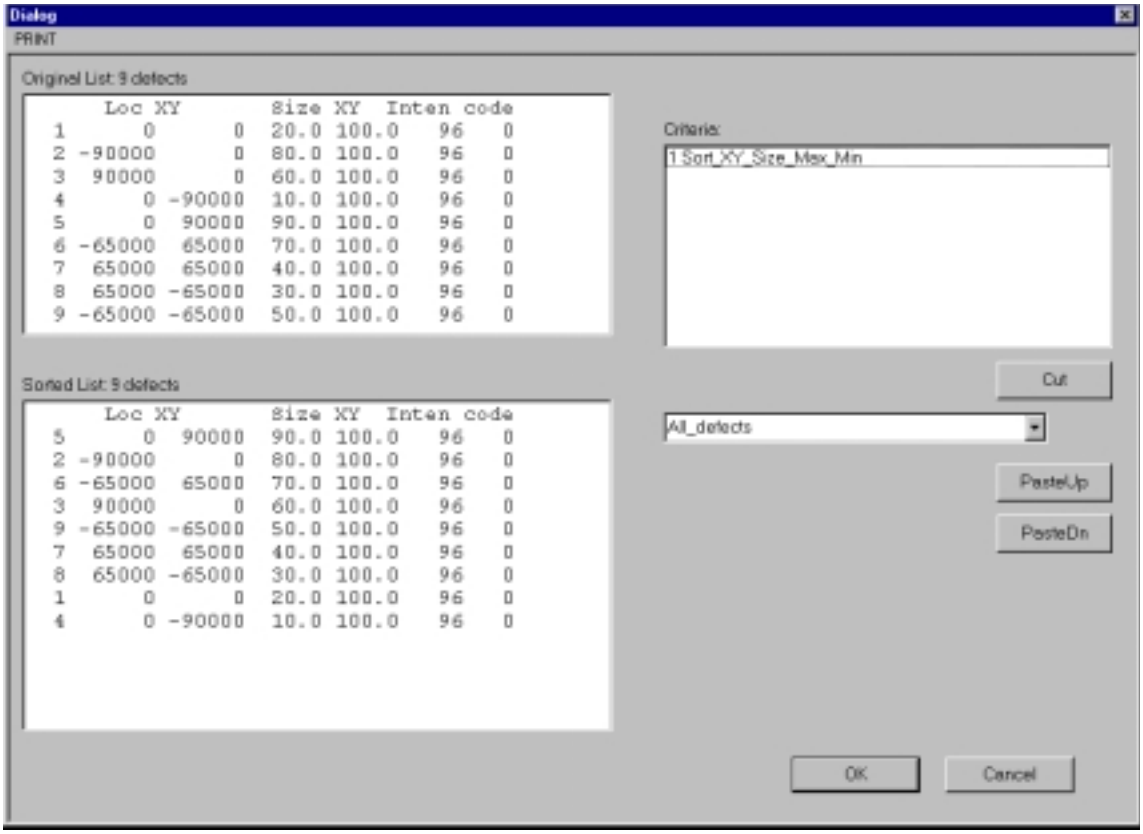


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results of the most recent selection and sort. In this case, it is the same set of 9 defects sorted from largest to smallest.

1. Click the option menu that shows the initial selection **AllDefects** and drag to select sort criteria from the list.
2. For locating large defects, select ***Sort_XY_Size_Max_Min***.
3. Click ***PasteDn*** to add it to the active list.
4. Click the ***OK*** button.
5. On returning to the ***Review*** screen, notice that the ***DefList*** tab shows a defect list sorted by size, with the largest numbers at the top.

**Figure 2-17 Defect Selection Window**




6. Click the first defect in the list. Verify that the defect is in the field of view. Center the defect in the crosshairs and then press the **MapOffset** key on the keyboard.
7. Try a few more defects and adjust the offset so that mapped defects consistently appear in the field of view.
8. If this is not possible, it may be necessary to redo the deskew. In that case, select the ***RedoCurrDsk*** button with the mouse or press the **RedoDsk** key on the keyboard.

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## Bare Wafer Deskew

Manual deskew on a bare wafer consists of measuring offsets to two isolated defects, that is, defects which appear in the microscope field of view by themselves at low magnification. The line joining the defects will not be horizontal like a wafer street, but the software can still calculate the rotation between the stage coordinates and the wafer map coordinates.

1. Load the appropriate recipe and map files.
2. Load a wafer.
3. Choose a small, isolated defect near the left edge of the wafer.
4. Center the defect at low magnification, and again at high magnification.
5. Click ***Accept*** in the ***Deskew*** sequence pane.
6. Repeat Step 3 to Step 5 for a defect near the right edge of the wafer.
7. In the ***Review*** sequence screen, which appears next, center the first defect at low magnification and again at high magnification.
8. Press the **MAP OFFSET** key.

## Reviewing Defects

The primary function of the CRS is to review defects. Maximum productivity is attained by using both white light and laser confocal images simultaneously to classify defects. Although the laser images might appear unusual at first, it soon becomes clear that their superior resolution and fine Z discrimination makes it easy to identify defects more quickly and accurately. Switching to surface and volume views of the same defect supports more detailed analysis.

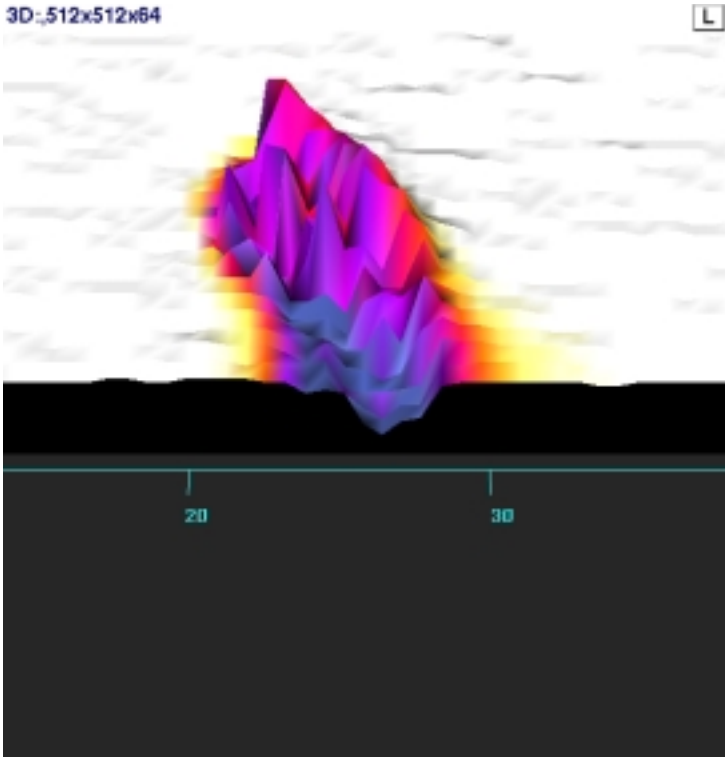
Figure 2-18 shows the different types of image that the CRS can produce for the same defect. View A is a 3D surface image with an XY cut across it. The 2D XY slice from a volume data set in view B is the same as a single frame from a live laser image. View C is the white light image. The 2D XY image in view C differs from view B by showing the brightness of the surface rather than a slice, as if looking at view A from directly above. Views E and F are YZ cross sections from surface and volume data sets, respectively. The surface cross section is a contour line marking the brightest level at each point on the Y axis, while the volume cross section shows the measured brightness at every height.

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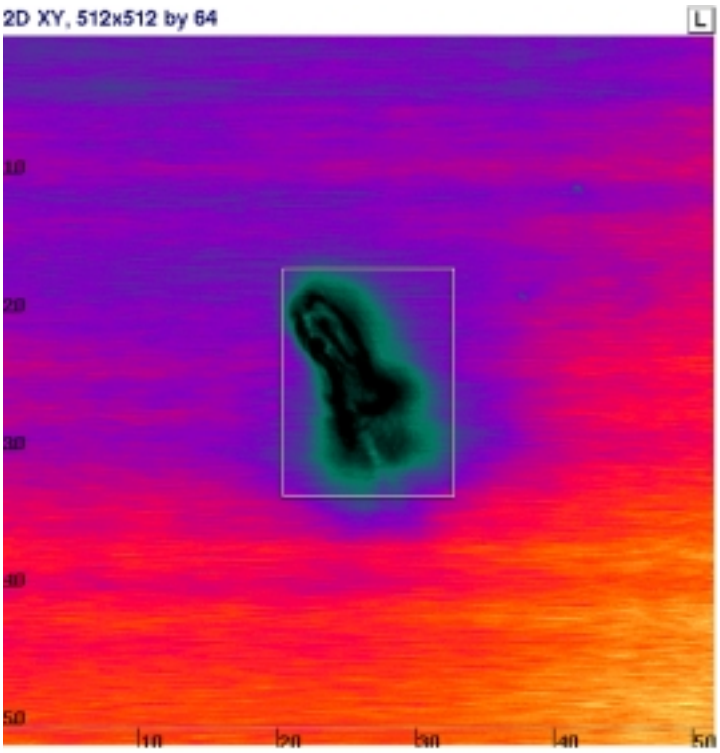
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**Figure 2-18 Multiple Views of a Defect**




A. 3D Surface

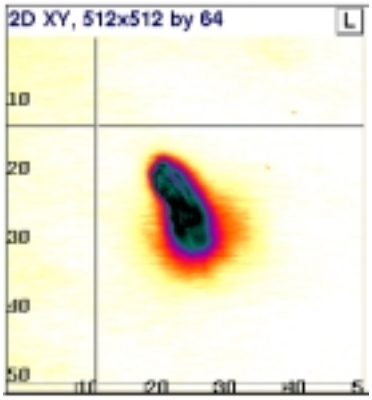
B. XY Volume



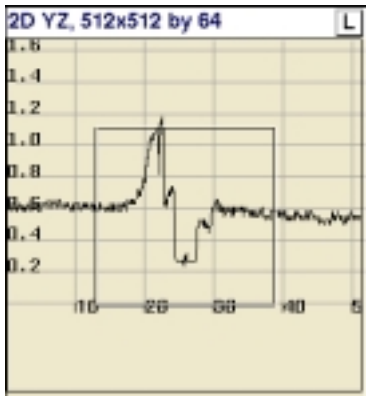

C. White Light

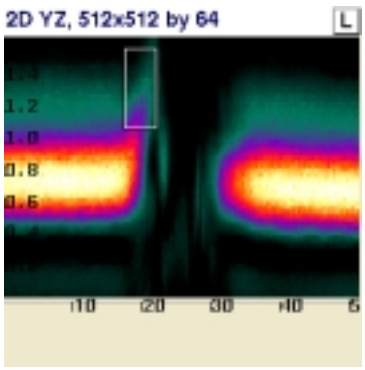


D. XY Surface




E. Surface Cut



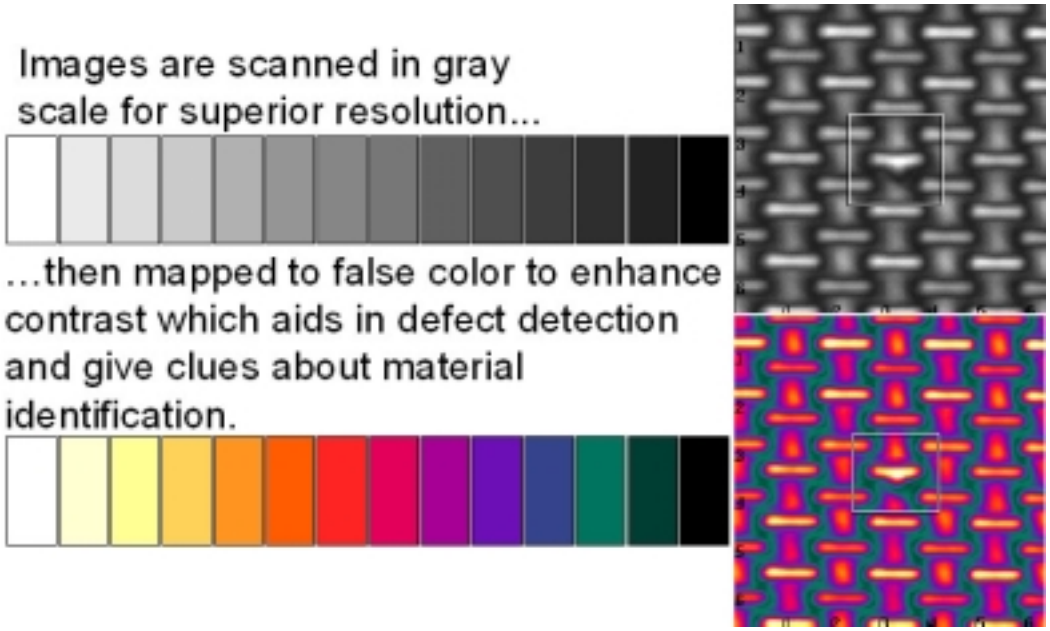

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Although the light from the laser is a single color, the laser images are colored on the screen. As Figure 2-19 shows, colors represent brightness levels, with white the brightest, followed by yellow, orange, red, purple, blue, green, and black. In 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 adjusted correctly, the parts of the image in focus are bright gold. 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 might also be necessary to adjust the laser intensity when doing so.

**Figure 2-19 Intensity/Color Mapping in Laser Images**




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. Decreasing the scan angle decreases the area scanned and increases the resolution in the same proportion. Figure 2-20 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.

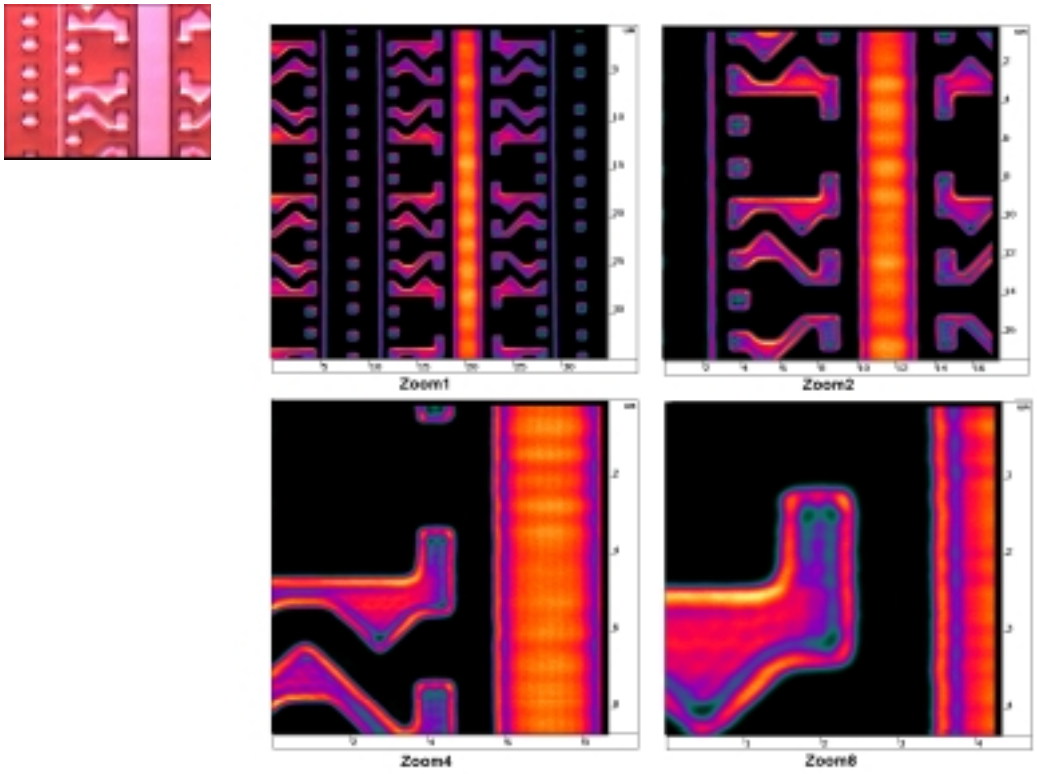
Each press of the **ZOOM** key doubles the magnification of the laser image and changes the value shown on the ***Zoom*** button to 2, 4, or 8. On the fourth press, the zoom returns to 1. The laser window has a scale on both the X and Y axes in units of microns that also updates according to the zoom setting.

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**Figure 2-20 Laser Image Zoom**



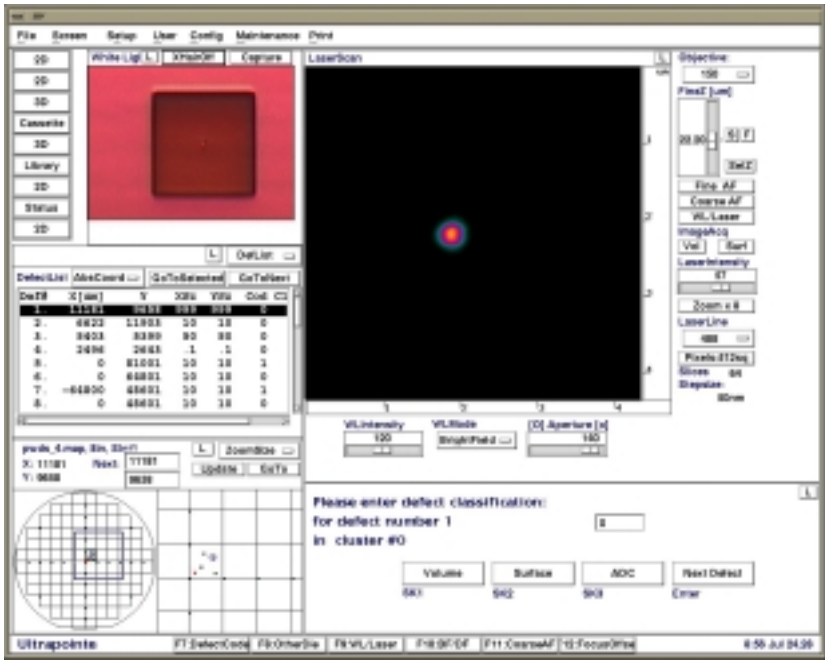

At maximum magnification, 150×, and maximum zoom, 8×, the laser beam scans over a patch approximately 4.2 µm on a side. With 512 pixels in each scan line, this gives a nominal resolution of close to 8 nm. In fact, the diffraction-limited laser light spot on the wafer surface is much larger than this, so that the pixels overlap, and usable resolution is about 0.15 µm. 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 Figure 2-21 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.

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**Figure 2-21 White Light and Laser Image of 0.3 µm Feature**



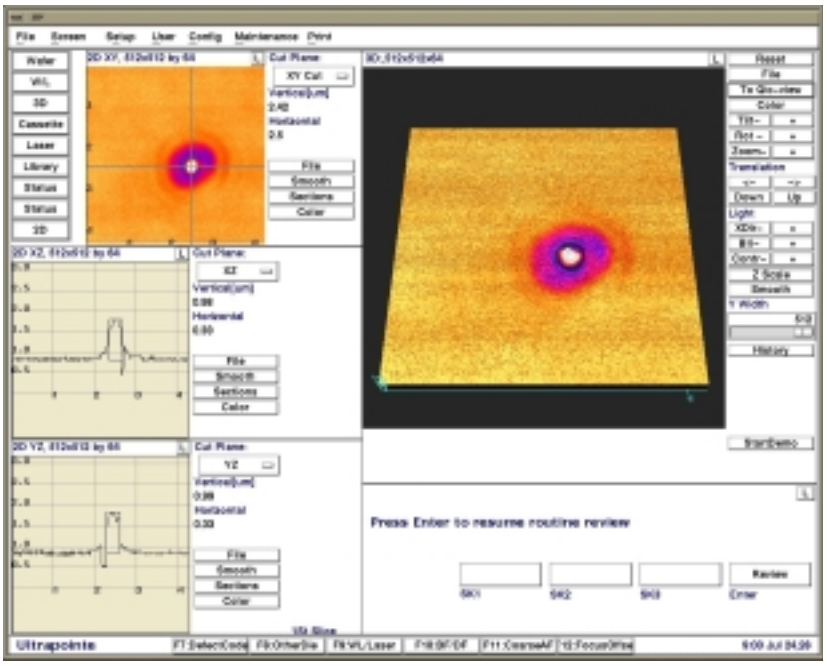

The surface images in Figure 2-22 show two views of the same dot, together with profiles cut through the dot in the XY and XZ planes. The upper left image has a pair of cutting cursors that indicate where the profiles are taken. In the profile panes, a rubberband cursor indicates the size of the dot, which is 0.33 µm in diameter and 1.0 µm 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.

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**Figure 2-22 Surface Images of 0.3 µm Feature**



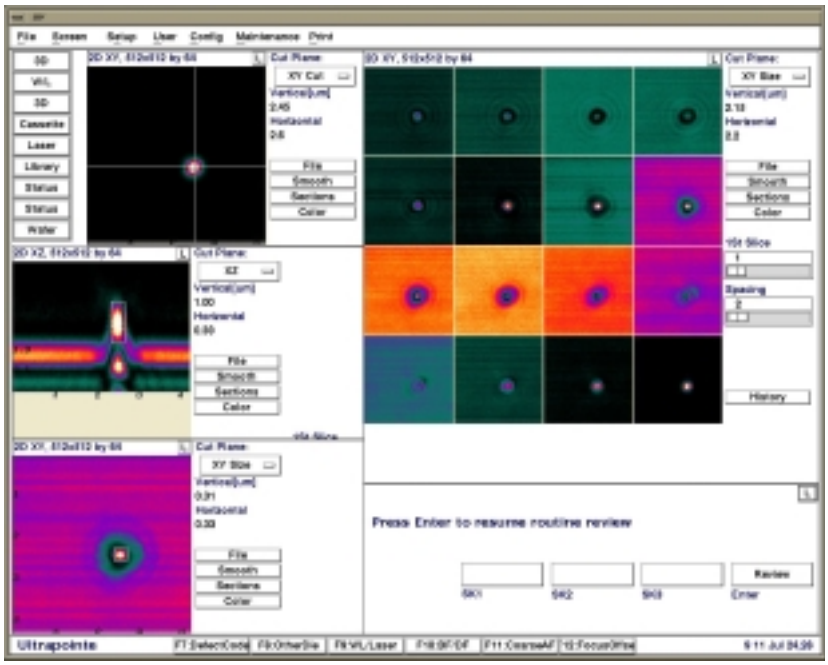

The volume images in Figure 2-23 give different views of the same dot. The cutting cursors in the upper left pane are centered on the dot, so that the XZ cut pane shows a clear profile of the dot. Again the rubberband box shows that the feature is 1 µm high and 0.33 µm wide. Structure smaller than the dot can be made out to some extent. The large pane shows a series of slices through the feature, at 0.1 µm 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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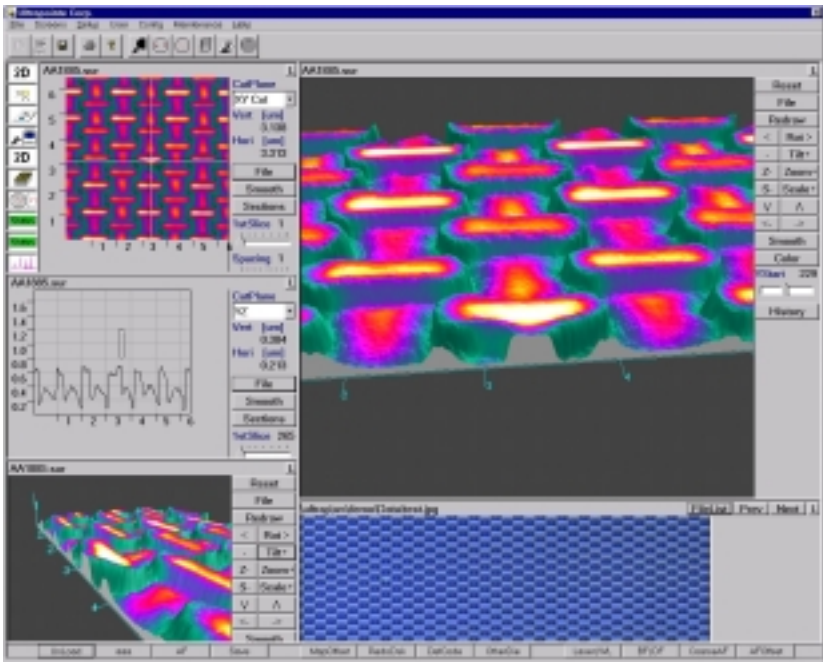
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**Figure 2-23 Volume Images of 0.3 µm feature**




The defect shown in Figure 2-24 was detected by an AIT tool and thought to be a “false defect” under white light review. However, the superior resolution of laser confocal imaging verified its existence.

**Figure 2-24 Real or False Defect?**



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A “Light Point Defect” (LPD) when it was detected by a Tencor 6200 is shown to be a ~0.22 µ particle. Note that the white light image (top left) reveals no size information.

**Figure 2-25 Light Point Defect Revealed as Particle**

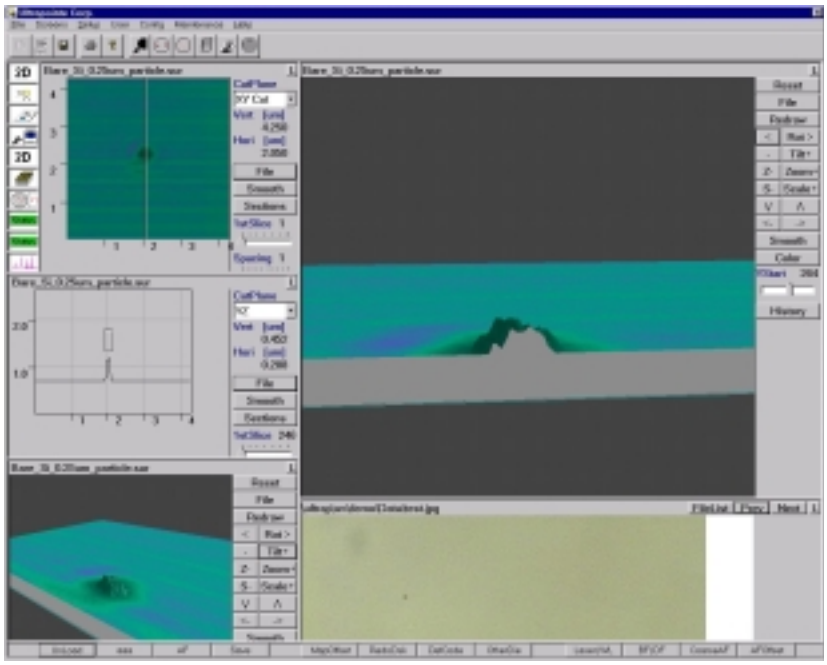
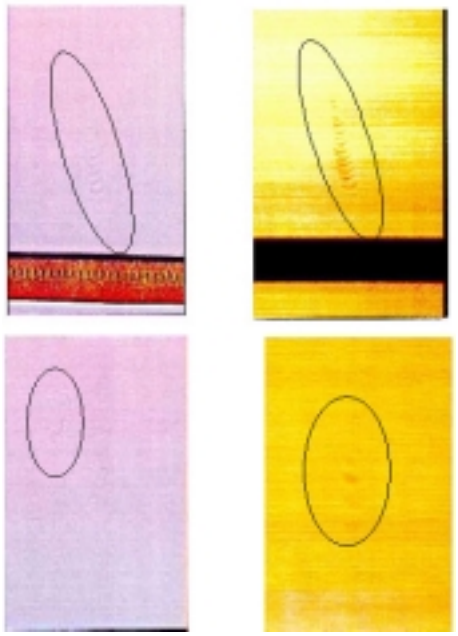


**Figure 2-26 Scratches on Wafer Surface**

White Light Image CRS Live Laser Image



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## To image a Defect

At this point, the wafer is deskewed, the first defect is in the center of the field of view, and the map offset is set. It is time to look at live images on the CRS.

1. Press the **LASER/WL** key or click the ***Laser/WL*** button on the screen if necessary to turn on the laser image.

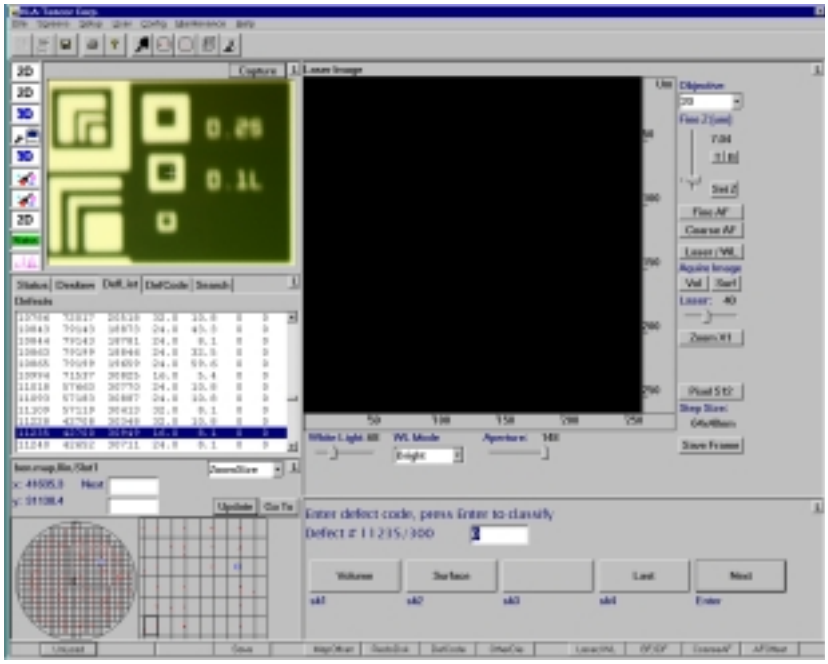
   An image appears in the laser window, unless, of course, the laser optics are out of focus, or the laser intensity is too low or too high.

2. Check the image focus. Try the ***Coarse AF*** button if the focus is bad, and the ***Fine AF*** button if the laser image is near focus.

   The CRS autofocuses, so the image should be fairly good. Sometimes it is necessary to move the wafer out of focus and back again, so users need to know how the focusing process works. In addition to the ***Coarse AF*** and ***Fine AF*** buttons, the **FINE Z** up and down keys, the ***Fine Z*** slider in the laser controls, and the joystick (set to Z mode, with the toggle away from the user) can all be used for focusing.

   The sequence of screen images in Figure 2-27–Figure 2-29 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 2-27 Badly Focused Image**



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**Figure 2-28 Almost Focused Image**

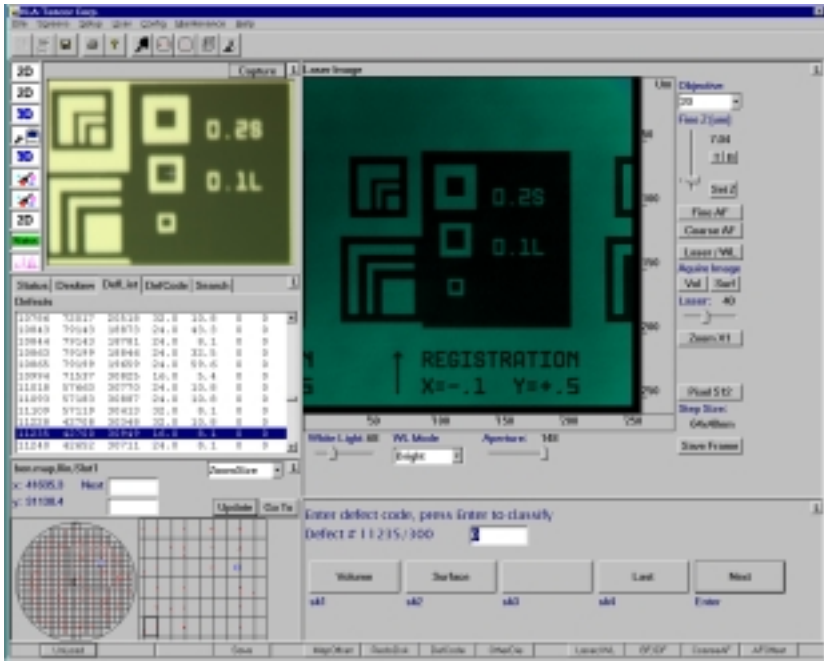
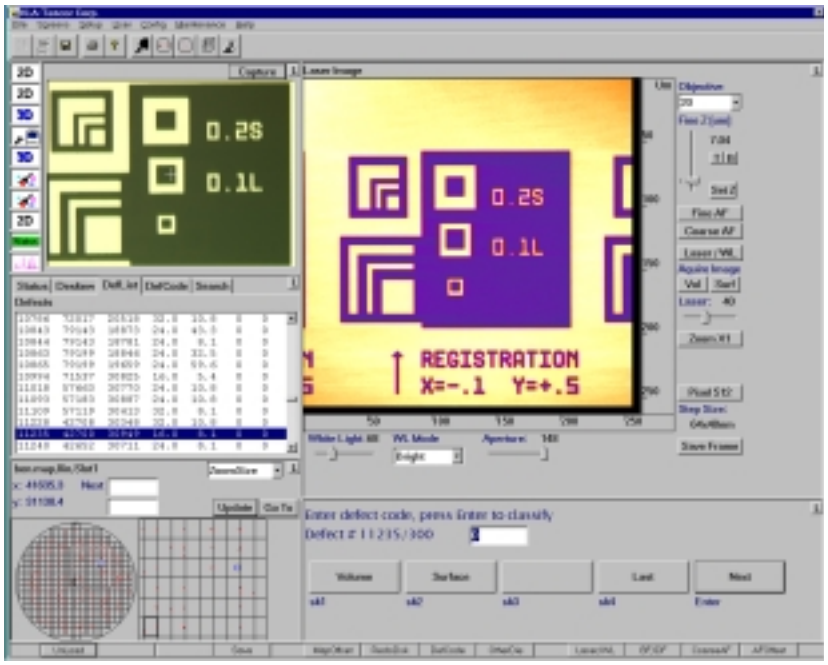



**Figure 2-29 Well Focused Image**




3. Check the image brightness. The sequence in Figure 2-30 shows laser images that are too dim, too bright, and just right. Figure 2-31 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 2-30 Adjusting Laser Image Brightness**

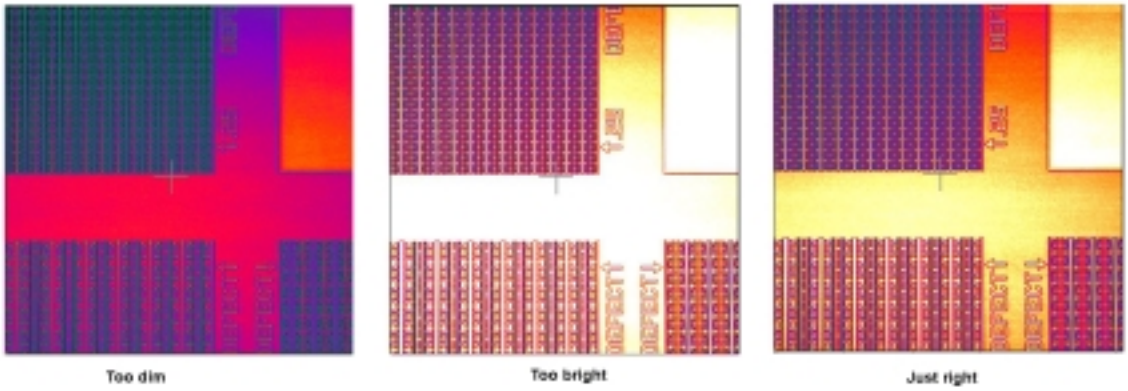
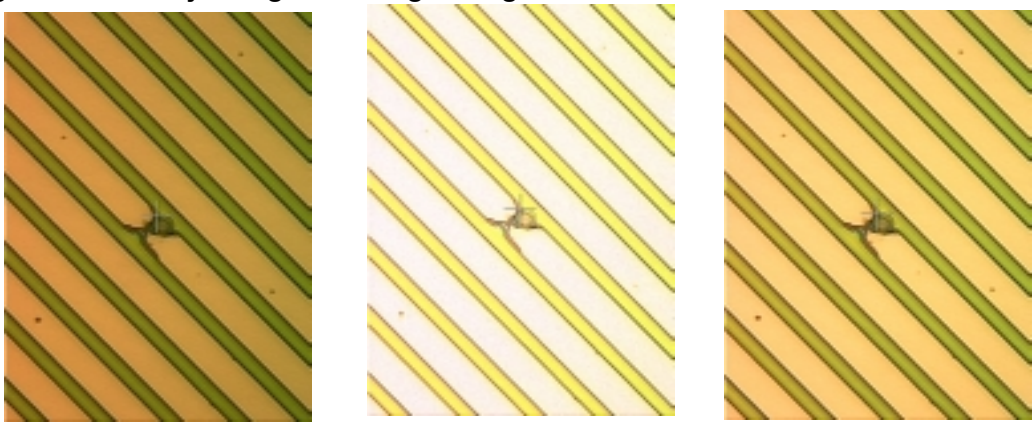



**Figure 2-31 Adjusting White Light Brightness**



Too dim Too bright Just right

1. 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 the most detail is visible, if it is small. If the magnification goes too high, press the **MAG**↓ key to go to lower magnification, or select an objective directly on the **Objective** menu to the right of the laser image window.

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2. If there is no image or the focus seems poor, try pressing the **COARSE AF** key, and then the **FINE AF** key, or click the corresponding window buttons.

**Figure 2-32 Laser Image Zoom Sequence**

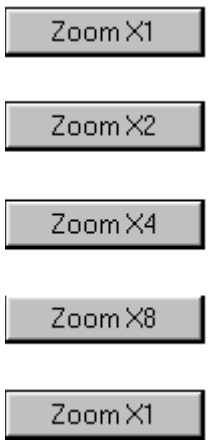
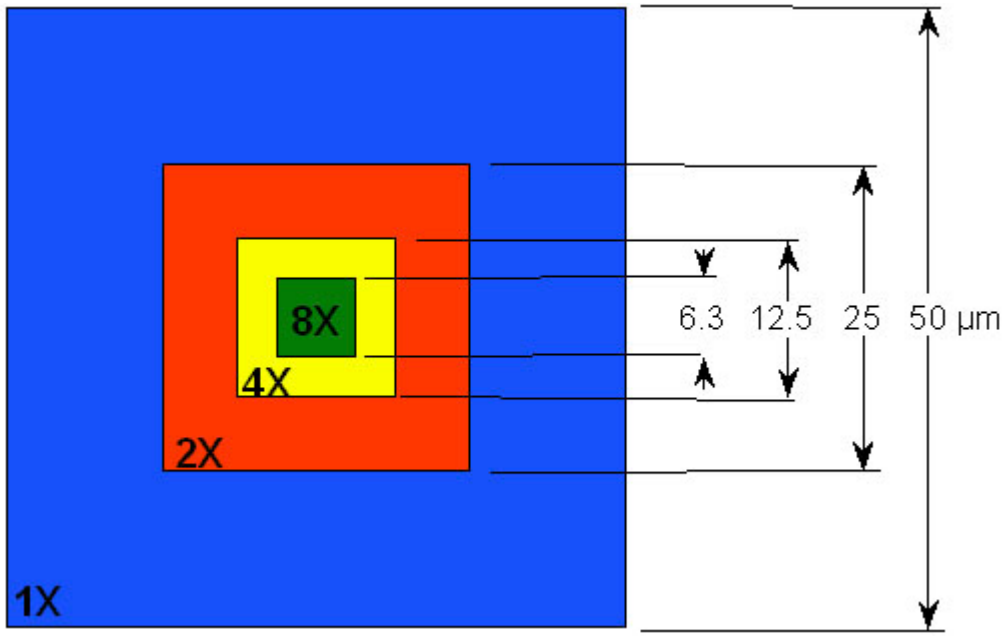



**Figure 2-33 Zoom Image Areas**




3. 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.

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**TIP**

*When starting near focus with visible surface features, try for better focus first and better illumination after.*

*When starting far from focus, it may be necessary to increase the illumination first, in order to be able to find the focus range while adjusting the stage height. Close to focus, decrease the illumination to avoid sensor overload. Then move to the best focus, and finally adjust the illumination.*

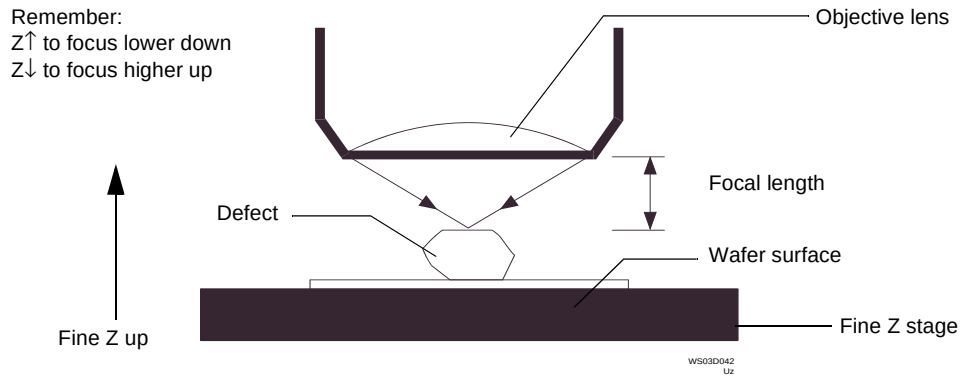
Suppose the machine is focused on a substrate (a uniformly illuminated bright laser image filling the whole laser window). To understand a defect's height information, press the Z↑ or Z↓ key while paying close attention to changes in the laser image. If the defect is a particle, then as the fine Z stage 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 in the surface layer. Try moving up and down while viewing a succession of defects.



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Figure 2-34 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.

**Figure 2-34 The Relationship Between Focus and Z-position**




## Getting Around

There are three ways to move to a specific defect location:

- Press **ENTER** to move to the next defect in the defect list, or **PREVIOUS** to move to the previous defect.
- Highlight a defect on the defect list tab in the ***Status*** pane.
- Click a defect in the wafer pane or zoom box.

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, switch to a lower power objective for finding a defect, and increase magnification as needed to view each defect. It should be possible to stay at 50× with a 6XXX or 7XXX map, or 100× with a 21XX or AIT.

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

## Optical Controls

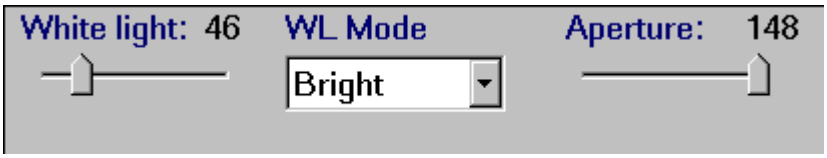
There are other ways to change the image of a defect, and to create different image types. The following sections describe several such methods.

**Figure 2-35 White Light Image Controls**

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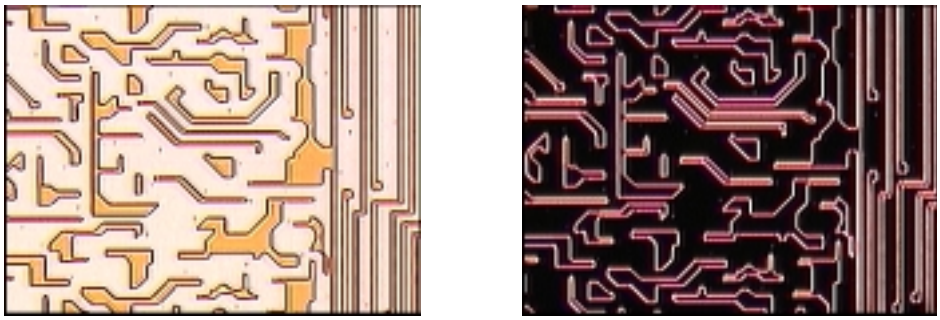



The White Light Intensity is set automatically according to the objective, but it can be adjusted for particular surfaces. Some reflect more or less light than the average, and need the intensity adjusted in order to give maximum visibility to specific features.

**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. Since most of the light is lost, higher illumination levels are needed for DarkField illumination. Flat surfaces appear dark, while edges and particles stand out clearly. DarkField objectives are available for the CRS in 5×, 20×, and 50×, but not at higher magnifications, since there would not be enough light.

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

**Figure 2-36 BrightField and DarkField White Light Images**



The laser image controls shown in Figure 2-37 appear to 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× are most commonly used.

The ***FineZ*** slider provides manual control of Fine Z stage movement over a vertical range of a little more than 50 µm. Positioning accuracy is in steps of 12 nm, and is given on the slider in increments of 0.01 µm. Dragging is the fastest way to move the slider over its whole range. Clicking the upper or lower box on the white slider bar moves the stage up or

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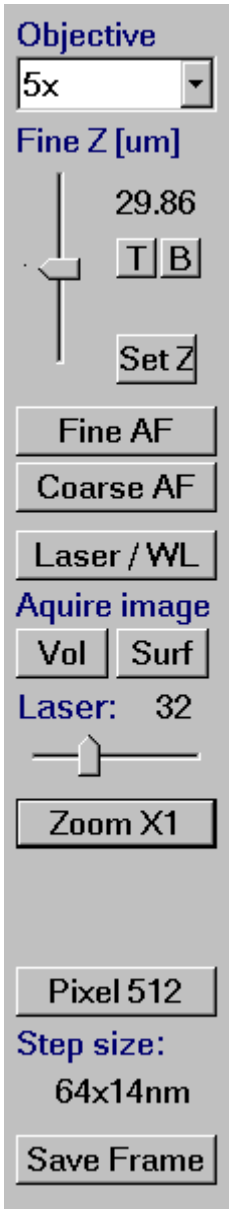
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down by 0.1 µm. The ***S***, ***F***, and ***SetZ*** buttons are used for 3D images, and are described later in this chapter.

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 0.25 µm 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. Flashes of light will appear in the laser window during AutoFocus even if only the white light view is turned on.

**Figure 2-37 Laser Image Controls**




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. 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.

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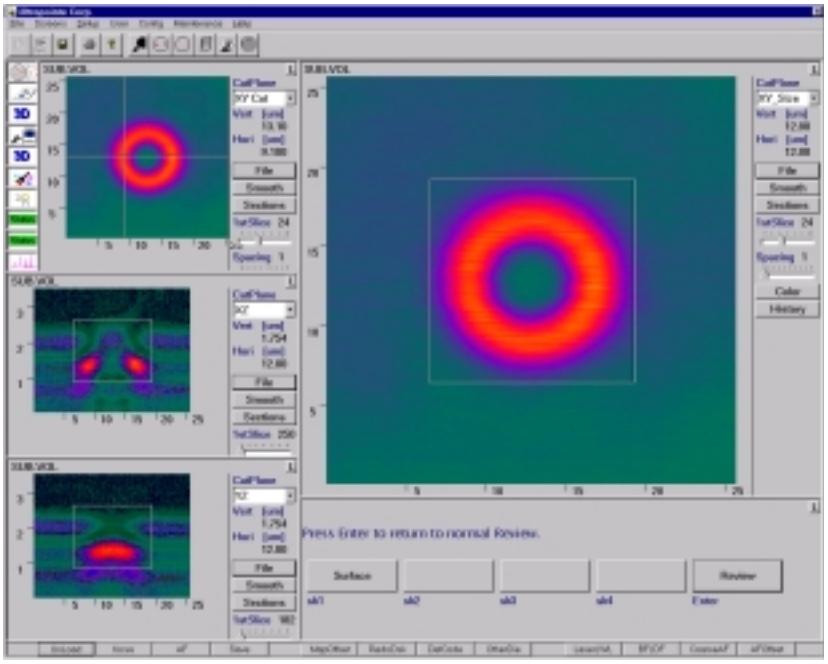
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## Making 2D and 3D Images

Once a defect is centered in the field of view, the CRS is ready to make 2D and 3D images. The unique images of the KLA-Tencor CRS give 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.

Figure 2-38 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 the major feature. At the right the horizontal and vertical sizes of the area inside the cursor appear.

**Figure 2-38 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 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 volume, cut down from 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

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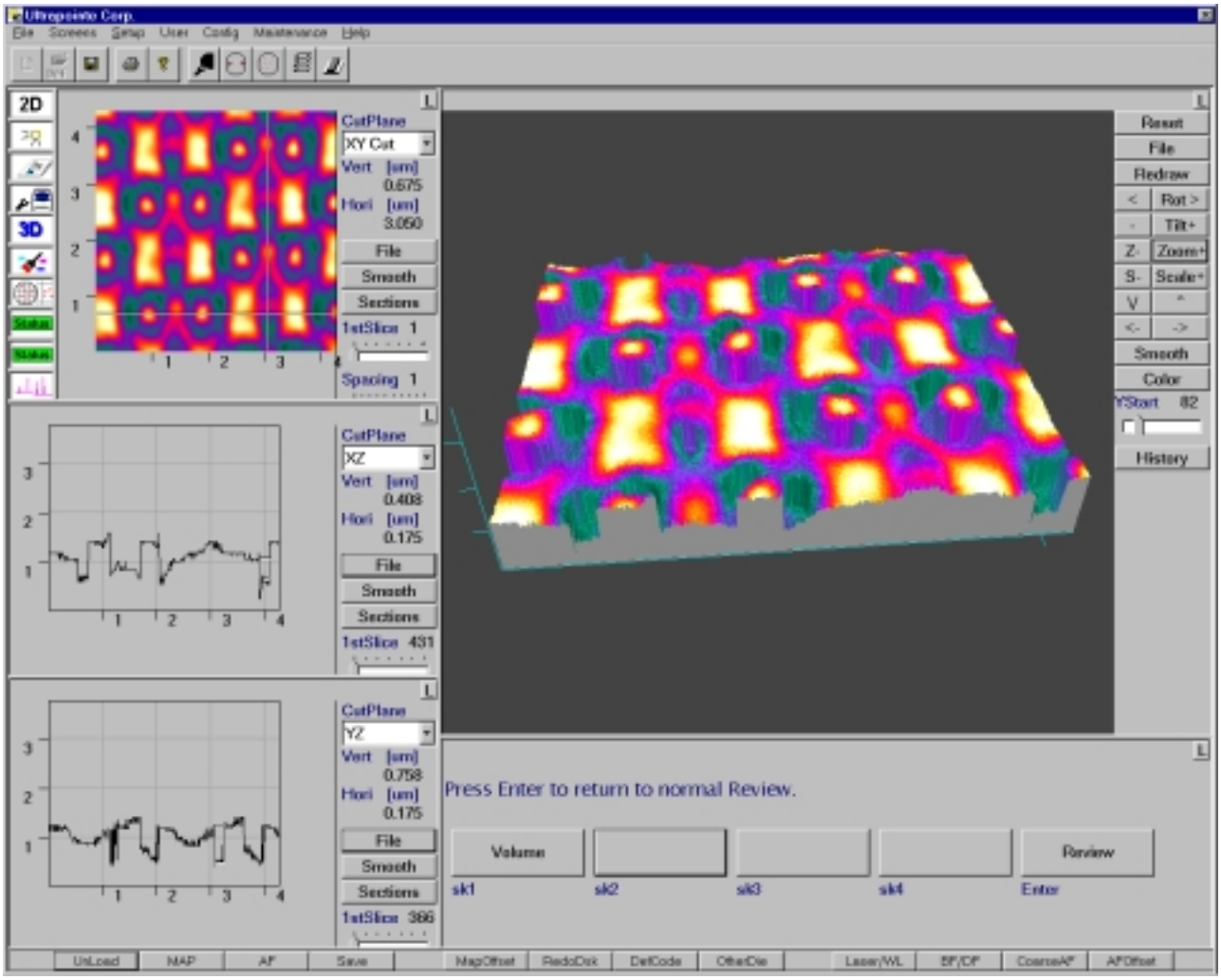
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and volume images can be rotated in three dimensions. The user can zoom in on any point in the image, and can stretch the image height to make pits and particles stand out.

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.

Figure 2-39 is an example of a surface image screen. The main view in the large image pane is the surface of the wafer, displayed at an angle so that features above and below the average surface level appear clearly. The image is cut at the ***YStart*** plane, showing the surface profile which is also visible in the ***XZ*** pane to the left. The view from directly above is in the top left window. It shows the same data as the surface window, but completely flattened. Unlike the volume image, different XY slice settings give exactly the same surface view. The ***XZ*** and ***YZ*** panes show surface profiles along the lines of the cutting cursors.

**Figure 2-39 Surface Image Screen**




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### To Make a 3D Image

1. In the Review screen, click 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.
2. Click the ***Tilt*** and ***Rotate*** buttons to achieve a desirable orientation.

### 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. The window contains several sets of controls. There are image type radio buttons, directory radio buttons, user account name radio buttons, and a file name scroll list. After making selections, clicking the ***Load*** button brings the selected image file into memory for display.

### 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 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 Print Images

Interesting images can be captured in hardcopy for the user's log book. It is useful to record the image settings at the same time.

1. Click the **PRINT** button in the button bar, or select **Print** from the **File** menu, or press **CTL+P**. The standard Windows NT ***Print*** dialog box appears.
2. Select the appropriate printer model and click ***OK*** to start the printing process.

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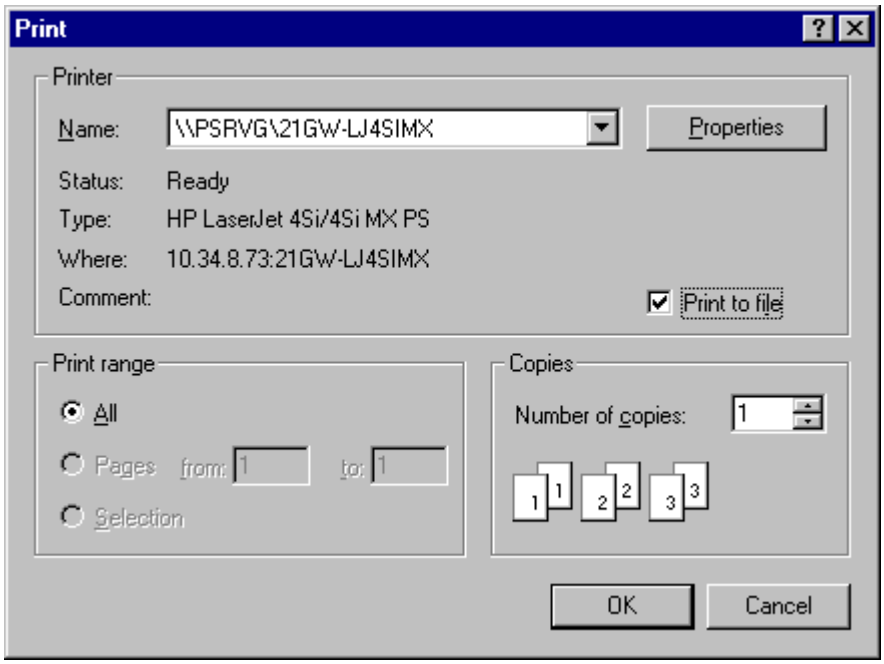
**TIP**

*To print a copy of any window, select the* **Print** *option from the* **Print** *menu in that window.*

## To Save Images to Files

1. Click
   - The ***Capture*** button in a white light image pane, to save the white light image only.
   - The ***Save Frame*** button in a laser image pane, to save the laser image only.
   - The ***FileList*** button in a library pane to save the image in that pane.
   - The **PRINT** command on the **File** or **PRINT** menu in any window, or the ***Print*** button on the button bar in any screen. Then click in the ***Print to File*** checkbox in the ***Print*** dialogue box, as in Figure 2-40, and then on the ***OK*** button.

**Figure 2-40 Print to File**




These buttons bring up the ***File Selection*** dialog box with an active ***Save*** button. Note that the **Laser Images** command on the **File** menu only lets the user load images, not save them.

2. Enter a name, choose a directory, and click ***Save***.

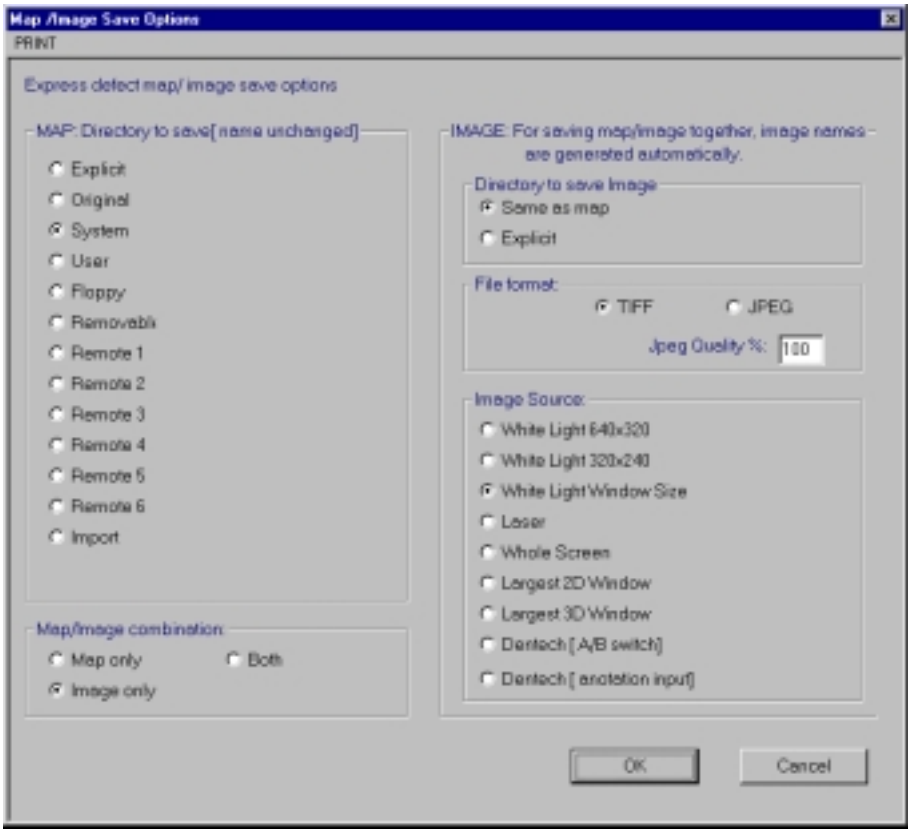
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3. To set options for ***Map/Image Save*** in a particular recipe, load the recipe, and then open the ***Recipe*** window again. Click ***File Save Options*** to bring up the ***Map/Image Save*** window, shown in Figure 2-41. In this window are five sets of radio buttons for various options. The user can set the directories for saving the map file and the image file; whether to save the map alone, the image alone, or both map and image; the image file format (TIFF or JPEG/100%); and the image source (white light image, laser image, whole screen, a particular pane, or two other options for a CRS connected to a Dentech unit).

**Figure 2-41 Map/Image Save Window**




4. Enter a name, choose a directory, and click ***Save***. This saves the entire screen.

**TIP**

*Pressing the key combination* **CONTROL+PRINT SCREEN** *copies the current window to the clipboard. Pressing* **ALT+PRINT SCREEN** *captures the entire screen. In either case the user can paste the clipboard image into any other application that handles images, such as the Windows Paint accessory, and save the image in a file on disk.*

## Classification

1. Press the **ENTER** key or click ***Return to Review*** to return to the review window.

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2. Click the **DefCode** tab in the ***Status*** pane. This will bring up a list of defect code numbers and names, and show the name of the defect code file currently loaded.
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**. Trainees may make entries in the wafer map provided for their practice.
4. Continue moving to defects and viewing them in various modes, including white light and laser at various magnifications, and surface or volume images. Try to determine what the various controls do.

   The instructor might tell the trainee to look at all the defects on the first wafer, or to go on to other wafers without looking at everything.

## Unloading the Wafer

1. When done looking at defects on the first wafer, click the **UNLOAD** button or press **F1** to unload the wafer. The robot returns the wafer to the cassette and the screen configuration returns to the starting layout, ready for loading the next wafer.
2. Continue to load, deskew, and review wafers as instructed. When finished, or when taking a break between wafers, log out of the application and leave it ready for someone else.
3. A prompt automatically appears at the end of a lot, offering to save the newly classified data. Trainees may choose to keep the new classifications, or discard them and leave the original data unchanged.

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## Logging Out

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

There is still much more to learn about such things as file handling, defect types and codes, and various setup options, before a trainee is ready to classify defects. Most of the information needed is specific to the company's processes and products, and cannot be provided here. Engineers who intend to continue further to learn how to administer accounts and set up recipes will want to go through the more advanced chapters of this manual.

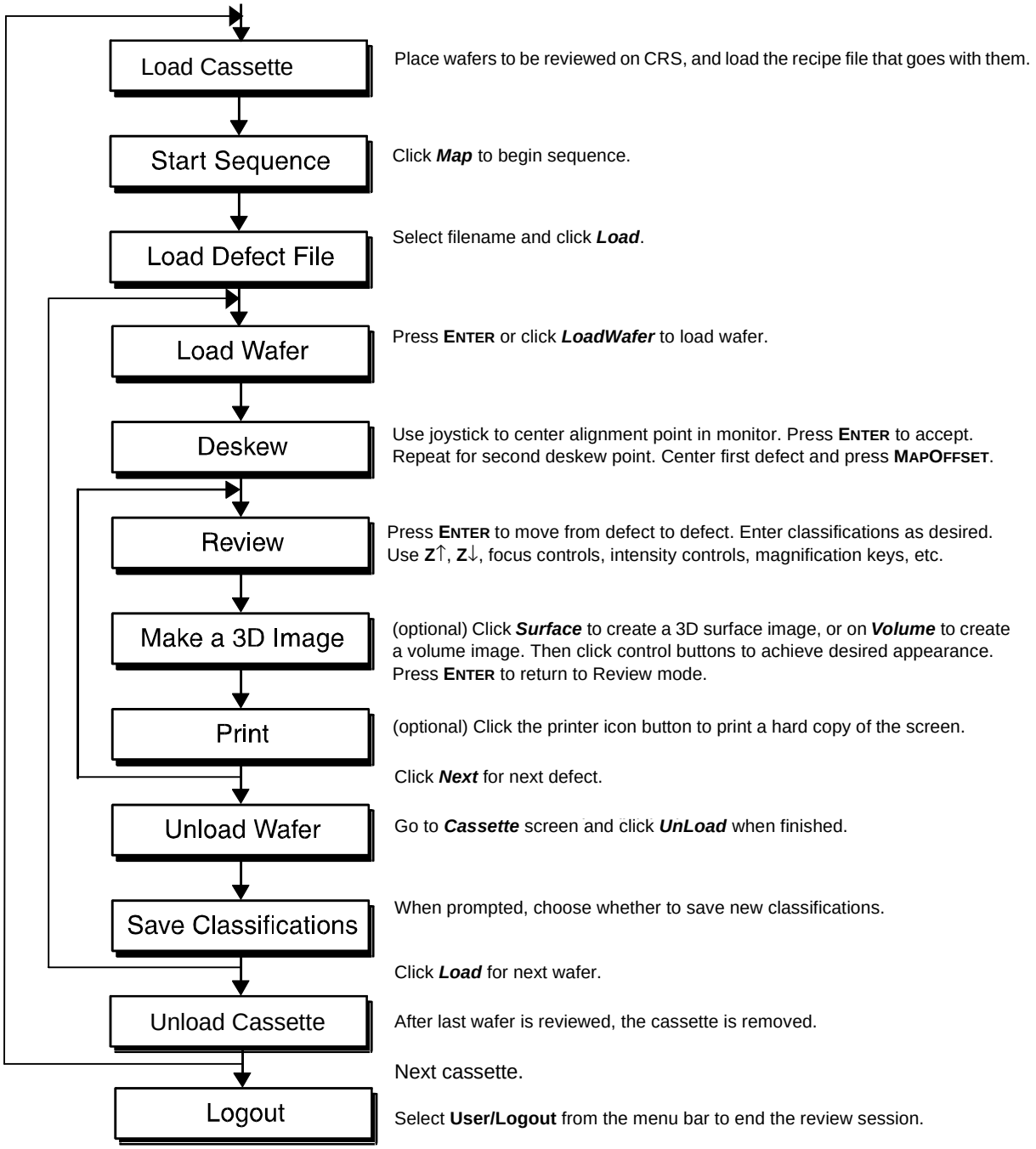
# KLA-Tencor CRS Sequence Flowchart

The flowchart in Figure 2-42 summarizes the basic steps using the KLA-Tencor CRS.



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**Figure 2-42 KLA-Tencor CRS Basic Operating Sequence Flowchart**




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# 3

# Deskew Setup

## Overview

Deskewing is the process of measuring the placement of the current wafer and calculating corrections to the wafer map, so that defects can be accurately moved into the field of view of the microscope. Errors arise from variations in wafer placement on the stage, and from similar variations in placement and calibration on the wafer scanner that produced the defect map.

The manual deskew process is described in the “Tutorioal” chapter. Automatic Deskew, or Auto 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 ensures that all defects appear in the center of the field of view. Loading and automatically aligning an 8-inch wafer requires just over a minute. That is as fast as a highly trained operator, but with accuracy and repeatability that a human cannot match

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This chapter covers setup for manual and automatic deskew on patterned and bare wafers. On a patterned wafer, the deskew process uses fabricated device features as deskew points, so that deskew can be set up once for an entire process level. A bare wafer has no regular features. Defects can be chosen as deskew points on each wafer individually, or the edges and the location of the wafer notch can be used to set up deskew for all wafers of a given type.

The flatfinder, or prealigner, normally rotates a wafer to within 0.04° of the correct alignment, and centers the wafer to within 0.0015 in. (38 µm). It is impossible to perform a physical calibration of the prealigner to match the 0.50 µm precision of the stage in the CRS, but it is easy to deal with these positioning errors in software. The process requires measuring the positions of two deskew points and one defect point on each newly loaded wafer, and using those measurements to calculate corrections for the entire wafer. Offsets to two points on the same wafer street give the correction for rotation, and the offset to the first defect after correcting for rotation gives the translation corrections in X and Y. Using these calculations, the CRS can position defects routinely within the field of view of the microscope, even at high magnification.



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# Choosing Deskew Points

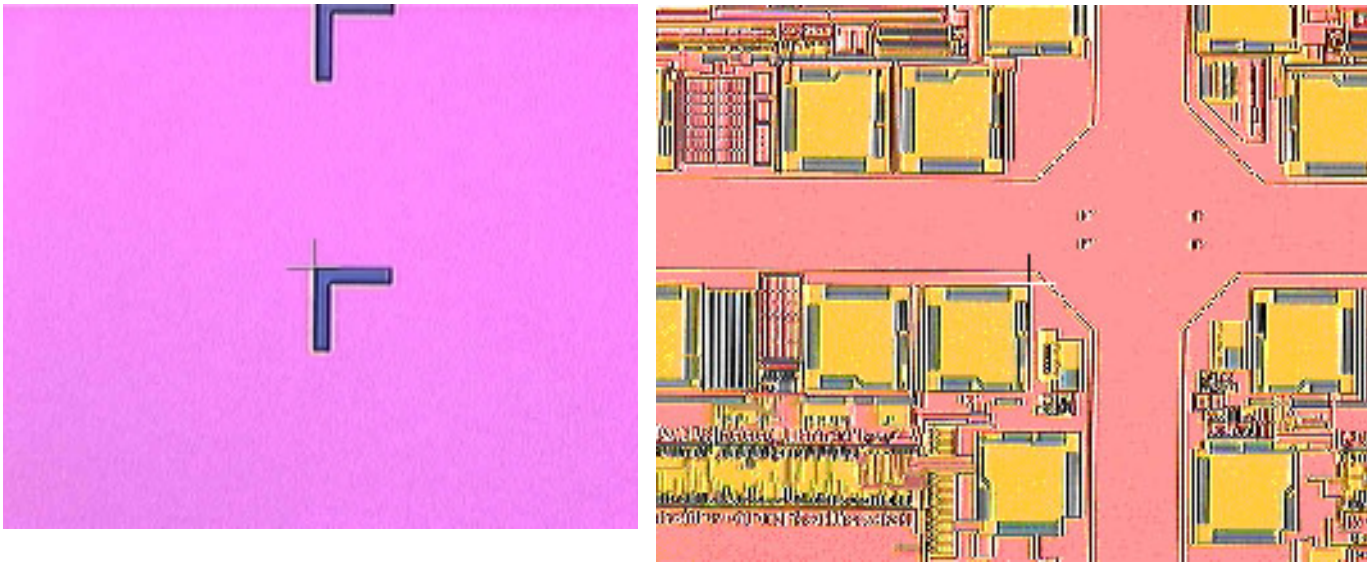
AutoDeskew on pattern wafers uses die dimensions and offsets, defined in the wafer map, to choose approximate deskew points at or near die corners. The precise deskew points have to be chosen in this region. They can be die corners or any other distinctive features. Many wafers have features in the wafer streets, as in Figure 3-1, some of which may be suitable. These, however, are not suitable.

The crosshairs in the image on the left in Figure 3-1 are perfectly centered on a feature that can be used as a manual deskew point. However, this is not a good deskew point for AutoDeskew, as there is an identical feature with the same orientation nearby. Repeating, highly symmetric features on multiple axes are poor choices for deskew points. As the software relies solely on image matching, and has no other information about the location of the deskew point, the software cannot tell if the correct feature is selected.

In the image on the right in Figure 3-1, where all of the "L" shaped features are visible, it is easy to tell where each feature fits in the larger pattern, but at high magnification they can confuse the system, which might 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 left pair of features, or the pair on the right.

**Figure 3-1 A Poor AutoDeskew Point**

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A better deskew point selection is a feature that is unique and easily seen at low magnification, as in Figure 3-2. This is better because features around it are different on both axes and have high contrast. Die corners are among the best choices for deskew points.



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**Figure 3-2 A Better AutoDeskew Point**

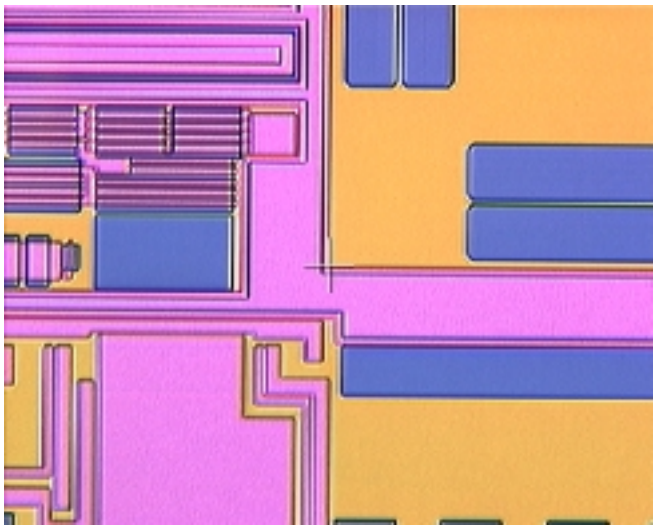


**Figure 3-3 Deskew Points on Wafer**

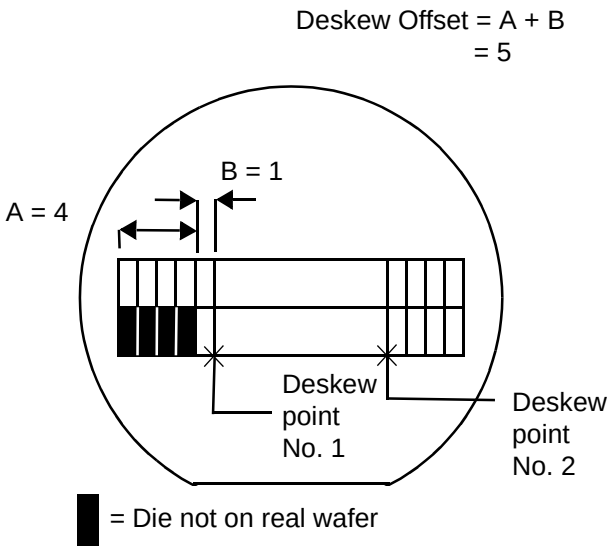



Figure 3-3 shows schematically (not to scale) where the deskew points might be located, at die corners, and some of the calculations done in the software to find the right die corners. Trying to locate a corner of a die that does not exist will of course fail, so the recipe can specify that a die location further from the edge will be chosen. The offset can be to the first real die, or if necessary one further in. The figure shows the first X-axis offset. The second X axis offset is counted from the right edge toward the left. In some cases, it may be advantageous to use a higher or lower wafer street for deskew, in which case an offset along the Y axis can be set. These parameters are normally set in the wafer map at the scanner, and need not be changed at the CRS.

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# Manual Deskew Setup

## Pattern Wafer

1. Load the appropriate recipe and map files.
2. Load a wafer of the desired process level.
3. Click ***SkipDeskew*** to go to the ***Review*** screen.
4. Click ***Laser/WL*** to turn on the laser image.
5. On the **Setup** menu, select **Deskew Options**.
6. Drag the ***Deskew Options*** window to the bottom left of the screen, so that the white light image pane is fully visible and most of the laser image pane is unobstructed.
7. Click ***Pattern Manual***.
8. Enter ***Deskew Die Offsets***, if necessary.
9. Select the desired magnification for review under ***Objectives***.
10. Click ***Deskew1***.
11. Click ***Low Mag***.
12. Verify that the deskew point is in the field of view, and use the joystick to align it with the crosshairs.
13. Click ***Hi Mag***.
14. Verify that the deskew point is still in the field of view.
15. Click ***Deskew2***.
16. Repeat Step 11 to Step 14 for the second deskew point.

If the deskew points do not appear within the field of view at high magnification, it is necessary to check the wafer map. Navigate to several die corners in different parts of the wafer, update the coordinate display, and check whether the reported position on the diagram in the wafer map pane is an intersection of the diagrammed wafer streets. If there is a problem with the map, corrections must be made on the wafer scanner.

## Bare Wafer

Setup is not required for bare wafer deskew with defects. The operator can choose defects as deskew points as each wafer is loaded.

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# Pattern AutoDeskew

Table 3-1 lists the steps in setting up AutoDeskew on a patterned wafer.

**Table 3-1 Setting Up AutoDeskew**

| | |
|---|---|
| Preliminaries | 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 panes with crosshairs for lining up the deskew points
- The joystick
- The ***Deskew*** sequence pane in the ***Deskew*** screen
- The ***Deskew Options*** window for other deskew settings, from the **Setup** menu
- The ***Wafer Map*** pane

The ***Deskew*** screen, in Figure 2-13 on page 2-14, 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 data, depending on the current selection on its option menu. The deskew setup functions include setting the location of deskew points and calculating the map offset.

Figure 3-4 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.

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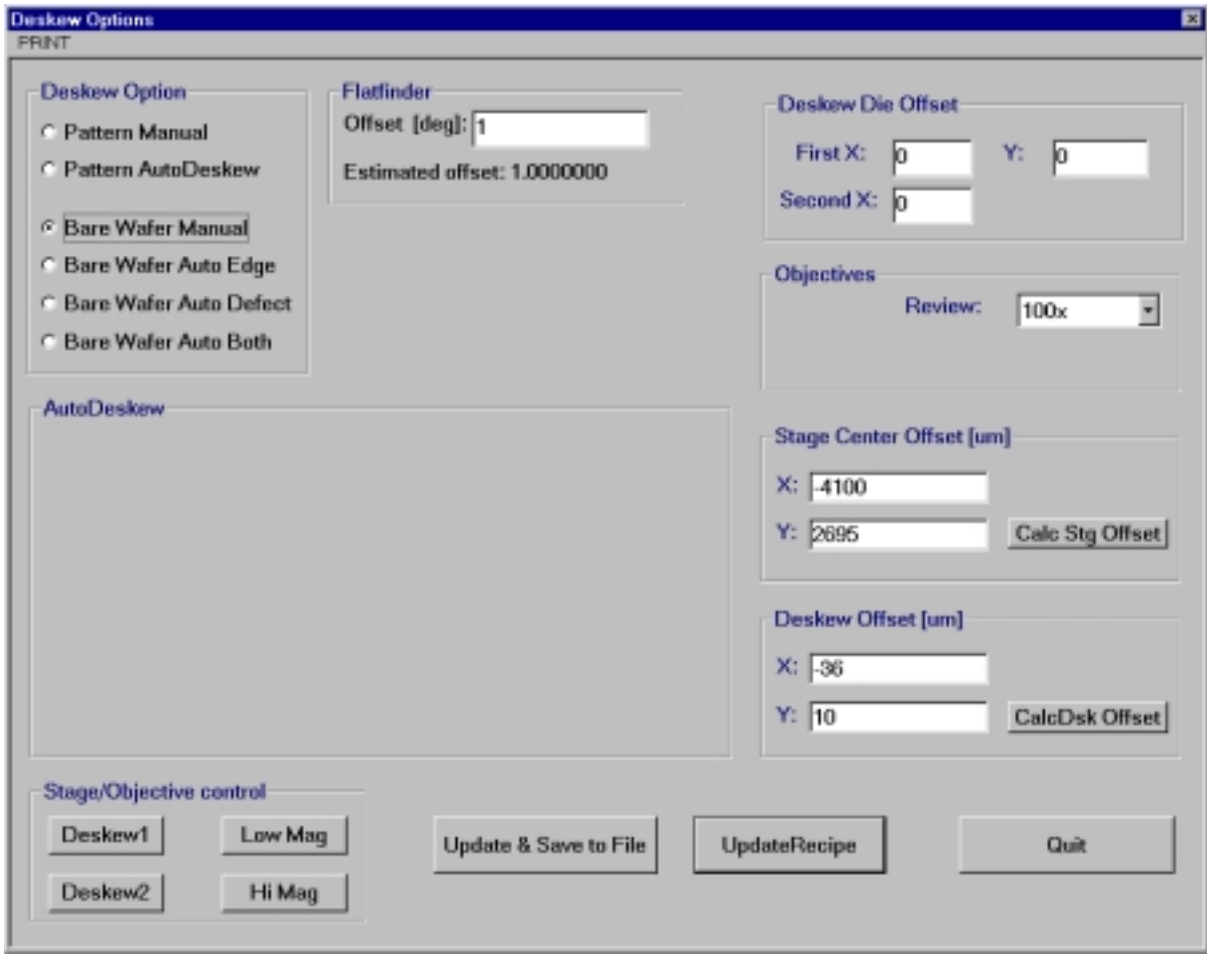
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**Figure 3-4 Deskew Sequence Pane**




Figure 3-5 shows the Deskew Options window, with controls for choosing among the different methods of deskewing, setting various offsets, and saving the deskew settings in the recipe file. At the bottom left of this window are controls for moving to deskew points and changing objectives, so that the entire deskew process can be performed in this window.

**Figure 3-5 *Deskew Options* Window**




For a fresh setup, it is good to verify deskew points by first performing a manual deskew before attempting AutoDeskew. Typically it will be possible to set up a recipe with

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AutoDeskew for a process layer and modify it slightly for use on other layers of the same product. Choosing a feature such as a die corner that is visible on all succeeding layers means that it will only be necessary to capture new images of the deskew points after each process step that is to be reviewed.

1. Load a recipe to be modified, and save it under a new name.
2. Select **Deskew Options** from the **Setup** menu.
3. Click the ***Pattern AutoDeskew*** radio button.

   The ***Reference Image Name:*** field is a text entry box for the image file name for deskewing this wafer type. 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.
4. Low magnification deskew is done at 5×. The ***AutoDsk, HiMag*** option menu offers the list of available objectives. A good choice is 50×.
5. Select an objective from the **Objectives Review:** option menu for performing review. A good choice here would typically be 100×.
6. There are two text entry boxes for setting up the X and Y map offsets, described in Figure 3-3 on page 3-3.
7. Enter 0 into the ***Offset [deg]*** entry field under ***Flatfinder***.
8. Close the window, and perform a manual deskew.
9. Select **Setup/Deskew Options** again from the menu.
10. The system will automatically calculate and display an estimated flatfinder angle offset in the ***Deskew Options*** field. Enter the number shown as the ***Estimated offset:*** into the ***Offset [deg]:*** text box.
11. Click the ***UpdateRecipe*** button to save the settings in the currently loaded recipe file, or on the ***Update & Save to File*** button to save to a different file.
12. 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.
13. Center the deskew point and set the stage offset using the ***Calc Stg Offset*** button.
14. Save the recipe again at this point.
15. Click this button 

to capture two reference images for the first deskew point.
16. Follow the instructions in the window that appears.

    The system will switch objectives to the high-magnification objective selected in the Deskew Options window.
17. 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.
18. Accept the first deskew point by clicking <Accept> in the SeqStat pane or selecting <Enter> on the keyboard.
19. Select Deskew Options again to continue.

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20. Select the second image capture button to capture the reference images for the second deskew 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 \ultrap\uv\data named with the user entered deskew image name appended with 1, Hi1, 2 and Hi2:

    deskew1.tif

    deskewHi1.tif

    deskew2.tif

    deskewHi2.tif

21. Load the four deskew reference images previously captured into memory by clicking Load Ref Images.
22. Save changes and close the Deskew Options window by clicking the ***UpdateRecipe*** button.
23. Select ***Redo Deskew*** from the keyboard or the screen.

    If all the steps have been carried out correctly in the proper order, the system will AutoDeskew the wafer and drive to the first defect location.

24. Center the first defect point on the crosshairs and push the **MAPOFFSET** key on the keyboard.
25. 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.
26. When satisfied with the map offset, open the ***Deskew Options*** window from the **Setup** menu. Click the ***Calc Stg Offset*** button and enter the offset numbers for the X and Y axes. When done, click ***UpdateRecipe***.
27. After this has been done, retest the AutoDeskew function to make sure that it works well by selecting ***RedoDsk*** 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.

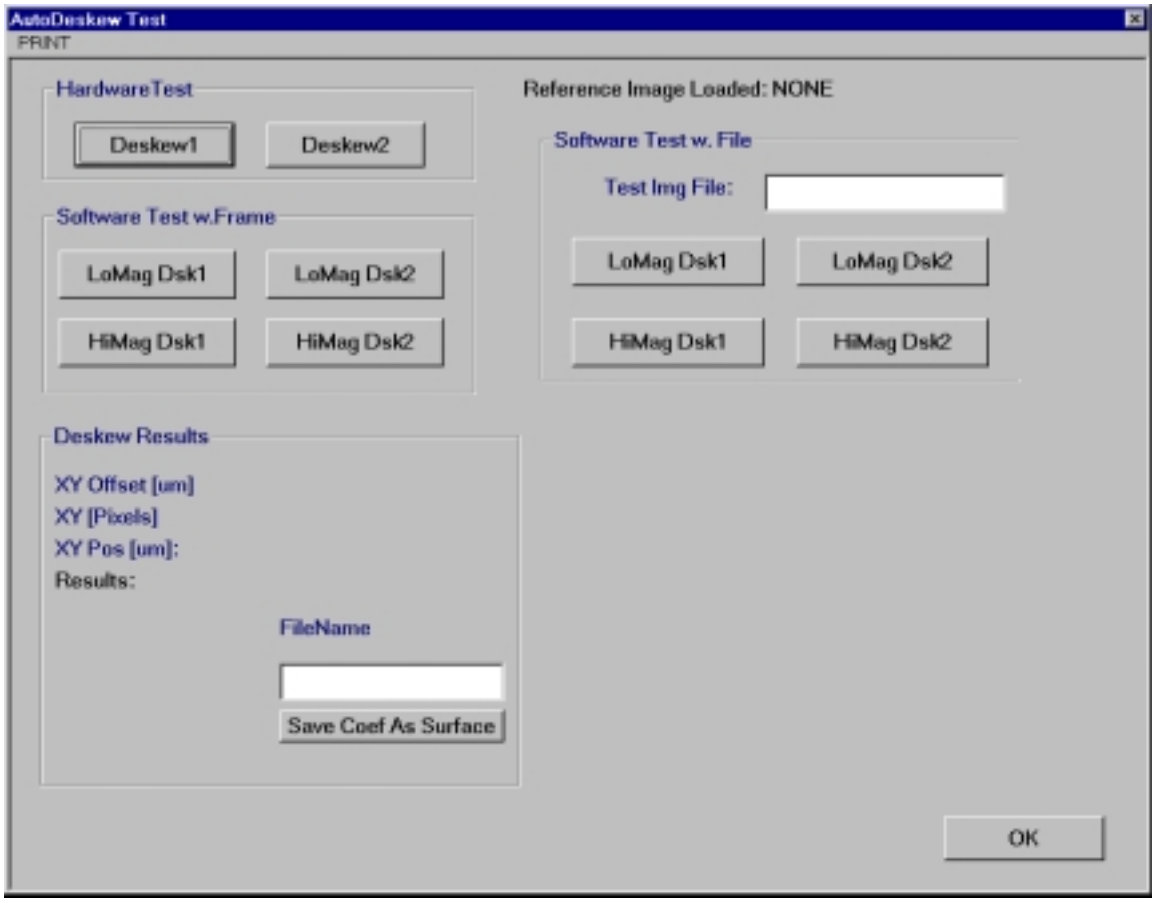
A further test has been added to the version 2.4 software. Select **AutoDsk Test** from the **Maintenance** menu to get the window in Figure 3-6. Click the ***HW Test*** buttons to drive to the deskew points, and on the ***SW Test*** buttons to check matching between the screen image and the stored image files. The window will report results for the deskew operation in microns and in pixels.

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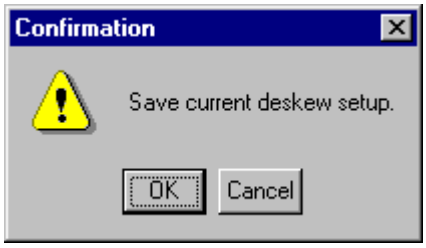
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**Figure 3-6 Testing AutoDeskew**




AutoDeskew is set up for this process level and product type.

**Figure 3-7 Save Deskew Setup Alert**




## Bare Wafer AutoDeskew Setup

Much of the process of setting up AutoDeskew on bare wafers is similar to the process for patterned wafers. Determining and entering values for ***Flatfinder***, ***Stage Offset***, and ***Deskew Offset*** is done in the same way. The main differences are in the selection of

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deskew points and (for deskew with edges) the capture of deskew images. Naturally, the die parameters are irrelevant on bare wafers.

Clicking Bare Wafer Auto Edge brings up a button for initiating AutoDeskew image capture. The deskew points are on the wafer edge, where it is horizontal or vertical, and the center of the wafer notch.

Clicking this button brings up a window similar to Figure 3-8. When the user clicks on the **>>** button, the software automatically advances the stage to the vicinity of the edge on the next of the four sides in turn, in the sequence ***Edge0***, ***Edge90***, ***Edge180***, ***Edge270***. In each case, the user finds the portion of the edge that most closely matches a horizontal or vertical line, and aligns that point with the cursor, as in Figure 3-8. The fifth and final point to match is the center of the wafer notch, shown in Figure 3-9.

**Figure 3-8 Bare Wafer Left Edge**

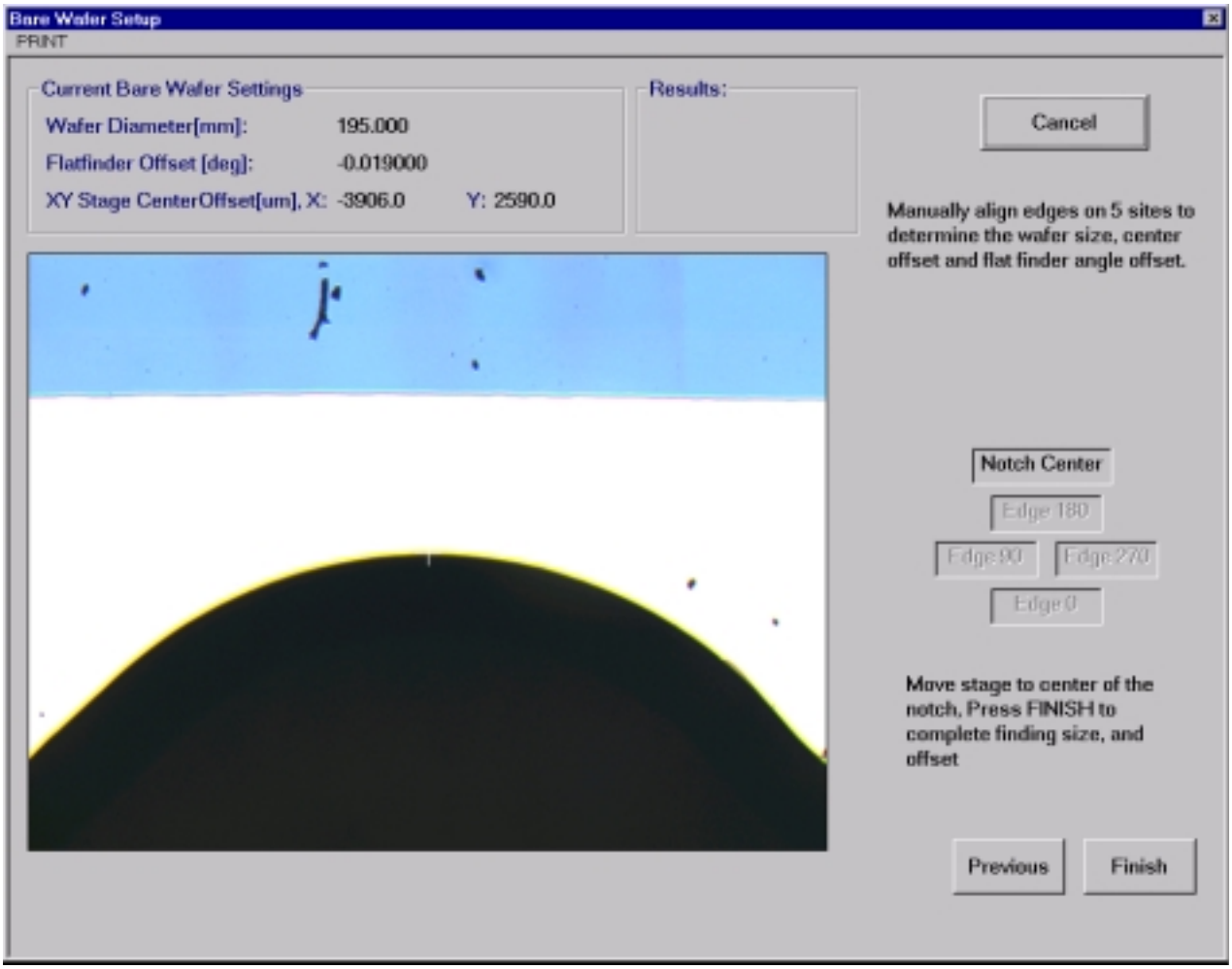



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**Figure 3-9 Bare Wafer Notch Center**




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# 4

# Advanced Operation

## Recipes

A *recipe* sets a variety of parameters and other defaults for a particular process level of a semiconductor product. Among these settings are

- Laser and white light illumination
- Display options such as resolution, zoom, color mappings, and crosshairs
- Wafer thickness for each diameter
- Deskew methods parameters
- Defect sorting and selection criteria
- Image save options
- ADC options

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### To Set Up a Recipe

1. Click **File** at the top menu bar and select **Recipe**.
2. Click ***LaserParms*** at the upper right of the pop up window.
3. Enter the desired values for ***White Light*** and ***Laser Intensity %***, ***Stage AF Intensity***, ***Zoom***, and ***Sample Thickness***. It is usually not necessary to change any other settings. Click ***OK*** when done.
4. To set up defect sort criteria, click ***SortParms***. Choose selection and sort criteria from the pull-down menu, then click ***PasteDn*** (or ***PasteUp***) to enter the new criteria. Click ***OK*** when done.
5. In the same way, click ***File Save Options***, ***Deskew Parms***, or ***ADC*** and make any needed changes. (Consult Impact ADC documentation for assistance with ADC settings.)
6. Click ***OK***, ***Quit***, or ***Close*** when done, or ***Cancel*** to leave a window without saving changes. Clicking ***X*** in the upper right corner of a window is equivalent to clicking ***Cancel***; it closes the window without saving changes.



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7. To save changes, select or enter a file name, choose a directory, and click ***Save***. Quit when done.
8. When new settings are saved to an existing recipe file, the alert shown in Figure 4-1 will ask for confirmation.

**Figure 4-1 Confirm Saving Changes to Recipe**




**TIP**

*To load the same recipe automatically at every login, use the login name as the file name for the recipe.*

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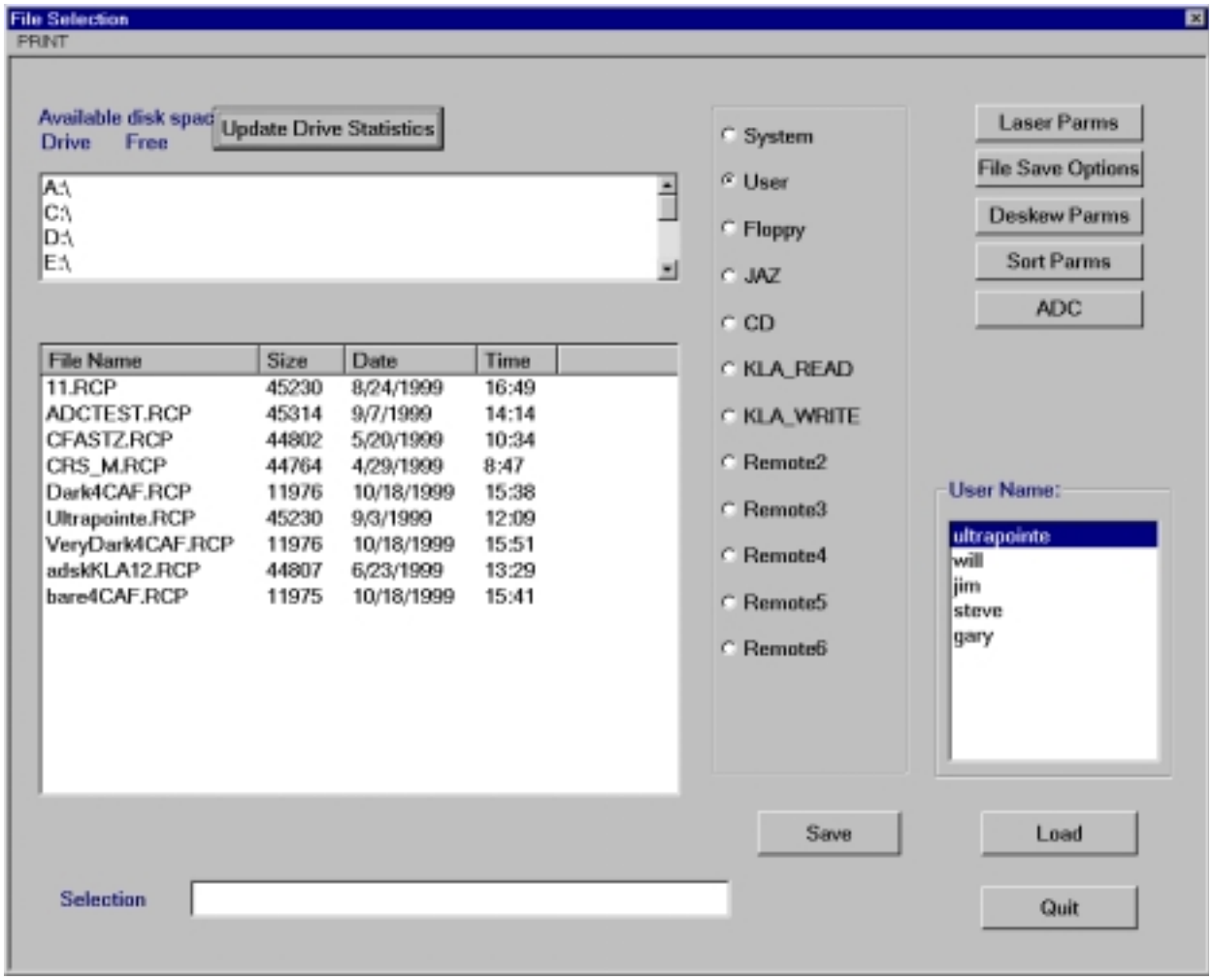
## To Retrieve a Recipe

Click **File** at the top menu bar and select **Recipe**. Select the directory, highlight the name of a recipe, and click ***Load***.



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**Figure 4-2 Recipe File Window**




Options in the **Config/System misc.** command can link a recipe to identifying characters of the Lot ID or Process ID to allow for automatic loading. See the description of "System Misc." on page 6–76, and Table 6-26, "Automatic Recipe Load Option Menu" on page 6–78.

## Setting Laser Intensity Values

KLA-Tencor strongly recommend that users obtain guidance from a KLA-Tencor CRS applications engineer before attempting to adjust these values.

There are two ways to adjust the laser scan parameters:

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

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## To Adjust the Laser Scan Parameters (Basic Method)

1. Load a wafer and go to the ***Review*** screen.
2. Select a 100× or higher objective. Center the ***FineZ*** slider bar in the laser window near 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 bright parts of the laser image color are gold in color). Write down the value.
4. Click **Maintenance** at the top menu bar and select **Manual Stage Control**. In the ***Stage Test*** window, highlight ***Z Dist Fr ConfigLim***. Read the number that appears above the command buttons.
5. Subtract 30 from the number to get the sample thickness parameter, and write it down. Quit when done.
6. Click **Setup** at the top menu bar and select ***Laser Param***.
7. Adjust the ***Sample Thickness*** slider bar for the wafer size to the number found in step 5.
8. Set the ***LaserIntensity%*** to the value found in step 3. Set the ***Stg AFIntensity*** to 30. Click ***OK***.
9. Test Coarse AutoFocus with a 5× objective and again at 100× or higher. Repeat at a few locations on the wafer. If it autofocuses properly then stay at the 100× or 150×, and drive to at least 10 defects to test Coarse AF. If everything is fine, then record the ***LaserIntensity%***, ***Stg AFIntensity*** and ***Sample Thickness***.
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.

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## To Adjust the Laser Scan Parameters (Advanced Method)

1. Load a wafer.
2. Switch to a 100× or higher objective.
3. Center the ***FineZ*** slider bar in the laser window near 26.
4. Use the joystick in Z-mode to bring the sample into focus.
5. Adjust the ***LaserIntensity*** slider bar in the laser window until the laser image is comfortably bright.
6. Click **Maintenance** at the top menu bar and select **Manual Stage Control**.
7. In the pop-up window, click on***Z Dist Fr ConfigLim***. Read the number that appears above the command buttons, and subtract 30 from it. This will be the sample thickness parameter. Select ***Quit*** when done.
8. Click **Setup** at the top menu bar and select **Laser Param**.
9. Adjust the ***LaserIntensity%*** to the number found in Step 5.
10. Adjust the ***Thickness*** slider bar to the number found in Step 7.



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11. 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.
12. Set the ***Stg AFIntensity*** to a value around 10.
13. Click ***OK***.
14. Do a stage autofocus for different objectives.
15. Write down whether the autofocus failed or not at any objective.
16. Increase the ***Stg AF Intensity*** by 5.
17. Repeat steps 14–16. Stop when autofocus fails for all objectives.
18. Summarize the results in a table similar toTable 4-1:

**Table 4-1 Autofocus Performance Versus Laser Intensity**

| Laser Intensity | Stage Autofocus Performance |
|---|---|
| 10 | Failed |
| 15 | Failed |
| 20 | OK |
| 25 | OK |
| 30 | OK |
| 35 | OK |
| 40 | OK |
| 45 | OK |
| 50 | OK |
| 55 | Failed |
| 60 | Failed |
| 65 | Failed |
| 70 | OK |

19. Move to a spot on the wafer where the reflectivity is moderate. Repeat the process above and construct another table (similar to Table 4-1) for the moderate reflectivity region of the wafer.
20. Move to a spot on the wafer where the reflectivity is the highest (for example, a metal area). Repeat the process to construct a third table for the high reflectivity region.
21. Examine all three tables carefully. Find the laser intensity that allows for the best stage autofocus performance in all three reflectivity regions.

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22. Click **Setup** at the top menu bar. Select **Laser Param**. Enter the best laser intensity value under ***Stg AF Intensity***. Click ***OK*** when done.
23. If this procedure fails to find a suitable autofocus level, it is advisable to check the optical alignment. If there are alignment problems, a service call is probably necessary.

# 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. The stage moves to the first deskew point based on the coordinates provided by the map.
2. In the wafer window, note the XY location as X1, Y1.
3. Use the joystick to center the first deskew point in the field of view. Click the ***Update*** button to see the XY coordinates. Write down the values as (X2, Y2).
4. Click ***Setup***, select ***Deskew Options***, and write down the values currently entered for ***StageCenterOffset***. These are the current X-offset and current Y-offset values.
5. The ***StageCenterOffset (X,Y)*** can be calculated by the formula:

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

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## Stage Center Offset for Bare Wafers

Manual method

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



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

9. Enter the new values in the ***Stage Center Offset*** fields.

Automatic method

1. Load map and wafer.
2. Deskew.
3. After the stage moves to the first defect, center the defect using the crosshairs.
4. On the **Setup** menu, select **Deskew Options**.
5. Click the ***Calc Stage Offset*** button.

# 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 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 features but defects. To establish the KLA-Tencor CRS coordinate system, two defects have to be selected as 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. Load a wafer map.
2. On the **Setup** menu select **Deskew Options**.
3. Click the ***Bare Wafer Manual*** radio button.
4. Load the wafer.
5. Switch to dark-field mode.
6. 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*** tab. If the defect is small, select a bigger one. The stage will drive to its location.
7. If the larger defect still cannot be found, drag open a new ***Status*** pane, and click the ***Search*** tab.
8. Click ***Reset Center*** to reset the search path.
9. Press and hold the ***Start*** button until the defect is found.
10. Use the joystick to move the defect to the center of the field of view. Click ***Accept Dsk1***. Click ***OK*** in the pop up confirmation window.

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11. Select the second defect, find it, and move it to the center of the field of view, click ***Accept Dsk2***. Click ***OK*** in the pop up confirmation window.
12. Select any reasonable size defect and Click ***GoToSelected***. The defect should be in the field of view at 5× or 20× if the deskew is correct. If not, push the ***RedoDsk*** key to start the deskew process all over again by using two different deskew defects.
13. 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, examine the defect under 50× (or higher) white light in darkfield mode. A particle looks shiny in the whole area it covers. A pit, on the other hand, usually looks bright around its edge but dim at the center. Of course, if the particle or pit is too small, say 0.1 µm, then not much 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. Darkfield mode is strongly preferred as it eliminates horizontal fringes seen in the live laser image.

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

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

1. Take a volume image by clicking ***Volume*** in the ***Review*** screen. Wait until the image is displayed in the volume image screen.
2. Move the horizontal and vertical cross-hairs in the ***2D XY*** pane so that they run over the defect.
3. Examine carefully the intensity profile in the ***2D XZ*** and ***YZ*** panes. If the defect is a particle, a small dark peak usually appears very faintly above the strong signal band of the substrate.
4. Click ***Surface*** to generate a surface based on the manipulated volume data set. Pull over a 3D window to view the 3D image of the particle.
5. Save the 3D slice data by clicking ***File***, and then on the ***Surface*** radio button, typing in a file name in the selection box, and clicking ***Save***.

   This archiving step is necessary for two reasons: 1) the surface image is 0.5MB as compared 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 in this task, we recommend reviewing in medium power objectives (such as 20× and 50×) and darkfield mode. This is easily accomplished on the KLA-Tencor CRS. However, in later review of a wafer on the SEM, finding defects is even more difficult. Consequently, the coordinate updating feature is provided, for modifying the original wafer map file with the XY stage coordinates of the CRS. Using the updated map file on the SEM can 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 4–7
3. Drive to the 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 the ***EditDefect*** button.
5. Click the ***Modify Current Def*** 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 reviewed.
7. After going through all the desired defects, unload the wafer and save the modified map file, either under the same filename or a different filename.
8. Using this new file on the SEM will give much better coordinate correlation between the wafer and the modified map then there was with the original map.

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## 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.

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.

To measure the Z peak:

1. Load a bare Si wafer. Switch to the objective 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.

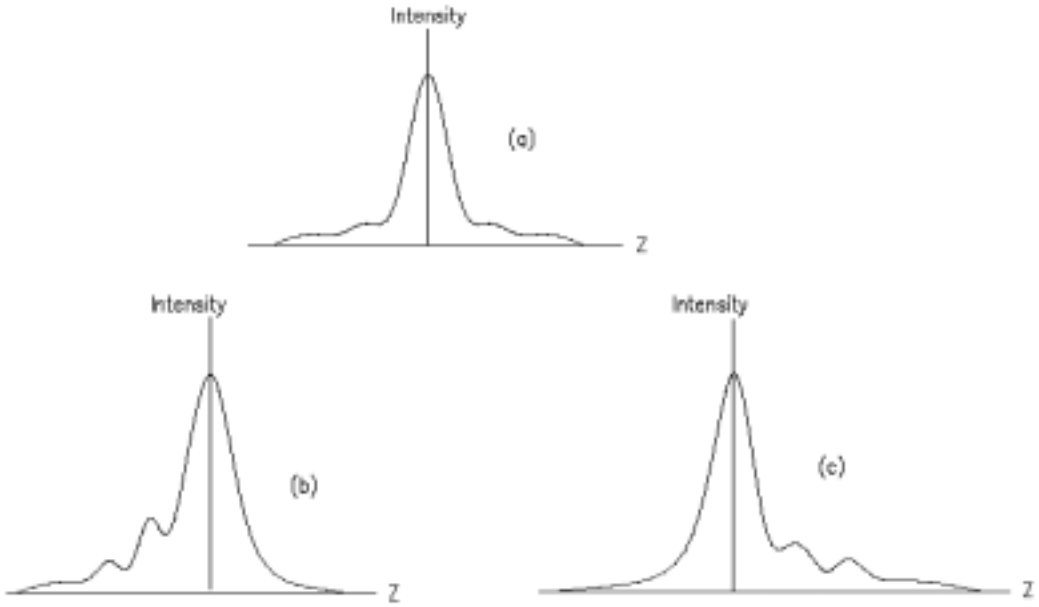


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3. Manually select the Z scan range. From the focus level, move the fine Z stage up 2 µm and hit the small ***T*** button. Move the fine Z stage back to focus level and then move it down by 2 µm, hit the small ***B*** button.
4. Acquire a volume image.
5. Pull up a 2D XY pane. Click the menu under ***CutPlane*** and select **Z Profile**.

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 4-3 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, press the Surface button for 3D imaging. For small, dark defects, care must be taken to avoid the pit/particle problem.

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# Making Wafer Maps

There are a few cases where it may be advantageous to generate a wafer map on the KLA-Tencor CRS instead of on a scanner. The map can be set up for a particular inspection task, as in the following examples.

- Monitoring repetitive defects caused by a defective mask or process tool.
- Monitoring the uniformity of a process, such as the W-plug etch back or the bonding pad profile at specific sites.
- Viewing specific features on a test wafer as a diagnostic for the system optics.

## Creating a Map

1. Choose **Edit Wafer Map** from the **Setup** menu.
2. Enter **`NONE`** in the ***LotID*** and ***ProcessID*** entry fields.
3. Select the right **WaferSize** and **FlatOrientation** from the menus in the window.
4. Select the appropriate slot number from the ***Wafer Info:*** list, and enter a wafer name in the text entry field. Click ***UpdateSlot***. Click ***OK*** .
5. Fill in the ***DieSize*** and ***ZeroDieOffset*** fields if the information is available. If not, they can be measured later in Step 8–Step 14.
6. Click ***OK*** to exit from the window.
7. Select the **File** menu and choose **Wafer Map**. Enter the filename for the new wafer map and click ***SaveFile***.
8. Load the map file in the normal manner.
9. Change to the ***Cassette*** screen. Select the appropriate slot number and click ***Load*** to load the wafer. The stage should stop at coordinate (0,0).
10. Use the joystick to move to a nearby die corner. Record its X and Y positions, which will become the ***Zero Die Offsets***.
11. 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 ***DieSize***.
12. Similarly, in the Y direction, measure the Y ***DieSize***.
13. Unload the wafer.
14. Click **Setup** at the top menu bar and select **Edit Wafer Map**. Fill in the values for ***DieSize*** and ***ZeroDieOffset*** in the appropriate fields.
15. Use the joystick to find a defect or feature that is of interest.
16. In the ***Status*** pane, make sure the **Status** tab is selected. Click ***Edit Def***. The ***Defect Editing*** window opens.
17. Fill in the data fields, then click ***Append***, and then ***OK***.
18. Repeat Step 15–Step 17 until the final defect (feature) has been entered.
19. Unload the wafer, and save the map file again.

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20. Load the wafer.
21. Choose **Deskew Options** from the **File** menu. In the window, select ***Bare Wafer Manual***.
22. Find a suitable defect (or feature) on the left hand side of the wafer to be the first deskew point. Center it in the white light screen. Press **ENTER** on the numeric keypad or click ***Accept*** in the ***Sequence*** pane. Click ***OK*** in the small pop-up window.
23. Repeat Step 22 for a defect on the right side of the wafer as the second deskew point.
24. Unload the wafer, and save the map file again.

Use the newly created map file in the same manner as a map generated by a surface scanner.

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# 5

# Applications

## Subsurface Imaging

IC manufacturing is moving to smaller geometries, higher integration, and complex multi-level connections. Thus, locating and classifying subsurface defects is important to improve yields. The KLA-Tencor CRS, with its ability to identify defects embedded on or below a film transparent to laser light, fits this need. Several examples of this capability are described in Chapter 1. Table 5-1 summarizes the penetration depth of the 488 nm laser line in microelectronics materials[1]:

**Table 5-1 Laser Penetration Depth for Selected Materials**

| Material | Depth, µm | Transparent? |
|---|---|---|
| **Si** | 0.113 | No |
| **Poly** | 0.028 | No |
| **$SiO_2$** | • | Yes |
| **$Si_3N_4$** | • | Yes |
| **Metal** | < 0.01 | No |
| **Glass** | • | Yes |

### 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) changes when moving the Fine Z stage up and down.

1. H.R. Philipp, “Optical Properties of Materials”

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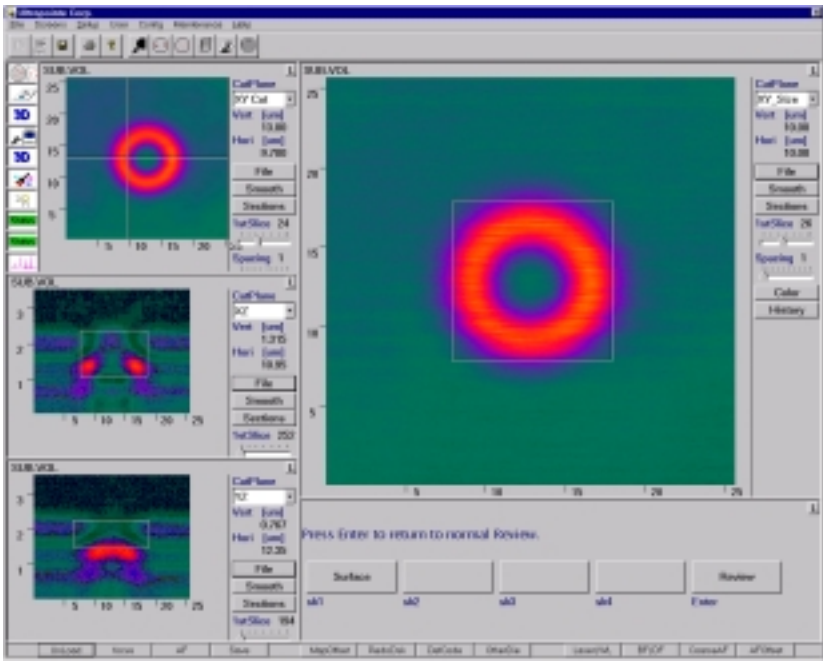
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- It is easier to spot a subsurface defect using a moderate magnification and low NA (numerical aperture) objective, for example 20× or 50×. A 5× objective can be used for large defects.
- If the subsurface defect is located in a complicated pattern 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.

### To Image Subsurface Defects

1. Carefully choose the ***FineZ*** scan range so that it covers the whole film thickness range.
2. Acquire a volume image. Display it in the ***Volume*** screen layout by clicking **Screen** and choosing **Volume**.
3. Switch to ***XY Cut*** view. Move the crosshairs to the defect site. In most cases, one should be able to see the substrate as well as the dielectric film signal in the ***XZ*** or ***YZ*** pane.
4. Change to ***XY_Size***, and use the rubberband cursor to roughly measure how deep the defect is with respect to the film surface. Make sure that the depth between the peaks of the dielectric signal band and the defect signal band is measurable.
5. In the large 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.

**Figure 5-1 Volume Imaging of Subsurface Defects**



6. Examine the multislices and the 2-D XZ or YZ intensity profile carefully. In many cases, two important questions can be answered by this examination:

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- 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 (Is it metallic, poly, or dielectric)? This is based on a comparison between the defect intensity and that of the surrounding devices.

### Limitations

It is not possible to 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 indicate its presence. Talk to a 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 the sample is one of the following:

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

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## Making Measurements

CD measurement 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.

### 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:



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$$Lateral\ Resolution\ =\ 0.5 \times \frac{\lambda}{NA}$$

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

Where Θ is ??. 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 using the 488 nm laser line:

**Table 5-2 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 |

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. Sometimes the return light from the line and the space can cause interference due to the coherent nature of the laser. Table 5-3 lists the NAs of the commonly used objectives.

**Table 5-3 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.

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### General Guidelines

- Use the 100× objective to start.
- The laser scan zoom should be appropriate; that is, the laser field of view should at least cover a few pitches.
- 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.

The confocal 2D XY image from a metal or poly level wafer is usually good. A 100× (or greater) objective is recommended.

Unless coated, photoresist is usually transparent to the laser wavelength. In some cases 3-D imaging is difficult due to strong interference and scattering. Using a different objective may help. 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 rather than the 3D image.

## 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 for certain type of films.

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

### Theory

Figure 5-2 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, so the location 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

$$d_{CRS} = (correction\ factor) \times d_{SEM}$$

The correction factor is a function of

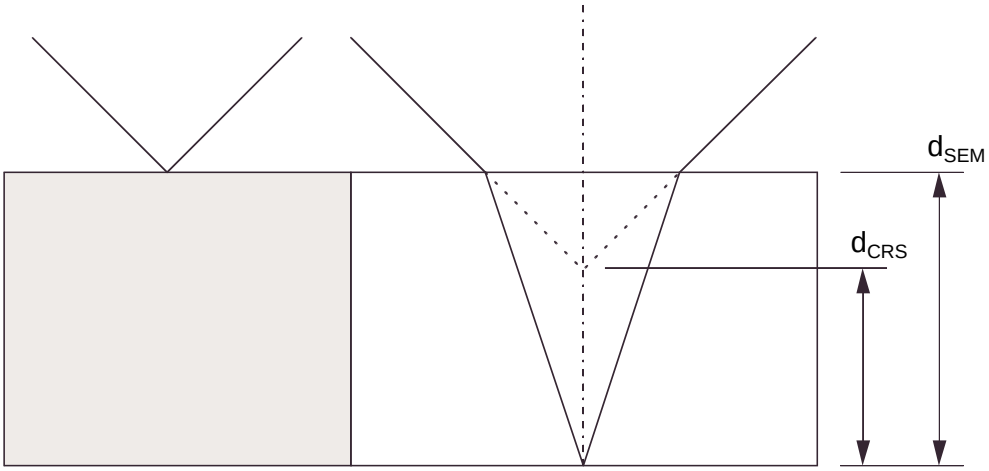
- The index of refraction of the materials involved



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- The film thickness
- The numerical aperture (NA) of the objective lens.

**Figure 5-2 The Optical Thickness of a Transparent Film**




WS03D032
Ufilm Thickness

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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. Carefully choose the ***Fine Z*** scan range to make sure the Z step size is much smaller than the film thickness.
4. Set the laser intensity appropriately. Try not to use too strong an intensity.
5. Acquire a surface image and measure $d_{CRS}$ from a ***2D XZ*** or ***YZ*** line profile window. Smooth the profile first if needed.
6. Apply the correction factor to get the real film thickness.



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### Case 2: Blanket Film

1. Load the wafer. Make sure the wafer surface is in focus.
2. Choose the 100× objective.
3. Carefully choose the ***Fine Z*** scan range to make sure the Z step size is much smaller than the film thickness.
4. Set the laser intensity appropriately. Try not to use too strong an intensity.
5. Acquire a volume image. Switch to XZ or YZ intensity profile window. Look carefully for the signal band from the film.

**NOTE**
*The film signal could be faint.*

6. In the ***2D profile*** window, click ***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.
7. Apply the correction factor if necessary.

### 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 5-4. The XY plot and correction factor calculation are shown in Figure 5-3.

**Table 5-4 Film Thickness Measurement Comparison**

| $SiO_2$ nominal thickness (Å) | $d_{SEM}$ (Å) | $d_{CRS}$ (µm) |
|---|---|---|
| 500 | 518 | 0.03± 0.01 |
| 1000 | 1038 | 0.05 ± 0.01 |
| 3600 | 3580 | 0.24 ± 0.02 |

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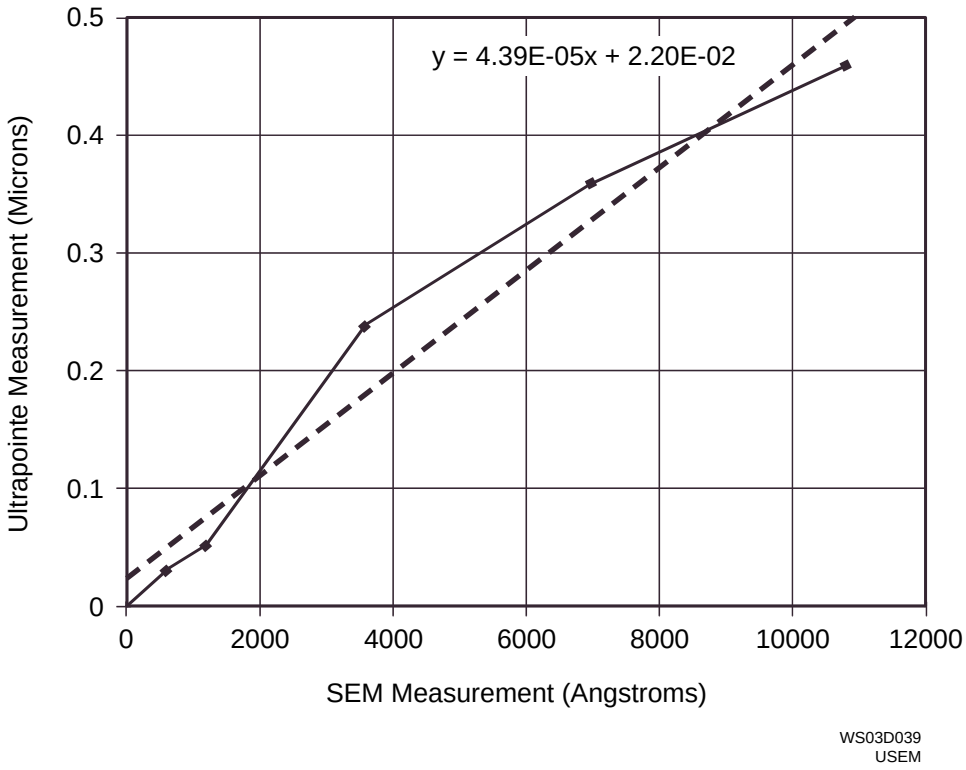


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**Table 5-4 Film Thickness Measurement Comparison**

| $SiO_2$ nominal thickness (Å) | $d_{SEM}$ (Å) | $d_{CRS}$ (µm) |
|---|---|---|
| 5500 | 6988 | 0.36 ± 0.02 |
| 10500 | 10843 | 0.46 ± 0.02 |

**Figure 5-3 Linear Fit to Thickness Measurements**




A linear fit is performed and a 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, many points are needed to obtain a favorable result.

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# 6

# Reference

This chapter is a review of CRS 3000 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, button bar, and keyboard commands. A CRS may not have all of the features described here, depending on which options are installed.

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## The User Interface

The KLA-Tencor CRS application software runs under Windows NT, using its mouse, menus, and function key user interface.

A window is a rectangular area on the screen for interacting with a particular application. It has a border and a *t*itle bar, and may also contain a menu bar, other 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

There are three input devices for controlling the KLA-Tencor CRS.

- The mouse accesses all functions graphically. Its motion controls the position of the pointer on the display screen and the mouse buttons allow selection by clicking, double-clicking, or clicking and dragging.
- The keyboard allows entering text 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 on function keys, for high throughput single-keystroke operation.
- The joystick is linked directly to the XYZ stage controller for manual stage movement.



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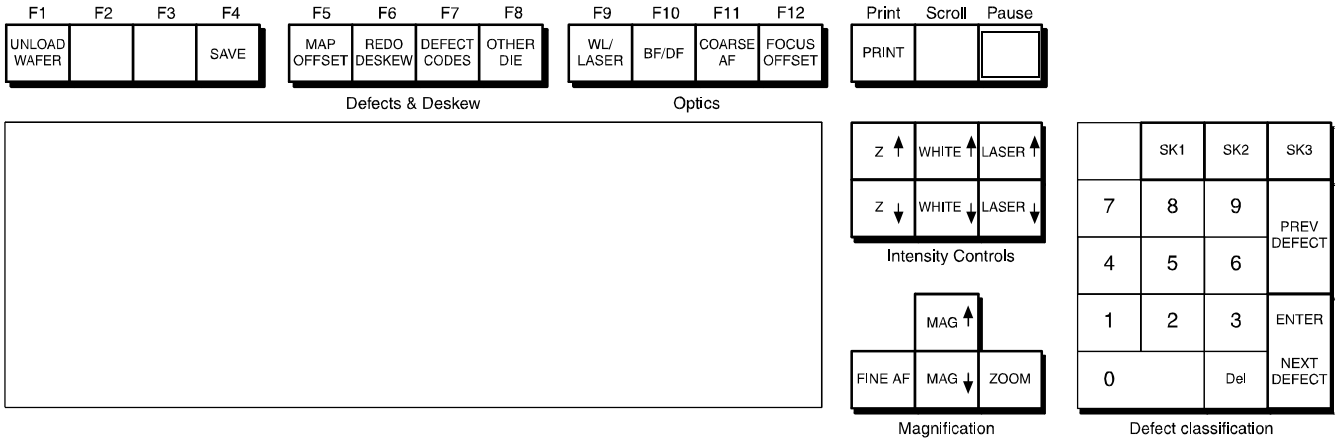
## Mouse

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. Clicking with the right mouse button in a data entry field brings up a popup menu, with the commands **Undo**, **Cut**, **Copy**, **Paste**, **Delete**, and **Select All**. Turning the wheel on a Microsoft Intellimouse or other wheel mouse causes scrolling lists to move up or down. 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. Figure 6-1 shows the keycaps for the special functions. Functions for defect classification are grouped on the numeric keypad, along with soft keys whose functions vary from one screen to another. Image control functions are to the left of the numeric keypad. Other frequently used functions are provided on the row of function keys, **F1**–**F12**, at the top of the keyboard.

**Figure 6-1 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 ***Load Wafer***, ***Deskew***, ***Review, Volume,*** and ***Surface*** screens shows the current functions of these keys and also of the **ENTER/NEXT DEFECT** key

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and the **PREV DEFECT** key. The names of these functions in the different screens are listed in Table 6-1.

**Table 6-1 Soft Key Functions**

| Screen | SK1 | SK2 | SK3 | Prev Defect | Enter/Next Defect |
|---|---|---|---|---|---|
| **Load Wafer** | Map | | NextWafer | PrevWafer | LoadWafer |
| **Deskew** | RedoCurrDsk | | SkipDeskew | | Accept |
| **Review** | Volume | Surface | | Last | Next |
| **Volume** | Surface | | | | Review |
| **Surface** | Volume | | | | Review |

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 6–71. They have been factory-configured for operator convenience in defect review and classification. Changes should only be made by engineers with extensive training and experience with the KLA-Tencor CRS. Table 6-2 lists the key labels on the standard keyboard and the CRS keycaps.

**Table 6-2 CRS Function Key Assignments**

| Key | CRS Name |
|---|---|
| F1 | Unload Wafer |
| F2 | |
| F3 | |
| F4 | Save |
| F5 | Map Offset |
| F6 | Redo Deskew |
| F7 | Defect Codes |
| F8 | Other Die |
| F9 | WL/Laser |

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**Table 6-2 CRS Function Key Assignments**

| Key | CRS Name |
|---|---|
| F10 | BF/DF |
| F11 | Coarse AF |
| F12 | Autofocus Offset |

### 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 ***Wafer Map*** 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 of joystick motion, so that the image on the screen appears to move in the direction opposite to 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. The user must move the stage 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.

## Software Controls

Via the mouse, a variety of controls are available on the screen. The types of controls are described in Table 6-3, starting with the menu bar and tool bar in Figure 6-2. Each menu

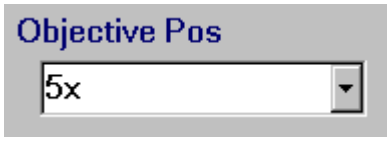
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offers a group of functions. Some of the most common functions are duplicated in the tool bar and identified with icons.

**Table 6-3 Window Controls**

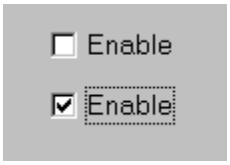
| Control | Description |
|---|---|
| Menu Bar<br> | Clicking a menu bar item activates an associated pull-down menu. Then clicking one of the pull-down menu items activates it. Alternatively, Clicking a menu bar item and dragging to the desired menu item, then releasing the mouse button, has the same effect. |
| Toolbar<br> | A row of buttons, each labeled with an icon, for common functions. Click a button to activate it. |
| Option Menu<br> | 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. Option menus are distinguished by the small button on the right bearing a downward pointing triangle. Clicking the button on an option menu opens the menu display. Selection is the same as in the main menu bar. |
| Push Buttons<br> | Clicking a push-button invokes its associated action. A ***Cancel*** button always cancels the current selection and returns to the most recent window or dialog box. To close a window or quit the application, click ***OK***. |

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**Table 6-3 Window Controls (continued)**

<table>
<tr><th>Control</th><th>Description</th></tr>
<tr><td>Toggle Buttons<br>
</td><td>Each click of a toggle button changes its status, from on to off or off to on. In this case the lower button is on, or enabled, and the upper button is off, or disabled. An outline around a button label indicates that it is active.</td></tr>
<tr><td>Window Drag Buttons<br>

<table>
<tr><th>Icon</th><th>Name</th><th>Function of Pane</th></tr>
<tr><td></td><td>Microscope</td><td>White light image</td></tr>
<tr><td></td><td>RT Slice</td><td>Real time laser image</td></tr>
<tr><td></td><td>Slice2D</td><td>2D slice images or contours</td></tr>
<tr><td>2D</td><td>Surface</td><td>3D surface images</td></tr>
<tr><td>3D</td><td>Reference Img</td><td>Show saved images</td></tr>
<tr><td></td><td>Cassette</td><td>Wafer or slot selection</td></tr>
<tr><td></td><td>Seq Status</td><td>Soft keys, defect data entry</td></tr>
<tr><td></td><td>Text Status</td><td>Tabbed status pane</td></tr>
<tr><td>Status</td><td>DefectMap</td><td>Wafer with zoom box</td></tr>
<tr><td></td><td>ADC</td><td>Automatic Defect Classification</td></tr>
<tr><td>ADC</td><td></td><td></td></tr>
</table></td><td>Clicking the L button in the upper right corner of a pane and dragging to another pane interchanges the two panes. There is also a toolbar of drag buttons bearing icons 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.</td></tr>
<tr><td>Radio Buttons<br>
</td><td>Radio buttons allow a single selection from several alternatives. Clicking one selects it and deselects the last one active.</td></tr>
</table>

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**Table 6-3 Window Controls (continued)**

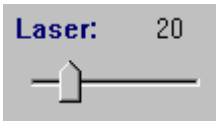
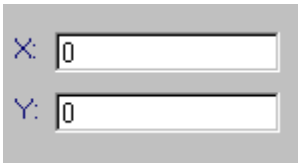
| Control | Description |
|---|---|
| Slider Bar   | The user can move the slider button within a bar in two ways: (1) by clicking and dragging the slider button to the desired value, or (2) clicking the gray area outside the button. This increments/decrements the slider bar by a fixed amount. Many scales have 10 as the increment. ***LaserIntensity*** moves by 1, and ***FineZ*** by 0.1 |
| Entry Field   | An entry field is a rectangular area for entering text or numbers. |

**Figure 6-2 CRS Application Menu Bar and Toolbar**




New Recipe File
(not implemented)
Defect Code File
(not implemented)
Save (not implemented)
Print
About
Load Wafer
Deskew
Review
Volume Image
Surface Image

# 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 6-4 describes the various directories accessible from the application. Note that depending on the particular configuration of a CRS, these directories may or may not be available. Moreover, directory names can vary somewhat from system to

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system. In particular, the KLA_READ and KLA_WRITE directories can be renamed, and more directories (REMOTE3, REMOTE4, and so on) can be created and named.

**Table 6-4 CRS Directories**

| Directory | Name | Description |
|---|---|---|
| c:\ultrap\uv\data | System | Accessible by all users |
| c:\ultrap\uv*[name]*\data | User | A private directory corresponding to a login name. Those with Operator privileges cannot access files in anyone else's directory. Users with Engineer, Administrator or Superuser privileges can access any user's directory |
| a: | Floppy | 3.5-in. disk drive |
| d: | Jaz | 2G Jaz drive |
| e: | CD | CD-ROM drive |
| f: | KLA_READ | 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 |
| g: | KLA_WRITE | 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. |
| h:, i:, j:... | REMOTEn | Other remote directories can be defined for communication with multiple instruments and computers |

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A directory is created for each user, and this is the default directory where all data is stored for that user. A User can access just this assigned user directory and the shared system directory on the hard drive, while an Engineer, Administrator or Superuser can access all user directories. The SYSTEM, FLOPPY, JAZ, CD-ROM, KLA_READ, KLA_WRITE, and REMOTE*n* directories can be accessed by all users.

The KLA_READ, KLA_WRITE, and REMOTE*n* 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 KLA_READ directory and sends the reviewed map file back to the host computer in the KLA_WRITE 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 KLA_WRITE directory. Generally, the KLA_READ and KLA_WRITE directories list only those filenames that match the file type selected. If the wafer map type is selected, however, all filenames in the KLA_READ, KLA_WRITE, or REMOTE2 directory are listed. (As part of the installation, the KLA_WRITE, REMOTE2 and KLA_READ 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. All filenames used with the CRS software are keyed with a file extension. For example: all surface filenames end with `.sur` and all volume file names end with `.vol`. A directory listing within the application on most media shows only those filenames with an extension that matches the file type selected, unless display of all files is selected.

The file extensions and their associated file types are listed in Table 6-5.

**Table 6-5 File Extensions**

| Extension | File Type | Description |
|---|---|---|
| `.bmp` | Bitmap file | A bitmap image in Windows Bitmap format |
| `.cod` | Defect code file | A text file listing defect codes and their descriptions |
| `.map` | Wafer map file | A text file describing a wafer and its associated defects |
| `.jpg` | JPEG file | A bitmap image in JPEG format |
| `.rcp` | Recipe file | A text file listing user-defined system settings |
| `.sur` | Surface file | A KLA-Tencor CRS image file of the 3D surface |
| `.tif` | TIFF file | A captured image in TIFF format |
| `.vol` | Volume file | A KLA-Tencor CRS image file of the volume scan |

A bitmap is any image described by the state of every pixel on the display screen at a given moment. There are many different bitmap file formats. On the KLA-Tencor CRS, bitmap images can be stored in `.bmp` (Windows Bitmap), `.tif` (TIFF, Tagged Image File Format), or `.jpg` (JPEG, Joint Photographic Experts Group) formats. Bitmap images can be loaded and displayed in the library window. These are intended as reference images for defect classification.

The user-defined descriptions of defect codes are stored in Defect Code Table files, which the users can edit, create, save and load. The format of the file is in two columns, of which the first contains the numbers 0–255, one per line. The second field contains a user-defined defect description.

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 can read many standard wafer map formats, and translate them to `.map`

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files. Typical contents of a wafer map file, and where these contents are displayed when the file is loaded, are described in Table 6-6.

**Table 6-6 Contents of Wafer Map Files**

| Information | Description |
|---|---|
| Identification | Product ID, lot ID and process ID are displayed in the ***Status*** tab. |
| Wafer information | Wafer size, die size, flat orientation and deskew points are displayed graphically in the wafer map pane. |
| 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. |

Recipe files are used to customize and automate many of the instrument's functions. Loading a properly specified recipe sets up the tool's scan parameters and defect sort criteria without any user input. When a user logs in, the system searches the login directory for a recipe with the same name. If the recipe is found, it is loaded automatically. The contents of the recipe are described in Table 6-7. Due to the complexity of these parameters, users with operator privileges cannot create recipes.

**Table 6-7 Recipe File Contents**

| Information | Description |
|---|---|
| Defect Sort Criteria | Defects from a wafer map file can be filtered or sorted with a set of sort criteria so that only the desired defects are reviewed. The sort criteria 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. |

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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 (or slices) taken at regular vertical intervals. From the volume data set, the system constructs 2D views and a 3D image of the surface.

The KLA-Tencor CRS allows users to view, manipulate, and store the surface as well as the volume data sets. The volume data set size is large (512 × 512 × 64 slices equals 16 megabytes), and the corresponding surface data is much smaller (512 × 512 × 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 (always 488 nm on the CRS 3000), and defect number.

When an image file is loaded from the top menu bar, the associated wafer map is also loaded. Loading images into individual 2D or 3D panes does not update the wafer map, nor does it require removing the wafer from the stage.



**NOTE**
*Any wafer on the stage must be unloaded before loading an image file from the top menu bar.*

## Menus

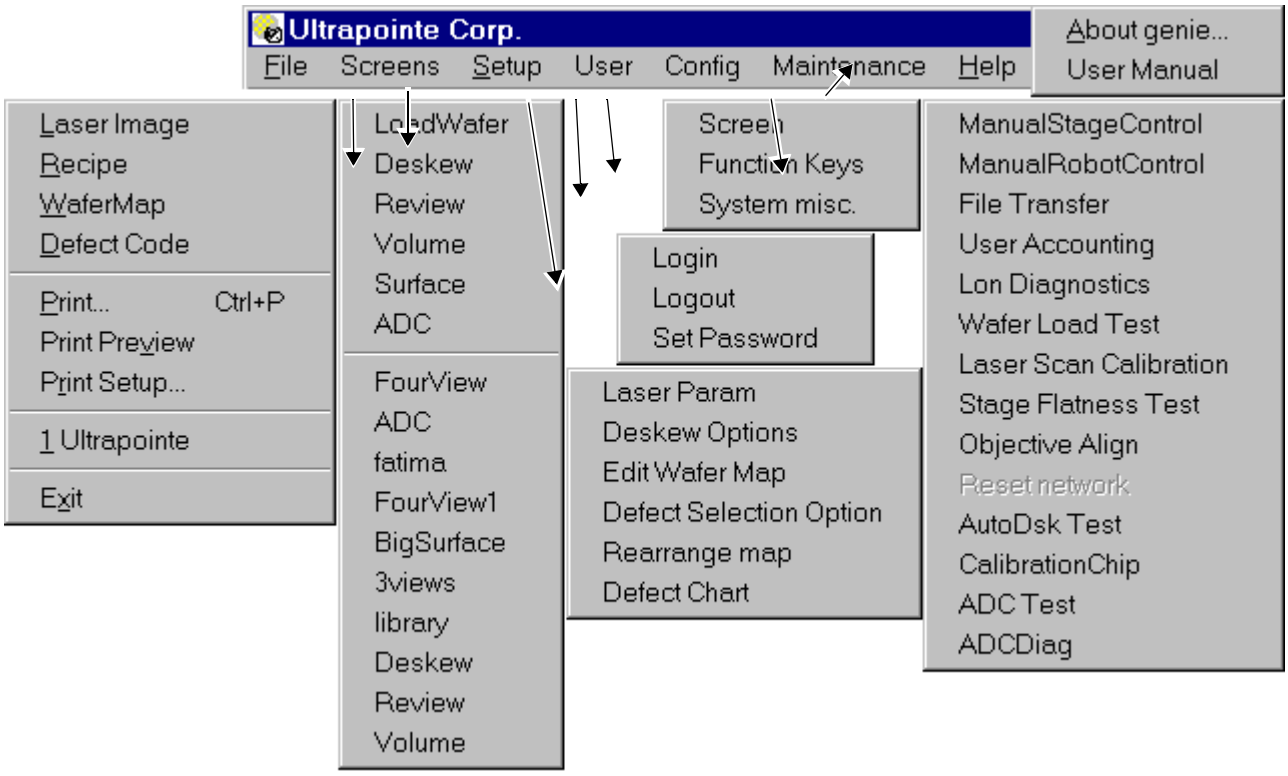
Figure 6-3 shows the contents of each of the menus in the CRS 3000 software. The options on the **Screen** menu (with the exception of ADC) change the contents of the main application screen. Other menu selections bring up smaller windows with further options, in many cases including further menus to select from.

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**Figure 6-3 CRS 3000 Menus**




Clicking 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 a menu name and release the mouse button before moving to make a selection, or click elsewhere to close the menu. The alternative is to click 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 menu and opens the new one.

Access to KLA-Tencor CRS functions depends on the level of privileges assigned to a login account. The KLA-Tencor CRS software supports four levels of users, called Users, Engineers, Administrators, and Superusers. Many functions are available to all levels. Those that are restricted are listed in Table 6-8 in order of their appearance on the menus. Those who are allowed to use a function have a check mark in the corresponding box in the table. User access to files is marked ✻, indicating partial access. Users have access to their own image

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files and the shared files in the system directory, but not to anyone else's directories or files. The other three groups can look at anyone's images.

**Table 6-8 CRS Menu Function Permissions**

| Function | User | Engineer | Administrator | Superuser |
|---|---|---|---|---|
| **File** | | | | |
| Laser Image | ❋ | ✔ | ✔ | ✔ |
| Recipe | ❋ | ✔ | ✔ | ✔ |
| WaferMap | ❋ | ✔ | ✔ | ✔ |
| Defect Code | ❋ | ✔ | ✔ | ✔ |
| Exit | | | ✔ | ✔ |
| | | | | |
| **Setup** | | | | |
| Laser Param | | ✔ | ✔ | ✔ |
| Deskew Options | | ✔ | ✔ | ✔ |
| Edit Wafer Map | | | ✔ | ✔ |
| | | | | |
| **Config** | | | | |
| Screen | | | ✔ | ✔ |
| Function Keys | | | ✔ | ✔ |
| System misc. | | | ✔ | ✔ |
| | | | | |
| **Maintenance** | | | | |
| Manual Stage Control | | | ✔ | ✔ |
| Manual Robot Control | | | ✔ | ✔ |
| File Transfer | | | ✔ | ✔ |
| User Account-ing | | | | ✔ |
| Lon Diagnos-tics | | | ✔ | ✔ |

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**Table 6-8 CRS Menu Function Permissions (continued)**

| Function | User | Engineer | Administrator | Superuser |
|---|---|---|---|---|
| Wafer Load Test | | | ✔ | ✔ |
| Laser Scan Calibration | | | ✔ | ✔ |
| Stage Flat-ness Test | | | ✔ | ✔ |
| Objective Align | | | ✔ | ✔ |
| AutoDsk Test | | | ✔ | ✔ |

**Figure 6-4 Error Messages for Unavailable Functions**




Engineer or




Administrator or




Superuser

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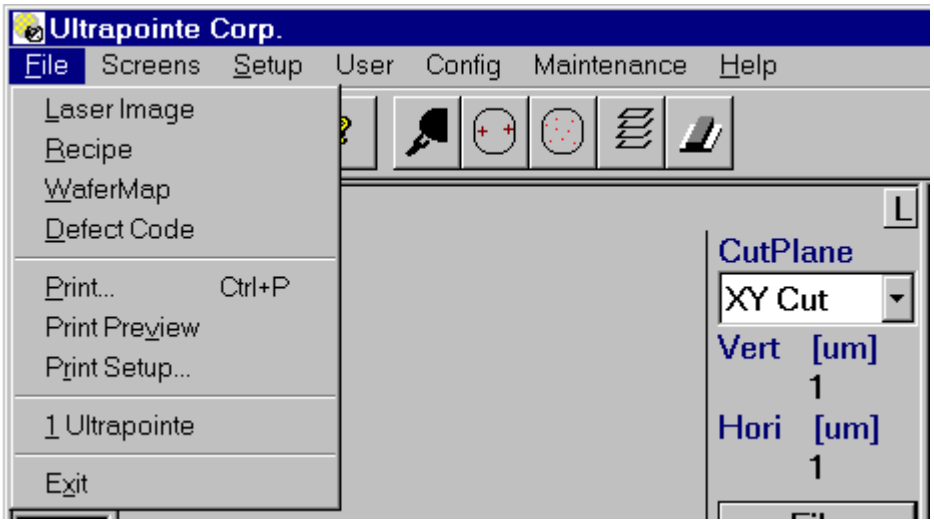
In addition to the mouse, the keyboard can be used for selecting menu items. Pressing and releasing the **ALT** key highlights the **File** menu, as does pressing the **ALT+F** combination. The key to use for each selection is shown by an underlined letter in the command name, for example, the **F** key for the **File** menu. With a menu highlighted, pressing the underlined letter in a different menu name highlights that menu. Pressing the left or right arrow key moves to the next menu in that direction, wrapping around from either end of the menu bar to the other.

Pressing the up or down arrow key opens the menu and moves to the top or bottom item. The items on the menu may have their own shortcuts, either the first letter of the command, or an underlined letter. If so, pressing the corresponding key selects the command. Some menus have two commands with the same shortcut, and in that case pressing the key only highlights the command. Pressing the same key again highlights the next command starting with the same letter, or returns to the first one if there are no more. If only one command has a particular shortcut key, pressing the key executes that command. Pressing **ENTER** with a command highlighted also executes the command. For example, the sequence **ALT+S D** opens the **Screen** menu and highlights the **Deskew Options** command. Pressing **D** again highlights **Defect Selection Option**, while pressing **E** executes the **Edit Wafer Map** command, opening the ***Edit Map*** window.

## File Menu

Figure 6-5 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.

**Figure 6-5 File Menu**




In each file dialogue box, the user selects radio buttons for file type and location. Authorized users (those with an Engineering, Administrator or Superuser account) can select from

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a menu of user accounts when accessing user directories. A user with a User 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 a file name, or selecting a file and then clicking the ***Load*** button, loads the file into the designated pane or panes.

The **Laser Image**, **Recipe**, **WaferMap**, and **DefectCode** commands bring up similar windows with nearly identical controls for loading and saving files, and for showing drive statistics, as shown in Figure 6-6, Figure 6-7 on page 6-18, Figure 6-11 on page 6-23, and Figure 6-13 on page 6-26

## Image File Selection

The ***Image File*** dialogue box shown in Figure 6-6 contains navigation and selection controls for loading volume (`.vol`), bitmap (`.bmp`, `.tif`, or `.jpg`), and surface (`.sur`) files from the application directories.

## Recipe File Selection and Editing

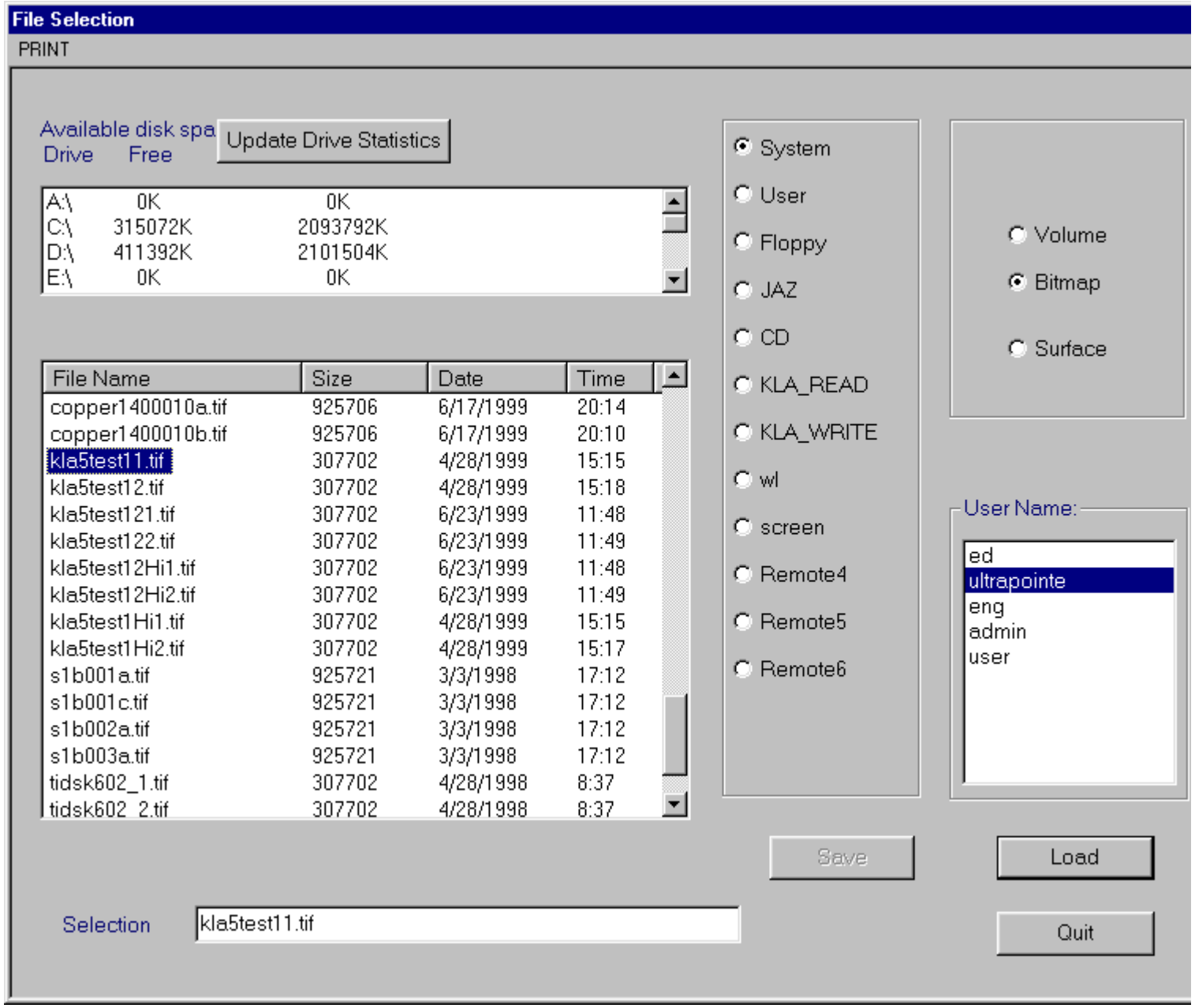
In addition to loading and saving recipe files, the file dialogue for recipe files in Figure 6-7 includes extensive options for editing the recipe parameters. The buttons at the right bring up windows for editing laser settings, file saving options, deskew parameters, defect sort criteria, and ADC settings. Editing recipe settings and then exiting the window with the ***Quit*** button preserves the settings during the current session, unlike the behavior of software on earlier UNIX-based CRS models.

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**Figure 6-6 Image File Dialogue Box**

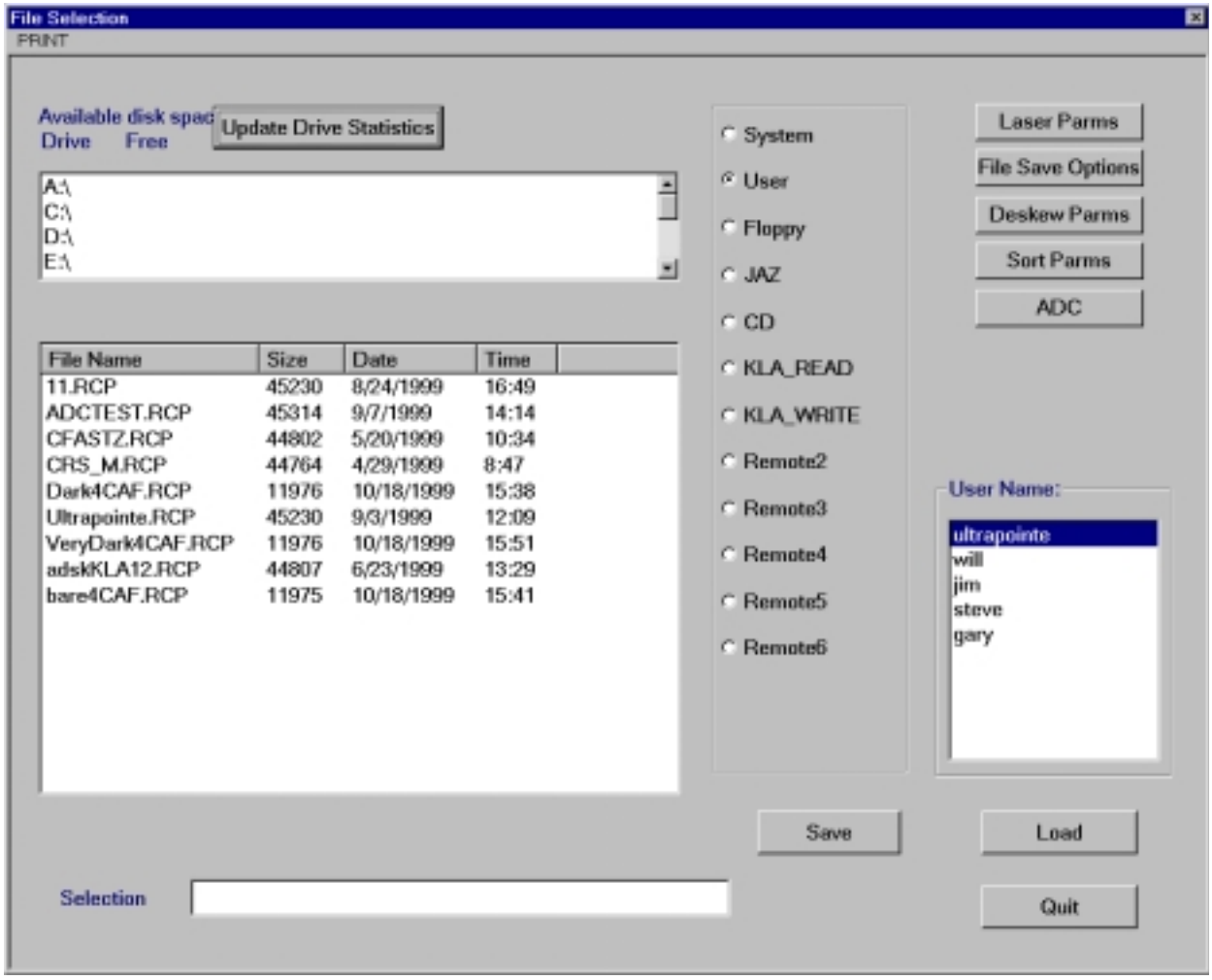



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**Figure 6-7 Recipe File Dialogue Box**




### LaserParams

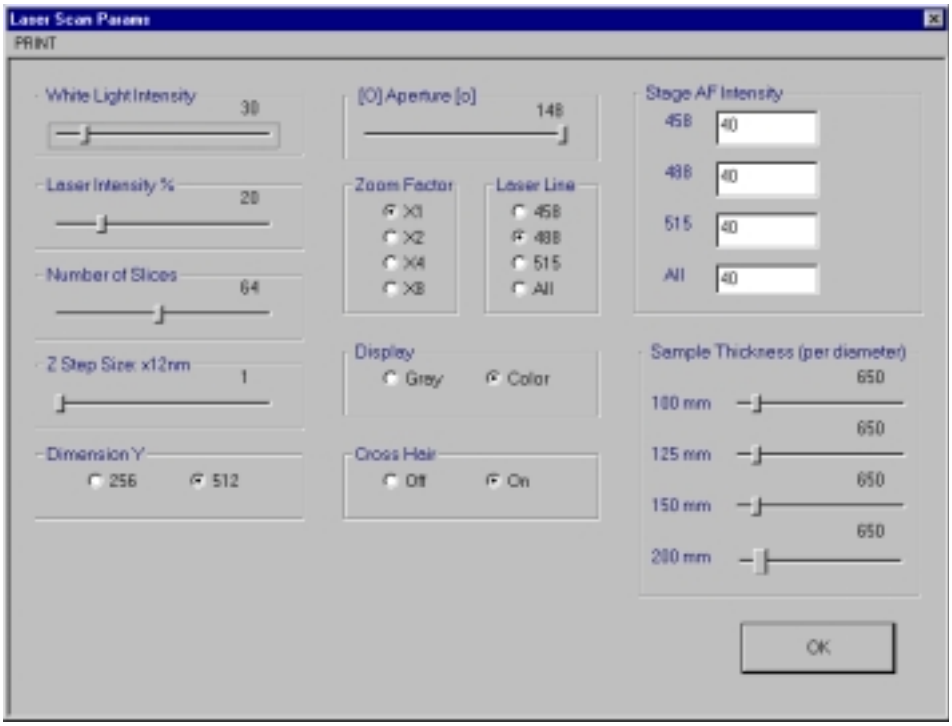
The ***LaserParams*** button brings up the ***Laser Scan Params*** window shown in Figure 6-8. It contains controls for laser and white light image and AF settings, wafer thickness, and parameters for volume data set capture. These parameters are number of slices, number of 12 nm steps between slices, and a choice of 256 × 256 or 512 × 512 pixels per slice.

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**Figure 6-8 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 on a scale of 0–100%, 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 5 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, ranging from 1–100 steps. This corresponds to a range of distances from 0.012 µm–1.200 µm. 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 is a box of radio buttons in this window, for selecting the default ***ZoomFactor***, with choices

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

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The ***StageAF Intensity*** entry fields set the laser light sensor gain in the range 5–90 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 6-9, but there is great variation in the industry. For example, 150 mm diameter wafers range in thickness from 600–800 µm and beyond. If there is any doubt about the thickness of a wafer, ask.

**Table 6-9 Standard Wafer Thicknesses**

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

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

### File Save Options

Figure 6-9 shows the options that can be set in a recipe for saving defect map and image files. The window contains five sets of radio buttons.

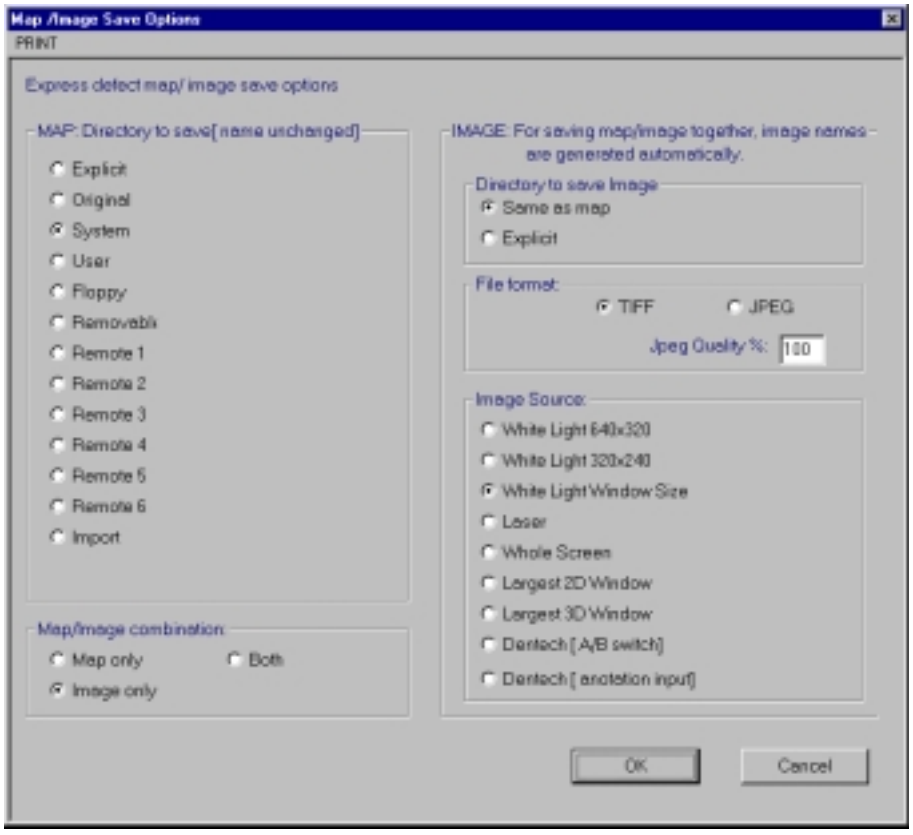
In normal use, defect maps are loaded automatically along with the wafer from one directory used for importing files from another instrument. When the wafer has been reviewed and the defects classified, the defect map should be saved automatically in a different directory, where it can be retrieved for 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.

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**Figure 6-9 Recipe Map/Image Save Options Window**




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, a selection of laser images and 3D slices, and two Dentech-compatible options. The entire screen, including all of the visible panes, can be saved in a single file. The ***OK*** button saves the user's choices, and the ***Cancel*** button discards them.

## Deskew Options

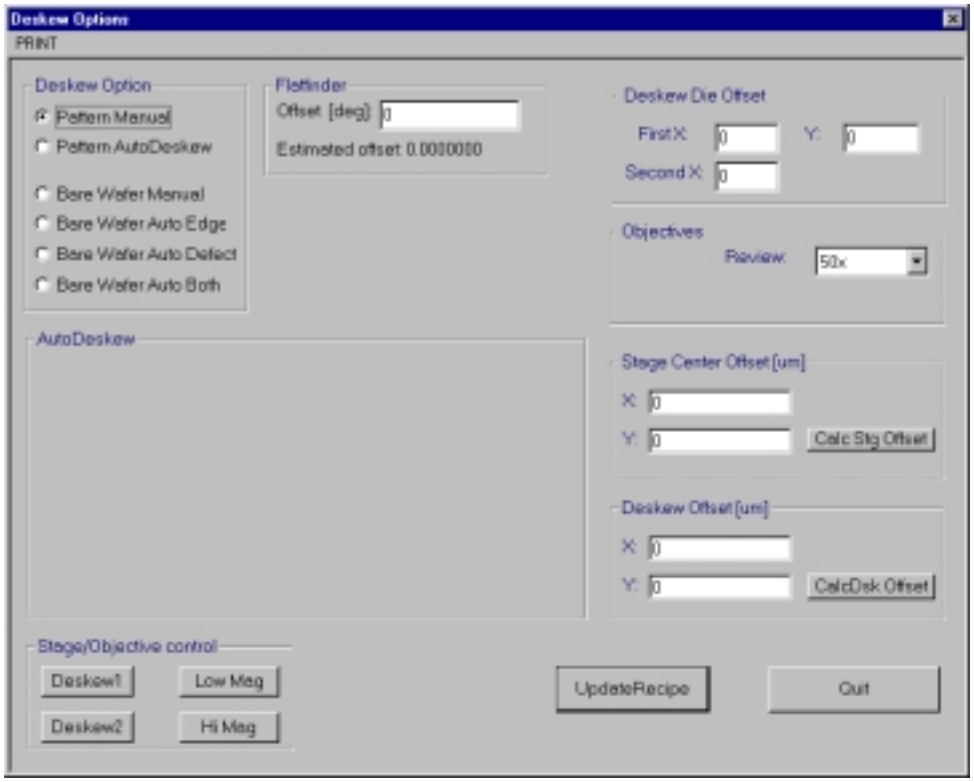
Figure 6-10 shows the ***Deskew Options*** window for setting parameters in the recipe. The ***Deskew Option*** radio buttons at the top left of this window give several choices for the types of deskew features on patterned or bare wafers, either manual or automatic.

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**Figure 6-10 Recipe Deskew Options Window**




A number of functions in this window are for setting up automatic deskew. The deskew process and the steps in setting up AudoDeskew are described in Chapter 3, “Deskew Setup.” The ***Deskew Option*** radio buttons select among the AutoDeskew options, or turn AutoDeskew off. There are manual deskew modes for both pattern and bare wafers. Switching off AutoDeskew leaves all of the parameters in place, so that doing an occasional manual deskew does not disturb the AutoDeskew setup.

The buttons in the ***Stage/Objective*** control section provide for movement to two chosen deskew points and changing between two preselected magnifications without leaving the setup window.

The ***Flatfinder Offset*** field is used to correct for any systematic error in alignment between the flatfinder, robot, and stage that remains after robot alignment. This is set in the calibration process.

The ***Deskew Die Offsets:*** 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.

After deskew, when the CRS displays the first defect, the user centers it, and then presses the Calc Stg Offset button. The Calc Stage Offset [um], X: and Y: entry fields display values

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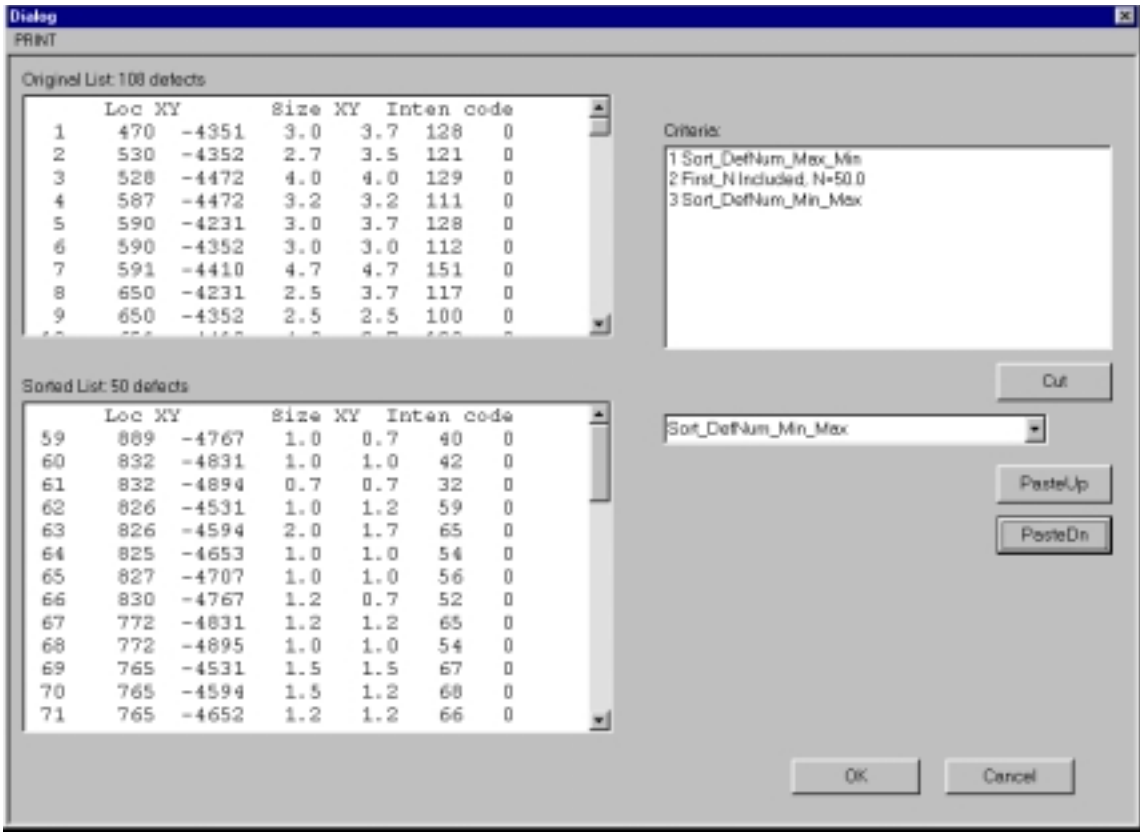
calculated by the CRS software, giving the differences between the X and Y values in the stored defect position and the actual stage position. Similarly the CalcDsk Offset button calculates an offset to be applied at the deskew position to allow for variations in die or feature placement.

The ***Update Recipe*** button accepts the entered values, and exits the ***Deskew Options*** window, while the ***Quit*** button discards any changes and exits.

## Sort Parameters

Figure 6-11 shows the ***Sort Parameters*** window, with an example of the filtering and sorting process. The selection criteria are, in order, a reverse sort, taking the first 50 items, and sorting them normally. Out of the 108 defects in this file, this process has selected the last 50, that is, defects 59–108, in that order, as shown in the lower list pane.

**Figure 6-11 Sort Parameters Window**




The menu at the right of this window offers the selection and sort criteria listed in Table 6-10, with the option to include or exclude defects by each selection criterion. Clicking a criterion from the menu brings up its parameter entry fields, and for selection criteria other than **All**, the ***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 the ***Cut*** button removes that criterion.

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**Table 6-10 Defect Sort Criteria**

| Criterion | Parameters | Comments |
|---|---|---|
| All_defects | | Select |
| First_N | N | Select or exclude N defects |
| Random_N | N | Select or exclude N defects |
| 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 |
| XCoordinate | Min, Max | Select range |
| YCoordinate | 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_XYSize_Min_Max | | Sort in ascending order by defect size |
| Sort_XYSize_Max_Min | | Sort in descending order by defect size |
| Sort_Defnum_Min_Max | | Sort in ascending order by defect number |
| Sort_Defnum_Max_Min | | Sort in descending order by defect number |
| Random_Percent | N | Select N%. |
| N_per_Cluster | N | Select N times number of clusters |
| ADCCode | | Select (see ADC manual) |
| Cluster | Cluster Number | Select |

Some of these criteria naturally go together, like **XSize** and **YSize** or **XCoordinate** and **YCoordinate**. Others are mutually exclusive, like **Sort Size MinMax** and **Sort Size MaxMin**. The software will allow users to choose any combination, even if it does not 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.

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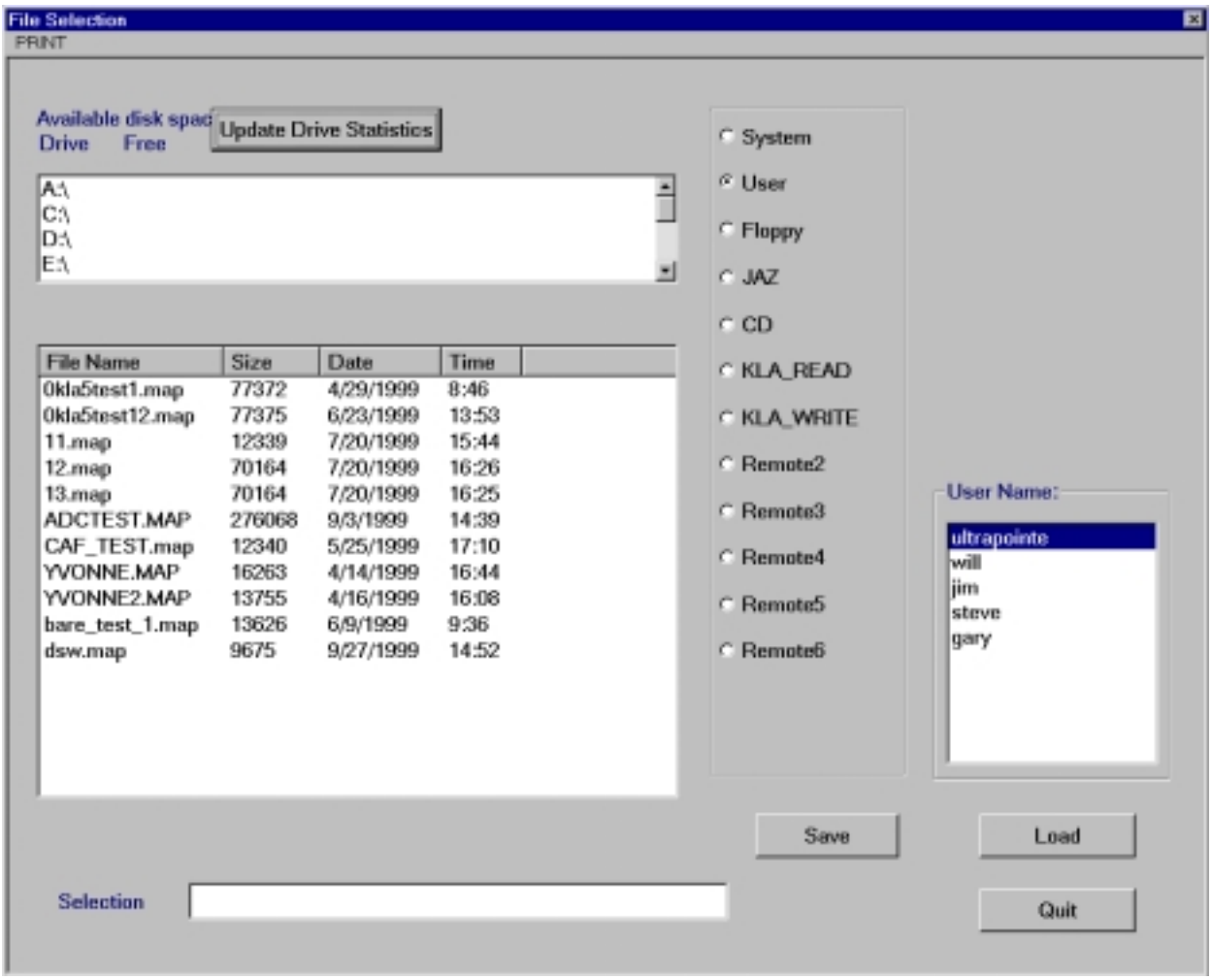


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## WaferMap

The **WaferMap** command brings up the ***FileSelection*** window in Figure 6-12, which allows the user to select a map file to load, or to name and save the current wafer map.

**Figure 6-12 File Selection Window**




## Defect Code (DefectCodeTable)

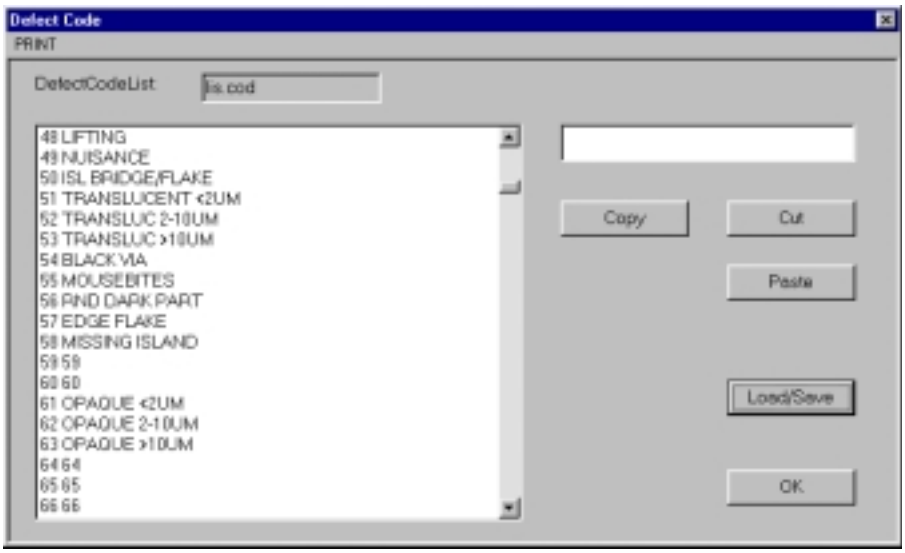
The **Defect Code** menu command brings up the defect code editor in Figure 6-13, showing the number and name of each defect type in a scrolling list at the left. Selecting an item in the scrolling list and then clicking the ***Copy*** button copies the defect number and name to the text entry field for editing. The name can be changed and saved back to the same defect code number, or the number can be changed, and the name saved to a different code number. The ***Cut*** button removes a defect from the list, leaving a gap in the numbering. Entering a number and name in the entry field, and then clicking Paste copies the name to the corresponding number, creating it if necessary. The ***Load/Save*** button in this window brings up the defect code ***File Selection*** window for loading and saving defect code files.

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**Figure 6-13 Defect Code Editing Window**




### Print…, Print Preview, Print Setup

These menu items brings up standard Windows NT dialog boxes for printing the current screen, previewing the page layout before printing, and for managing printers and print options.

### Exit

The last item on the **File** menu is **Exit**, which opens the window in Figure 6-14. Clicking ***OK*** quits the application. Clicking ***Cancel*** returns to the application.

**Figure 6-14 Exit Window**




## Screen Menu

The **Screen** menu shown in Figure 6-15 lists all of the available screen layouts for the built-in system screens, and for user-definable screen layouts that can be modified using the ***Screen*** editor on the **Config** menu. (“Screen” on page 6–68)

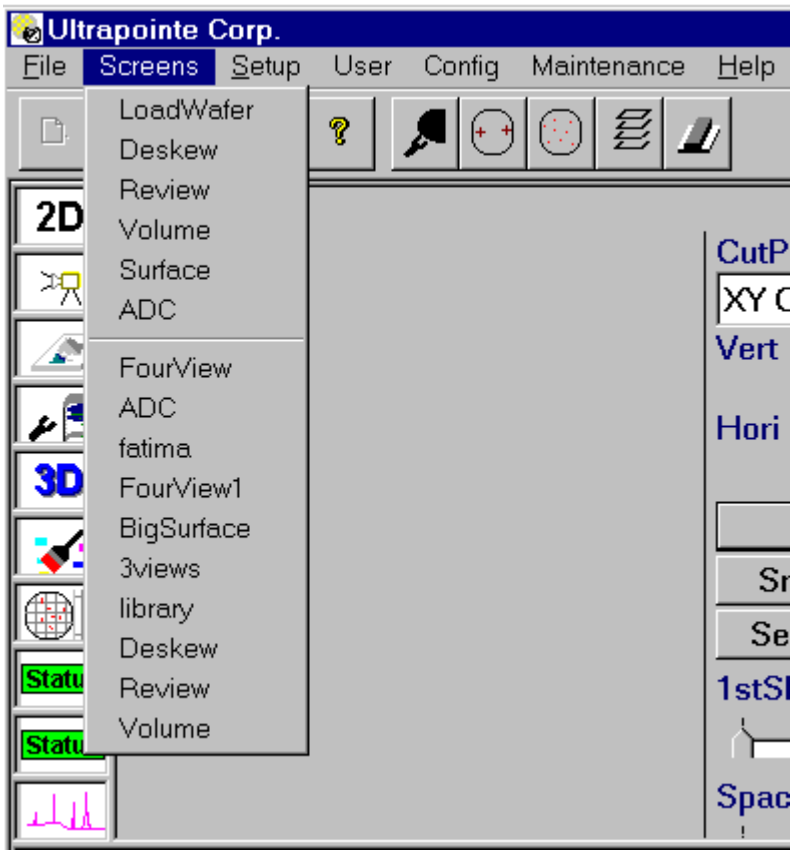
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The screen layouts above the bar in the middle of the menu are system screens. The first three, ***Load Wafer***, ***Deskew***, and ***Review***, are invoked automatically in sequence by the software when an operator logs in, and the load, deskew,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

**Figure 6-15 Screen Menu**




The screens listed below the bar are user screens, which can vary from one system to another. 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.

## 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 6-3 on page 6-5.

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 five tab options.

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### Pane Sizes

All window pane types have three distinctive looks, depending on the size of the window, as described in Table 6-11.

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**Table 6-11 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. |
| Button | When a pane is less than 95 pixels wide, a button is displayed with an icon 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 (labeled ***L***) in one pane and drag it to another pane, then release the mouse button—the two panes interchange positions. Inactive panes are shown as buttons with icons.

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, on switching 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. After switching from a screen with three 2D windows to a different screen that has two 2D windows, and back again, one of the three 2D window will have no image.

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### Global and Local Data

Operations originated from the top menu bar are global in nature; that is, they affect all panes in a window. Most operations originated from within a particular pane affect that pane 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 pane updates the surface only in that pane and does not update the wafer map. However, loading a volume file from within a 2D pane also updates the other panes.

### Defect Map Panes

Figure 6-16 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 6-12.The option menu in the top pane has eight options, four for maps showing defects in different color codes, and four to display the corresponding color palettes. These options are shown below starting with Figure 6-17 on page 6-33. The lower left pane is a map of the entire wafer in its correct orientation showing the die



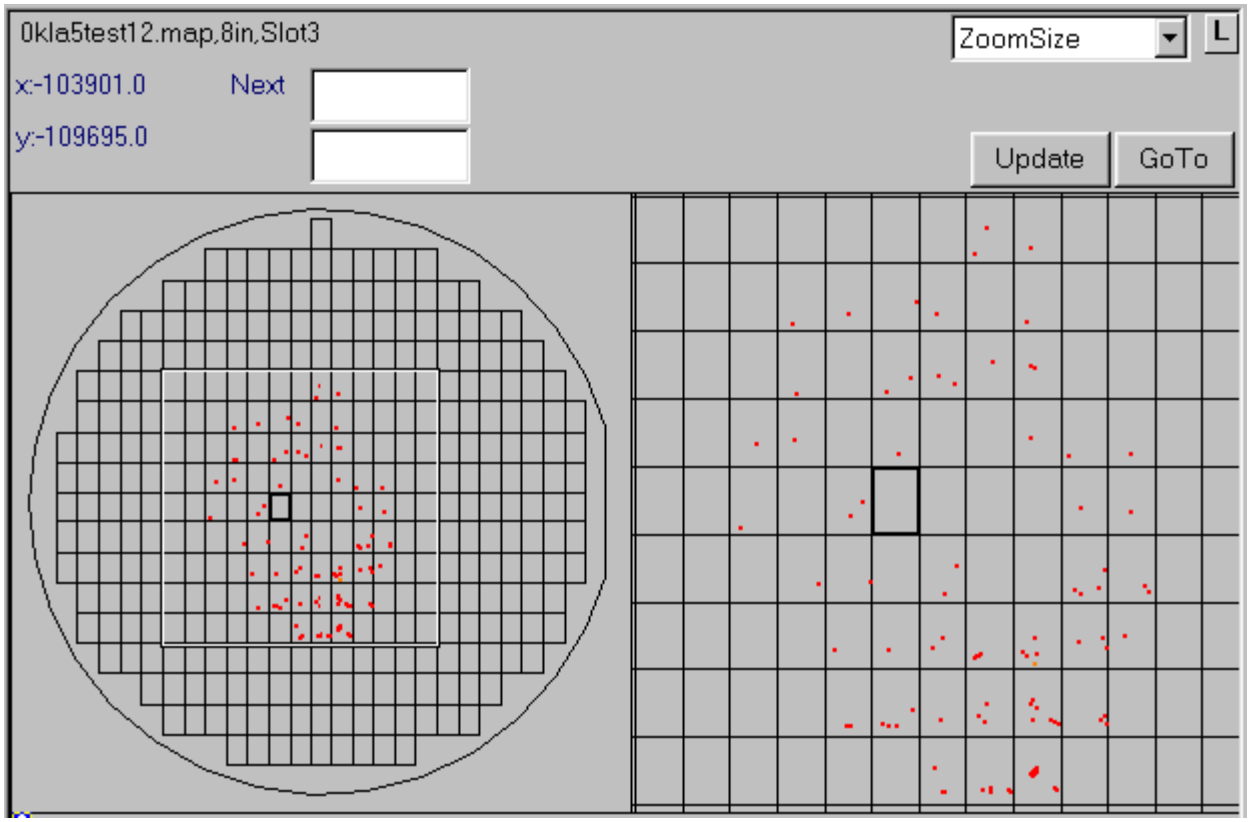
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boundaries, with defect locations displayed as colored dots. Within this pane is a zoom box that indicates the area to be shown magnified at the lower right. The user can move the zoom box by clicking and dragging on the upper left corner, and can 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.

**TIP**

*When the cursor is close enough to the upper left corner of the zoom box to grab it, the cursor changes to a cross. When the cursor can grab the lower right corner, the cursor changes to a double-headed diagonal arrow.*

**Figure 6-16 Defect Map Panes**




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**Table 6-12 Properties of Defect Map Panes**

| Window Element | Description |
|---|---|
| Full Wafer View | The primary view of the Wafer Map pane is the left half that depicts the entire wafer. As mentioned above, this view shows all of the defects, the die layout, 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.<br><br>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 with the size and location of the box. |
| 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 6-13. They can be viewed by selecting **Palett-Size** from the wafer map option menu. |
| Cursor | The blue cursor on the wafer map shows the position of the stage according to the most recent command from the computer. To update the cursor and the x and y coordinates, click ***Update***. |



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

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Table 6-13 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.

**Table 6-13 KLA and Tencor Map Colors**

| Defect Color | KLA Area ($\mu m^2$) | KLA Equivalent Length (µm) | Tencor Intensity |
|---|---|---|---|
| Red | < 0.06 | < 0.25 | < 50 |
| Orange | < 0.25 | < 0.50 | < 100 |
| 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 |

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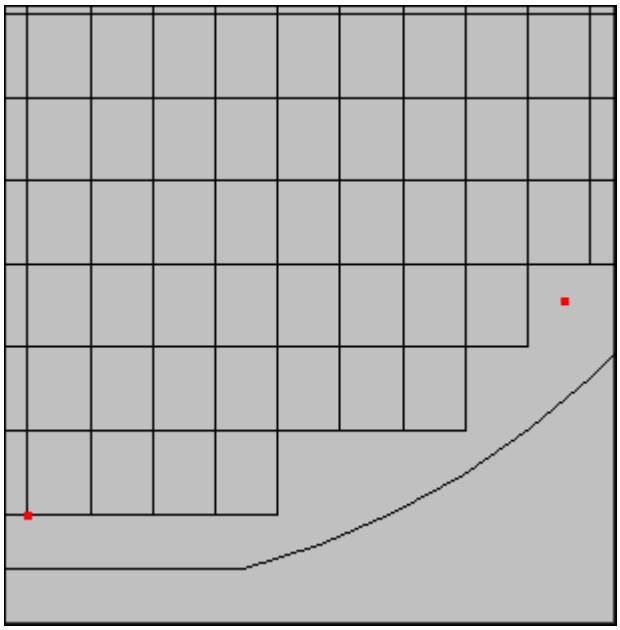
Clicking close to a defect on the wafer map directs the stage to bring that defect under the microscope. Clicking anywhere else on the wafer map brings the point clicked on under the microscope. Clicking a defect in the defect list highlights it, and double-clicking it moves to that defect. Wafer coordinates of a point can be entered manually in the text entry fields labeled ***Next***, X in the upper field, and Y in the lower field. Then clicking the ***GoTo*** button starts the stage moving to the exact coordinates specified.

Figure 6-17 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.



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**Figure 6-17 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.

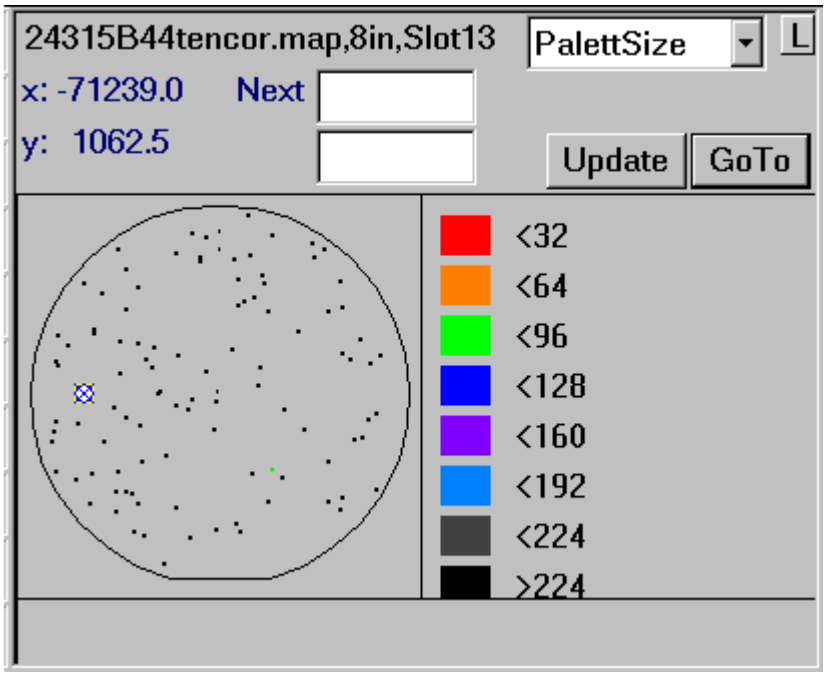
Figure 6-18 and Figure 6-19 show the four color palettes used for the wafer map display. The ***Size*** palette provides eight colors mapped to specific size ranges. The same eight colors can be used for distinguishing clusters of defects on the ***Cluster*** palette. The ***Status*** and ***Current*** 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.

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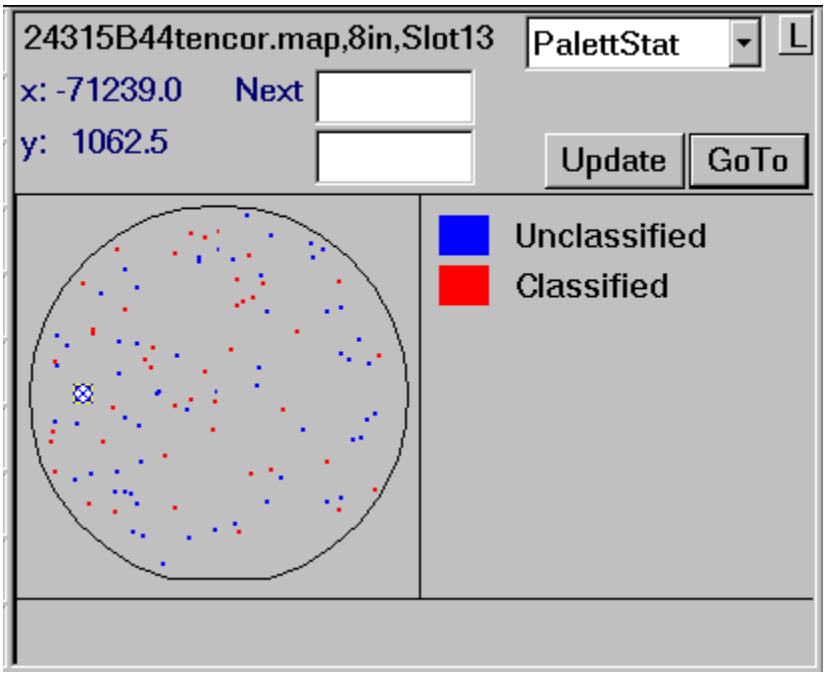


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**Figure 6-18 Color Palette Panes: Size and Status**




**PalettSize** Palette



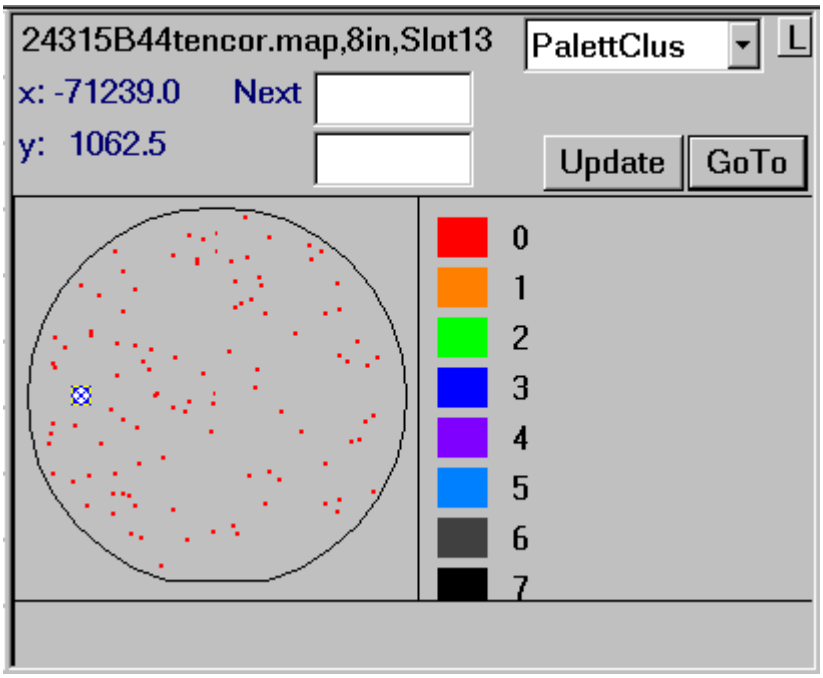

**PalettStat** Pal-

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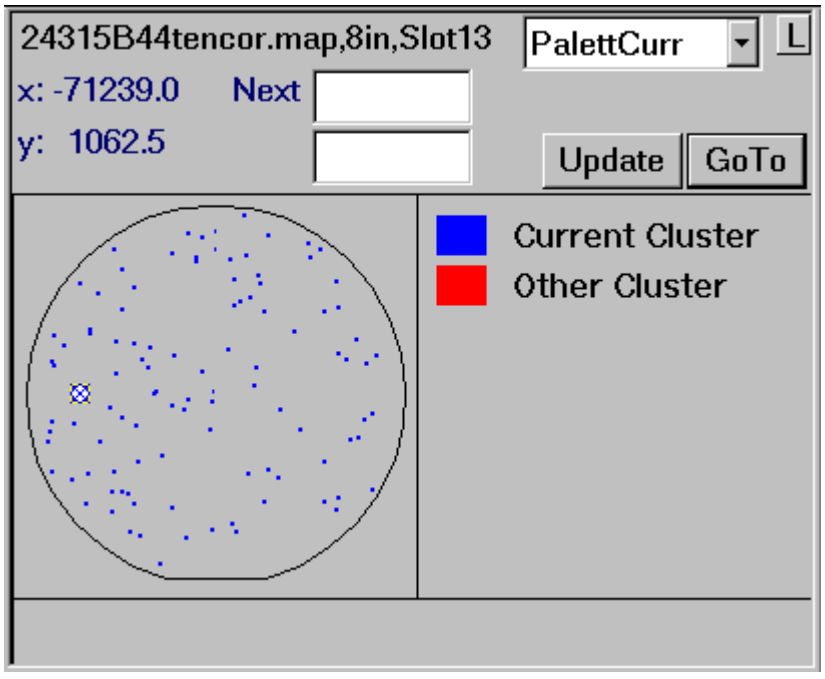


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**Figure 6-19 Color Palette Panes: Cluster and Current**




**PalettClus** Palette




**PalettCurr** Pal-

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### Cassette Pane

The ***Cassette*** pane shown in Figure 6-20 provides controls for loading and unloading wafers, and indicates which wafers are represented in the map file. At the left are icons representing the robot arm and the stage (square, left) and the prealigner (I-shaped, top). During loading and unloading operations the current station is highlighted. When a wafer is present on the robot, prealigner, or stage, the icon changes, as shown in Figure 6-21. The sequence for loading a wafer is

- No wafer shown
- Wafer on robot
- Wafer on prealigner
- Wafer on robot
- Wafer on stage

When a wafer is unloaded, this sequence is reversed,

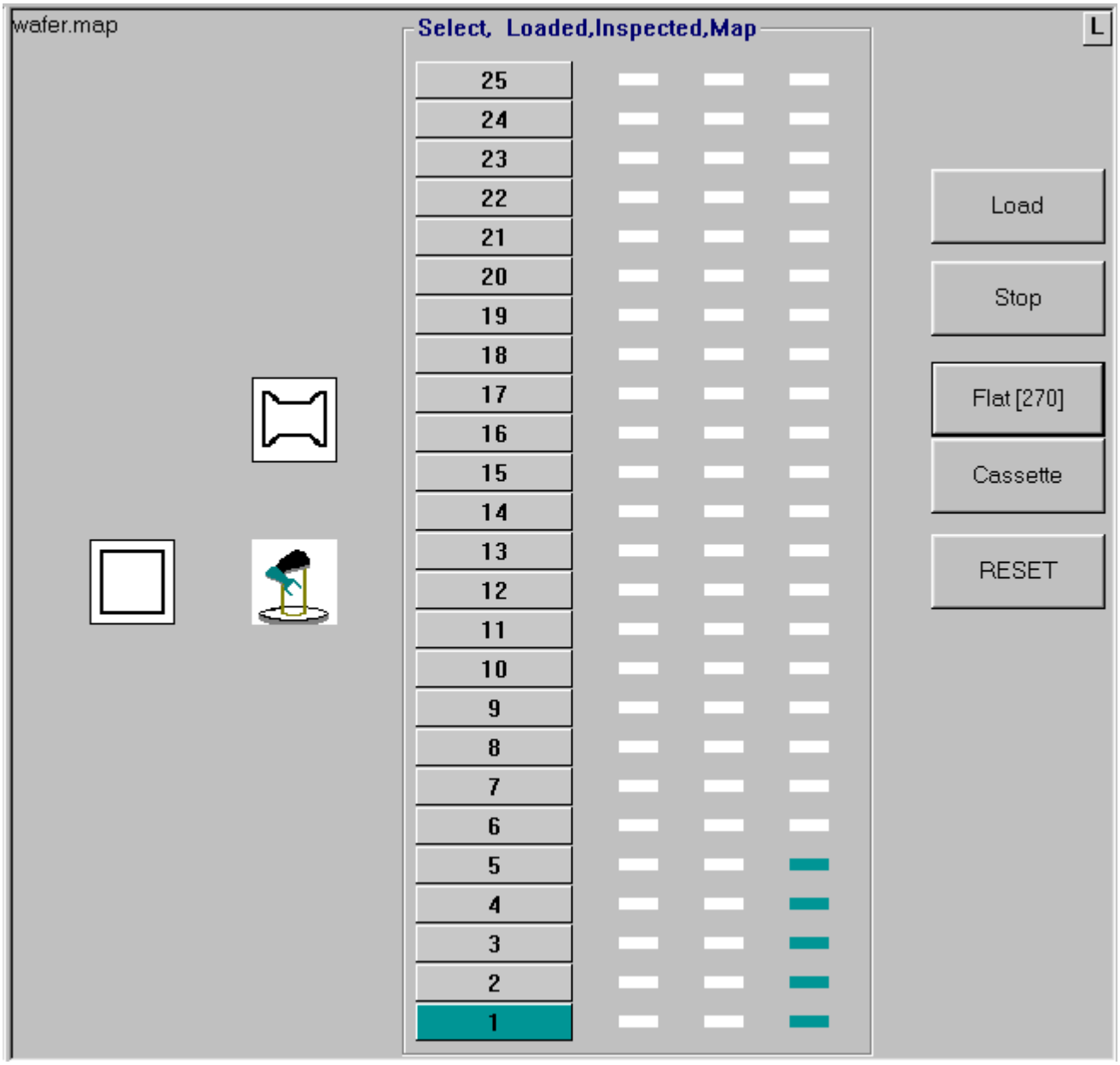
For each wafer slot, the display shows whether the slot is selected, whether the wafer in that slot has been inspected, and whether there is a map for it. Users can remap the cassette by means of the **Edit Wafer Map** function on the **Setup** menu (“Rearranging Map” on page 6–63), physically moving a wafer to a particular slot and dragging its representation on the screen to the same slot.

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**Figure 6-20 Cassette Pane**

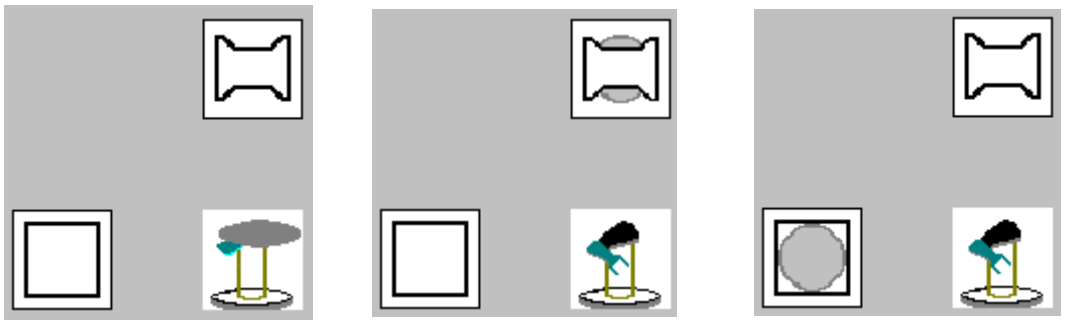



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**Figure 6-21 Wafer Location Icons in Cassette Window**



Wafer on Robot  Wafer on Prealigner  Wafer on Stage

The first step in loading a wafer is to click its slot in the pane to select it. The buttons at the right of the cassette pane control the wafer loading and unloading process. Their functions are described in Table 6-14.

**Table 6-14 Cassette Pane Controls**

| Button Label | Function |
|---|---|
| Load/Unload | Selected wafer is prealigned and then placed on the stage, or is removed from the stage and placed back in its slot in the cassette. |
| Stop | Halt robot, in case of error. |
| Flat [0] | This button sequences through the wafer flat or notch positions, 0° (down), 90° (left), 180° (up), or 270° (right). |
| Cassette/SMIF | Switch source between Cassette and SMIF. |
| RESET | Robot to home position. |

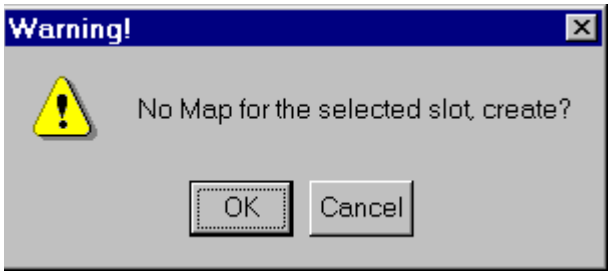
Clicking a cassette slot for which there is no wafer map brings up the dialogue box in Figure 6-22, which asks whether to create a new wafer map. If the slot was selected in error, clicking the ***Cancel*** button will prevent creation of a new map. Clicking ***OK*** creates an empty map, which can be edited in the ***Edit Wafer Map*** window, shown in Figure 6-46 on page 6-62.

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**Figure 6-22 No Map Dialogue Box**




### Tab Pane

The Tab pane has five options, selected by clicking one of the tabs at the top of the pane. Table 6-15 lists the tabs and their functions, and the tabs are shown individually below .

**Table 6-15 Tab Pane Options**

| Tab Name | Function |
|---|---|
| Status | Wafer data |
| Deskew | Offset, navigation data |
| DefList | Selected and sorted list of defects |
| DefCode | List of defect codes |
| Search | Search patterns |

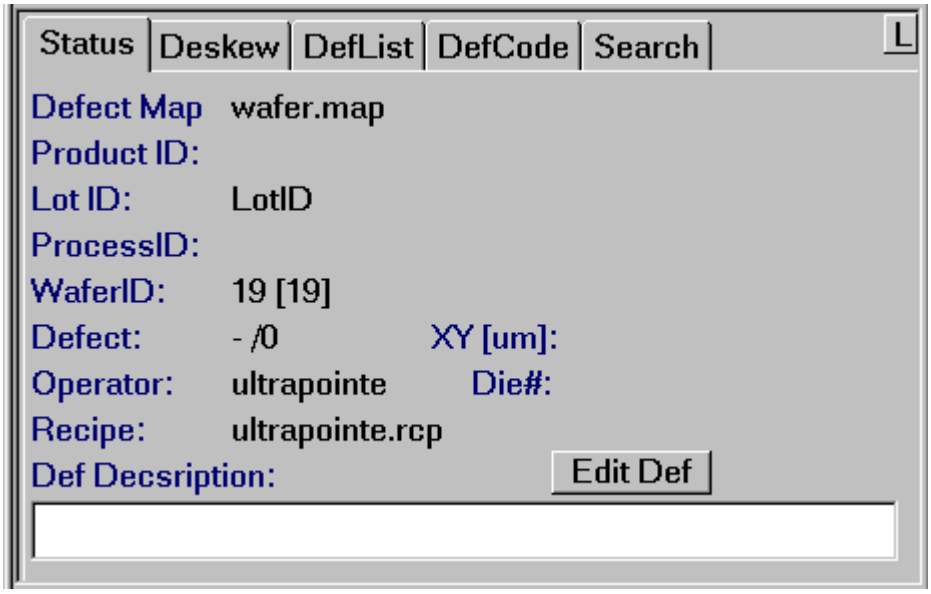
The ***Status*** tab shown in Figure 6-23 displays information about the wafers in the current map file, the currently loaded wafer, the most recent defect, the user account currently logged in, and the current recipe.

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**Figure 6-23 Status Tab**




Clicking on the ***Edit Def*** button on this tab brings up the ***Edit Defect*** window, shown in Figure 6-24. At the top, the window displays the name of the current defect map, the number of the currently selected defect, and the first unused defect number, where a new defect entry can be created.

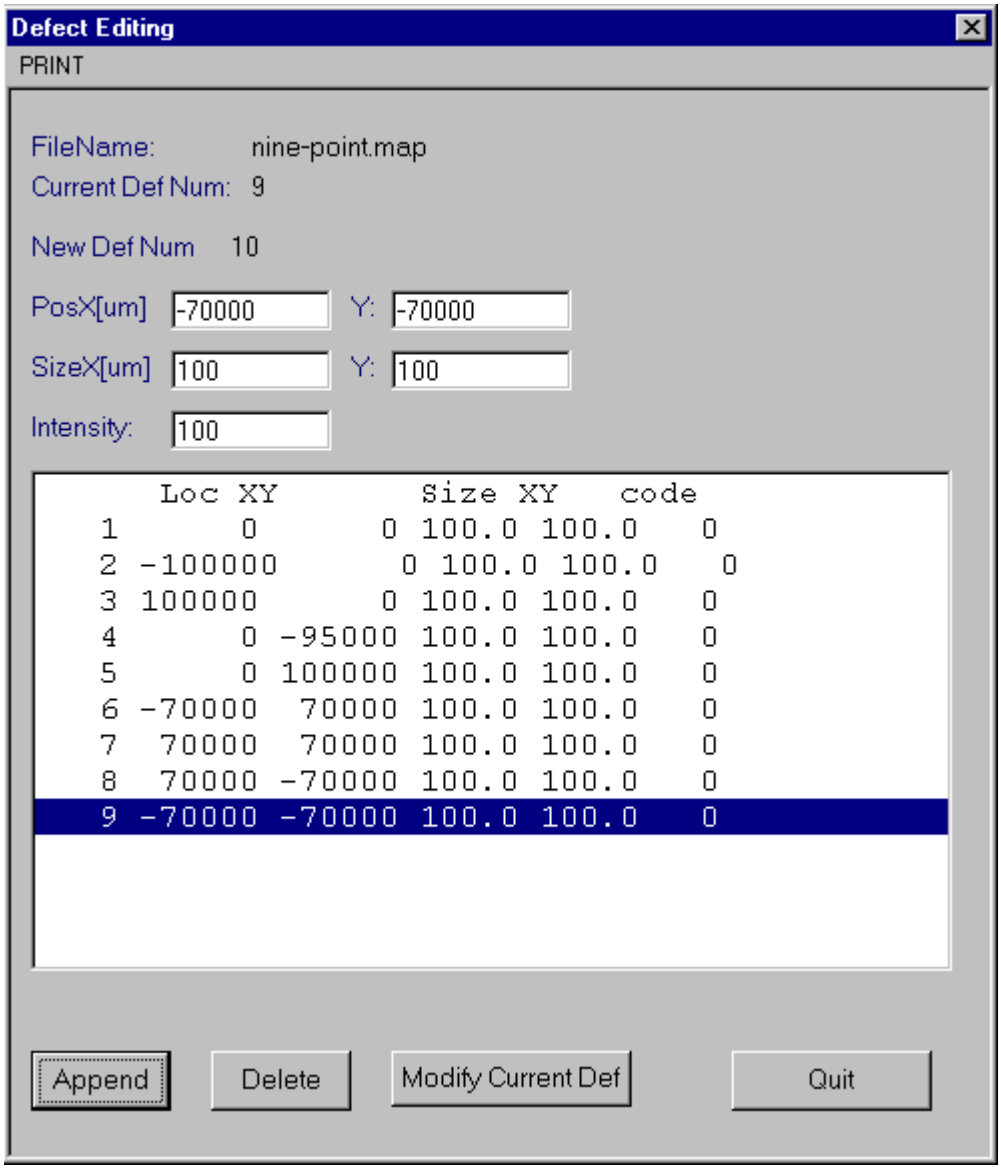
The list at the bottom tabulates the parameters of each defect, consisting of position, size or intensity, and defect code number. When the ***Edit Defect*** window is opened, the coordinates of the current stage position are copied to the ***PosX[um]*** and ***PosY[um]*** data entry fields, where they can be modified. New defects can be added with the ***Append*** button, existing defects can be removed from the list with the ***Delete*** button, and the data for a defect (position, size, and intensity) can be changed by editing the entry fields and clicking on the ***Modify Current Def*** button.

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**Figure 6-24 Edit Defect Window**




This window is useful for creating wafer maps for testing purposes, where the points entered are not necessarily defect locations, as in the nine-point map below.

**NOTE**
*Use of this function is an advanced operation. Please contact a KLA-Tencor applications engineer for proper training.*

Figure 6-25 shows the ***Deskew*** tab. It reports current deskew data, consisting of deskew point locations, die size, map offset, and skew in degrees, to 7 decimal places. This tab also offers a button for turning deskew off.

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**Figure 6-25 Deskew Tab**

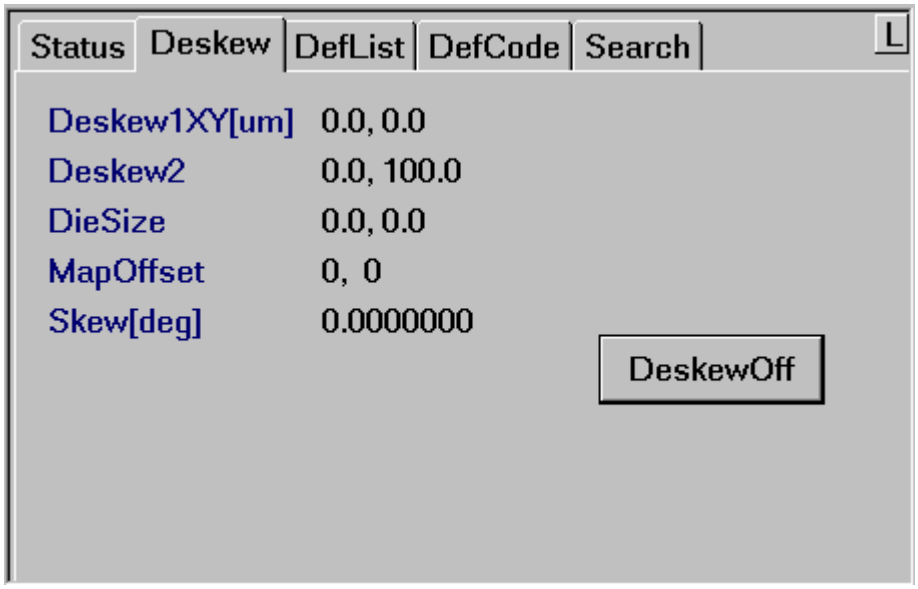
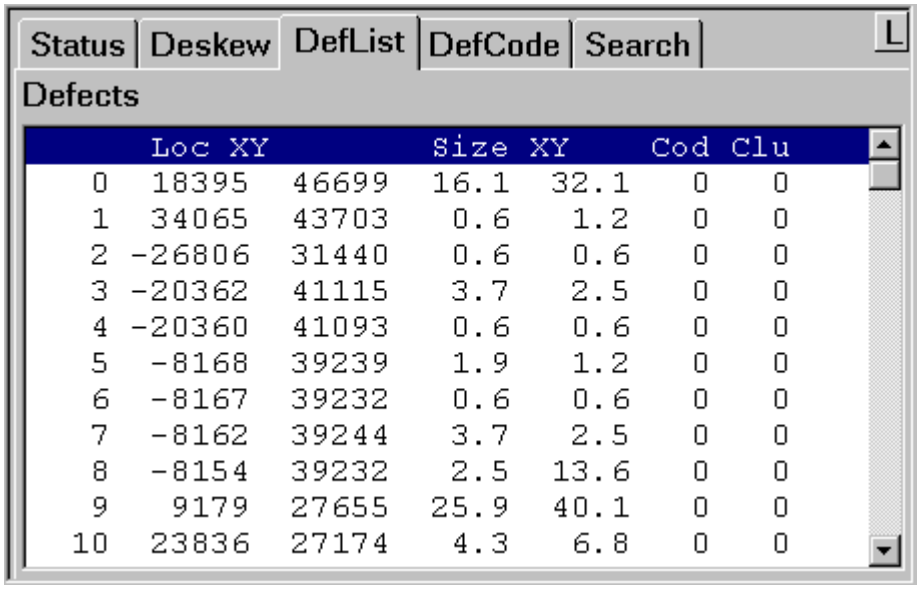



Figure 6-26 is the ***Defect List*** tab, showing a scrolling list of data for the mapped defects on the current wafer, as well as the headings for a KLA map.

**Figure 6-26 Defect List Tab**




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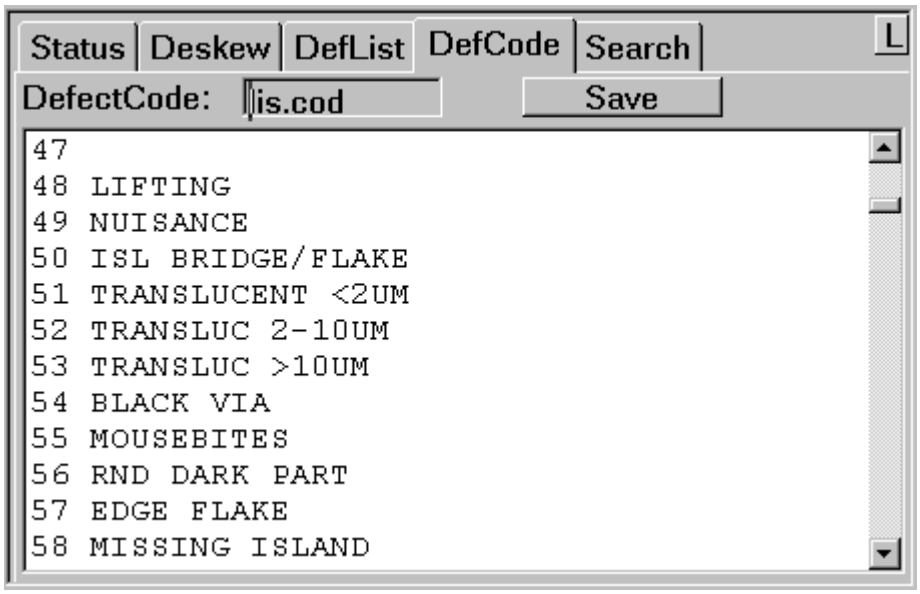
Defects are displayed in the format described in Table 6-16 for KLA maps with defect size data. The `Size XY` columns are replaced by an `Intensity` column when reviewing Tencor maps.

**Table 6-16 KLA Defect List Format**

| Column Heading | Data |
|---|---|
| | Defect number |
| `Loc XY` | Defect X position |
| | Defect Y position |
| `Size XY` | Defect X size |
| | Defect Y size |
| `Cod` | Defect classification code |
| `Clu` | Cluster number |

Figure 6-27 is the ***DefCode*** tab, showing a scrolling list of defect code numbers and names. The Save/No Save button toggles between ***Save*** and ***No Save***.

**Figure 6-27 DefCode Tab**




The ***Search*** tab (Figure 6-28) 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. There are two ***StepSize*** radio but-

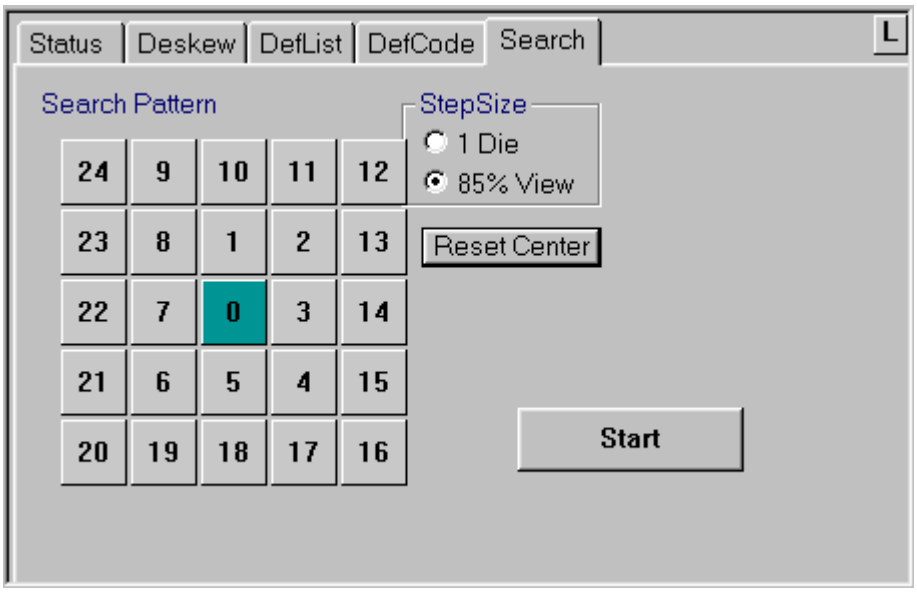
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tons. The ***85%view*** button moves the stage by 85% of the current laser window width, taking into account the objective magnification as if the laser zoom were set to 1. The overlap between views guarantees complete coverage of the region around the starting point. The ***Reset Center*** button makes the current position the starting point for a new search pattern.

**Figure 6-28 Search Tab, 85% View**




Clicking on ***Start*** jumps to the next area in the search pattern. The user can click any square in the pattern and continue from there to the end of the pattern. If the user clicks and *holds* on the ***Start*** button, the stage automatically advances after a short delay. The search pattern spirals outward, following the numbers 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 square.

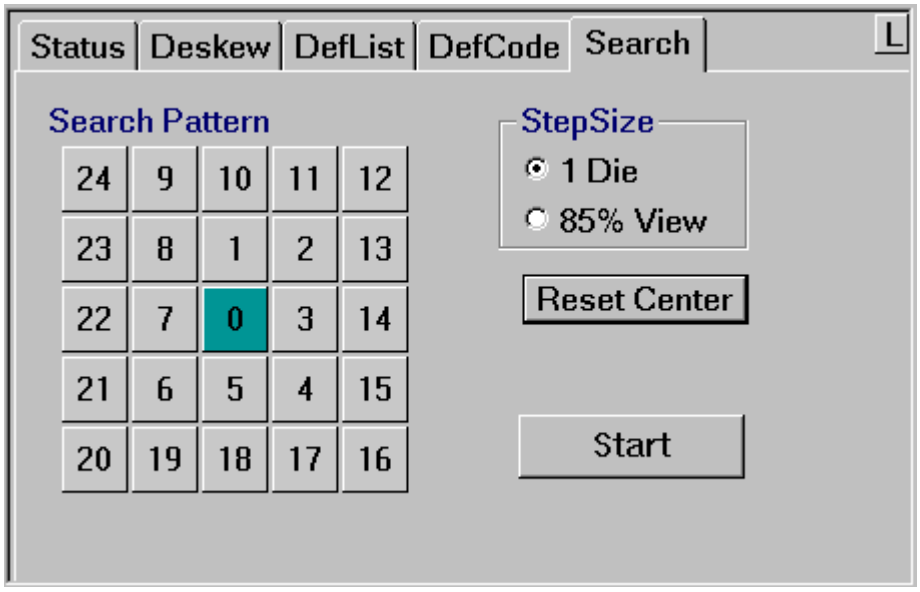
By changing the step size from **85%View** to **1 Die**, as in (Figure 6-29), this same utility may also be used to compare a region die by die, examining the same area, or even the same single feature, regardless of the magnification or zoom. To jump to the adjacent right die, click the square just 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. Using the ***Start*** button moves systematically through a 5 × 5 array, starting at the selected die position.

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**Figure 6-29 Search Tab, Die Jumping**

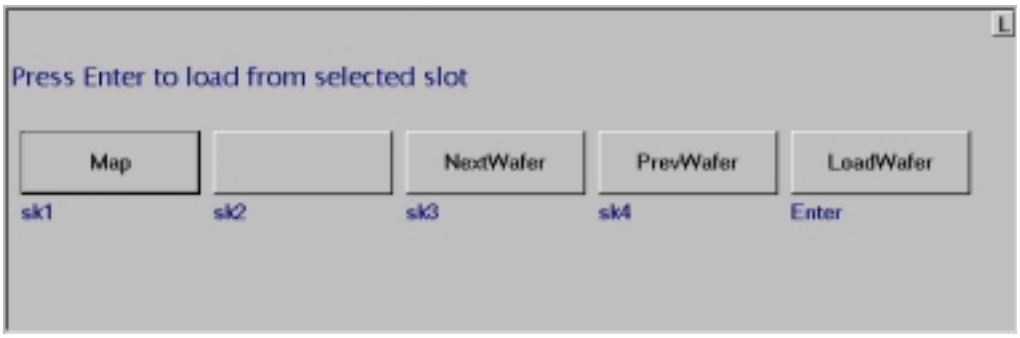



### Sequence Panes

There is a sequence pane in each of the three sequence screens, ***Load Wafer***, ***Deskew***, and ***Review***. Each of these panes shows the current functions of the four soft keys and the **ENTER** key, together with an appropriate message. The ***Review*** screen also has an input field for a defect classification code. The ***Surface*** and ***Volume*** panes use the **ENTER** key to return to the ***Review*** screen.

There are four functions available in the Load Wafer pane in Figure 6-30. The user can load a different map (**SK1**), or load any of three wafers.

**Figure 6-30 Load Wafer Sequence Pane**



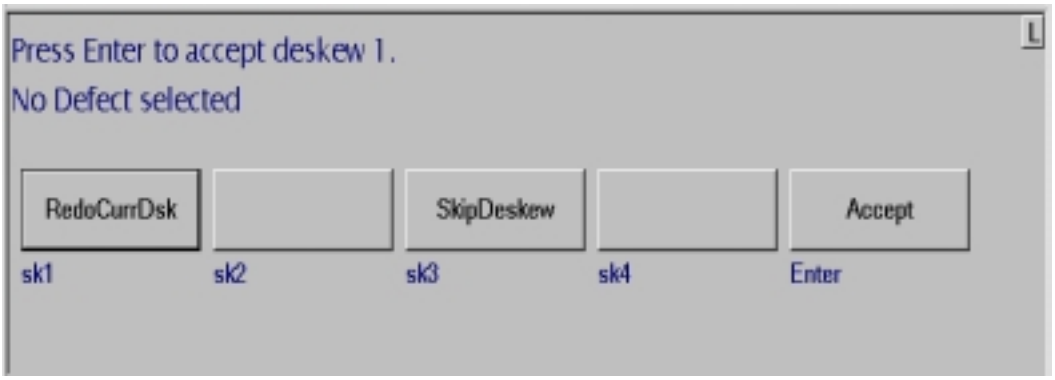

When the wafer is loaded, the software switches to the ***Deskew*** screen. The ***Deskew*** sequence pane in Figure 6-31 provides functions for starting deskew over (**SK1**), skipping it (**SK3**), or continuing by accepting the current deskew point (**ENTER**).

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**Figure 6-31 Deskew Sequence Pane**




When deskew is complete, the CRS is ready for defect classification. Figure 6-32 is the ***Review*** 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 the previous or next defect (**SK4** or **ENTER**).

**Figure 6-32 Review Sequence Pane**

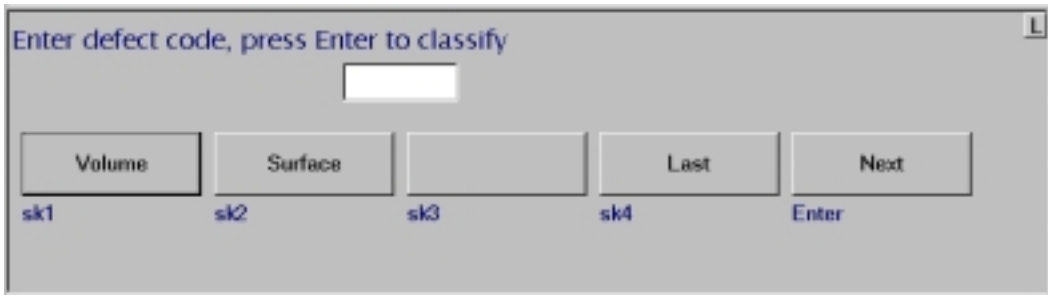
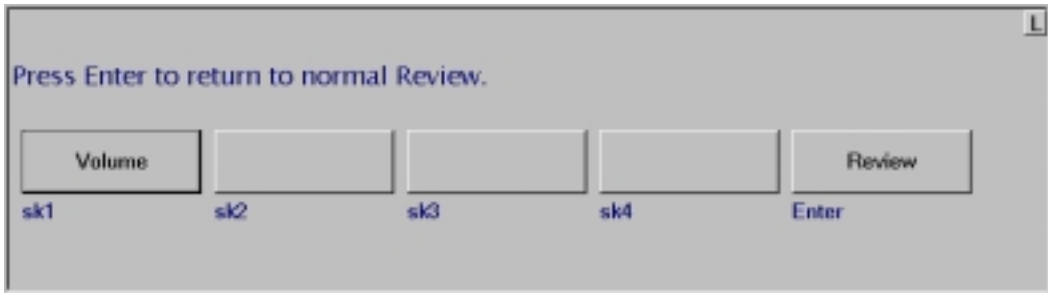



Figure 6-33 is the sequence pane in the ***Surface*** screen, with controls to switch to a ***Volume*** screen or to return to the ***Review*** screen (**ENTER**) after examining the 3D images. The ***Volume*** sequence pane is identical except that its **SK1** button switches to the ***Surface*** screen.

**Figure 6-33 Volume Sequence Pane**




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### Laser and White Light Controls

The controls described in Table 6-17 appear among Laser Image controls, but affect both laser imaging and white light imaging. Because they are used frequently, these functions are also accessible directly from the keyboard (Figure 6-1 on page 6-2) for faster throughput.

**Table 6-17 Mechanical Imaging Controls**

| Control | Keys | Description |
|---|---|---|
| **Objective** option menu | MAG↑, MAG↓ | Several objective magnifications are displayed, depending on which have been installed. Objectives with magnifications of 5×, 20×, 50×, 100×, and 150× are standard. There are options for 2.5× and 250×. |
| ***FineZ*** slider bar | Z↑, Z↓ | The Fine Z stage is a precision piezo-driven stage capable of making 4096 vertical steps of12 nm each. The maximum travel of the Fine Z stage is a about 50 µm.<br><br>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 µm. |
| ***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. |

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**Table 6-17 Mechanical Imaging Controls**

| Control | Keys | Description |
|---|---|---|
| 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 the CoarseAF button (located just below the FineAF button). The system automatically finds the proper focus position. If, after a coarse autofocus command, the focus is good but not great, try a subsequent click the FineAF button. |
| 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.<br><br>The Laser/WL button is a toggle switch that alternates between either white light mode only, or simultaneous laser and white light mode. It is apparent 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. |

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### White Light Control

Figure 6-34 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 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. .

**Figure 6-34 White Light Image**






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### Laser Imaging Controls

The controls described in Table 6-18 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 and Surface Screens" on page 6–53. 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.

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.

**Table 6-18 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. |
| ***T***, ***B***, and ***Set Z*** buttons | Move the stage up until the defect signal from below focus vanishes from the screen. Click ***T*** (top). Move down through focus and continue until the top of the defect signal vanishes again. Click ***B*** (bottom). If ***T*** and ***B*** are set at the same height, the start position is set to the ***T*** 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 |
| ***Acquire Image: Vol*** and ***Surf*** buttons | Capture volume or surface image |

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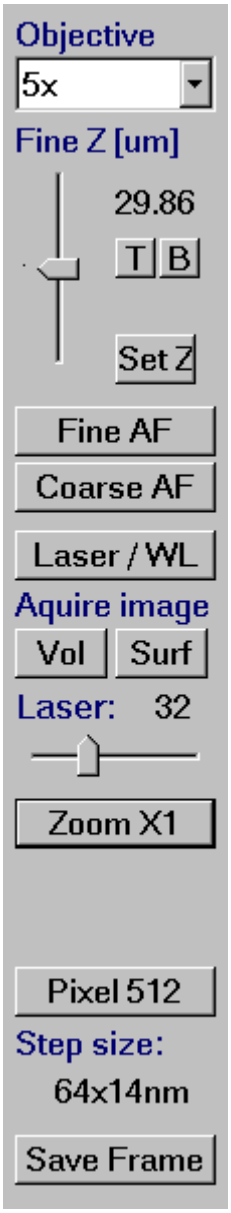



**Table 6-18 Laser Image Screen Controls (continued)**

| Control | Description |
|---|---|
| ***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.<br><br>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, 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. |
| ***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. |
| ***Step Size*** display | Displays the number and spacing of slices in volume images. |

## Load Wafer Screen

After logging in and initializing the hardware, the first screen the user sees is the ***Load Wafer*** screen in Figure 6-35. 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.

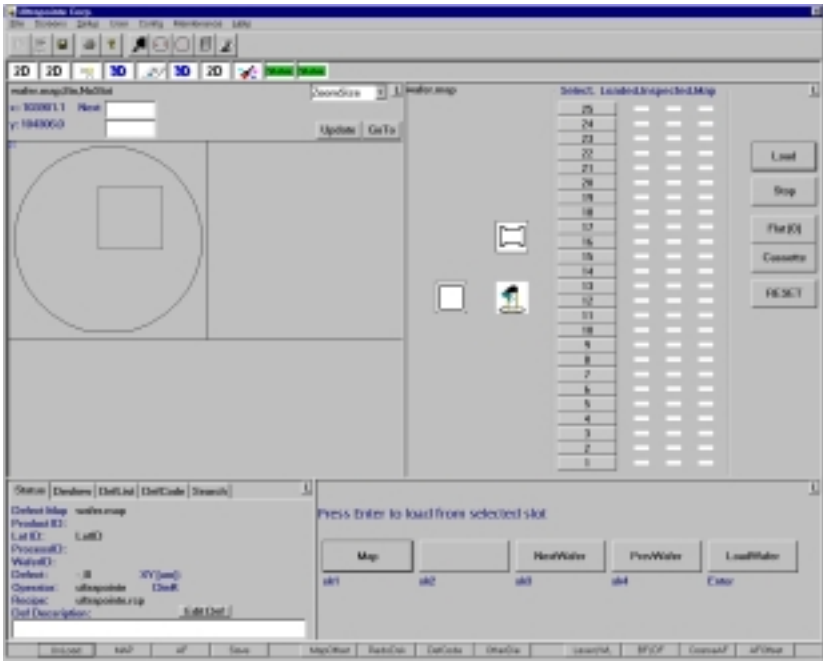
In normal operation, when reviewing a cassette of wafers, the user loads the selected wafer at this point. For other purposes the full power of the CRS software is available from the menus.

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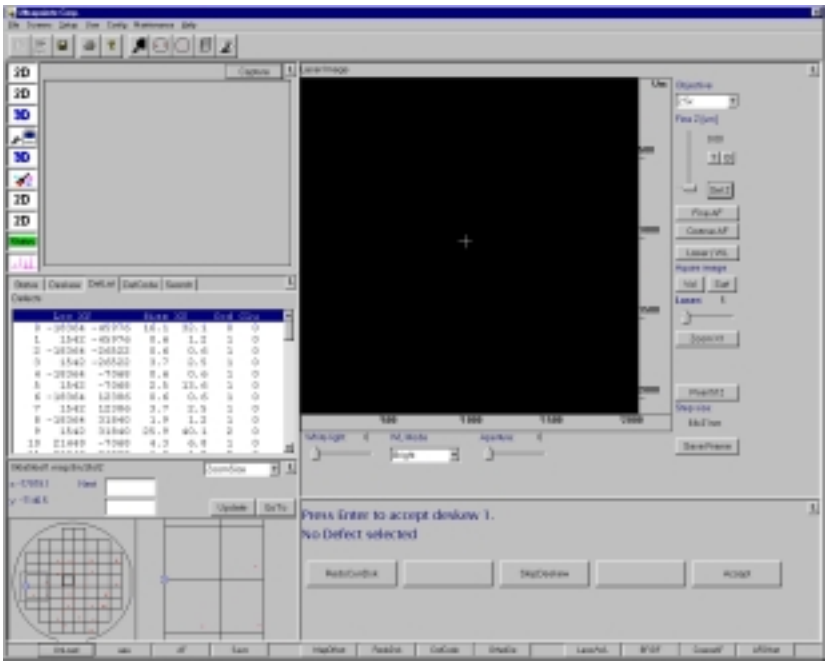
**Figure 6-35 Load Wafer Screen**



## Deskew Screen

The ***Deskew*** screen is shown in Figure 6-36. 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 the tab pane, above the wafer map panes.

**Figure 6-36 Deskew Screen**



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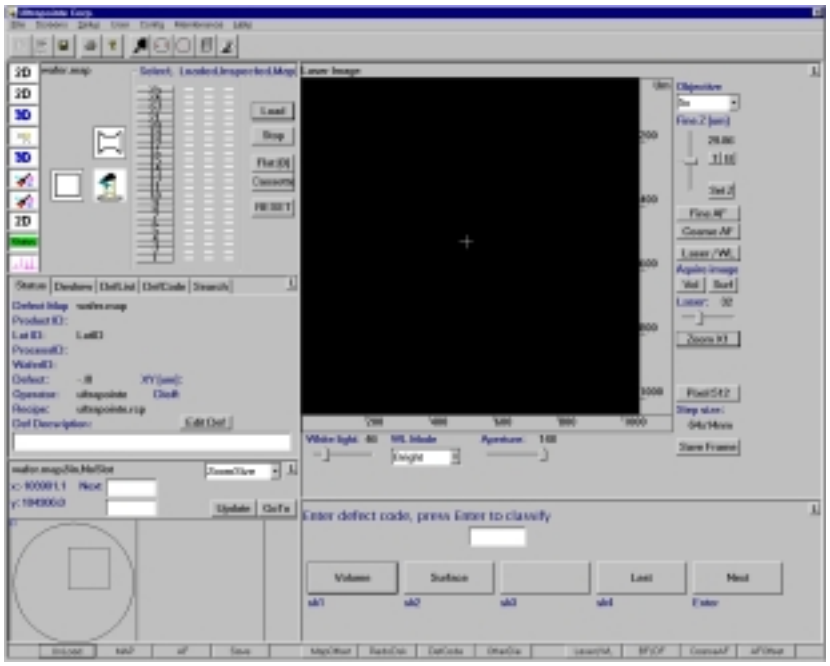


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The user normally begins by turning on the laser image. The deskew process consists of moving two deskew points under the crosshairs with the joystick, and accepting their positions when they are ready. From the first two points the CRS calculates the angular correction needed for accurate positioning. At the first defect, 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.

## Review Screen

**Figure 6-37 Review Screen**



With the preliminaries out of the way, the process of defect review and classification can begin. The ***Review*** screen in Figure 6-37 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 ***Last*** and ***Next*** defect button, linked to **SK4** and the **ENTER** key.

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 convenient feature is changing from the ***DefList*** option to ***DefCode***, the list of defect names and codes (see Figure 6-27 on page 6-43), in case it is necessary to look up one of the more unusual defect types. Dragging in a library pane or switching to a library screen to look at images of previously classified defects is also useful sometimes.

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## Volume and Surface Screens

Figure 6-38 shows a CRS ***Volume*** screen with four views from the same volume data set, and Figure 6-39 shows a ***Surface*** screen, again with four views, this time from the surface image data set extracted from the previous volume data.

**Figure 6-38 Volume Screen**

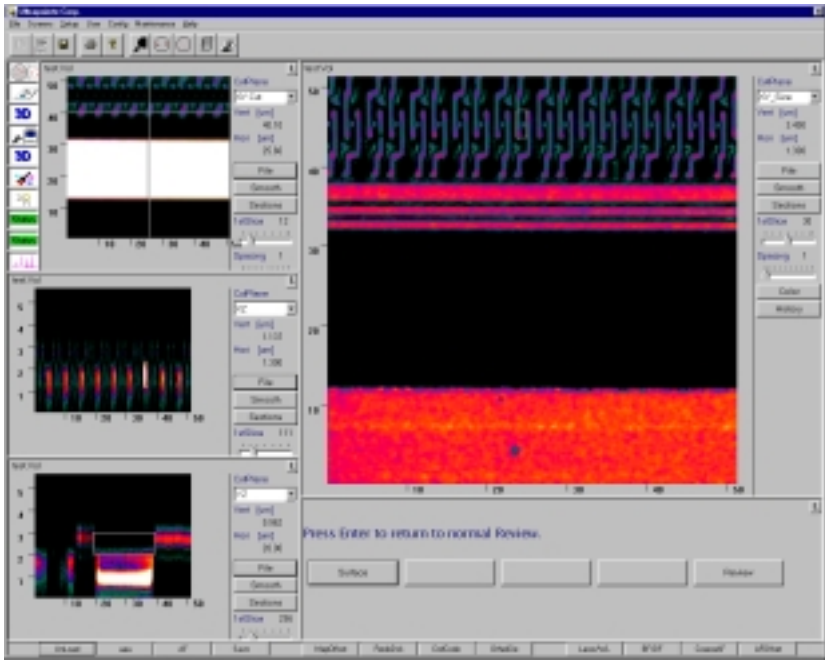
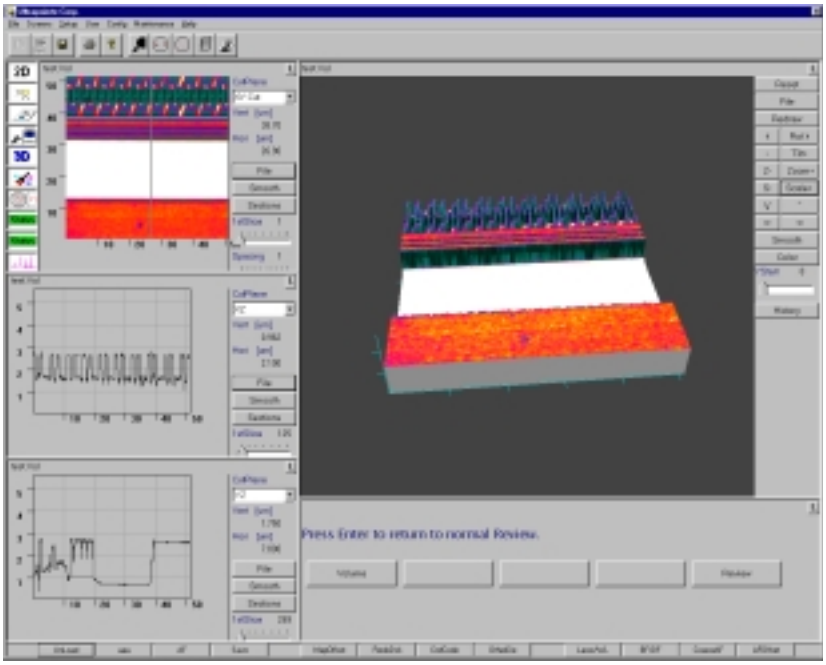


**Figure 6-39 Surface Screen**



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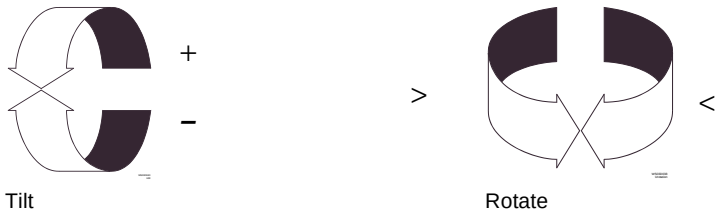
The 3D surface image controls are summarized in Table 6-19, with further comments following. The CRS software calculates views of these 3D data sets as if they were moved around in space, at varying angles and with variable zoom. Images can be viewed in false color or gray scale. The Z height can be expanded to bring out features in relief better. Since the laser images can be somewhat noisy, a smoothing function is included to produce a better approximation of the true surface.

**Table 6-19 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 |
| **<** ***Rot*** **>** buttons | Rotate around Z axis. |
| **-** ***Tilt*+** buttons | Rotate around X axis. Raising back edge is positive. |
| ***Z-*** ***Zoom*+** buttons | Center at a selected point, and magnify or demagnify image. |
| ***S-*** ***Scale*+** buttons | Decrease or increase vertical scale |
| ***V*** **^** buttons | Move down or up within image, without rotation. Apparent image motion is opposite to arrow. |
| <- -> buttons | Move left or right within image, without rotation. Apparent image motion is opposite to arrow. |
| ***Smooth*** button | Use averaging to reduce image noise. |
| ***Color*** button | Switch between false color and gray scale |
| ***Y Start*** slider | Select XZ slice for front of image. The surface behind the selected slice remains visible, while lower numbered slices are removed from the image. |
| ***History*** button | Image file data |

The action of the ***Tilt*+** and **-** buttons and the ***Rot*>** and **<** buttons is shown in Figure 6-40.

**Figure 6-40 Action of Tilt and Rotate Buttons**




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Zooming is used to frame the region of interest within the field of view. The ***V***, **^**, **<-**, and **->** buttons move the surface image within the window.

Since a monochromatic light source is used for laser imaging on the 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 in both the 2D and 3D laser images are referred to as false color. All 3D surface images are initially displayed in false color. The ***Color*** button toggles between false color and gray scale.

To enhance the surface topography of a 3D image, click the ***Scale +*** button to increase the scale of the Z axis. This is particularly useful for thin defects. It may be useful to reduce the Z scale with the ***Z-*** button in images of surfaces with high relief.

Smoothing can give a more accurate portrayal of a 3D image if there is surface noise. Clicking on the ***Smooth*** button instructs the computer to mathematically average around each point in the entire surface region. This 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.

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.

To save a 3D surface image, click 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 filename. Click ***Save*** and the image is saved for future retrieval. To load an image file, select a directory and file name, and click ***Load***.

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### The 2D Panes

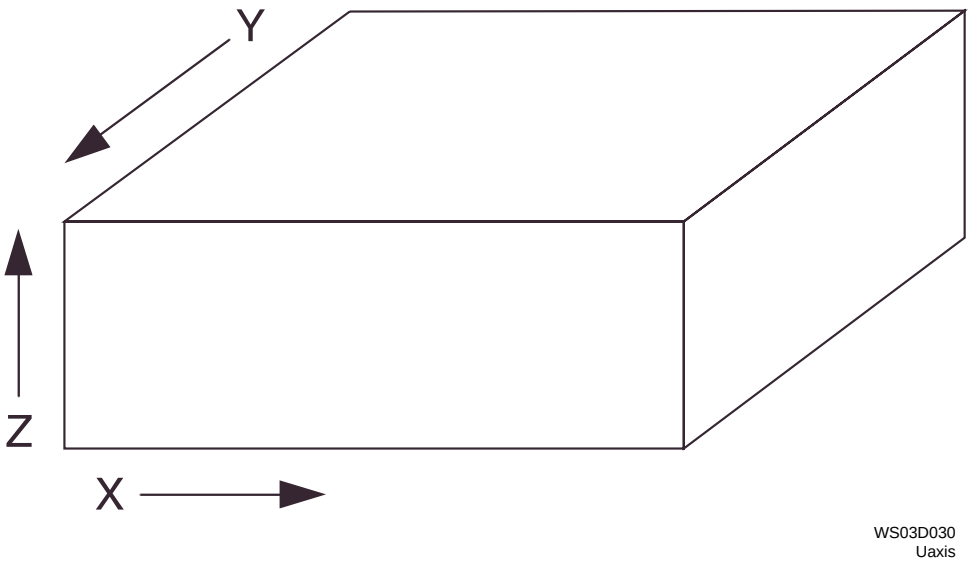
The 2D panes are extremely powerful analytical tools. They not only provide views of images from the top, but also from the front and side, providing both critical topographical and subsurface information.

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. Figure 6-41 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.



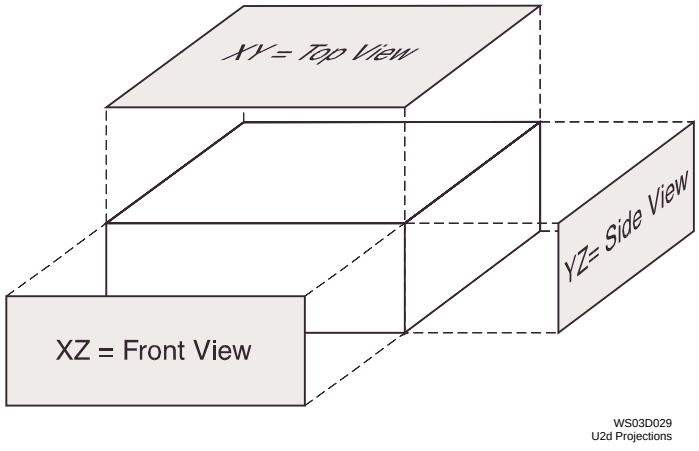
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**Figure 6-41 2D Axis Conventions**




Moreover, when using the 2D panes, it is important to understand the conventions used to represent the various two dimensional view projections. Figure 6-42 depicts the three different views that are accessible via the 2D window.

**Figure 6-42 2D View Projections**




The XY cut is a horizontal slice view, the same as live laser imaging. The XZ and YZ cuts represent cuts in the interior parallel to the front and side views respectively.

Figure 6-43 on page 6-58 shows the 2D image controls for viewing slices of 3D images. The first control, the **Cut Plane:** option menu, is summarized in Table 6-20, while the remaining controls are described in Table 6-21 on page 6-58. The **Cut Plane:** option menu

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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 6-20 2D Slice Viewing Options**

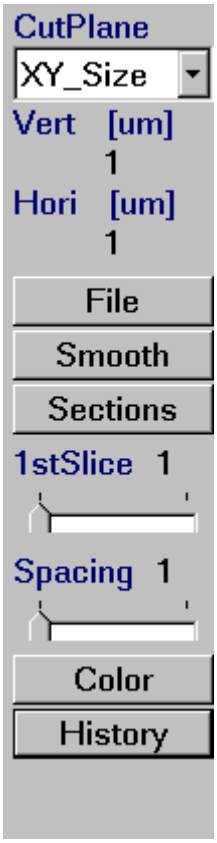
| Function | Surface Images | Volume Images |
|---|---|---|
| XY Size | Top view; provides a rubberband cursor for measuring features. | |
| XY Cut | Top view; provides cutting cross hair cursors that control the XZ and YZ views. | |
| XZ | Front view; surface topography information only; controlled 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 6-43 2D Image Controls**




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 the user to choose which slice to observe. To control the slice number, use the ***1st Slice*** slider bar.

The size cursor box that is displayed in the **XY Size** option is identical to that in the ***Wafer Map*** pane. Clicking and dragging on the upper left corner of the box, *moves* the entire box. Clicking and dragging on the lower right corner of the box controls the *size* of the box. As the size varies, the numerical dimensions of the box are displayed under the ***Horizontal*** and ***Vertical*** sections of the 2D window.

Selecting the **XY Cut** option displays a pair of crosshair cursors. Clicking and dragging anywhere on the *horizontal* cursor in the ***XY*** view controls the slice displayed in any open ***XZ*** window. To measure the height of a particle defect, move the horizontal cutting cursor so that it bisects the particle. In the ***XZ*** window, a profile appears that represents the protrusion of the particle above the surface. Now measure the defect in the ***XZ*** window by adjusting its cursor box to surround the defect.

Likewise, the vertical crosshair in the ***XY Cut*** view controls the profile that is displayed in the ***YZ*** view. Clicking and dragging the *intersection point* of the horizontal and vertical crosshairs control both the ***XZ*** and ***YZ*** views simultaneously. The ***1st Slice*** slider bars in the ***XZ*** and ***YZ*** views display the positions of the cutting cursors and the numbers of the slices displayed, counting from the top left as 0,0 to the bottom right as 512, 512.

**Table 6-21 2D Slice Image Control Functions**

| Function | Surface Images | Volume Images |
|---|---|---|
| ***File*** button | To load and save image files. | |
| ***Smooth*** button | Executes an averaging routine to eliminate spurious noise. | |
| ***Sections*** button | 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. |

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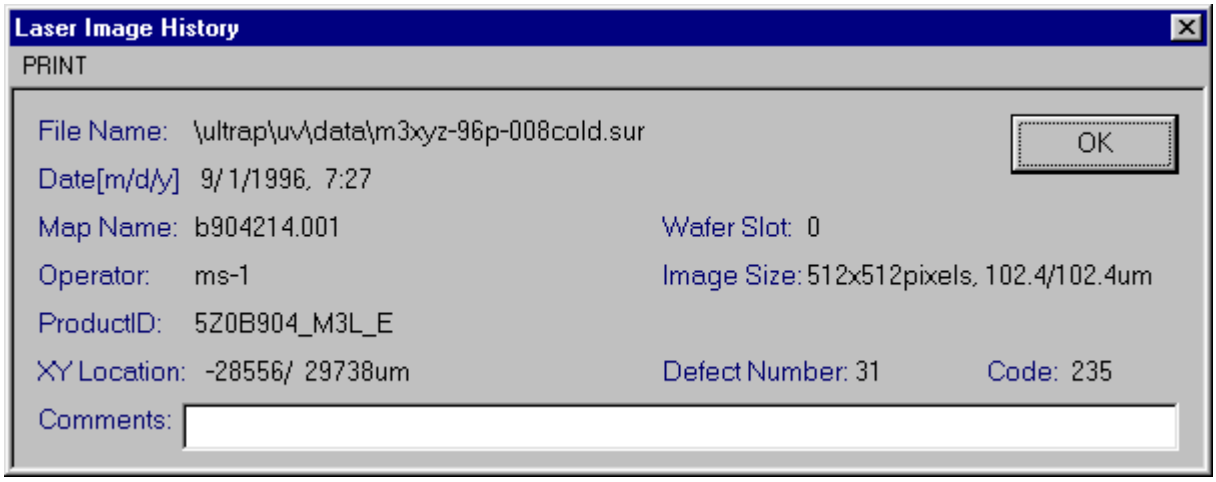
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**Table 6-21 2D Slice Image Control Functions**

| Function | Surface Images | Volume Images |
|---|---|---|
| ***1st Slice*** slider | 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, counts from top or left. |
| ***Spacing*** slider | For section view only, defines the number of slices between views. | |
| ***Color*** button | Toggles image between false color and gray scale. | |
| ***History*** button | Source data on current image | |

The ***Laser Image History*** window in Figure 6-44 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 6-44 Image File History Window**




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 or by the ***1st Slice*** slider in the slice 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.

A typical volume image is comprised of 512 pixels in X, by 512 pixels in Y, by 64 slices in Z. In 2D windows the ***1st Slice*** slider bars can select any individual slice of pixels in any plane. For example, the XY view begins with a 512 × 512 image of the bottom slice.

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Moving the ***1st Slice*** slider bar selects which of the 64 slices appears. This is the equivalent of selecting a focus position during live laser imaging. Slice number 1 is the bottom-most slice in Z and slice number 64 is the top-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. 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 appears.

Sometimes users may want to observe more than one slice at a time. This is the purpose of the ***Sections*** button, which changes the image sequentially from a single slice view to 4, 9, and then 16 slices simultaneously, by sectioning the window into a 2×2, 3×3, or 4×4 grid. Clicking on the ***Sections*** button again in a 4×4 view goes back to a single slice view. 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. For example, if ***1st Slice*** is set to 7 and ***Spacing*** is set to 3, the slices displayed will be numbers 7, 10, 13, 16, 19, 22, 25, 28, 31.

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 pixels all appear the same regardless of their intensity value. Therefore, there is no way to distinguish between the various intensity levels from the appearance of the pixels. However, the ***Threshold*** slider bar that appears in these views makes these distinctions. Any pixels which are brighter than the threshold value appear in the image, 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.

The ***Z Profile*** view is unlike all the others. The horizontal axis is Z position and the vertical axis is reflected intensity, on a scale of 1 to 255. This view shows the variation in reflected intensity with Z position for any single XY location, as defined by the ***XY Cut*** view). The software can display multiple peaks, which can give complete outline views of layers or defects in cross-section. Contact a KLA-Tencor CRS applications engineer for details on this advanced feature.

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## Setup Menu

The Setup menu shown in Figure 6-45 includes recipe setup functions that are also accessible from the recipe file screen in Figure 6-7 on page 6-18. 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.

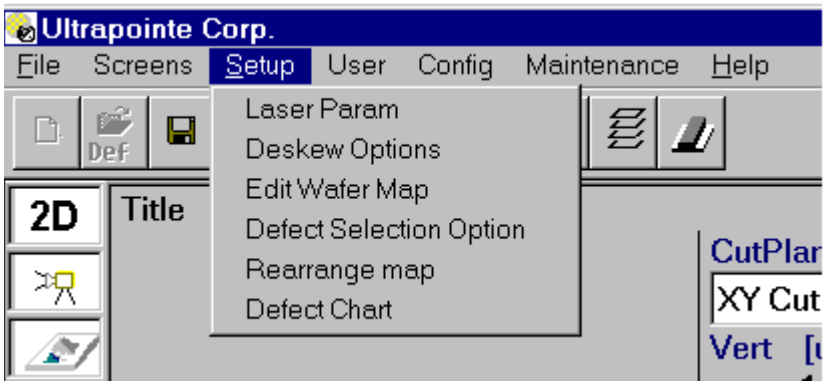
### LaserScan Parms

See “LaserParams” on page 6–18, under “Recipe File Selection and Editing”. The window brought up by this menu item and that button are identical in function and appearance.



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**igure 6-45 Setup Menu**




## Deskew Options

See “Deskew Options” on page 6–21, under “Recipe File Selection and Editing”. The window brought up by this menu item and that button are identical in function and appearance.

## Edit Wafer Map

Figure 6-46 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.

**IMPORTANT**

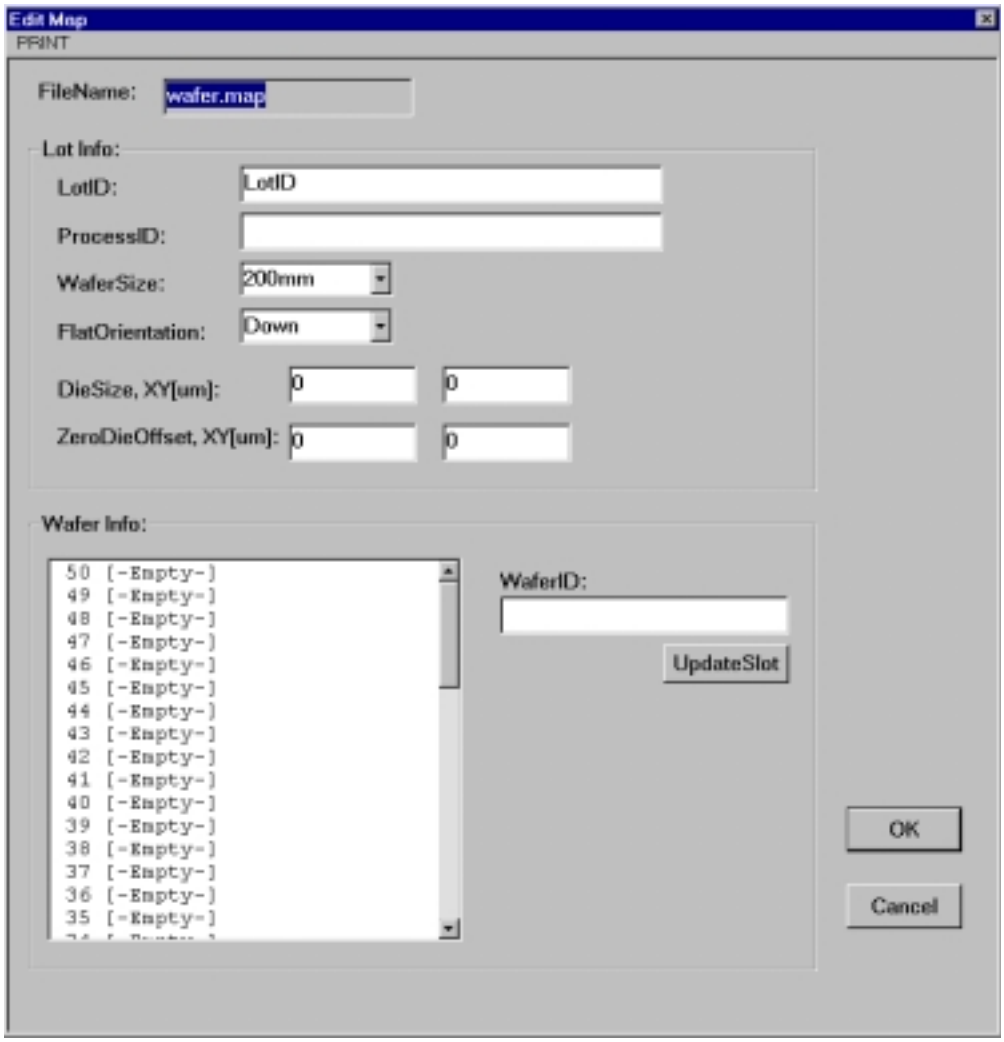
*Bringing a KLARF map file from a 255X to a CRS, changing it on the CRS, and then returning the file from the CRS to the 255X will result in an error when attempting to load the file.*

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**Figure 6-46 Edit Wafer Map Window**




This dialog box controls the parameters described in Table 6-22 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.

**Table 6-22 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. |
| ***Process*** ID | Enter or edit PID |
| ***Wafer Size*** option menu | Select 100, 125, 150, or 200 mm. |
| ***Flat Orientation*** option menu | Choose from Down, Left, Up, and Right. |

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**Table 6-22 Wafer Map Parameters**

| Field | Description |
|---|---|
| ***Slot*** menu | Shows matching of wafer IDs and slots. |
| ***DieSize, XY [um]*** entry fields | X and Y dimensions of die |
| ***ZeroDieOffset, XY [um]*** entry fields | X and Y distances between wafer center and die corner |
| ***Wafer Slot*** and ***Wafer ID*** entry fields | Select a slot number and enter a wafer ID for that slot. A valid wafer file must have at least one slot with a wafer ID. |
| ***Update Slot*** button | Makes changes to the slot menu, entering the wafer ID for the specified slot. |
| ***OK*** button | Accepts all changes and closes window |
| ***Cancel*** button | Discards all changes and closes window |

## Defect List Sort

This is identical to Figure 6-11 on page 6-23.

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.

## Rearranging Map

Figure 6-47 is the window for rearranging a wafer map file, in case the wafers have to be moved to different slots. The slots with wafer maps are displayed in green.

To move a wafer map from one slot to another

1. Click a green button for 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 following 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.

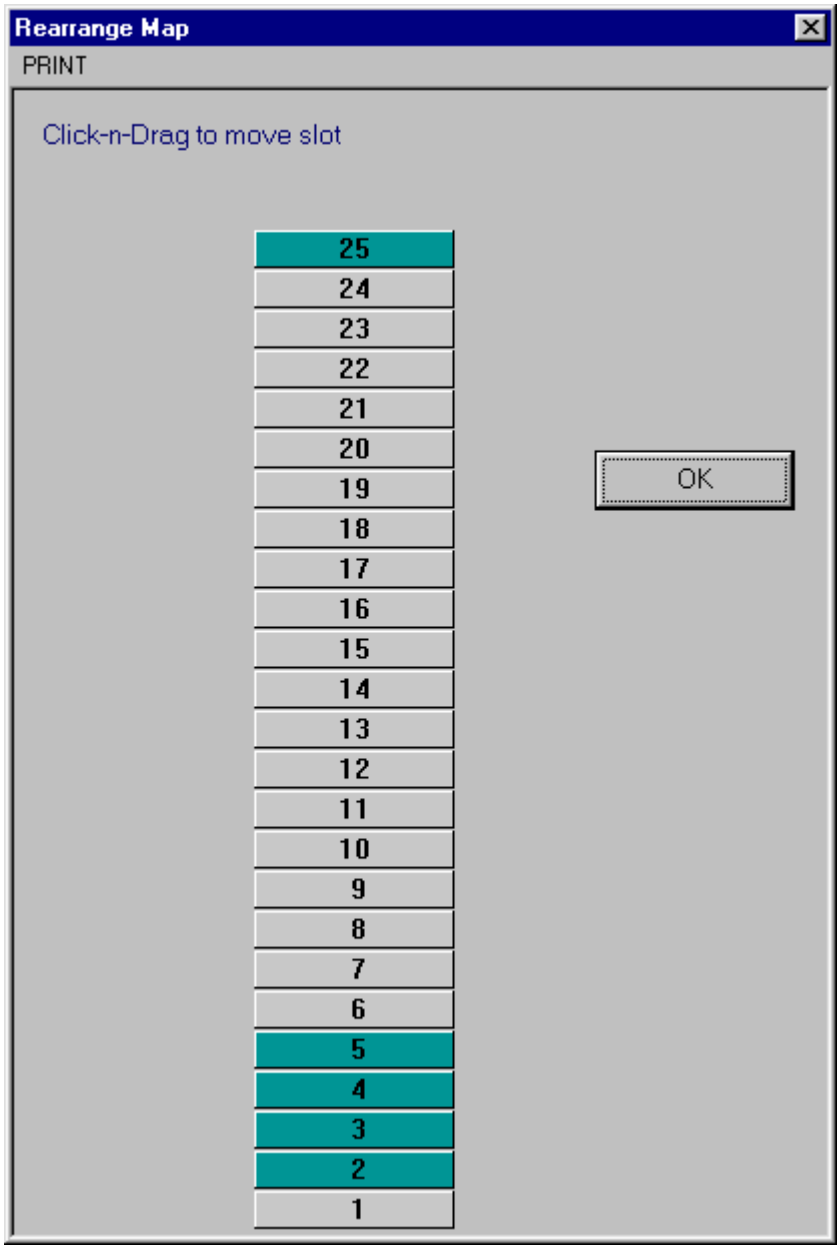
Click ***OK*** when done rearranging the map. Use the **Wafer Map** function on the **File** menu to save the new map with an appropriate name.

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**Figure 6-47 Rearranging Wafer Map**




**IMPORTANT**
*Do not use this feature if the defect map file will be returned to the KLA 255X for analysis. The 255X does not accept defect map files that have had their slot numbers altered.*

## Defect Chart

Figure 6-48 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, process ID, and Wafer. Below the histogram is a line identifying the X axis as

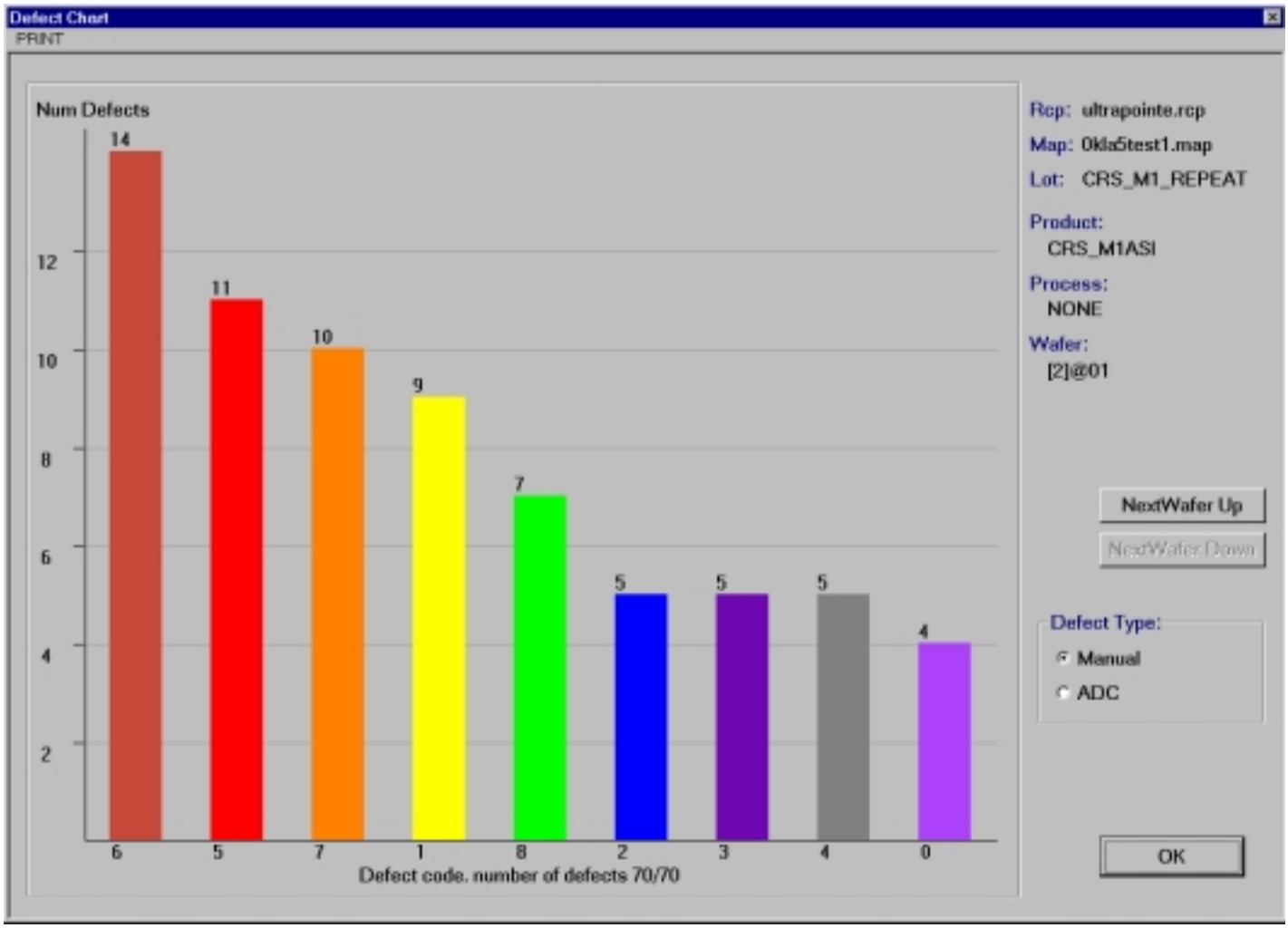
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the defect code number, and giving the number of defects classified and the number of defects in the wafer map. The ***NextWafer Up*** and ***NextWafer Down*** buttons let the user navigate within the window to look at defect statistics for several wafers. Defect codes can be charted from either manual or ADC review. The ***OK*** button exits.

**Figure 6-48 Defect Chart Window**




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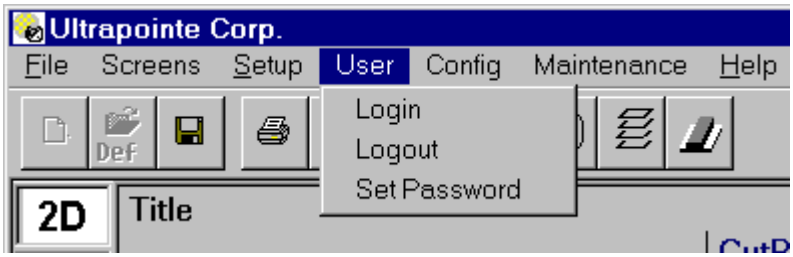


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## User Menu

The User menu is displayed in Figure 6-49. There are three selections, all related to user accounts: **Login**, **Logout**, and **Set Password**.

**Figure 6-49 User Menu**




The **Login** command returns the user to the initial ***Login*** window. The window 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.

The **Logout** function is similar to the **Login** function. Both end the current user session, but **Logout** returns to the ***Start*** screen rather than the ***Login*** screen. The next user must not only log in, but reinitialize the hardware and software.

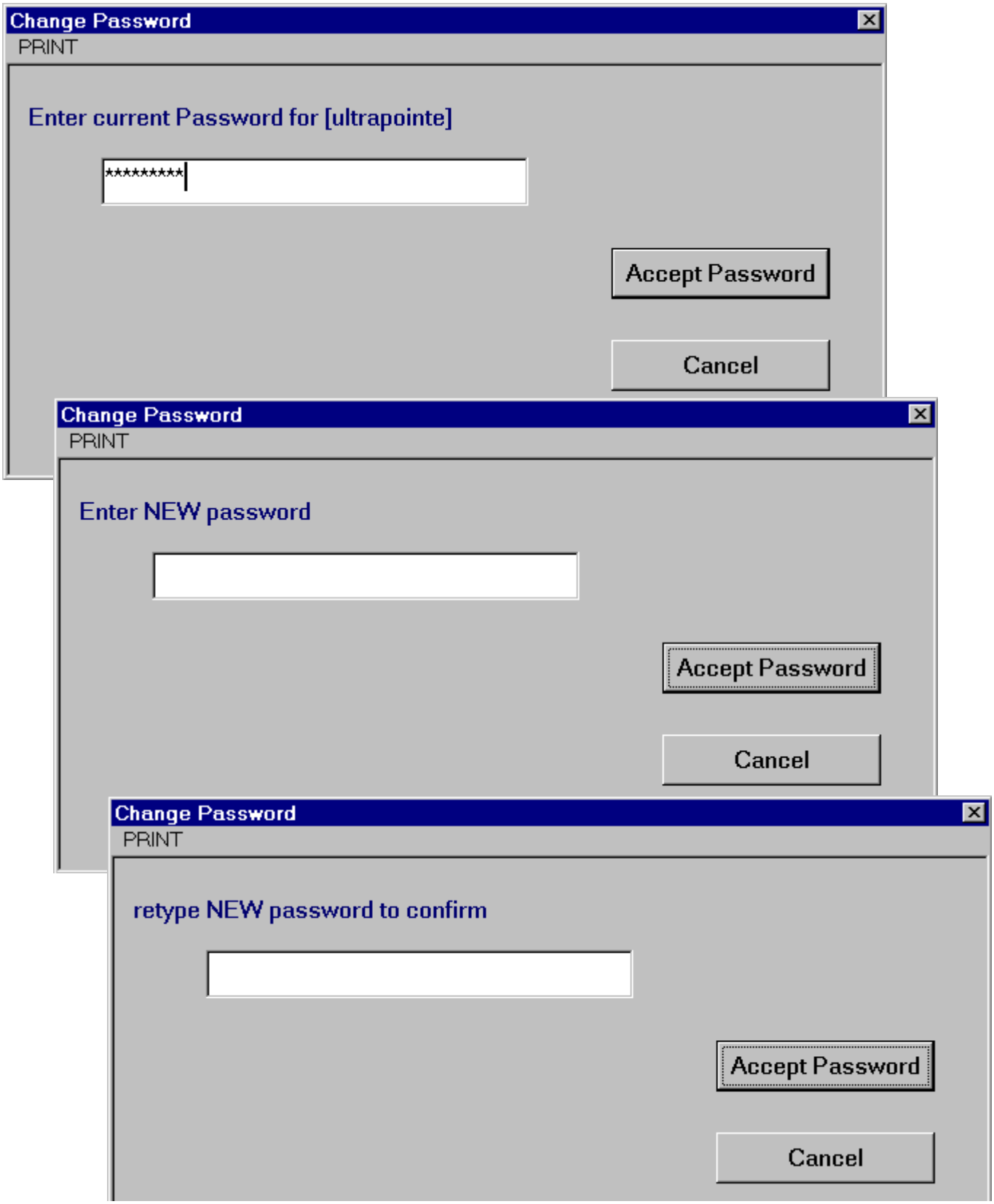
Figure 6-50 shows the sequence of windows for changing a password. The user is prompted to enter the current password, then the new password. Both appear as a sequence of asterisks, so careful typing is essential. Clicking on ***Accept Password*** proceeds, and clicking on ***Cancel*** abandons the process, leaving the previous password intact.

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**Figure 6-50 Set Password Windows**




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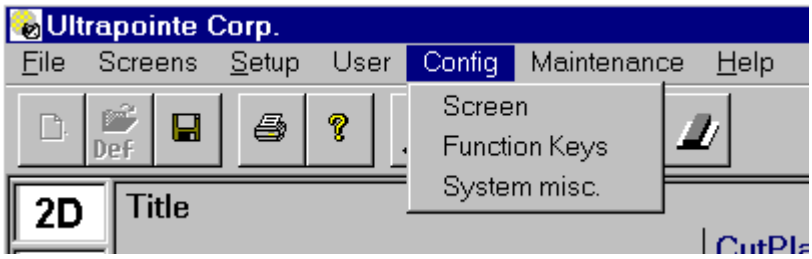


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## Config Menu

The **Config** menu shown in Figure 6-51 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 in meeting special requirements.

**Figure 6-51 Config Menu**




### 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 which users cannot add, delete, or rename. However, it is possible to modify their appearance by assigning different default panes. User screens can be renamed or deleted, and their panes can be rearranged. User screens are not employed by the software. Users can select them from the **Screens** menu with the mouse.

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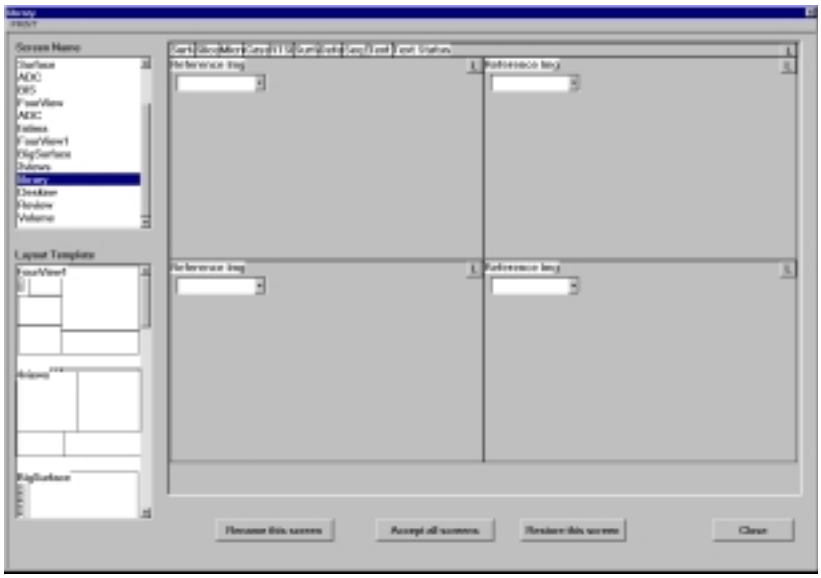
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### To Create a User Screen

1. Select **Screen** from the **Config** menu to bring up the ***User Screen Edit*** window shown in Figure 6-52.

   The list box shows the names of various screen layout templates.

**Figure 6-52 Configure Screen**



2. Select a layout to modify.
3. A miniaturized version of the layout appears. To rearrange it, drag and drop panes into the mini-layout in the normal manner.

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4. In the ***Rename User Screen*** window shown in Figure 6-53, enter a name to assign to the screen layout. Click ***OK*** when completed.

**Figure 6-53 Rename Screen**

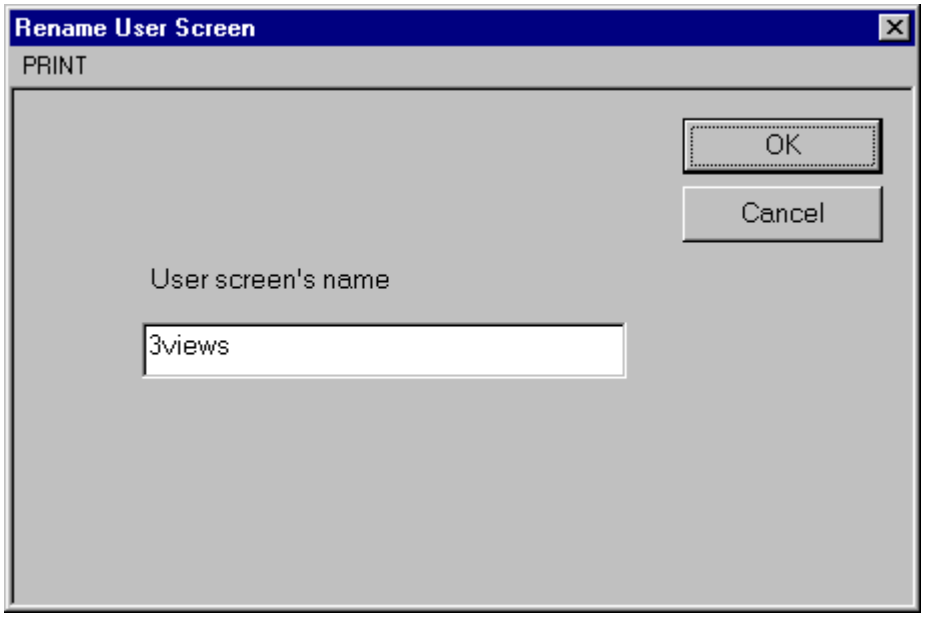
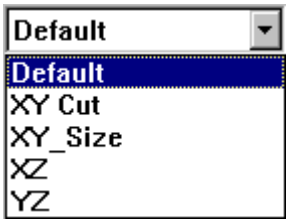


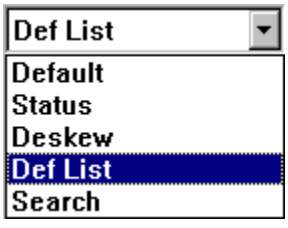

**Figure 6-54 Screen Edit 2D Option Menus**




These are almost the same options available in the option menu in the pane (see "Tab Pane" on page 6–39), except that there is no selection for **DefCod**. The **Default** option resets the pane to the default state.

5.The ***2D*** and ***Status*** panes can be individually configured for various display options. Clicking on the option menu in the ***Slice2D*** pane brings up selections for default settings, or for view (***XY***, ***XZ***, or ***YZ***) and cursor type (***Size*** or ***Cut***) options, shown in Figure 6-54. Finally, clicking on the Tab pane or button brings up an option menu shown in Figure 6-55.

**Figure 6-55 Tab Pane Option Menu**



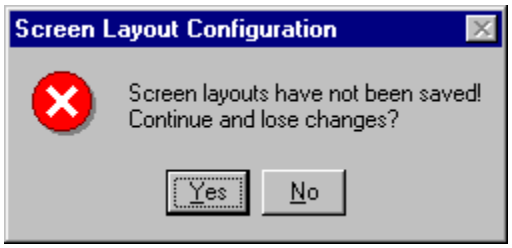

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1. When the definition of the screen layout is complete, click ***Close***.
2. A window appears, asking whether to discard (***Yes***) or keep (***No***) the changes.

**Figure 6-56 Save Screen Changes Alert**




### To Modify a Sequence Screen

The procedure to change a Sequence screen is similar to that of a User screen except for the following restrictions:

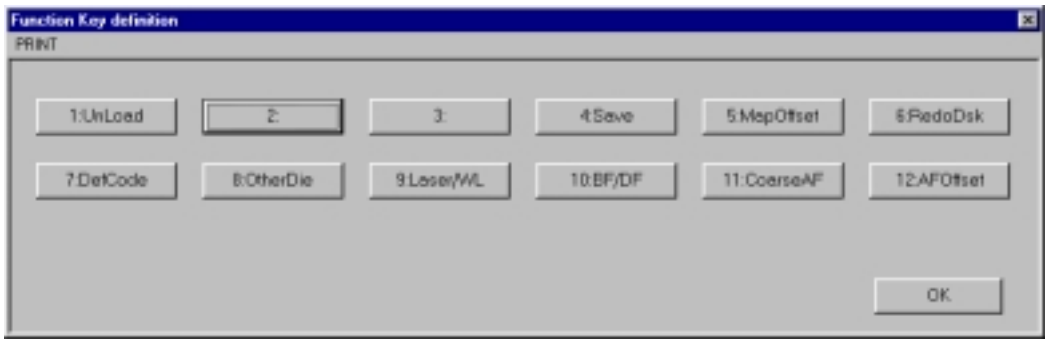
- It is not permitted to add, delete, or rename sequence screens. Only their appearance can be changed, by selecting a different layout or rearranging panes.
- A sequence screen *must* have the ***SeqStat*** (***Sequence Status***) pane as part of its layout, and should have it in an area large enough to display all of its controls. All other panes can be swapped with any of the available set of panes or 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 a KLA-Tencor Applications Engineer to have 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 Figure 6-57 and explained in Table 6-23.

**Figure 6-57 Function Key DefinitionWindow**




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**Table 6-23 Default Function Key Assignments**

| Button Name | Command Abbreviations | Commands in Full |
|---|---|---|
| 1:Unload | 0 24:Unload | 24 Unload Wafer |
| 2: | | |
| 3: | | |
| 4:Save | 0 58:SaveMap/Img Popup | 58 SaveMap/Image Popup |
| 5:MapOffset | 0 22:CalcMapOffset | 22 Calc Map Offset |
| 6:RedoDsk | 0 21:RedoDeskew | 21 ReDo deskew |
| 7:DefCode | 0:42:DefCodeTable | 0 42 Popup Def code table |
| 8:OtherDie | 0 20:NextDie | 20 Goto next die |
| 9:Laser/WL | 0 15:WL/Laser | 15 Toggle:WL/Laser |
| 10:BF/DF | 0 14:Norm/DarkF<br>1 3:FineAF | 14 Toggle:Normal/Dark<br>3 Fine AutoFocus |
| 11:CoarseAF | 0 4:StageAF | 4 Stage AutoFocus |
| 12:AFOffset | 0 57:AF offset | FineAF offset |

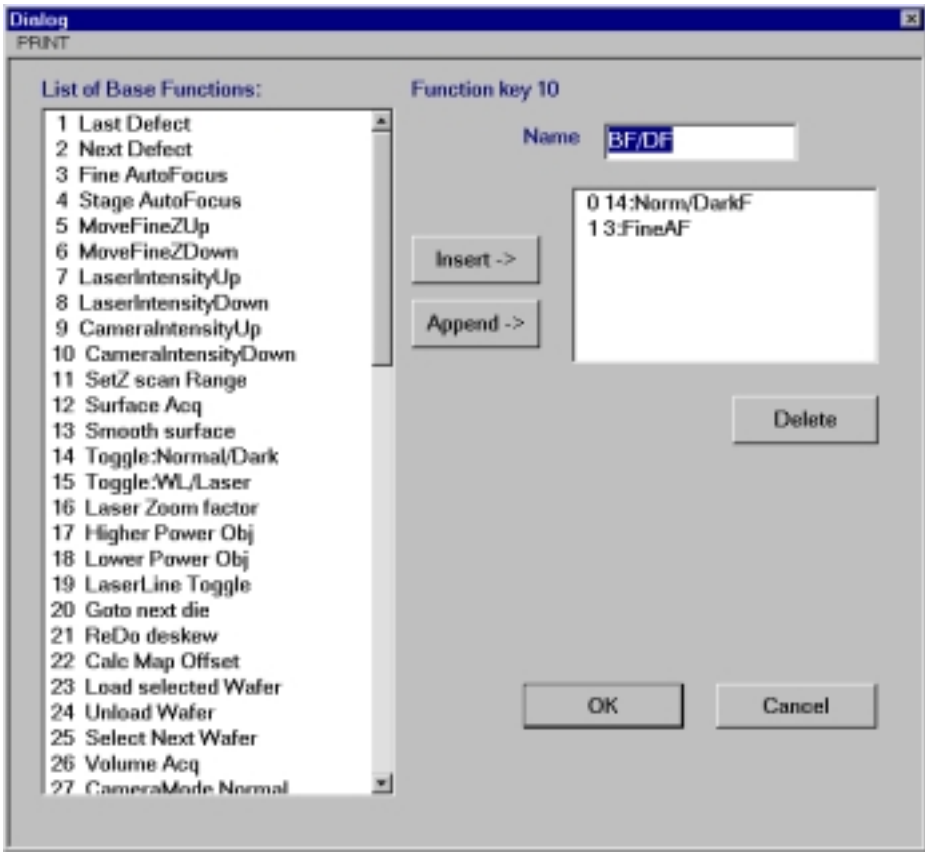
Clicking on any of these buttons opens the ***Macro Editing*** window for that button, as shown in Figure 6-58. The top line shows the key being defined (**F10** in this case), with the ***Name*** entry field just below it. Any name up to 10 characters long can be entered, although of course it helps 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.

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**Figure 6-58 Function Key Macro Editing Window**




The list of available functions is also a scrolling menu. Table 6-24 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.

**Table 6-24 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 |

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**Table 6-24 Functions for Key Bindings (continued)**

| Name | Abbreviation |
|---|---|
| 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 |
| 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 |

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**Table 6-24 Functions for Key Bindings (continued)**

| Name | Abbreviation |
|---|---|
| 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 |
| 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 |

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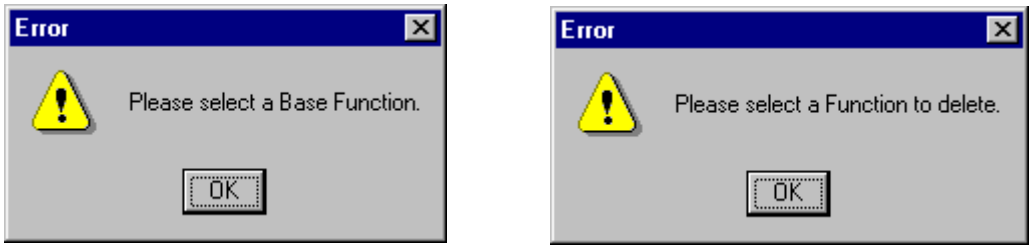
**Table 6-24 Functions for Key Bindings (continued)**

| Name | Abbreviation |
|---|---|
| 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 |

The ***Delete*** button removes the current selection, if any, from the ***Functions in Key*** list.

If no line has been selected to insert or delete, the software prompts for a selection with one of the alerts shown in Figure 6-59.

**Figure 6-59 Function Key Edit Alerts**




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

## System Misc.

An assortment of parameters can be set in the ***System Configuration*** window shown in Figure 6-60 for saving in the `uvconfig.ini` file. The controls in this window are described in Table 6-25, except for recipe autoload options, which are listed in Table 6-26. Also from this window these parameters can be reread from the file, to use newly saved values. The values do not take effect when set in this window or saved, but only when `uvconfig.ini` is read in, either at startup or from this window.

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**Figure 6-60 System Configuration Window**




**Table 6-25 System Configuration Parameters**

| Field | Description |
|---|---|
| ***LaserSaverTimer[minutes]*** entry field | Specifies the number of minutes of mouse or keyboard inaction before the system switches to the laser saver mode, in which both the laser and white light halogen lamp are switched to an idle state to prolong longevity. |
| ***SaveBackupMapTimer*** entry field | The time between automatic backups of the current map file. Default is 10 minutes. Setting this value to 0 disables automatic backup. |
| ***Next die position*** radio buttons | 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 sets the direction to look for the next die: Bottom/Left/Top/Right. |

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**Table 6-25 System Configuration Parameters (continued)**

| Field | Description |
|---|---|
| ***Recipe Load Option:*** autoload recipe name option menus: 1st choice and 2nd choice | See Table 6-26 “Automatic Recipe Load Option Menu”. |
| ***DefectCode Autoload Using ProcessID*** toggle button | Enable or disable using 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 by this CRS. |
| ***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 Figure 6-8 on page 6-19. The autodeskew software can be instructed to use this value in comparing images of the deskew points. |
| ***Edit File*** button | Opens `uvconfig.ini` in Windows Notepad. |
| ***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.ini` file. |
| ***OK*** button | Done. |

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Click the option menu **Recipe Load Options** to see the choices for automatic recipe loading, which are explained in Table 6-26. The default of **Manual** requires the user to load the recipe. An option such as **First 5 char…** directs the system to look for recipe names that match the first 5 characters of the Lot ID, Process ID, etc. (depending on the selection).

**Table 6-26 Automatic Recipe Load Option Menu**

| |
|---|
| Manual |
| First 5 char productID |
| First 7 char productID |
| First 5 char lot ID |
| First 7 char lot ID |



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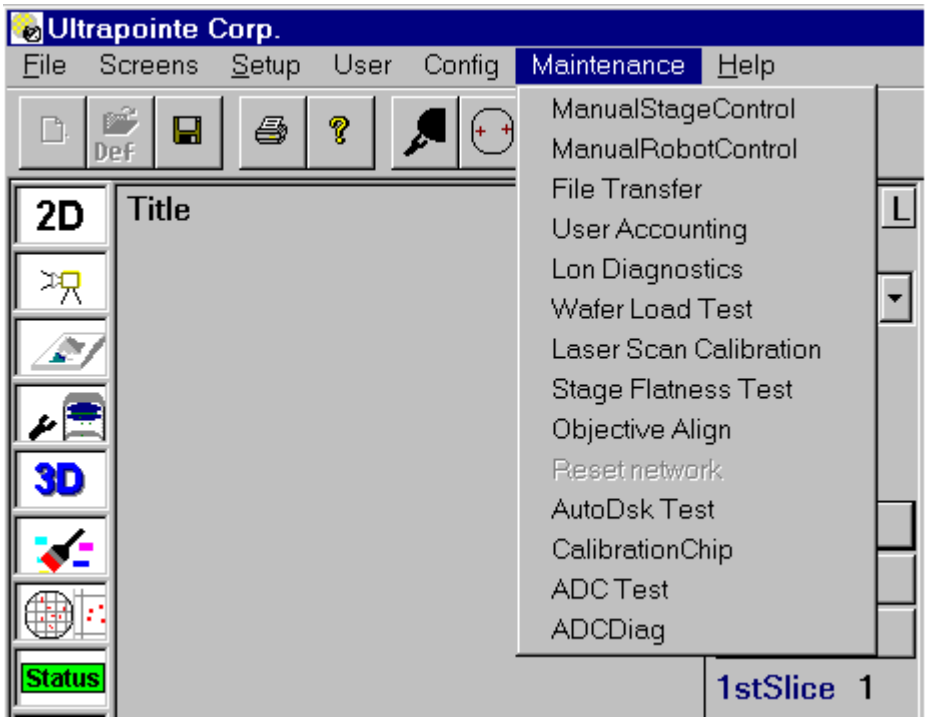
**Table 6-26 Automatic Recipe Load Option Menu (continued)**

| |
|---|
| First 5 char processID |
| First 7 char processID |
| Product ID |
| Lot ID |
| Process ID |
| Product+Lot ID |
| Product+Process ID |
| Lot+Process ID |
| MapFile Name Match |

## Maintenance Menu

Functions for troubleshooting system problems, configuring the system, and performing calibration procedures that have been automated are on the **Maintenance** menu shown in Figure 6-61.

**Figure 6-61 Maintenance**




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**WARNING**

*Maintenance functions should be used only by trained service personnel or customer engineers who are 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.*

## Manual Stage Control

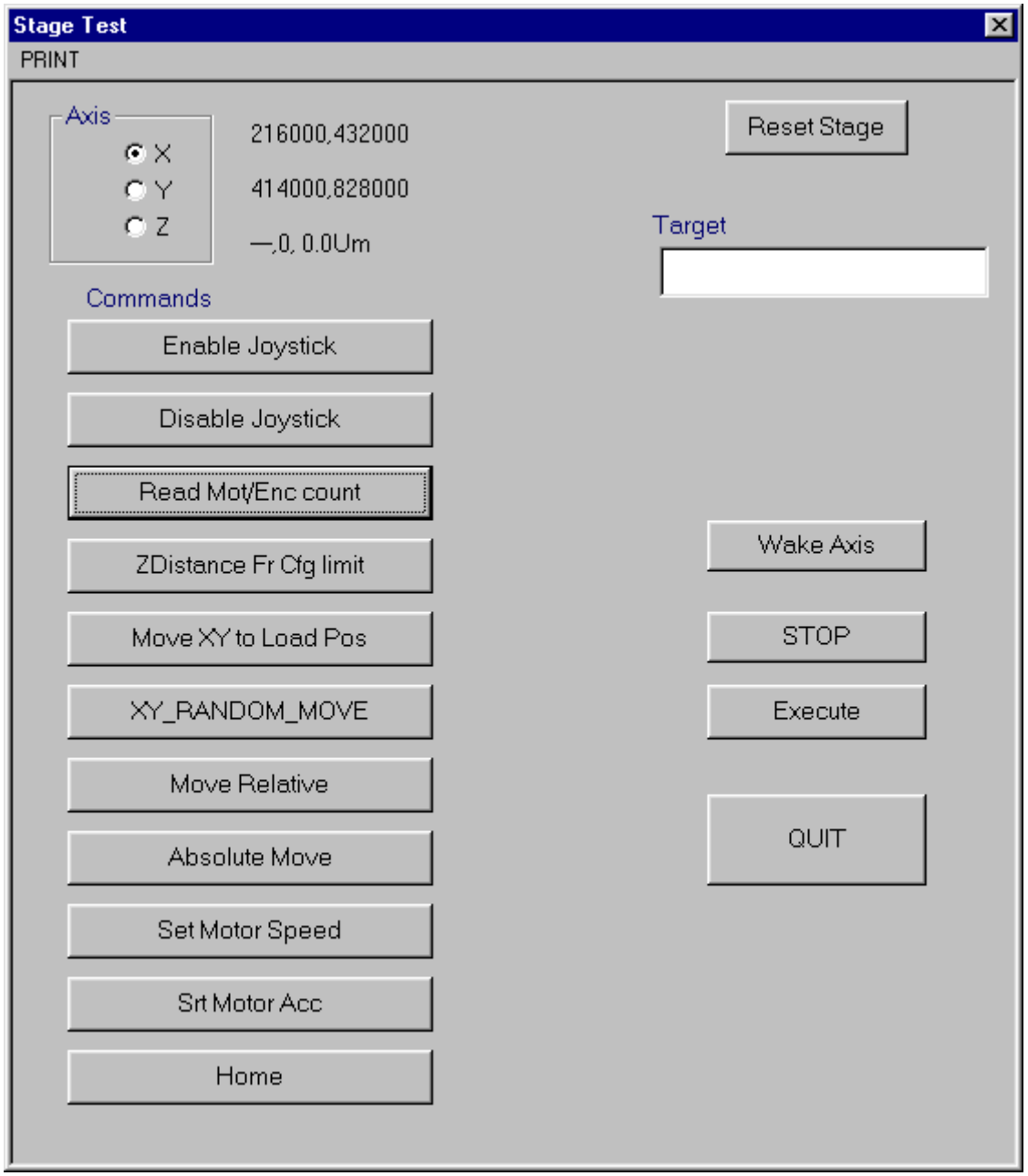
The **Manual Stage Control** menu command brings up the ***Stage Test*** window shown in Figure 6-62. A column of command buttons gives control of the stage position and motion parameters, and of the joystick. The radio buttons at the top selects one of the three axes of motion for the next command to apply to. Command buttons are provided to reset the stage, wake an axis, abort the currently running command, execute the selected command on the selected axis (if applicable), and quit. Some commands display results in the three lines next to the ***Axis*** box.

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**Figure 6-62 Manual Stage Control Window**




## Manual Robot Control

The **Manual Robot Control** menu command opens the ***Robot Test*** window shown in Figure 6-63. 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 ***Reset Robot*** button returns the robot to its starting state, a function essential during service but not needed in normal operation.

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The ***SMIF/Reg*** radio buttons indicate which station will be used as the wafer source. The ***Robot Get Wafer*** button tells the robot to pick up a wafer from a designated location, and the ***Robot Put Wafer*** button tells the robot to place a wafer in a designated location. Error messages result when telling the robot to get a wafer when it has one, or to put a wafer when it does not have one. Errors also result if the robot is instructed to put a wafer in a location where a wafer is detected or has a map entry. The ***QUIT*** button exits the window, leaving the robot and any moved wafers where they are.



**WARNING**

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

An important use of the ***Robot Test*** window is for removing a wafer left on the stage after the CRS is powered down without shutting down the software.

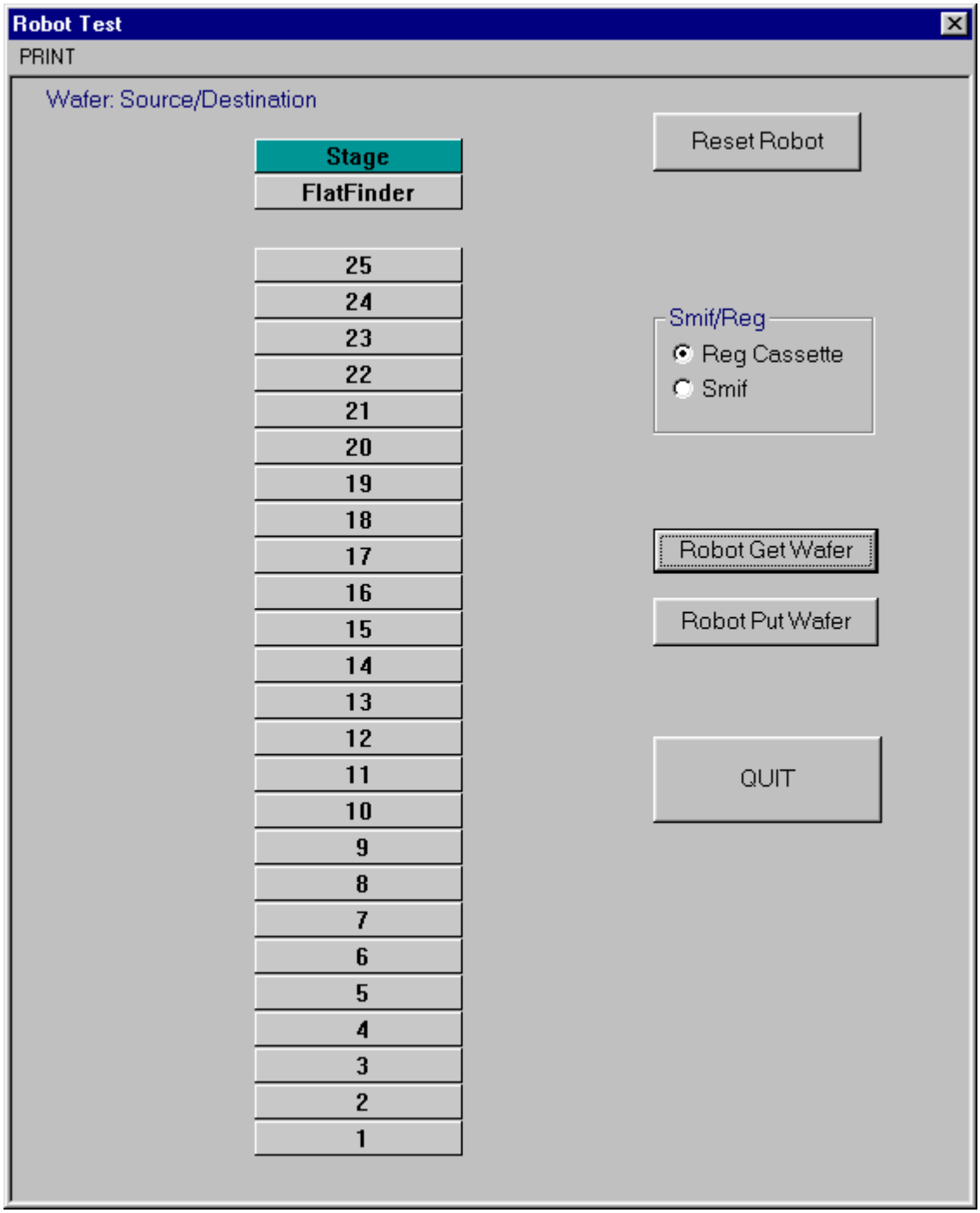
1. Place a cassette of the right size on the CRS.
2. Determine the number of an empty slot in the cassette.
3. Open the ***Robot Test*** window.
4. Click the ***Stage*** button.
5. Click ***Robot Get Wafer***.
6. Click the numbered button for the empty slot.
7. Click ***Robot Put Wafer***.

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**Figure 6-63 Manual Robot Control Window**




The ***Robot Get Wafer*** button instructs the robot to pick up a wafer from the selected location, following a routine preprogrammed in the robot controller. The steps in the program are

1. Retract the robot arm.

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2. Move to the selected position.
3. Extend the arm below the wafer.
4. Apply vacuum to the robot end effector, and release vacuum from the wafer location.
5. Raise the arm to pick up the wafer
6. 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.

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, and the robot does not move.

The CRS cannot always tell whether there is a wafer in a cassette slot. In ***Robot Test***, 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.

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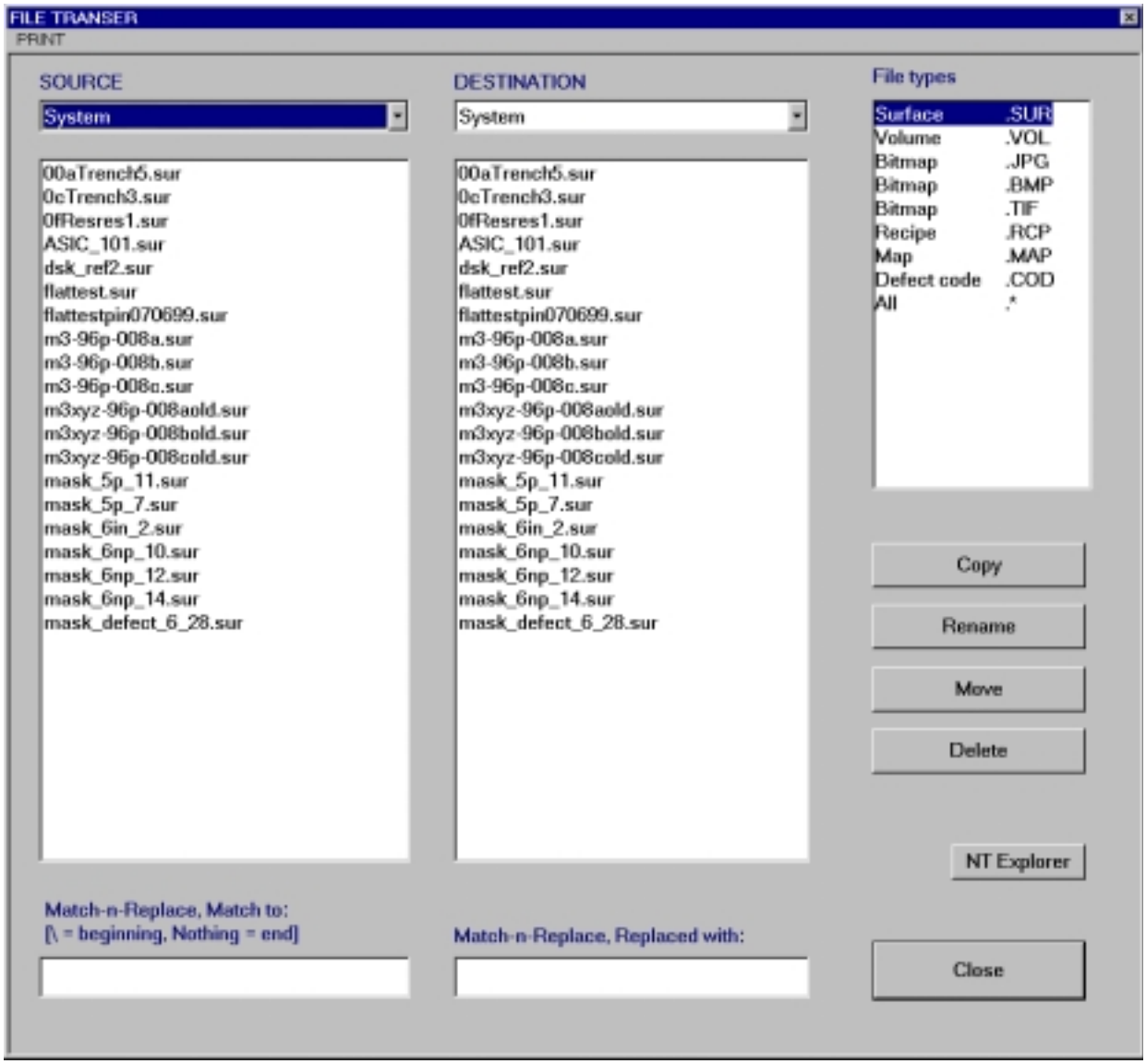
## File Transfer

The ***File Transfer*** window shown in Figure 6-64 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 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 clicking on radio buttons selects file types. 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. The ***NT Explorer*** command button starts the Windows NT file management utility in a new window.



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**Figure 6-64 File Transfer Window**




CRS file types and extensions are listed in Table 6-5 on page 6-9. The ***File Transfer*** dialog box usually shows files of only one type at a time. When the **All** option is selected, all files in the directory are listed together. When the Map file type is selected along with the FLOPPY, KLA_READ, KLA_WRITE or REMOTE2 directory, then all filenames are listed.

Clicking on a file from the ***Source*** directory selects that file for later deleting, moving, copying, or renaming.

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The actions described in Table 6-27 can be performed in the ***File Transfer*** dialog box:

**Table 6-27 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 ***Match-n-Replace, Replace with:*** entry field. That is, the selected file is copied to the new directory, optionally renamed, 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 ***Match-n-Replace, Replace with:*** entry field. |
| Rename | The selected file from the From directory is renamed with a name from the ***Match-n-Replace, Replace with:*** entry field. |

There are several ways to select files in the ***File Transfer*** window.

- To select a single file from the ***From:*** filename list box, click 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.



**NOTE**
*Only one file can be selected at a time for Rename.*

## UserAcct

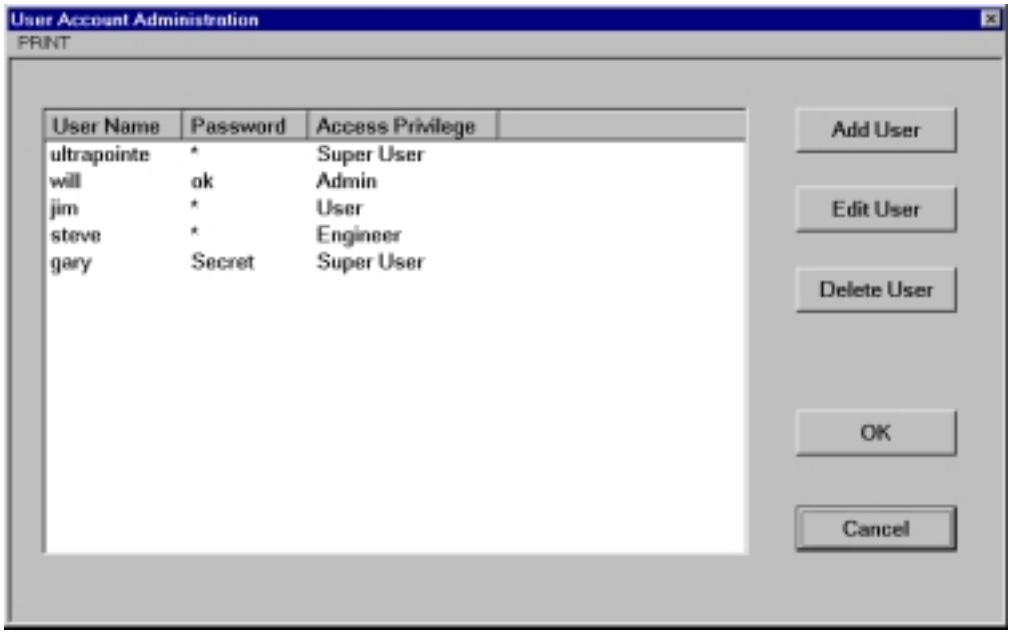
The ***User Account Administration*** window shown in Figure 6-65 provides functions for adding, deleting, and editing user accounts and privileges. These functions are only available to accounts with Superuser privileges. The window contains a list of current user accounts, each with a user name, a password, and a privilege level. The password may be blank, in which case it is indicated in the Password column as '*'. The four privilege levels are described in Table 6-8 on page 6-13.

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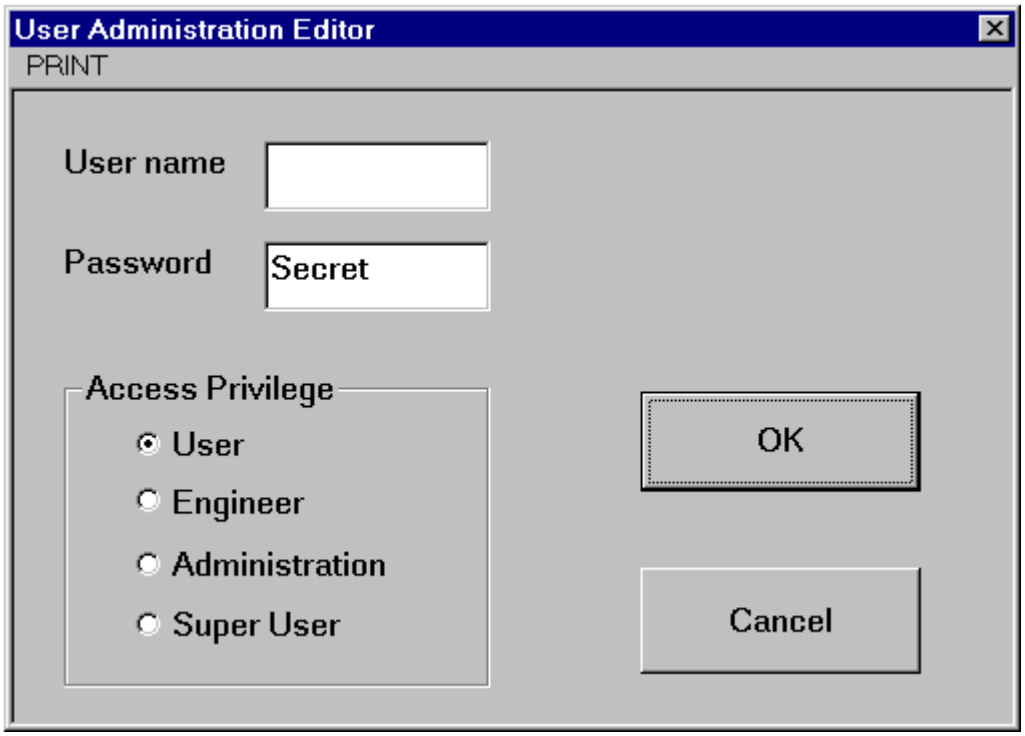
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**Figure 6-65 User Account Administration Window**




The ***Add User*** button brings up the ***User Administration Editor*** window shown in Figure 6-66. The ***User Name*** field is initially blank, and the ***Password*** field contains the default password, Secret.

**Figure 6-66 User Administration Editor Window**




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Enter a name and password in the data entry fields, and select an ***Access Privilege*** level. Then click ***OK***.

To delete an account, select the account and click ***Delete User***. Deletion is immediate, with no confirmation dialogue.

To make changes to an account, select the account, click ***Edit User***, make changes to the name, password and access privilege, and click ***OK***.

Clicking ***Cancel*** in the ***User Administration Editor*** window or in the main ***User Account Administration*** window discards the most recent changes.

## LONDiagnostics

The LON (Local Operating Network) is completely contained within the CRS unit, connecting the computer 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.

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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 and Superuser accounts, but not to User or Engineer accounts. Some of the functions shown in the LON Diagnostics window are used only on models of the CRS other than the 3000 model.

Figure 6-67 shows the ***Lon Diagnostics*** window. It contains a large number of controls, which are summarized in Table 6-28.



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**Figure 6-67 LON Diagnostics Window**

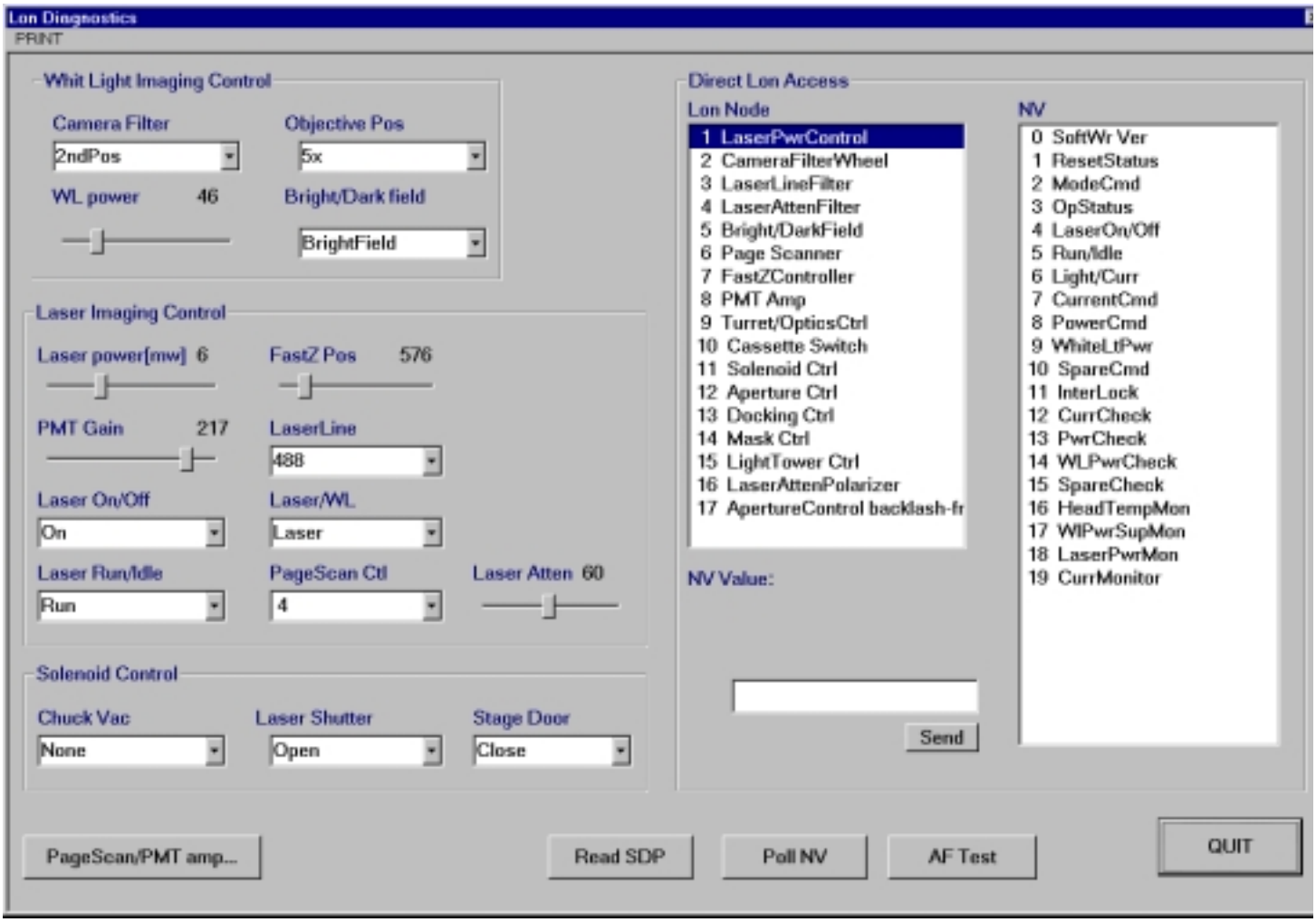



**Table 6-28 Lon Diagnostics Window Controls**

| Control | Settings | Comments |
|---|---|---|
| **White Light Imaging Control** | | |
| **Camera Filter** option menu | • Polar<br>• 2nd position<br>• Dim<br>• Yellow<br>• All Pass<br>• Reset[H] | • Polarizing filter<br>• 488 nm notch filter<br>• Neutral filter<br>• Not used on CRS 3000<br>• No filter<br>• Home position (All Pass) after full turn |



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**Table 6-28 Lon Diagnostics Window Controls (continued)**

| Control | Settings | Comments |
|---|---|---|
| **WL Power** slider | • 0–255 | |
| **Objective Pos** option menu | • 5<br>• 20<br>• 50<br>• 100<br>• 150<br>• Home | • To 5× |
| **Bright/Dark Field** option menu | • BrightField<br>• DarkField | |
| **Laser Imaging Control** | | |
| ***Laser Power(mw)*** slider | • 0–25 | |
| ***PMT Gain*** slider | • 0–255 | |
| **Laser On/Off** option menu | • On<br>• Off | |
| ***Laser Run/Idle*** option menu | • Run<br>• Idle | |
| ***FastZ Pos*** slider bar | • 0–4095 | • In 12 nm steps |
| ***LaserLine*** option menu | • 458<br>• 2nd Pos<br>• 488<br>• 4thPos<br>• 515<br>• ALL | • The CRS 3000 has only the 488 nm laser line. |
| **Laser/WL** option menu | • White Light<br>• Laser | • White light only<br>• Laser and white light |
| **PageScanCtl** option menu | • 0<br>• 4<br>• 8<br>• 12 | • 1×<br>• 2×<br>• 4×<br>• 8× |

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**Table 6-28 Lon Diagnostics Window Controls (continued)**

| Control | Settings | Comments |
|---|---|---|
| ***Laser Atten*** slider bar | • 0–60 | |
| **Solenoid Control** | | |
| **Chuck Vacuum** option menu | • None<br>• 4in<br>• 6in<br>• 8in | |
| **Laser Shutter** option menu | • Closed<br>• Open | |
| **Stage Door** option menu | • Close<br>• Open | |
| **Direct Lon Access** | | |
| **LON Node** list box | • Varies with different models and configurations of the CRS | |
| **NV** (Network Variables) list box | • Varies with different models and configurations of the CRS | |
| NV Value: | • Readout of Network Variable value | |
| NV entry field | • Enter values to send to LON | |
| ***Send*** button | • Sends value in NV entry field to selected variable at selected LON node | |
| **Misc.** | | |
| ***Page Scan/PMT amp…*** button | • Open ***Page*** Scanner***/PMT Amp*** window | |
| ***Read SDP*** button | • Get register values from frame grabber | |
| ***Poll NV*** button | • Read all network variables, and report an error for missing values | |
| ***AF Test*** button | • Open ***Test Dialog: Continuous AF*** window | |
| ***Quit*** button | • Close ***Lon Diagnostics*** window | |

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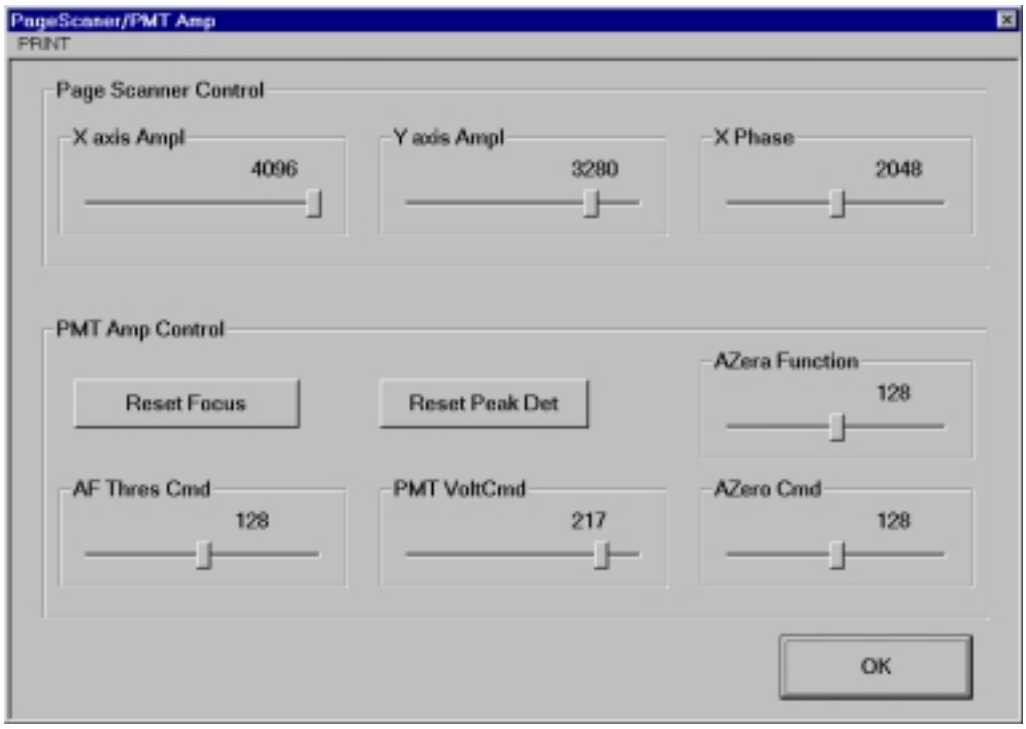
### LON Nodes

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.

### PageScan…/PMT Amp Window

The ***PageScan/PMT amp…*** button brings up the window shown in Figure 6-68, with three slider controls for the mirror assembly that scans the laser beam, and six controls for the PMT amplitude. In normal use the page scanner amplitudes in the X and Y directions are 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 ***PMT Amp*** controls are set at the factory, and not adjusted in normal operation or service. The ***Quit*** button closes the window.

**Figure 6-68 Page Scanner/PMT Amp Window**




## WaferLoadTest

Figure 6-69 shows the window for the wafer loading test. The user selects the wafers to load by clicking on the numbered buttons. An integer must be entered in the ***Iteration*** entry field to specify how many times the test should be repeated for all of the selected wafers. Pressing the ***Start*** button begins the sequence. The ***Start*** button changes to the ***Stop*** button during testing. Clicking on it interrupts the test after the current wafer load/unload cycle is completed. Iteration and wafer numbers are displayed. throughout the test. The iteration numbers count down from the set value to 0, at which point the test cycle stops, showing 0:0 for the iteration and wafer numbers. The robot prealigns, loads, and unloads each wafer in

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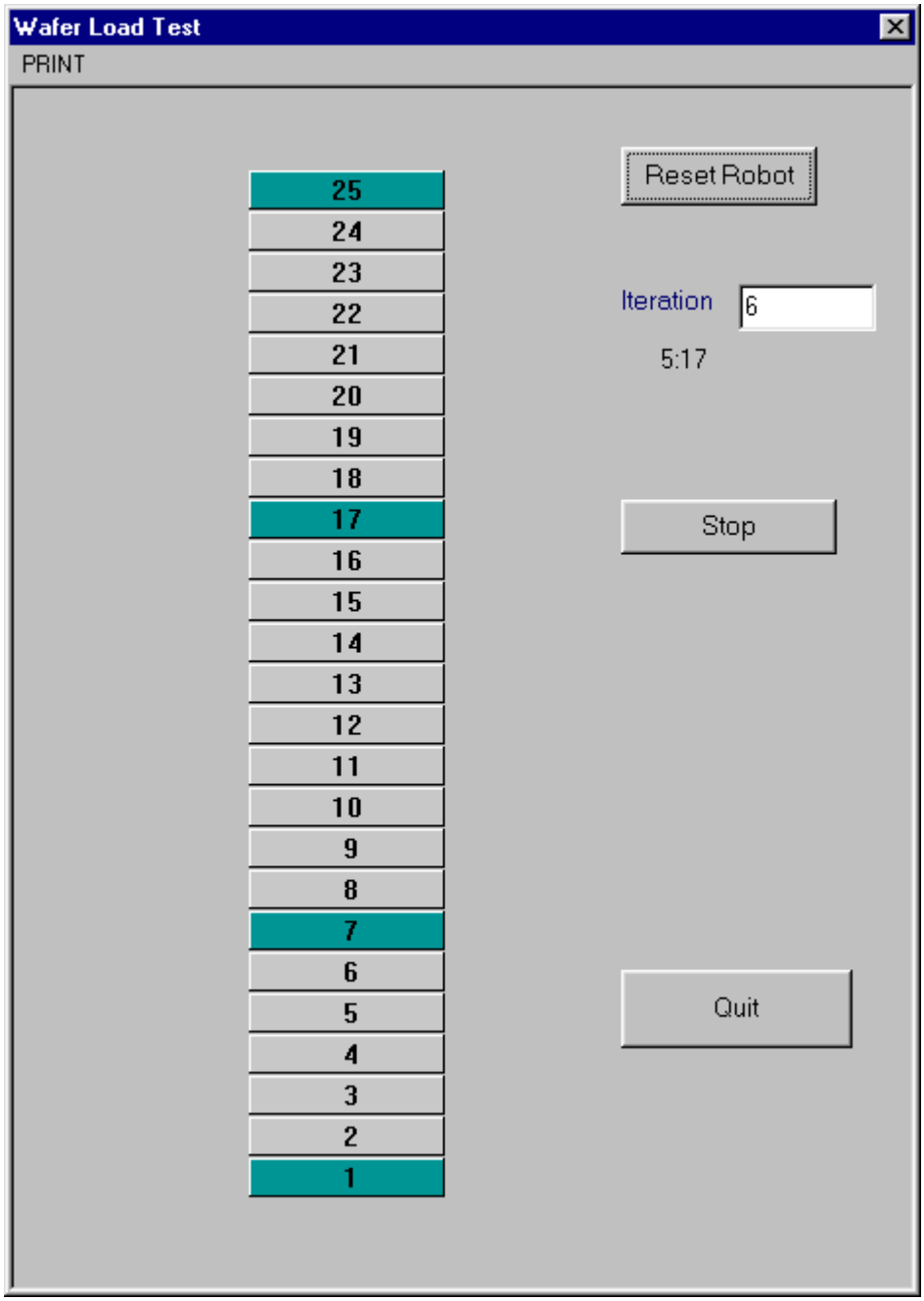
turn during each iteration. If the Cassette pane is open in the main window, it indicates the current wafer in the ***Loaded*** column, and changes the robot, prealigner, and stage icons to show the location of the wafer.

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**Figure 6-69 Wafer Load Test Window**




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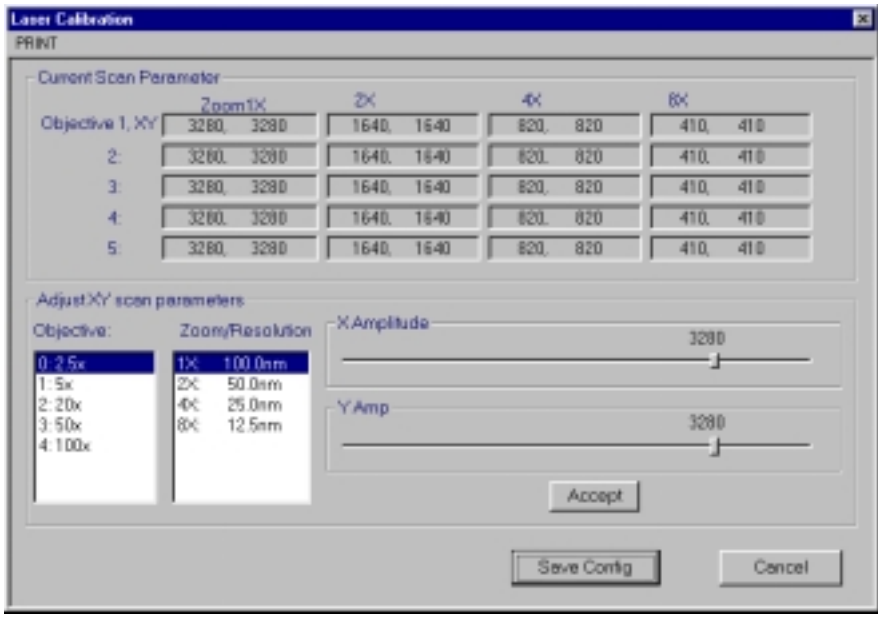


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## Calibration

Figure 6-70 shows the ***LaserScan Calibration*** window. It displays laser scan parameters for each of the four zoom levels. 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 6-70 Calibration Window**




Clicking on ***Save Config*** in the ***Laser Calibration*** window brings up the dialogue box in Figure 6-71. Clicking on ***OK*** would save the new zoom amplitudes for the selected objective and zoom level to `uvconfig.ini`, while clicking on ***Quit*** would discard the changes.

**Figure 6-71 Confirm Saving Configuration File Alert**




## StageFlatnessTest

Figure 6-72 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 10 µm. In the example, it is over 1000 µm. When the window comes up, the large results area is blank, and the default values

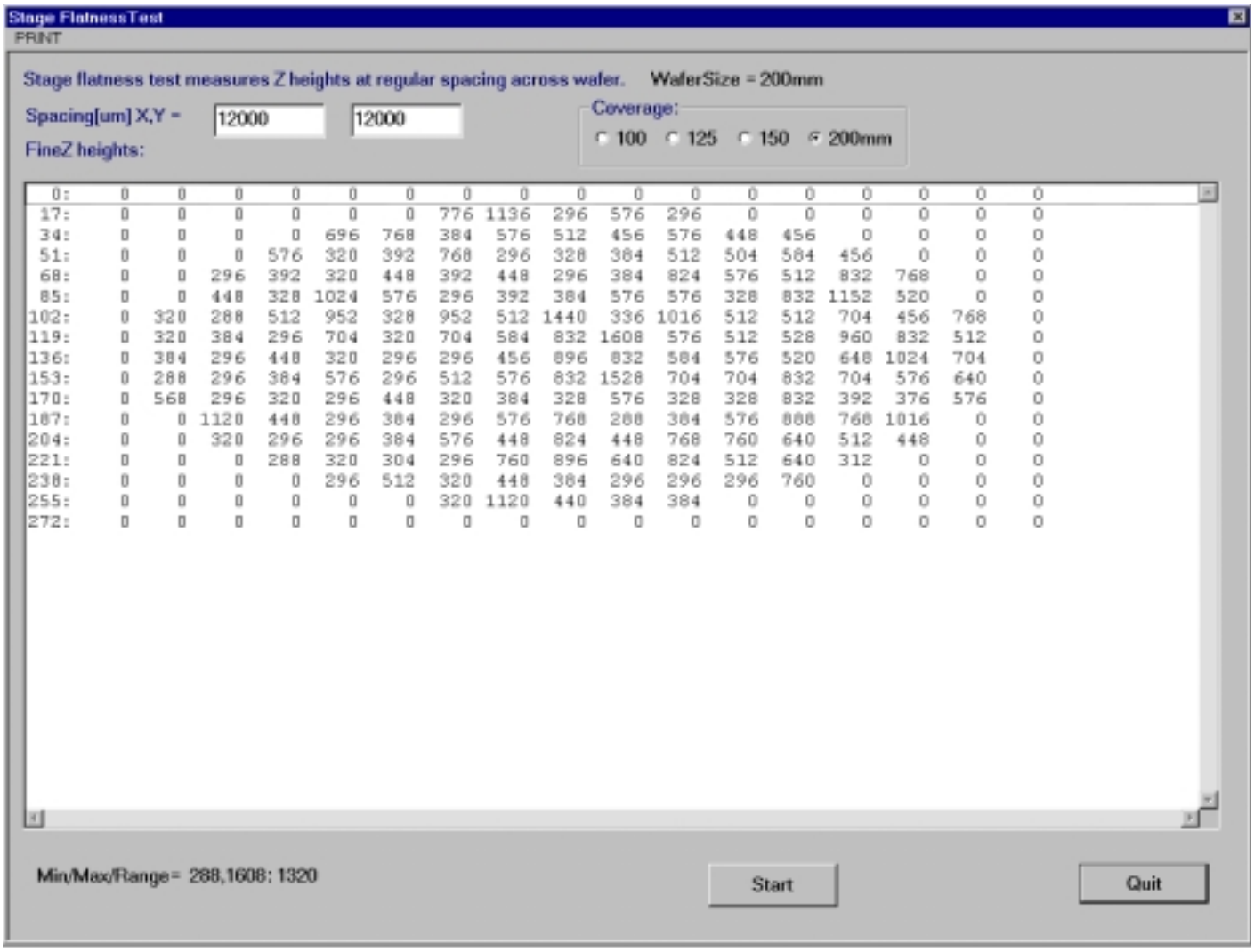
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for the current wafer size are entered in the ***Spacing*** fields. These numbers should normally not be changed. Clicking on ***Start*** begins the process of scanning at intervals across the surface, finding the focus at each XY location, and recording the stage height at that point.

**Figure 6-72 Stage Flatness Test Window**




## Align Stage/Objectives

Figure 6-73 shows the window for aligning the stage to the objectives, starting with 150×. A similar window appears for each of the other objectives, in sequence during this test. When the image is focussed, with suitable white light and laser illumination levels, click the ***Accept/Next*** button. The CRS queries the stage controller for the current position, and records the offset for the objective. When all of the objectives are aligned, the user is prompted to save the new values. In any of the alignment windows the ***Cancel*** button

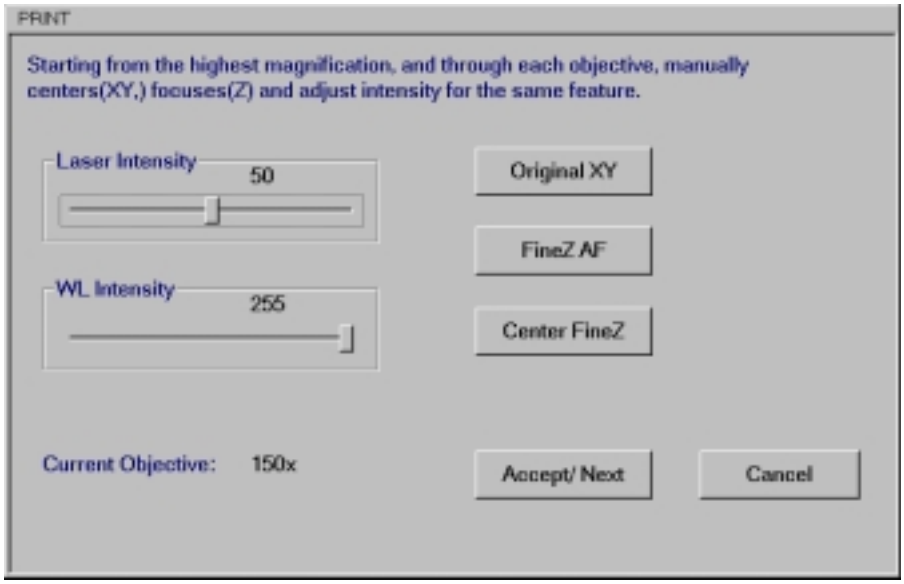
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aborts the alignment process without making changes to the system configuration, and exits. In the last window, clicking on ***OK*** saves the changes, and clicking on ***Cancel*** exits the window without saving any changes.

**Figure 6-73 Align Stage/Objectives Window**




## TestAutoDsk

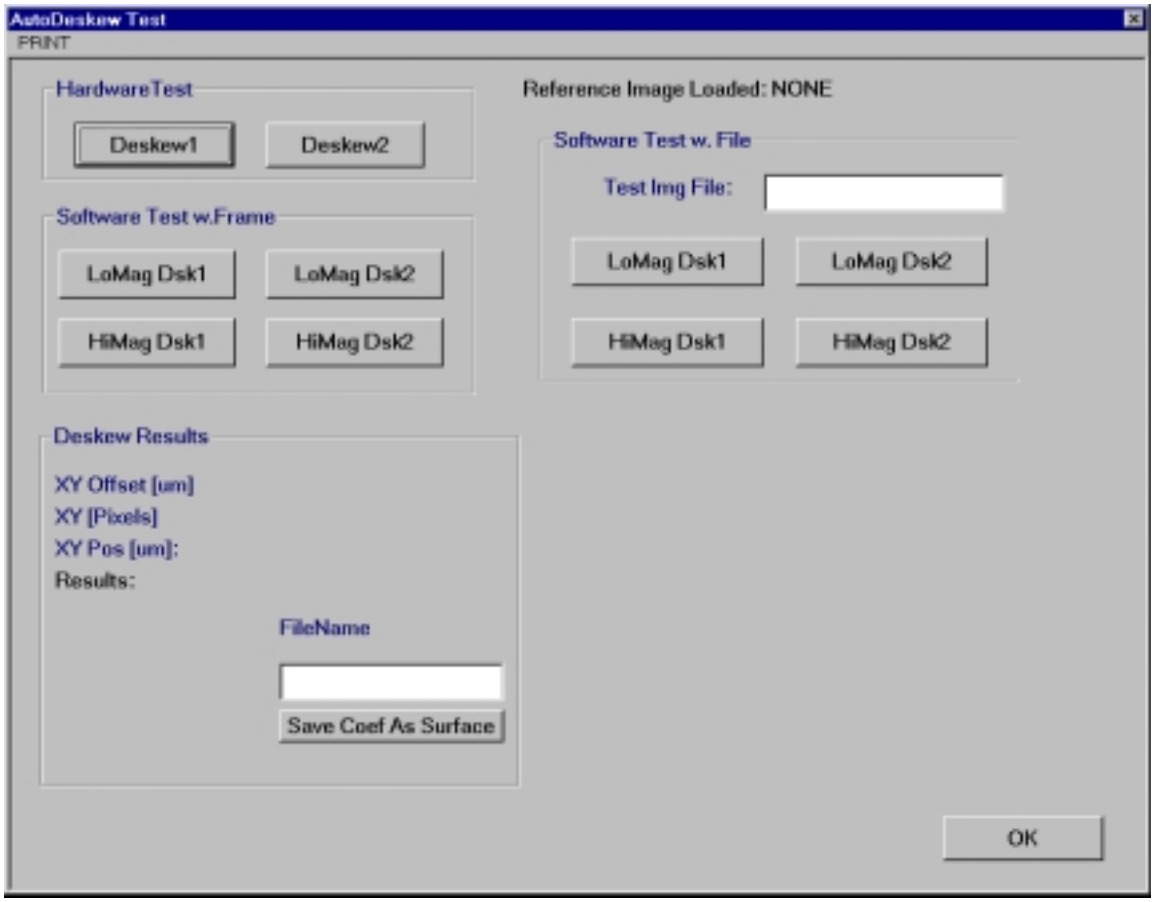
Figure 6-74 shows the initial state of the Test Auto Deskew window. There are tests of the hardware (for locating the first two deskew points), the software (for comparing the captured image files with the current images), and the image files. The tests return various measurements which an expert can use to evaluate the AutoDeskew process.

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**Figure 6-74 Test AutoDeskew Window**




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# System Startup and Shutdown

The following two sections describe the proper technique to power up and power down the 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 Power Off (**EPO**) mushroom button has been pressed, it must be released before power can be applied. Release the ***EPO*** 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.



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## System Shutdown

Normally the system should remain on at all times except during an unusually long period of non-operation (2 weeks or more). In this event, it is important to properly shut down the system.

**IMPORTANT**

*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 can be corrupted if the system is simply powered down rather than shut down in an orderly manner. This damage is usually 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.*

**TIP**

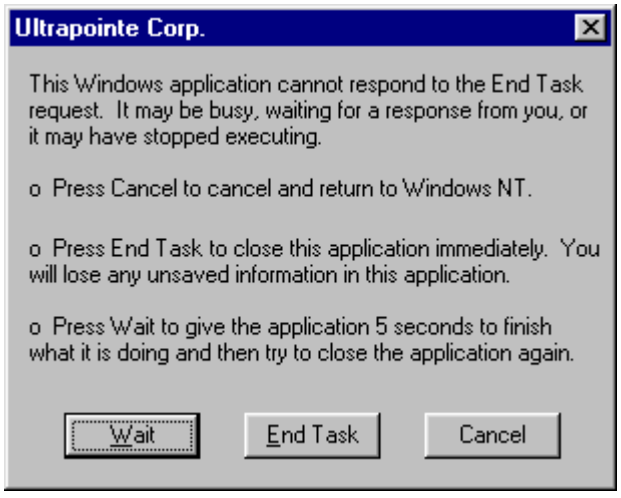
*A user with Engineer or higher permissions can begin by quitting the KLA-Tencor CRS application.*

1. Click **Shut Down…** on the **Start** menu. Click ***Shut down the computer?***

   The computer system now begins its shutdown process.

2. If the CRS application is still running, the dialog box shown in Figure 6-75 might appear, asking how to deal with it. Click ***End Task***.
3. 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 CRS by pressing **OFF**.

**Figure 6-75 Windows NT End Task Dialog**




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# A

# Preparing for CRS 3000 Installation

## Planning for Installation

### Planning

The installation procedure takes approximately three days, barring any unforeseen disruption. Training takes an additional two days. Please be sure to have the time and work force available at the scheduled time of installation.

### Equipment Delivery

Check the shipping crate 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.



**IMPORTANT**
*Do NOT unpack the CRS system until the 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 system must be shipped in the same container to properly protect its mechanical components.*

### Installation

All of the requirements listed below must be met.

**Pre-Installation Qualification Checklist**—Found on the next page. The 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.

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**Forklift**—Capable of transporting the CRS 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 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 engineers and operators with the basic operation of the CRS system.

## Pre-Installation Qualification Checklist

(U.S.A ONLY)

Attention to this detailed information will minimize delays and expenses during the installation of the instrument. It is the responsibility of the customer to provide the correct power socket (within reach of the CRS's power cord), exhaust connections, and also air and vacuum lines of suitable length with the correct connectors for both the CRS and the supply fittings.

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**IMPORTANT**
*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 the Receiving department NOT to open the crate upon receipt.**

**Table A-1 Pre-Installation Checklist**

| | | |
|---|---|---|
| ❒ | 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 volt (factory configured). Current is 30 amp @ 208 volt. 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 (170 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 $m^3$/min). Heat output is 14,000 BTU/hr (main system only). 10 feet of 3.5 inch ducting is provided. |



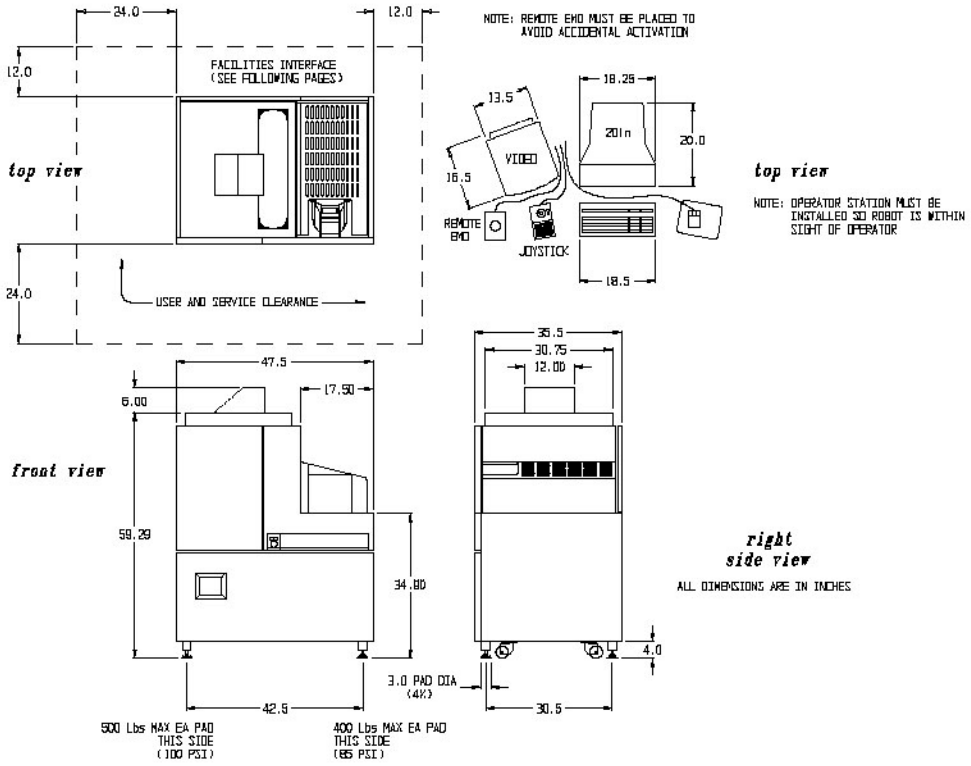
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**Table A-1 Pre-Installation Checklist (continued)**

| | | |
|---|---|---|
| ❒ | FLOOR | Must be level and capable of supporting 1255 lbs (570 kg) |
| ❒ | SPACE | Requires 24 in. 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 ft. from the wall. An 8 ft. × 13 ft. area is suitable for both the CRS instrument and the operator's workstation. Figure A-1 |

Figure A-1 shows the typical layout of a CRS installation, including the location of the facilities interface panel for power, exhaust, air, and vacuum connections.

**Figure A-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 volt (factory configured) |
| Current | 30 amp @ 208 volt |
| Cord: | 3-conductor, 10-gauge 10 feet long, non-terminated |
| Safety Interlock: | Optional |

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**Accessories:**

| | |
|---|---|
| Type: | Alternating Current, single phase |
| Voltage: | AC 120 volt, 10-15 Amp (depending on options) |

## External Vibrations

**Table A-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 |

An equipment rack, pictured in Figure A-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).

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**Figure A-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 Installation Scheduling Form

We have made all necessary preparations for installing the CRS which we have received. It is in its crate ready for moving to the clean room.

Signature_____

Name_____

Date_____

Company Name _____



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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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B

# PRELIMINARY CRS 3000 Specifications

## OPTICAL SYSTEM

### General

| | |
|---|---|
| Optical Train | Proprietary Ultrapointe Design |
| Objective Turret | Five-position, user-selectable, and motorized |
| AutoFocus | Proprietary laser-based autofocus with manual override (patent pending) |
| Objectives | 5×, brightfield/darkfield, 0.13 NA, 12.0 mm working distance |
| | 50×, brightfield/darkfield, 0.70 NA, 0.50 mm working distance |
| | 100×, brightfield, 0.95 NA, 0.30 mm working distance |
| Optional Objectives: | 20×, brightfield/darkfield, 0.40 NA, 3.0 mm working distance |
| | 150×, brightfield, 0.95 NA, 0.27 mm working distance |

Preliminary

### White Light

| | |
|---|---|
| Illumination Source | 100 Watt Halogen |
| Optical Filters | Neutral Density, Yellow, Holographic Notch (Gemini) |
| Camera | Sony: color, three-chip CCD, Model D×C950 |
| 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) |

### Laser

| | |
|---|---|
| Illumination Source | 20 mW, air cooled, stabilized Argon-Ion. Class IIIb. |
| Wavelength | TEM 488 nm |
| Output Power | Variable from 6 to 20 mW |
| Spatial Filter | Ø 25 µm |
| Spot Size | Ø 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 |



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| | |
|---|---|
| Frame Rate | 512 × 512: 13 frames/s |
| Field of View | User Selectable (all at 100×):<br>6.25 × 6.25 µm<br>12.5 × 12.5 µm<br>25 × 25 µm<br>50 × 50 µm |
| Pixel Size | 12.5 nm (at 100× and 6.25 × 6.25 µm field of view) |
| Laser Magnification | Approximately 19,600× (with 100× and 6 × 6 µm FOV on 17-inch monitor) |

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# COMPUTER

## Processor

| | |
|---|---|
| **Model** | CRS 3000 |
| **Platform** | Pentium Class |
| **Processor** | Intel Pentium II (2) |
| **Clock rate (Mhz)** | 450 |
| **L2 Cache (Kbytes)** | 512 |
| **CPUmark* 99** | 33.5 |
| **SPECint*95** | 18.50 |
| **Wintune 98 Advanced CPU Integer** | 110.78 |
| **SPECfp*95 (floating point 95)** | 13.3 |
| **Random Access Memory (MB)** | 512 |

## Graphics

| | |
|---|---|
| **Model** | CRS 3000 |
| **Graphics** | 24-bit |
| **Colors** | 16.7 million |
| **Resolution** | 1280 × 1024 |
| **Performance – Open GL Benchmark** | 25.66 |
| **Performance – 3D Winbench 97** | 202.0 |
| **Performance - 3D Hi Res (s)** | 12 |
| **Standard Monitor** | 17 in. |

| | |
|---|---|
| 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/s), RS-232 (1 Kb/s), or Floppy diskette |
| Network Protocols | TCP/IP, Microsoft Networks, Novell NetWare, Network File System (NFS) and |

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| | |
|---|---|
| | GEM/SECS |
| Defect Scanner Protocol | |
| KLARF | 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 |
| OSI | IQ via Ethernet or Floppy |
| Hitachi | WI-8XX/AS-3000 via Floppy or Ethernet |
| Defect Capacity | 65,000 defects/wafer |
| Defect Codes | 256, user definable |

### Storage

| | |
|---|---|
| Floppy Drive | 3.5 in., 1.44 MB magnetic |
| Hard Disk Drive | 9.1 GB Ultra SCSI-2 |
| Jaz Drive | 2 GB (Removable Media) |
| Image File Size (512 × 512 × 64) | Surface:525 Kbytes |
| | Volume:16.78 Mbytes |
| Full Screen (1280 × 1024) | Tiff 4 Mbytes |
| | JPEG351 Kbytes |
| White Light Image (640×480) | Tiff905 Kbytes |
| | JPEG60 Kbytes |
| White Light Image (320×240) | Tiff232 Kbytes |
| | JPEG15 Kbytes |

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### Other

| | |
|---|---|
| Operating System | Windows NT 4.0 (Service Pack 4) |
| Input Devices | 101-key Keyboard & Mouse |
| Access Levels | Service, Administrator, Engineer and Operator (password controlled) |
| Recipe Parameters | 3D View, 2D View, Status View, White Light Intensity, Laser Intensity, Aperture, XY Resolution, No. of Z slices, Z step size, Laser Line, Wafer Thickness, Y Dimension, BW/Color, AF Intensity, Stage Center Offset, Sort Parameters, ADC Parameters, Manual/AutoDeskew Parameters, File Save Parameters |

## WAFER TRANSPORT

### General

| | |
|---|---|
| Cassette Type | SEMI Standard; 3/16 in. & 1/4 in. 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 |
| Cleanliness | Class 1 |



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### Prealigner

| | |
|---|---|
| Make & Model | Equipe Technologies PRE 200-B |
| Detection Type | Non-contact, optical |
| Drive | DC Servo |
| Repeatability, Theta | ±0.04° |
| Repeatability, X/Y alignment | ±0.0015 in. (±38 µm) |
| Throughput | 3 s/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, R | Theta Axis, Θ | Z Axis, Z |
|---|---|---|---|
| **Range of Motion** | 4.45 in. | 345° | 7 in. |
| **Repeatability** | ±0.001 in. | ±0.005° | ±0.001 in. |
| **Speed** | 24 in/s | 720°/s | 17 in/s |

## XYZ STAGE

### XY Axes

| | |
|---|---|
| Range | 206 mm (each axis) |
| Drive | Stepper Motor (each axis) |
| Positioning | Closed-loop with Linear Optical Encoders (each axis) |
| Speed | Variable. 150 mm/s maximum. |
| Raw Accuracy | < ± 10 µm |
| Repeatability | ± 2.0 µm, bi-directional, 3O |

### Coarse Z

| | |
|---|---|
| Range | 13 mm |
| Drive | Stepper Motor |
| Positioning | Open loop, micro-stepping |
| Repeatability | ±10 µm, bi-directional, 3O |

### Fine Z

| | |
|---|---|
| Wafer Chuck | Aluminum alloy, Teflon impregnated; Vacuum assisted |

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| | |
|---|---|
| Range | 50 µm |
| Drive | Piezo electric crystal |
| Positioning | Closed-loop positional sensor |
| Resolution | 12.5 nm |

# SYSTEM GENERAL

## External Frame

| | |
|---|---|
| Cleanliness | Class 1 |
| Particle Generation | <0.01 each of >0.3 µm added per 1 cm² 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 based on 8-inch Wafers

| | |
|---|---|
| Load Wafer to 1st Deskew Point[1] | 28 s |
| Manual Deskew to 1st Defect | 15 s |
| AutoDeskew : 2 point[1] | 20 s |
| Move & Focus | 2.4 s (live laser mode, 8 mm travel) |
| Unload Wafer[1] | 13 s |
| Image Acquisition | 5.5 s (512 × 512 × 64) |
| Image Display (512 × 512 × 64) | 2 s |
| Image Storage (512 × 512 × 64) | Surface Image:0.1 s |
| | Volume Image:4.0 s |

## Reliability

| | |
|---|---|
| Halogen Lamp Lifetime | > 4300 h |
| Laser Lifetime | > 1 year (covered under initial 1 year system warranty) |
| System MTBF | >1000 h |
| Up Time | > 95% |

# System Options

Additional locator plates (for other cassette sizes)

SMIF Indexer (factory configurable only) (special led times apply - contact factory)

Mini environment

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Operator Console Cable Extension Kit for customized location of user interface

Signal Tower

IMPACT ADC (automatic defect classification – see quote for system hardware requirements)

Automatic Deskew Option (see quote for system hardware requirements)

GEM/SECS II Communication interface (special led times apply - contact factory)

Sony analog video printer (CE version available, contact factory for quote)

Codonics digital printer with interfaces

Operator console (vertical rack to hold monitors, printers and keyboard

## Included Features

6, 8 in. locator plates

Single 25 slot wafer cassette load port

Surface imaging software package (3-D optional on some models)

Volume imaging software package (3-D, sub-surface & cross-sectional optional on some models)

3 Objectives: 5×, 50×, BF/DF; 100×, High resolution—Sony camera

13-inch auxiliary video monitor (CE version available—call factory for details)

Dual Pentium NT-based processor

19 in. graphics monitor, keyboard, mouse, trackball, joystick and cables

9.0 GB hard disk capacity

Exhaust blower box with interconnecting ducts

KLARF Interface (limited interfaces on some models)

Tencor File Format Interface (limited interfaces on some models)

Gemini optics set

Integrated white light package (digitized white light image)

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NFS software interface to Ethernet

CE compatibility (European destinations require optional CE version SONY video monitor and CE version analog printer if applicable

# FACILITIES, ENVIRONMENTAL, AND SHIPPING

## Facilities

| | |
|---|---|
| Electrical - Main System | AC 240/220/208/200 V (factory configurable), 1ø, 30 A @ 208 V |
| Electrical - Options | AC 120 V, 1ø, 15 A (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) | 1 < 5 Hz1 µm p-p |
| | 5 < 10 Hz4 µm p-p |
| | 10 < 50 Hz6 µm p-p |
| | > 50 Hz2 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 in. flexible duct |
| Heat Output | 14,000 BTU/hr (main system only) |

## Physical

| | |
|---|---|
| DIMENSIONS: | |
| Main System | 60.0 in. × 47.5 in. × 35.5 in. (152 × 121 × 90 cm) (H × W × D) |
| Wafer Plane | 900 mm from floor to wafer #1 (SEMI standard) |
| 13-inch Video Monitor | 13.5 in. × 13.6 in. × 61.3 in. (34 × 35 × 41 cm) (H × W × D) |
| 17-inch Computer Monitor | 16.1 in. × 15.7 in. × 17.7 in. (41 × 40 × 45 cm) (H × W × D) |
| 20-inch Computer Monitor | 18.5 in. × 18.5 in. × 19.7 in.” (47 × 47 × 50 cm) (H × W × D) |
| Codonics NP-1600 Printer | 12 in. × 17 in. × 21 in. (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 lb (570 kg) |
| 13-inch Video Monitor | 37 lb (17 kg) |
| 17-inch Computer Monitor | 55 lb (25 kg) |
| 20-inch Computer Monitor | 81 lb (37 kg) |
| Codonics NP-1600 Printer | 60 lb (27 kg) |
| Sony UP-5500 Printer | 23 lb (10 kg) |

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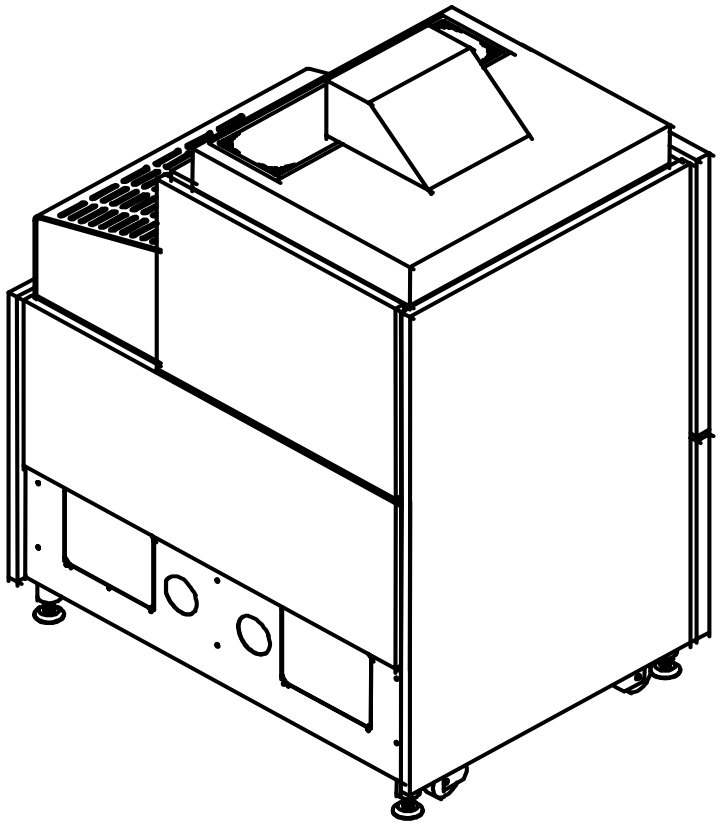
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### Shipping

| | |
|---|---|
| Method | Air ride van |
| Main System Crate Dimensions | 48 in. × 64 in. × 73 in. (122 × 163 × 185 cm) (W × D × H) |
| Main System Crate Weight | 1852 lb (840 kg) |
| Accessories Crate Dimensions | 48 in. × 48 in. × 34 in. (122 × 122 × 86 cm) (W × D × H) |
| Accessories Crate Weight | 370 lb (168 kg) (will vary with options) |

## Drawings

**Figure B-1 CRS 3000 Isometric View**

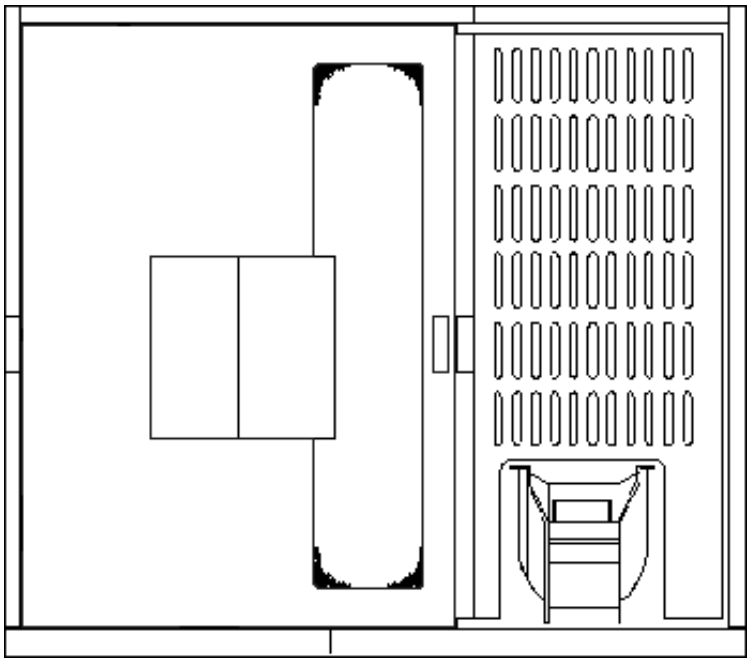


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**Figure B-2 CRS Top View**

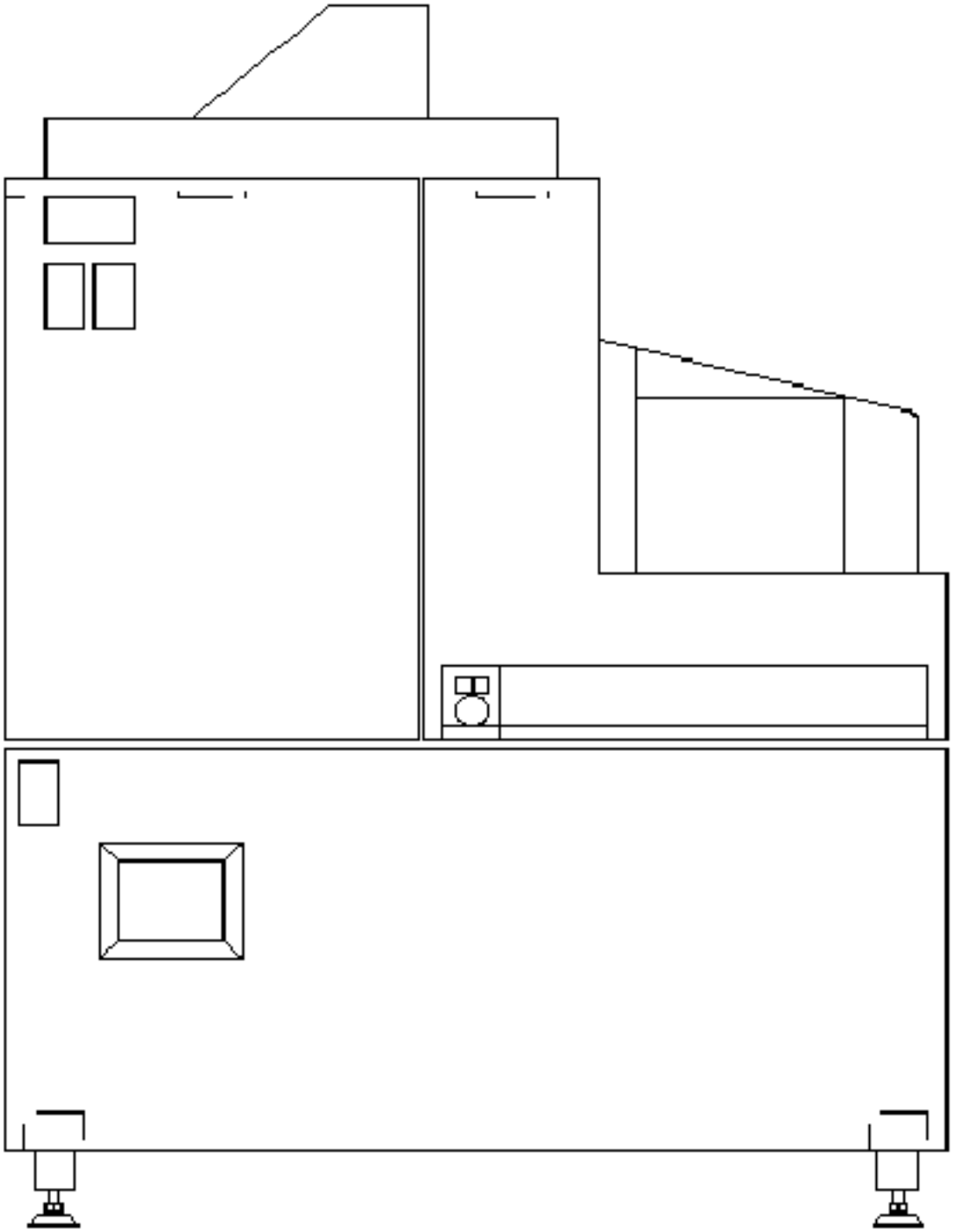


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**Figure B-3 CRS Front View**

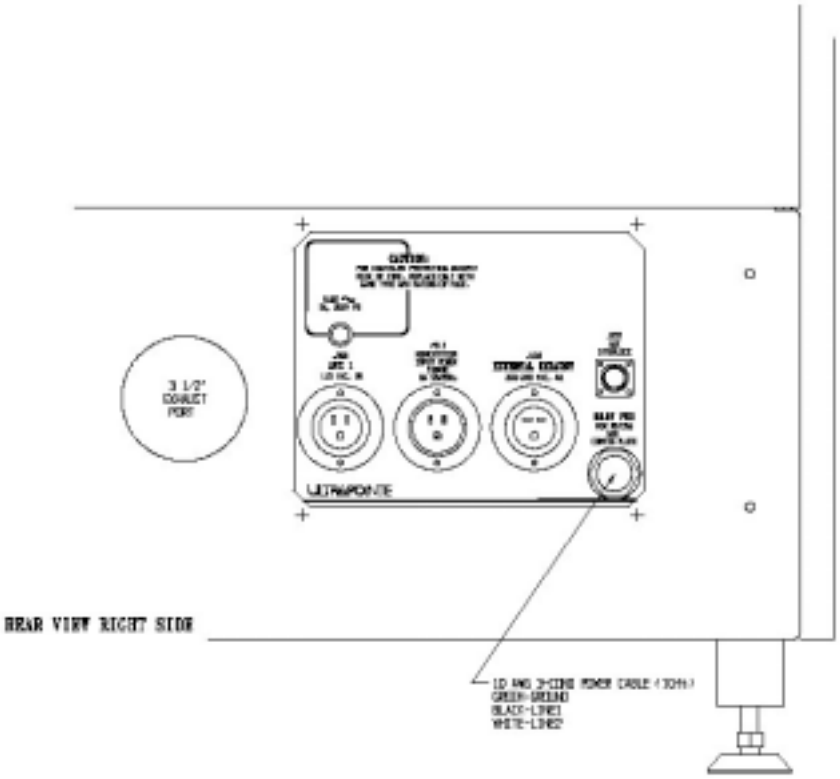


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**Figure B-4 Power Panel, Right Rear of CRS**

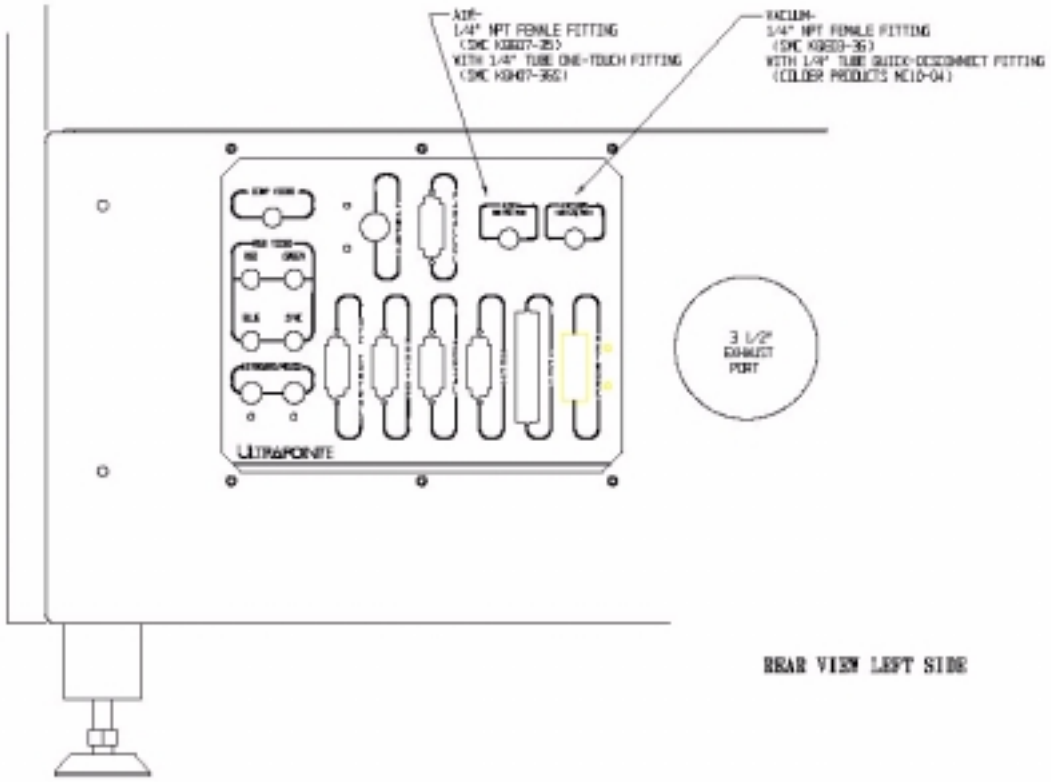



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**Figure B-5 Connector Panel, Left Rear of CRS**




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# 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 0.25 µm 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 fea-



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tures 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 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 0.5 µm 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 µm 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 0.15 µm with 458 nm laser light.

Preliminary

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 (0.008 µm) 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.

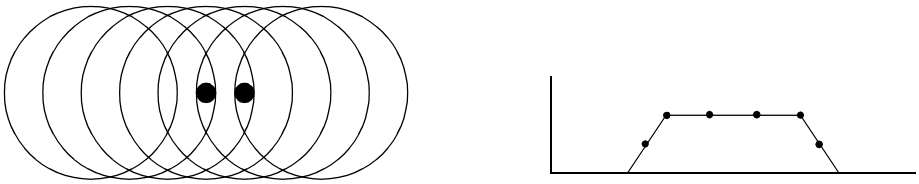
When the laser spot or the stage is moved by less than the wavelength, neighboring spots overlap. This tends to smear out the image of a feature smaller than the wavelength to about the spot size, as shown schematically in Figure B-6. The laser light spots are represented by circles, which is not physically 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.



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**Figure B-6 Resolution Limit**



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:

$$\text{Resolution} = l/(2 \times N\,A) \qquad \text{(EQ 1)}$$

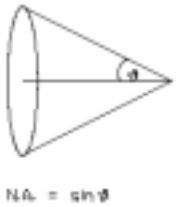
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where λ is the wavelength of the incoming light and N.A. is the numerical aperture of the lens which, for a non-immersion lens, is defined as the sine of the opening angle formed by the center ray and the extreme edge ray focusing at the focal point, as shown in Figure B-7.

**Figure B-7 N.A. and Opening Angle**




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 µm. So the best resolution achievable by the white light microscope is about 0.29 µm. 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 mm/0.29 µm = 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

$$D.O.F = \frac{250}{\Gamma^2} + \frac{250\Psi_{eye}}{\Gamma N.A.} + \frac{\lambda}{2(N.A.)^2}$$

where Γ is the magnification of the microscope, $\Psi_{eye}$ 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 µm. 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 µm 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.

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**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:

$$d_z(3dB) = \frac{0.45\lambda}{1-\cos\theta}$$

For a 100× objective with 0.95 N.A., and an average wavelength of 550 nm, the 3dB depth response is about 0.36 µm. 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 µm 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 µm to 0.76 µm. 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

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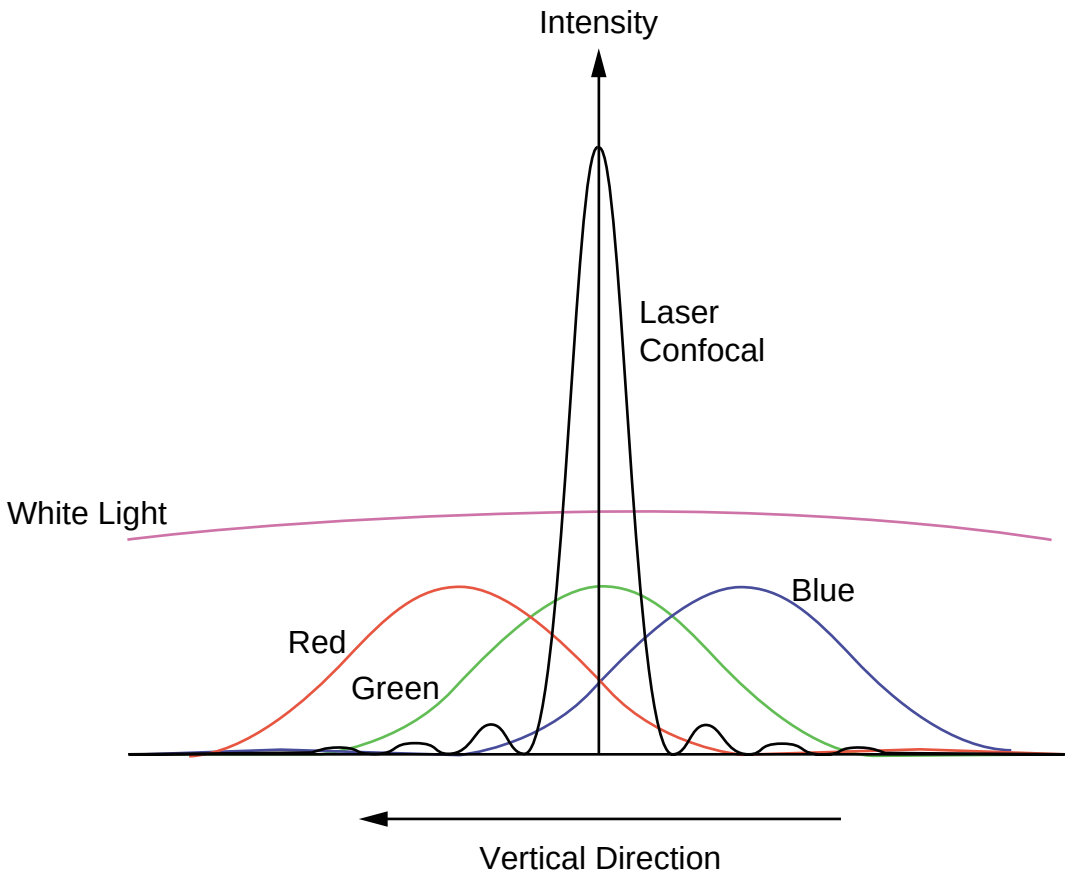


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a white light confocal system is worse than that of a monochromatic laser confocal system. Strictly speaking, only the monochromatic system can claim the full resolution of what was discussed earlier.

**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. Figure B-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 0.3 µm. 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 µm.

**Figure B-8 White Light vs. Laser Confocal Depth of Focus**




WS03D012
Confocal

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# C

# PRELIMINARY CRS 3000 Preventive Maintenance

The first section describes situations that do not require a service engineer to rectify. However, if there is any question about these actions, contact a CRS service engineer. The second section covers routine customer maintenance tasks.

## Lockup Recovery

It is possible for a CRS system to lock up to varying degrees, which are summarized in Table C-1. KLA-Tencor is interested in knowing about and fixing lockups that have any frequency.

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**Table C-1 Lockup Symptoms and Recovery**

| Lockup Symptom | How to Recover |
|---|---|
| System slows down | Restart the application. |
| Application does not respond to keyboard and mouse, but other windows continue to respond | Restart the application. |
| Software responds to mouse but not to keyboard, or the reverse (responds to keyboard but not mouse). | Disconnect and reconnect the cable for the non-responding unit at CRS back panel. If this fails, reboot the computer |
| Screen freezes and does not respond to mouse, keyboard, or data from the CRS | Cycle power. |
| Software works but instrument does not respond | Shut down the computer normally, and then cycle power |

The possible recovery actions include

- Restarting the CRS application program
- Rebooting the computer system



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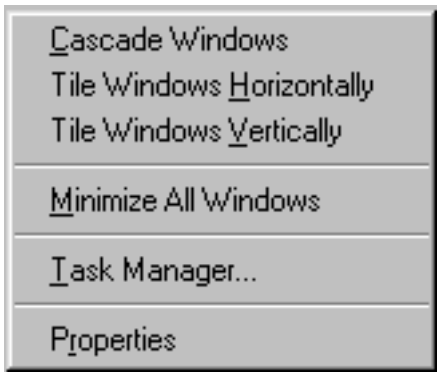
- Cycling power of the entire instrument
- Checking hardware connections

Whatever the recovery method, the problem and the corrective action should be recorded in the system log book for maintenance purposes. The following table lists lockup symptoms and their associated recommended recovery actions. For the sake of simplicity, it is possible to recover from all lockups using the reboot procedure. This just takes longer than restarting the CRS application.

## Restarting the CRS Application

1. If possible, exit normally using the **Exit** command on the **File** menu.
2. If the **Exit** command cannot be reached or does not function, try to quit using the **ALT+F4** key combination.
3. If **ALT+F4** does not terminate the application, bring up the Windows NT Task Manager. One way to do this is to right click with the mouse on the Taskbar and select **Task Manager** from the popup menu shown in Figure C-1.

**Figure C-1 Taskbar Popup Menu**



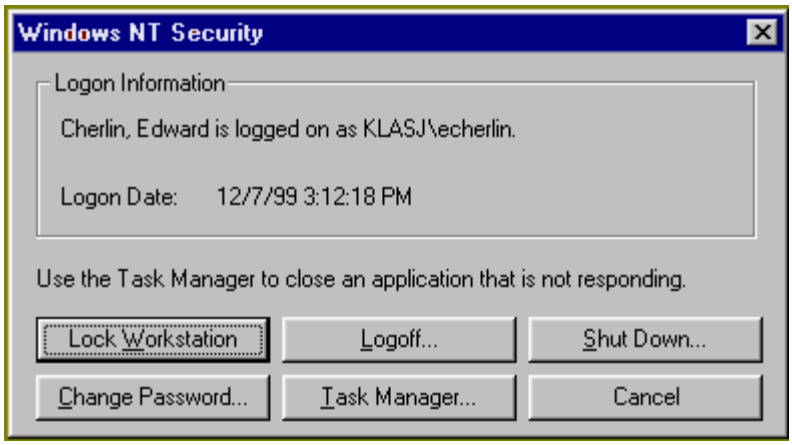

Another way starts with the **CONTROL+ALT+DELETE** key combination, which blanks the screen and then opens the ***Windows NT Security*** dialog box, shown in Figure C-2.

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**Figure C-2 Windows NT Security Window**



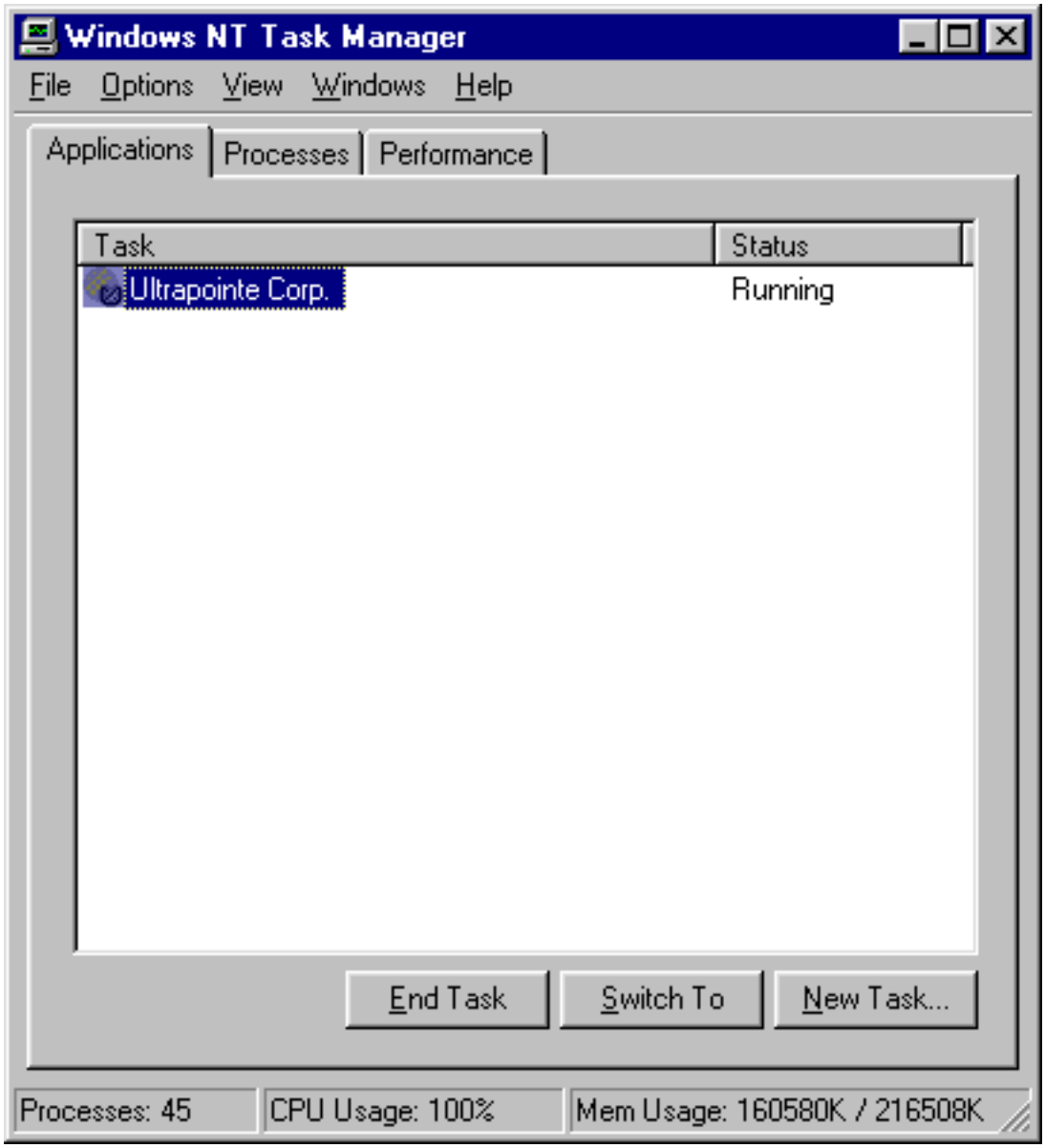

1. Click the ***Task Manager …*** button. A window opens, as in Figure C-3, and the rest of the Windows display returns.
2. In the ***Applications*** tab in the ***Task Manager*** window, select ***Ultrapointe Corp.***, and then click the ***End Task*** button. If the program cannot shut itself down, it is necessary to confirm this command by clicking on a second ***End Task*** button in the dialog box shown in Figure C-4.
3. Once the application has been terminated, restart it by clicking on its icon on the desktop or selecting it from the **Start** menu.

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**Figure C-3 Task Manager Window**

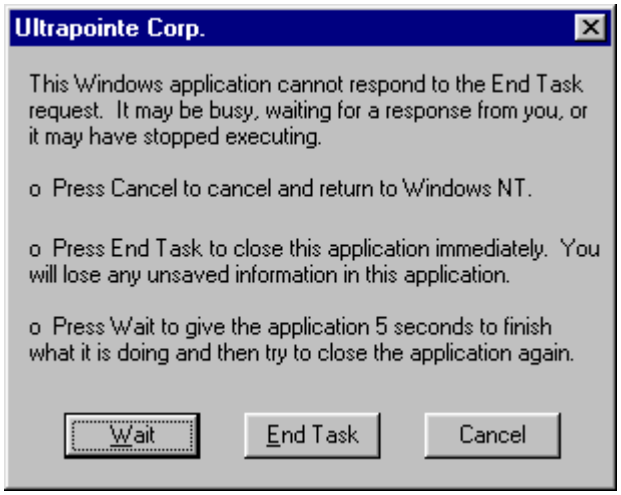



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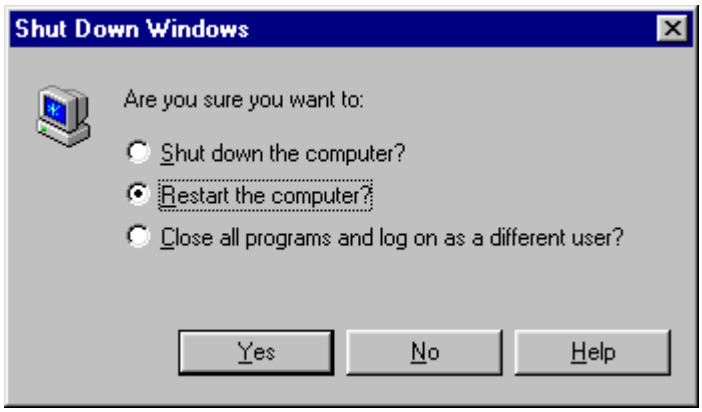
**Figure C-4 Confirm End Task**




## Rebooting the Computer

1. Quit or terminate the application.
2. Select **Shut Down…** from the **Start** menu. The ***Shut Down Windows*** window shown in Figure C-5 offers the choice of shutting down completely, rebooting, or logging in on a different account.

**Figure C-5 Shutting Down**




## 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 CRS without a proper shutdown process.

1. Shut off the power by pressing the red **OFF** button on the front panel of the CRS.

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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. Otherwise the **ON** switch has no effect.

3. If the CRS cannot start normally, a service call is needed.

## Wafer Removal

There are two conditions under which a wafer can be left in the instrument.

1. 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. In this case, the operator must remove the wafer using the application software immediately after restarting the CRS application.
2. The instrument might become non-functional (due to a component failure) and unable to restart while a wafer is in the optics chamber or in the prealigner. In this case it is necessary to remove the wafer manually.

### Wafer Removal Using the Application Software

When the system is functioning, wafers can be removed from the optics chamber or the prealigner using the ***Manual Robot Control*** window, which appears as a menu selection under **Maintenance**. This menu selection is available normally only to users with Administrator or Superuser permissions. However, if the CRS application starts up with a wafer on the XYZ stage (in the optics chamber), the ***Robot Test*** window appears regardless of the privilege level of the account.

First the alert shown in Figure C-6 appears. After the user clicks on ***OK***, the ***Robot Test*** window shown in Figure C-7 appears.

**WARNING**

*The **Robot Test** window should be used with great care because the usual safeguards in the software are not active in this window. For example, the robot will attempt to put two wafers in one slot, or replace a wafer into a cassette of the wrong size, if told to do so.*

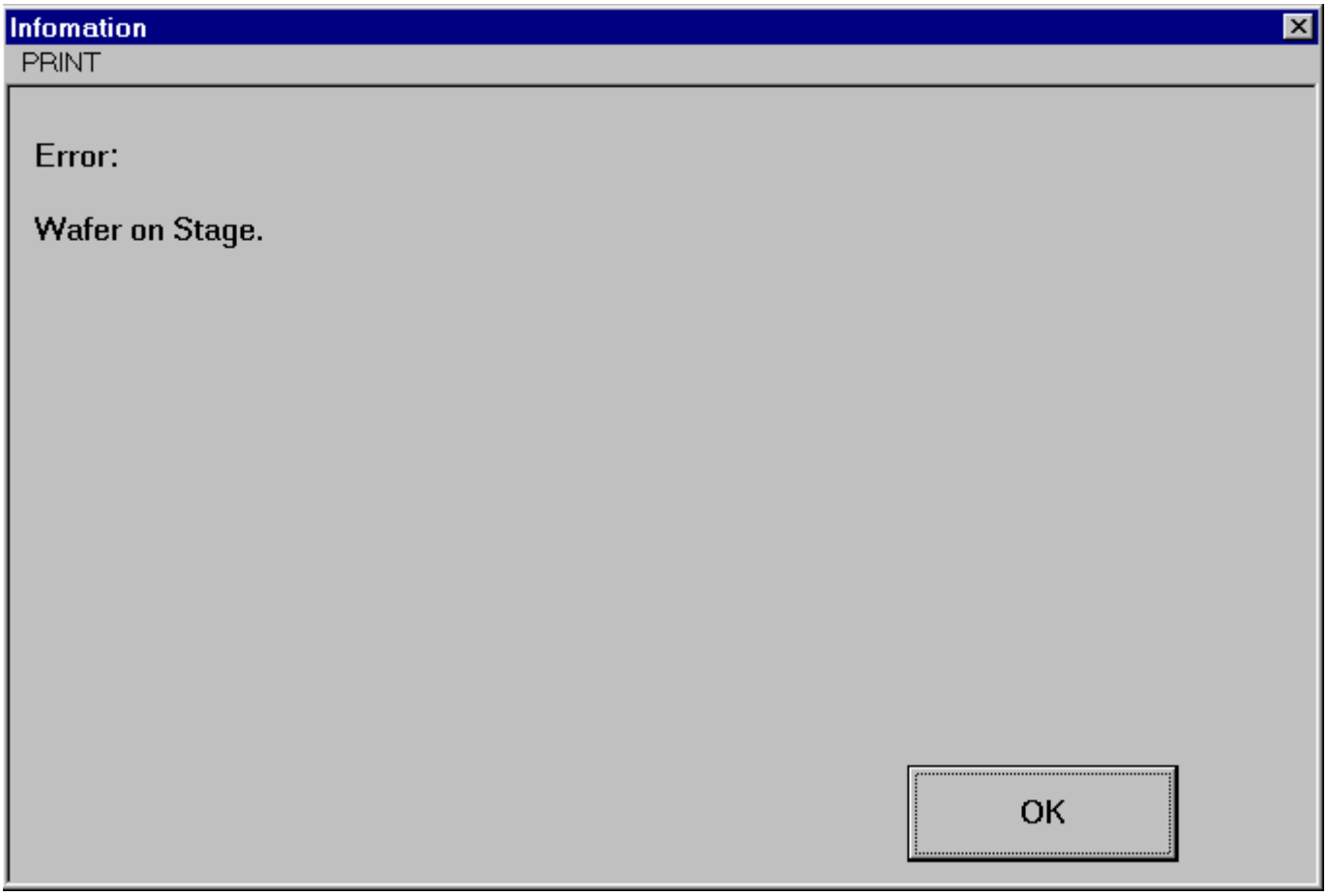
1. Click the **Stage** selection in the **Source/Destination** list at the left of the window, then click ***Robot Get***. The robot arm enters the optics chamber and retrieves the wafer.
2. To put the wafer back into the cassette, first inspect the cassette to find a slot that is empty.
3. Click the appropriate slot number in the **Source/Destination** list at the left of the window.
4. Click ***Robot Put*** to deposit the wafer in that slot.
5. Click ***Quit***. The CRS continues with normal operation.

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**Figure C-6 Wafer on Stage Alert**




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**WARNING**

*Be sure that*

- The cassette size matches the wafer.
- The correct slot has been highlighted in the list at the left of the window.
- The selected slot is empty.

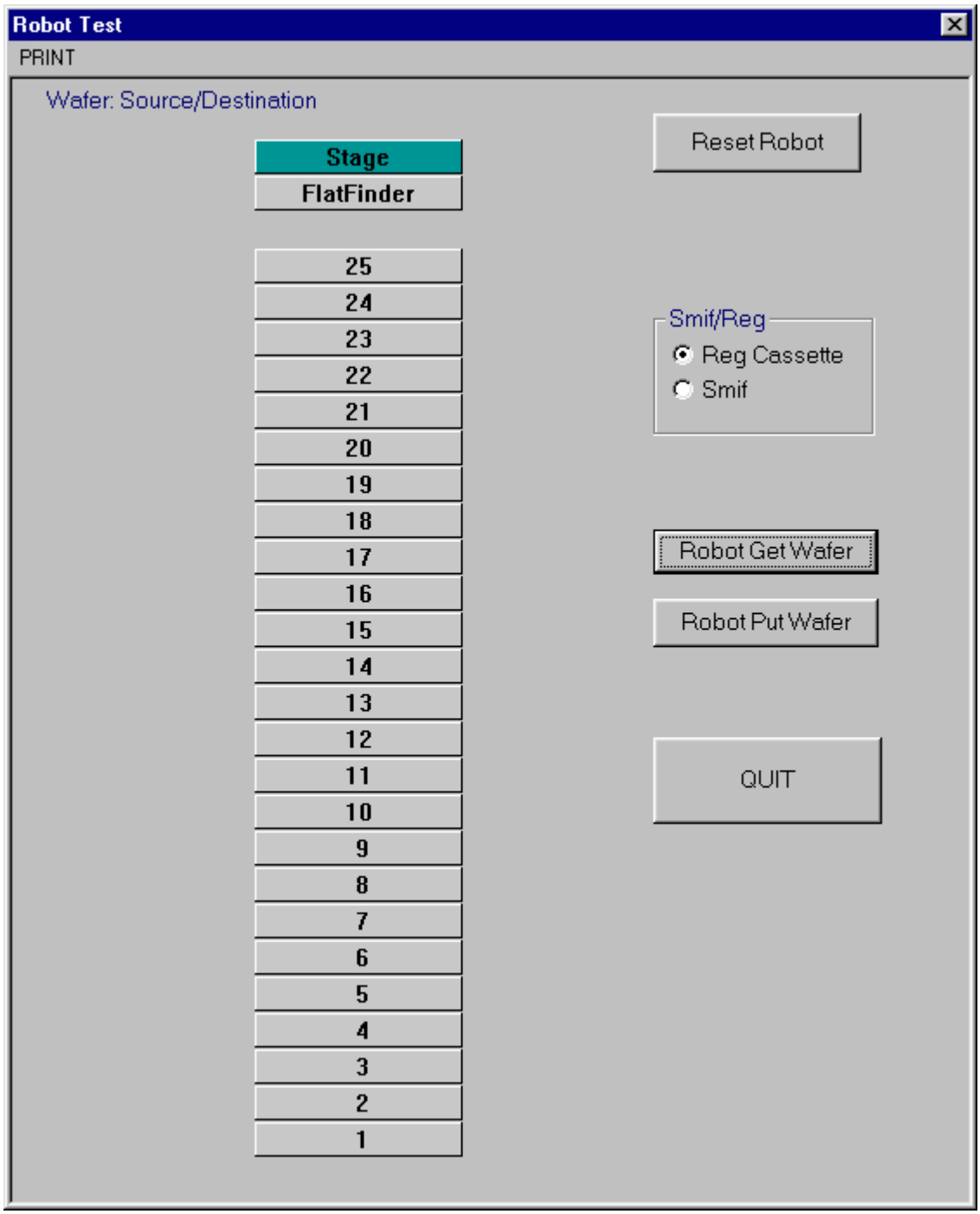
*before clicking on* Robot Put.

The procedure for removing a wafer from the prealigner is similar, except that a ***Robot Get*** operation is performed with the **FlatFinder** selection highlighted in the source/destination list.



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**Figure C-7 Robot Test Window**




## Manual Wafer Removal

If the CRS application software is inoperable, it is possible to remove a wafer from any of the major components in the system by hand. The default state of the vacuum solenoids in

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the system is on, so it is highly recommended to 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 the CRS contains powerful mechanical components that move under computer control. It is strongly recommended that manual wafer removal be done only with the power to the CRS turned off.*

If a wafer is on the robot, it can be easily removed with a vacuum wand. When the system is powered off, the robot arm can be easily moved to a more appropriate position to remove the wafer.

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, some preparation is needed.

1. Shut down the CRS.
2. The vacuum solenoids are open with power off, leaving vacuum connected to the stage chuck. In order to release the wafer, disconnect the external vacuum line from the CRS.
3. Take out the two screws near the base of the facia plate that surrounds the wafer door.
4. Gently tilt out the bottom of the plate to remove it.
5. Behind the facia plate is the wafer door, which can be raised manually.
6. With the wafer door raised, reach into the system with a vacuum wand and remove the wafer from the XYZ chuck.
7. Restore the facia plate and the vacuum connection.

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# Preventive Maintenance

These Preventive Maintenance (PM) procedures describe the maintenance operations on the CRS Confocal Review Station that can be routinely performed by on-site 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 factory PM operations performed on a less frequent basis.

## Safety Precautions

Please be sure to read the Safety Section in the CRS User Manual thoroughly prior to executing any of these procedures.



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## The Preventive Maintenance Schedule

Table C-2 outlines the PM procedures listed in this section as well as the time intervals at which they should occur.

**Table C-2 Preventive Maintenance Procedure 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. |
| 6 Halogen bulb change | Install new Halogen bulb for white light illumination | 4 mos. |
| 7 Bi-annual PM | Optics cleaning, alignment, and calibration. System tests. | 6 mos. |

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### System Wipe Down

1. Wipe the plastic robot safety cover with a cleanroom-compatible cleaning cloth and water only.
2. Gently clean the exterior of the machine with a cleanroom-compatible cleaning cloth and a diluted solution of isopropyl alcohol.

**WARNING**

*The solution of isopropyl alcohol is a flammable liquid and must be kept from sparks, flame or heat.*

**NOTE**

*The user should check with the factory if other solvents or cleaning solutions are to be used.*



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## 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, and store the backup elsewhere. The following procedures describe backup and restore operations.

The procedure to backup the hard drive uses the backup software provided with the Jaz drive. For any other backup program, consult its documentation for the procedure to follow.

Normally remote directories should be backed up where they reside, not through the CRS. If the CRS user directories become too large to back up on a single Jaz cartridge, it may be time to archive or discard some of the files, although multiple cartridge backup is certainly possible.

1. Place a Jaz 2.2 Gigabyte cartridge in the Jaz drive within the drive bay.

**IMPORTANT**
*Make sure not to overwrite the most recent backup.*

2. Open **1-Step Backup** from the Windows NT **Start** menu.
3. If the backup options are already set, continue with Step 6.
4. When running 1-Step Backup for the first time, set the directories and files to save by clicking on the ***Customize*** button. Set up the options in accordance with company backup policies.

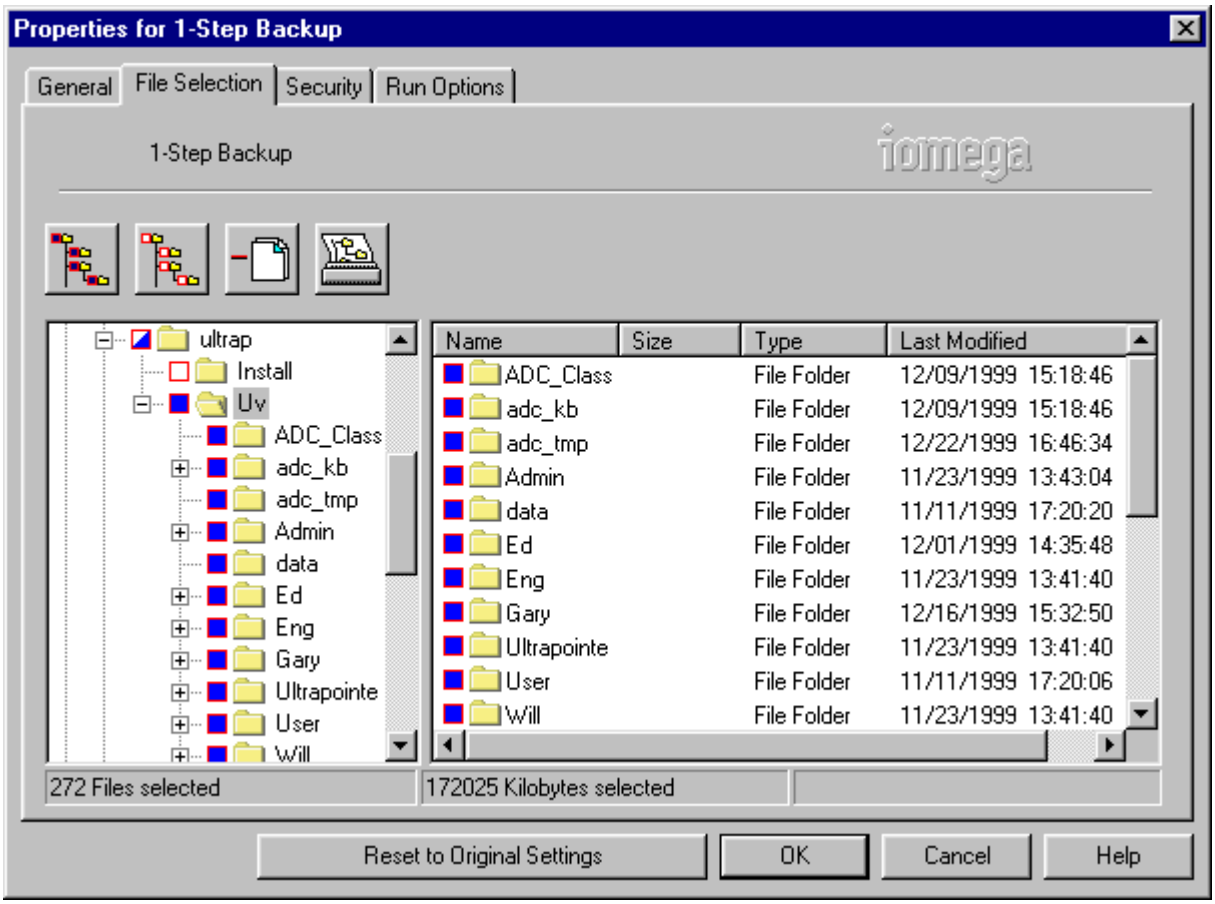
**TIP**
*The simplest way to set backup options is to click the red box for the* `C:\ultrap\uv` *directory on the* ***File Selection*** *tab, as shown in Fig. 8, and leave all of the other options to their default settings. This will mark all user directories and all program and configuration files within the* `uv` *directory for backup.*

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**Figure C-8 Backup File Selection**




5. When the backup settings are satisfactory, click the ***OK*** button to store the settings and return to the main window.
6. Click ***Backup Now***.
7. When the program says it is done, remove the cartridge, label it, return it to its holder, and store it in a safe place.

**NOTE**

*This is a typical backup operation; more or less data may be backed up depending on the user's preference or company standards. Contact KLA-Tencor for recommendations.*

## To Restore Damaged or Deleted Files

1. Insert the backup Jaz cartridge containing the files to be restored.
2. Select **1-Step Restore** from the **Start** menu.
3. Follow the directions in the program for selecting files to restore.

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## Chuck Cleaning

The backsides of wafers come into contact with three components in the CRS—the robot end effector, the stage chuck, and the prealigner chuck. These three surfaces must be cleaned periodically to minimize the risk of backside contamination.

1. Cleaning the robot end effector is straightforward. Use a clean-room compatible clean wipe and a cleaning solution of either isopropyl alcohol or water.
2. Cleaning the prealigner chuck is also straightforward. A special tool is supplied by for cleaning the chucks. 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.

   Accessing the stage chuck inside the optics chamber requires some preparation.
3. Initialize the robot to get it out of the way, using the ***RESET*** button in the ***Cassette*** pane.
4. Move the stage to the wafer load position, that is, centered in the wafer load door, and as close to the door as possible. One way to do this is to select **Stage Test** from the **Maintenance** menu, and click the ***Move XY to Load Pos*** button, but this requires high level permissions. Other methods are to load and unload a wafer, or to use the joystick.
5. Select a turret position containing no objective, if possible. If there is no open position, then select the lowest power (shortest) objective (usually 5×).
6. Open the ***Lon Diagnostics*** window from the **Maintenance** menu.
7. A menu called **Stage Door** appears near the bottom of the window. Select **Open**.
8. With the wafer door open, reach in with the chuck cleaning tool to wipe the surface of the chuck. Be careful not to come into contact with any of the objectives.
9. Select **Close** from the **Stage Door** menu when the cleaning operation is complete.

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## Laser Lifetime and Laser Interlocks

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 or 40 days remain) and a replacement should be scheduled.

1. Select **Lon Diagnostics** from the **Maintenance** menu.
2. On the right hand side of the ***Lon Diagnostics*** window is a panel labeled ***Direct Lon Access***. In it are two menus.The left column (labeled **Lon Node**) lists the I/O boards in the instrument, and the right column (labeled **NV**) lists the available network variables for the I/O board selected in the left column. Select **1 LaserPwrControl** in the left menu.
3. Select **8 PowerCmd** in the **NV** menu.



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4. Click the text entry box below the left column and enter 128, which corresponds to 25 mW of laser power. Click the ***Send*** button to change the current laser power setting to 25 mW.
5. Click **19 CurrMonitor** in the **NV** menu.
6. The result, shown under ***NV Value:***, should be between 14 and 22.
7. When the CurrMonitor variable is above 22, schedule a replacement.

The wafer door interlock should be tested at the same time as the laser lifetime is checked.

1. Load a wafer of any kind into the instrument using routine operating procedures.
2. Focus on the surface of the wafer and obtain a laser image on the workstation screen.
3. Open the wafer door using ***Lon Diagnostics***.
4. Verify that the laser image goes away, because the wafer door interlock has shuttered the laser.
5. Verify also that the laser image reappears when the door closes.

## Robot Alignment Check

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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.



**WARNING**
*Use extreme care with the* ***Manual Robot Control*** *command because it bypasses normal safeguards against wafer breakage.*

### Robot to Cassette Alignment Check

1. Place a full cassette of wafers on the cassette platform.
2. Select the ***Manual Robot Control*** window from the **Maintenance** menu to bring up the ***Robot Test*** window.
3. Execute the following steps for each wafer in the cassette.
4. Click the button for the cassette slot.
5. Click ***Robot Get***.
6. Click ***Robot Put***.
7. 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 quietly and that there is no rubbing between the wafer and the cassette.



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## Robot to Prealigner Alignment Check

1. Place a cassette of wafers on the cassette platform.
2. Bring up the ***Robot Test*** window from the **Maintenance** menu.
3. Click the button for a slot in the cassette containing a wafer, and then click ***Robot Get***.
4. Click the ***Prealigner*** button, and then click ***Robot Put***.
5. 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.
6. Click ***Robot Get***.
7. Click the slot button.
8. Click ***Robot Put***.

## Robot to XYZ Stage Alignment Check

1. Place a cassette of wafers on the cassette platform.
2. Bring up the ***Robot Test*** window from the **Maintenance** menu.
3. Click the button for a slot in the cassette containing a wafer.
4. Click ***Robot Get***.
5. Click the ***Stage*** button.
6. Click ***Robot Put***.
7. Observe the motion of the robot as it enters the stage and 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.
8. Click ***Robot Get***.
9. Click the numbered slot button.
10. Click ***Robot Put***.

## Robot Safety Interlock Check

To ensure the robot cover and cassette interlocks are working properly while avoiding possible injury or equipment damage, follow the procedure exactly. If any portion of this test fails, power down the system and contact Customer Service immediately.

1. Load a test wafer.
2. Remove the cassette from the cassette platform. The system responds with the alert shown in Figure C-9.

**WARNING**

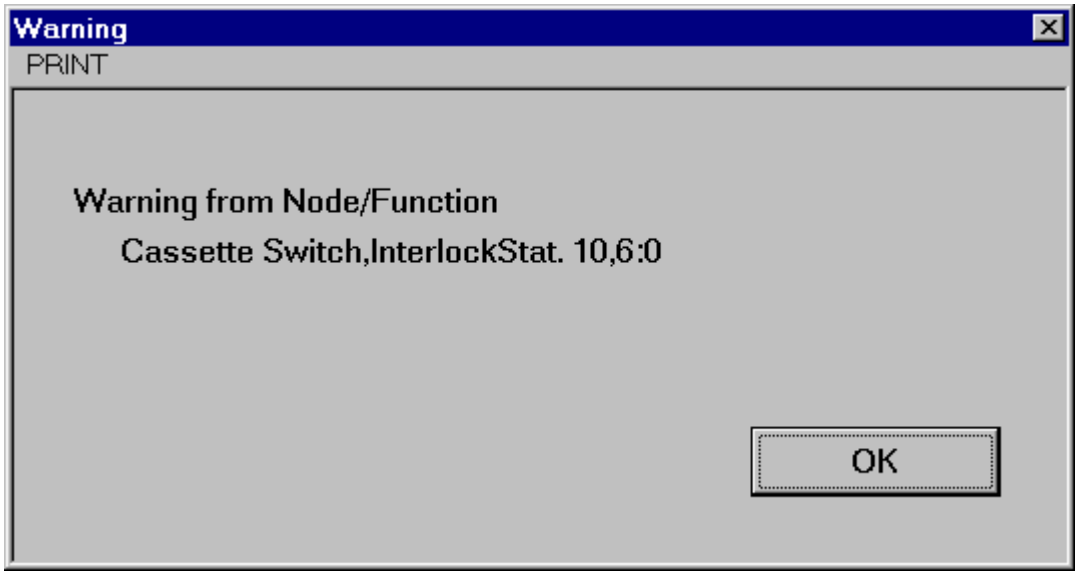
*Be sure cassette area is clear of personnel and equipment.*

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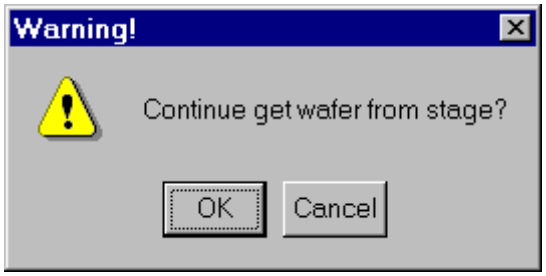
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**Figure C-9 Cassette Interlock Opened Message**




3. Click ***OK***.
4. Press the **UNLOAD** key **(F1)**. The system responds with the alert shown in Figure C-10.

**Figure C-10 Cassette Not Present Alert**



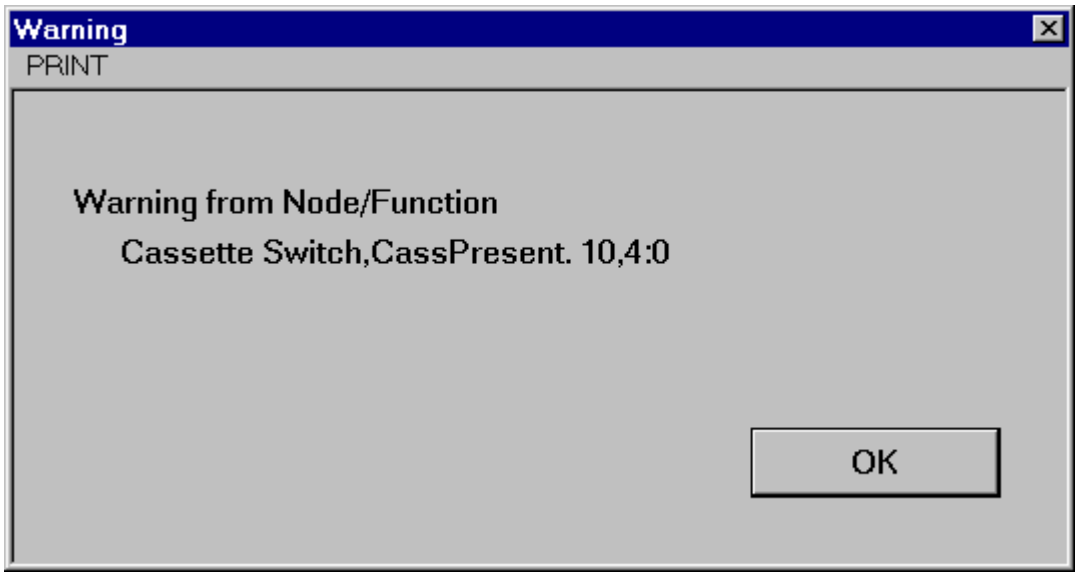

5. Replace the cassette. The message window shown in Figure C-11 appears.

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**Figure C-11 Cassette Present Message**




6. Press the **UNLOAD** key **(F1)** to unload the wafer. The alert shown in Figure C-12 appears.

**Figure C-12 Cassette Warning**




7. Click ***OK***.
8. Reload the test wafer.
9. Remove the robot safety cover and observe the alert. Click ***OK***.
10. Press the **UNLOAD** key **(F1)**, and observe the alert. Click ***OK***.
11. Replace the robot safety cover and observe the alert. Click ***OK***.
12. Press the **UNLOAD** key **(F1)** to unload the wafer, and observe the alert. Click ***OK***.

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## Changing the Halogen Bulb



**LASER**

*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 call placed to service.*

1. Perform a normal shutdown of the CRS.
2. Wait 15 minutes for the halogen bulb to cool.



**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.*

3. 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.
4. 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.
5. 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 thumb-screw and observe that the socket can now be rotated within the lamp housing.
6. Rotate the lamp housing clockwise until it contacts a stop, then pull the socket out axially.
7. 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.



**IMPORTANT**

*Do not touch a new bulb with bare fingers. Always use a cloth or wear gloves, or both. Touching the bulb will contaminate its surface, leading to premature failure.*

8. Install the new bulb by depressing the socket levers while pressing the bulb into the socket.
9. Replace the socket and bulb in the lamp housing.

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10. Snug down on the radial thumbscrew to hold the socket in place.
11. 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 except by disassembling 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.*

12. Load a patterned wafer into the machine using normal operating procedures. The auto-focus operations will not work because the laser interlocks are open.
13. Manually focus on the wafer using the joystick and the lowest power objective available.
14. 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.
15. 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.
16. Repeat steps 14–15 until the illumination is optimized. Tighten the radial thumbscrew when done.
17. 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.
18. Do a system shutdown and turn off the power to the machine with the red **OFF** button.
19. Restart the machine as previously described. Cycling the power should bring back the laser.

## Factory PM

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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# D

# Networking

## TCP/IP Setup

1. Obtain an IP address, subnet mask, and DNS host IDs from the network administrator. Check whether any other network settings are required.
2. From the **Start** menu, go to **Settings** and open **Control Panel**.
3. Double-click ***Network*** to open it.
4. In the ***Network*** window, click the ***Protocols*** tab.
5. Click ***TCP/IP Protocol***, and then on the ***Properties*** button.
6. In the ***IP Address*** tab in the ***Microsoft TCP/IP Properties*** window, click ***Specify an IP address***.
7. Enter the previously obtained values in the ***IP Address***, ***Subnet Mask***, and if necessary Default gateway fields.
8. Click the DNS tab, and enter DNS name or IP addresses.
9. Fill in data on other tabs if required.
10. Click ***OK*** in ***Microsoft TCP/IP Properties*** and ***Network*** windows to save settings and close windows.
11. Reboot the computer to activate the new network settings.

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# Glossary

## Symbols

**µm** Micron, one millionth of a meter ($10^{-6}$ m). One inch = 25,400 µm.

**.bmp** Extension for a Windows bitmap graphics file

**.cod** Extension for a defect code file, containing defect code numbers and descriptions

**.jpg** Extension for a JPEG image file, containing a captured image in JPEG format

**.map** Extension for a wafer map file, containing a description of a cassette of wafers and their defects

**.rcp** Extension for a recipe file, containing user-defined system settings

**.sur** Extension for a surface file, containing 3D CRS surface image data

**.tif** Extension for a TIFF file, containing a captured image in TIFF format

**.vol** Extension for a volume file, containing multiple-slice CRS volume image data

## Numeric

**1st slice** Slider bar to choose the slice of a 3D image to view in an ***XY*** window

## A

**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; analog to digital converter

**analog to digital converter** Electronic device which accepts a continuously varying electrical input, and outputs digital measurements of the input voltage

**ATM** Equipe Atmospheric robot

**AutoDeskew** A 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.

**Automatic Defect Classification** Wafer review and classification of defects without human intervention, using image processing of live CRS images and a Knowledge base of correctly classified defect images.

## B

**beamsplitter** Partially reflecting surface which divides a beam of light into transmitted and reflected beams travelling in different directions

**BF/DF** brightfield/darkfield

**blanket film** In semiconductor fabrication, a thin film covering the entire wafer surface

**BOM** Bill of Materials

**brightfield** Illumination of the microscope field of view at all angles that can reflect back to the objective aperture, so that the background of the image is bright from specular reflection. Contrast with darkfield.

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## C

**calibration** Measuring and setting parameters to ensure uniform imaging at all settings

**CAF** Continuous AutoFocus

**cassette** Wafer holder designed for mounting on fabrication and inspection tools in precise alignment for loading and unloading wafers

**cassette rotator** Optional 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 rectangular 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.



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**Class 1** Of a cleanroom having fewer than 1 particle of 0.5 µm size or larger per cubic foot of air.

**coarse Z stage** The portion of the stage which moves in the vertical direction with an accuracy of 0.5 µm and a range of 2 cm. Contrast with fine Z stage.

**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

**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.

**correction factor** In film measurement, the ratio between the actual film thickness determined by an SEM and the thickness measured optically without correcting for refraction at the film surface.

**critical dimension** Size of a feature in an IC, such as the width of a line, that must be controlled within narrow limits in order for the device to work correctly

**CRS** Confocal Review Station

**cutting crosshairs** Crosshairs in a 2D XY view window indicating where the XZ and YZ cut planes will be taken from a 3D image

## D

**DAC** digital to analog converter

**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.

**darkfield** Illumination of the wafer at an angle, so that only scattered light and not reflected light returns through the objective. The background wafer surface appears dark, since it reflects light well and scatters it very little, while pits, particles and edges scatter light well. Contrast with brightfield.

**defect** Any structure or substance 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 a defect code to each defect 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’ and ‘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. A defect map.

**defect intensity** In Tencor defect maps, a measure of the seriousness of the defect

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**defect map** A file containing the locations of the defects on a wafer, as determined by a surface scanner. A defect file.

**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.

**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 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.

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**digital to analog converter** Electronic device which accepts a digital input signal representing a number, and outputs a voltage proportional to the value of the input

**DSW** KLA-Tencor Defect Standard Wafer, a reference wafer

## E

**end effector** The component of a robot wafer handler which contacts the wafer, including the support surface and vacuum outlets. The end effector and chuck 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.



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# F

**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 levels 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 stage

**FCB** — FGB

**FGB** — Frame Grabber Board (FGB) = Frame Capture Board (FCB) = Surface Data Processor (SDP). It translates laser return signals from the PMT into live laser images and injects them into the video to the monitor, and also feeds image data to the computer for creating 3D surface and volume images.

**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

**fine Z stage** — The topmost section of the stage, moving 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 stage. Also called Fast Z.

**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 plane of best focus in an optical system

**focus offset** — A value to be added to the Z position as the last step in an autofocus operation. Used when the features of greatest interest are above or below the brightest slice, or there are two peaks in the brightness.

**FOUP** — Front Opening Unified Pod

**FOV** — Field of View

**Frame Capture Board** — FGB

**Frame Grabber Board** — FGB

**FWHM** — Full Width at Half Maximum, a measure of the spread of the peak of a distribution

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## G

**GEM** Generic Equipment Model of the SECS standard, for fab tools and inspectors. See SECS.

**GEM/SECS** See GEM, SECS.

**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.

## H

**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.

**High-Speed Message Services** A network communication protocol similar to TCP/IP, intended to replace SECS-I. Abbreviated HSMS

**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 very narrow band around a specific frequency

**HSMS** High-Speed SECS Message Services Standard

## I

**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** Internet Protocol address, consisting of four numbers in the range 0-255 separated by dots. For example, 10.38.3.25 or 255.0.0.0.

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**isolation platform** A floating internal frame mounted on pneumatic vibration isolators, which supports the stage, robot, prealigner, and cassette plate

## J

**J** Joule

**Joule** A unit of electric energy

## K

**keyfile** A CRS file which specifies the installed software options

**killer defect** Any defect which prevents an IC from performing its intended function

**KLA 255X** A surface scanning instrument which creates a defect map, usable by the CRS, for each wafer that it scans.

**KLA map** File format and data types developed by KLA for its surface scanning instruments

**KLARITY** KLA-Tencor software for yield analysis and control

**knowledge base** Data on defects specific to a process or process level, used in ADC for defect recognition and classification

**KTDS** KLA-Tencor Defect Standard pattern wafer (proposed)

## L

**laser line** The wavelength of highest power emission from a laser.

**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.

**LON** Local Operating Network connecting control boards within the CRS

**lot ID** Identification number for a batch of wafers

## M

**mini- environment** An enclosure around a machine to prevent entry of contaminants

## N

**N.A.** Numerical Aperture

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**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 an optical element, used as a measure of light-gathering ability

## O

**offline review** Review carried out on a separate instrument, providing superior defect classification and also allowing scanning systems to be used at maximum efficiency

**one-touch** A type of pneumatic 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.

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## P

**PAL** Programmable Array Logic IC

**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

**PCB** Printed circuit board

**PDF** Portable Document File format

**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.

**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** A photomultiplier tube



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**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

**Portable Document File** A format readable with Adobe Acrobat software.

**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. Privilege levels in the uv application are Operator, Administrator, Engineer, and Super User.

**prtscreen** **Print Screen** key

**PSF** point spread function

**psig** Pounds per square inch gauge, a unit of measurement for the difference in pressure between a system and the external atmosphere. A measurement in psig is less than the corresponding measurement in psi by the pressure of the atmosphere, approximately 15 psi.

**PWDS** SEMATECH Patterned Wafer Defect Standard

## Q

**quick disconnect** A type of pneumatic connector, used on the vacuum line into the CRS

## R

**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. Contrast toggle button.

**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

**reference wafer** A wafer taken as a standard for calibration

**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

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**resolution** The smallest distance at which two features can be distinguished in an optical system

**review** Examine and classify the defects found by a scanning system on a wafer

**rf** radio frequency

**rms** Root-mean-square (square root of average of squares), a name for $\sqrt{\frac{\sum x^2}{N}}$ or $\sqrt{\frac{\int V^2 dt}{T}}$. The second formula gives the voltage in AC circuits averaged over one complete cycle.

## S

**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. Contrast with specular reflection.

**SDP** FGB

**SECS** SEMI Equipment Communication Standard. SECS-I is a transport protocol usable over RS-232 connections or other two-way data connections. SECS-II specifies message formats and their meanings apart from the method of message transport.

**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)

**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

**signature** *See* defect signature

**SK** Soft (user definable) function Key

**slider bar** Visual control allowing a variable to be set anywhere in its range

**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

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**specular reflection** Mirror-like reflection, in which a beam of light is redirected in a beam. Contrast with scattering.

**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** A 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** FGB

**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

## T

**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. Contrast with radio button.

**turret** The rotating holder for the various microscope objectives

## U

**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

## V

**V-A** Volt-Ampere, a measure of electric power

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## W

**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 (mm) or inches (in.). Standard sizes are

| Metric | US |
|---|---|
| 100 mm | 4 in. |
| 125 mm | 5 in. |
| 150 mm | 6 in. |
| 200 mm | 8 in. |

**wafer thickness** Parameter in CRS software for setting the thickness of the wafer or other object to be viewed

**working envelope** operating envelope

## X

**XY view** The top view in a 3D image

**XZ view** A computed image of a vertical slice along the X axis through a volume image, giving a front view of the cut surface

## Y

**YZ view** A computed image of a vertical slice along the Y axis through a volume image, giving a side view of the cut surface

## Z

**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 window, the captured image can be zoomed by an arbitrary ratio in software.

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**Symbols Numerics A B C D E F G H I J K L M N O P Q R S T U V W X Y Z**

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