INFICON

Ideal for CIGS Thin Films.
Control Simultaneous Deposition of Up to Eight Materials.

Guardian™

Co-Deposition Control System for Thin Film Processes

Control of Simultaneous Co-Deposition of Multiple Materials

PRECISE CONTROL FOR EMERGING TECHNOLOGIES

Guardian Co-Deposition Controller, powered by electron impact emission spectroscopy (EIES), significantly improves the reproducibility of film quality during fabrication of CIGS films. Guardian provides precise control of deposition rates from 0.1 to 10,000 Å/s. The system operates one or two sensors, up to 8 optical inputs and controls up to 8 deposition sources, enabling co-deposition of up to 8 materials.

The unique Guardian EIES sensor (patent pending) measures deposition rates more accurately without interference from residual gases while monitoring CIGS processes. Its Windows®-based software provides easy setup and operation of multi-material thin film deposition processes. It is fully compatible with INFICON Sentinel® sensors, providing easy integration into existing systems. Guardian Co-Deposition Controller is ideal for controlling simultaneous co-deposition of multiple materials in applications such as CIGS for photovoltaics, MBE, OLEDs, and superconducting thin films.

FEATURES AT A GLANCE

- Monitor and control simultaneous deposition of up to 8 materials.
- Deposition rates from 0.1 to 10,000 Å/sec.
- Integrated EIES and QCM thin film process control.
- Ideal for CIGS thin films.

SYSTEM OVERVIEW

A complete Guardian system consists of at least one sensor, one detector, an optical filter, a controller/interface unit, and a PC-compatible computer (user-supplied) with Guardian software. EIES is generally used to control deposition of multiple materials, so most EIES systems include additional sensors, detectors, optical components such as beam splitters, and Quartz Crystal Monitors (QCMs) for calibration or controlling deposition rate for some materials. The block diagram in Figure 1 shows a typical Guardian system configuration. In this system, the Guardian controls the deposition rate of four materials, using EIES for three of the materials and a QCM for the fourth. (A common configuration for deposition of CIGS materials in photovoltaics applications.)

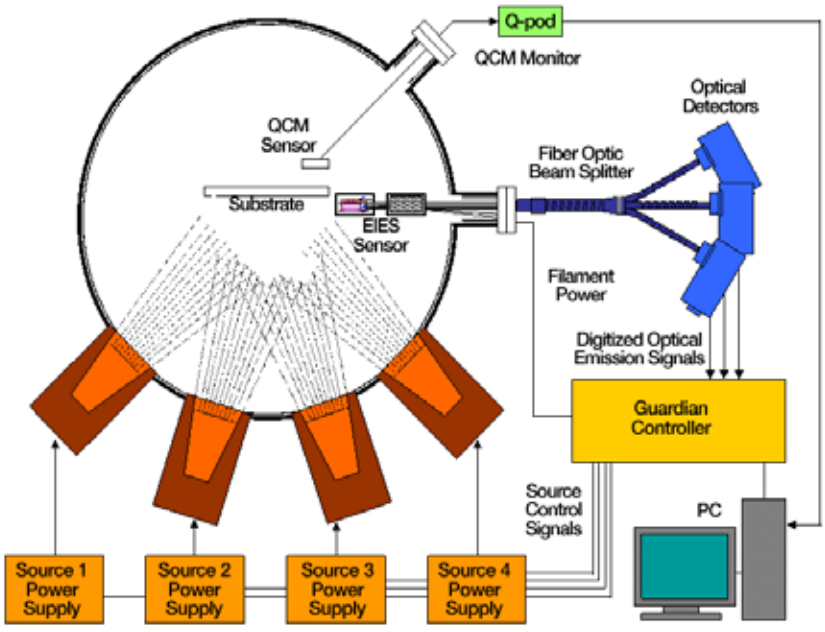

Figure 1 - Typical system configuration.

TO CONFIGURE THE GUARDIAN CO-DEPOSITION SYSTEM, CONSIDER THE FOLLOWING:

What are the primary and secondary emission wavelengths for your deposition materials? If different materials have peaks too close to each other, you may need to monitor a secondary wavelength, which has lower signal strength. During the deposition process, what background gases are present in your vacuum chamber, and what are the emission wavelengths for those gases? If emissions from background gases interfere with the deposition materials', a gas compensating sensor is recommended. EIES is most effective with the uniquely defined spectra of atomic species. Molecular species that

species that generate unstable or broad emission spectra cannot be measured accurately. EIES is not recommended for organic materials. These, and other factors, determine the optimum EIES system configuration for each specific application. Papers have been published that describe these considerations in more detail. When you are configuring your EIES system, please contact us for a thorough discussion of your application.

The standard sensor has one thermionic emitter (filament) positioned near the vapor flux of the materials being deposited. The light generated travels through the light tube to the detector. A filter at the detector inlet passes the specific wavelength of interest. This sensor works well at high vacuum.

The gas compensation sensor incorporates a second filament in addition to the standard sensor. This second filament is positioned so that it sees only the background gases, not the vapor flux of the materials being deposited. The Guardian software then subtracts the background gases from the signal of interest, significantly improving stability. The gas compensation sensor is recommended when emissions from background gases, such as H_2O & CO_2, interfere with the signal from the material of interest.

The detector uses a photomultiplier tube (PMT) to convert the optical/light signal from the sensor into a high resolution digital signal. A filter at the detector inlet selects the specific material wavelength of interest. The detector inlet has a built-in filter holder for standard 1"(25mm) diameter filters. For a single material system the optical detector module can mount directly on the feedthrough. For multiple materials, a beam splitter can be used to couple the optical signal from one sensor into several detectors. The gain of each detector can be adjusted individually to optimize performance for different materials.

Users familiar with optical beam handling equipment can readily design and build their own beam splitters, using standard components available from many suppliers. For best results, we recommend splitting the main beam into no more than 3 or 4 beams. We offer a fiberoptic beam splitter that splits the main sensor optical beam into 2 to 4 beams. Please contact us with your requirements.

A filter is placed in the inlet of each detector, and blocks all light except one wavelength, which is usually the primary or secondary emission wavelength for the material of interest. Filters with narrow bandwidths reject adjacent wavelengths, but also pass less of the wavelength of interest. Numerous optical filters are available on the market; we offer filters with a good balance between bandwidth and signal levels for most applications.

The Guardian controller provides power for 1 or 2 sensors and up to 8 optical detectors, produces up to 8 source control output signals, and provides digital I/O functions (12 relays, 12 logic inputs). The controller is also the digital interface between all of these functions, and your computer. Two controller models are available: The basic controller (900-031) operates one sensor, the other (900-051) runs two. Both models operate standard or gas compensation sensors.

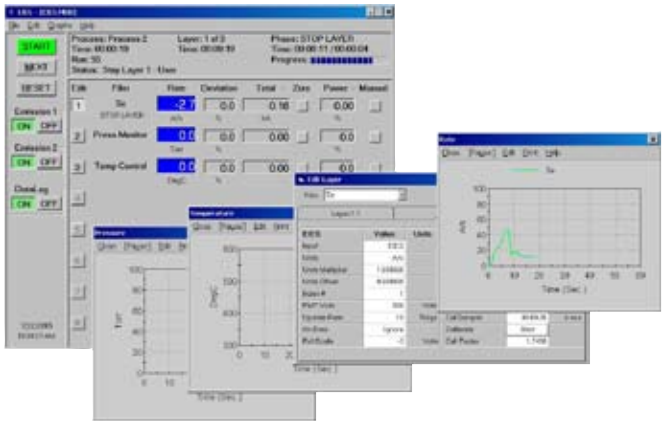

Figure 2 - Guardian software provides all of the functions required for an eight sensor, eight output, multi-layer co-deposition controller. Process settings, numeric data, and graphs can be displayed during all phases of deposition.

The final component of an EIES system is your computer and the Guardian software supplied with every controller. The software provides everything you need to setup and operate the EIES system, and run a multi-material thin film deposition process.

The software integrates a QCM, such as Q-pod transducer or SQM-242 card, for calibration of the EIES to a QCM reference, or for deposition control. The SQM-242 and SAM-242 option cards can also be used for calibration and control of analog devices.

HOW ELECTRON IMPACT EMISSION SPECTROSCOPY WORKS

Guardian is powered by Electron Impact Emission Spectroscopy (EIES), a highly advanced method of controlling thin film properties during deposition of multiple films. The material being deposited is excited by a thermionic emitter, which results in creation of photons. The light created passes through an optical filter to a photomultiplier tube (PMT) detector, which measures the intensity of emission of the passed wavelength. Guardian then generates a signal to control the source for that material. Additional detectors, with appropriate optical filters, are used for multiple materials.

SPECIFICATIONS

Sensors*		* patents pending
Operating Pressure		< $5x10^{-4}$ Torr
Temperature		450°C maximum during operation and/or bakeout
Size (approximate)		$^3/_4$" x $1^1/_4$" x $1^3/_4$" (19 x 32 x 45 mm)
Filament Life (typical)		~1000 hours
Sensor-Feedthrough Linkage		rigid ss tube, length adjustable from ~ 7" to 17" (~ 175 to 430 mm)
Feedthrough / Flange		one optical and four electrical feedthroughs on $2^3/_4$"CF (NW35CF)
Detector		
Photomultiplier Tube (PMT)		Hamamatsu R7518 or equivalent
Spectral Response		185 to 730 nm
Detection Limit		better than 5 fW of optical input power
PMT Gain		10^3 to 10^7 (detectors are independently adjustable)
Output Resolution		20-bit
Optical Entrance Port		built-in filter holder, for filters up to 1" (25mm) diameter and 0.2" (5mm) thick
Size		2" x 5.5" x 2.75" (50 x 140 x 70 mm) mounting holes on 3 sides (optional mounting brackets available)
Controller		
Sensors		900-031: operates one sensor 900-051: operates one or two sensors
Detectors		8 optical detector channels
Control Outputs		8 source control outputs, 0 to ±10 VDC programmable
Digital I/O		12 relay outputs and 12 logic inputs
Power		100-240 VAC, 50/60Hz, 150W
Size		19" x 3.5" x 12" (483 x 89 x 305 mm)
Compliance		CE
User Interface	software:	Windows® based setup program included with Controller
Displays	deposition rate:	4-digit numeric display of all channels, from 0.001 to 999.9 Å/s, and graphical X-Y scrolling plot with selectable scales.
	thickness:	5-digit numeric display with range selection, from 000.01 to 999.99 KÅ
Computer	user-supplied:	any PC with Windows® Vista/XP/2000 operating system, and Ethernet or RS-232 interface

INFICON Instruments for Intelligent Control™

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