INFICON

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

Guardian™

Codeposition Control System for Thin Film Processes

Control of Simultaneous Codeposition of Multiple Materials

PRECISE CONTROL FOR EMERGING TECHNOLOGIES

Guardian Codeposition 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 0.001 to 9999 Å/sec. The system operates one or two sensors, up to six optical detectors and controls up to eight deposition sources, enabling codeposition of up to eight materials.

The unique Guardian EIES sensor 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 Codeposition Controller is ideal for controlling simultaneous codeposition of multiple materials in applications such as CIGS for photovoltaics, MBE, and superconducting 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 Windows®-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.)

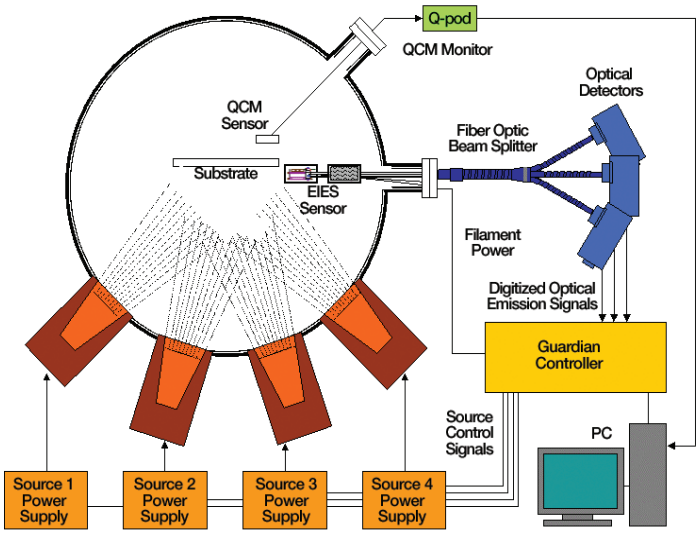

Figure 1: Conceptual system configuration.
(See manual for source to sensor alignment requirements.)

FEATURES AT A GLANCE

- Monitor and control simultaneous deposition of up to eight materials.
- Deposition rates from 0.001 to 9999 Å/sec.
- Integrated EIES and QCM thin film process control.
- Ideal for CIGS thin films.

TO CONFIGURE THE GUARDIAN CODEPOSITION 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 generate unstable or broad emission spectra cannot be measured accurately. EIES is not suitable 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 compensating 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 compensating sensor is recommended when emissions from background gases, such as H_2O and 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 25 mm (1 in.) 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 three beams. We offer a fiberoptic beam splitter that splits the main sensor optical beam into two or three 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 one or two sensors and up to six optical detectors, produces up to eight 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 (782-900-031) operates one sensor, the other (782-900-050) runs two. Both models operate standard or gas compensating sensors.

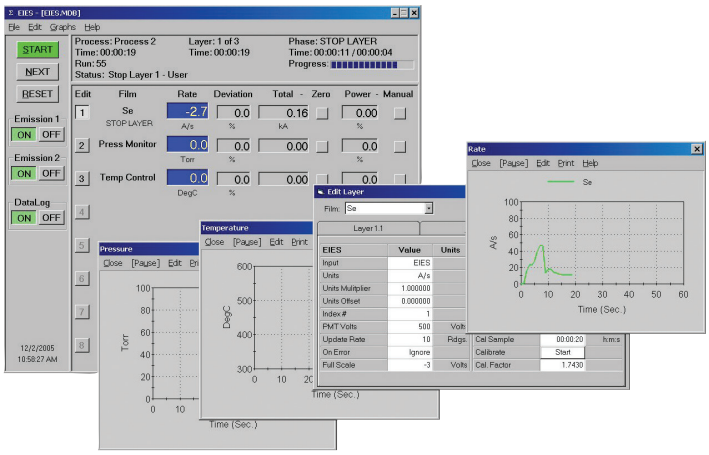

Figure 2: Guardian software provides all of the functions required for a six optical detector, eight output, multi-layer codeposition controller. Process settings, numeric data, and graphs can be displayed during all phases of deposition.

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		Guardian Sensor Patent US 7,719,681 B2
Operating pressure		$<5x10^{-4}$ Torr
Temperature		450°C maximum during operation and/or bakeout
Size (approximate)		19 x 32 x 45 mm (0.75 x 1.25 x 1.75 in.)
Filament life (typical)		~1000 hours at 2 mA emission (Yttria), 4 mA for Thoria
Sensor-feedthrough linkage		Rigid ss tube, adjustable from 175 to 550 mm (7 to 22 in.)
Feedthrough / flange		One optical and four electrical feedthroughs on 2.75 in.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 25 mm (1 in.) diameter and 5 mm (0.2 in.) thick
Size		50 x 140 x 70 mm (2 x 5.5 x 2.75 in.) Mounting holes on three sides (optional mounting brackets available)
Controllers		782-900-031: operates one sensor 782-900-050: operates one or two sensors
Sensors		016-600-G22: Standard Sensor Assembly 56 cm (22 in.) 016-601-G22: Gas Compensating Sensor Assembly 56 cm (22 in.)
Detectors		Six optical detector channels
Control outputs		Eight source control outputs, 0 to ±10 V (dc) programmable
Digital I/O		12 relay outputs and 12 logic inputs
Power		100 to 240 V (ac), 50/60 Hz, 150 W
Size		483 x 89 x 305 mm (19 x 3.5 x 12 in.)
Compliance		CE
User interface	software:	Windows-based setup program included with controller
Software displays	deposition rate:	4-digit numeric display of all channels, from 0.001 to 9999 Å/s, and graphical X-Y scrolling plot with selectable scales.
	thickness:	4-digit numeric display with range selection, from 0.001 to 9999 KÅ
Computer	user-supplied:	Any computer with Windows Vista/XP/2000 operating system, and Ethernet or RS-232 interface

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