Electron Microscopy

MODEL

IBS/e

# Ion Beam Sputter Deposition and Etching System


**Improves High Resolution Electron Microscopy Imaging by Depositing Ultra-Thin, Fine Grain Metal and Carbon Films on Specimens.**

SBT

SOUTH BAY TECHNOLOGY, INC.

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# Ion Beam Sputter Deposition and Etching System

***The Model IBS/e is a high vacuum thin film deposition system designed to precisely deposit sub-nanometer grain, conductive coatings onto specimens prior to examination in the electron microscope. Thin, conductive films are deposited onto specimens to prevent charging effects and to enhance contrast. Thin films are deposited using two ion beam sources directed at a target material, eliminating radiation or heating effects common with other coating techniques. Extremely thin, continuous metal or carbon films are deposited without risking damage to delicate features present on the specimen. Virtually any target material can be used for ion beam deposition with precise control over the deposition thickness. An optional third ion source allows specialized ion beam etching techniques to be employed. The ability to deposit amorphous, continuous films makes the IBS/e system ideal for high resolution electron microscopy techniques.***

## Applications

Specimens examined in high resolution electron microscopes utilizing field emission electron sources demand fine grain, ultra-thin conductive coatings for image capture and specimen analysis. Low voltage SEM specimens must frequently be coated with a conducting film to reduce charging and enhance contrast in images. Ultra-thin films on specimens for examination by both AFM and STM are sometimes needed to decrease surface resistivity, bind small particles to a substrate, and reduce distortion from tip/specimen interaction. All of these techniques require uniform thin films to be deposited on the specimens of interest without heat or radiation. Standard coating techniques such as DC diode, vacuum evaporation, and other thermally driven methods are incapable of handling these requirements. The IBS/e is capable of precisely depositing thin films without exposing specimens to damaging photon flux. Additional applications include producing SEM samples for “channeling contrast”, Electron Back Scatter Diffraction (EBSD) Patterns, Orientation Imaging Microscopy (OIM) and multilayer deposition for research and development applications.

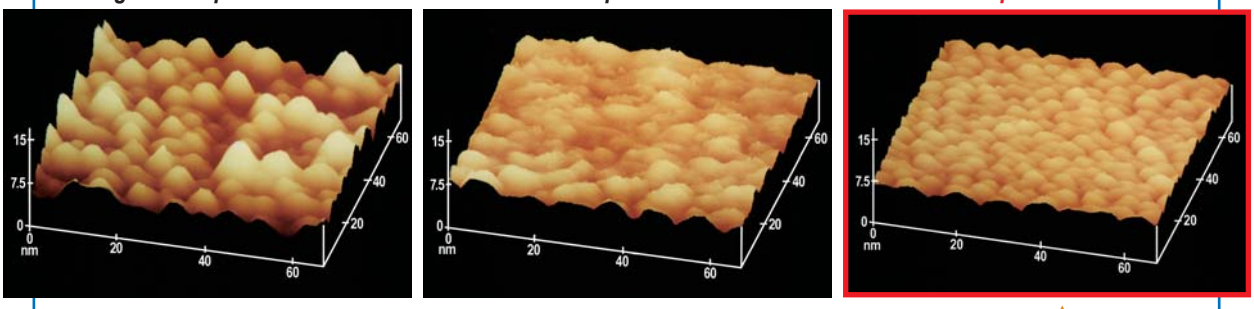
Reactive etching and deposition can be achieved by introducing reactive gas such as oxygen or nitrogen through an optional micro-mixing valve.

## Ion Sources

The IBS/e ion sources are specifically designed for simple operation and fast servicing. Both sources are directed at a target material which is sputtered with ejection energies of < 40 eV onto the specimen. Operating at 10kV, the ion sources produce a beam flux of 15mA/cm$^2$ to produce a uniform distribution over the entire specimen. Ion beam current is displayed digitally for quick evaluation of the operating conditions. The sources are easily dismounted through the vacuum chamber door. 24 hour factory Quick Exchange Service is available for the anode assemblies.

An etching ion source is optional for nano-machining samples prior to sputter deposition. Etching improves image contrast on highly polished cross section SEM samples and can expose interesting aspects of various types of biological samples.

***DC Magnetron Sputtered Pd on Si*** ***Vacuum Evaporated Pd on Si*** ***Ion Beam Sputtered Pd on Si***




***Note the superior continuity and uniformity of the Ion Beam Sputtered sample.***

Images courtesy of Lawrence Livermore National Laboratory.

## Specimen Stage Control

The Independent Rotate and Tilt Stage (IRT) drives specimens under the sputtered material with a wide range of parameters. Both the tilt and rotate axes are independently controlled to uniformly coat specimens. The IRT allows directional or rotary shadowing at fixed angles as well as variable speed controls for both tilt and rotation. The variable tilt angle rate improves uniformity by decreasing the tilt rate as the tilt angle increases. Specimens can be parked at 180° to shield them during target oxide removal.

The standard specimen stage can accommodate 2" wafers as well as SEM mounts and TEM specimens. Using the Large Area Stage (LAS) accommodates specimen wafers up to 4" diameter for ion beam sputter deposition.

## High Vacuum System

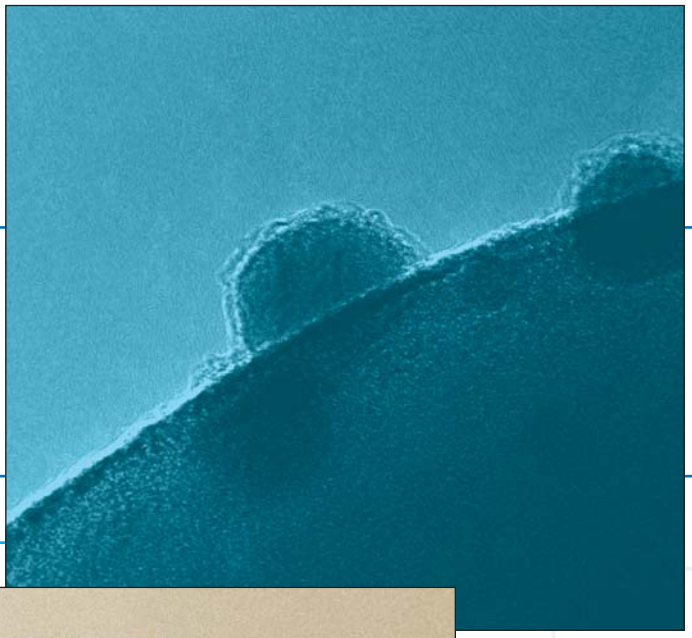
The Model IBS/e creates a clean, hydrocarbon free, high vacuum automatically using a turbomolecular pump. Vacuum level is displayed digitally using a cold cathode high vacuum gauge. The system reaches a base pressure of $10^{-7}$ torr within minutes, allowing oxide-free metal films to be deposited without the need for liquid nitrogen trapping.

## Film Thickness Monitor

Monitoring the film thickness precisely is done with a quartz crystal thickness monitor (QCTM). The QCTM will precisely monitor and repeatably terminate the sputtering process at preset film thickness or preset time, whichever occurs first.

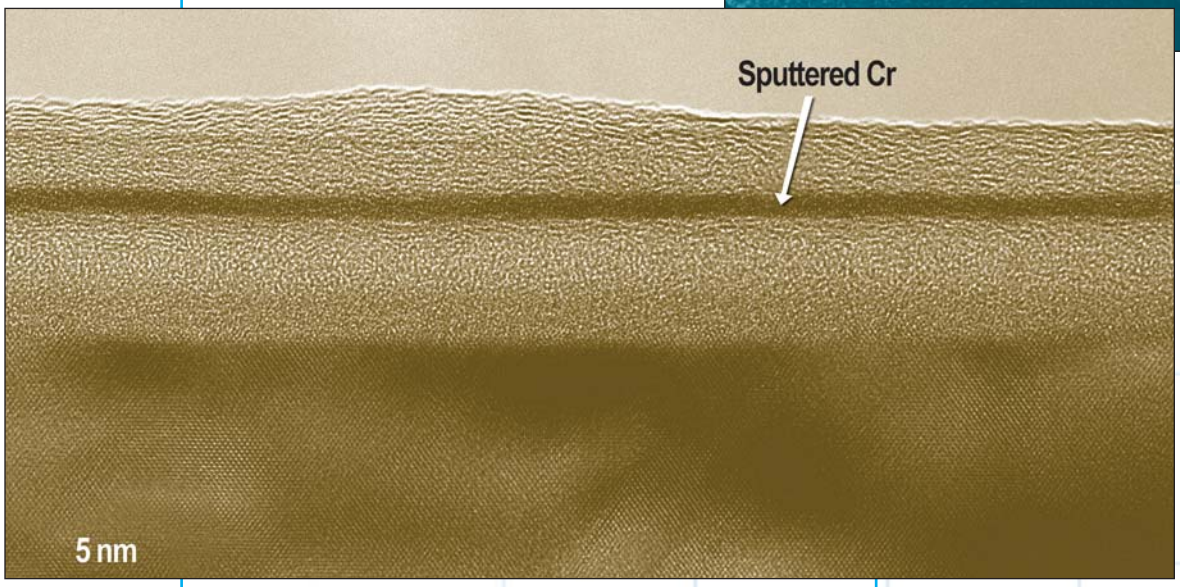
## Targets

Four different target materials are selectable for deposition without breaking vacuum. Each target can be rotated into the sputter position simply by rotating a thumbwheel. The ability of the IBS/e to produce oxide free coatings without liquid nitrogen trapping allow refractory metals such as chromium, tungsten, and tantalum to be deposited without problems.



***8 Angstrom W film deposited on Pd/$SiO_2$ sample. Slow deposition and precisely controlled specimen tilt and rotation enhances the uniformity of the tungsten film.***

Image courtesy of Larry Allard, Oak Ridge National Laboratory and David Joy, University of Tennessee.




***TEM micrograph showing uniformity of chromium film deposited to protect carbon film on silicon.***

Image courtesy of Haifei Wang, Read-Rite Corporation

## ▶ Typical Target Materials:

| | |
|---|---|
| Chromium | Carbon |
| Tungsten | Gold |
| Tantalum | Gold/Palladium |
| Platinum | Palladium |
| Iridium | Silver |

## ▶ Specifications:

| | |
|---|---|
| **Vacuum System** | |
| Roughing Pump: | 40 l/m $N_2$ |
| Turbo Pump: | 250 l/s $N_2$ |
| Base Pressure: | $10^{-7}$ torr |
| Operating Pressure: | x $10^{-5}$ torr (10 to 15 minutes) |
| Vacuum Gauge: | Cold cathode |
| **Ion Sources** | |
| Beam Energy: | 2.5 kV to 10 kV |
| Beam Flux: | 15 mA / $cm^2$ |
| **IRT Stage** | |
| Tilt Range - Deposition Mode: | 0 to +/- 99° |
| Tilt Range - Etch Mode: | 0 to +/- 99° |
| Tilt Range - With Large Area Stage: | 0 to +/- 17° |
| Specimen Stage: | 2" Standard; 4" Optional |
| Tilt Angle Rate: | Variable |
| Rotational Speed: | 0 to 40 RPM |
| **Gas** | |
| Source Gas: | Ar, 99.999% pure |
| Pressure: | 2 sccm @ 5-7 PSI |
| Vent Gas: | $N_2$ @ 5 PSI |
| **Power/Utilities** | |
| 110 VAC / 15 A | 50/60 Hz |
| 220 VAC / 7.5 A | 50/60 Hz |

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Cover background image of iridium coated mozzarella cheese courtesy of William McManus MS, Electron Microscopy Facility Supervisor, Department of Biology, Utah State University