SOUTH BAY TECHNOLOGY, INC.

1120 Via Callejon ■ San Clemente ■ California ■ 92673 ■ USA
Telephone: (949) 492-2600 ■ Fax: (949) 492-1499

e-mail: info@southbaytech.com
www.southbaytech.com

Applications Laboratory Report
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Evaluating Surface Roughness of Ion Beam Sputtered Iridium Using a Large Area Stage

Purpose

Ion beam sputtered films have many advantages over other sputtering methods, the selection of which depends on the primary application. For electron microscopy applications, the primary requirements of the sputtered material are the films must be uniform in thickness over the entire sample area, continuous, and amorphous. It has been demonstrated that thin, amorphous, conductive coatings are created using the Model IBS/e Ion Beam Deposition and Etching System and provide excellent results for electron microscopy samples. However, in other applications such as thin film research, the actual topography and roughness of the deposited film may be of interest.

This report shows results obtained from deposition experiments run using the Large Area Stage (LAS) of the Model IBS/e. Evaluating the surface roughness and topography of the deposited film at various locations of the LAS was done to characterize any dramatic changes in these properties as a function of distance. Scanning probe microscopy (SPM) was used to image the surface of the deposited film and to measure the surface roughness as well.

Materials and Methods

A plain silicon wafer was obtained and cleaved into small square pieces of approximately 10mm^2. These samples were all initially cleaned on the smooth, polished surface of the wafer using acetone and isopropyl alcohol. Each wafer piece was mounted onto a LAS specimen carrier that was approximately 100mm (4”) in diameter. Wafer pieces were oriented in various locations on the specimen carrier and then numbered according to their location on the carrier. Below is a schematic of the locations for each sample with their corresponding number.

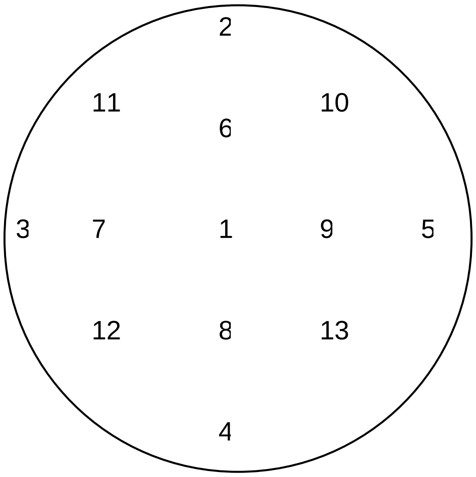

Figure 1: Schematic illustration of the position of each sample during the ion beam deposition process. Individual silicon samples were mounted to the 100mm (4”) diameter carrier at each location during the coating process.

A model IBS/e Ion Beam Deposition and Etching system equipped with a Large Area Stage was used for preparing the samples for deposition of the films. Figure 2 shows the system configuration and the chamber, including the LAS.

Samples were deposited with iridium using the standard 1” (25mm) target under the following conditions:

Target:	Iridium (Ir)	**Rotation:**	2.5 on dial
Voltage:	8 kV	**Tilt:**	+ / - 10°
Current:	6 mA (3 mA per gun)	**Deposition Pressure:**	8.2 x 10^{-6} Torr
Time:	30 minutes		

Figure 2: The Model IBS/e Ion Beam Sputter Deposition and Etching System. The inside of the vacuum chamber is shown at right with the Large Area Stage (LAS) installed. Targets are mounted to the chamber lid and can hold up to 4 different target materials.

Once the samples had been processed they were subsequently imaged using a Veeco, DI Nanoscope IIIa Multimode scanning probe microscope. The system was operated using a silicon nitride (S_3N_4) tip mounted on a triangular cantilever working in contact mode. All samples were imaged in a dry environment, with the left channel as height and the right channel as cantilever deflection. Coupled with the topographic images taken for visual inspection, roughness data was also collected to help quantify the overall roughness of the deposited film for each sample. The Root Mean Square (RMS) and the Average Roughness (Ra) were both calculated based on the height signals obtained by each scanning profile of the samples (1).

Results

As described above, each sample was imaged and a subsequent roughness calculation was performed to find possible variables in these values that could be correlated to the distance from the target. Table 1 is a summary of the scan data obtained from these calculations.

SAMPLE	RMS (NM)	RA (NM)
1	0.264	0.211
2	0.310	0.245
3	0.321	0.255
5	0.459	0.367
6	0.350	0.275
7	0.237	0.188
8	0.305	0.393
10	0.383	0.302
13	0.368	0.293

Table 1: Summary of the roughness data obtained from surface scans of each sample.

An image montage of all of the surface images taken are shown in Figures 3-5. Primarily all of the surface SPM images have very similar characteristics as far as the overall appearance of the films. None of them appear to have too much variation in their surface roughness or in grain size and distribution. In most cases the films look relatively uniform and continuous over the entire area of the LAS.

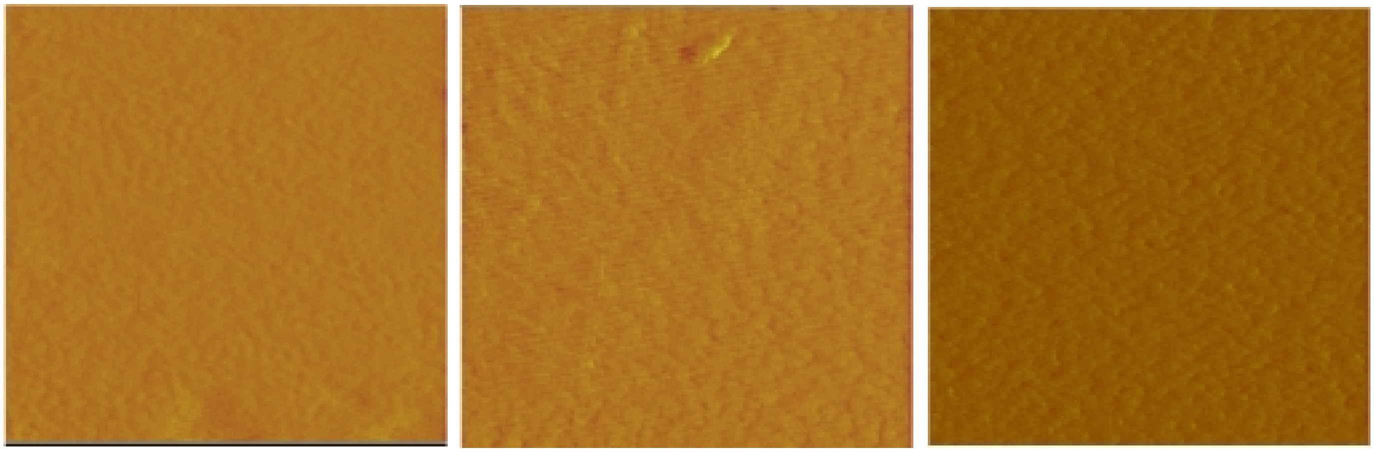

Figure 3: SPM images showing the results from each scan. From left to right, Sample 1, 2, and 3.

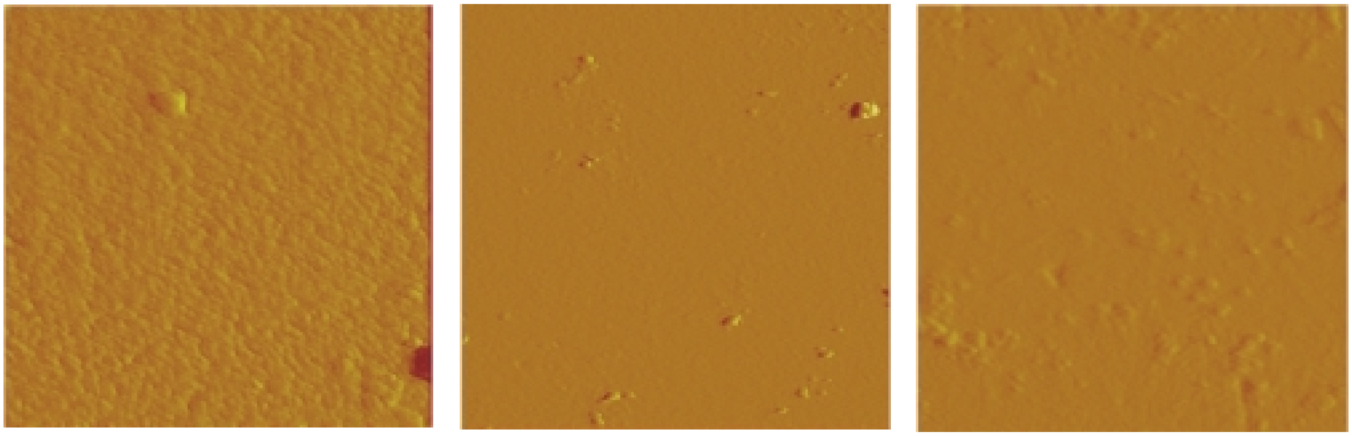

Figure 4: SPM images showing the results from each scan. From left to right, Sample 5, 6, and 7.

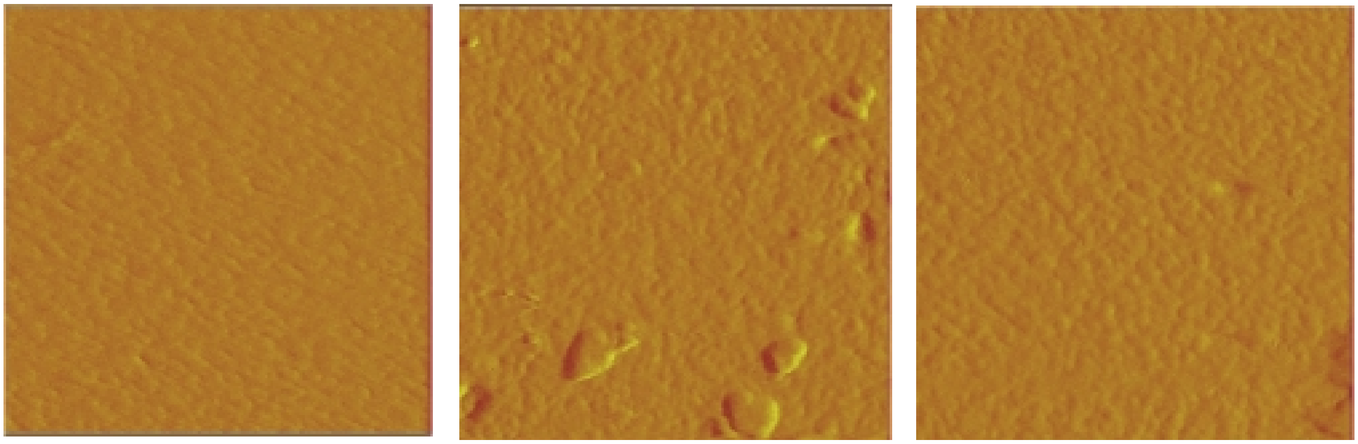

Figure 5: SPM images showing the results from each scan. From left to right, Sample 8, 10, and 13.

Conclusions

There seems to be no real difference in the quality of the thin films deposited onto the samples regardless of their orientation on the Large Area Stage. The Ra and RMS were both calculated for all samples individually and this data showed a range of 0.195 nm in variation. Therefore, the largest difference in surface roughness measured on any of the 13 samples used was 1.95Å when comparing the lowest value with the highest value. Minute changes in the roughness of a deposited film at this scale will make no significant impact on electron microscopy applications.

Understanding system parameters and the effects geometry could have on the outcome of the sample is important when using equipment for analytical situations. The Model IBS/e has been well characterized by many users as well as the SBT Applications Laboratory, and therefore has a well-rounded application to the fields of materials and biological analysis

References

1. B. Pesic, University of Idaho, College of Mines. All SPM image and analysis data are courtesy of Dr. Pesic.
2. 2000. Vacuum Deposition Technology: Physical Sputtering. *Vacuum Technology and Coating*. Jan/Feb, p. 41.