Title: Preparation of Thin Films by Ablation with Anaconda Ion Beam Generator.

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Thin films of silicon carbide are produced by using the technology of ion beam evaporation. Various analytical methods are used to analyze film thickness, film composition and crystallizability for samples obtained with different target-substrate distances.

1. Introduction
The technologies relating to intense, pulsed, charge particle beams, largely supported by inertial confinement fusion programs, have been developed for several decades. In recent years, it has been realized that these technologies are also applicable in industrial fields. For example, the ion beam evaporation (IBE) is an efficient and economical method for preparation of both thin films and nanosize powders.

The IBE is a technology that evaporates the target material by irradiating a target surface with an intense, pulsed ion beam. Due to the large ion stopping power in solids,
in solids, very high energy density can be obtained in a small target volume close to the surface. This volume of target material is instantly evaporated and ionized expanding from the target surface into vacuum. When a substrate is located facing the target surface, the expanding material strikes the substrate and cools on the substrate surface resulting in a very thin film.

ANACONDA is an intense ion beam generator developed by Los Alamos National Laboratory for research on the application of ion beams to material processing. We have used the ion beam generated by ANACONDA (400 keV, 30 kA, 1 μs) to evaporate SiC target and to deposit the evaporated material on a silicon substrate. The deposited film was analyzed by using profilometry, Rutherford Backward Scattering (RBS) and X-Ray Diffraction (XRD) for film thickness, film composition and crystallizability, respectively.

2. Experimental setup

Figure 1 shows the configuration of the ANACONDA ion beam diode, which is an extraction type B, diode. The ion beam is extracted from the annular anode and focused onto the target. Typical waveforms of the diode voltage and current are shown in Fig. 2. The ions are mostly carbon and oxygen with a small proton component. The ion beam intensity obtained at the focus point has a FWHM of 6 to 8 cm.

The target is a sintered SiC disk with 5 cm diameter. It is located at the focus of the ion beam at an angle of 45 degrees to the axis.

A silicon substrate is located in front of and parallel to the target with a separation variable from 11.5 to 18 cm. The film samples on the substrate were obtained by firing 40 shots of ion beam on the target without breaking the vacuum.

3. Results of analyses

In order to obtain the thickness of the film, a portion of substrate is masked during film deposition giving a sharp edge to the film. Figure 3 shows this edge obtained by using a profilometer. Figure 3(a) and 3(b) show the samples obtained with target-substrate distances of 11.5 cm and 18 cm, respectively. From Fig. 3, the film thicknesses are ~ 0.8 μm and ~ 0.3 μm for the target-substrate distances of 11.5 cm and 18 cm, corresponding to deposition rates of 20
Fig. 3 Profile of the film surface showing film thickness, for films obtained with target-substrate distance of (a) 11.5 cm and (b) 18 cm, respectively.

Table 1 Film composition obtained by RBS.

<table>
<thead>
<tr>
<th>target-substrate distance</th>
<th>Si (%)</th>
<th>C (%)</th>
<th>O (%)</th>
</tr>
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<tbody>
<tr>
<td>11.5 cm</td>
<td>33</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td>18 cm</td>
<td>21</td>
<td>62</td>
<td>17</td>
</tr>
</tbody>
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The sample obtained with target-substrate distance of 11.5 cm was analyzed by using XRD. Figure 4 shows the major peaks obtained by the XRD. It is seen from Fig. 4 that, except for the peaks of the substrate material, the observed diffraction peaks are mainly given by β-SiC, indicating that the thin film has cubic silicon carbide structure.
Fig. 4  XRD peaks of the SiC film on silicon substrate obtained with target-substrate distance of 11.5 cm.

References


