§16. Sputtering in Rough Surface

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The angle and energy distributions of reflected particles have been measured for highly-oriented pyro-graphite (HOPG) bombarded by 1 keV H^+ ions at an incident angle 80 degree from surface normal. Figure 1 shows the surface structure of HOPG by a scanning electron microscope. The picture indicates that the surface structure of HOPG differ from the flat surface.

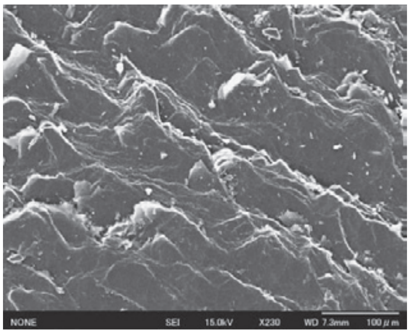

Fig. 1 A SEM image showing surface structure of HOPG.

In order to analyze the influence of the surface structure of the target material, the two-dimensional fractal surface model [1] (Fourier filtering method) is incorporated into the ACAT code [2] with the periodic boundary condition. In the Fourier filtering method, the height z at a horizontal position $\boldsymbol{r} = x\boldsymbol{i} + y\boldsymbol{j}$ is given by the two-dimensional discrete inverse Fourier transform as

$$z(\mathbf{r}) = \sum_{k_x=0} \sum_{k_y=0} \{A(\mathbf{k})\cos(\mathbf{k}\cdot\mathbf{r}) + B(\mathbf{k})\sin(\mathbf{k}\cdot\mathbf{r})\}, \qquad (1)$$

where $\boldsymbol{k} = k_x\boldsymbol{i} + k_y\boldsymbol{j}$ is a wave vector. The spectral density $S(\boldsymbol{k})$ expressed by

$$S(\mathbf{k}) = A^2(\mathbf{k}) + B^2(\mathbf{k}) \propto (k_x^2 + k_y^2)^{-\beta}, \qquad (2)$$

and $\beta = 4 - D$, where D is the fractal dimension.

Shown in Fig. 2 is the surface structure described by the fractal method with D=2.3. In the present work, the fractal dimension 2.3 has been employed to represent the surface structure of HOPG. Figure 3 indicates the measured intensities of H^- and H^+ reflected from HOPG bombarded by 1 keV H^+ at the 80 degree incident angle together with the flat and the fractal ACAT results. The flat ACAT results indicate the sharp peak abound the mirror angles. Meanwhile, the reflected angle dependence of the experimental data is weaker than the dependence predicted by the flat ACAT results. Considering the rough surface, the incident angle has the effective local incident angles, β, shown in Fig. 4. Thus, the incident angle has some distribution.

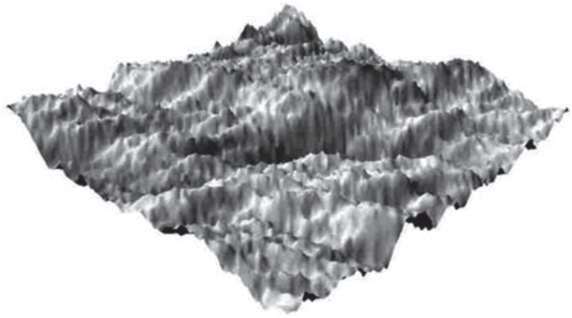

Fig. 2 Fractal surface with fractal dimension 2.3

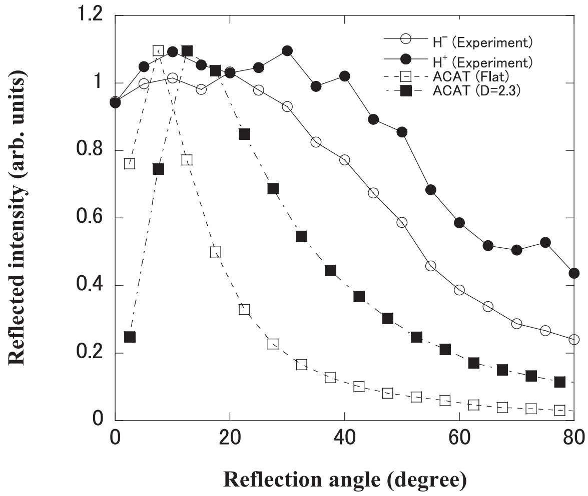

Fig. 3 Measured reflected H^- and H^+ intensities bombarded by 1 keV H^+ ions at an incident angle 80 degree from surface normal. Also shown in the figure are the results calculated the flat and the fractal ACAT.

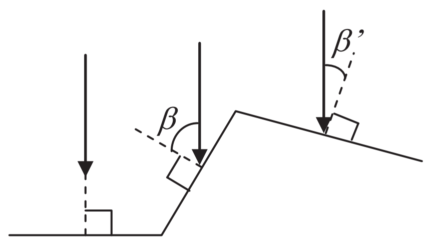

Fig. 4 Schematic representations of local angles in the rough surface.

From the ACAT calculations, the rough surface tends to broad the distribution and to suppress the incident angle dependence on reflection due to the local incident angles.

1) Barnsley , M. F. et al.: in: *The Science of Fractal Images*, Springer-Verlag, New York, 1988.
2) Yamamura, Y., Mizuno, Y.: IPPJ-AM-40 (1985).