§15. Reflection Characteristics of Low-energy Particles Injected into Highly-oriented Carbon Nano-materials

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Low energy particle interaction with the matter surface has been studied in general interest because of not only physical viewpoint but also the applicability for the surface analyses. The scattered particles consist of reflected and sputtered particles. In the low energy region of the order of a few keV, the sputtering yield is much smaller compared to the fraction of the reflected particles. Material surface is considered to be two dimensional, but Monte Carlo simulation requires the modification of the two dimensional surface model and the actual surface may have fractal structure having dimension between 2 and 3. Thus the structure of the surface could affect strongly on the reflection characteristics of the incident particles. Other viewpoint of the interaction is retention of light elements in the materials, which is also related to the structure. In the fusion device the bulk hydrogen retention and hydrogen diffusion in carbon materials is important because of the hydrogen recycling and tritium inventory under a fusion reactor environment. It is interesting that we may find nanostructure carbons around the first wall of the vacuum chamber.

We have studied the reflection characteristics for the first wall materials such as W, Mo, Carbon and V-alloys [1, 2, 3]. In this study we report the results of the measurements of the reflected particles from carbon systems, carbon nanotube (CNT), carbon nanowall (CNW), graphite sheet (Nilaco) and highly-oriented pyro-graphite (HOPG). Figure 1 shows the reflected H^+ ion intensity as a function of the reflected angles b and the time-dependence of the intensity, when 1 keV H^+ beam is injected. We found the clear difference between the vertically- and horizontally-oriented systems: the reflected particle intensity of the CNT and CNW shows sharp peak, while that of carbon sheet and HOPG are much broader, indicating structure effect. It is noted that we synthesized samples of CNT and CNW as vertically-oriented structure system. On the other hand, commercially-available graphite sheet and HOPG are known to be horizontally-oriented systems. The energies of reflected ions decrease monotonously with b and the structure effect seems to be small. These phenomena are very similar for both of reflected positive and negative ions. We also observe time-dependent behavior of the reflected ions: the intensity and the energy of the reflected particles drastically decrease with time. The intensities of the reflected particles were partly recovered by baking the sample, indicating the retention of the injected particles. Figure 2 shows the comparison of the angle-dependence of the reflected ion intensity with the ACAT simulation. Even if we assume the fractal dimension, we cannot reproduce the experimental results well.

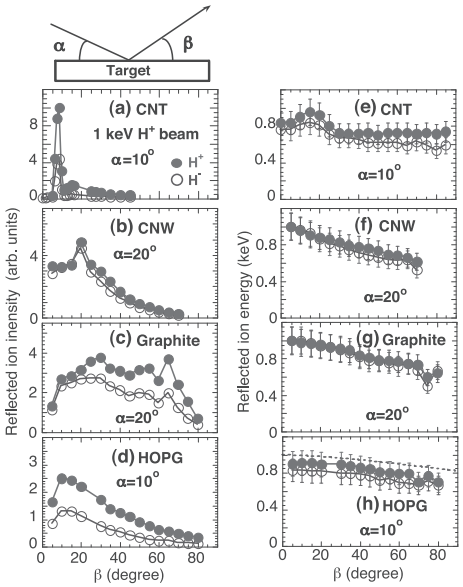

Fig. 1: Characteristics of the reflected H^+ ions intensity as a function of the reflected angle and time-dependence of the intensity for 1 keV H^+ beam injection on CNT, CNW, graphite and HOPG targets with the definition of incident (α) and reflected (β) angles.

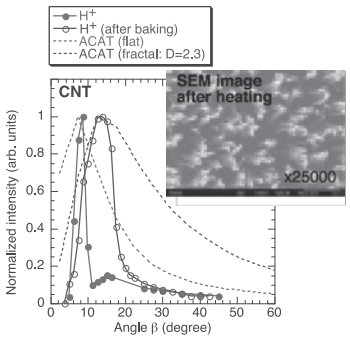

Fig. 2: Characteristics of the reflected H^+ ions for 1 keV H^+ beam injection on CNT target (solid lines). Results of the ACAT simulation are also shown (dashed lines). SEM image after the baking is also shown.

1) M. Wada *et al.*, *Rev. Sci. Instrum.* **73** (2008) 955.

2) H. Yamaoka *et al.*, *J. Nucl. Mater.* **337-339** (2008) 942; *Rev. Sci. Instrum.* **77** (2006) 03C301; *J. Nucl Mater.* **363-365** (2007) 1304; *Rev. Sci. Instrum.* **79**, 02C701 (2008).

3) N. Tanaka *et al.*, *J. Nucl. Mater.* **390-391** (2009) 1035.