§43. Kinetic and Potential Energy of Excited Atoms and Molecules on Wall Surfaces Bombarded with Light Ions

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It has already been known that the excited atoms and molecules generated at the wall surface would seriously affect to the edge plasma[1]. However, the number of the articles which reported the kinetics of the excited species is very scarce. This fact makes it difficult to build any proper models about fundamental atomic and molecular processes. Sputtering and backscattering processes induced by ion bombardment on the wall surfaces are especially important because of the efficient energy transfer between nuclear stopping and electronic excitation[2]. Further, adsorption and desorption of chemically active species or radicals make the processes be more complicated.[3]. The objective of this study is to investigate the kinetics of the excited atoms by observing light emission on the solid surfaces under irradiation of keV energy ion beam.

The experiment was carried out by using an ion-beam line in National Institute for the Fusion Science. Fig. 1 shows a schematic illustration of the experimental apparatus. Prior to the experiment of some light ion irradiation, we observed the light emission on a polycrystalline tungsten surface under irradiation of Kr^+ ions. After analyzing the mass to charge ratio by a sector magnet, the Kr^+ ion beam extracted from a Freeman-type ion source was introduced into the collision chamber through a collimation hole with 5mm diameter. The ion beam entered in direction normal to a polycrystalline tungsten surface which was set on a linear-motion feed-through. Light emission was observed by a visible spectrometer through an UV condenser lens which was set in right angle with respect to the ion beam axis. Each photon signal was detected by a photo-multiplier tube in the single-photon counting mode. The current and energy of the ion beam were 30~60 μA and 33 keV, respectively. The pressure of the chamber maintained below 7×10^{-5} Pa by a turbo molecular pump.

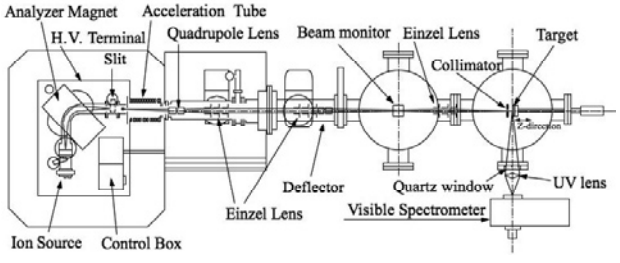

Fig. 1 A schematic illustration of the experimental apparatus

Fig. 2 shows the typical emission spectrum observed on the surface. Many atomic lines were successfully identified as WI, II 6p→6s and KrII 5p→5s transitions[4]. Note that almost no impurity was found in the wavelength range from 350 to 600 nm. Although we tried to introduce oxygen gas in the collision chamber, no marked change was observed. Rather high flux density of incoming Kr^+ ions (~ 10^{15} ions / (cm^2·s)) might prevent adsorption of oxygen atoms on the surface.

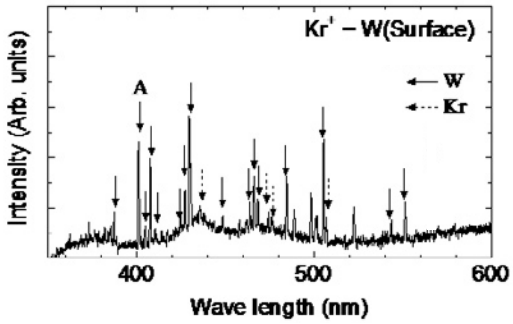

Fig. 2 Optical emission spectrum of sputtering W atoms and backscattering Kr^+ ions on a polycrystalline tungsten surface under irradiation of Kr^+ (33 keV) ions

The mean velocity of the sputtering atoms in direction parallel to the surface normal, or $\langle V_\perp \rangle$, can be obtained by measuring the line intensity as a function of distance Z from the surface[2] as shown in Fig. 3. The $\langle V_\perp \rangle$ of W atoms in the $5d^5(^6S)6p\ ^7P_4$ excited state, which corresponds to the upper level of the 400.88 nm line labeled "A" in Fig. 2, became ~6300 m/s[4] if we assume the lifetime is equal to 59.4 ns[5] of the isolated atom.

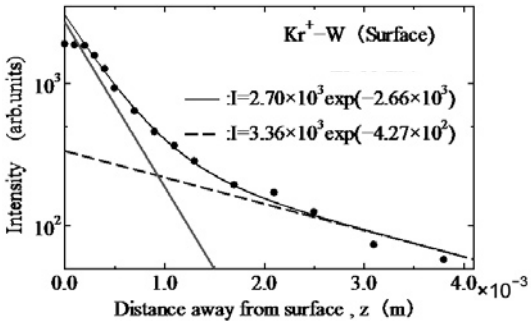

Fig. 3 Emission intensity of the peak "A" as a function of the distance from the surface[4]

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2) Suchanska, M., Prog. Surf. Sci., *54* (1997) 165.
3) Ghose, D., Brinkmann, U., and Hippler, R., Surf. Sci., *327* (1995) 53.
4) Nogami, K. *et al.*, The proceeding of SISS-13 (The International Symposium on SIMS and Related Techniques Based on Ion-Solid Interactions at Seikei University) submitted.
5) Den Hartog, E. A. *et.al.*, J. Opt. Soc. Am. **B4** (1987) 48.