(BL5B)

Measurements of Total Yields of Exciton-Induced Desorption from Argon Films Condensed on Solid Neon

Takashi Adachi, Takato Hirayama*, Ichiro Arakawa and Makoto Sakurai**

Department of Physics, Gakushuin University , Mejiro, Toshima, Tokyo 171-8588.
**Department of Physics, Rikkyo University , Nishi Ikebukuro, Toshima, Tokyo 171-0021.*
***Department of Physics, Kobe University, Rokkodai-cho, Nada-ku, Kobe 657-8501.*

1. Introduction

Electron or photon irradiation of the surface of rare gas solids produces the electronic excitations which can be followed by the desorption of various kinds of particles. Investigation of the desorption induced by electronic transitions (DIET) will reveal the dynamics of the electronic excitations and relaxations in solid and, especially, at the surface. DIET at the surface of rare gas solids has been extensively studied since 1980s [1]. We have reported the results of measurements of absolute photo-desorption yields from the surface of solid Ne [2], Ar [3, 4] and Kr [5] at excitonic excitation regime. At a film, which is thicker than 400 atomic layers, condensed on a metal substrate, the absolute photo-desorption yields are about 1.5, 0.2, and 0.03 atoms/photon for Ne, Ar, and Kr, respectively, at the excitation energy of the first order bulk exciton. The quantitative analysis of the absolute desorption yields and the thickness dependence reveal relaxation channels from the primary excitonic excitation to the desorption. The desorption yield of Ne was quantitatively explained by the internal sputtering mechanism [2]. In the case of Ar [3, 4] and Kr [5], the dominant desorption mechanism is the excimer dissociation which is followed by collision cascade.

The diffusion of excitons and these behavior at the interface between a solid rare gas and a substrate are important process to be considered for the estimation of the desorption yields and these thickness dependence. In the previous works, we adopted the assumption that the excitonic excitation is quenched immediately when it reaches at the interface. In the present study, we measured the photo-desorption yields from Ar films condensed on the solid Ne. The behavior of the exciton at the interface between two different rare gas solids are investigated.

2. Experimental

Experiments have been carried out at the beam line BL5B in UVSOR of the Institute for Molecular Science, Okazaki. The experimental procedure and set-up have been described in detail elsewhere [5] and are briefly summarized here. A liquid helium cryostat was installed in an ultrahigh-vacuum chamber with a base pressure of 5×10^{-9} Pa. Neon gas was introduced into the main vacuum chamber and was condensed on the surface of a platinum substrate attached to the liquid helium cryostat. The temperature of the sample was kept at 6 K or lower during the experiments. The thickness of the solid Ne was about 200 atomic layers. Argon gas was introduced and condensed on the surface of the solid Ne. Ar films of various thickness up to 800 atomic layers were investigated. The film thickness was calculated from the exposure on the assumption that the condensation coefficient of each gas at 6K was unity.

The absolute desorption yield was calculated from the absolute values of the intensity of the incident photons and of the number of Ar atoms desorbed. The absolute number of the incident light was monitored by measuring a photoelectron current emitted from the gold mesh which was installed in the beam line. The absolute number of the desorbed atoms was calculated from the rise of partial pressure of Ar, which was measured by a quadrupole mass spectrometer, during the irradiation of the sample and the total pumping speed for Ar.

3. Results and Discussions

The dependence of the total photo-desorption yields of Ar on the incident wavelength is shown in Fig. 1 for three different film thicknesses. For the film of 3 atomic layers in thickness, clear peaks are observed at 103 nm and 101 nm, which corresponds to the excitation energy of the first order bulk excitons, B1(3/2) and B1 (1/2), of solid Ar, respectively. For the film of 150 atomic layers, an additional peak appear at the wavelengths corresponding to the second order bulk (B2, 91 nm (3/2)) exciton. For the 520 atomic layers film, the small shoulder at 106 nm and the peak at 96 nm are observed, which corresponds to the creation of the second order surface (S2) and the first order surface (S1) excitons, respectively. The spectrum at 520 atomic layers is almost identical to that of the thick Ar film which is solely and directly condensed on the metal substrate.

Figure 2 shows the thickness dependence of the absolute desorption yields at B1 exciton excitation energy for two different systems; the Ar film condensed on the solid Ne and that on the metal substrate. The difference of the desorption yields between them at the thickness less than 10 atomic layers is originated from the difference in the behavior of the exciton at the interface. In the case of Ar on metal, the exciton is immediately quenched when it reaches at the surface of the metal substrate. In thin films, therefore, it results in low desorption yields. On the other hand, in the case of the Ar film condensed on solid Ne, the interface of Ar/Ne plays as a reflector for B1 exciton of Ar because the excitation energy of B1 exciton can not be transferred to solid Ne. Consequently the high desorption yields are observed at thin Ar film condensed on solid Ne. The quantitative analysis of the absolute desorption yields are now in progress.

References

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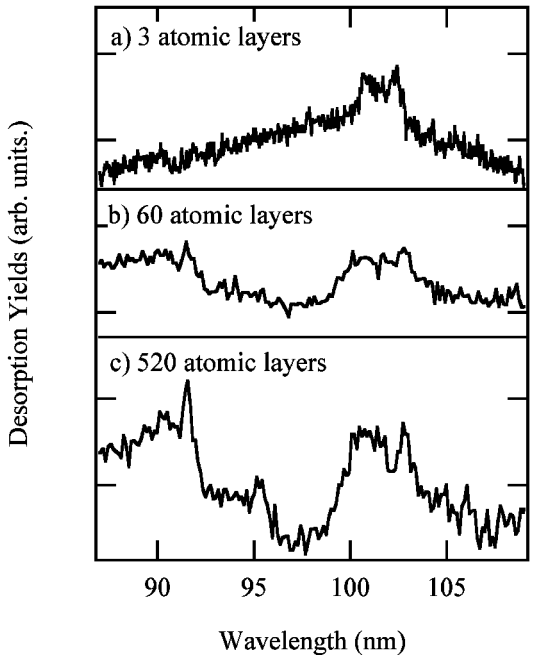

Fig. 1 Wavelength dependence of total desorption yields of Ar condensed on solid Ne.

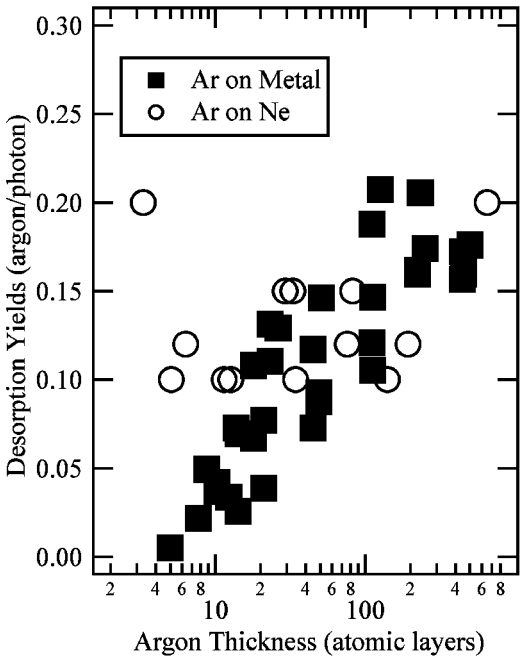

Fig. 2 Thickness dependence of absolute desorption yields at the excitation of B1 exciton.