ABSOLUTE MEASUREMENTS OF THE TOTAL YIELD OF ELECTRON STIMULATED DESORPTION OF NEON

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When the surface of rare-gas solid is irradiated by electrons, photons or ions, desorption of various kinds of particles (atoms and clusters in ground, electronically excited, and ionized states) occurs. The desorption process, where the kinetic energy of desorbed species is transferred from the electronic excitation energy, is called “desorption induced by electronic transitions (DIET)”, and has extensively been studied[1)]. Investigating these desorption phenomena will reveal the dynamics of the electronic excitations and the relaxation processes in the solid. In this report, we present the results of absolute measurements of the "total" yield of the electron stimulated desorption of Ne. The "total" means that we detected all the Ne particles desorbed, i.e., atoms and clusters in ground, electronically excited, and ionized states.

Two mechanisms of the excited atom desorption were proposed and have been confirmed experimentally. One is called "cavity ejection (CE)" mechanism which is valid for the solid has negative electron affinity, e.g. solid Ne and Ar. The CE process is due to the repulsive force between an excited particle with an expanded electronic orbit and surrounding ground state atoms. The excited particle is then pushed out from the surface if it is created on the surface. The other desorption process is called "excimer dissociation (ED)" mechanism. If the dissociation of excited dimer (excimer) occurs in the vicinity of the surface of rare gas solid, an energetic atom is created and can desorb from the surface. The kinetic energies of metastable atoms desorbed via CE and ED are 0.18eV and 1.4eV, respectively[2)].

The sample, a solid Ne film, was condensed on a copper plate at the temperature of 6K, which was attached to a liquid helium cryostat. The cryostat was installed in a ultra-high vacuum chamber with a base pressure of 2×10^{-8} Pa or lower. The thickness of the Ne film was estimated from the exposure assuming the condensation coefficient of Ne to be unity. The incident electron current was about 5×10^{-8} A. The absolute desorption yield was calculated from the pumping speed and the rise of the partial pressure of Ne during the irradiation of the sample. The partial pressure of Ne was measured by a quadrupole mass spectrometer calibrated with a Bayard -Alpert type ionization gauge.

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Figure 1 shows the thickness dependence of the absolute desorption yield. Incident electron energy is 120 eV. Desorption yields larger than 1 atoms/electron were observed at all the sample thickness studied. For thin films, excitons are indirectly produced by the secondary electrons from the copper substrate. Desorption yields of Ne enhance as the thickness increases up to 25 atomic layers.

In photon stimulated desorption (PSD) experiments, the total desorption yields of about 1 atoms/photon by the creation of bulk exciton, and about 2~4 atoms/photon by the ionization of Ne have been found[3]. Such a large desorption yield was explained by a mechanism that the excited atom which was created at the 2nd or 3rd layer under the surface can desorb by CE or ED mechanisms and blows up a number of the ground state atoms in the over layers because the cohesive energy of solid Ne is very small (0.019 eV). In the case of electron stimulated desorption, an electron with an energy of 120 eV can create a number of excitons and ions, all of which can contribute to the desorption. Shorter penetration depth for a 120eV electron (~3 ML) compared to that for a photon (>10ML) will further increase the desorption yields. It is not clear at present why the desorption yield decreases at the thickness of Ne films over 100 atomic layers.

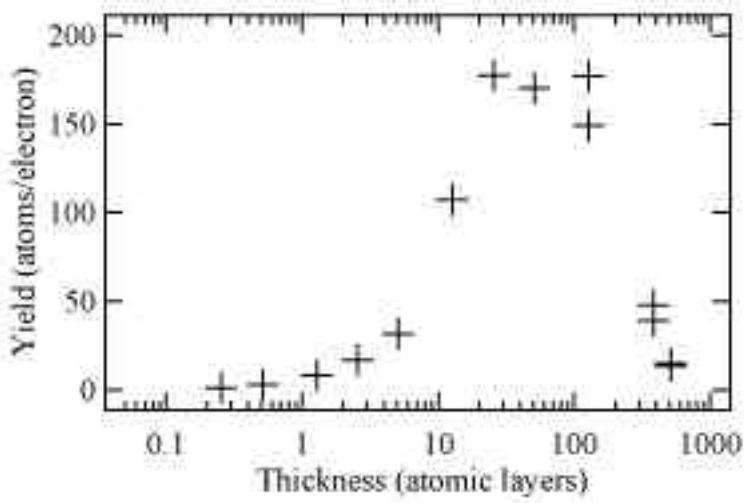

Fig.1 Total desorption yield of Ne by electron impact as a function of the thickness of Ne films. Electron incident energy is 120eV.

1) for recent review, see I.Arakawa, Molec. Crystal Liq. Crystal, **314**, 47 (1998), M.Runne and G.Zimmerer, Nucl. Instrum. Meth. Phys. Res. B **101**, 156 (1995).

2) T.Hirayama, A.Hayama, T.Koike, T.Kuninobu, I.Arakawa, K.Mitsuke, M.Sakurai, and E.V.Savchenko, Surf. Sci. **390**, 266 (1997).

3) I. Arakawa, T. Adachi, T.Hirayama and M.Sakurai, Surf. Sci., submitted.