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Development of a compact cylindrical mirror analyzer (CMA) and its application for H^+ kinetic energy distribution measurements of condensed ammonia (NH_3)

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Introduction

When a core-electron of a surface is excited, an ion may be desorbed by the following three step processes: 1) a core-electron transition (~0.1 fs), 2) an Auger transition leaving two valence holes (1~10 fs), 3) ion desorption due to hole-hole Coulomb repulsion and electron missing from valence orbitals (10~100 fs) (Auger stimulated ion desorption (ASID) mechanism). To clarify details of ASID mechanism measurements of ion kinetic energy (KE_{ion}) is required, because they provide information on the slope of potential energy curve. So we developed a compact cylindrical mirror analyzer (CMA) (Fig. 1).

Compact CMA

The CMA consists of a shield for electric field, inner and outer cylinders, a pinhole with a diameter of 2 mm and an electron multiplier (BURLE, 5901 MAGNUM). It is mounted on a conflat flange with a diameter of 70 mm with a positioning mechanism. The acceptance polar angles from the surface normal are 24-28°. The acceptance solid angle is 0.16 sr and the energy resolution (FWHM) is estimated as E/æE = 20.

Results and Discussion

Figure 2 shows the KE_{ion} distributions for condensed ammonia (NH_3) at h3 = 412.5 eV corresponding to N 1s ionization, at h3 = 400.7 eV corresponding to the $4a_1$ Ŷ N 1s resonant transition of surface NH_3 and at h3 = 397.6 eV below the N K-edge. At N 1s ionization the KE_{ion} distribution (Fig. 2a) show a broad peak at 6.3 eV and the width is broad. The result supports the ASID mechanism at N 1s ionization. On the other hand, at the $4a_1$ Ŷ N 1s resonance the KE_{ion} distribution (Fig. 2b) displays a relatively narrow peak at 3.1 eV. For the H^+ desorption the following four-step mechanism is proposed: (1) $4a_1$ Ŷ N 1s transition, (2) extension of the HN-H_2 distance in the $(N\ 1s)^{-1}(4a_1)^1$ state within the lifetime of N 1s hole (ultrafast extension), (3) a spectator Auger transition leading to a two-hole state with an excited electron in the $4a_1$ orbital, and (4) H^+ desorption [1]. In this mechanism a narrow kinetic energy distribution is expected because H^+ desorption is mainly driven by the common $(N\ 1s)^{-1}(4a_1)^1$ potential energy surface.

References

[1] M. Nagasono, K. Mase, S. Tanaka, and T. Urisu, Surf. Sci. 390 (1997) 102.

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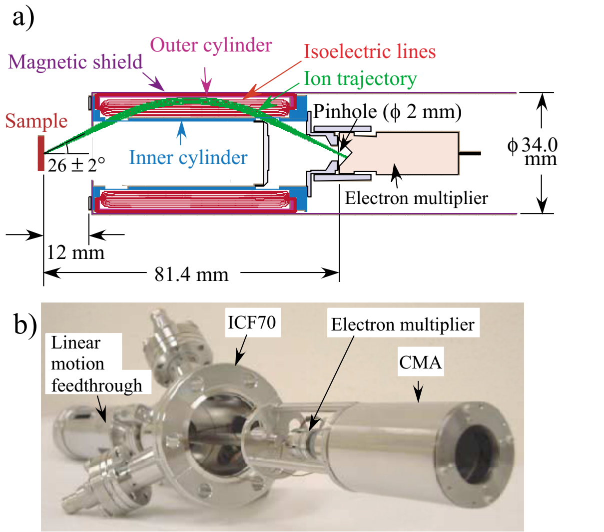

Fig. 1. a) Cross section of the miniature CMA analyzer. The trajectories of ions from a pointed source for polar angles of 24°~28° with 1° step are shown based on the simulation with the SIMION 3D version 7.0. b) Photograph of the miniature CMA analyzer.

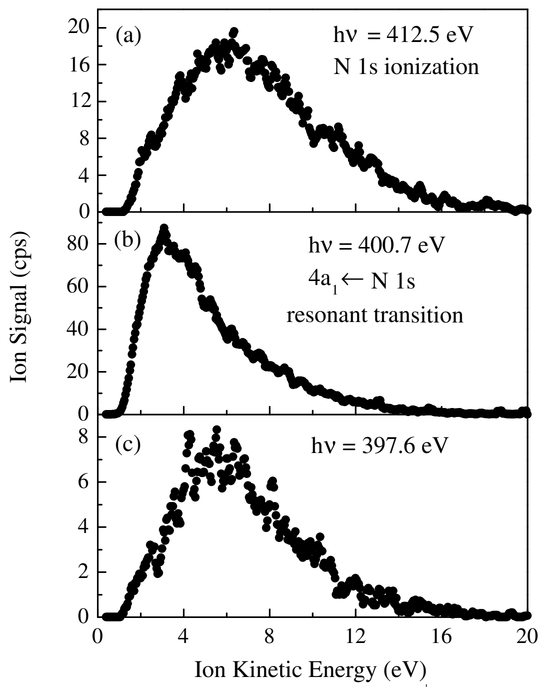

Fig. 2. Kinetic energy distributions of H^+ desorbed from condensed NH_3 at a) h3 = 400.7, b) 412.5 and c) 397.6 eV.