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Construction and evaluation of an electron-ion coincidence apparatus using a large transmission coaxially symmetric mirror electron energy analyzer

Kouji ISARI[1], Eiichi KOBAYASHI[2], Kazuhiko MASE[*3], Kenichiro TANAKA[4]

[1]Research Center for Nanodevices and Systems, Hiroshima Univ., Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8527, JAPAN

[2]AIST, Higashi, Tsukuba, Ibaraki 305-8565, Japan

[3]KEK-PF, Oho, Tsukuba, Ibaraki 305-0801, Japan

[4]Department of Physical Science, Hiroshima Univ., Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526, Japan

Introduction

When a surface is irradiated by electrons or X-rays, ions are known to be desorbed by following three-step processes, that is, (1) a core-electron transition leaving a core hole (~0.1 fs), (2) an Auger transition leaving multiple valence holes (1~10 fs), and (3) decay of the multi-hole state, causing ion desorption (10~100 fs) (Auger stimulated ion desorption (ASID) mechanism) [1, 2]. To clarify details of ASID mechanism measurements of ion desorption yield for the selected core-excitation-final-states or the selected Auger-final-states are required. For this reason we have developed electron-ion coincidence (EICO) apparatus using a cylindrical mirror electron energy analyzer (CMA) [3-5] and investigated details of ASID mechanisms so far [4, 5]. The performance, however, was limited by the CMA (solid angle ≤ 1.1 sr and $E/\Delta E \le 100$) [5]. To improve this we have developed a new EICO apparatus using a coaxially symmetric mirror electron energy analyzer with a large transmission originally proposed by K. Siegbahn et al. [6].

New EICO apparatus

Figure 1 shows a photograph of the EICO analyzer, which consists of a coaxially symmetric mirror electron energy analyzer, a compact time-of-flight ion mass spectrometer, and a positioning mechanism. The electron energy analyzer consists of inner and outer electrodes, three sets of compensation electrodes, a slit with a diameter of 0.8 mm, micro channel plates (MCP), and a magnetic shield [7]. Compensation electrodes are used to suppress the disturbance of the electric field near the end plates. The designed resolution and the solid angle are estimated as $E/\Delta E$ = 300 and 1.2 sr, respectively. Without the compensation electrodes, the electric field near the end plates is seriously disturbed. In this case a simulation showed that the electron energy resolution and the collection solid angle are degraded to $E/\Delta E$ = 50 and 0.3 sr, respectively [7].

The performance of the new EICO analyzer was evaluated at the PF-8A. The spot size of the synchrotron radiation was about 2 mm x 1 mm on a clean Si (111) surface. We measured a Si 2p photoelectron spectrum at hν = 269 eV, and based on the curve fitting by a Voigt function of the Si 2p peak we estimated the actual resolution as $E/\Delta E$ = 120. The value is better by a factor of about 1.5 than that for the previous EICO analyzer using a CMA. We measured Auger electron photoion coincidence (AEPICO) spectra of H_2O condensed at 100 K for $4a_1 \leftarrow$O 1s resonance at hν = 533.6 eV. The Signal to background ratio is much better than that obtained with the previous EICO apparatus [5]. In order to evaluate the performance of the EICO apparatus, we introduced the following standard independent of the photon intensity, that is

(Coincidence ion counts [cps])/(photoion counts [cps])

The value for the new EICO apparatus is one order of magnitude better than that for the previous one. Hence, the measurement time required for a certain coincidence ion counts is reduced by one order of magnitude.

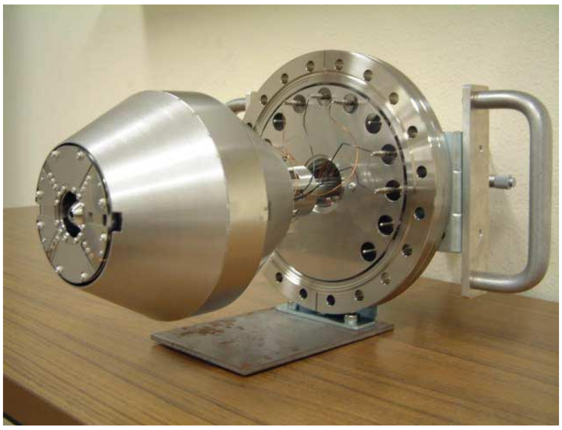

Figure 1 A photograph of the new EICO analyzer.

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* mase@post.kek.jp