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Surface chemical imaging of energy filtered photoemission electron microscopy (EXPEEM)

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Introduction

Surface chemical imaging is one of the important techniques to investigate the surface chemical processes. We can successfully obtain chemical surface imaging of of Au islands on a Ta sheet by means of energy-filtered photoemission electron microscopy (EXPEEM).

Experimental

Figure 1 is a sketch of the EXPEEM system used in this study. The sample is biased at –10 kV against the objective lens which is grounded. The accelerated photoelectrons go through the objective lens, intermediate lens and then arrive at the Wien filter. In the Wien filter, magnetic field and electric field are perpendicularly applied. Thus only the electrons satisfying the $\vec{E} = \vec{v} \times \vec{B}$ travel straightly through the Wien filter and give the surface images. By choosing kinetic energies characteristic to the elements, the image reflects their distribution.

The Au was evaporated in vacuum on the Ta sheet through the Ni mesh with 10 m square opening in a 25 m period. The thickness of the Au islands are 1 μm.

EXPEEM instrument was installed at BL11B and the X-ray energy was fixed at 2300 eV which was just above the Au M_4 edge.

Results and discussion

Fig.2 shows the EXPEEM image of Au islands on the Ta sheet using electrons with various kinetic energies. Fig.2a is the image with the secondary electrons with kinetic energy = 0eV. Because the X-ray energy is just above the Au M_4 edge, the Au islands are brighter than the Ta substrate. When the higher kinetic energies of photoelectrons are selected to pass the Wien filter, the brightness of the image decreased a lot because the decrease of the amount of secondary electrons. Fig. 2b shows the image using electrons with kinetic energies of 60 eV which was just below the Au $3d_{5/2}$ photoelectron peaks. Au gives the brighter image due to the inelastic electrons of Au 3d photoelectron peak. Fig.2c is the image of electrons with the kinetic energy at 102 eV just at the energies of Ta 3p photoelectrons where we had a brighter Ta image. Spatial resolution was 2 m and energy resolution was 15 eV. Fig. 2d shows the image of electrons with their kinetic energies at 112 eV. The contrast became worse and Au islands were hardly identified. Thus the image contrast shown in Fig.2c reflected the $Ta_{3/2}$ photoelectron kinetic energies and element distribution. As far as we know this is the first surface chemical photoelectron imaging using a high energy X-ay with a spatial resolution of 2 m.

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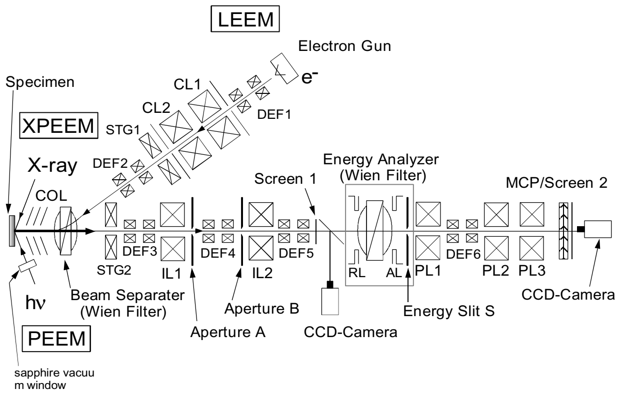

Figure 1. Sketch of the EXPEEM system with a retarding Wien-filter.

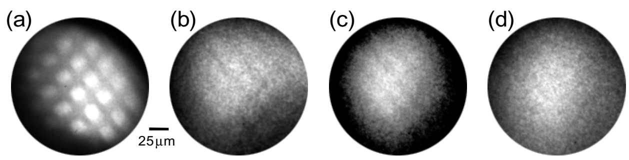

Figure 2. Energy-filtered XPEEM images of Au on Ta substrate. Kinetic energy =0 eV(a), 60 eV(b),102 eV (c) and 112 eV(d). The photon energy was 2300 eV. The photoelectron energy of (c) corresponds to Ta $3p_{3/2}$.