

Further Development of EXPEEM System and its Application to Au on TaOx

Tetsuya TSUTSUMI¹, Takahiro KAWASAKI¹, Nobuaki MATSUDAIRA¹, Hironobu NIIMI¹, Shushi SUZUKI¹, Wang-Jae CHUN^{1,2}, Kiyotaka ASAKURA^{1*}, Yoshinori KITAJIMA³ and Yasuhiro IWASAWA⁴

¹Catalysis Research Center, Hokkaido University and ²CREST JST, Kita-ku, Sapporo 060-0811, Japan

³KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

⁴ Department of Chemistry, The University of Tokyo, Hongo, Tokyo 113-0033, Japan..

Introduction

It is quite important to obtain the surface real time chemical imaging in order to understand the chemical processes accompanying the diffusion and reaction between different phases. EXPEEM (Energy-filtered Photoemission Electron Microscopy) is a new spectromicroscopy which can visualize the surface chemical state and element distributions by selecting the kinetic energies of photoelectrons. Especially oxygen diffusion is important for partial oxidation reactions. Previously we reported the first EXPEEM image obtained by a Wien filter energy analyzer using a high energy X-ray emitted from a bending magnet.[1] Here we will report the EXPEEM results of O 1s images for Au islands deposited on a Ta substrate using an undulator beam line.

Experimental

The details of EXPEEM instrument are described elsewhere.[1,2] In this work we used the 5th order higher harmonics emitted from an undulator at BL2A. The X-ray was monochromatized by a Ge(111) double crystal monochromator. The ejected photoelectrons were collected by a cathode objective lens and filtered by a Wien filter. In order to decrease the spherical aberrations we put an angle limiting aperture with a 25 μm opening. In addition, a narrower energy selecting slit than reported before[1] was used after the Wien filter to get a higher energy resolution ($\Delta E=3$ eV).

Results and discussion

Fig. 1 shows the Au on TaOx EXPEEM images. In the previous studies we measured Ta 3p_{3/2} peak for the imaging of Ta. But the large background hinders the well-contrasted picture of Ta regions.[1,2] We tried to observe the Ta 3d_{5/2} peak which had a kinetic energy 400 eV higher than the Ta 3p_{3/2}. Because the lens conditions are adjusted for the secondary electrons with their Kinetic energy nearly 0 eV, they will be satisfied much better for the electrons with not so high energy. Thus it was expected that the observation of Ta image using Ta3d_{5/2} would be extremely difficult. In spite of this expectation, we could successfully observe the Ta region using Ta3d_{5/2} peak only by changing sample bias. Fig.1 shows the EXPEEM picture. Fig.1 (a) is the image obtained by the

secondary electrons. Fig.1 (b) and (c) are the image using Au 3d_{3/2} peak and Ta 3p_{3/2}, respectively. Although the clear Au domain appeared in Fig.1(b), yet the contrast was not so good in Fig.1(c) as reported in the previous one. Fig.1(d) shows a picture of the EXPEEM image using Ta 3d_{5/2} photoelectrons. Dark Au and bright Ta regions appear with good contrast, indicating that the EXPEEM image can be obtained for higher kinetic energy if the optical axis is well adjusted by changing the sample bias. Our final goal is to observe the oxygen diffusion. We tried to obtain the EXPEEM image of oxygen which should have about kinetic energy as large as 1800 eV. Fig.2 shows the EXPEEM image using O 1s photoelectrons and 5 eV above the O 1s peak. In both pictures, Au appeared brighter but the Ta region became brighter on Fig.2a. This is due to the photoemission of O 1s photoelectron. Contrast is not yet satisfactory but the result indicates that there is possibility to visualize O 1s peak after the fine adjustment of optics and lens conditions.

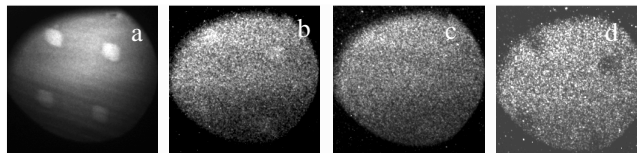


Fig.1 EXPEEM pictures of (a)secondary electron (b)Au 3d_{3/2} (c) Ta 3p_{3/2} (d) Ta 3d_{5/2}

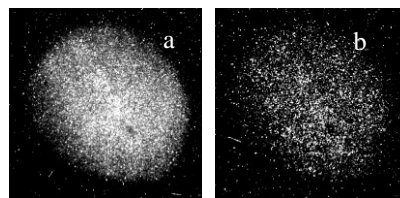


Fig.2 O 1s EXPEEM images of Au on TaOx (a)O 1s photoelectron was selected. (b) photoelectrons 5 eV above the O 1s was selected.

References

- [1] H. Yasufuku, *et al.*, Chemistry Letters, 842 (2002).
- [2] Tsutsumi, *et al.*, PF activity report. **20**, 70 (2003).

*askr@cat.hokudai.ac.jp