

Preparative study of XANAM surface chemical mapping

Shushi SUZUKI*^{1,4}, Motohiro NAKAMURA², Kumiko KINOSHITA², Yuichiro KOIKE³, Keisuke FUJIKAWA², Wang Jae CHUN^{1,4}, Masaharu NOMURA³, and Kiyotaka ASAKURA¹

¹Catalysis Research Center, Hokkaido University, Sapporo 001-0021, Japan

²Graduate School of Engineering, Hokkaido University, Sapporo 060-8628, Japan

³KEK-PF, Tsukuba 305-0801, Japan

⁴CREST-JST, Kawaguchi 332-0012, Japan

Introduction

Nanoscale elemental analysis is a fundamental issue. Many approaches have been actively pursued in the field of scanning tunnelling microscopy (STM) and noncontact atomic force microscopy (NC-AFM), although it is still difficult to obtain a chemical mapping directly. We previously proposed a new approach aiming at this purpose [1-3]. We named the methodology as "X-ray Aided Non-contact Atomic force Microscopy (XANAM)". In this report, we demonstrated that the latest results on preparative studies for chemical and elemental mapping by means of XANAM: a point spectroscopy and 2D spectroscopic imaging on a Au deposited Si substrate.

Experimental

The experiments were performed with an UHV NC-AFM chamber equipped with 4 axes remote control movement system to the X-ray beam direction. Piezo-thin film AFM cantilevers (NIKON) with resonance frequency of 100~115 kHz were used. We used a SPM controller produced by Nanonis. A Au-covered Si wafer sample was prepared by vacuum evaporation.

Results and Discussions

We found a significant response in the cantilever deflection to the X-ray energy at the absorption edge of the observed elements as shown in the previous papers [1-2], which means the cantilever can distinguish the elements directly with the aid of X-ray beam. In this paper, we have improved the S/N ratio by replacing the electronic measurement systems and observed a clearer peak appearing at the edge position as shown in Fig. 1(a). An important feature of the signal is that it does not follow the absorption spectrum of a surface element. At the same time we also find the gradual background change around the absorption edge. Furthermore, we have succeeded a 2D spectroscopic imaging for surface chemical mapping. Tentative results on 2D spectroscopic imaging on the Au surface, which reveals also clear X-ray induces Z response at each scan at the X-ray energy above the Au L₃ absorption edge as shown in Fig. 2.

We proposed a XANAM mechanism [1] as follows; The change of interaction is induced by the change of electron density in the chemical bonding between a cantilever tip and a sample surface, which is caused by the electron transition from the core level to the bonding orbital. The appearance of the clear peak supports the

above proposal. In addition the gradual change suggests the presence of other type of interaction such as charging and/or thermal effect that may follow the absorption spectrum.

This work was supported by a CREST grant from JST, a Grant-in-Aid for Scientific Research for young scientist promotion from the JSPS and an Industrial Technology Research and Development Projects grant from the NEDO.

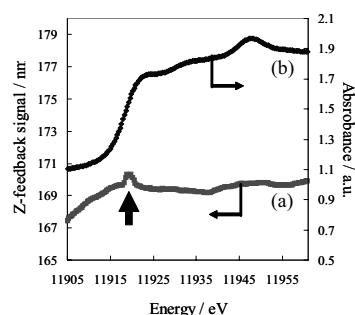


Fig. 1 (a) A spectrum of Z feedback signal dependence on X-ray energy on the Au surface. $f_0=114.8$ kHz, $\Delta f=-1$ Hz $A=2.9$ nm (b) An absorption spectrum of a Au foil.

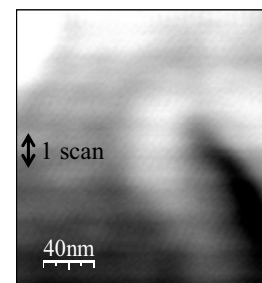


Fig. 2 NC-AFM image of Au deposited surface under X-ray energy scan, 200×200 nm², $f_0=101.7$ kHz, $\Delta f=-5$ Hz $A=1.0$ nm

References

- [1] S. Suzuki, Y. Koike, K. Fujikawa, W.-J. Chun, M. Nomura, and K. Asakura, Chem.Lett. 33, 636-637 (2004).
- [2] S. Suzuki, Y. Koike, K. Fujikawa, N. Matsudaira, M. Nakamura, W.-J. Chun, M. Nomura, and K. Asakura, Catal. Today 117, 80 (2006).
- [3] S. Suzuki, M. Nakamura, K. Kinoshita, Y. Koike, K. Fujikawa, N. Matsudaira, W.-J. Chun, M. Nomura, and K. Asakura, J. Phys. in press.

*szk@cat.hokudai.ac.jp