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A Challenge to XANAM- a New Nanoscale Chemical Mapping Microscopy

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Introduction

Since the invention of the scanning probe microscopy, atomic-level spatial resolution of conductive and insulating material surfaces has been achieved. Recently many efforts have been done to obtain chemical information by developing techniques based on these microscopes. However, it is still difficult to obtain a chemical mapping directly. In this study, we reported a novel phenomenon, which will be a basic concept for a new elemental analysis at the atomic level based on the non-contact atomic force microscopy (NC-AFM).

Recent investigations on the NC-AFM imaging mechanism show that the forces between a cantilever and a surface atom are not only physical forces such as van der Waals force and electrostatic force but also chemical bonding force, which may depend on the electron density of bonding and anti-bonding orbitals. If the electron density of these orbitals can be controlled by X-ray excitation of core level electron, one may control the interaction between the surface atom and the cantilever. The core electron has a binding energy specific to elements and their chemical state. Thus one can get a chemical mapping using the NC-AFM aided by X-ray irradiation. We named the methodology as ”X-ray Aided Non-contact Atomic force Microscopy (XANAM)”.[1] We have demonstrated X-ray could affect the force between the surface and the AFM tip apex at the X-ray absorption edge. In this paper we report the reproducibility of this phenomenon.

Experimental

The experiments were performed with an UHV NC-AFM chamber, which is equipped with 4 axes remote movable system from outside of the X-ray beam hatch. A piezo-thin film AFM cantilever (NIKON) was used with a typical resonance frequency of 88 kHz. A partially Au-covered sample was prepared by vacuum evaporation of Au on a Si substrate through a 1000 L Ni mesh put on the substrate. After NC-AFM observations of the sample surface, we put the cantilever above the Au island, and stopped the scan feedback routine of the cantilever. Frequency shift as a function of X-ray energy around the Au L_3 absorption edge was measured. The frequency shift signal was normalized by incident X-ray intensity. For comparison, we carried out the same experiment on the bare Si surface in the same energy range.

Results and Discussions

Figure 1(a) and 1(b) show a series of frequency dependency spectra on the X-ray energy near the Au L_3 absorption edge energy above the Au islands and the bare Si regions, respectively. Consequently, we only found a sudden frequency shift of the NC-AFM cantilever just above the Au L_3 X-ray absorption edge, as shown in Fig. 1. Although the detailed mechanism and physics are unclear at the moment, the phenomenon suggested that NC-AFM could distinguish Au from Si under the X-ray irradiation tuned at the absorption edge energy. Although we found the phenomena occurred repeatedly, their signal change was very small and was often interfered by accidental noises in the experimental halls.

We are improving signal-to-noise ratio in the frequency dependency spectra on the X-ray energy for more precise measurements by replacing a preamplifier and a feedback instrument and after the long shutdown of Photon Factory in 2005 spring we will get the nanoscale chemical image and establish the XANAM.

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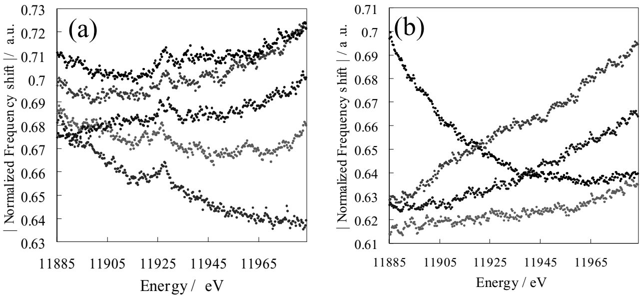

Figure 1 Frequency shift spectra normalized by I_0 on both Au (a) and Si (b) regions with X-ray scanning around the Au L_3 absorption edge region.

References

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