

Improvement of XANAM apparatus for chemical mapping

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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 report a novel phenomenon, which will provide 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 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 improvement of this apparatus for more reproducible and higher signal to noise (S/N) ratio measurements.

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. A piezo-thin film AFM cantilever (NIKON) was used with a typical resonance frequency of 114.8 kHz. We replaced our original SPM controller with that produced by Nanonis. A Au-covered Si wafer sample was prepared by vacuum evaporation. After NC-AFM observations of the sample surface, we fixed the cantilever with keeping the cantilever-sample interaction force constant. The distance Z as a function of X-ray energy around the Au L₃ absorption edge was measured.

Results and Discussions

By improvement of scan control system, we have obtained clearer Z distance dependency spectra on the X-ray energy than the previous data, as shown in Fig. 1(a). Figure 1(b) is a Au adsorption spectrum of a Au foil measured separately. Consequently, we found a peak (indicated by an arrow) in Z variation at the Au L₃ adsorption edge energy, which reproduced our previous result [1]. But the S/N ratio is much improved. We think the XANAM system has high enough to observe the nanoscale chemical image on the surface. We are planning to try making chemical map on a sample surface with mixed elements.

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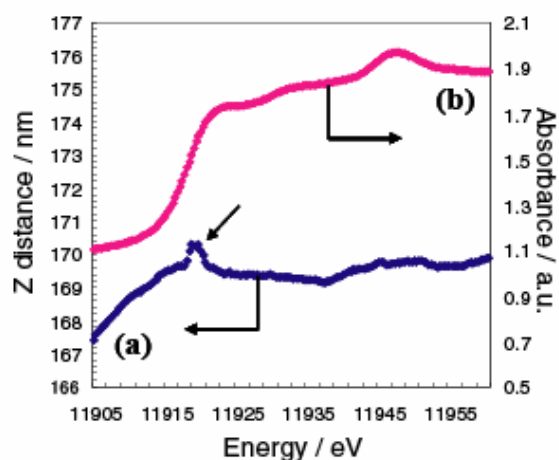


Fig. 1 Z distance signal recorded as a function of X-ray energy around the Au L₃ absorption edge (a), X-ray absorption spectrum of Au foil (b).

References

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