7C/2003G301

A Deflection Spectrum Peak of NC-AFM Cantilever at the Au L_3 Edge Energy

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Introduction

Many efforts have been done to obtain chemical information by developing techniques of SPM family[1]-[5]. However, it is still difficult to obtain a chemical map directly by STM and NC-AFM. In this study, we report a novel phenomenon that will be a base for a new elemental analysis at the atomic level by SPM, named ”X-ray Aided Non-contact Atomic force Microscopy (XANAM)”. 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. To test the above hypothesis, we carried out a simple experiment to see how the frequency shift depends on X-ray energies near the absorption edge, using a partial Au-deposited Si substrate sample.

Experimental

The experiments were performed with UHV NC-AFM chamber, which is equipped with. 4 axes remote movable system from outside of the X-ray beam hatch. A piezoresistive AFM cantilever was used with a typical resonance frequency of 88 kHz. After a NC-AFM image was aquired, 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 mesured. 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 shows an typical NC-AFM image of partial Au deposited Si surface. After a NC-AFM image was aquired, we put the cantilever above the Au island, as shown in Fig. 1 by a square, and stopped the scan feedback routine of the cantilever.

Consequently, we only found a sudden frequency shift of the NC-AFM cantilever just above the Au L_3 X-ray absorption edge in the normalized frequency shift spectra, as shown in Fig. 3. 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. We are planning to measure element selected NC-AFM image by this system soon. 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. This phenomenon will lead to a new nano-level element selected imaging method aided by X-ray called as XANAM.

This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) and the Japan Science and Technology Corporation (JST).

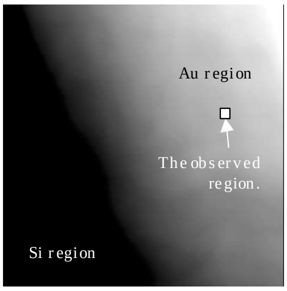

Figure 1: NC-AFM image of partial Au deposited Si surface, 3.5x3.5 μm^2, Δf = -20 Hz, A_0=27 nm.

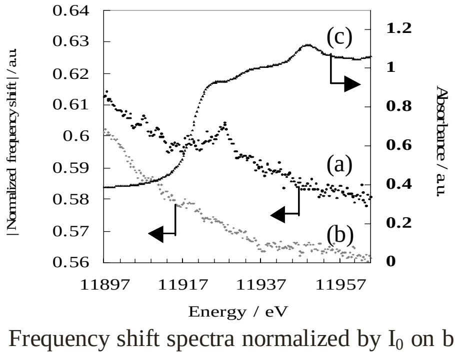

Figure 2: Frequency shift spectra normalized by I_0 on both Au (a) and Si (b) regions together with absorption spectrum of Au foil (c).

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