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Electrostatic force Cancelation in the XANAM measurement

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Introduction

STM and NC-AFM can provide atomic-scale information of surface structures. However, they could not give the elemental information directly. Previously, we have proposed the X-ray aided noncontact atomic force microscopy (XANAM), a new SPM technique for chemical analysis in combination with Synchrotron X-ray. We found interaction between X-rays and the attractive force in NC-AFM measurements on Au [1-3] as two characteristic features; one is a peak occurred near the absorption edge energy of sample's element, and another is a gradual change across the absorption edge energy. We expect that the former is useful for nano-chemical analysis and have examined to optimize measurement condition. Here we additionally found the appropriate condition to measure the former phenomenon by adjusting sample bias (Vs) even in the case of a Ni deposited Si sample.

Experimental

The experiments were performed with a home-made XANAM system which is composed of UHV NC-AFM and a 4 axes sample-AFM-tip stage to adjust the sample position relative to the X-ray beam. Piezo-thin film AFM cantilevers (NIKON) with resonance frequency of 90~100 kHz were used, which were then controlled by a SPM controller produced by Nanonis. We used Ni covered Si wafer samples were prepared by the vacuum evaporation of Ni.

Results and Discussions

Figure 1 shows Z-feedback signal (Z_f) measured in the constant frequency shift mode as a function of Vs at two constant X-ray energies, which are ±50 eV lower and higher energies than the Ni K absorption edge of 8333 eV. The curves show parabolic shape like contact potential difference (CPD) without X-ray irradiation, however Vs at parabolic minima are shifted to the value around +9 V. The shift is caused by electrostatic charging effect induced by X-ray irradiation. Interestingly, $|dZ_f/dVs|$ at the low X-ray energy is larger than the one at the high X-ray energy. At any event, the two curves are asymptotically close near their parabolic minima, which means we can decrease the magnitude of electrostatic charge effect by choosing Vs at the parabolic minimum. Figure 2 shows Z_f with scanning X-ray energy around the Ni K absorption edge at two Vs; One is at +5.0 V and another is at +9.8 V of the parabolic minimum. Peaks (arrowed in Fig. 2) are observed near the absorption edge in the both, but the peak for +9.8 V was clearer than the one for +5.0 V by setting at the parabolic minimum. We consider that the peak is originated from a short-range force as was suggested [1-3]. Finding minimum is important to observe the peak particularly for XANAM imaging.

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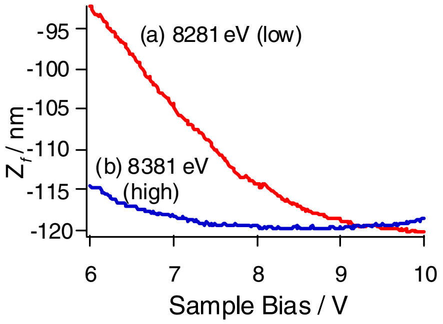

Fig. 1 (a) Z feedback signal vs Vs at X-ray energy of 8281 eV, and (b) 8381 eV.

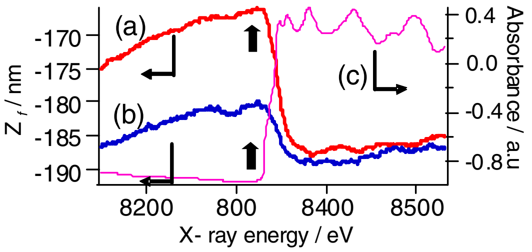

Fig. 2 (a) Z feedback signal vs X-ray energy at Vs of +5.0 V, (b) Vs of +9.8 V, and (c) Ni K absorption spectrum.

References

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