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Introduction of qPlus sensor type cantilever for XANAM measurements

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In recently, noncontact atomic force microscopy (NC-AFM) could provide extended-information about molecular images related to chemical bonding order [1]. However, elemental analysis even by the technique is still a difficult remained-issue. We proposed the X-ray aided noncontact atomic force microscopy (XANAM) previously, 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 [2-4] as two characteristic features; one is a peak occurred near the absorption edge energy of sample's element only, and another is a gradual change across the absorption edge energy. We expect that the former is useful for nano-chemical analysis and imaging as our final goal, because the former one is more sensitive to the absorption edge energy. In addition, we currently consider that the former should be strongly related to the chemical interaction. However, our AFM instrument equipped a cantilever of a piezo-thin film type, which was not easy to high resolution measurements of XANAM. Thus, we adopted a qPlus sensor type cantilever as a new force detection system to improve signal to noise ratio and stability of measurements, for detecting the former force component preferentially. The qPlus sensor is made from quartz tuning fork which is normally used as a high quality factor resonator of a stable frequency reference in a wrist watch. Previously, Giessibl reported first that the qPlus sensor could be applied to NC-AFM measurement as a cantilever with attaching a tiny sharpened metal wire tip like a STM tip, which provided a highly resolved NC-AFM image of Si(111)-(7x7) at the atomic level[5]. Here, we fabricated a home made the qPlus sensor, and examined its performance for the XANAM measurement. In this case, we have succeeded to measure the current signal between the tip and the sample induced by X-ray irradiation as well as the deflection signal of the sensor.

The experiments were performed at BL-7C of the Photon Factory, High Energy Accelerator Organization (KEK- PF). A noncontact atomic force microscope was operated in a home-build ultrahigh vacuum (UHV) chamber. Two X-ray beryllium windows for X-ray entrance and exit were placed at the front and the back sides of the UHV chamber, respectively. The microscope stage had four kinds of freedom to set the sample surface on the X-ray beam pass. Au-covered Si substrates were used as samples. A home-build qplus sensor was used as a cantilever on which an electrochemically-etched W tip was attached by glue. X-ray energy dependencies of force parameters and current conductivity were measured simultaneously. All the data were recorded by Nanonis scanning probe microscopy (SPM) controller combined with X-ray experimental setup at the beam line.

We carried out simultaneous measurements of dependency of electric current on the tip-surface distance between a W-tip and a gold film, as well as for frequency shift (deflection corresponded to force) of the qplus sensor (Fig. 1). These measurements were conducted under X-ray irradiation with various energy ranges. The current signal was increased with the X-ray incident energy and frequency shift of the qPlus sensor was also slightly changed to some extent. However, the distance might be far from the surface to detect strong dependency of the chemical interaction between the tip and the surface. In order to achieve the goal, the design of the qPlus sensor is currently modified to be more functionalized one in the high stable manner under the X-ray irradiation.

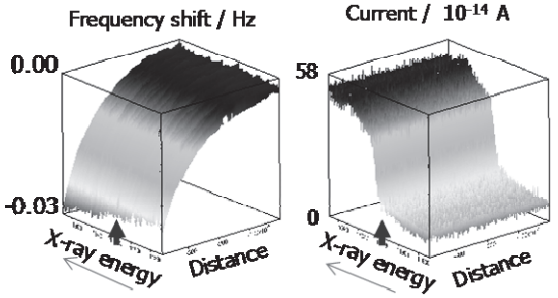

Fig. 1 X-ray energy dependency of the frequency shift (left) and current (right). The Au L_3 absorption edge was denoted by an arrow in each figure.

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