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XANAM with Quartz tuning fork cantilever

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Scanning tunnelling microscopy (STM) and noncontact atomic force microscopy (NC-AFM) provide information of physical and chemical properties of substrate surfaces at the atomic level. However, elemental analysis by those methodologies is still a difficult issue. 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. Previously, 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 imaging as our final goal. 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 quartz tuning fork (QTF) 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 QTF is normally used as a high quality factor resonator for use as a stable frequency reference for a wrist watch. Previously, Giessibl reported first that the QTF 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[4]. The QTF cantilever has three merits compared to the Si-based cantilever fabricated by semiconductor processes. First, a substance of the tip is selectable among any solid materials. It requires X-ray absorption edge energy of the tip material should be distinctively different from the one of target atoms on sample surfaces. For the XANAM measurements, this is advantageous to avoid the influence of X-ray absorption at the tip. Second, the QTF cantilever is a self-sensing and self-actuating probe. It means additional resonators and optics to measure tip deflection are not required. Thus, the instruments can be simplified and downsized to be a compact design. The second feature is also advantageous to ensure keeping the X-ray beam position between a tip and a sample surface for a long experimental time at the beam line. Then, we fabricated a home made the QTF cantilever, and examined its performance for the XANAM measurement.

In order to fabricate the QTF cantilever, we used a QTF device which is normally used for a wrist watch with resonance frequency of ~32.7 kHz. The size of QTF is 2 mm x φ1 mm without a wiring part. A small tiny metal wire was attached with adhesive glue onto a prong of the QTF by micromanipulator (Suruga Seiki Co., Ltd.). An exclusive cantilever holder was fabricated to set the QTF cantilever on the AFM stage. We used Au deposited on a Si wafers to evaluate the performance of QTF cantilever for the XANAM measurement.

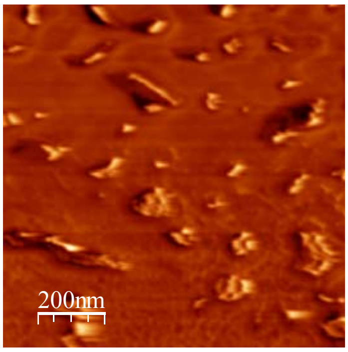

Fig.1 AFM image of Aui deposited surface on Si surface

Figure 1 shows a picture of QTF cantilever and a sample in our UHV chamber at the beam line. Figure 2 shows Au coated surface. We confirmed resolution of AFM images was improved. Although stability of QTF cantilever for scanning was improved under X-ray irradiation, the stability of the QTF cantilever was not sufficient to get several image frames. Thus, further improvement of the QTF cantilever is required to establish the XANAM imaging. This work is supported by a Grant-in-Aid for Scientific Research for young scientist promotion (A) (No. 20686004), from the JSPS.

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