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Development of New SR-STM for Renovated 13A Beamline

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Introduction

Real-space chemical imaging of surfaces in an atomic resolution is an ultimate goal for surface science and nanotechnology. Aiming for the goal, we have developed synchrotron-radiation assisted scanning tunneling microscopy (SR-STM) [1-3]. The unique microscopy enables us to take x-ray absorption spectra (XAS), which are sensitive to the core energy levels, below the STM tip and obtain elemental and chemical information of the localized area. So far, we have obtained images showing spatial distribution of specific elements with a resolution of ~ 20 nm. Recently, we have modified the system in order not only to improve its performance but also to accommodate a focused beam of a newly renovated beamline. Here, we briefly report on the modification.

System Modification

One of the beamlines we have used, BL-13A in PF, KEK, was recently renovated to improve light intensity by a factor of 10. The beam spot size can be focused into ~100 μm area, 10 times smaller than before. We thus expect improved light density by 3 orders, which will dramatically intensify the elemental / chemical signal in our measurements and improve its spatial resolution.

In order to implement our system to the newly renovated beamline, however, we needed to modify our setup. One of the reasons is because for the measurements of SR-STM, the sample area just below the tip has to be irradiated by the beam, and the previous beam alignment / positioning system did not have spatial precision high enough to locate the 100 μm diameter beam below the tip. We therefore redesigned our STM system and installed a multi-directional piezo-actuated positioning stage with sub-micron precisions.

Figure 1 shows a schematic of the piezo stage of the newly designed STM. The stage moves the STM unit situated on it in both X and Y directions and rotates it in the azimuthal direction (θ). Each motion has 6 stacked piezo actuators and their motions are controlled in a manner invented by Pan *et al.*[4].

We also introduced a pneumatic active anti-vibration table having a XYZ positioning function (VAAV1000L, Showa Science Co.). The whole ultrahigh vacuum chambers containing the STM unit, the piezo stage, and other sample preparation / characterization tools are located on the pneumatically floating table in order to isolate them from the floor vibration. The table has a unique function which enables us to position the whole system in the XYZ directions with an accuracy of ±10μm. Using the two positioning systems; the piezo stage and the pneumatic table, we can easily align the focused beam just below the tip.

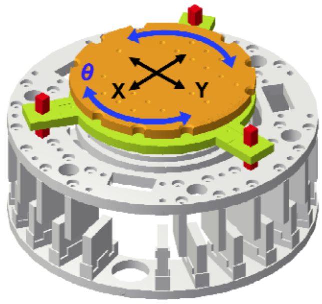

Fig. 1, schematic of piezo stage

As an electrode for the local XAS, we use an STM tip coated with insulator except its apex in order to block electrons emitted from the area other than below the tip. So far, we used a glass coated tip [5]. Since making reliable tips was not easy, however, we fabricated a new insulator-coated tip; to make the tip we first deposit SiO_2 thin film on a sharpened W wire using RF sputtering and then remove the insulating film from the tip apex with focused ion beam (FIB). We have tested the blocking performance of the film and found that the films grown in slow growth rate are packed densely enough to block the injected electrons.

Using the renovated beamline, the modified SR-STM setup, and a newly developed SiO_2 coated tip, we have successfully taken XAS on C_{60} film and found that the spectra exhibit fine structures reflecting chemical environments of carbon atoms in the molecules, which obviously could not be achieved in the previous settings, giving us promising expectation for highly resolved chemical imaging.

References

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