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Scanning Tunneling Microscope Combined with Synchrotron-Radiation for Element Specific Analysis

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Introduction

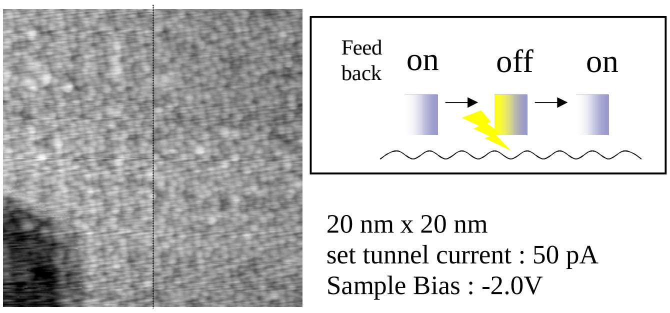
In order to achieve the imaging of scanning tunneling microscope (STM) with chemical information, we are developing the STM system combined with synchrotron radiation (SR-STM). That is, we are trying to get the photoemitted electrons excited by the SR-light by an STM tip during the STM observation. In the previous report, we have reported that we successfully observed the absorption spectra of Si *L* edge by the STM tip as the clear tip height jump at the edge in the constant-current observation mode[1,2]. This result implies that the STM can be used as a elemental analysis. Then, the question is how can we get the signal from only a small area. In other words, how is the spatial resolution of this elemental specific STM measurement. In this paper, we will report the recent trial to measure the spatial resolution of the SR-STM system.

Experimental

All the experiments have done at the beamline BL-19A. The experimental settings are the same as those reported in the previous papers[1,2]. In recent measurement, in order to obtain the effect of the photo-illumination from the smaller area and improve the spatial resolution, we have applied a STM tip coated with a polymer (polyethylene glycols) to avoid the unwanted current detected at a Tip wall.

Results and Discussion

In the previous measurement, we measured the change of the tip height when impinging the light and changing its energy. To measure correctly the tip reaction between different surface positions, however, measuring the tip height change is not suitable. Since the initial tip height can be different depending on the sample position having different electronic state and the reaction at the different surface position may be different from each other. Therefore, we should measure the change of the tip current (i.e. photocurrent) instead of the tip height when the light illuminates the sample and changes its energy. The schematic illustration for the photocurrent measurement is presented in the right hand side of Fig. 1. During the photocurrent measurement we have to fix the tip height as same as that without light illumination. Thus we set the feed back-loop off when the light illuminates the sample and measure the photocurrent at the center of the scanning position (dashed line in the figure). The timing of the light illumination was controlled by the computer-controlled shutter. Although the observed STM image is a little disrupted because of the vibration noise of the shutter, we can still observe the Si(111)7×7 structure in an atomic resolution. Figure 2 shows the current change observed by coated tip (blue, ×10) and non-coated tip (red). Photon energy was changed from 93 eV to 105 eV during the observation. One can see the jump of the photocurrent at the Si *L* edge (~ 100 eV) clearly in both measurements with coated and non-coated tip. The reduction of the detecting photocurrent with the coated tip (~1/10) compared to the non-coated one implies the improvement of the spatial resolution with the coated tip. The absolute spatial resolution of the photocurrent imaging is now under progress applying the metal or semiconductor dots sample fabricated by the electron beam lithography.



20 nm x 20 nm
set tunnel current : 50 pA
Sample Bias : -2.0V

Fig.1 Illustration of photocurrent measurement by STM tip (right) and the STM image obtained at a time(left). Photocurrent is measured at the center of the image (dashed line). Atomic structure of Si(111)7×7 is observed during the photocurrent measurement.

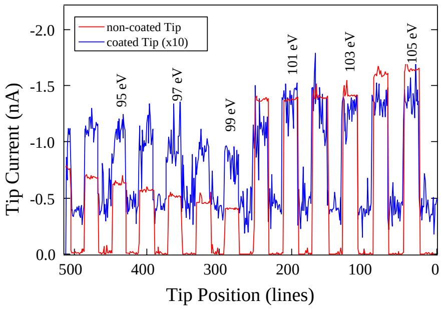


Fig.2 Photon energy dependence of the photocurrent measured by the coated tip(red) and non-coated tip (blue). Si *L* absorption edge is clearly seen.

References

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