STM and high-resolution photoemission spectroscopic analyses on nano-scale selective oxidized Si(111) surfaces

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Si(111) clean surface consists of two triangle structures referred to as stacking fault (FH) and stacking un-fault (UH) sites. We found clear selectivity of these sites on initial oxidation of Si(111) surface, when this surface was oxidized with ozone[1]. We aim to pioneer nano-scale selective oxidation methods. Late years, many researchers pick up on features of the high controllability of translational energy and the narrow energy distribution relative to supersonic molecular beams (SSMB's) and have been studying surface treatment processes by the SSMB's. Y. Teraoka et al. clarified the energy barrier height in oxidation reactions by O_2 SSMB's and obtained the important information to control the oxidation reactions on Si(001) surfaces[2]. We attempted the nano-scale selective oxidation on Si(111) surfaces by controlling translational energy of oxygen molecules.

The monochromatic synchrotron radiations were used for Si-2p and O-1s photoemission measurements. In order to perform surface sensitive measurements, the take-off angle of photoelectrons was set to be 20° with respect to the surface. The O_2 SSMB's are continuously generated by the adiabatic expansion of O_2, He and/or Ar mixture. The nozzle can be heated up to about 1300 K so that the upper limit of the O_2 incident energy is 2.3 eV (calculated value).

The p-type Si(111) sample was previously processes by Shiraki method. The Si(111) surface was cleaned by flashing at 1400 K under ultra-high vacuum conditions.

We measured Si-2p and O-1s photoemission spectra of Si(111) 7x7 surface oxidized by irradiation of O_2 beams with translational energy from 0.76 to 2.3 eV onto this surface at room temperature. O-1s photoemission intensity of the oxygen-saturated surface by O_2 SSMB's at 2.3 eV was larger than the irradiation at 0.76eV. Si-2p photoemission spectra for Si(111) surfaces oxidized to saturation coverage by O_2 beams with the incident energy of 2.3 eV indicate larger signals relative to Si^{4+} compared with 0.76 eV.

[1] K. Miki et al., Phys. Rev. Lett., to be submitted.
[2] Y. Teraoka et al., Surf. Sci., 507-510, (2002) 797.

Development of observation of photon helicity in soft x-ray region by means of photoelectron diffraction

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In the soft x-ray region, photon polarization measurement method for any photon energy has not been fully established, because a phase retarder cannot work in whole soft x-ray region. The azimuthal shifts of forward focusing peaks in photoelectron angular distribution (PEAD) pattern depend on the photon helicity. This phenomena is being utilized for the stereo-view of atomic image1). In contrast, the azimuthal shift measurement for the well-known crystal may give the information of the photon helicity.

The well-known Si(100) crystal was selected as a sample in this experiment. The wafer was prepared by chemical treatment using hydrofluoric acid. In order to directly compare the unpolarized light provided by the standard soft x-ray source Mg-Kα, the incident photon energy $h\nu$ =1261eV was selected. For the theoretical simplicity, the 2s initial state was measured. The measured kinetic energy is E_k=1110eV.

We measure a PEAD pattern at gap=53.06mm, phase=39.92mm, which is shown in Fig. 1. The PEAD pattern is clearly observed. The rectangle is a region around the forward focusing peak caused by the 1st nearest neighbor atom. Then the close-up of the region is measured, which is shown in Fig. 2. The forward focusing peaks moves clearly with changing ID phase. The result implies that the electric field of the photon on the sample is rotated in a clockwise direction at positive phase value. In near future, the helicity value will be calculated in the use of a theoretical fitting.

1) H. Daimon, *Phys. Rev. Lett.* **86**, 2034 (2001).

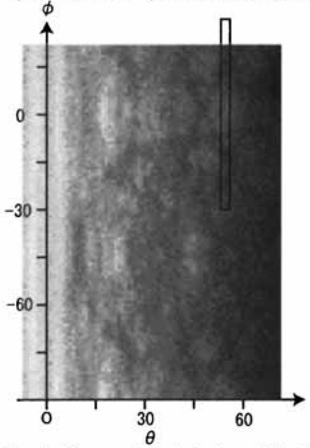

Fig. 1. Measured Photoelectron diffraction pattern of Si(100). Rectangle is a measured region for Fig.2.

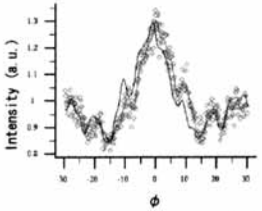

Fig. 2. Red: measured forward focusing structure of first nearest neighbor with +39.92mm of ID phase. Blue: it with -39.92.