Chemical-state-selective Mappings for Silicon Compounds by PEEM Combined with Synchrotron Soft X-ray Excitation at the Si *K*-edge

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Due to recent rapid miniaturization of Si-based electronic devices, it has become important to develop microscopic methods to observe mapping for Si-based materials. Surface morphological and elemental mappings can be obtained by SPM and the other microscopic methods using focused electron beams. However a method for microscopic mapping dependent on the valence states has not been established. Here we demonstrate the chemical-state-selective mappings of micro-patterns formed on Si surface by means of PEEM combined with synchrotron soft X-ray excitation. The samples investigated were Si/SiO_x micro-patterns formed on Si(001) surface. The copper mesh of 7.5 micron hole width was put on the Si(001) surface as a mask, and 3 keV O_2^+ ions were bombarded up to $3x10^{18}$ atoms $\cdot$ cm^{-2}. Images were observed using PEEM (Elmitec PEEM Spector) after taking off the mesh.

Figure 1 shows the Si *K*-edge X-ray absorption spectra for reference samples of Si(001) and SiO_2 measured by total electron yield. The peaks A and B are originating from the resonance excitations from the Si 1s into sigma* orbitals in the respective valence states.

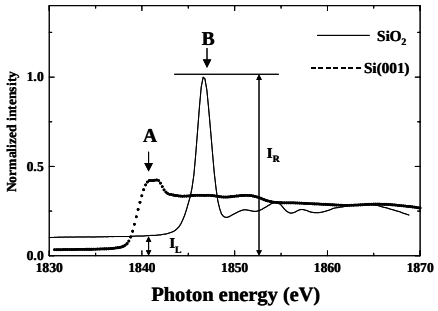

Fig.1 X-ray absorption spectra for Si(001) and SiO_2 at the Si *K*-edge

In fig.2, PEEM images for micro-patterned Si/SiO_x sample excited by various photon energies are displayed. It is clearly seen that the brightness of the image (c) is reverse to that of the image (a). Compared with the X-ray absorption spectra, it is deduced that the bright areas in image (c) are due to SiO_2, while dark areas originate from Si(001). Since the surface of this sample is topographically flat, it is demonstrated that the present method can be applied to the observation on the microscopic pattern depending not on the morphology but only on the valence states of silicon.

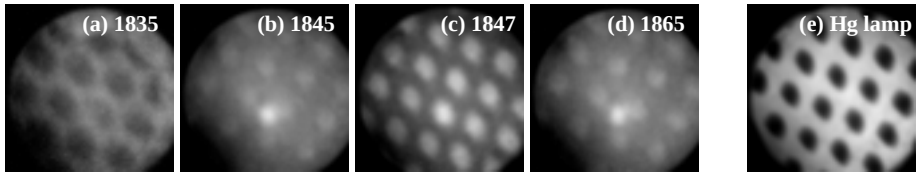

Fig.2 PEEM images for Si/SiO_x micro-pattern. The photon energy is shown in each image. Field of view is 50 micron.