ONLINE ISSN : 1348-2246
PRINT ISSN : 0910-6340

Analytical Sciences
Vol. 26 (2010) , No. 8 p.835

[PDF (795K)] [References]

Chemical-State-Selective Mapping at Nanometer Scale Using Synchrotron Radiation and Photoelectron Emission Microscopy

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For surface analyses of semiconductor devices and various functional materials, it has become indispensable to analyze valence states at nanometer scale due to the rapid developments of nanotechnology. Since a method for microscopic mapping dependent on the chemical bond states has not been established so far, we have developed a photoelectron emission microscopy (PEEM) system combined with synchrotron soft X-ray excitation. The samples investigated were Si/SiO_x micro-patterns prepared by O_2^+ ion implantation in Si(001) wafer using a mask. PEEM images excited by various photon energies around the Si *K*-edge were observed. The lateral spatial resolution of the system was about 41 nm. The brightness of each spot in PEEM images changed depending on the photon energy, due to the X-ray absorption intensity of the respective chemical state. Since the surface of this sample was topographically flat, it has been demonstrated that the present method can be applied to observations of the microscopic pattern, depending not on the morphology, but only on the valence states of silicon. We have also *in-situ* measured the changes of the PEEM images upon annealing, and elucidated the mechanism of the lateral diffusion of oxygen and valence states of silicon at the nanometer scale.

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doi:10.2116/analsci.26.835

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