

Development of PF-STXM and its application to environmental geochemistry

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Scanning transmission X-ray microscopy (STXM) has been applied to various fields in earth and environmental sciences such as aerosol chemistry, geomicrobiology, soil science, and nanomineral sciences. In particular, the technique has been used in the world because of its great importance in imaging distribution of carbon, or in particular carbon functional group, with about 50 nm spatial resolution. However, STXM that can be used to measure NEXAFS at carbon K-edge has not been in use in Japan. We have constructed STXM in Photon Factory (PF-STXM) from 2012 and started to use it for various topics in earth and environmental sciences.

In the PF-STXM, soft X-rays from the undulator are monochromatized by the grating and focused at the four-way aperture slit. The FZP with the outermost zone width of 30 nm is placed at 1 m distant from the aperture slit. First order diffraction selected through an order sorting aperture (OSA) is focused onto the sample with the focal distance of 0.7-5 mm, and then the transmitted X-rays are detected. The PF-STXM at present is mainly operated at BL-13A in Photon Factor, where the energy range available is from 250 eV to 1600 eV, which covers K-edges of carbon, nitrogen, oxygen, potassium, and aluminum. The beam size of the STXM was around 50 nm focused with Fresnel zone plates (FZP). The intensity of focused X-rays at the sample was expected to be up to 10^7 photons/s. Instead of a photomultiplier tube (PMT) which is commonly used in STXM, a silicon avalanche photodiode (APD) is utilized to detect the transmitted X-rays in PF-STXM. Compared with other STXM system in the world, our STXM is made so compact and light that it is easily connected to and removed from the multi-purpose beamlines. The experiments reported below are performed at BL-13A and BL-16A of Photon Factory.

The PF-STXM has been used for various applications. Among them, we would like to present recent results on (i) speciation of calcium in mineral dust with 50 nm spatial resolution, (ii) characterization of carbon adsorbed on particulate matter in river water, and (iii) spatial distribution of rare earth elements in bacterial cell.

Keywords: STXM, PF, Aerosol, Particulate matter, Bacteria