

Cathodoluminescence of albite activated by alpha-particle induced luminescence centers

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Cathodoluminescence (CL) halo in quartz caused by alpha-radiation has been investigated for the application to geodosimetry. The halo in feldspar minerals, however, has not been studied from the perspective of CL spectroscopy. In this study, the halos of various albite implanted by He⁺ ion have been characterized by CL spectral analysis to clarify emission mechanism for the applications to geodosimetry and geochronology.

Single crystals of albite (Ab₉₈₋₁₀₀Or₂₋₀) from Minas Gerais, Brazil (Ab1), Niigata, Japan (Ab2) and Shiga, Japan (Ab3) were selected for CL measurements. He⁺ ion implantation (dose density: $1.23 \times 10^{-4} \sim 7.38 \times 10^{-4}$ C/cm²) on the samples was performed using a 3M-tandem ion accelerator at 4 MeV corresponding to the energy of alpha-particles from ²³⁸U.

CL imaging of Ab1, Ab2 and Ab3 shows CL halo on the surface of He⁺ ion implanted sample. Approximately 15 μm width of CL halo in the section is consistent with theoretical range of alpha-particles from disintegration of ²³⁸U in albite. Their CL spectra in the halos consist of emission bands at around 400, 580, 660 and 730 nm. These spectra can be deconvoluted by Gaussian curves in energy units, resulting in four components centered at 3.05, 2.10, 1.86 and 1.56 eV. An integral intensity of the Gaussian component at 1.86 eV positively correlates with radiation dose of He⁺ implantation in the halo area of individual albite. It suggests that the component at 1.86 eV (666 nm) might be assigned to radiation-induced defect center formed by He⁺ ion implantation. CL line analysis along the halo section reveals that a change in the CL intensity along depth direction substantially corresponds to the Bragg's curve, suggesting energy loss process of specific ionization along the track of a changed particle. Therefore, the CL emission of albite related to radiation-induced defect center can be used to quantitatively evaluate the radiation dose of alpha-particles induced on feldspar minerals as an indicator applied for a geodosimeter.

Chemical state of Fe in fine and ultrafine particles in the urban atmosphere

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Iron is the most common transition metal in atmospheric aerosol particles and plays an important role in atmospheric chemistry and biological processes. In order to understand the size-dependent speciation and mixing state of Fe in fine and ultrafine fraction of ambient atmosphere, we have performed nano to bulk scale analyses on urban atmospheric particles, utilizing synchrotron-based X-ray absorption near-edge structure (XANES), scanning electron microscopy (SEM), and (scanning) transmission electron microscopy ((S)TEM). The samples were collected using a 9-stage cascade impactor at Hakozaki, Fukuoka, Japan during the sampling campaign in October and November of 2009.

(I) Super-micron particles (1-8 μm): Individual particle analysis shows that Fe is included in ~40 % of the particles. Most of those particles are composed mainly of Si and Al, and their Fe concentrations determined by energy dispersive X-ray analysis (EDX) were less than 20 at.% (6 at.% in average). Iron K-edge in XANES spectrum indicates that major Fe speciation of the super-micron particles is Fe₂O₃. Indeed, STEM elemental map reveals the presence of discrete Fe oxide, likely aggregate of hematite, on aluminosilicate in addition to Fe-bearing aluminosilicate such as biotite and chlorite.

(II) Submicron-sized particles (0.06-1 μm): The XANES spectrum reveals that major Fe speciation in this size range is closely related to Fe₂O₃ and/or Fe₃O₄. However, the TEM shows an aggregate of rounded nano-particles at the size of ~50 nm in diameter and Fe is always associated with Mn, which was not observed in the super-micron size range.

Up to the present, several studies have determined the major speciation of Fe in the atmospheric particles as Fe₂O₃ using XAFS. However, our detailed characterization by a combination of TEM and XAFS allowed to conclude that the occurrence and elemental mixing state of Fe are not uniform as determined only by XAFS but are largely variable as a function of the particle size. Still, the mixing state of Fe in the small-sized fraction observed in the present study provides an useful insight to better understanding the size-dependent catalytic effect and bioavailability of Fe in the urban aerosol particles.