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Cathodoluminescence characterization of radiation-induced luminescence centers in albite

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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 features. In this study, CL of various albite implanted by He^{+}ion has been measured to characterize their CL for application to geodosimetry and geochronology.
Single crystals of albite ($Ab_{98-100}Or_{2-0}$) from Minas Gerais, Brazil (Ab1), Niigata, Japan (Ab2) and Shiga, Japan (Ab3) were selected for CL and Raman measurements. He^{+}ion implantation (dose density: 0.0001231 - 0.000738810 C/cm^{2}) on the samples was performed using a 3M-tandem ion accelerator at 4 MeV corresponding to the energy of alpha-particles from ^{238}U. A scanning electron microscopy-cathodoluminescence (SEM-CL) was used to obtain CL spectra and CL images of these albite. Operating conditions were set at 15 kV (accelerating voltage) and 1.0 nA (beam current).
CL images of Ab1, Ab2 and Ab3 exhibit CL halo on the surface of He^{+}ion implanted sample. Approximately 15 micron meter width of CL halo in the section is consistent with theoretical range of alpha-particles from disintegration of ^{238}U in albite. Their CL spectra in CL halo area consist of emission bands at around 400, 580 and 730 nm which are assigned to Ti^{4+}, $Mn^{2+}$and Fe^{3+}impurity centers, respectively. The intensities of these CL emissions decrease with an increase in radiation dose of He^{+}implantation. Raman spectroscopy on the halo areas reveals that full widths at half maximum (FWHM) of pronounced peaks at 480, 520 and 780 cm^{-1}increase with an increase in radiation dose. It implies that He^{+}implantation causes a breakage of the framework, providing a reduction of CL emission centers assigned to Ti^{4+}, $Mn^{2+}$and Fe^{3+}impurity center. Ab3, however, has an emission band at around 660 nm in the sections of halo area. The higher the radiation dose of He^{+}implantation, the higher the intensity of CL emission at 660 nm becomes. These results suggest that CL emission at around 660 nm might be assigned to radiation-induced defect center formed by He^{+}ion implantation. CL spectra in the halo areas of Ab1, Ab2 and Ab3 can be fitted by Gaussian curves in the energy unit, resulting in four curves 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. In the section of the halo area, the intensity of the component at 1.86 eV increases exponentially from implanted surface to the inside, with its maximum at approximately 15 micron meters inside from the surface. CL line analysis along the sections of the halo area shows that the intensity of the CL emission assigned to radiation-induced defect center reciprocally corresponds to the Bragg's curve, which indicates energy loss process of specific ionization along the track of a changed particle. These facts imply that CL of albite could be used to evaluate the radiation dose of alpha-particles emitted from radionuclide-bearing minerals within feldspar minerals as an indicator applied for a geodosimeter.

Keywords: cathodoluminescence, albite, radiation damage, CL halo, lattice defect, alpha-particle