An attempt to make a cathodoluminescence (CL) geodosimeter: CL measurement of synthetic and natural quartz after He+ implantation

Yoshitada Horikawa[1], Kosei Komuro[2], Shin Toyoda[3]

[1] Geoscience, Tuskuba Univ, [2] Geoscience, Tsukuba Univ, [3] Applied Phys., Okayama Univ. Sci.

In natural rocks, low-quartz grains are often seen to host light-colored halos around a contact of radionuclide-bearing mineral under cathodoluimnescence (CL). First found by Smith and Stenstrom (1965), these CL halos have been believed to form by radiation-damage because the widths are identical with the calculated traversed distances (range) of alpha particles emitted from natural radionuclides in radioniclide-bearing minerals. Recently, Komuro et al. (2002, in prep.) succeeded for the first time in producing CL halos in synthetic low-quartz after He+ implantation. By this has been confirmed experimentally that CL halos in low-quartz are to form by alpha radiation. The contrast between a halo and the host low-quartz is generally known to increase with age and concentration of radionuclides in adjacent radioniclide-bearing minerals (Owen, 1988; Closel et al., 1992; Komuro et al., 1995). It is expected that CL halos could be a new dosimetric tool that register ancient accumulative dose if a relationship between accumulative dose and a property of a halo such as contrast can be identified.

In the present study, He+ ion implantation experiment followed by CL measurement was carried out on synthetic and natural low-quartz samples of various origins in order to investigate the relationship between dose and CL halo development by alpha radiation. He+ ion implantation experiment was executed with a 3M-Tandem ion accelerator in Takasaki Research Center of Japan Atomic Energy Research Institute (JAERI). Accelerated energy of He+ was set at 4 MeV, which roughly corresponds to the energy of alpha emission from the decay of 238U. CL measurement was made on the basis of Horikawa and Komuro (2002, this volume). The important conclusions obtained in the present study are as follows:

(1) CL observation of synthetic low-quartz samples after He+ implantation with various doses detected CL halo formation for a dose density of more than 2.17E-5 C/cm2.

(2) CL observation of both synthetic and natural low-quartz samples after He+ implantation with various doses shows that CL color of a halo changes continuously with dose density, indicating that CL halos can be a new dosimeter.

(3) The degree of color change of the halos in both synthetic and natural low-quartz samples decreases with increasing dose density, indicating that CL color of a halo saturates at a dose density of certain value.

(4) The results of He+ implantation for natural low-quartz show that the color changes of a halo and the host quartz are different if the origin is different. This could be ascribed to the number of the precursors of non-bridging oxygen bond, an origin of the emission of the CL halos (Götze et al., 2001), or possibly those of some other due lattice defect.

(5) For a common application of CL halos as a geodosimeter among various quartz of different origin, it would be helpful to obtain some coefficients to correct the differences in the CL property of the halos.

This study was partly supported by Inter-University Joint Research program using the JAERI facilities and by Grants-in-AID of the Japan Nuclear Cycle Development Institute (JNC) Cooperative Research Scheme on the Nuclear Fuel Cycle.