

## Temperature quenching effect on the cathodoluminescence of quartz

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Cathodoluminescence (CL) has been extensively used in sandstone diagenetic studies because of the different CL properties of authigenic and detrital quartz (e.g. Marshall, 1988; Demars et al., 1996). The CL characteristics of quartz, however, are still debated by the reason of complicating features of diverse defect centers and impurity centers. Furthermore CL intensity of quartz considerably varies with sample temperature. In this study we attempt to estimate the effect of temperature quenching on the CL emission of quartz.

The sample used for CL spectral measurement is colorless quartz occurred in basaltic geode from Poona, India. All measurements were made with a CL scanning electron microscopy (CL-SEM), which comprises a SEM (Jeol: JSM-5410) combined with an integral monochromator (Oxford: Mono CL2). The sample stage can be controlled at various temperatures using liquid nitrogen and embedded heater. CL spectra were collected over the wavelength range from 350 to 800 nm with a photon-counting system by using PMT under the condition of a scanning electron beam of energy 15 kV and current 0.07 nA.

CL spectra with doublet peaks of 450 nm and 500 nm were obtained below 203 K, while no obvious CL emission could be detected above 243 K. Under high irradiation current of 1.0 nA, however, weak blue and red luminescence, of which peaks were at around 450 nm and 630 nm, appeared at room temperature. Blue luminescence at 450 nm to 500 nm may be assigned to E' center caused by oxygen deficient defect in framework lattice (Stevens Kalceff and Phillips, 1995; Krbetschk et al., 1997). A decrease in sample temperature rapidly diminishes red CL emission around 630 nm, which might be related to STE and/or O-Al-O (Stevens Kalceff and Phillips, 1995). We employ blue CL emission for a sequence of CL spectral measurements at various temperatures.

The temperature quenching effect on CL emission efficiency was evaluated by assuming the configuration model based on the Frank-Condon principle. Since the CL emission bands generally have a Gaussian space in energy unit, the wavelength  $L$  (nm) data were converted to energy  $E$  (eV) where the CL intensities were multiplied by  $L \times L$  due to transformed unit. The CL emission efficiency ( $A$ ) was obtained from integrated intensities after a Gaussian peak fitting of the corrected intensities. In this case blue CL spectral curves were deconvoluted into two Gaussian peaks with 450 nm (2.75 eV) and 517 nm (2.4 eV). The CL efficiency of both emissions considerably increased as sample temperature is raised, where the efficiency for both emissions at 81 K was approximately 100 times those at 298 K, although Hanusiak and White (1975) reported enhancement of CL intensity for quartz by 1300 times below 193 K compared with room temperature. Such unusual temperature effect on CL emission is peculiar for quartz.

The plot of the value of  $\ln(1/A-1)$  against  $1/T$  ( $T$ : absolute temperature) exhibits a linear relationship to each other between 81 K to 163 K and 183 K to 223 K for both emissions of 2.4 eV and 2.75 eV respectively. We obtained activation energy of 0.03 eV from 81 K to 163 K and 0.25 eV from 183 K to 223 K for the emission of 2.4 eV. Almost same activation energy was evaluated for the emission of 2.75 eV. It indicates two processes of temperature quenching responsible for different excitation state. At lower temperature the electron was excited from ground state by obtaining relatively low energy of 0.03 eV. As temperature increases, additional energy in excess of 0.25 eV promotes the electron in the trap with the radiationless return to the ground state. It leads to abrupt extinction of CL emission at higher temperature.

### -References-

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