High spatial resolustion observation of the strain at the grain boundary of minerals using Scanning Near-field Optical Microscopy

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The spatial resolution of conventional optical microscopy is limited to about 400 nm. In order to overcome this limitation, a Scanning Near-field Optical Microscopy (SNOM) was developed in the early 1980s. SNOM system attains high spatial resolution (smaller than the wavelength of the incident light) using evanescent waves, which are formed by radiation to a small hole. In this research, we attached a SNOM system to our AFM system (SPM-9500J3 Shimadzu co.,) to measure the stress distribution in minerals. The photoexcitation of a sample and the collection of the fluorescence from the sample were achieved by using a single near-field optical probe (illumination-collection mode). For excitation, an Ar+ laser (488 nm, 3 mW) was coupled to a near-field probe with a 300 nm aperture through a 20* objective lens. Distance between near-field probe and sample was regulated with a shear-force control system. Simultaneous observations of topographic mapping and fluorescence mapping were conducted by synchronization between shear force scanning and photon counting. For observations of fluorescence spectra collected from a small area, the fluorescence from the sample was introduced into a 30 cm single polychromator equipped with a CCD camera with 1024 * 256 pixels.

To evaluate our SNOM system, an Al2O3 / ZrO2 eutectic was used for the sample. The grain size of this eutectic is from 100 nm to 10 um and conventional microspectrometry cannot reveal stress distribution in the sample. In this study, SNOM measurement was applied for the stress mapping in a single grain of Al2O3 / ZrO2 eutectic. The SNOM mapping showed that the grain boundary of the eutectic was more anistropic stress than the center of the Al2O3 grain.

SNOM imaging of natural polycrystalline diamonds, carbonados from the Central African Republic (CAR) were measured. Carbonado is an aggregate of micron-sized diamond crystals. They are black coloured with high porosities and indicate very intense luminescence derived from strong radiation of alpha particles. The origin of carbonados is enigmatic, but several hypotheses ranging from the high pressure origin to the radiation origin without pressure have been proposed. If carbonados are formed at the deep part of the earth, they may have residual stress corresponding to the environment at which carbonados existed. To clarify the history of the formation of carbonados, we measured the stress distribution of carbonado samples using the SNOM system. Topography and SNOM imaging of carbonados indicated that grain boundaries and pore parts of carbonados were low intensities of fluorescence. The stress distribution of carbonados was estimated from the shifts and splitting of the fluorescence spectra.