Raman spectroscopy of seifertite

*Masahiro KAYAMA[1], Eiji Ohtani[1], Masaaki Miyahara[2], Shohei Kaneko[1], Toshimori Sekine[3], Shin Ozawa[1], Naohisa Hirao[4]

1. Tohoku University, 2. Hiroshima University, 3. HPSTAR, 4. Japan Synchrotron Radiation Research Institute

Seifertite is one of the SiO_2 polymorphs and is a high pressure phase with an α-PbO_2 structure. It is known to lie in lunar and martian meteorites and constrains shock pressure and duration of an impact event that these meteorites have experienced on the host bodies. Seifertite is thermodynamically stable at more than ~100 GPa, which is not realistic for an impact event on the Moon and Mars. However, it can be transformed as a metastable phase from cristobalite at least ~11 GPa and 0.01 s, and can consequently be quenched down to an ambient condition. As a result of this process, seifertite remains present in some of the lunar and martian meteorites. The estimated shock pressure and duration provide valuable information on the size of the crater and impactor that collided don the host bodies. Although Raman spectroscopy has been previously measured for seifertite in meteorites, it was not successful to obtain the seifertite signature because of a potential vitrification or transition into other SiO_2 phase by heating due to the laser irradiation. Therefore, only synchrotron-XRD and TEM analyses allow us to determine the structure, where silica grains are excavated with a focused ion beam (FIB) system from meteorite. Here, Raman spectral signatures of seifertite has been obtained from synthetic and meteoritic silica grains, implying its identification with high-spatial resolution as nondestructive analysis.

Seifertite in silica grains of synthetic samples and lunar (NWA 4734) and martian meteorites (Zagami, NWA 2975) were identifications by a synchrotron XRD analysis at Spring-8 BL-10 and were employed for Raman spectroscopy. Seifertite were synthetized from synthetic cristobalite powders using multi-anvil press at 16 GPa, 673 K and 0.5 hour. Raman spectroscopy were performed for synthetic and meteoritic silica grains using Nd: YAG 532 nm at 20 mW for 3 minutes exposure time.
Raman spectra of synthetic seifertite have pronounced peaks at 380, 515, 564, 739 and 796 cm^{-1} and weak peaks at 401, 496, 539, 547, 606 and 749 cm^{-1}. Similar Raman signature was obtained from seifertite in lunar and martian meteorites. These Raman shifts and relative intensities are well corresponding to the values calculated within the density-functional perturbation theory for seifertite. Based on the calculation, thee Raman peaks at 380, 515, 564, and 796 cm^{-1} are assigned to Ag, those at 401, 496, and 539 cm^{-1} to B1g, 606 and 749 cm^{-1} to B2g, and 547 and 739 cm^{-1} to B3g modes. After laser beam irradiation for 30 minutes, the distinct Raman signature can be detected from synthetic and meteoritic seifertite. Therefore, Raman spectroscopy enables determination of the structure and identification of SiO2 polymorphs with high-spatial resolution and without destruction.

Keywords: Seifertite, Raman spectroscopy, Meteorite

