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Technical improvements on Paris-Edinburgh high-pressure cell for neutron diffraction and ruby fluorescence measurements

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Neutron is a complementary probe to X-ray for material sciences in determining crystal structures. In particular, neutron diffraction is powerful to locate hydrogen positions in hydrogen-bearing compounds. The spallation neutron source of new generation is now being constructed in Tokai, Ibaraki Pref. as a part of the J-PARC facility. In the history of high-pressure neutron science, the most crucial technical progresses would be the developments and uses of Paris-Edinburgh (P-E) presses in strong neutron sources in European countries and US. In order to use practically a P-E press in J-PARC in future, it is necessary to improve these conventional techniques for achieving higher pressure with larger sample volume. We especially redesigned the parts of anvils and gaskets surrounding samples acquiring higher intensities for the same initial sample volume as original anvils. There are two main points for our improvements; a new anvil made of Ni-WC with a wide conical aperture for getting higher signal intensity and an optical window for monitoring ruby fluorescence spectra, a hybrid gasket made of TiZr and Al-alloy for reducing absorption of incident neutron beam.

High-pressure generation tests have been performed several times using Bi as a pressure calibrant and measurements of ruby fluorescence spectra at the same time. In-situ and high-quality X-ray diffraction experiments were also carried out using synchrotron radiation at PF-AR, KEK, with NaCl pellets as pressure calibrants. The sample volume was 50 mm^3 and the highest pressure obtained was above 13 GPa. The neutron diffraction measurements were carried out at BL19, MLF, J-PARC. As a result, 3 times higher intensities of neutron scattering from Pb pellet were obtained using our improved anvils than conventional single toroidal anvils. This suggests that our new anvils are expected to give sufficient intensity for crystal structure analysis from smaller amount of sample in a shorter measurement time even under higher pressure. Our study indicates that some important improvements were produced by the development of new cell assemblies. Furthermore, the required improvements and future prospects to the technique will be proposed.

Keywords: Paris-Edinburgh cell, high pressure, neutron diffraction, hydrous minerals, J-PARC, hydrogen bonding