Development of miniaturized McWhan type high pressure cell for elastic and inelastic neutron scattering experiments

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Over the past few decades, a considerable number of studies have been devoted the physical properties of Ce-, Yb- and U-based intermetallics, the so-called strongly correlated electron systems. In these systems, an external pressure is often a key to bring about a new type of ground state accompanied with exotic physical phenomena, such as a heavy fermion superconductivity or valence transition and so on. Accordingly, nowadays the concern with an application of high pressure generation techniques to various sorts of experimental measurements has been growing remarkably. So far, most of neutron scattering experiments, especially inelastic neutron scattering experiments, of strongly correlated electron electrons systems or magnetic materials have been being performed using so-called McWhan type high pressure cell developed by Onodera et al.[1] in Japan. This apparatus, however, is not adequate to the experiments below 1 K as a cell volume is considerably large (100 mm $\phi \times$ 140 mm height). Therefore, there is an urgent need to develop a better suited pressure cell for the elastic and inelastic neutron scattering experiments at such extremely low temperature to study physical phenomena near a quantum critical point. In this work, we have newly designed the McWhan type pressure cell with smaller heat capacity. Cylinder was made of an aluminum-based new hardened material, Mesoalite. An ultimate tensile strength of this material is almost twice as high as that of conventional duralumin (A7075). Support cylinder was made of ZrO_2 whose neutron transmittance is 50 % larger than that of Al_2O_3. Consequently, we succeeded in reducing the cell volume to one-third (66 mm$\phi \times$ 92 mm height) and improving the neutron transmittance up to about twice comparison with those of the McWhan type pressure cell designed by Onodera et al.[1]. A cross-section diagram of newly designed McWhan type pressure cell for neutron scattering experiments below 1 K is drawn in figure. Pressurization examination was performed at room temperature. Glycerin and a single crystal of NaCl were used as a pressure transmitting medium and a manometer, respectively. Generated pressures were determined based on a compressibility of NaCl by estimating a lattice constant from its (200) reflections at various external loads. At present, we succeed in generating pressure above 2.3 GPa by this pressure cell. With a suitable change to the specification, it is possible to improve the highest pressure.

[1] A. Onodera et al., Jpn. J. Appl. Phys., 26 (1987) 152.

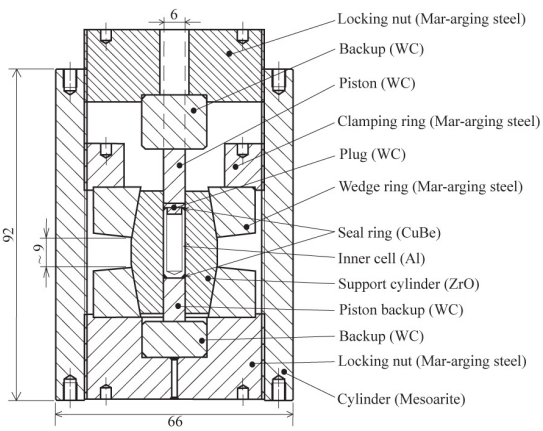

Fig. 1. A cross-section diagram of miniaturized McWhan type pressure cell for elastic and inelastic neutron scattering experimetns.