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Optical pressure sensors for DAC experiment: application in high-pressure studies

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Structural properties of melts and minerals are widely examined by in situ spectroscopic studies with externally heated diamond anvil cell (HDAC) [1]. While the temperature can be controlled with an accuracy of plus/minus 0.5-1.5 degree C with this technique [2], a direct pressure measurement is complicated by the differences in compressibility and thermal expansivity for the variety of samples. Only few spectroscopic standards can be used for pressure determination in the HDAC experiments involving silicate melts. One of the non-reactive pressure sensors which was calibrated in the wide pressure- and temperature ranges is ^{13}C diamond [3]. Its first-order Raman shift is distinct from that of diamond anvils and indicates the pressure in immediate proximity to the sample.

The objective of this work was to test the precision of ^{13}C diamond pressure marker at high pressures and elevated temperatures. Experiments were carried out in the HDAC, with pure H_2O as a pressure medium and two optical pressure markers - ^{13}C diamond aggregate chip and ruby chip. Already well established phase transitions in H_2O system and ruby fluorescence pressure scale were used as references for checking the precision of pressure determination with ^{13}C diamond Raman shift.

In the temperature (22-300 degree C) and pressure (up to 4.8 GPa) ranges studied, a good agreement between the phase transitions in H_2O system and the pressure values obtained from two pressure sensors was achieved during heating cycles. The average difference between pressures calculated from ^{13}C diamond Raman shift and those calculated from ruby fluorescence line shift (0.16 GPa) lies within the reported uncertainty of calibrations [3], [4], [5]. The largest full width at half-maximum (FWHM) for the first-order Raman peak of ^{13}C diamond was found to be approximately 9.9 cm^{-1} at 300 degree C, that is much smaller than FWHM for ruby fluorescence lines.

Experiments in the H_2O system demonstrated that ^{13}C diamond is a precise pressure sensor which immediately detects sudden pressure drops in the case of sample decapsulation. These features are essential for the pressure control in in-situ studies of magmatic phenomena, such as mixing behavior of magma and volatiles, structural changes in melts and fluids, crystallization sequences.

References

1. Smith R.L. and Fang Zh. (2009) Techniques, applications and future prospects of diamond anvil cells for studying supercritical water systems. Journal of Supercritical Fluids, V. 47, P. 431-446.

2. Bassett W.A., Shen A.H., Bucknum M., and Chou I.M. (1993) A new diamond cell for hydrothermal studies to 2.5 GPa and from -190 degree C to 1200 degree C. Reviews of Scientific Instruments, V. 64, P. 2340-2345.

3. Schiferl D., Nicol M., Zaug J.M., Sharma S.K., Cooney T.F., Wang S.-Y., Anthony T.P., Fleischer J.F. (1997) The diamond $^{13}C/^{12}C$ isotope Raman pressure sensor system for high-temperature/pressure diamond-anvil cells with reactive samples. Journal of Applied Physics, V. 82, P. 3256-3265.

4. Zha C.S., Mao H.K., and Hemley R.J. (2000) Elasticity of MgO and a primary pressure scale to 55 GPa. PNAS, V. 97, P. 13494-13499.

5. Ragan D.D., Gustavsen R., Schiferl D. (1992) Calibration of the ruby R_1 and R_2 fluorescence shifts as a function of temperature from 0 to 600 K. Journal of Applied Physics, V. 72, P. 5539-5544.

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