13A/2006G031

Equation of state for gold with a He-pressure medium

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Introduction

Gold is widely used as an x-ray pressure gauge in high-pressure experiments, where gold is enclosed in the pressure chamber together with a sample, the lattice parameter of gold is measured by x-ray diffraction, and the obtained volume is converted to pressure by using a known equation of state (EOS) of gold. The accuracy and precision of the gold EOS directly affect the pressure values in this method. The reported results of gold EOS are, however, largely controversial [1-4]. In order to establish the EOS of gold, we have repeated powder x-ray diffraction experiments with great care. It is vital to achieve hydrostatic or quasihydrostatic conditions in the sample chamber, and hence we used a He-pressure medium.

Experiments

Powder x-ray diffraction experiments were done independently at PF and ESRF. We used the same techniques; diamond-anvil cell, monochromatic x-rays, and an image plate detector. Ruby luminescence was used as a primary pressure gauge in the experiments [5].

Results

The He-pressure medium in general gives excellent hydrostatic conditions. However, at higher pressures and for strain-sensitive samples like gold, it produces sizable effect of nonhydrostaticity. Figure 1 compares the measured lattice parameter a_m of gold under pressure determined from the 111 and 200 reflections. One notices that $a_m(200)$ show much larger scatter compared with a_m (111) in different experimental runs. This is because a_m (200) is easily affected by the nonhydrostatic stress, and the stress conditions are different in each experimental run [6]. On the other hand, $a_m(111)$ is least affected by the nonhydrostatic stress, and accordingly gives the lattice parameter close to that expected under hydrostatic condition. Figure 2 shows the variation of volume obtained from $a_m(111)$ under pressure. All our experimental data converge to give the following EOS parameters: bulk modulus B_0 = 167 GPa, the pressure derivative of the bulk modulus at atmospheric pressure B_0' = 5.9 [6]. These values are in excellent agreement with those obtained by ultrasonic measurements and by first-principles calculations.

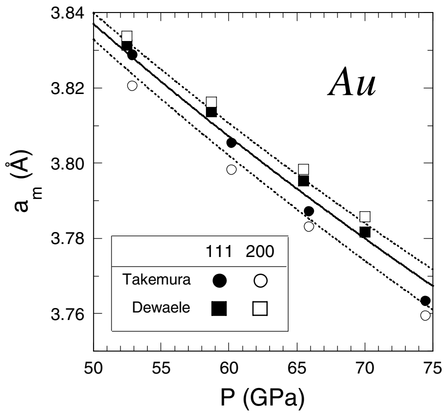

Fig. 1. The measured lattice parameter a_m as a function of pressure in two runs. The dotted curves are fits to the respective data obtained from the 200 reflection, while the solid curve is a fit to the 111 reflection in both runs.

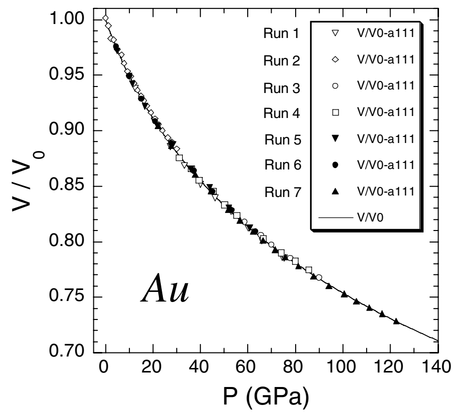

Fig. 2. Equation of state for gold from all our experimental runs.

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