High-pressure equation of state for gold with a He-pressure medium
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High-pressure powder x-ray diffraction experiments have been done on gold with a He-pressure medium up to 130 GPa at room temperature. We have conducted independent experiments at the Photon Factory and ESRF in order to check any systematic experimental errors. Effects of uniaxial stress were evident, in both experiments, at pressures higher than 30 GPa in ruby luminescence spectra and x-ray diffraction patterns. This demonstrates the pressure limit of solid He as a purely hydrostatic pressure medium. The stress states were analyzed with the use of the gamma-plots [1]. The uniaxial stress components were calculated by assuming the elastic moduli of gold under high pressure, and were found to range from ~0.6 GPa to ~0.9 GPa, depending on the experimental conditions. The difference of the stress states is the likely cause for the discrepancy in the equation of state parameters of gold previously reported [2, 3]. By properly correcting the effects of uniaxial stress components on the measured lattice parameter, the equation of state of gold is now well established.

Keywords: diamond anvil high-pressure apparatus, equations of state, high-pressure X-ray diffraction

Infrared spectroscopy of aluminum trihydride a-AlH3 under high pressure
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Aluminum trihydride (AlH3) has seven crystalline polymorphs (a-, a′-, β-, γ-, δ-, ε-, ξ-) composed of the octahedral AlH6 unit. The a-phase (a-AlH3, space group R-3c: a = 4.499 Å and c = 11.804 Å) is reported to be most stable and insulator with an interatomic Al-H distance (rAlH = 1.72 Å) between the values expected for covalent bonding (~1.5 Å) and ionic one (~2.0 Å). a-AlH3 has been studied as a candidate for the hydrogen storage material owing to its high gravimetric hydrogen density (10.1 mass%) and low dehydriding temperature (370-470K). However, there are still some unresolved matters regarding recyclability because it’s necessary to apply ~10 GPa pressure for re-hydrogenation of aluminum, namely Al-H bond formation. So, to evaluate the bonding properties of a-AlH3, we performed the high-pressure infrared spectroscopy of a-AlH3 using diamond anvil cell. a-AlH3 was synthesized by the metathesis reaction of LiAlH4 and AlCl3 in diethyl ether followed by a desolvation process. The specimen with ~1 μm thick is loaded in the rhenium gasket with KBr which is pressure transmitting medium. Infrared vibrational absorption spectra are measured for a-AlH3 with increasing pressure between 1.9 and 60 GPa at ambient temperature. The peak frequency shifts monotonically and no notable spectral changes are observed up to 60 GPa, which agrees with recent x-ray diffraction measurement performed by Goncharenko et al., while the sample gradually get black beyond 45 GPa. The mode Gruneisen parameter γ for the Al-H bond stretching-mode is derived to be 0.37 from the observed peak shifts and the bulk modulus reported by Baranowski et al. The value is almost same as those for alanates, LiAlH4 and NaAlH4, which are typical covalent-bonding materials.

Keywords: high-pressure research, infrared spectroscopy, hydrogen storage