Development of the falling-sphere technique for measuring the viscosity of liquid iron-sulfur alloys at high pressures

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Abstract

Sulfur is one of the important potential terrestrial planetary core materials and knowledge of the viscosity of liquid iron-sulfur alloys at high pressure is important for understanding the properties such as the convection and geomagnetic evolution of the Earth's outer core. Measurements of the viscosity of liquid iron-sulfur alloys have been attempted using the X-ray radiography falling-sphere method, which measures the terminal velocity of a marker sphere sinking in the liquid sample. However, in the viscosity measurement of liquid iron-sulfur alloys, a chemical reaction between the metal marker sphere and the liquid is a serious problem. In this study, we have developed a newly alumina coated metal marker sphere (Pt), whose diameter is 100 μm with a very thin alumina layer (2 μm in a thickness). Use of the alumina coated sphere can prevent such a chemical reaction and the viscosity of liquid iron-sulfur alloys can be successfully obtained at higher pressures. Also in order to reliably estimate the viscosity of the Earth's outer core, the precise activation energy and activation volume are required over as wide a range of pressure as possible. We have developed a diamond/SiC composite anvil for the multi-anvil press, which has good X-ray transparency and has superior hardness compare to a conventional tungsten carbide (WC) anvil. Combining the diamond/SiC composite anvil with the X-ray radiography falling-sphere method, the marker sphere sinking in the liquid can be observed through the diamond/SiC composite anvil. Therefore, since the effective view range required for the X-ray radiography falling-sphere method is not limited by narrowing the anvil gap of the multi-anvil press, the pressure range of the viscosity measurement can be expanded. Here we present the development of the falling-sphere technique and the results of the viscosities of liquid iron-sulfur alloys at pressures up to 14 GPa.

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