Noncontact AC Calorimetry of Liquid Silicon with Suppressed Convections in a Static Magnetic Field

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Thermal transport properties of liquid silicon, such as heat capacity, total hemispherical emissivity, and thermal conductivity, are important parameters used in computer simulations for the growth of a single high quality, large diameter silicon crystal. However, these properties have not been well determined because of the existence of contamination from the container and of convections under gravity. In order to overcome these problems, noncontact AC calorimetry with suppressed convections has been developed.

Liquid silicon was levitated by the electromagnetic levitation technique in a vacuum. The convection in the levitated silicon was suppressed by the static magnetic field of 0 to 4 T generated by a superconducting magnet. The liquid silicon was periodically heated by a semiconductor laser. The temperature response of the liquid silicon was measured by a two-color pyrometer. The experiment was conducted in the temperature range between 1700 and 2050 K.

The molar heat capacity of liquid silicon was obtained from the temperature amplitude. The total hemispherical emissivity and thermal conductivity were obtained from the phase difference between the laser power and temperature response signals. The average values of the heat capacity and the total hemispherical emissivity are 28.2 $\pm$ 3.3 $J \cdot K^{-1} \cdot mol^{-1}$ and 0.28 $\pm$ 0.03 respectively, and their temperature dependences are negligible in this temperature region. The apparent value of the thermal conductivity is decreased with increasing static magnetic field up to 2 T. However, the thermal conductivity converged on the value of 62.4 $\pm$ 5.3 $W \cdot m^{-1} \cdot K^{-1}$ for a static magnetic field of 2 to 4 T. This result suggests that the convection has been suppressed and is negligible, leading to accurate measurement of the thermal conductivity.

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