# Improvements of Noncontact Laser Calorimetry for Measurement of Heat Capacity and Thermal Conductivity of Molten Silicon

Hidekazu Kobatake [S], Hossein Khosroabadi and Hiroyuki Fukuyama [C]
*Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Aoba-ku Sendai, Miyagi, Japan*

Takao Tsukada
*Department of Chemical Engineering, Tohoku University, Aoba-ku Sendai, Miyagi, Japan*

Satoshi Awaji
*Institute for Material Research, Tohoku University, Aoba-ku Sendai, Miyagi, Japan*

The thermophysical properties of liquid silicon, such as heat capacity and thermal conductivity, are indispensable input parameters for numerical modeling of silicon crystal growth. In spite of the importance of the thermal properties, it has been difficult to measure the properties of molten silicon because of the existence of both convection and contamination from contact materials. The newly developed noncontact modulated laser calorimetry method in a static magnetic field enables us to measure heat capacity, thermal conductivity and the total hemispherical emissivity of a high temperature liquid while suppressing convection and contamination [1-4]. However, the problem of large uncertainty still remained in this measurement because of the difficulty in the noncontact temperature measurement.

In this study, we improved the temperature measurement technique as follows. (1) Temperature calibration is based on Planck's law using a single color pyrometer, which has a different measurement wavelength from the laser wavelength; (2) Appropriate temperature range for obtaining a high-resolution temperature profile; and (3) In-situ measurement of the temperature amplitude and phase shift using a frequency response analyzer. The improvements significantly reduce the uncertainties in heat capacity and thermal conductivity.

This development was supported by SENTAN, JST.

[1] H. Fukuyama, et al. *Meas. Sci. Technol*.**18,** 2059 (2007).
[2] T. Tsukada et al. *Int. J. Heat Mass Transfer* **50,** 3054 (2007).
[3-4] H. Kobatake, et al. Appl. Phys. Lett. **90**, 94102 1-3 (2007), *J. Appl. Phys.* **104**,