An Optical Based AC-Calorimetry Method for In-Plane Thermal Conductivity Measurement

Dihui Wang [C, S]
Mechanical engineering, University of Pittsburgh, PIttsburgh, PA, U.S.A.
diw25@pitt.edu

A modified ac-calorimetry method using modulated laser heating and thermoreflectance temperature sensing with micrometer spatial resolutions has been developed to measure the in-plane thermal conductivity (kr) tensor of bulk and thin-film materials, with the measurable kr range proved to be as low as 1 W/mK. This modified method combines both the advantage of the conventional ac-calorimetry method and recent advances in time-domain and frequency-domain thermoreflectance experiments, enabling measurements of kr with both high accuracy and ease of operation. In this work, details of this method including its experimental configuration, thermal modeling, sensitivity analysis, and uncertainty estimation are fully discussed. General guidelines in choosing the optimum laser spot size and the modulation frequency that yield the smallest measurement uncertainty are provided. Other details such as the requirements on the sample geometry, the effect of the transducer layer, and the effect of heat loss is also discussed. As a demonstration, the in-plane thermal conductivities of both fused silica and single-crystalline silicon have been measured using this newly developed optical-based ac-calorimetry method, with the results agreeing perfectly well with the literature value