Feasibility Study of a Novel Technique for Measurement of Liquid Thermal Conductivity with a Micro Beam Sensor

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This paper proposes a novel technique to measure the thermal conductivity of liquid with approximately 1 ml of sample, which is significanlty smaller than that required in conventional methods such as a transient hot-wire method. Our technique utilizes a micro beam sensor fabricated on a silicon substrate across a trench. To demonstrate feasibility, we carried out a numerical analysis of transient heat conduction around a uniformly-heated, thin platinum beam sensor that was submerged in a liquid sample. The sensor was assumed to be 50 nm thick, 0.5 mm wide and 5 or 10 mm long. The temperature of the sensor increased after heating. However, in contrast to the transient hot-wire method, the temperature of the sensor reached a steady state because the temperature at both ends was kept constant at the substrate temperature. The time to reach the steady state was extremely short, less than 0.2 ms after heating, because of the size of the sensor. Since this is considerably shorter than the onset of natural convection, the temperature at the steady state conduction will be easily obtained with experiments. The average temperature of the sensor at the steady state increased with decreasing the thermal conductivity of the sample. The thermal conductivity is therefore determined from this theoretical relationship with measured temperature. The proposed method is new in terms of its principle that utilizes a steady state for measurement within an extremely short time as well as its benefit of requiring an extremely small amount of sample.