Mechanical Engineering Master's Defense

Construction of a Thermal Conductivity Measurement Platform for Bulk and Thin Film Samples Based on the 3ω Technique

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abstract

Nanostructured materials show significant enhancement in the thermoelectric figure of merit (zT) due to quantum confinement effects. Improving the efficiency of thermoelectric devices allows for the development of better, more economical waste heat recovery systems. Such systems may be used as bottoming or co-generation cycles in conjunction with conventional power cycles to recover some of the wasted heat. Thermal conductivity measurement systems are an important part of the characterization processes of thermoelectric materials. These systems must possess the capability of accurately measuring the thermal conductivity of both bulk and thin- filmed samples at different ambient temperatures.

This paper discusses the construction, validation, and improvement of a thermal conductivity measurement platform based on the 3ω technique. Room temperature measurements of thermal conductivity done on control samples with known properties such as undoped bulk silicon (Si), bulk gallium arsenide (GaAs), and silicon dioxide (SiO_2) thin films yielded 150 (W/m − K) , 50 (W/m − K) , and (1.46 W/m − K) respectively. These quantities were all within 5% of literature values. In addition, the thermal conductivity of bulk SiO_2 was measured as a function of temperature in a Helium-4 cryostat from 75K to 250K . The results showed good agreement with literature values that all fell within the error range of each measurement. The uncertainty in the measurements ranged from 19% at 75K to 30% at 250K . Finally, the system was used to measure the thermal conductivity of CdSe nanocomposites in In_2Se_3 matrix as a function of the concentration of In_2Se_3. The observed trend was in qualitative agreement with the expected behavior.

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