Investigation of Thermal Transport across Interfaces using Time Resolved Thermal Wave Microscopy

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Manipulating phonon mediated thermal transport using interfaces is an exciting field of research with many technological applications. For example, thermal management strategies in micro-electronic and micro-electro-mechanical devices are becoming increasingly important with decreasing device size. Nanocrystalline diamond films provide an attractive and cost effective solution to channel heat away from sensitive devices. However, these films have grain dimensions on the order of the phonon mean free path and as a result the grain boundary thermal resistance plays a dominate role in limiting thermal transport. Thermoelectric energy conversion for both power generation and solid state cooling provides another example. A key challenge for improving the efficiency of thermoelectric materials is balancing the competing requirements of high electrical conductivity and Seebeck coefficient with low thermal conductivity. Great strides towards achieving this goal have been made by tailoring phonon properties using specially designed nano-sized materials (e.g. quantum dots, nanorods, nanowires, superlattices).These examples illustrate that establishing a clear understanding of the fundamental role interfaces play in controlling phonon transport is central to the development of new phononic structures. In this presentation we use a laser-based time-resolved thermal wave imaging technique to investigate lateral thermal transport across an isolated bicrystal interface as well as across an ensemble of interfaces in a nanocrystalline thin film. For the case of an isolated interface the Kapitza resistance is extracted directly from the temperature discontinuity across the interface. For the thin film, the ensemble average Kapitza resistance is extracted by comparing the temperature dependence of the conductivity to an effective medium approach that directly addresses role of the interface. Our experimental results are discussed in relation to the structure of the interface.