MAR11-2010-003665
Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Nanoscale heat transfer and thermoelectrics for alternative energy[1]

RICHARD ROBINSON, Cornell University

In the area of alternative energy, thermoelectrics have experienced an unprecedented growth in popularity because of their ability to convert waste heat into electricity. Wired in reverse, thermoelectrics can act as refrigeration devices, where they are promising because they are small in size and lightweight, have no moving parts, and have rapid on/off cycles. However, due to their low efficiencies bulk thermoelectrics have historically been a niche market. Only in the last decade has thermoelectric efficiency exceeded $\sim$20% due to fabrication of nanostructured materials. Nanoscale materials have this advantage because electronic and acoustic confinement effects can greatly increase thermoelectric efficiency beyond bulk values. In this talk, I will introduce our work in the area of nanoscale heat transfer with the goal of more efficient thermoelectrics. I will discuss our experiments and methods to study acoustic confinement in nanostructures and present some of our new nanostructured thermoelectric materials. To study acoustic confinement we are building a nanoscale phonon spectrometer. The instrument can excite phonon modes in nanostructures in the $\sim$100s of GHz. Ballistic phonons from the generator are used to probe acoustic confinement and surface scattering effects. Transmission studies using this device will help optimize materials and morphologies for more efficient nanomaterial-based thermoelectrics. For materials, our group has synthesized nano-layer superlattices of Na_xCoO_2. Sodium cobaltate was recently discovered to have a high Seebeck coeficent and is being studied as an oxide thermoelectric material. The thickness of our nano-layers ranges from 5 nm to 300 nm while the lengths can be varied between 10 μm and 4 mm. Typical aspect ratios are 40 nm: 4 mm, or 1:100,000. Thermoelectric characterization of samples with tilted multiple-grains along the measurement axis indicate a thermoelectric efficiency on par with current polycrystalline samples. Due to phonon confinement in nano-structures, it is expected that the thermoelectric efficiency of these sheets will be much higher than that of single crystalline $Na_{0.7}CoO_2$, when the nanosheets have single grains along the heat transport path.

[1]This work is supported by KAUST (KUS-C1-018-02), NSF (DMR 0520404), and the DOE (DE-SC0001086)