MAR11-2010-020211

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

Material tradeoffs in direct thermal to electric energy conversion systems

ALI SHAKOURI, Baskin School of Engineering, University of California, Santa Cruz

Thermoelectric devices allow direct conversion of heat into electricity without any moving parts. However the energy conversion efficiency has been limited due to parasitic Joule heating in the thermoelectric material as well as the heat leakage from the hot to the cold junction mainly through phonons. Using thermionic emission over heterostructures and electron energy filtering, high Seebeck coefficient and high electrical conductivity can be achieved simultaneously. Embedded nanoparticles can also be used to scatter mid and long wavelength phonons and reduce the lattice thermal conductivity with small impact on electrical transport. While the tradeoff in material properties can be reduced with nanoengineered structures, the overall efficiency/cost tradeoff has not been analyzed in detail. In a waste heat recovery system, in addition to the thermoelectric device, the heat sink and the electrical and thermal resistances have to be co-optimized. A recent analytic theory is reviewed which shows the potential of thermoelectric waste heat recovery in a wide range of applications. Co-optimization of the thermoelectric module with the heat sink will permit minimizing the amount of material used in the system and reduce the overall energy payback. Optimization of the thermoelectric system in maximum output power regime, which is important in many practical applications, lead to interesting conclusions about the asymmetric role of thermal resistances with hot and cold reservoirs.