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“Thermoelectric Materials and Device Technologies for Energy Conversion and Sensing”

ABSTRACT: Thermoelectric devices can be used to convert waste heat into electricity and have the potential to improve energy efficiency at industry, transportation, and everyday life. According to the recent data published by the Department of Energy, in the U.S. alone, each year approximately 100 billion gallons of gasoline is wasted as heat. The recovery of even a fraction of this heat into electric power would have a striking impact on energy crisis. In addition to power generation, thermoelectric phenomena can be used for sensing and refrigeration applications. Recent studies show that the market for thermoelectric technology is rapidly expanding covering military, industrial, medical, and consumer applications.

In this seminar, different techniques to engineer thermoelectric properties of materials are briefly reviewed and the challenges in fabrications and characterizations of high efficiency thermoelectric devices are discussed. The main emphasis is on nano-scale effects, which allow engineering new materials with significantly higher energy conversion efficiency, and on the new opportunities enabled by these materials for commercial applications. Recent experimental and theoretical results for nanostructured thermoelectric materials are presented. These include recent superlattice thin film structures and nano bulk materials developed for enhanced energy conversion efficiency. Different aspects of the electron and phonon transport in nano-scale are further discussed. In such structures, interfacial potentials, electron and phonon interface scatterings, density of states modifications, non-equilibrium transport, and quantum size effects can be exploited to improve the efficiency of thermoelectric energy conversion.

Self-powered wireless networks, infrared sensors, body heat powered wearable electronic devices and medical implants, energy saving for powering mobile phones, on-chip micro refrigerators for CPUs and wavelength division multiplexers, and waste heat recovery in vehicles and industrial processes are some examples for immediate applications of the thermoelectric devices.

Short Bio: Prof. Vashaee is an expert in superlattices and nanostructured materials for energy conversion and sensing applications. In the past, he has contributed to the development of several key thermoelectric structures including heterostructure thermionic devices and bulk nanocomposite materials. He has published over 150 technical articles, and is the winner of the 2004 Goldsmid Award for research excellence in thermoelectrics from the International Thermoelectric Society. He received his PhD from University of California at Santa Cruz in 2004, worked at MIT as postdoctoral scholar, at Oklahoma State University as assistant professor, and joined North Carolina State University ECE department as associate professor in 2014.