Physics Colloquium, University of South Florida
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Bulk Thermoelectric Materials Measurements: A Look Behind the Curtain:

Discussion of Various Techniques: Cautionary Remarks, Pitfalls & Potential Sources of Error

Prof. Terry M. Tritt
Dept. of Physics & Astronomy, Clemson University, Clemson, SC

This talk will give an introduction to thermoelectric (TE) materials and some of the challenges that these materials present to the researcher in order to obtain high TE performance. TE materials are solid-state materials that exhibit typically low thermal conductivity values on the order of 1-5 Wm-1K-1. Therefore, very precise and reliable measurements of electrical resistivity (ρ) thermopower (α) and thermal conductivity (κ) measurements are a necessity. Good TE materials are gauged by their dimensionless figure of merit, ZT = α2σ T/κ, typically between 1 and 2. Synthesis methods and techniques (along with doping) must be developed to finely control these values including electronic band structure and various scattering mechanisms that affect both the heat and charge carried by the charge carriers (κe) and the phonons (κL), κT = κe + κL. Depending on the application, these materials may be used for cooling (200K - 400K) or for power generation applications (700K - 1300K). Measurements over such a broad range presents its own challenges. The electrical resistivity, ρ, is also measured over these broad temperature ranges in order to use the Wiedemann-Franz relationship (κe ≈ L0κT) to extract the lattice or phonon thermal conductivity, κL. Here L0 is the Lorentz number which can depend on the specific material, σ, is the electrical conductivity and T is the absolute temperature in K. Low temperature measurements using our customized steady state thermal conductivity techniques (T < 300K) are needed in order to better understand the dominant scattering mechanisms at low temperatures that might affect the electrical resistivity and thermal conductivity at higher temperatures. Then, these thermal conductivity results can be compared with those obtained by laser flash methods. Typically, it is very important to minimize κL in order to achieve the highest TE performance. Thus, measuring these properties as precisely as possible and then comparing both the magnitude and temperature dependence of the results obtained from various techniques yields greater confidence in the values that are achieved. Results from various methods will be compared and discussed. In addition, other high temperature mechanisms such as bipolar conduction in narrow gap semiconductors will be presented.

Prof. Terry M. Tritt is an Alumni Distinguished Professor of Physics at Clemson University. This is one of 18 such positions supported by the Clemson University Alumni Association and awarded to faculty who exemplify the highest qualities of service to the university and the students while also exhibiting international standing in their field of research. Prof. Tritt is a graduate of Clemson University obtaining his BA in 1980 and Ph.D. in 1985. He then served as a National Research Council Fellow at the Naval Research Laboratory (NRL) in Washington, DC (1985-1989) and then as a Research Physicist at NRL from 1989 until 1996 before joining the faculty at Clemson University in Aug. of 1996. The focus of his current research centers on materials for thermoelectric (TE) refrigeration and power generation applications. His primary research expertise lies in electrical and thermal transport properties and phenomena (a special focus in measurement and characterization techniques) in new and novel materials, especially thermal conductivity. His recent activities are focused on the synthesis and characterization of TE nanomaterials and nanocomposites & investigation and characterization of their TE material's parameters, especially thermal conductivity. Prof. Tritt has served as a symposium organizer of four Materials Research Society Symposia on Thermoelectrics Materials (MRS Volumes 478, 545, 626 and 1044). He has served as an author and lead editor of a MRS Bulletin Theme (March 2006) on Thermoelectric Materials and Devices. He edited a three-volume set on "Recent Trends in Thermoelectric Materials Research" (Academic Press-2000) and has also edited a book by Kluwer Press in 2005 on Thermal Conductivity.