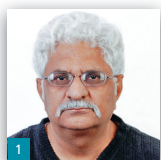


Editorial

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The increasing energy demands in the world coupled with decreasing nonrenewable energy resources and environmental concerns have contributed to issues concerning energy production and utilization and have made it an absolute priority for international research. In this context, increasing the efficiency of energy production and utilization of all forms of waste energy has become important. Thermoelectric materials that can harvest waste heat energy into useful electricity, have attracted the wide attention of research groups around the world.

The efficiency of a thermoelectric material depends on the figure of merit, $ZT = S^2\sigma T/\kappa$, where S , σ and κ are the Seebeck coefficient, electrical conductivity and total thermal conductivity, respectively. Increasing ZT , however, is nontrivial as it is controlled by opposing physical properties – electrical and thermal conductivities. Insulating materials that have high S and low κ suffer from low σ , while metals with high σ exhibit small S and large κ . Hence a phonon glass electron crystal (PGEC) approach which has the potential to give the highest ZT is being actively developed. The advent of new synthesis techniques to create nanostructured materials such as superlattices and inclusion of nanoparticles in semiconducting matrices are showing potential to realize PGEC type materials. In this context, this special issue of *Emerging Materials Research*, focused on the theme of “thermoelectric material,” is timely to spread the message of energy utilization and optimization at large.

S. J. Poon and A. S. Petersen from the Department of Physics, University of West Virginia, present an analysis based on the effective medium approach to thermal conductivity with an application to core-shell nanocomposites.¹ The effective medium method is used to study the thermal conductivity of nanostructured phases consisting of embedded particles in a host. Beyond the average T-matrix single-particle approximation, the effect of higher-order interparticle terms on heat transport is estimated to be small, which can be validated by using a reformulated differential effective medium (DEM) approach. However, the

effect of higher-order terms on heat transport is found to become significant when phonon scattering from embedded particles is considered. Applying the DEM approach to two-phase nanocomposites, particularly core-shell materials that mimic a three-dimensional superlattice, results in a large reduction in thermal conductivity and potentially high ZT .

D. B. Moore, Z. Jones, M. J. Stolt, L. Sitts, S. Disch and D. C. Johnson of the Department of Chemistry and Materials Science Institute, University of Oregon, Eugene, OR, USA, Institut Laue-Langevin, Grenoble and France M. Beekman of the Department of Natural Sciences, Oregon Institute of Technology, Klamath Falls, OR, USA, report on the structural and electrical properties of $(\text{PbSe})_{1-16}\text{TiSe}_2$.² The synthesis and characterization of a new layered compound with the composition $(\text{PbSe})_{1-16}\text{TiSe}_2$ in thin-film form is reported in their study. The structure of the new compound was characterized by specular and in-plane synchrotron X-ray diffraction studies, which indicate that the compound can be described as a layered intergrowth of PbSe and TiSe_2 in which the individual constituents are precisely layered yet rotationally (turbostratically) disordered with an average in-plane domain size of the order of 10 nm. In contrast to crystalline $(\text{PbSe})_{1-16}\text{TiSe}_2$ prepared by solid-state reaction at high temperature, the electrical resistivity in the range of 20–300 K is nearly temperature independent. The Seebeck coefficient at room temperature was measured to be $S = 66 \mu\text{V/K}$ at the carrier concentration of $n = 2.1 \times 10^{21} \text{ cm}^{-3}$, indicating behavior characteristic of a heavily doped semiconductor. The electrical transport properties for the $(\text{PbSe})_{1-16}\text{TiSe}_2$ compound are compared and contrasted to those of other misfit-layered and turbostratically disordered $(\text{MX})_{1+s}(\text{TX})_n$ compounds.

D. Thompson, D. Hitchcock, A. Lahwal and T. M. Tritt from the Department of Physics, Clemson University, discuss the single-element spark plasma sintering (SPS) of silicon-germanium (SiGe) alloys.³ Various compositions of the thermoelectric material SiGe were synthesized directly from single elements (SE) via the

SPS process. Through proper choice of commercially available powders, sintering conditions and stoichiometry, n-type and p-type samples with thermoelectric properties comparable to those of the $\text{Si}_{80}\text{Ge}_{20}$ alloys, used in radioisotope thermoelectric generators for space missions, were generated using the SE SPS process. The SE SPS technique is a rapid process requiring only 1 h for synthesizing the desired material. This new synthesis technique is a viable alternative to traditional synthesis methods and provides the potential to discover novel avenues for improving the thermoelectric dimensionless figure of merit of SiGe alloys.

R. Basu, S. Bhattacharya, R. Bhatt, A. Singh, D. K. Aswal and S. K. Gupta, from Bhabha Atomic Research Centre, India, have studied the effect of Te doping on the structural, morphological and thermopower of PbSe for the composition $\text{PbSe}_{1-x}\text{Te}_x$.⁴ The samples were prepared by melting and rocking method. Scanning electron microscopy indicated that all the samples have lamellar morphology. The X-ray diffraction analysis suggested that the lattice parameter increases linearly with dopant concentration (x). The temperature dependence of thermopower measured for samples

having different x revealed unusual increase in thermopower for the composition $x=0.5$; for example, at 427°C, the thermopower values for $\text{PbSe}_{0.5}\text{Te}_{0.5}$, PbTe and PbSe were respectively 292, 188 and 134 $\mu\text{V/K}$. A dramatic thermopower enhancement for $\text{PbSe}_{0.5}\text{Te}_{0.5}$ is attributed to scattering of the majority charge carriers by the defect sites.

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