A thermoelectric generator directly converts heat into electricity with no moving parts. The long term reliability of these systems has enabled the unattended use of thermoelectric generators in many deep space probes exploring the solar system and beyond. On earth, thermoelectrics could provide a substantial amount of electrical power from residential cogeneration and waste heat recovery from sources such as automotive exhaust. When connected to an external power supply, a thermoelectric generator becomes a solid-state (Peltier) refrigerator, cooling one end and heating the other. Such systems can be used to cool a spot instead of traditional environment cooling thereby greatly improving overall efficiency. Thus far, the use of thermoelectric generators has been limited to niche applications by the low efficiency of the thermoelectric materials.

Several new classes of compounds from oxides and intermetallics to composite materials have been discovered which show enticingly high efficiencies. A general feature of these new materials is that they all involve complex nanostructured materials [1]. The rationale behind these successes can typically be generalized into (a) quantum confinement of electrons to enhance thermopower (Seebeck coefficient), (b) low lattice thermal conductivity through structural complexity on various length scales, and/or (c) substructure approaches which separates the ‘electron-crystal’ from the ‘phonon–glass’. By reviewing recent advances in the field, these strategies are evaluated to help guide the development of revolutionary thermoelectric materials.

Figure 1: Nanostructured thermoelectrics may be formed by the solid state partitioning of a precursor phase. The metastable Pb$_2$Sb$_2$Te$_{11}$ phase (left) will spontaneously assemble into lamellae of Sb$_2$Te$_3$ and PbTe. The SEM images show dark regions corresponding to Sb$_2$Te$_3$ and light regions of PbTe. Electron backscattering diffraction reveals that the lamellae are oriented with coherent interfaces, shown schematically (right).

References

Short Biography
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