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Recent Advances in the Development of Skutterudites as Efficient Power Conversion Thermoelectrics[1]

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Ever increasing demand for fossil fuels contrasting with their gradually depleted reserves, coupled with the fact that, on average, 60% of energy in industrial processes turns into heat dictate a new energy strategy relying more on renewable energy sources and recovery of waste industrial heat. Thermoelectric (TE) conversion can play a meaningful role in this new paradigm provided more efficient TE materials can be identified and developed. How efficiently a material converts heat into electricity (or, conversely, electricity into a heat pump) by purely solid state means is judged by the thermoelectric figure of merit defined as $ZT = (S^2\sigma T)/\kappa$, where S, σ, κ, and T stand for the Seebeck coefficient, electrical conductivity, thermal conductivity, and the absolute temperature, respectively. During the past dozen or so years, the worldwide search has brought to light several novel and prospective TE materials. Among them, perhaps the most promising for mid-temperature (500K-900K) energy conversion are cubic, open structure materials called skutterudites. In this talk I describe their structure and relate it to transport properties that govern efficient TE conversion. Nanometer-scale inclusions in a bulk matrix have recently been vigorously explored as a means of enhancing scattering of heat-carrying phonons as well as attempting to enhance the Seebeck coefficient by carrier confinement. I discuss criteria the nanostructure should satisfy in order to improve the figure of merit and illustrate the concepts on skutterudite nanocomposite structures grown recently by highly non-equilibrium processes. Finally, I discuss virtues of skutterudites as power conversion thermoelectrics in the recovery of waste heat in automotive operations.

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