Breaking the Thermal Conductivity Glass Limit

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In the development of high performance bulk thermoelectric materials, one of the successful strategies follows the phonon-glass electron-crystal concept. In this concept, efficient thermoelectric materials should have crystalline structure for good electronic transport properties (electron-crystal) but allow high degree of lattice imperfection to drive down the lattice thermal conductivity to the so-called glass limit κ_G (phonon-glass), where the phonon mean free path is below the periodicity of a crystalline structure. Examples include caged structures, like filled skutterudites and clathrates, and nano-inclusions in bulk matrices. In this presentation, such "classic" phonon-glass electron-crystal concept is revisited. We show evidences suggesting this glass limit may have already been broken several times. In addition, we present our coordinated studies of the basic relationships between nanostructures and the macroscopic properties of a family of high performance thermoelectric materials made by both equilibrium and non-equilibrium synthesis method; and discuss the result of time-of-flight inelastic neutron scattering characterization and atomic-scale image of defect and matrices. Explanation for the significantly enhanced thermoelectric figures of merit in some of these materials will be proposed.

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