Finding Novel Routes to Intrinsically Lower Thermal Conductivity

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Finding intrinsic novel routes to lower thermal conductivity is an important research objective, not only for thermoelectric applications, but for developing effective new insulating materials also. One increasingly popular method is to process grains in materials through ballmilling, SPS, etc. While this is an effective method, it is entirely extrinsic and in this talk I will focus on several routes we have been investigating to lower thermal conductivity on an intrinsic level [1-3]. If compounds with intrinsic low thermal conductivity can be “material designed”, it is simply a matter of process to further ballmill, etc. to introduce grains into the materials to assumedly lower the thermal conductivity further. Boron cluster compounds are hard materials with high sound velocity, yet despite this, they are known to generally possess intrinsic low thermal conductivity [4,5], and we synthesize and control several systems to investigate novel routes to lower thermal conductivity.

Several mechanisms such as the following will be discussed.

A) High number of atoms in the unit cell [Crystal complexity or “amorphous limit” as first proposed by Slack [6] and Golikova [7], respectively]

B) Rattling [Not just in cage compounds like skudderudites or clathrates, but can atoms residing in the voids among the cluster network structures rattle?[2]]

C) “Symmetry mismatch effect” [We propose there may be a mechanism to lower the thermal conductivity when there exists a mismatch of the crystal structure symmetry with that of the basic building blocks [3]]

D) Disorder [We have previously proposed a way to more quantitatively evaluate and have a measure of/control the disorder in similar systems[2]]

E) Finding/introducing particular structural features like atomic dumbbells which are indicated to lower thermal conductivity [1].

References

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