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Effective Mass of Thermoelectric Materials with Non-Parabolic Kane Bands

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Effective mass is a concept commonly used to describe electronic transport in semiconductors using a classical analogy to the kinetic theory of gasses. We describe many important electronic transport parameters explicitly with an electronic band mass including: Density of states, charge carrier concentration, mobility, and in particular for thermoelectrics, the Seebeck coefficient. For systems with known electronic band structures these properties can be calculated leading to subtly different definitions of effective mass. In the free electron or parabolic band model the effective masses are the same and we use the term effective mass interchangably. However the differences between these defintions or uses of effective mass become apparent in non-parabolic band structures where it is desirable to describe the transport in terms of a effective mass that changes with energy (or Fermi Level). For example Kane bands, which become more linear and less parabolic at higher energy, have an increased density of states and therefore higher DOS effective mass than a parabolic band. While it is often assumed that also results in a higher thermopower (Seebeck coefficient), calculations of thermopower and Hall carrier concentration from the Kane model show the thermpower is actually reduced. Examples in thermoelectric materials will be discussed.