Thermal Transport in Superlattices

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Thermal transport in epitaxial superlattices has recently received intense attention, not only due to provide deeper insight about phonon physics, but also because of their applications in a variety of optoelectronic and thermoelectric energy conversion devices. There are several potential mechanisms for superlattices to influence phonon transport, namely: (i) reflection due to acoustic impedance mismatch and phonon spectra mismatch at interfaces; (ii) scattering due to interface defects; (iii) mode conversion at interfaces; (iv) changes in dispersion relation due to zone folding. The last effect has many other effects, namely, reduction in group velocity and changes in phonon relaxation rates. It is at present not understood which mechanism is dominant under a certain type of condition.

In order to clarify the mechanism of thermal transport, we have performed both systematic experiments and molecular dynamic simulations of thermal transport in superlattices. We will present results of both these studies and then draw some general conclusions. The experiments suggest acoustic impedance mismatch is an important factor and must be increased to reduce thermal conductivity. However, bandgap formation does not seem to be as important in the samples we studied. Finally, the effect of alloying on thermal transport in superlattices will be discussed.