Coherent and Localized Phonon Heat Conduction

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Although classical size effects on phonon heat conduction are now well-established and understood, manipulating phonon heat conduction via waves is still a dream to be realized due to the broadband and short wavelength nature of phonons. In this talk, I will show, however, the wave effects on heat conduction can be observed and exploited to manipulate phonon heat conduction. In superlattice structures, ballistic phonon transport across the whole thickness of the superlattices implies phase coherence. We observed this coherent transport in GaAs/AlAs superlattices by fixing the periodic thickness but varying the number of periods. Simulations show that although high frequency phonons are scattering by roughness, remaining long wavelength phonons maintain their phase and traverse the superlattices ballistically. Accessing the coherent heat conduction regime opens a new venue for phonon engineering. We show further that phonon heat conduction localization happens in GaAs/AlAs superlattice by placing ErAs nanodots at interfaces. This heat-conduction localization phenomenon is confirmed by nonequilibrium atomic Green's function simulation. These ballistic and localization effects can be exploited to improve thermoelectric energy conversion materials via reducing their thermal conductivity. This material is based upon work supported as part of the "Solid State Solar-Thermal Energy Conversion Center (S^3TEC), an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Award Number: DE-SC0001299/DE-FG02-09ER46577.