東京大学グローバルCOEプログラム　機械システム・イノベーション国際拠点

東京大学 THE UNIVERSITY OF TOKYO

GMSI Global Center of Excellence for Mechanical Systems Innovation

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# Thermal transport by phonons in thin films


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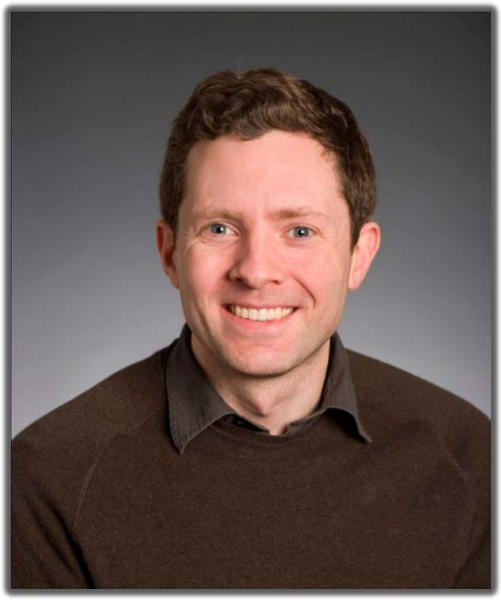
The thermal conductivity of a thin film in the in-plane and cross-plane directions is less than that of the corresponding bulk material. This reduction is due to changes in the phonon density of states and phonon-boundary scattering. The density of states effect is only expected to be important in very thin films and is not discussed. The focus is on the boundary scattering effect in films with bulk-like density of states.

The frequencies, group velocities, and mean free paths of phonons from the full Brillouin zone of bulk Stillinger-Weber silicon are first predicted using lattice dynamics calculations.
The Matthiessen rule is then used to calculate the mean free paths in thin films by modifying the bulk mean free paths using geometric models to account for boundary scattering. Two variations of the boundary scattering model are presented and compared.

Using the film mean free paths, the in-plane and cross-plane film thermal conductivities are calculated. The results are compared to a new analytical model for thin film thermal conductivity. A Monte Carlo-based method is then presented that allows for analyzing phonon transport in silicon thin films with periodic holes and the thermal conductivity predictions are compared to experimental data.

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