Manipulating Thermal Transport with Nanoporous Patterns across Thin Films

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Periodic nanoporous thin films have been extensively studied for their potential applications in thermoelectrics, heat waveguides, thermal cloaks, thermal diodes, and heat imaging. This talk will address several important issues for the corresponding thermal studies. Firstly, the observed in-plane thermal conductivity (k) reduction was attributed to diffusive pore-edge phonon scattering or coherent phonon transport within a periodic structure (i.e., phononic effects). Approaches to justify the importance of phonon coherence will be discussed. Secondly, nanoporous patterns other than periodic circular nanopores deserve more attention. Here we will emphasize periodic nanoslot patterns that provide more flexibility to tune the in-plane thermal anisotropy of thin films. The narrow neck between adjacent nanoslots can introduce a ballistic thermal resistance to lower the k along the direction perpendicular to nanoslots, while keeping a much higher k along the direction parallel to nanoslots. For thin films or two-dimensional structures, such nanoslot patterns can be used to improve the thermoelectric performance or extract the in-plane phonon mean free path distribution. Finally, new applications of nanoporous thin films will be discussed, e.g., thermal cloaking as the thermal counterpart for optical invisibility cloaks, and an ultra-high heat transfer coefficient for device cooling applications.