Actively switching the thermal conductivity of thin films via external stimuli: electric fields, liquid infiltration of proteins and modulated laser energy

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Dynamically regulating thermal transport in solids enables possibilities of thermal energy control, such as new computing mechanisms utilizing phonons, a novel means to control phonon-coupled waves and particles such as polaritons and polarons, or the ability to use thermal signatures as a metric for sensing environmental changes. In this work, I will present results from our recent studies in developing nanoscale thermal conductivity “switches”, or the ability to change the thermal conductivity of a thin film system through the application of some external stimulus. We will discuss three different types of thermal conductivity switches or devices based on: 1) the application of electric fields across lead-zirconate titanate (PZT) thin films to manipulate the phonon-ferroelastic domain wall scattering rates; 2) hydration of squid ring teeth recombinant protein thin films to increase the mean square displacement oscillations in crystalline domains, which relaxes upon drying; and 3) trigging the metal-insulator transition (MIT) in VO_2 two-terminal devices with absorbed heat from a modulated laser train to create photo-thermally gated electrical devices.