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Tuning thermal transport ultra-thin silicon membranes: Influence of surface nanostructures[1] SANGHAMITRA NEOGI, DAVIDE DONADIO, Max Planck Institute for Polymer Research, Mainz, Germany — A detailed understanding of the behaviour of phonons in low-dimensional and nanostructured systems provides opportunities for thermal management at the nanoscale, efficient conversion of waste heat into electricity, and exploration of new paradigms in information and communication technologies. We elucidate the interplay between nanoscale surface structures and thermal transport properties in free-standing silicon membranes with thicknesses down to 4 nm. We demonstrate that whereas dimensional reduction affects the phonon dispersion, the surface nanostructures provide the main channel for phonon scattering leading to the dramatic reduction of thermal conductivity in ultra-thin silicon membranes. The presence of surface nanostructures, by means of pattern formation and surface oxidation, leads to a 40-fold reduction in the in-plane thermal conductivity of the thinnest membrane. We also investigate the effect of chemical substitution and the geometry of the nanostructures in the thermal transport properties of the membranes. We show that local strain induced by nanostructuring enables tuning of the thermal conductivity of these nanophononic metamaterials[1]. [1] B. L. Davis and M. I. Hussein, Phys. Rev. Lett., 112, 055505 (2014).

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