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Probing Thermomechanics at the Nanoscale: Impulsively Excited Pseudosurface Acoustic Waves in Hypersonic Phononic Crystals

D. NARDI, Q. LI, K. HOOGEBOOM-POT, M. MURNANE, H. KAPTEYN, JILA - University of Colorado at Boulder, USA, M. SIEMENS, Department of Physics and Astronomy - University of Denver, USA, M. TRAVAGLIATI, Center for Nanotechnology Innovation @NEST - IIT, Pisa, Italy, F. PARMIGIANI, Dipartimento di Fisica - Universita' degli Studi di Trieste, Italy, G. FERRINI, F. BANFI, Dipartimento di Matematica e Fisica - Universita' Cattolica, Brescia, Italy — Hypersonic-frequency surface acoustic waves can be generated by ultrafast laser excitation of nanoscale patterned surfaces and are of great interest because of their high sensitivity to the mechanical properties of the material in which they propagate. By modeling nanoscale thermomechanics from first principles, we can calculate a composite system's initial heat-driven response and follow its evolution in time. A spectral decomposition of the response on the calculated eigenmodes of the system allows evaluation of impulsively excited pseudosurface acoustic wave frequencies and lifetimes, expanding our understanding of surface waves scattering in mesoscale metamaterials, while providing crucial information about non-destructive photoacoustic characterization and imaging of nanostructures for nanoelectronics, nanomedicine and photovoltaic applications. The model is successfully benchmarked against time-resolved optical diffraction measurements performed on 1D and 2D surface phononic crystals, probed using extreme ultraviolet and near-infrared light. Reference: D. Nardi et al., Nano Lett. 11, 4126 (2011).

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