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Comparing the Transition from Diffusive to Ballistic Heat Transport for 1D and 2D Nanoscale Interfaces[1] J. HERNANDEZ-CHARPAK, K. HOOGEBOOM-POT, JILA, CU-Boulder, E. ANDERSON, LBNL, M. MURNANE, H. KAPTEYN, D. NARDI, JILA, CU-Boulder — How is thermal transport affected by spatial confinement in nanoscale systems? In past work we and others demonstrated that the Fourier Law of heat diffusion fails for length scales smaller than the mean free path of the energy carriers in a material. Here we probe how the transition from macroscopic diffusive behavior of phonons through the quasi-ballistic regime is different for 1D and 2D nano-confined hot spots. We study a series of periodic nickel lines (1D) and dots (2D) with linewidths varying from 750 to 30 nm deposited on both sapphire and silicon substrates. The thermal relaxation of these femtosecond-laser-excited nanostructures is monitored by the diffraction of extreme ultraviolet (EUV) light obtained from tabletop high harmonic generation. The short wavelength of EUV light, combined with the coherence and ultrashort pulses of high harmonic sources, provides a unique and powerful probe for nanostructured materials on their intrinsic length and time scales. The relaxation dynamics are linked to an effective thermal boundary resistivity with the assistance of multi-physics finite element analysis to quantify the stronger deviation from macroscopic diffusive behavior as a function of nanostructure linewidth in 2D hot spots compared to 1D.

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