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# Investigate and Control Thermal Spectra in Nanostructures and 2D Van der Waals Materials

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**Abstract :** Controlling heat transfer and thermal properties of materials is important to many fields such as energy efficiency and thermal management of integrated circuits. Significant progress over the past decade has been made to improve material performance through structuring at the nanoscale, however a clear relationship between structure dimensions, interfaces, and thermal properties remains to be established. The main challenge comes from the unknown intrinsic spectral contribution from different phonons. Here, we describe our current progress on quantifying and controlling thermal spectra based on our recently developed technical approach using ultrafast optical spectroscopy. Our work brings further the promise of rational material design to achieve high performance through a synergistic experimental-modeling approach. This approach can be broadly applicable to a wide range of materials and energy systems. In particular, we demonstrate in-situ characterization and tunable thermal properties of 2D van der waals materials through ionic intercalations. The significant impacts of this research in improving the efficiency of thermal energy conversion and management will also be illustrated.

**Keywords :** energy, mean free path, nanoscale heat transfer, nanostructure, phonons, TDTR, thermoelectrics, 2D materials
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