Radiative heat conductances between dielectric and metallic parallel plates with nanoscale gaps

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Near-field radiative heat transfer (NFRHT) is a promising field of study due to its fundamental importance and its potential impact on a variety of applications including thermophotovoltaic (TPV) energy conversion, thermal rectification, and nano-lithography. For several decades, theorists have predicted orders-of-magnitude enhancements in the radiative heat transfer between planar surfaces when the separation between them is significantly less than Wien's wavelength (~10 µm at room temperature), due to the tunneling of evanescent surface waves. Despite these interesting predictions, an experimental demonstration of these enhancements of NFRHT for the parallel-plane geometry has remained elusive due to numerous technical challenges.

Here, we present experimental work [1] that quantifies the radiative heat conductance between parallel plates separated by gaps smaller than 100 nm. Our measurements, performed in vacuum, were enabled by two custom-fabricated microcalorimeter devices that can resolve picowatt-level heat flows, as well as a custom-built nanopositioning platform that allows the gap between the plates to be precisely varied from <100 nm to 10 µm. The radiative heat conductances between prototypical materials (SiO_2-SiO_2, Au-Au, SiO_2-Au, Au-Si) were measured, and we report 100- to 1000-fold enhancements in radiative conductance at room temperature as the gap size was systematically reduced, in agreement with the predictions of near-field theories. Our experimental set-up will enable systematic studies of a variety of near-field-based thermal phenomena, with important implications for thermophotovoltaic applications, that have been predicted but have defied experimental verification. In addition to this work, we also present interesting aspects of radiative heat transfer between thin films. These experimental and computational observations have important ramifications for energy conversion and thermal management technologies.

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