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Radiative Heat Dissipation Between Macroscale Metallic Surfaces Via Near-Field and Thin-Film Effects

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Background Modern microelectronics continue to trend towards increasing power usage and decreasing size. As a result, heat dissipation has become a significant bottleneck for microelectronics advancement. An increasing amount of heat needs to be transferred without sacrificing the small size of the device. Previous attempts at solving this problem have not recognized radiation as a viable means for dissipating heat in these devices, mainly due to the limitation of dealing in the far field.

Photon tunneling in the near field can enhance radiative heat transfer to overcome the blackbody limit governed by Planck’s law when the vacuum gap between two radiating media is much less than the characteristic thermal wavelength. Achieving nanometer gaps and parallelism across the mesoscale lateral size of plate–plate configurations has been a major challenge. Previous methods of creating the vacuum gap include the formation of low-density pillars, a solution that would be expensive and difficult to scale up for implementation outside of a laboratory setting. Invention Description Researchers at Arizona State University have developed a near-field thermal dissipator that uses nanosized polystyrene particles to create a nanometer gap between aluminum thin films of different thicknesses. For a setup of 13-nm-thick Al films coated on silicon chips with a vacuum gap distance of 215 nm, the near-field radiative heat flux was experimentally measured to provide an enhancement of 6.4 times over the blackbody limit and 420 times over that of the far-field radiative heat transfer between bulk aluminum at a temperature difference of 65 K with a receiver film at room temperature. Potential Applications • Noncontact heat control for microelectronics • Radiative refrigeration • Thermal power generation Benefits and Advantages • Design thicknesses and gaps can be readily controlled and tuned based on application • Polystyrene nanoparticles maintain uniform gap distance and promote uniform heat dissipation performance Related Publication: Super-Planckian radiative heat transfer between macroscale metallic surfaces due to near-field and thin-film effectsResearch Homepage of Professor Liping Wang