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Near-field Thermal Radiation for Thermal Energy Conversion and Heat Modulation

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Near-field thermal radiation with heat flux beyond blackbody limit has spurred lots of potential applications in thermal energy conversion including thermophotovoltaic, thermoradiative, thermionic, radiative cooling, non-contact heat management and so on. This talk will first review recent theoretical studies from my group in near-field thermal radiation with metamaterials for thermal energy conversion and with tunable materials for near-field radiative heat control. In particular, near-field thermophotovoltaic devices enhanced by different selective emitters, such as metalodielectric multilayer, nanowires, and gratings based on different physical mechanisms, will be theoretically explained. Designs of near-field thermal rectifier, thermal switch and thermal modulator based on thermochromic VO_2 and gate-tunable graphene will be described. Then I will discuss our recent experimental measurements of super-Planckian near-field thermal radiation between planar samples. By using polystyrene spherical nanosized particles, we achieved a vacuum gap down to 215 nm between two 5 × 5 mm^2 silicon chips coated with ultrathin Al films of different thicknesses. We experimentally demonstrated radiative heat flux enhanced by 7.4 times over blackbody limit and by 480 times compared to far-field radiative heat transfer between metallic surfaces due to both near-field and thin-film effects. In another work, SU8 polymer posts were successfully fabricated with well-controlled thickness to serve as spacers for creating the nanometric vacuum gaps. The near-field thermal radiation between two 1 × 1 cm^2 heavily-doped silicon chips was measured to be 11 times over the blackbody limit at 190 nm vacuum gap precisely determined by the capacitance method. Finally, some preliminary experimental results for thermal regulation of near-field radiation with temperature-controlled VO_2 and electrically-gated graphene will be presented.

BIOGRAPHY

Dr. Liping Wang received his Ph.D. in mechanical engineering with a focus on nanoscale radiative heat transfer in 2011 at Georgia Institute of Technology under the guidance of Professor Zhuomin Zhang. He started his academic career as an assistant professor at Arizona State University in 2012 and was promoted to associate professor with tenure in 2018. Dr. Wang's research aims to selectively control thermal radiation for energy applications by fundamentally understanding and exploring novel physical mechanisms in nanoscale radiative transport. Besides, he has been investigating near-field thermal radiation for energy harvesting and thermal management applications, in addition to the development of many novel optical and thermal metrologies. His research findings have been published in more than 60 peer-reviewed high-impact journal papers in applied physics, optics, heat transfer, and materials. Dr. Wang has been serving as Secretary for ASME K9 Nanoscale Thermal Transport Committee since 2018, and organizing many international heat transfer conferences. He is the recipient of *2017 AFOSR Young Investigator, 2016 JQSRT/Elsevier Viskanta Young Scientist Award,* and *2015 NSF CAREER* Awards, as well as *2013 Top 5% ASU Engineering Faculty Teaching Award*.

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