Plasmonics in nanoparticles for solar energy conversion and thermal transport

Zhuomin Zhang

George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, 801 Ferst Dr. NW, Atlanta, GA 30332, USA (zhuomin.zhang@me.gatech.edu)

When absorbing particles (such as metallic nanoparticles) whose dimensions are much smaller than the electromagnetic wavelength, localized surface plasmon resonance (LSPR) can be excited, giving rise to enhanced scattering and absorption cross sections. One way to increase the efficiency of solar thermal conversion is by dispersing nanoparticles in liquids to create highly absorbing liquid, i.e., “black” liquid. Photothermal effects can enable steam generation using solar radiation or a laser source. For solar thermal systems, increasing the absorption peak and broadening the absorption band are both important, since the ultimate goal is to achieve high total power absorption. For this reason, we propose to combine a carbon-cone and gold-shell to boost the total solar absorption efficiency factor (SAEF) of nanoparticles [1]. Further, we study the effects of geometry, material, as well as the surrounding on the SAEF [2]. The wavelength range of consideration is from ultraviolet (300 nm) to near-infrared 1100 nm, since water is highly absorbing beyond 1100 nm. We have identified carbon-core gold-shell [1] as well as star-shaped gold nanostructures [2] as promising systems that can boost SAEF by exciting plasmonic resonances. The effect of graphene-coated nanoparticles on light absorption will also be investigated.

Dielectric materials can support surface phonon polaritons (SPhPs). In an array of nanoparticles, such as SiC or SiO_2, localized SPhPs can be coupled between neighboring structures, resulting in substantial energy transfer via propagating SPhPs that could contribute more to heat conduction than phonon transport in the system. We have illustrated that the near-field emission spectrum from ordered nanoparticle arrays is dictated by the density of states of propagating SPhPs when they are present [3]. Moreover, we will employ the coupled dipole method as well as the dispersion-based analysis of propagating surface modes to calculate the thermal conductivity of a chain of SiC nanoparticles.

References

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