Extraordinarily transparent compact metallic metamaterials

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Abstract

Metals are highly opaque, yet we show numerically and experimentally that densely packed arrays of metallic nanoparticles can be more transparent to infrared radiation than dielectrics such as germanium, even for arrays that are over 75% metal by volume. Despite strong interactions between the metallic particles, these arrays form effective dielectrics that are virtually dispersion-free, making possible the design of optical components that are achromatic over ultra-broadband ranges of wavelengths from a few microns up to millimetres or more. Furthermore, the local refractive indices may be tuned by altering the size, shape, and spacing of the nanoparticles, allowing the design of gradient-index lenses that guide and focus light on the microscale (see figure a). The electric field is also strongly concentrated in the gaps between the metallic nanoparticles, and the simultaneous focusing and squeezing of the electric field produces strong 'doubly-enhanced' hotspots (see figure b) which could boost measurements made using infrared spectroscopy and other non-linear processes over a broad range of frequencies, with minimal heat production.

References

[1] Extraordinarily transparent compact metallic metamaterials. *Nature Communications* (2019) 10:2118 | https://doi.org/10.1038/s41467-019-09939-8.

Figures

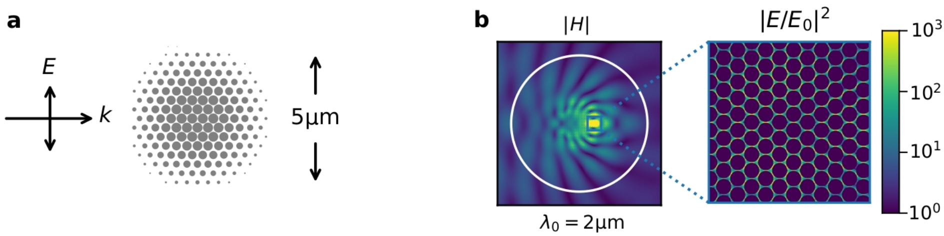

Figure 1: (a) Schematic of a 'concentrator' gradient-index lens composed of gold nanocylinders on a triangular lattice with 50nm site-to-site separation (b) Magnetic near-fields and broadband 'doubly-enhanced' electric field hotspots