Extremely Thin Infrared Absorbers
Made of Metallo-Dielectric Core-Shell Nanospheres

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During the first years of Metamaterials, losses were usually considered undesirable for the most of envisioned applications. Oppositely, in 2008 a paper titled "Perfect Metamaterial Absorbers" just took advantage of the losses (N. I. Landy et al., Phys. Rev. Lett., vol. 100, p. 207402, 2008). A perfect absorber was built as a 2D periodical array of resonant particles responding to both the electric and magnetic field. Just at the resonance frequency a narrow band of quasi-perfect absorption appears. An important drawback is that this absorber is polarization dependent and very sensible to the incidence angle. Subsequent papers (X. Liu et al., Phys. Rv. Lett., vol. 104, p. 207403, 2010; J. Hao et al., High performance optical absorber based on a plasmonic metamaterial, Appl. Phys. Lett., vol. 96, p. 251104, 2010) addressed this problem by using as unit cell a metallic cross or a metallic square over a metallic plane. The same plausible explanation was given in all these papers: in order to avoid any reflected power, the effective medium impedance must match to that of vacuum and, in order to reduce the transmitted power, the imaginary parts of ε and μ must be high enough, so that most of the power is dissipated inside the slab.

In this work, we studied a perfect absorber that absorb all radiation in a sharp frequency region and is almost transparent outside that band. The perfect absorber under consideration is a square periodic array of nanospheres composed by a core of metal and a shell of dielectric (see Fig. 1). Figure 2 shows the absorption coefficient obtained by full wave simulations. Nanospheres can be seen as electrically small resonators creating effective electric and magnetic surface currents which, with a geometry properly designed, allow the cancelation of the incident field into the back side of the surface while no reflection is scattered forward to the front side. Although the theory was mounted for normal incidence, we expect that, due the isotropy of the proposed unit cells, the stability of the absorption coefficient will be good respect to different polarization states and incidence angles. From the practical point of view, this idea can be used for designing thin infrared absorbing sheets in comparison with conventional absorbers, what might means the reduction of future photonic devices.

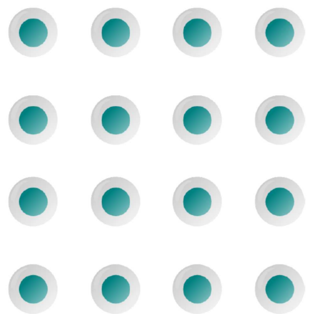

Fig. 1 A 2D periodic array of Metallo-Dielectric Core-Shell Nanospheres.

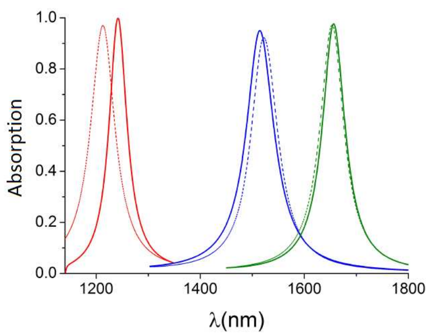

Fig. 2 Absorption coefficient: theory (dotted lines) and simulations (solid lines). Core of Ag covered by a shell of Si (red), Ge (blue), and a certain theoretical material.