A New Dielectric Metamaterial building block with a strong magnetic response below 1.5 micrometers region. Silicon Colloids nanocavities

Lei Shi, T. Umut Tuzer, Roberto Fenollosa and Francisco Meseguer*

Centro de Tecnologias Fisicas, Unidad Asociada ICMM/CSIC-UPV Av. Los Naranjos s/n, Valencia, 46022, Spain
Instituto de Ciencia de Materiales de Madrid CSIC

fmese@fis.upv.es

A new dielectric metamaterial building block has been processed and characterized (Fig. 1 inset). It is based on high refractive index silicon spherical nanocavities with Mie resonances appearing in the near infrared optical region. Both, experiments and theoretical calculations (Fig. 1) clearly show that a single silicon nanocavity supports well defined and robust magnetic resonances, even in a liquid medium environment, at wavelength values up to six times larger than the cavity radius [1].

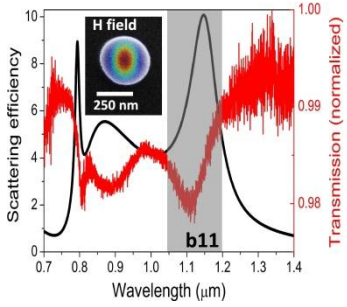

Figure 1: Scattering (black) efficiency as a function of wavelength and the experiment transmission spectra (red line) of single silicon nanocavity (diameter: 306 nm) are shown. The SEM image and the magnetic field distribution inside the nanocavity are also shown inset.

Furthermore, based on those "optical magnetism" silicon nanocavities, strong magnetic interaction between optical waveguide and silicon nanocavities are also reported [2]. The magnetic field component of light in dielectric materials generally plays a negligible role at optical frequency values. However, it is a key component of metamaterials with optical magnetism [3]. Here, the analytical method, as well as the finite difference time domain (FDTD) simulation, shows a three dimensional (3D) magnetic trap effect when the magnetic like Mie resonances of the silicon nanocavities are excited (Fig. 2).

References

[1] Lei Shi, T. Umut Tuzer, Roberto Fenollosa and Francisco Meseguer, Adv. Mater., DOI: 10.1002/adma. 201201987, (2012) accepted.
[2] Lei Shi and Francisco Meseguer, Opt. Express, (2012) accepted.
[3] R. Merlin , Proc. Natl. Acad. Sci. USA, 106, 1693, (2009).

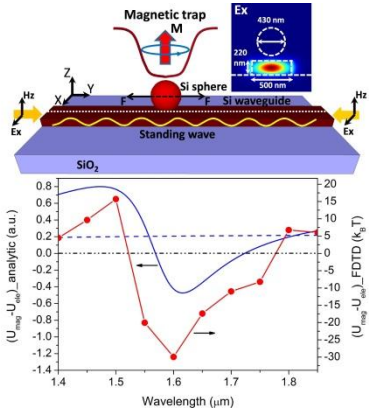

Figure 2: Upper, schematic view of a spherical silicon nanocavity located above the top side of a silicon waveguide. The waveguide cross section and the field distribution of Ex in the waveguide is shown inset. Lower, the potential difference between the high magnetic field region and high electric field region at the waveguide as a function of wavelength for both the analytical model (blue line) and FDTD simulation (red line). For comparison purposes, we have also plotted the PS sphere as a blue dash line. The diameter of silicon and PS spheres are 430 nm, and the intensity of guided light in waveguide is 0.9 mW.