Enhancement of optical scattering by using metamaterial structures

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Optical super-scatterers can have significant practical applications in sensing, spectroscopy, bio-medical imaging, solar cells and other applications which need efficient manipulation of scattering. Recently some studies have reported the phenomenon of super-scattering from radially anisotropic nano-wires [1]. Super-scattering from a subwavelength nanostructure occurs when the normalized scattering cross section (NSCS) is greater than unity [2]. Generally, super–scattering is observed for narrow spectral band and strongly depend on the losses in the materials involved. In this study, we present the realization of the super-scattering phenomenon in the broad visible region by using cylindrical hyperbolic metamaterial (CHMM) structures consisting of practical materials with loss.

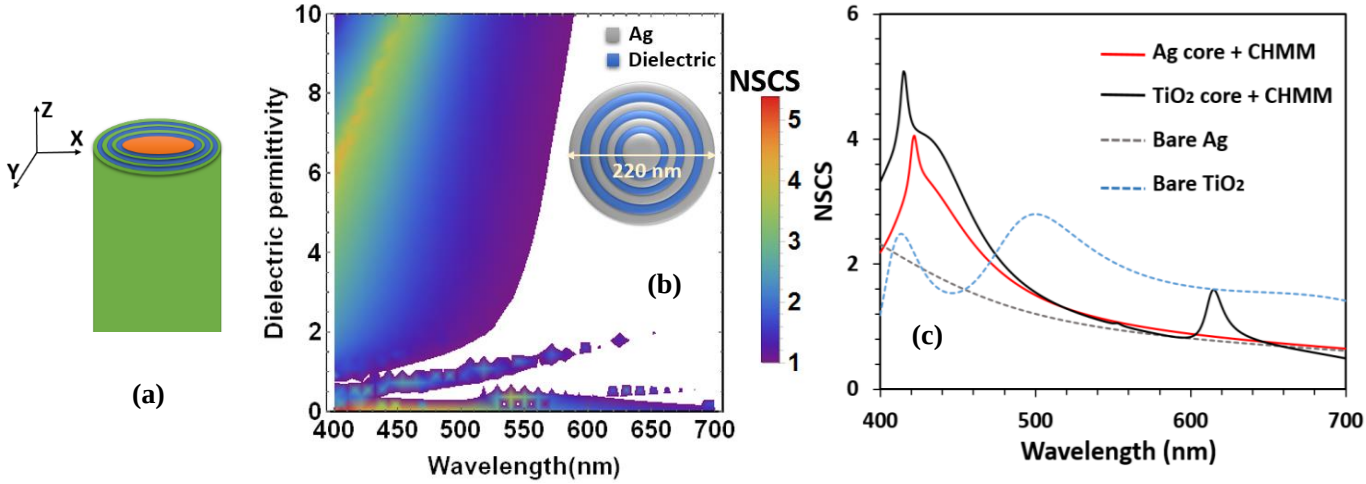

Fig. 1 (a) Schematic of a structure showing a core material with CHMM shell. (b) Optimization of NSCS for a structure with silver (Ag) as core material (c) Comparison of NSCS for different structures with diameter 220nm.

Fig. 1(a), represents the general schematic of the proposed super-scatterers which consists of a core material with CHMM shell. In Fig. 1(b), we show the optimization results of NSCS for one of the structure with Ag core (radius=50 nm) and CHMM shell (six layers of thickness 10 nm). Using this optimization we selected Titanium dioxide (TiO_2) as the suitable dielectric material and then compared the NSCS of different structures as shown in Fig. 1(c). We observe that due to the use of CHMM structure, scattering is enhanced for a broader spectral range with twofold enhancement around 425 nm, when compared to the other bare core structures. Further tuning can be done with respect to the thickness of individual layers and core radius to obtain the super-scattering effect in different spectral regions such as near infrared region.

References:

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[2] Zhichao Ruan, Shanhui Fan, Phys. Rev. Lett. 105, 013901 (2010)