Dielectric ring shaped metamaterial perfect reflector

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1. Introduction

All-dielectric metamaterials have an upper hand over conventional metal-dielectric composites. Due to the absence of metallic inclusions, power dissipation is negligible. The functionality of dielectric metamaterials relies on the excitation of Mie-resonance in nanoparticles of high dielectric constant. Silicon is a highly permittivity material, and the fabrication techniques pertaining to it are well understood. In this article, a design of dielectric ring shaped particle based metamaterial perfect reflector has been proposed .

2. Design and Numerical Analysis

Design

The metamaterial is basically a periodic arrangement of silicon rings as shown in figure 1.

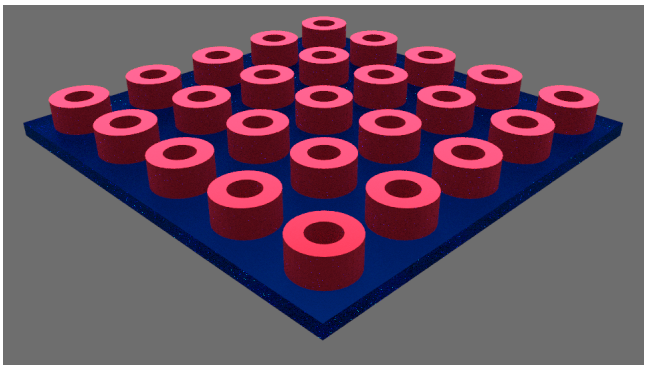

Figure 1. Design of the proposed metamaterial

The outer diameter (d) is 600 nm, height (h) is 300 nm and periodicity (a) is 720 nm. Inner diameter (d_1) has been varied from 150 nm to 300 nm and effect of inner diameter has been studied. Metamaterial perfect reflector made up of an array of cylinders has also been analysed here, which can be tuned to operate at different wavelength by varying the diameter and height of the nanocylinder.

Numerical analysis

Unit cell of the metamaterial was analyzed in COMSOL Multiphysics with periodic boundary conditions. Wave was made to propagate normal to the plane of periodicity. In this way, reflection spectrum has been calculated for different values of d_1 (150 nm, 200 nm, 250 nm and 300 nm). The obtained reflection spectrum has been shown in figure 2.

3. Results

Reflection spectrum shown in figure 2, has been calculated for different values of inner diameters. It can be noticed that as the inner diameter d_1 increases, reflection peak shifts towards the shorter wavelengths. It can also be noticed that in case of ring shaped nanoparticle, reflection coefficient is much higher than that in case of disk shaped particles (when $d_1 = 0$).

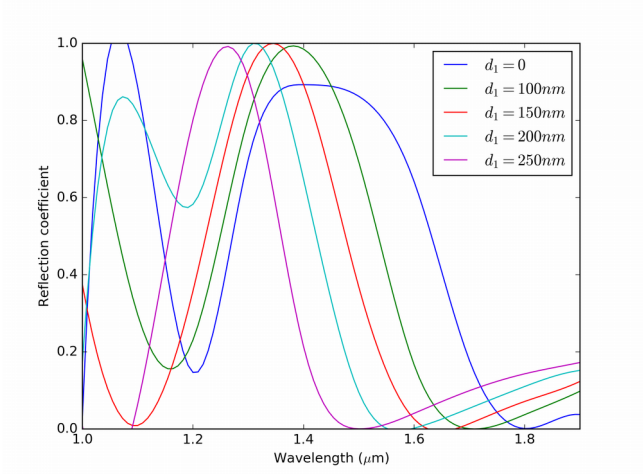

Figure 2. Reflection spectrum

Conclusion

The dielectric ring type metamaterial perfect reflector has been successfully proposed.

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References

[1] Slovick, Brian, et al., Phys. Rev. B, **88.6** (2013) 165116
[2] Moitra, Prakshit et al., App. Phys. Lett., **104.17** (2014) 171102
[3] Moitra, Prakshit et al., ACS Phot. **2.6** (2015) 692-698