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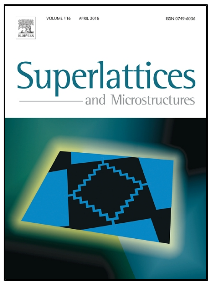

Ellipsoidal all-dielectric Fano resonant core-shell metamaterials

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Ellipsoidal all-dielectric Fano resonant core-shell metamaterials

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Abstract

In this paper, ellipsoidal core (Si) and shell (SiO_2) metamaterial has been proposed for highly directional properties. At the wavelength of magnetic resonance, Fano dip occurs in the backward scattering cross section and forward scattering enhancement takes place at the same wavelength so that there is an increment in the directivity. Effect on the directivity by changing the length of ellipsoidal nanoparticle along semi-axes has been analyzed. Two Fano resonances have been observed by decreasing the length of the nanoparticle along the semi-axis having electric polarization, where first and second Fano resonances are attributed to the dipole and quadrupole moments, respectively. These Fano resonant wavelengths in ellipsoidal nanoparticle exhibit higher directivity than the Kerker's type scattering or forward scattering shown by symmetrical structures like sphere. So, this core-shell metamaterial can act as an efficient directional nanoantenna.

Keywords: Directional nanoantennas; Magnetic response; Fano resonance; metamaterials.

1. Introduction

Recent advances in the field of metamaterials have revolutionized the emerging field of nanophotonics by manipulating light at the subwavelength scales. This astonishing property of metamaterials is underpinning a lot of applications in nanoantennas [1], [2], photovoltaics [3], [4], super lens [5], [6], cloaking [7]-[9] and biomedicine [10]. However, metallic nanoparticles do a great job of confining light to deep-subwavelength structures. But conductive losses of metallic nanoparticles make them less attractive and in the visible region, losses of metals become more prominent. So they are prohibited to many important applications like nanoantennas, sensing and quantum light sources. Moreover, it is very cumbersome to fabricate such a complicated geometry of split ring resonators (SRRs) which are used to obtain magnetic response in metallic nanoparticles.

In order to overcome these inevitable problems of metallic nanostructures, recently all-dielectric metamaterials have been proposed [11]-[22]. All-dielectric resonators support electric as well as strong magnetic resonance even in the visible region. In the dielectric nanoparticles, magnetic resonance takes place by circular displacement current and in the metallic SRRs, resonance occurs due to conduction current. However, in both the structures, electric field revolves around the resonator and magnetic field oscillates up and down in the middle of the resonator at the magnetic resonance. First experimental demonstration of magnetic resonance in the dielectric resonators has been shown in the GHz region, where it has been proved that dielectric resonators have three times higher quality factor than that of metallic SRRs [12]. Now, magnetic resonance has also been achieved in the visible region in all-dielectric nanoparticles [17], [18]. Dielectric nanostructures deliver another striking phenomenon of directional scattering which is well explained using Kerker's type scattering [24]-[26]. Further, to improve directional scattering, Fano resonance has been achieved in the dielectric nanoparticles [27]-[29]. Fano