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Original research article

Investigated the Fano resonance in the nano ring arrangement

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ABSTRACT

Field enhancement in Plasmonic and FANO mode at nano antennas are noticed recently, here, we are modeled a nano antenna for achieving Fano resonance and for this aim, we are made asymmetric formation in nano ring structure and studied the parametric effects on Fano resonance controlling. We have debated on E-field enhancements at resonances with comparison the parameters effect on Fano resonance energy. We show that the single ring has plasmonic mode and adding an inner ring made Fano resonance and shows that the energy in dark mode is increased drastically. Here, the study of the inner ring position is indicated that how the bright mode and dark mode have appeared in nano antenna. Figure of merit (FOM) is studied for different additional material effects on prototype structure and $\Delta(E)$ variation is noticed. The structure is modeled with FDTD simulation by the CST microwave studio and for substrate; we selected SiN with a thickness of 40 nm. Here for achieving dark mode energy, novel shape of the dual ring nano antenna is suggested for concentration of the energy in small point to increase the interaction between nano particle and bio-particle.

1. Introduction

The renewed interest in the so-called field of plasmonics has come from recent advances in the investigation of the electromagnetic properties of nano-structure materials. The ability of metallic nanostructures to confine and enhance incident radiation offers unique possibilities for manipulating light at the nanoscale by using surface plasmons. The surface plasmon polaritons (SPPs) have been noticed tremendously for enhancement of the electromagnetic energy in a subwavelength and optical regime base on Interaction of light with metal-dielectric materials and the 300–1000 nm wavelength is selected for plasmonic application [1–3].

The Metamaterial is introduced as an especial material with negative permittivity and permeability that are not available in nature and natural structures and made artificially abnormal formation in metal and recently is noticed for making nano antenna [4–6]. Enhancement of the electromagnetic field on a metal surface is taking attention for enhancing sensitivity. The quality of the spectroscopic signal of molecule absorption is important that is called surface enhanced Raman scattering (SERS) [7,8]. During the last decade, Various forms of the nano-antenna in different shape and arrangement is suggested at the optical and infrared range for bio-sensing and spectroscopy application such as monopole (nano rods) [9], Dipole [10], Bowtie

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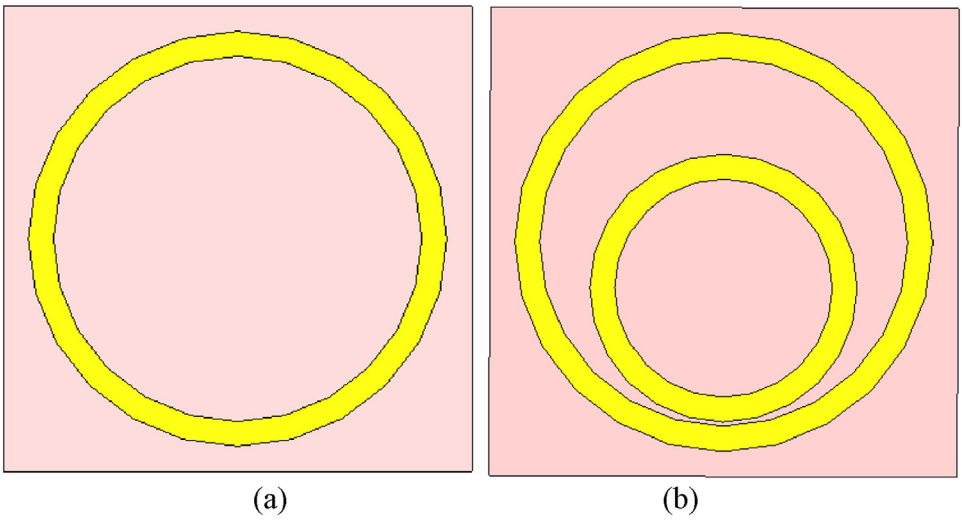

Fig. 1. Prototype nano-antenna top view (a) nano ring antenna (b) the prototype Fano antenna.

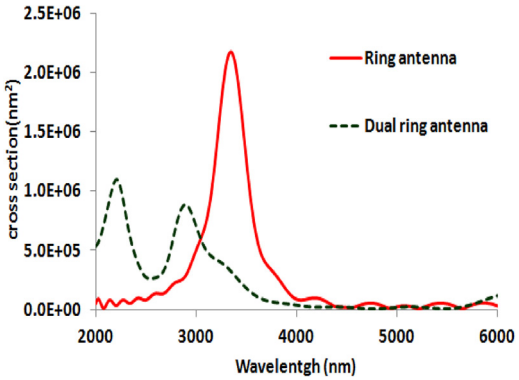

Fig. 2. The extinction cross section for both prototype structures.

[11], disk [12] for basic model. Recently, complicated structures such as a U shape [13], SRR (split ring resonator) is developed based on the metamaterial structure [14]. The interaction between plasmon modes of individual nano-structure can generate the subradiant bonding and subradiant antibonding plasmon modes. In plasmonic nanostructures, the asymmetry line shape of the Fano resonance appears the interaction of non-radiative (dark quadrupole) modes with radiative (bright dipole) modes. In addition, the line shape of Fano resonance can be influenced by the near-field interaction between the dark and bright modes [15–17]. The Fano resonance known by the asymmetric line, shape based on hybridization of different plasmon modes and for high-Q structure [18,19]. Asymmetric structure is noticed more Fano resonances such as Ring/Disk Plasmonic Nanocavities [20], interactions between dipole and Multi-pole plasmons in T-shaped nano-rod dimer [21] or Using hotspots in a single-stone ring-like structure [22] and For symmetric formation, Heptamers disk have been studied too much for the simple arrangement [23] or necklaces arrangement [24].

In plasmonic nanostructures, the asymmetry line shape of the Fano resonance appears by interaction of non-radiative (dark quadrupole) modes with radiative (bright dipole) modes. In addition, the line shape of Fano resonance could also be influenced by the near-field interaction between the dark and bright modes [25–27]. Single Fano resonance achieves the interference between one bright mode and one dark mode, combining a bright mode with multiple dark modes can result in multiple Fano resonances [28].

Figure of merit (FOM) is a numerical value as a definition for the quality characteristic and performance of a device or a material for special parameter and in optical devices, various factors are noticed for FOM measurement such as wavelength ($\Delta\lambda$), current density (ΔI) and energy change (ΔE) [29–31].

At the first step, the ring structure is implemented and plasmonic mode is obtained. For the second step, the inner ring added to the structure, the Fano resonance is achieved, and for making asymmetric structure, the shift of the inner ring is noticed. The comparison shows how the inner ring will affect on the bright and dark mode in nano antenna. We show that