Nano Antenna Design for Optical Frequencies

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ABSTRACT

Suitably shaped metal nanostructures acts as resonant optical antennas that efficiently collect light an confine it to a sub wavelength volume which has been modified by using the dielectric resonators working at optical frequencies. In radio frequencies and microwaves a category of antenna known as dielectric resonator antenna (DRA), whose radiant element is dielectric resonator (DR). In this paper we study the results obtained by placing the two cylindrical dielectric resonator (DR) in series rather than in parallel through a Nanostrip made of silver at optical frequency of 193.5 THz. Numerical demonstrations showing the fundamental antenna parameters for circular cylindrical NDRA type have been carried out for the short (S), conventional (C), and long (L) bands of the optical communication spectrum.

Key words: Nanoantenna Array, Dielectric Resonator Antenna, Plasmonics, Optical Communication, Return Loss.

I. INTRODUCTION

The concept of antennas at optical frequency has recently opened up new fields of experimental and theoretical research in nanotechnology and antenna science apart from optical devices [1]. The growing interest in optical antennas and Nano scale metals can be attributed to their ability to support Plasmon resonances that interact with optical fields [2]. The meritorious advances of nanotechnology experienced in recent years have increased the interest in optical antennas as devices for efficiently manipulating light by means of their optical properties such as concentration, absorption and radiation of light at nanoscale.in this instead of normal RF antenna the concept of NDRA has been introduced [3].Generally, DRs as ideally isolated electromagnetic devices may exhibit infinite resonant modes. Through an appropriate excitation of certain resonant modes, the DRs may be used as resonant cavities or efficient radiators. Thus with the knowledge of its resonant modes, the one can qualitatively predict the antenna behaviour and estimate the produced far field, which is fundamental to the antenna design. As in the case of the circular cylindrical resonator, the T , T , and H modes have been the most used ones in applications involving radiation and behave qualitatively, respectively as: a short vertical magnetic dipole, a short vertical electric dipole, and as a horizontal magnetic dipole [4]. Here, vertical and horizontal refers to the directions which are parallel and orthogonal, respectively, to the cylinder axis. The design of a single dielectric cylindrical resonator nanoantenna has been studies earlier following by the design of two element dielectric resonator nanoantenna which was placed parallel over the metal nanostrip which was separated by the dielectric substrate.

2. DESIGN

Each radiating element chosen has a circular-cylindrical shape and is composed by silicon with h=325nm and d=510nm. The resonator is above the nanostrip and positioned to obtain a maximum wideband. The antenna substrate is composed by SiO_2 and the ground plane is composed by silver. The thickness of the SiO_2 layer between the nanostrip and the ground plane is h_1=145nm. There is a layer of thickness h_3=10nm made of SiO_2 between the nanostrip and the DR. The nanostrip has w=340nm of width and h_2=20nm of height. The metallic regions of the nanostrip are composed by silver. Whose dispersive properties were described by the Drude model assuming =5, fp=2175THz, and γ=4.35THz [5][8]. A DRA was investigated in nanoscale and operating at optical frequencies.

The dielectric resonators are placed in series over the nanostrip. The resonators are composed of silicon (= 11.56).The resonance frequency of DR's H mode in free space, can be estimated from, [6]

According to this equation the mode can resonate at 193.5 THz when *d* and *h* are assumed proportionally. The length of nanostrip which is assumed to be under the resonator is taken as "s", which plays a very crucial role in the variation of the result.[7]

The first design considered, has two cylindrical resonator elements, each of equal height and diameter, one is kept near the end of nanostrip and the other is kept at the midpoint of the length of nanostrip. The other design differs in the position of the second resonator which has been shifted away from the centre line of nanostrip .The design has been altered for same applications as for the two dielectric resonator array in parallel which is image processing and spectroscopy[8]

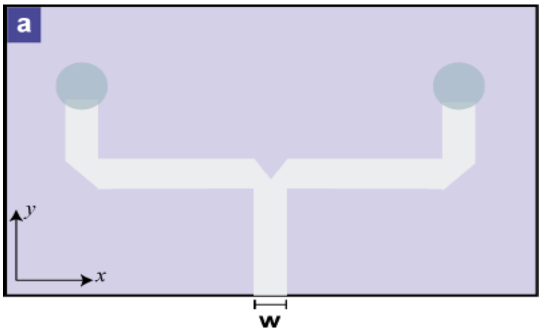

Figure a) Top view

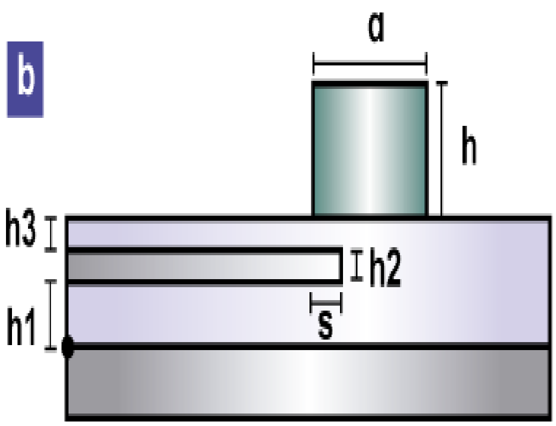

Figure b) lateral view of parallel fed dielectric resonator nanoantenna

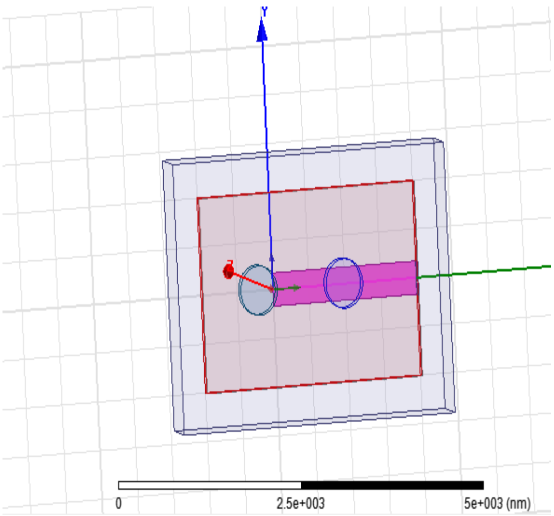

Figure 1 top view of serially placed dielectric resonators

In this the height of the substrate, the ground plane as well as the cylindrical resonator is taken same, but the difference is in the silver nanostrip whose width is same i.e 340nm but as the resonators has to be placed serially so just a single strip is needed for this. The other modification is done when the other resonator which is placed on the midway of the nanostrip is shifted away a little bit away from the axis.

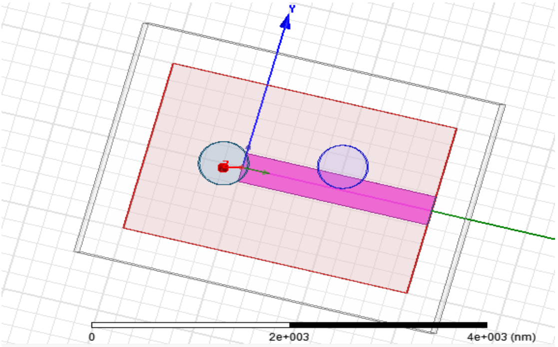

Figure 2 top view of shifted resonator

3. RESULTS

The results are simulated on HFSS14.0 software used to obtain the parameters like return loss, gain, VSWR, radiation pattern, etc. The results of the initial design that of parallel placed resonators has return less of approximately -16db and the gain obtained is approximately 8.5db.

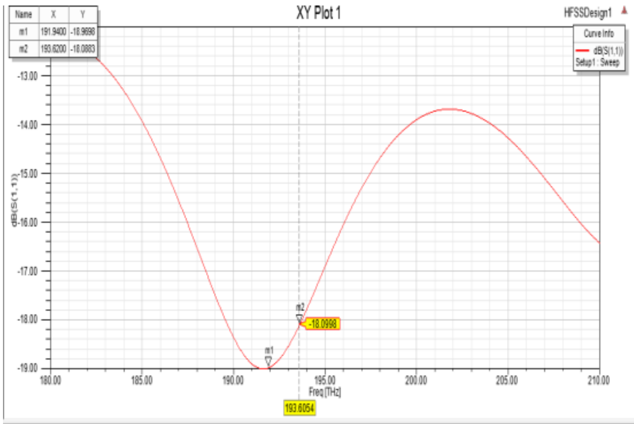

Figure 3 return loss for serial midway placed dielectric resonator is -18db

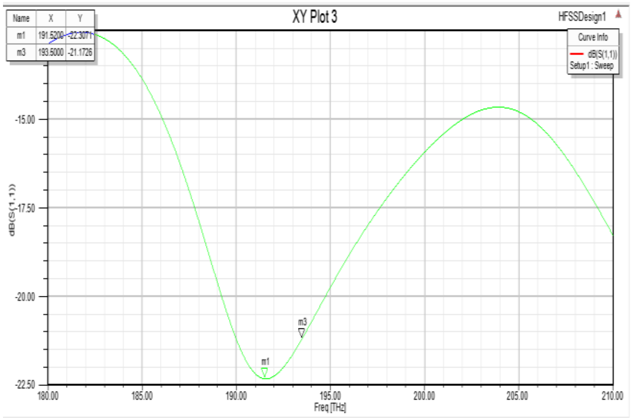

Figure 4 return loss of serially shifted resonator is -21db

The VSWR is another important parameter which estimates for the reflection coefficient of the antenna.The VSWR for the for the serial midway dielectric resonator nanoantenna is 1.28 and for shifted dielectric resonator nanoantenna is 1.9.

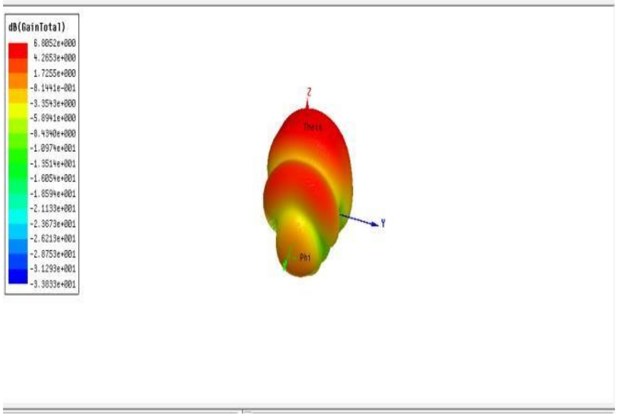

Figure 6 gain for the serial midway dielectric resonator nanoantenna is 6.8db

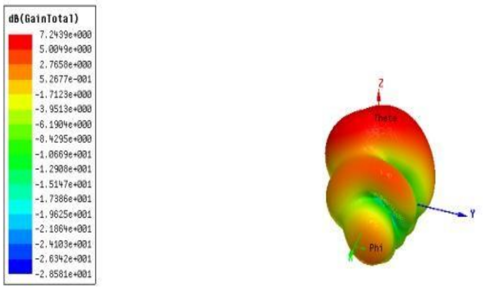

Figure 7 gain for the serial shifted dielectric resonator nanoantenna is 7.4db

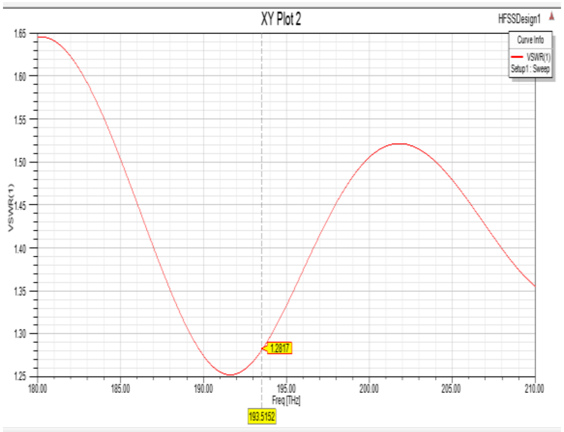

Figure 8 VSWR for the serial midway dielectric resonator nanoantenna

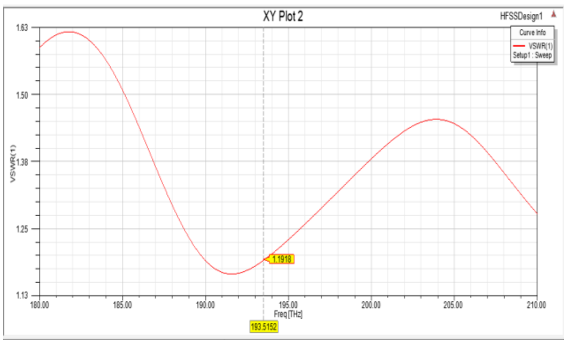

Figure 9 VSWR for the serial shifted dielectric resonator nanoantenna

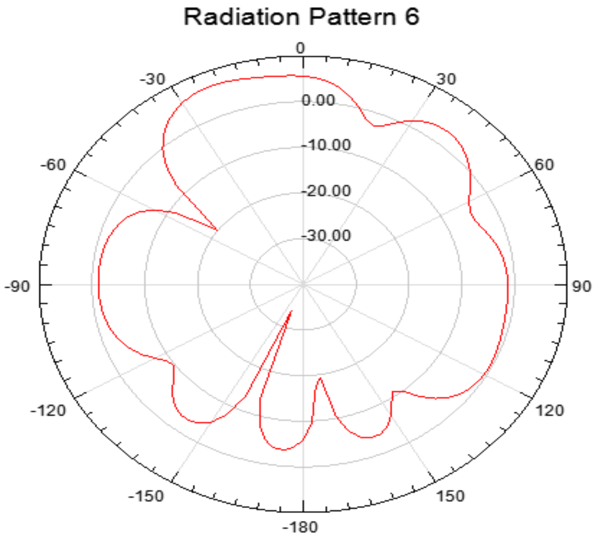

Figure 10 radiation pattern for the serial midway dielectric resonator nanoantenna

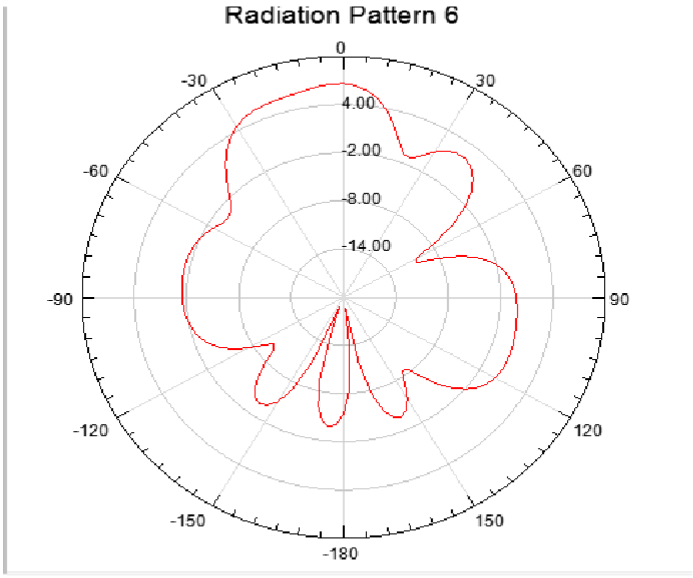

Figure 11 radaition pattern for for the serial shifted dielectric resonator nanoantenna

4. CONCLUSIONS

In this paper a summerised analysis of the serial dielectric resonator nanoantenna array has been done and the simulated results obtained are better than the parallel placed resonators.Moreover the size of the nanoantenna is more compact,the nanostrip which is made of silver used in the serial resonator design is just a single strip unlike the initial design hence, cost effective.the resonators placed are in series hence the power distribution in this design is easy as compared to that of the parallel one.These type of nanoantennas are wideband type which also acts as coupling device with the optical devices.

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