Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

Study and Analysis of Spectral Field Intensity Enhancement of Circular Bow-Tie Nano Antenna with Varies Geometric Parameters

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***Abstract*— The Antenna is key element in whole wireless communication system. The circular Bowtie Nano Antenna plays a vital role in transmitting and receiving of a band signals, to design wideband resonance of Nano-Antenna we required to understand and design of antenna in balanced way. There are many methods are available to obtain the spectrum response of the antenna by excitation. The Circular Bowtie Nano Antenna geometric parameters like Bow angle, Bow gap and thickness of insulator determines the Spectrum characteristics of Circular Bowtie Nano Antenna. Thus in this paper we have designed and simulated by using FDTD Technique with varies values of Bow angle and Bow gap and analysis is done in field intensity enhancement. The design of Circular Bowtie Nano Antenna is well suitable for wireless broadband communication like design of the Photonic devices that is characterized for field intensity improvement.**

Keywords*— Field intensity enhancement, circular Bowtie Nano Antenna, Bow_angle, Bow_gap.

I. INTRODUCTION

Advancement in Nanotechnologies, Nano material, Nano particles, Nanowire and Nanotubes are emerged as very important elements in development of optoelectronics devices [1]. Nano particles show a many unique characteristics that from their geometries, gives best performance of the optical devices. In particular, Bowtie Nano Antenna is one of the candidates for the modern wireless communications system. Optical antenna is ability to induce large and localized EM fields. Optical antenna operates based upon the metal structure and the resonance of excited field. If an incident field is interact with exact dimensions of optical antennas, Plasmons are generated due to resonant coupling between the EM waves and oscillation of free electrons in the metal structure. Field is reflected when incident wave is less than the resonance frequency, because motion takes place in the carrier charge acts out from the screen of incident field. When the incident field frequency above the resonance frequency; field is transmitted due to the charges are not able to respond quickly enough to screen out the incident field [2]. Incident field is absorbed and reradiated only when at the resonance frequency. By proper orientation of reradiated waves can be more intensely localized fields generated. This will be used for plenty of applications like spectroscopy, lithography, microscopy, chemical studies, and biosensing [3, 4]. Now day's trends created in the field of research by use of optical antennas to improve performance of photo detectors [5, 6].There are so many novel shaped optical antennas, like Nanotriangle monomers, nanosphere, nanorods dipole antenna bowtie antenna , yagi_Uda antenna, and so on [4]. Among these Nano antennas, bowtie and dipole antenna are suitable for integrating with 1D photo detectors because of their geometries. Bowtie and dipole are nanotriangle dimmers and nanorod dimmers respectively, bowtie and dipole antenna can be considered as opposing tip_to_tip Nanotriangles with tip angle (bow angle) varies from zero degree to wider angles. The adjacent of two Nano pieces of metal as of antenna concentrates the incident wave into a nanoscale gap. The characteristics of optical bowtie antenna have been studies [7, 8], and we demonstrated that dipole antenna can boost photo response of 1D IR detectors [9]. In this paper, we will present the design of bowtie Nano antenna and analysis of spectral field resonance at varies values of geometric parameters like bow angle and bow gap (tip-to-tip gap) to field intensity enhancement with an optimized parameters. The experimental results showed that for signal wavelength of 500nm with enhancement of 15 times.

II. DESIGN OF CIRCULAR BOWTIE_NANO ANTENNA

A. Bowtie antenna geometry

The Bowtie_Nano Antenna structure is defined by the following parameters, such as

- Radius of circular bowtie (R_o)
- Bow angle (χ)
- Bow gap (G_a)
- Thickness of Substrate (T)
- Thickness of Metal (τ)

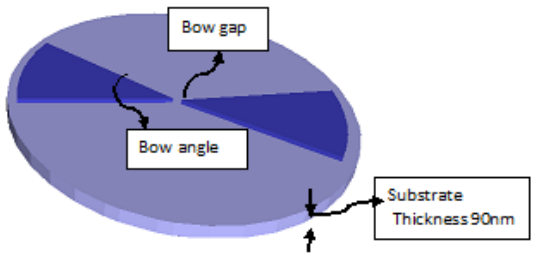

Figure 1 Structure of circular Bowtie_Nano Antenna.

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To authenticate the spectral response of Circular Bowtie_Nano Antenna, a renovated Drude dielectric field is employed as represented in the following Equation 1

$$\xi_u = \xi_\infty - \frac{u_m^2}{u^2 + ju\gamma} \qquad (1)$$

Where

ξ_∞, u_m and $1/\gamma$ representing the Dielectric constant and in the case of silver, the constraints employed are shown below.

$\xi_\infty = 4.039$, $u_m = 9.154$ and $\gamma = 0.815eV$

In this paper the FDTD simulations were used for facilitate the design and performance of the Bowtie_Nano Antenna. For modeling the calculation region were 2500nmx2500nmx2500nm. A symmetric mesh was used outside the antenna with a maximum step of 9nm. In order to study the spectrum characteristic of field intensity enhancement of the Nano antenna was induced by Normal incident Plan wave Polarized in the Y-direction.

In the design of model we used the following some constant value parameters are

Radius of circular bow (R_o) = 1000nm
Thickness of silicon Substrate (T) = 90nm
Thickness of silver Metal (τ) = 60nm

B. Field Intensity Enhancement

The spectrum attributes of field enhancement(E/E_{in}) in which the Nano-antenna is tempted by a normal incident plane-wave polarized in the y direction ,and the Nano antenna is also simulated by an electric field emitter placed at the gap equidistantly between the two halves of the Bowtie_Nano Antenna to evaluate the field intensity enhancement attributes. The electric dipole is situated in the identical plane as the antenna and has been oriented in its longitudinal direction. The field enhancement is evaluated as per Equation 2 given below.

$$E/\mathrm{E}_{in} \qquad (2)$$

III. RESULTS AND DISCUSSIONS

Except the thickness of the substrate the influence of the Bow angle and Bow gap parameter on the properties of Nano Antenna were studied and analyzed by systematically varied in order to investigate the effect on the field intensity Enhancement of Bowtie Nano Antenna.

A. Bow gap dependent Field intensity Enhancement spectrum

Simulation results are obtained for varies Bow angle. With particular bow angle the bow gap is varied in systematically step size of 10nm these spectrum graphs are shown in the fig 2 to 7. It shows that more field intensity Enhancement at low bow gap of 20nm. In further inspection of spectrum at particular bow angles at 30 degree and 35degree the spectral field enhancement is 13 to 15 times was observed that clearly shown in the fig 15. This because of the electric field is concentrated at the gap of the Bowtie antenna with maximum voltage located in the centre gap due to the strong coupling between the two Nano Antennas.

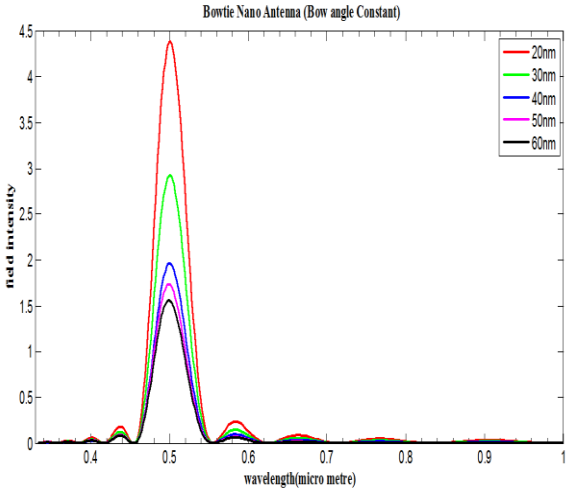

Figure 2 field intensity Enhancement at 20^0 of Bow angle with varies bow gap.

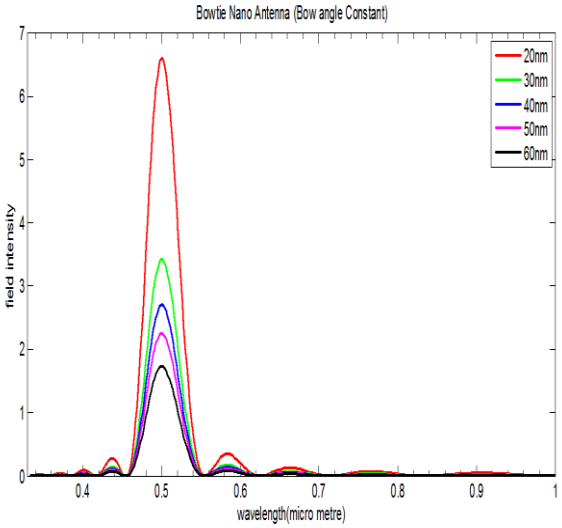

Figure 3 field intensity Enhancement at 25^0 of Bow angle with varies bow gap.

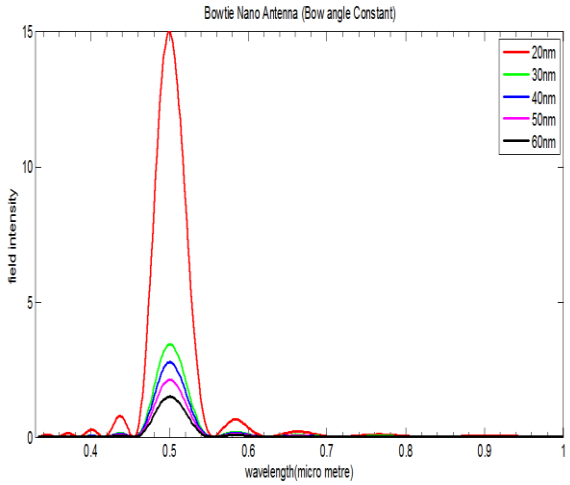

Figure 4 field intensity Enhancement at 30^0 of Bow angle with varies bow gap.

International Journal of Engineering Research & Technology (IJERT)
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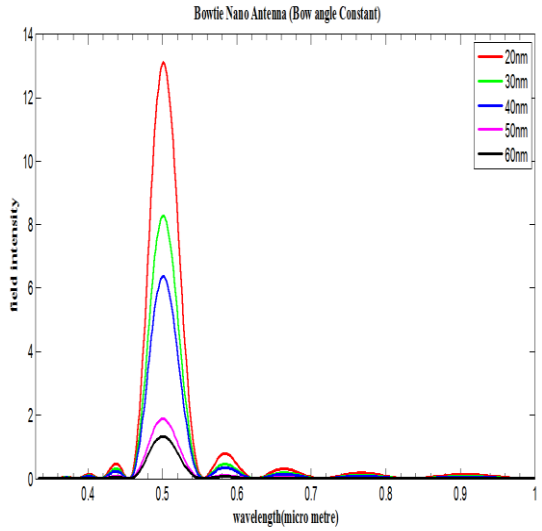

Figure 5 field intensity Enhancement at 35^0 of Bow angle with Varies bow gap.

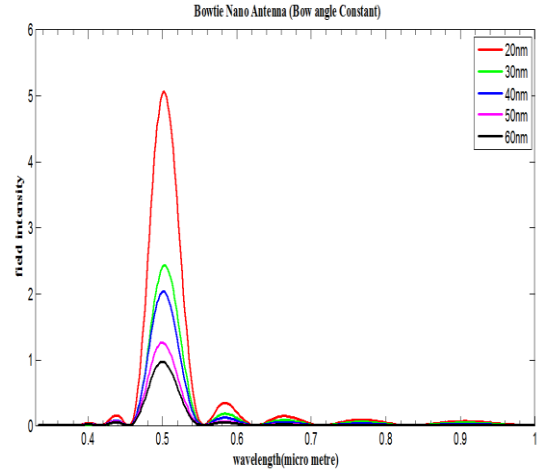

Figure 6 field intensity Enhancement at 40^0 of Bow angle with varies bow gap.

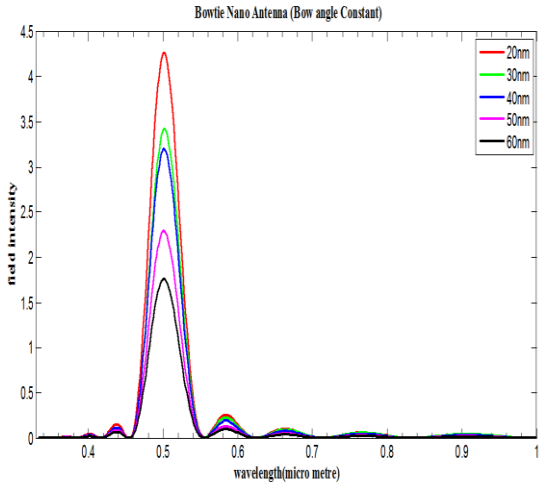

Figure 7 field intensity Enhancement at 45^0 of Bow angle with varies bow gap.

This bow angle of 30degree and 35 degree is the much optimized angle for the better field enhancement of the Bowtie Nano antenna. In our experiment we used half wave length of Nano Antenna 500nm wavelength of signal source and observed very nearest resonance at particular wavelength is obtained. Simulated results for 20nm gap with varies Bow angle 20^0 , 25^0,30^0,35^0, 40^0 , and 45^0 is shown in fig 9. In that at tip_tip_of the bowtie region more E-field radiation patter is observed at a bow angle of30^0,35^0 and at higher the value of angle the radiation pattern is diminished. Similar the Simulated y directional E-field views for varies widened bow gap at 35^0 are shown in fig. 10.

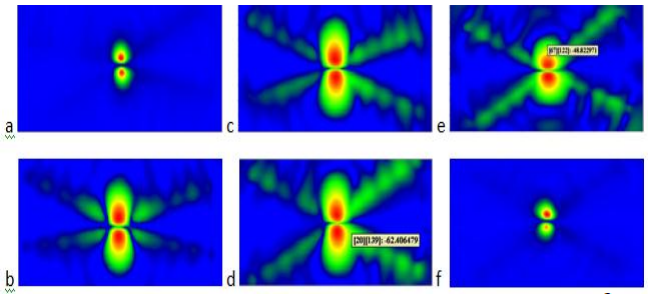

Figure 9 simulated results for 20nm gap with varies Bow angle a. 20^0 b. 25^0 c. 30^0 d. 35^0 e. 40^0 f. 45^0.

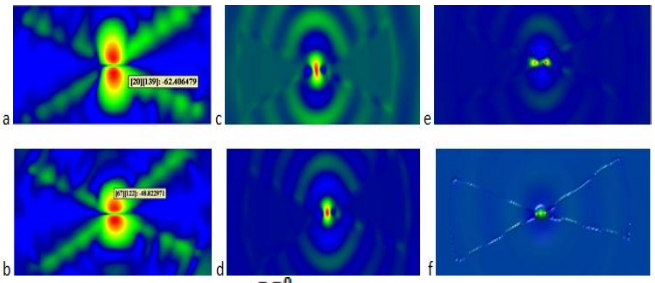

Figure 10 simulated results of 35^0 bow angle with varies Bow gap. a. 20nm b. 30nm c.40nm d.50nm e.60nm f.70nm

Bow gap dependent Field intensity Enhancement spectrum

Similarly Simulation results are obtained for varies Bow gap. With particular bow gap the bow angle is varied in systematically step size of 5 degree, for these obtained spectrum graphs are shown in the fig 11 to 14.

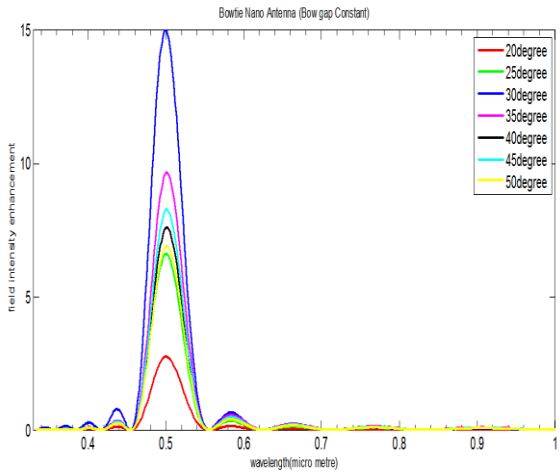

Figure 11 field intensity Enhancement at 20nm of Bow gap with varies widen bow angle.

International Journal of Engineering Research & Technology (IJERT)
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It shows that more field intensity Enhancement at low bow gap of 20nm because at the tip region of the bowtie antenna the concentration of the electric charges is more since lower the bow gap the polarization at gap is more. In detailed inspection of spectrum at particular bow angle like at 30 degree and 35 degree the spectral field enhancement is 9 to 15 times was observed and it is shown in the fig 16. That clearly shows that field enhancement decreases with increase in the bow gap size of the Bowtie Nano Antenna. 30 degree Bow angle is the much optimized angle for the better field enhancement of the Bowtie Nano antenna.

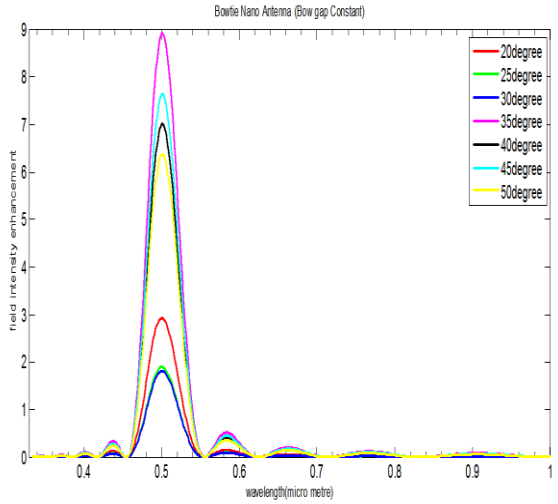

Figure 12 field intensity Enhancement at 30nm of Bow gap with varies widen bow angle.

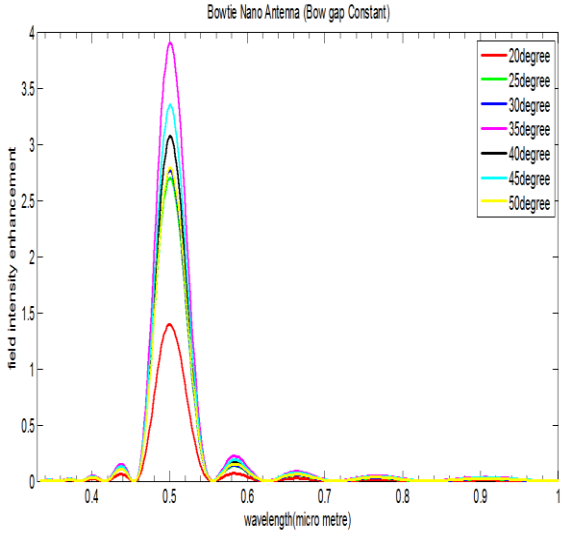

Figure 10 field intensity Enhancement at 40nm of Bow gap with varies widen bow angle.

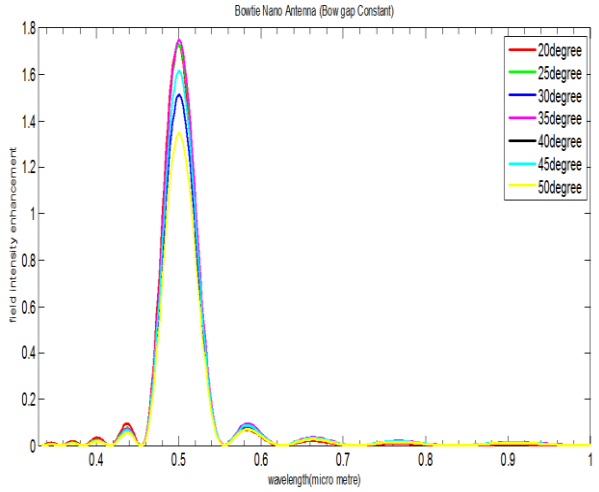

Figure 13 field intensity Enhancement at 50nm of Bow gap with varies widen bow angle.

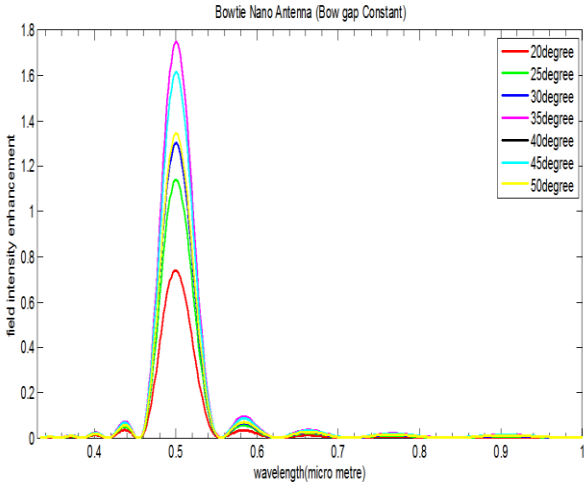

Figure 14 field intensity Enhancement at 60nm of Bow gap with varies widen bow angle.

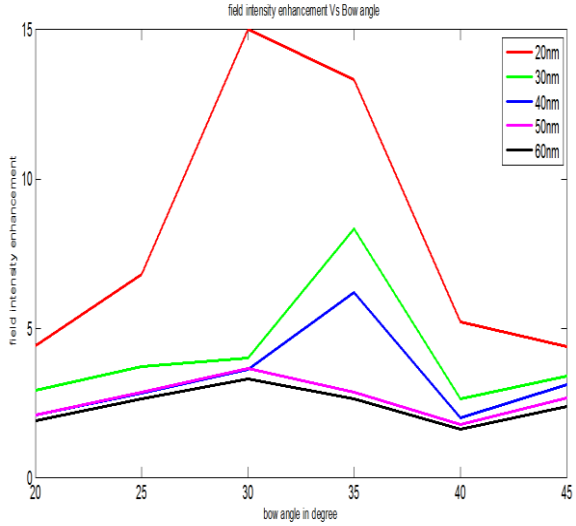

Figure 15 Field intensity Enhancement Vs Bow angle

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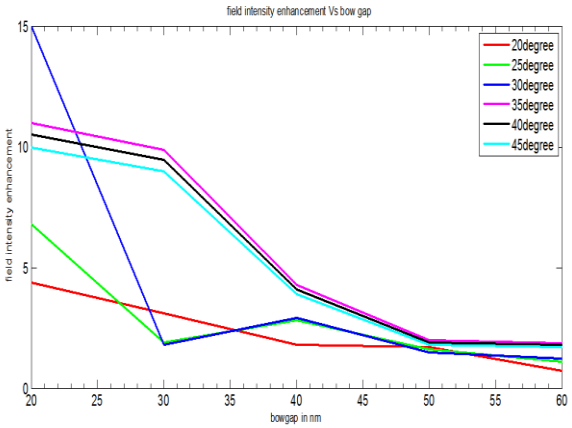

Figure 16 Field intensity enhancement Vs bow gap

IV. CONCLUSION

The design of Circular Bowtie_Nano Antenna at varies Bow Angle and Bow gap was studied. The E_field intensity Enhancement of Bowtie Antenna is more at 30 degree and 35 degree Bow angle with Bow a gap of 20nm. It was shown that the decrease in bow gap increases the field Intensity Enhancement. At varies stages of simulated experimental results analysis shows that the bow angle at 30 degree angle is the best angle value for design of Bowtie Nano Antenna. This Bowtie Nano Antenna becomes a very important element to the Nano_scale Photonic devices.

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