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A Design of Nanoantennas by Nonlinear Micro-ring Resonator Device

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Abstract

This paper presents fascinating simulation results of light pulse, traveling within a micro-ring resonator system that has shown unexpected results with various applications. The design sys consists of a nonlinear micro-ring resonator system, incorporating an add /drop filter micro-ring model. The proposed fabrication material used is InGaAsP/InP, which can provide the required output behaviours. The input light pulses are Gaussian pulse, whereas the suitable simulation parameters are input power, pulse width, ring radii and the material refractive indices. The potential applications of a new design of optical generated high frequency by micro-ring resonator device are used.

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Keywords : Nano-antenna, Nonlinear micro – ring resonator,Optical Nano device

1. Introduction

Nnanoantennas can be design and fabrication of optical antennas [1-4] with prescribed spatial patterns is an interesting gand challenging task. One of the main challenges here is the fact that, in optical frequencies, metals do not usually exhibit high conductivities as in RF and microwaves, but rather, they have permitivities with negative real parts. Therefore, conventional techniques of designing the radiating elements and the waveguides based on the metal properties may be less applicable at optical frequencies, while plasmonic resonance phenomena [5-6] are often used in optical antenna design such Core-shell nanowire optical antennas fed by slab waveguides. In Ref. [7], the scattering of electromagnetic waves is maximized at a certain resonant wavelength determined by the material parameters, and the particle geometry, even though the size of the particle may be much smaller than the free-space wavelength. The peculiar characteristics of interaction of light with plasmonic nanoparticles have been known for a long time, and recently, owing to the advancement in nanofabrication

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technologies, the interest in the scattering resonance associated with the presence of plasmonic nanoparticles has been resurrected and explored in details, both experimentally and theoretically[8-12].

This work combines the knowledge of nano-optics and nano-fabrication for the development of optical antennas. In a three-step approach, our structures are first modeled, designed and simulated using THz frequency, Optical to electrical converter, and generated THz signal for Optical Dipole Antennas (ODA)[13-14]. Extensive studies of field distribution, extinction efficiency and their dependence on geometry are carried out prior to physical design.

2. Optical Nanoantennas

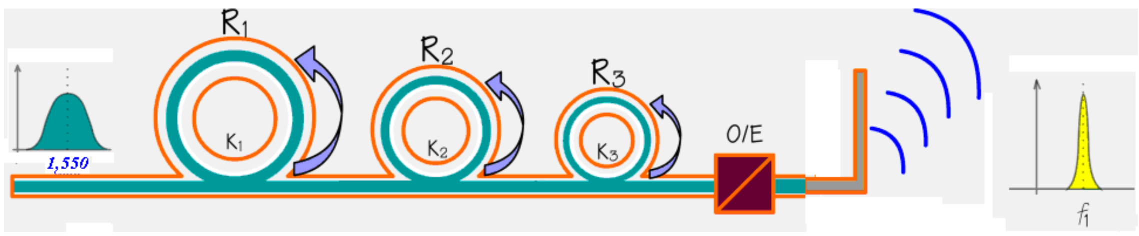

Fig. 1. Sketch diagram of optical antennas

Fig. 1 shows the system of the optical antenna system which consists of a micro ring resonator system, optical to electrical converter (P6703B product of Tektronix) support 1.2 GHz, with the Tektronix P6700 Series optical-to-electrical (O/E) converters change optical signals into electrical signals for convenient and nano antenna dipole by fabrication on thin film [7].

A light pulse is input into a ring resonator system with constant Gaussian's field amplitude (E0), which is the combination of terms in attenuation (α) and phase (ϕ0) constants, which results in temporal coherence degradation. Hence, the time dependent input light field (Ein) and L is a propagation distance (waveguide length) as shown in equation (1).

$$E_{in}(t) = E_0 e^{-\alpha L + j\phi_0(t)} \tag{1}$$

The nonlinearity of the optical ring resonator device is of the Kerr type; i.e., the refractive index is given by

$$n = n_0 + n_2 I = n_0 + n_2\left(\frac{P}{A_{eff}}\right) \tag{2}$$

where I and P are the optical intensity and optical power, respectively. The linear and nonlinear refractive indexes are n_0 and n_2 respectively. A_{eff} is the effective mode core area of the device, which the micro ring and nano ring resonators, the effective mode core areas range from 0.10 to 0.50 μm2.

When a Gaussian pulse is input and propagated within a micro ring resonator, the resonant output is formed, thus, the normalized output of the light field is the ratio between the output and input fields ($E_{out}(t)$ and $E_{in}(t)$) in each roundtrip, which can be expressed as

$$\left|\frac{E_{out}(t)}{E_{in}(t)}\right|^2 = (1-\gamma)\left[1 - \frac{(1-(1-\gamma)x^2)\kappa}{(1-x\sqrt{1-\gamma}\sqrt{1-\kappa})^2 + 4x\sqrt{1-\gamma}\sqrt{1-\kappa}\sin^2(\frac{\phi}{2})}\right] \tag{3}$$

Equation (3) indicates that a ring resonator in this particular case is very similar to a Fabry-Perot cavity, which has an input and output mirror with a field reflectivity (1-κ), and a fully reflecting mirror. κ is the coupling coefficient, and χ =exp(-αL/2) represents a roundtrip loss coefficient, $\phi_0 = kLn_0$ is the linear phase shifts and $\phi_{NL} = kLn_2(P/A_{eff})$ is nonlinear phase shifts, $k = 2\pi/\lambda$ is the wave propagation number in a vacuum. Where L is a waveguide length, and α is linear absorption coefficient, respectively [15].

3. Simulations result

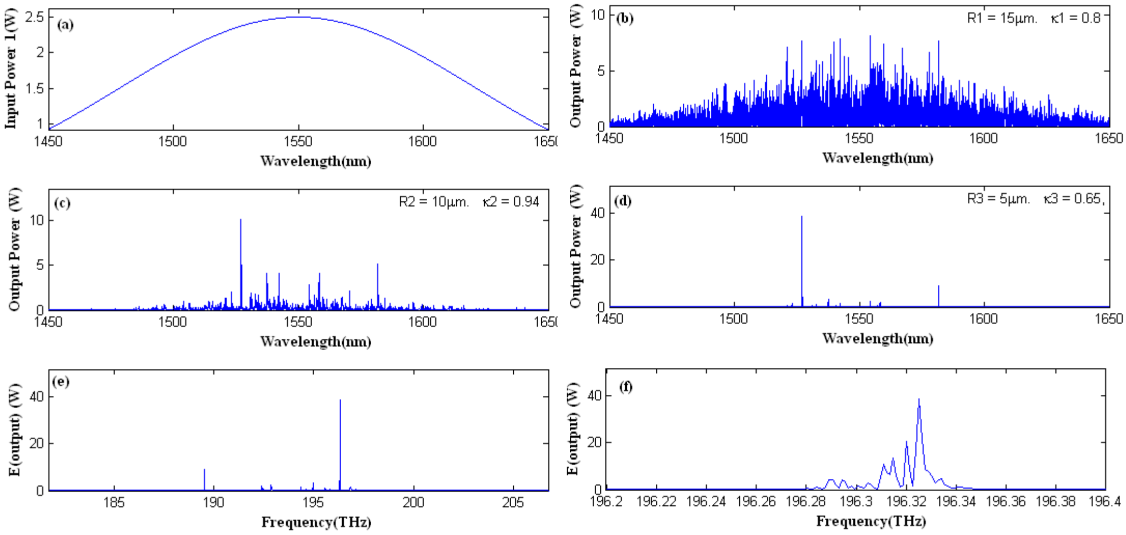

Fig. 2. show result of optical antenna ring resonator

The wavelength and frequency domain results are shown in Fig. 2 (a) input signal is a Gaussian pulse 2.5 W and center wavelength of 1550 nm. The result output signals of first ring (R1) are the chaotic signal and filtering signals obtained by the second (R2) and the third rings (R3) shown in Fig. 2 (b)-(c). The parameters of ring radii are 15µm, 10 µm and 5 µm for R1-R3 as shown in Fig.2 (b-d), the single peak is 40 W as shown in Fig. 2 (d). The coupling coefficients (κ1, κ2, κ3) of the rings R1-R3 are 0.80, 0.94 and 0.65. The center wavelength is 1.55 µm, with the output signals of O/E converter as shown in Fig.2 (e). We can change the optical signal to Electrical signal by O/E at the frequency between 190-196 THz; power output is 40W shown in Fig. 2 (f), which has frequency of 1.138 THz from output signal by divider frequency method shown in Fig.1.

In Fig. 3 (a) input signal is a Gaussian pulse 3 W and wavelength of 1,550 nm. The result output signals of first ring (R1) are the chaotic and filtering signals obtained by the second (R2) and the third rings (R3). The parameters of ring radii are 10µm, 7 µm and 5 µm for R1-R3 as shown in Fig.3 (b-d); the single peak is 100 W as shown in Fig. 3 (d). The coupling coefficients (κ1, κ2, κ3) of the rings are R1-R3 0.80, 0.90 and 0.65. The center wavelength is 1.55 µm, with the output signals of O/E converter as shown in Fig.3 (e). We can change the optical signal to Electrical signal by O/E at the frequency between 194 THz, power output is 100W shown in Fig. 3(f), which has frequency 188.5 THz from output signal by nano-optics and nano-fabrication for the development of optical antennas[10].

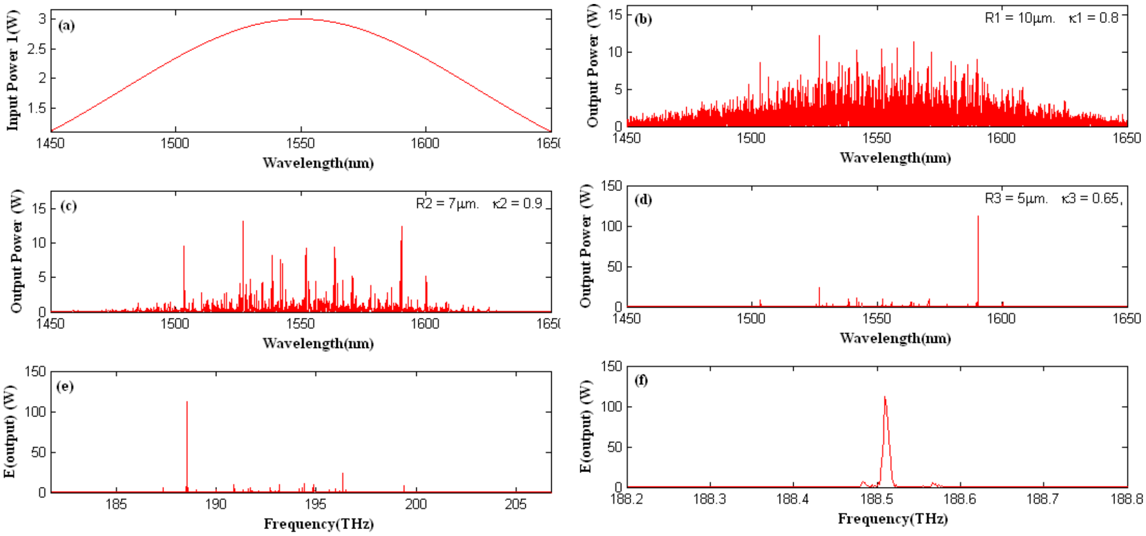

Fig. 3. shows result of optical antenna at wavelength 1550 nm

4. Conclusion

We have reviewed the recent advances in the study of the generation THz frequency for dipole optical nano antennas at frequency 188.5 THz. We have analyzed the relation of the wavelength domain and the frequency domain of the emitted power with the received power of this antenna. The radiuses and couple coefficient of micro ring resonator have been optimally designed. The optimum designed optical antenna can be used in space laser system.

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References

[1] S. J. Oldenburg, R. D. Averitt, S. L. Westcott, and N. J. Halas, ”Nanoengineering of optical resonances,” Chem. Phys. Lett. 288, 243-247 (1998).
[2] P. M¨uhlschlegel, H.-J. Eisler, O. J. F. Martin, B. Hecht, and D. W. Pohl, ”Resonant optical antennas,” Science 308, 1607-1608 (2005).
[3] J. Li, A. Salandrino, and N. Engheta, ”Shaping light beams in the nanometer scale: A Yagi-Uda nanoantenna in the optical domain,” Phys. Rev. B (Condensed Matter and Materials Physics) 76, 245403-245407 (2007).
[4] P. Muhlschlegel, H. J. Eisler, O. J. F. Martin, B. Hecht, and D. W. Pohl, “Resonant optical antennas,” Science, vol. 308, pp. 1607–1609, 2005.
[5] J. Kottmann, O. Martin, D. Smith, and S. Schultz, ”Spectral response of plasmon resonant nanoparticles with a non-regular shape,” Optics Express 6, 213-219 (2000).
[6] S. I. Bozhevolnyi and V. M. Shalaev, “Nanophotonics with surface plasmons—Part II,” Photonic Spectra, vol. 40, no. 2, p. 66, 2006.
[7] Jingjing Li, Nader Engheta, “Core-shell nanowire optical antennas fed by slab waveguides”, IEEE transections on antennas and propagation, Vol. 55, No. 11,3018-3026, 2007.
[8] J. Li and N. Engheta, “Optical leaky-wave nano-antennas using plasmonic nanowires with periodical variation of permittivity,” presented at the 2005 Annual Meeting of the Optical Society of America (OSA), Tucson, Arizona, Oct. 16–20, 2005.
[9] H. Ditlbacher, B. Lamprecht, A. Leitner, and F. R. Aussenegg, ”Spectrally coded optical data storage by metal nanoparticles,” Opt. Lett. 25, 563-565 (2000).

[10] S. Nie, and S. R. Emory, "Probing Single Molecules and Single Nanoparticles by Surface-Enhanced Raman Scattering," Science 275, 1102-1106 (1997).
[11] S. K¨uhn, U. H°akanson, L. Rogobete, and V. Sandoghdar, "Enhancement of Single-Molecule Fluorescence Using a Gold Nanoparticle as an Optical Nanoantenna," Phys. Rev. Lett. 97, 017402 (2006).
[12] Stout B, Devilez A, Rolly B, Bonod N. Multipole methods for nano-antennas design: applications to Yagi–Uda configurations. J Opt Soc Am B 2011, 28, 1213–1223.
[13] Z. Jiasen, and X.W. Jing Yang, and Q. Gong, "Electric field enhancing properties of the V-shaped optical resonant antennas," Optics Express 15, 16852-16859 (2007).
[14] Boriskina SV, Dal Negro L. "Multiple–wavelength plasmonic nanoantennas". Opt Lett, 35, 538–440 , 2010.
[15] S. Mithata, N. Pornsuwancharoen and P.P. Yupapin, "A simultaneous short wave and millimeter wave generation using a soliton pulse within a nano-waveguide", IEEE Photon. Technol. Lett., 21(13) 932-934 (2009).