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Characteristics of Localized Circularly Polarized Light inside Hexagonal Patterned Media for All-Optical Magnetic Recording

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Abstract: All-optical magnetic recording with circularly polarized light has been studied for developing ultra-high speed recording. In this paper, circularly polarized light is generated in bit-patterned media by illuminating linearly polarized light to plasmonic cross antennas for high density recording and the electric intensity inside the media is discussed.

1. Introduction

For high speed recording, all-optical magnetic recording with circularly polarized light has attracted attention[1][2]. In this paper, we design plasmonic cross antennas which are able to generate the localized circular polarized light and investigate the electric field inside the particle media of hexagonal pattern for high density recording[3]. The Stokes parameters[4] are discussed to evaluate this plasmonic antenna with the particle media.

2. Computational methods

To compute electromagnetic fields in a dispersive medium, the FDTD method with the ADE method[5] is applied. In computation, a three dimensional mesh size $1.0\times1.0\times1.0$ nm^3 and time increment 1.9×10^{-18} s are selected. The analytical region is surrounded by CPML. The dipole antenna with the particle medium shown in Figure 1 is analyzed to determine the length of the cross antenna generating the localized circularly polarized light in the recording media. Incident light is assumed to be a linearly polarized sinusoidal plane wave propagating in the negative *z*-direction. The amplitude of electric field is 1.0 V/m and the wavelength is 780 nm. The particle parameters are selected for 2 Tbit/inch^2 recording density. Materials of the antenna and the particle media are gold and cobalt, respectively. Their dispersion relations are assumed to be the Drude model[6].

3. Numerical results

Figure 2 shows characteristics intensity and phase-shift for the dipole antenna whose length is varied from 80 to 105 nm to observe the intensity of the electric field at the middle of the center particle. By made a comparison of the media without the antennas, the intensity enhancement is defined. The phase shift is assumed to be zero degree at the antenna length for which the intensity enhancement becomes a peak.

Considering the characteristics described in Figure 2, two antenna lengths are selected as 84 and 97 nm as shown in Figure 3, respectively, for which the difference of the phase-shift becomes 90°. Here, θ is an angle formed by the *x*-axis and the electric field component of the incident light on the *x*-*y* plane.

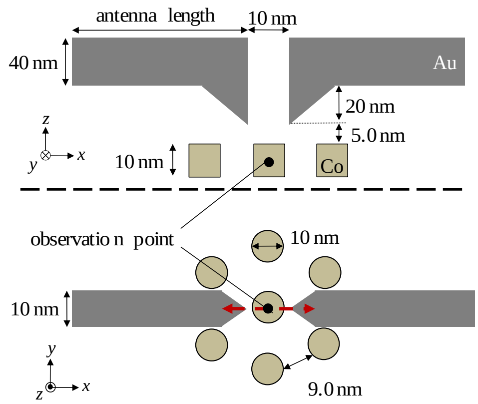

Figure 1. Dipole antenna model with the particle medium.

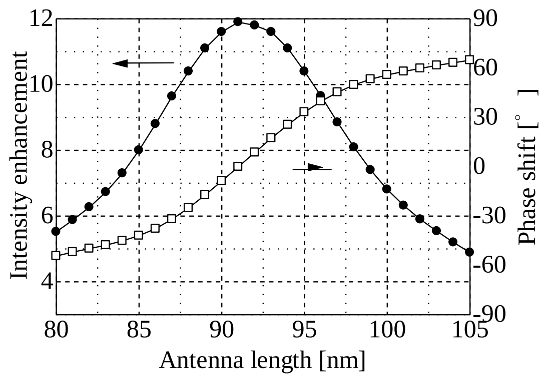

Figure 2. Characteristics of intensity and phase-shift for the dipole antenna at the observation point.

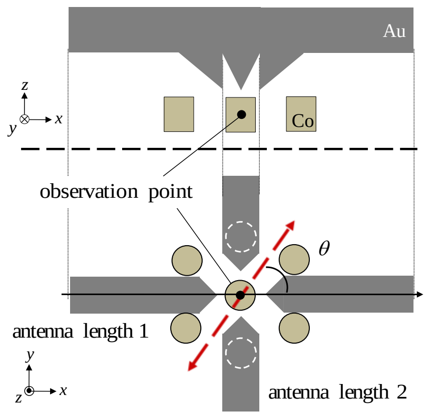

Figure 3. Cross antenna model with the particle medium.

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Figure 4 shows the time response of the electric fields of the cross antenna for the angle $\theta = 50.3°$ and $129.7°$ to match the value of the intensity enhancement at the center of the medium. It takes about 40 fs to be in steady state. Figure 5 shows the polarization characteristic at the center of the medium. By switching the angle θ, right-hand and left-hand circularly polarizations are generated from the linearly polarized light.

Here, we consider the Stokes parameter to evaluate the total intensity enhancement I and the degree of the circular polarization C', which are defined as

$$I = \langle E_x^2(t) \rangle + \langle E_y^2(t) \rangle + \langle E_z^2(t) \rangle , \quad (1)$$

$$C' = 2\langle E_x(t) E_y(t) \sin(\delta_x - \delta_y) \rangle / I . \quad (2)$$

Figure 6 shows the field distributions on the x-y plane of I and C' around the middle of media. Circularly polarizations are not generated at the adjacent particles, however, right-hand one is generated at the only center particle as shown in Figure 6 (a). I of the center particle becomes the highest value of all the particles: the intensities which are the average of the center section in the particle and adjacent particles are 0.98 and 0.45 $(V/m)^2$ as shown in Figure 6 (b).

4. Conclusions

The plasmonic cross antenna to generate the localized circularly polarized light in the particle medium of the hexagonal pattern is designed for all-optical magnetic recording. It is shown that right-hand and left-hand circularly polarized lights are generated inside the only center particle from the linearly polarized light. The intensity ratio of the center particle to the adjacent particles is around double.

5. Acknowledgments

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6. References

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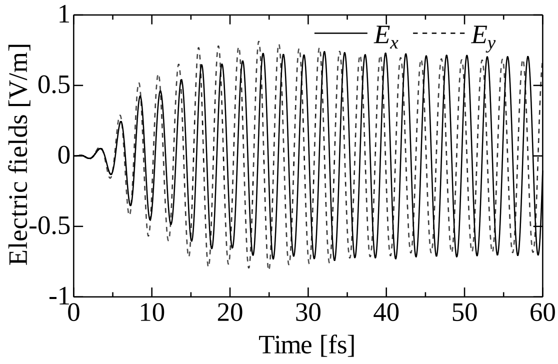
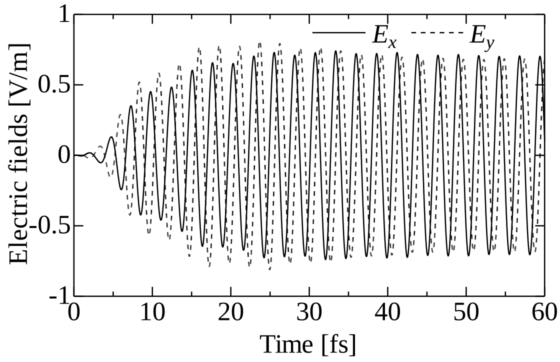
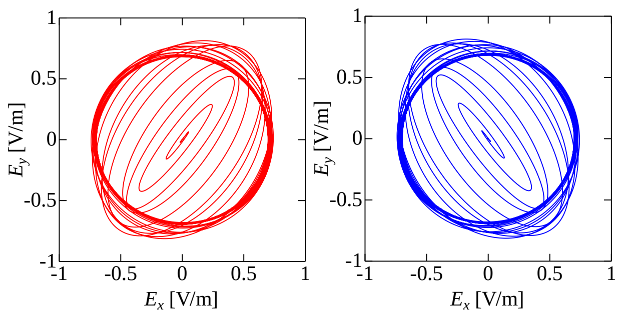


(a) $\theta = 50.3°$.



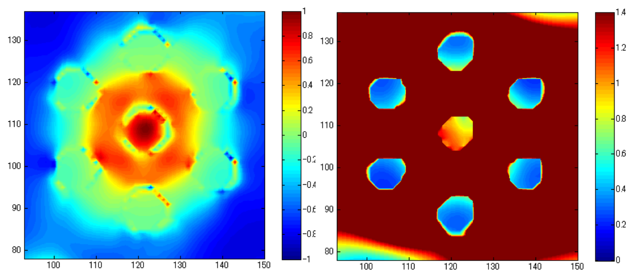
(b) $\theta = 129.7°$.

Figure 4. Time response of the electric fields at the observation point.



(a) $\theta = 50.3°$. (b) $\theta = 129.7°$.

Figure 5. Polarization characteristic at the observation point.



(a) Field distribution of C'. (b) Field distribution of I.

Figure 6. Field distribution on the x-y plane aroound the middle of the media.