

Polarization Characteristics of Nanoscale Cross Antennas

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Abstract: All-optical magnetic recording with circularly polarized light has been studied for developing ultra-high density recording. In this paper, an asymmetric cross antenna, constituted by two perpendicular dipole antennas of different length, is investigated to generate localized circularly polarization from linearly polarized incident light. The characteristic of localized polarization is clarified for varying the direction of the incident light.

1. Introduction

For ultra-high speed recording, all-optical magnetic recording with circularly polarized light has attracted attention^[1]. In this technology, recording is performed using left-handed and right-handed circularly polarized light. In this paper, characteristics of a nanoscale dipole antenna^[2] are discussed and an asymmetric cross antenna^[3] is proposed to generate left-handed and right-handed localized circularly polarization from linearly polarized incident light.

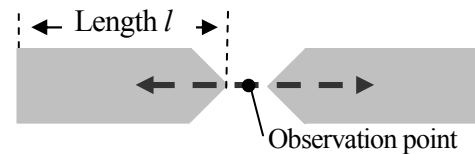
2. Calculation method

Finite-difference-time-domain (FDTD) method combined with the auxiliary differential equation (ADE) method^[4] is used to calculate electromagnetic fields in a dispersive medium. A three dimensional mesh size $1.0 \times 1.0 \times 1.0$ [nm³] and time increment 1.9×10^{-18} [s] are used. Analytical region is surrounded by the convolutional PML (CPML).

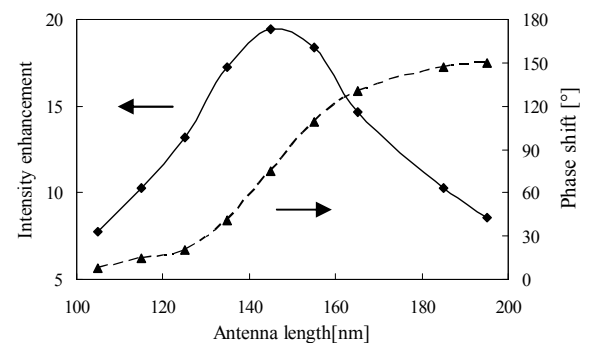
3. Computational model and numerical results

Designing an asymmetric cross antenna to generate circular polarization from linear polarization, characteristic of a linear dipole antenna has to be clarified. Therefore, a linear dipole antenna shown in Fig.1(a) is considered. Material of the antenna is silver which is characterized by the Drude model. Incident light is assumed to be a sinusoidal plane wave with the amplitude of $E=1.0$ [V/m] in the wavelength of 780 nm, and linearly polarized along to the antenna arm. The antenna arm have a squared cross section of 30×30 [nm²] and gap size of 30 nm. To observe the resonance, the antenna length l is varied from 100 nm to 200 nm.

Fig.1(b) shows the intensity and phase-shift characteristics at the center of the antenna gap. The intensity becomes maximum at about 150 nm. At this length, intensity increases about 18 times and phase is shifted by roughly 90° compared with incident light.



(a) Linear dipole antenna model. The dashed arrow indicates the direction of incident linear polarization.



(b) Intensity and phase-shift characteristics at the center of the antenna gap.

Fig.1. Linear dipole antenna.

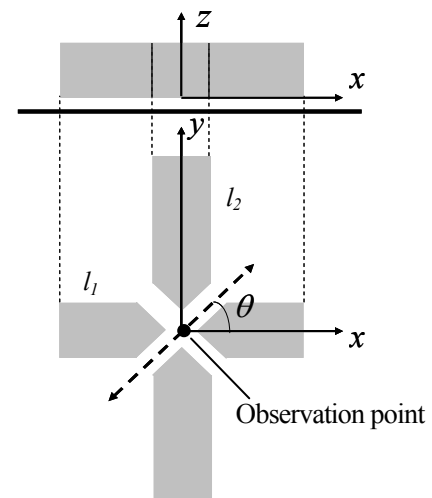


Fig.2. Asymmetric cross antenna model. The dashed arrow indicates the direction of incident linear polarization.

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Fig. 2 shows an asymmetric cross antenna, constituted by two dipole antennas with common gap and different antenna lengths. Considering the characteristics described in Fig.1(b), two antenna lengths l_1 and l_2 are to be 135 nm and 165 nm, respectively, because difference of phase shift for these lengths is about 90° . Here, the incident direction θ is assumed to be 58° or 122° to match the value of intensity enhancement.

Figs. 3 and 4 show the time response of the electric fields of the cross antenna for the incident direction 58° and 122° , respectively, at the center of antenna gap. It takes about 20 fs to be in steady state, where the amplitude is matched and the difference of phase shift becomes 90° . In the steady state, the amplitude increases about 15 times than the incident light.

Figs. 5 and 6 show the polarization characteristic for the incident direction 58° and 122° , respectively, at the center of antenna gap. By varying the incident direction, right-handed and left-handed circularly polarizations are generated and transient behavior in which linearly polarized light is transformed into localized circularly polarized light is clarified.

4. Conclusions

The asymmetric cross antenna is investigated for the all-optical magnetic recording with circularly polarized light. Transient behavior of transformation of linearly polarized light into localized circularly polarized light is shown and the characteristic of polarization is clarified for the direction of incident light. It could be shown that this antenna is available for generating left-handed and right-handed localized circularly polarization.

Reference

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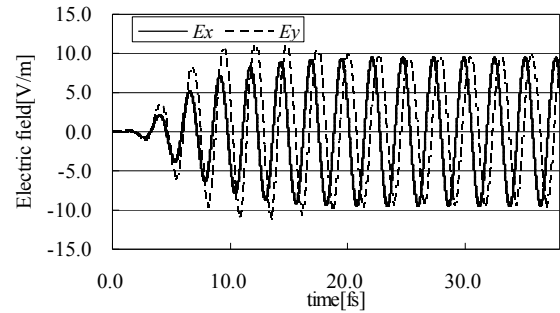


Fig.3. Time response of the electric field at the center of the antenna gap with the incident direction $\theta=58^\circ$.

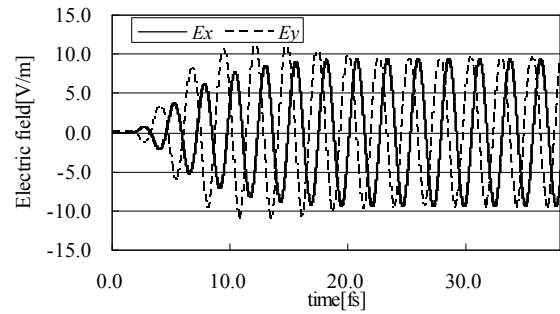


Fig.4. Time response of the electric field at the center of the antenna gap with the incident direction $\theta=122^\circ$.

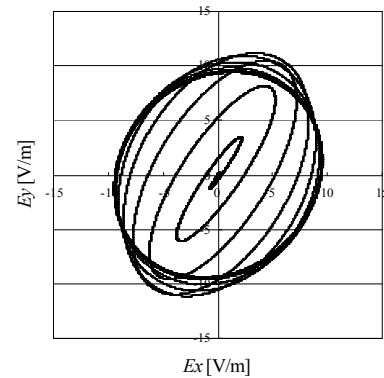


Fig.5. Polarization characteristic at the center of antenna gap with the incident direction $\theta=58^\circ$.

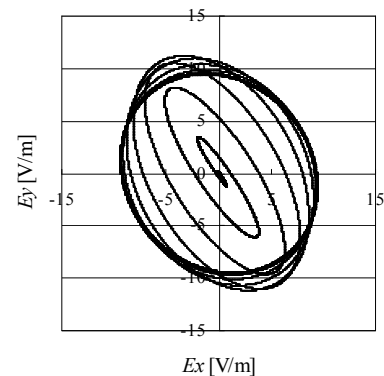


Fig.6. Polarization characteristic at the center of antenna gap with the incident direction $\theta=122^\circ$.