L-13

Confined Circularly Polarized Light Generated by Plasmon Antenna with Plasmonic Waveguide

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All-optical magnetic recording by applying circularly polarized light is a promising new technology for high speed magnetic recording. In this study, a new plasmon array that combines plasmon cross antenna for creating confined circular polarization and plasmonic waveguide (PW) for high efficiency energy propagation is investigated. The circularly polarized light is evaluated by the digrees of circularity *C*. The circular polarization generated by plasmon antenna with PW is localized to 5 nm in diameter at the center of the cross antenna. The C value within the confined area can be kept at 0.8. It is revealed that the localized circularly polarized light can be generated by the plasmon antenna with plasmonic waveguide.

1. Introduction

All-optical magnetic recording with circularly polarized light is expected to be useful for high-speed recording[1)]. It is, however, unsuitable for creating small magnetic domains on the order of ten nm, which is necessary for high density magnetic recording. One of the methods which has been proposed to resolve this problem is using a plasmon antenna to generate a confined circularly polarized light[2, 3)]. A system using plasonic waveguide[4)] (PW) was also investigated to achieve a high efficiency in energy propagation. In this paper, we studied a system to localize circularly polarized light. We evaluated the degrees of circularity *C* and power intensity of electric field *I*[5)] as the confined circularly polarized light. The circular polarization can be confined to 5 nm in diameter, of which the value of *C* is kept at 0.8.

2. Calculation model for circular polarized light generated by plasmon antenna with PW

The combination between a plasmon antenna for creation confined circularly polarized light and high efficiency PW was studied. This simulated model was composed of optical wave path, plasmonic waveguide, and plasmon antenna, as shown in Fig. 1. The optical wave path was made of Ta_2O_5. A PW made of Au was placed along the Ta_2O_5 optical path. The thickness of the Au PW and the distance between the optical path and the PW was 180 nm and 5 nm, respectively. The shape of the PW is shown in Fig. 1 (b). The thickness was uniform, but the width W decreases in the *z* direction. The W of the top half of the PW was 3,000 nm, but in the bottom half the W decreases as the sides taper together. This tapering was for leading energy to the bottom of the PW. An asymmetric cross antenna was placed on the bottom of the PW. The lengths of the cross antenna were 50 nm and 30 nm, with each at a thickness of 35 nm, and covered with Al_2O_3. A laser light with 780 nm of wavelength provided a linear polarized light (transverse magnetic wave). The electric field intensity had a Gaussian distribution with 1 V/m at the center and 780 nm in the diameter of the optical spot ($1/e^2$). Angle of incidence was 80 degrees, which was set to the meet the condition of total reflection.

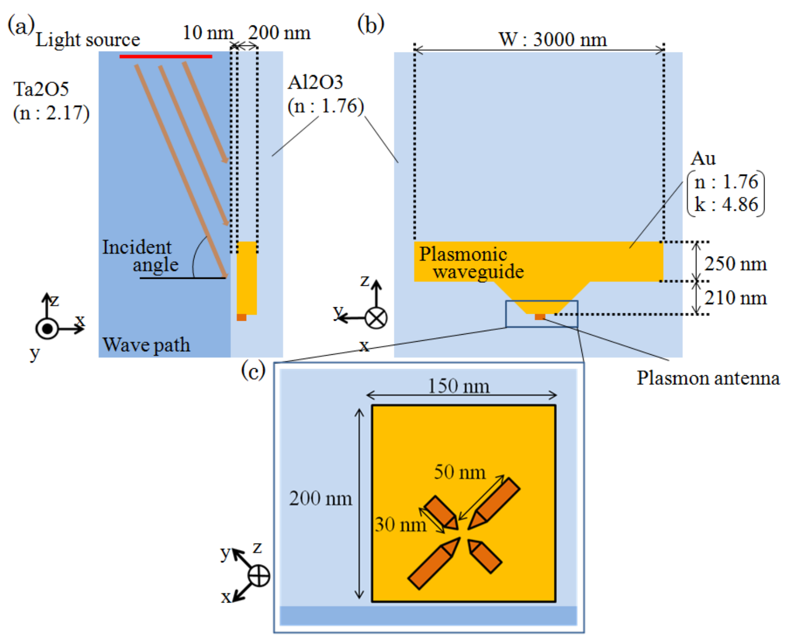

Fig. 1 Simulation model

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3. The evaluation of confined circularly polarized light

The electric field at the center of the cross antenna was calculated. Fig. 2 shows each components of the electric field (*E*x, *E*y and *E*z) as a function of time. After 70 fs from laser irradiation, the amplitude of electric field *x* and *y* components were almost the same value (*E*y/*E*x = 1.05), and the phase difference between *E*x and *E*y is 90 degrees. Furthermore, degrees of circularity *C* and power intensity of electric field *I*[6] were evaluated as the confined circularly polarized light. There values were defined as follows:

$$C = \langle 2ExEy\sin r\rangle / (\langle Ex^2\rangle + \langle Ey^2\rangle + \langle Ez^2\rangle),$$

where < > corresponds to taking a time average, *r* is the phase difference between *x* and *y* component of electric field,

$$I = \langle Ex^2\rangle + \langle Ey^2\rangle + \langle Ez^2\rangle.$$

C and *I* were calculated at 1 nm below the plasmon antenna, which was placed on the bottom of the PW after 70 fs from laser irradiation. The *C* and *I* are shown in Fig. 3 (a) and (b), respectively. A circularly polarized light was confined to 5 nm in diameter. The *C* value of the confined area was kept at 0.8. Power intensity *I* was concentrated at the edge of the plasmon antenna. This result means that the propagated surface plasmon polariton along with the PW was transformed into the optical near field at the plasmon antenna. However, we need to have a peak at the center of the cross antennas.

The plasmon antenna is effective for high density recording. The PW is useful for high efficiency energy propagation. It was revealed that the combination of the plasmon antenna with the PW created a localized circularly polarized light. We are going to study more details with recording media for our future research.

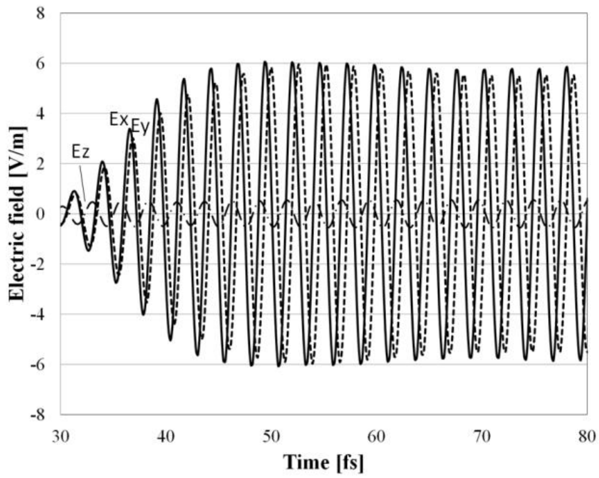

Fig. 2 Time responses of electric field *x*, *y*, and *z* components (*E*x, *E*y and *E*z) at the center of the cross antenna placed on the bottom of the SPPW.

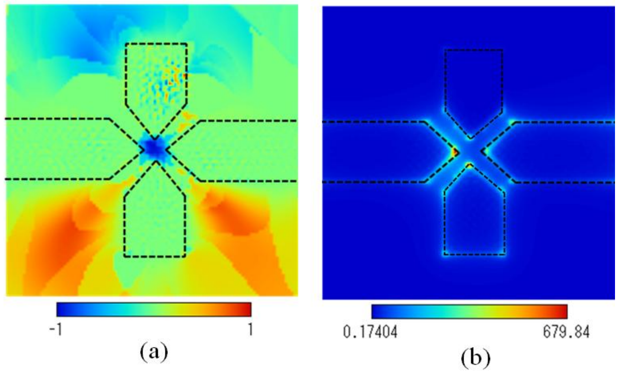

Fig. 3 (a) and (b) shows the degrees of circularity *C* and power intensity of electric field *I* at 1 nm below the plasmon antenna, respectively.

4. Conclusion

A new antenna array combining plasmon antenna and plasmonic waveguide was studied. It is demonstrated that the combined model of cross antenna for high density magnetic recording and plasmonic waveguide for high efficiency energy propagation can generate a circularly polarized light at the center of the cross antenna from laser light in an optical wave path. The circular polarization can be confined to 5 nm in diameter. Additionally, the value of *C* within the confined area can be kept at 0.8. This technique is expected to be useful for ultra-fast, high density and high energy efficiency magnetic recording.

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6. References

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