20a-C3-8

Enhanced Nano-size Circularly Polarized Light Generated by Cross V-groove Aperture Antenna

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1. Introduction

In the last decade, the circularly polarized light has been widely used in various novel applications, such as probing the geometric and electromagnetic chiral properties of biomolecules [1], all-optical magnetic recording [2] and control of the spin-wave emission [3] in submicron regions. To implement those researches in nano-regions, it is essential to generate nano-size circularly polarized light. Nakagawa et al. [4] has reported that nano-size circularly polarized light could be generated with a cross aperture antenna. However, the intensity of generated circularly polarized light is not enhanced. Here, we propose a new type cross V-groove aperture antenna with a diameter of 10 nm, which could generate circularly polarized light, with its intensity enhanced more than 1000 times.

2. Simulation model and results

A schematic of cross V-groove aperture antenna is shown in Figure 1. Two V-grooves are fabricated orthogonally in a gold film with a thickness of H = 35 nm, and a circular aperture with a radius of R = 5 nm is fabricated at the cross point of two V-grooves. The depths of two V-grooves are same to the thickness H of the gold film. The groove angle θ and the length of the grooves L are 70 degrees and 200 nm, respectively. A circularly polarized (degree of circular polarization C = 1) plane wave at a wavelength of 633 nm illuminates the cross V-groove aperture from the top along the z-axis. The simulation is carried out with a commercial software, Comsol Multiphysics 4.3b based on the finite element method. A uniform mesh is used with the smallest mesh size of 1 nm at the position of aperture.

Figure 2(a)-(c) show distributions of degree of circular polarization C, intensity enhancement I and figure of merit $F = IC^2$ on the observation plane, which is 5 nm away from the bottom plane of aperture. We found that 10 nm size circularly polarized light with C larger than 0.99 and I enhanced more than 1000 times is generated at the center of observation plane. Figure 2(d) shows a distribution of F on the cross section A. F is larger than 1000 at the center of observation plane and is still larger than 100 at a position 17 nm below the center of aperture. Consequently, the cross V-groove aperture antenna is practical. The optimization of the geometry of the aperture and the influence of wavelength will be also discussed.

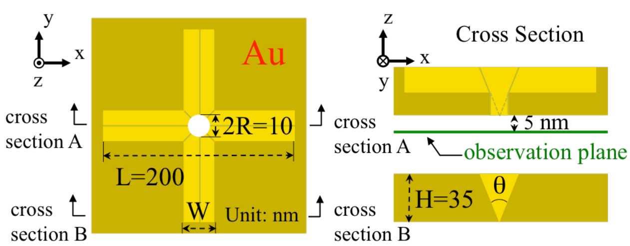

Fig. 1 A schematic of cross V-groove aperture antenna

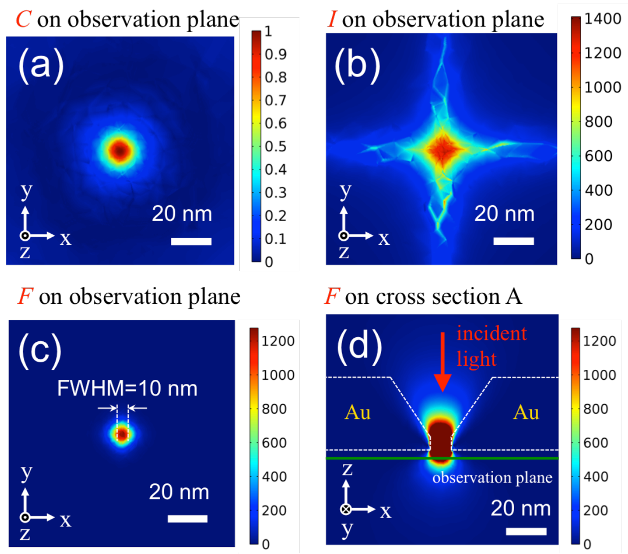

Fig. 2 Distributions of (a) degree of circular polarization C, (b) intensity I and (c) figure of merit F on observation plane. (d) Distribution of F on cross section A.

3. Conclusions

We have proposed a new type cross V-groove aperture antenna that could generate nano-scale circularly polarized light with an intensity enhanced 1000 times. The aperture may open the door to new technology utilizing a nano-circularly polarized light, such as analysis, manipulation of molecules, spins in magnetic materials, etc.

Acknowledgements

This research was partly supported by the National Institute of Information and Communications Technology (NICT) and KAKENHI Grants-in-Aid for Scientific Research (B) (26286023).

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