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Energy Concentration by Plasmonic Waveguide for Highly Efficiency Thermally Assisted Magnetic Recording

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Abstract: Thermally assisted magnetic recording using a plasmon antenna has been studied for high density magnetic recording. In the other hand, it was reported that a plasmonic waveguide is effective to increase energy efficiency for thermally assisted magnetic recording. It was studied that the delivering energy efficiency by surface plasmon polaritons on a Au sheet with a Fe pole, and the energy concentration by a plasmon antenna placed on the bottom of the Au sheet. The energy localization was performed by the protrusive rectangular plasmon antenna located on the bottom surface of the Au sheet. Its energy intensity was about 4 times of a conventional plasmon antenna.

１． Introduction

Thermally assisted magnetic recording (TAMR) using a plasmon antenna is a promising way for ultra-high density magnetic recording [1, 2]. A plasmonic waveguide (PW) is a key technology for TAMR to deliver light energy from a source to the antenna apex. We reported an improvement in energy efficiency by using the PW which delivers energy in the form of surface plasmon polaritons (SPPs) [2]. We found a higher efficient PW structure by applying a magnetic pole to the PW, whose energy efficiency was very sensitive to PW's surroundings. It was revealed that a new designed PW delivers energy 4 times higher to the antenna tip than a conventional waveguide without PW. Energy concentration by plasmon antenna placed on the bottom of a PW was, therefore, investigated. SPPs delivered on the PW can be localized into 10 nm in diameter on a recording medium.

２． SPPs energy delivering on Au sheet with magnetic pole.

The energy of SPPs delivering on the surface of a metal sheet is highly sensitive to the surroundings of a PW. To find a higher efficient PW structure, the dependencies of the efficiency on thickness of a metal sheet, and on gap length between the metal and a dielectric waveguide core with a simple computational model, as shown in Figure 1. An electromagnetic wave was calculated by the Finite-Difference Time-Domain (FDTD) method. The dielectric waveguide, which had a Ta_2O_5 core and an Al_2O_3 clad, was set along with an Fe magnetic pole parallel to the *x* direction. The Au metal sheet was placed in the clad between the core and the Fe magnetic pole in parallel. A linear polarized laser light with 780 nm of the wavelength irradiated with an incident angle at 60 degrees. Mur's absorption boundary condition was adapted to avoid the reflected SPPs by the side of the Au sheet. The *x* component of the Poynting vector, which corresponded to the propagating direction of the SPPs, was calculated to evaluate the SPPs energy delivering on the interface of the Au sheet. The SPPs propagated at both interfaces of laser incident side and side opposite from laser incident side between the Au sheet and the Al_2O_3 clad. The energy density at the laser incident side of the Au sheet after 80 fs of laser irradiated is shown in

Figure 2. The envelope of energy density at the laser incident side and the side opposite form laser incident were defined as $P_{\text{laser incident side}}$

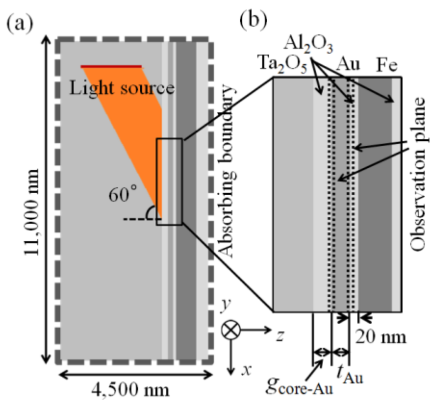

Figure 1. Simulation model for evaluation of SPPs energy. (a) and (b) show side view and enlarged view, respectively. SPPs were delivered at interface between Au sheet and Al_2O_3 clad.

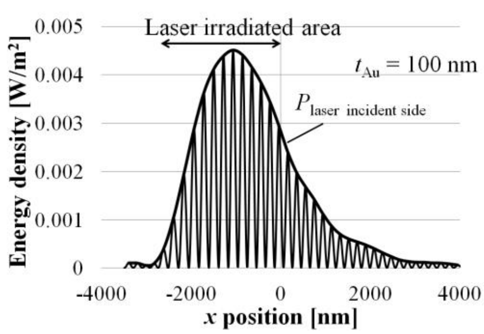

Figure 2. Energy density of SPPs at laser incident side of Au sheet when t_{Au} = 100 nm.

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and $P_{othre\ side}$, respectively. With increasing the Au thickness t_{Au} from 10 to 50 nm, the $P_{laser\ incident\ side}$ peak proportionally increased, and it was saturated when the t_{Au} was thicker than 50 nm. In contrast, the $P_{other\ side}$ peak decreased with increasing the t_{Au}, and saturated at t_{Au} = 80 nm. This result for the $P_{other\ side}$ was totally different from the previous result without the Fe pole [3]. When the t_{Au} > 80 nm, the high intensity SPPs can be delivered on the laser incident side of the Au. The peak energy density depending on the $g_{core\text{-}Au}$ was also calculated at t_{Au} = 100 nm, and shown in Figure 3. When the t_{Au} = 100 and $g_{core\text{-}Au}$ = 200 nm, the highest energy, which reached ~ 2 times of the reported PW model [2], was delivered at the downside of the Au.

３． Generation of optical near field in localized area using PW

It is also important to generate an optical near field in a localized area for writing in TAMR. The near field antenna with the PW applying the designed optimal structure as discussed in the section 2, as shown in Figure 4, was investigated to concentrate energy into 10 nm in diameter. The antenna shape was a rectangular which had a protrusion located at the bottom of the Au sheet. The electric field generated by the plasmon antenna was observed in medium under the plasmon antenna.

The intensity of the generated electric field by the plasmon antenna is shown in Figure 5. The localized spot into 10 nm can be created by the protrusive plasmon antenna placed on the bottom of the Au sheet, as shown in Figure 5. It was confirmed that the peak intensity of the electric field increased about 4 times of the energy which was generated by a conventional plasmon antenna model [2].

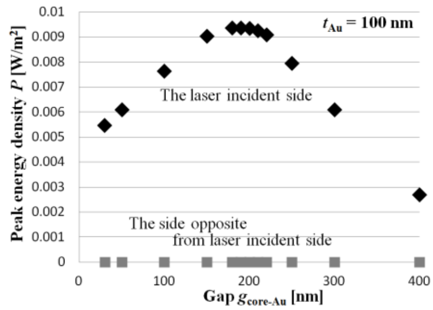

Figure 3. Peak energy densities of SPPs depend on gap between core and Au $g_{core\text{-}Au}$.

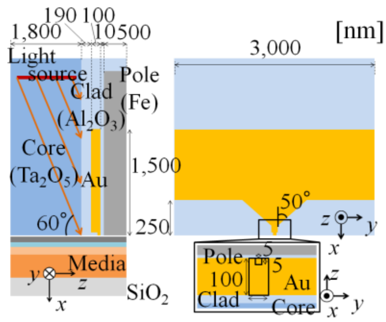

Figure 4. Simulation model for generating optical near field using PW. t_{Au} = 100 nm, $g_{core\text{-}Au}$ = 190 nm.

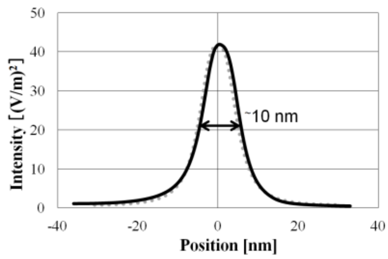

Figure 5. Intensity of electric field generated by plasmon antenna with PW.

４． Summary

It was studied that the delivering energy efficiency by SPPs on a Au sheet with a Fe pole, and the energy concentration by a plasmon antenna placed on the bottom of the Au sheet. We found that the PW structure for delivering high energy SPPs, which were the t_{Au} > 80 nm and the $g_{core\text{-}Au}$ = ~200 nm. The energy localization was, therefore, performed by the protrusive rectangular plasmon antenna located on the bottom surface of the Au sheet. Its energy intensity was about 4 times of a conventional plasmon antenna. It was revealed that using PW is effective in generation of a high intensity optical near field.

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