S1-3

局所表面プラズモン利用アンテナの形成

Fabrication of Nano-Antennas for Localized Surface Plasmon

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Abstract: A new technology applying local surface plasmon was studied to increase memory density of Hard Disk Drives. Surface plasmon antennas have been fabricated over a magnetic layer with inter-dielectric layer, and femto-second laser was exposed over the antennas to evaluate surface plasmon effect. Small written magnetic domains which are caused by the effect of local surface plasmon were observed. It is also revealed by computational analysis that a circularly polarized light for All Optical Magnetization Switching can be confined into 10 nm in diameter by the effect of surface plasmon. Surface plasmon, therefore, is very powerful effect not only for increase memory density but also for increase recording speed for magnetic memory.

1． Introduction

We faces on a deep concerning probrem about "Information Explosion[1]" as shown in Fig. 1, becaus an enormous amount of digital data is created day by day in the world. We have not enough memory capacity to keep the information in our strage system, as shown in Fig. 2[2]. Hard Disk Drive (HDD) is the most important strage system, but we have an acute problem, which is so-called trilemma as shown in Fig. 3, to increase memory density. The trilemma is as follows: 1) the smaller magnetic domanins are written in a memory disk, the louder noise appears by magnetic particles in memory disk; 2) the smaller magnetic particles have less stable energy, then stored information vanishs in a second if smaller particles are applied; 3) information cannot be written in stable materials which are required to small magnetic particles, because the stable materials which have enough stability cannot be reoriented by stray field from magnetic head.

Thermally Assited Magnetic Recording (TAMR) has been proposed[3-5] as one of the methods to solve this trilemma. The recording materials for TAMR have enough stablity to retain information at room temperature, but the part where we want to write information will be heated by light during the process of recording. At higher temperature than room temperature, magnetic materials are less stable than at room temperature. Stored informaiton at room temperature, therefore, can be kept in tact, but the stored information can be changed by stray field from magnetic head at higher temperature with thermally assisted process.

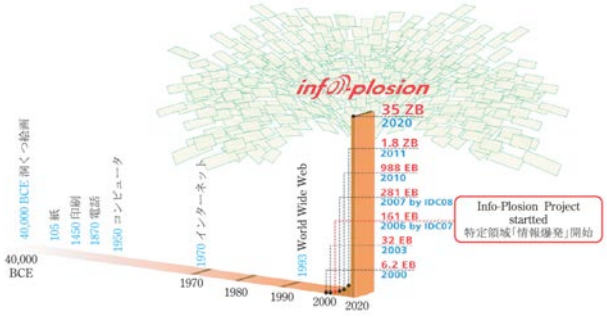

Figure 1. Information Explosion[1].

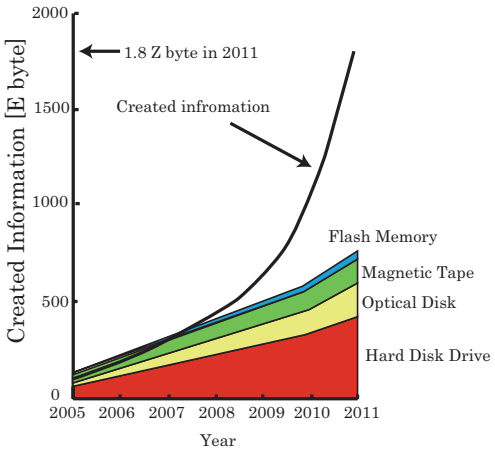

Figure 2. Created information and capacity of memory systems.

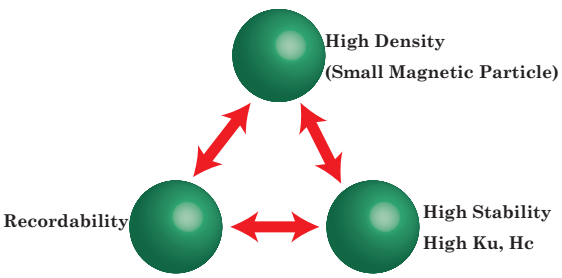

Figure 3. Trilemma of Hard Disk Drive technology.

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2． Local Surface Plasmon Antenna

The goal of the recording size is around 10 nm, but heating local area smaller than 10 nm by light is beyond the deflection limit. Even if we use a special lense such as an immersion lense, 100 nm in diameter is the smallest diameter as light spot. We applied an effect of local surface plasmon to confine light energy. Conduction electrons in metal can move and resonate along with electric field of light. When we choose an effective material and its shape, exposed optical energy can be confined into 10 nm in diameter and be enhanced a few handred times at most by the local surface plasmon effect.

As a basic study for local surface plasmon, we fabricated some surface plasmon antennas over a magnetic film with a dielectric inter-layer, as schematically shown in Fig. 4. Some magnetic written domains by the effect of local surface plasmon were observed and confirmed by magnetic force microscope, as shown in Fig. 5. We confirmed a writtend domain which shows 67 nm × 62 nm mark caused by surface plasmon effect, even though exposed laser spot was around 50 μm in diameter.

We have also shown a result by calculation that such surface plasmon antennas were effective to confine circulally polalized light into a small particle for All Optical Magnetization Switching[7, 8].

Acknowledgements　This work is mainly supported by a Grant of Nihon University Strategic Projects for Academic Research, and also partially supported by a Grant-in-Aid for Scientific Research (C) #23560413, a Grant of Storage Research Consortium.

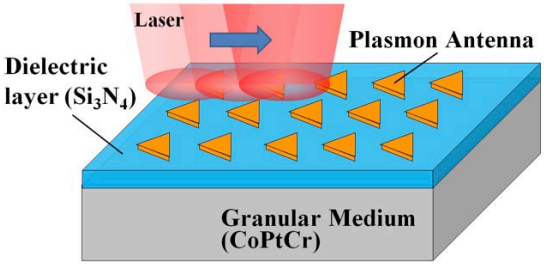

Figure 4. Image view of the antennas placed over a magnetic layer with a dielectric inter-layer[6].

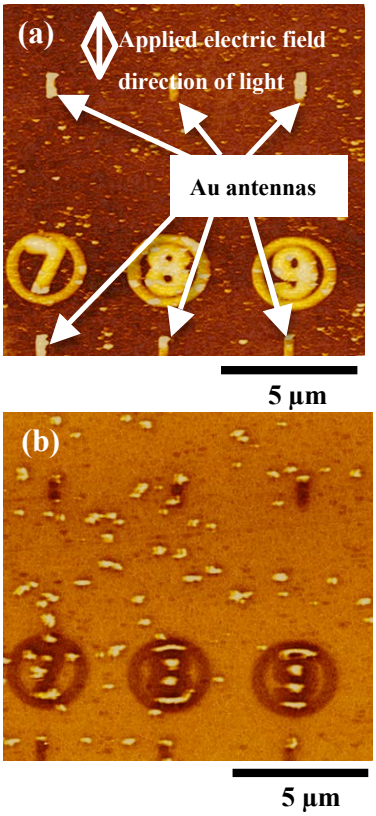

Figure 5. The surface morphology (a) and the magnetic domains (b) after a 90 fs laser pulse train was exposed over the surface of the $Co_{55}Pt_{30}Cr_{15}$ – SiO_2 granular film [6].

3． 参考文献

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