Surface Plasmon Techniques for Ultra-High Density Magnetic Recording

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Magneto-Optical (MO) recording is one of the primitive techniques to apply spin manipulation using light to change the temperature of magnetic films. MO recording itself is very simple to locally heat the magnetic film to change the magnetization *M*, but the mechanism of MO recording is more sophisticated than expected. The distribution of *M* caused by light absorption affects spin manipulation, such as Direct Over Write (DOW)[1], Magnetic Super Resolution (MSR)[2], MAMMOS[3], and 3D-MAMMOS[4], because each magnetic layer which has different characteristics on temperature is layered over a substrate. Some functional layers take roles by changing its stray field and/or exchange coupling between layers depending on temperature distribution in DOW, MSR, and MAMMOS.

Recently, we also use a heat technique on magnetic recording, so called Thermally Assisted Magnetic Recording (TAMR)[5]. Since the TAMR technique is just assisting magnetic recording by heat, it is simpler than the MO recording technique. The most improved key point in TAMR, compared with MO recording, is an extremely small spot size of light. Almost 10 nm in diameter is the spot diameter of light is the tentative goal for TAMR, even though sub-micron in diameter was the smallest spot size for MO recording. Sub-micron limit is caused by the diffraction limit for visible light, but we need around 10 nm spot in diameter for TAMR. Beyond the diffraction limit, we have chosen the near-field optical light which is generated by localized surface plasmon[6-9]. A light spot of 10 nm in diameter is available by applying the near-field. It was confirmed not only by simulation but also by the experimental result[10] that some magnetic domains were written by the local heat which was generated by surface plasmon antennas as well as femto-second laser.

How to deliver light power into a small plasmon antenna tip close to magnetic core is also an important key issue to create a heat spot on magnetic layer for TAMR. Some hybrid magnetic head systems with optics have been propoese[5, 11]. Planar Solid Immersion Mirror (PSIM)[11, 12] as well as plasmonic waveguide applying surface plasmon polaritons[11] have a high potential to effectively deliver light power in a hybrid magnetic head.

As the possibility that magnetization can be controlled by the helicity of ultra-short laser pulse was reported[13], the idea of all optical magnetic recording has been carried out. The method applying the helicity of light has a potential to accelerate magnetic recording speed, but its recording density is limited by the spot size of the circularly polarized light. Surface plasmon antenna for circularly polarized light was also studied[14]. It was revealed by a simulation that a circularly polarized light in a magnetic particle of 15 nm in diameter was able to be confined by a surface plasmon technique.

Spin manipulation using light is a new idea as well as an old idea. If we learned from the historical MO recording techniques, and applied them to current issues, we could improve the techniques beyond TAMR.

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