Insight into new magnetic recording principle with magnetoelectric writing

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The recording areal density has continued increasing to nearly 1Tbpsi with Perpendicular Magnetic Recording (PMR). However, it seems that the growth rate of a recording areal density is fairly reduced for the trilemma problem due to particulate magnetic recording principle. Of course, such alternative technologies or methods as energy assisted recording (HAMR, MAMR etc.) have been worked on with energy towards realizing the next generation recording system where they are still based on a particulate magnetic recording principle. Considering a magnetic recording (i.e. head/media system), STT and SOT are not suitable for magnetic recording principle. So in this paper we propose a new magnetic recording principle with voltage effect on magnetization-switching, especially Magnetoelectric Effect of Cr2O3 sesquioxide, that is to say that magnetic bits are written on Cr2O3 antiferromagnetic media by E(electric field)・H(magnetic field) product.

Magnetoelectric (ME) effect has so far been paid attention to be applied to a nonvolatile memory (NVM). Cr2O3 is a typical sesquioxide with ME effect and its antiferromagnetic Neel temperature is TN =307 K, which is higher than RT. A robust isothermal electric control of exchange-bias at RT is actually reported for bulk Cr2O3 single crystal sample when both of electric field E = 0.02 [MV/cm] and magnetic field H = -1.54 [kOe] was applied [1]. But ME effect has not yet been clarified in Cr2O3 thin films because of its large leakage current and imperfect antiferromagnetic-ordering while ME effect like behavior up to 200K is reported to be observed in an ultrathin Cr2O3/Fe2O3 Nano-Oxide Layer (NOL) [2]. When considering the application of ME effect to magnetic recording technology with voltage-controlled magnetization switching, there are some problems except the above issue, which should be resolved. The first is to realize and design an effectually high exchange-bias filed between antiferromagnetic (AFM) Cr2O3 and ferromagnetic (FM) thin film multilayers in the higher temperature range than RT, which means higher Neel temperature (TN) and higher blocking temperature (TB), where the properly low coercive force of FM is also required. The second is to invest FM layer with a perpendicular anisotropy which is thought to be caused by both of the hybridization of FM 3d and O 2p orbitals and the magnetic coupling at the interface between FM and Cr2O3. The third is to confirm ME effect in the thin film Cr2O3 after getting Cr2O3 thin film which shows good electrical properties.

In this paper, electrical and magnetic performances of the thin film Cr2O3/Fe2O3 sesquioxide were investigated. We successfully fabricated the Cr2O3 and Fe2O3 thin films with small leakage current and good magnetic properties.
We successfully confirmed ME effect of Cr2O3 thin films (100nm~500nm) and the switching of both exchange bias field and residual magnetization using Co/Cr2O3 exchange bias bilayer with low FM layer coercivity (~20 Oe) structure, shown in Fig.2 under both of ME filed cooling and isothermal process conditions for the first time in the world [3],[4]. In addition, we succeeded in enhancing TM of Fe2O3 higher than 400K by Ir-doping where perpendicular-spin-alignment of Fe2O3 was also confirmed in both of Mossbauer spectroscopy and weak ferromagnetic moment measurement with SQUID magnetometer. These results support our new magnetic recording principle concept with voltage controlled magnetization switching of AFM Cr2O3 thin film above room temperature at the first step.
In addition, we also propose low EH product writing with positive exchange coupling in Chromia/Co bilayer system where an induced weak ferromagnetic moment is also observed of antiferromagnetic Chromia. The related experimental results and phenomenologically analytical consideration will be discussed.

This study was partially supported by ImPACT Program led by Council of Science, Technology and Innovation (CSTI), Cabinet Office of Government of Japan, and JST-ALCA Program.

References

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