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Computer Simulation for Magnetic Tunnel Junctions Exchange-Biased by Co/Ru/Co/Ru/Co Synthetic Antiferromagnet

Korea Institure of Sci. and Tech.(KIST),
Y. R. Uhm, and S. H. Lim

1. Introduction

The switching asymmetry can be relieved by substituting a synthetic antiferromagnet (SyAF) for a single AF layer. In this structure, the magnetic flux closure is formed within the SyAF [1]. In spite of many merits of a SyAF, a potentially serious problem may result from magnetization-flop [2]. The strong pinning is one of importance factors for providing magnetization flop. However, in a practical density level, the cell dimensions are expected to be in the submicron size range. Fundamentally, the thickness of junction should be thinner considering highly density memory. The thin thickness of free layer is for low coercivity, not but high density. In case of pinning layer, this is relating with thickness of junction, directly. In this study, we focused unpinned SyAFs with three ferromagnetic layers, which is no pinning layer of AF, and its effect of resistance for magnetization flop. A particular emphasis is given to no unidirectional pinning for applying MRAM.

2. Model and Computation

The modeled related in MTJs structure in this work is NiFe (7.5 nm)/ Al_2O_3 (0.7 nm)/ Co (2 nm)/ Ru (3 nm)/ Co (4 nm)/ Co (2 nm). The milti-layer with aspect ratio of 2.0 are size in $(\mu m)^2$ of 0.8 × 0.4, 1.2 × 0.6, 4 × 2, 8 × 4, and 16 × 8. The magnitude of the antiferromagnetic coupling field between the two Co layers separated by a thin Ru layer was 1000 Oe (the negative sign indicates the antiferromagnetic coupling), which was estimated from the interlayer exchange coupling coefficient (J) of 1 erg/cm^2.[2] The magnetic induced anisotropy is 5 Oe in free layer, and exchange coupling of free layer with upper pinning layer is 26 Oe. The direction of all layers are parallel to the length direction.

3. Results and discussion

Computer simulation in a single domain multilayer model has been carried out in this work to investigate magneto-resistance behavior in Magnetic tunnel junctions exchange biased by Co/Ru/Co/Ru/Co synthetic antiferromagnets for MRAM applications. The resistance to magnetization-flop of multi SyAF layer is stronger than that of common

SyAF as shown in Fig. 1. When the magnetization-flop occurs on multi SyAF layer, this effect is significantly controlled. The three ferromagnetic layers are very strongly exchange coupled antiferromagnetically. So that, the total exchange energy is as twice as that of comman SyAF. The magnetization configuration is illustrated in Fig. 2. As the cell size decreases, the resistance to magnetization-flop increases due to increased shape anisotropy and hence increased coercivity of the Co layers in the SyAF. The MTJs with strong pinning of SyAF with three ferromagnetic layers are not suitable for MRAM applications. This emphasizes a possibility of MTJs unpinned SyAF layers.

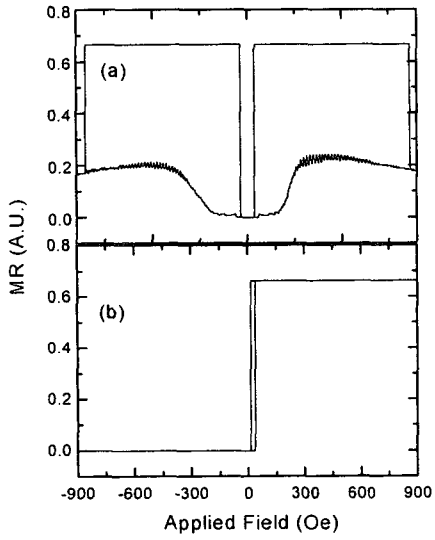

Fig. 1. MR hysteresis loops of MTJs with unpinned SyAFs for the largest cell size of 16 μm × 8 μm using (a) Co(I)/Ru/Co (II) and (b) Co(I)/Ru/Co(II)/Ru/Co(III) at applied field of ⊥900 Oe. Fig. 1.

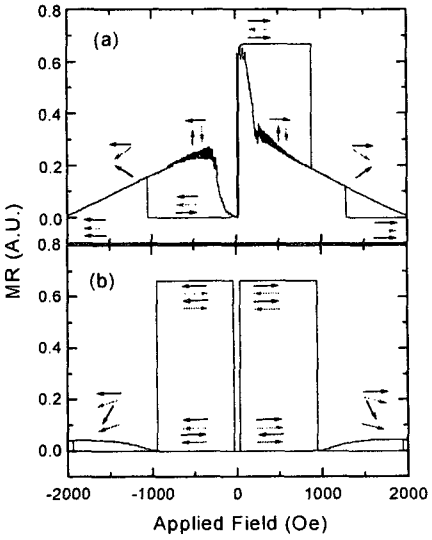

Fig. 2. MR hysteresis loops of MTJs with unpinned SyAFs for the largest cell size of 16 μm × μ8 m using (a) Co(I)/Ru/ Co(II) and (b) Co(I)/Ru/Co(II)/Ru/Co(III) at applied field of ⊥2000 Oe.

Reference

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