Perpendicular Magnetic Anisotropy Features of [Co/Pd] Multilayer Matrix and Related Synthetic Anti-Ferromagnet Structure

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1. Introduction

Perpendicular spin torque transfer magnetic random access memories (*p*-STT MRAMs) are increasingly becoming one of the most reliable candidates for use in practical devices.[1] In past years, among various PMA materials including a $L1_0$ alloy, multilayer (ML), and rare earth-transition metal (RE-TM) alloy, the artificial ML matrix consists of ferromagnetic metals and noble metals, such as Co/Pd, Co/Pt, Fe/Pd, and Fe/Pt,[2-4] and their alloy compositions[5-7] have been widely explored due to its large PMA features.

2. Experimental Details

Various [Co/Pd] MLs with Ta/Ru/Pd seed layers were prepared by utilizing a DC/RF-magnetron sputtering system on oxidized Si substrates at room temperature. After the different thicknesses of the Co and Pd layers were tested within a nominal thickness range from 1 Å to 9 Å, the optimized thicknesses were selected for subsequent evaluation in this work. Two samples were prepared as follows: subs./Ta /Ru /Pd /$[Co /Pd]_7$/Pd (Sample A) and subs./Ta /Ru /Pd /$[CoO /Pd]_2$/$[Co /Pd]_7$/Pd (Sample B).The CoOlayer was grown by a reactive sputtering method, while the other Co layer was fabricated under only an Ar ambient. Finally, post thermal annealing was carried out at various temperatures under perpendicular magnetic field of 3 Tesla.

3. Results and Discussion

The ordinary ML matrix (Sample A) revealed an anisotropic energy of around 3 Merg/cc, while the modified [Co/Pd] ML matrix (Sample B) provided a significantly higher K_U value of 7.43 Merg/cc after annealing. By utilizing the high-resolution x-ray diffraction (HR-XRD)θ-2θscan, all the samples have been confirmed to have a (111) crystal orientation. The Rocking curve measurement showed that the crystal orientation quality of annealed Sample B seems to be better than that of Sample A. Therefore, we expect that the difference in the main peak location, peak shift, and FWHM widths between Sample A and B may be associated with the induced lattice strain in the Sample B under annealing.The x-ray photoelectron spectroscopy (XPS) suggests an evidence for the presence of Co-O bonding states and annealing dependent oxygen atom diffusion event, along with HR-XRD results.

4. Conclusion

In summary, we present thermally stable behaviors of $[Co/Pd]_n$ ML matrix incorporated with a $[CoO/Pd]_m$ bottom layer. Post thermal annealing even at the higher temperature of 450°C allows for a proper diffusion process of oxygen atoms associated with initially formed Co-O binding during deposition. The diffused oxygen atoms may lead to structural reconfiguration in the ML matrix by providing proper lattice strains in the [Co/Pd] ML framework. The ordinary ML matrix revealed an effective anisotropic energy of around 1.25Merg/cc, while the modified [Co/Pd] ML matrix provided a significantly higher K_{eff} value of 3.40Merg/cc after annealing.

5. References

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