強い層間交換結合を用いたSTT-MRAM向け垂直SAFの作製

Fabrication of p-SAF Structure with Strong Interlayer Exchange Coupling

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A perpendicularly magnetized MgO-based magnetic tunnel junction (p-MTJ) is a promising candidate for use as a memory cell in spin-transfer-torque (STT) switching-type magnetoresistive random access memory (STT-MRAM). For steady read/write operations in a p-MTJ, the reference layer should have an identical magnetization direction for all memory cells, and a synthetic antiferromagnetic (SAF) structure has been widely applied. From the viewpoint of STT-MRAM applications, introducing the higher antiferromagnetic (AF) exchange coupling field of a perpendicularly magnetized SAF (p-SAF) structure has been considered preferable to prevent any read/write disturbance. SAF coupling manifests itself as a feature of the interlayer exchange coupling (IEC) effect through a thin spacer layer made of Ru, Rh, or Ir, for example. Its energy density (J_{ex}) oscillates as a function of the spacer layer thickness. For Ru, Parkin et al. demonstrated that the highest J_{ex} occurred at the "first peak" of the oscillation, where the Ru thickness (t_{Ru}) was less than 0.5 nm [1]. In the study, we fabricated [Co/Pt] superlattice [2] based p-SAF structures with t_{Ru} ranging from 0.34 to 1.05 nm to attain highly stable p-SAF structure with the 1st IEC peak.

We first fabricated p-SAF structures with the following stacked structure: Si-O substrate / Ta (5.0) / Ru (8.0) / Pt (2.0) / [Pt(0.16)/Co(0.24)]$_5$(2.0) / Ru (t_{Ru}) / [Co(0.24)/Pt(0.16)]$_5$ (2.0) / Pt(2.0) / capping (unit in nm), where t_{Ru} = 0.34–1.05 nm. We obtained large exchange field (H_{ex}) of up to 10.0 kOe and 6.5 kOe, for the as-deposited and the annealed (T_a = 400ºC, 1h) sample, respectively. The maximum J_{ex} was obtained at t_{Ru} = 0.43 to be 2.2 erg/cm^2, which was three times higher than that at 0.95 nm (~0.7 erg/cm^2). We also fabricated top-free-type p-MTJs with a newly developed p-SAF structure that exhibited strong AF coupling (T_a = 350ºC, 1h). We attained a two-times-larger H_{ex} (~5.5 kOe) with a wide AF-coupled plateau compared with those of previous samples with a thicker Ru spacer corresponding to the 2nd peak [3]. At the same time, we achieved a high MR ratio of 150% at an RA product of 5.3 Ωμm^2. The use of p-SAF coupling at the 1st IEC peak is advantageous for achieving a highly stable reference layer for every STT-MRAM generation.

This study was partly supported by the Normally-Off Computing Project of NEDO.

References:

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