Ir スペーサー層を有する p-SAF 構造を用いた垂直磁化 MTJ の作製とスピントルク反転特性

Preparation of p-SAF-type perpendicular magnetic tunnel junctions with Iridium spacer layer and their spin-transfer-torque switching properties

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A perpendicularly magnetized magnetic tunnel junction (p-MTJ) is a promising candidate as a memory cell of spin-transfer-torque switching magnetic random access memory (STT-MRAM). Perpendicularly magnetized synthetic antiferromagnetic (p-SAF) coupling in the reference layer is one of the key technologies to yield steady read and write operation of the cell. So far, Ru spacer based p-SAF has been intensively developed because of the high AF exchange coupling field (H_{ex}). Although there have been other candidates such as Ir and Rh besides Ru, they have not been extensively investigated yet. In this study, for the first time we utilized Ir and Rh as the spacer layer and systematically investigated magnetic properties of the p-SAF films. We also evaluated STT-switching properties in the p-MTJs with Ir spacer.

The structure of the p-SAF films is Si-O substrate / Ta(50) / Ru(60) / Pt(20) / $[Pt(1.6)/Co(2.4)]_{n=6}$/ Spacer(t) / $[Pt(1.6)/Co(2.4)]_{n=6}$ / Pt(20) / capping layer (thicknesses are in Å), where n is repetition number. Figure 1(a) shows the antiferromagnetic exchange coupling energy (J_{ex}) for various spacers as the function of t and the M-H curve for the Ir at t = 4.8 in the inset. The maximum H_{ex} and the maximum J_{ex} values were 12 kOe and 2.6 erg/cm^2, respectively. The maximum J_{ex} value is over 20% higher than that for the Ru.[1] Moreover, the first peak for the Ir is broader than that for the Ru, suggesting that Ir has very high potential for manufacturability of STT-MRAM because it tolerates the thickness variation of the spacer layer.

We also fabricated p-MTJ stacks with the Ir spacer layer and microfabricated them into nano-pillars (18 - 60 nm in diameter(ϕ)) to evaluate their STT-switching properties. Figure 1 (b) shows a minor loop of an R-H curve for the 25 nmϕ nano-pillar. High TMR of 133% at low RA-product of 5.2 Ωμm^2, H_{ex} exceeding 8 kOe, and high switching efficiency of about 2 were achieved. These results indicate that the p-SAF with Ir spacer layer is superior to that with Ru spacer layer and more suitable for STT-MRAM.

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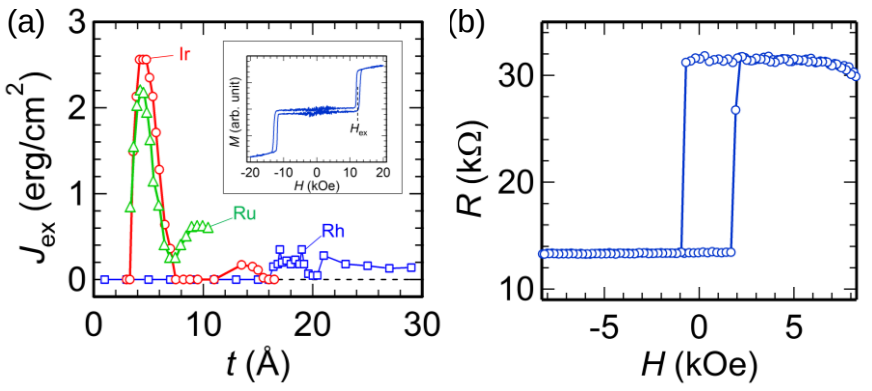

Fig.1 (a) Antiferromagnetic exchange coupling energy (J_{ex}) for functions of spacer layer thickness (t) and magnetization (M-H) curve for the p-SAF film with a 4.8 Å-thick Ir spacer layer (inset). (b) Minor loop of an R-H curve for the 25 nmϕ MTJ with the Ir-spacer p-SAF reference layer.

[1] K. Yakushiji, H. Kubota, A. Fukushima, and S. Yuasa, Appl. Phys. Express **8**, 083003 (2015).