CoFeB/Ta/[Co/Pd] 強磁性電極を用いた磁気トンネル接合

Magnetic tunnel junctions using CoFeB/Ta/[Co/Pd] ferromagnetic electrodes

東北大学通研附属ナノ・スピナロジカル実験施設 1, 東北大学 CSIS2, 東北大学 WPI-AIMR3, 東北大学 CIES4

石川慎也 1, 佐藤英夫 2, 山ノ内路彦 1,2, 池田正二 1,2,4, 深見俊輔 2, 松倉文礼 1,2, 大野英男 1,2,3,4

Laboratory for Nanoelectronics and Spintronics, RIEC, Tohoku Univ. 1, CSIS, Tohoku Univ. 2, WPI-AIMR, Tohoku Univ. 3, CIES, Tohoku Univ. 4. S. Ishikawa 1, H. Sato 2, M. Yamanouchi 1,2, S. Ikeda 1,2, S. Fukami 2, F. Matsukura 3,1,2, and H. Ohno 1,2,3,4

E-mail: shinya08@riec.tohoku.ac.jp

To realize high-density nonvolatile memory with perpendicular anisotropy magnetic tunnel junctions (p-MTJs), one needs to achieve both a high thermal stability factor ($\Delta$) and a low intrinsic critical current ($I_{C0}$) at reduced dimension [1]. For high $\Delta$, multilayer electrodes have an advantage because the product of effective magnetic anisotropy energy density and thickness can increase by increasing stacking number.

We reported that a high $\Delta$ over 90 was obtained in MTJ using multilayer electrodes consisting of CoFeB/Ta/[Co/Pt]$_n$ at the junction diameter less than 20 nm [2]. However, $I_{C0}$ is too large to switch magnetization solely by current, which may be due to a large damping constant ($\alpha$) of Co/Pt multilayer [3]. In this work, we investigate magnetic and MTJ properties for CoFeB/Ta/[Co/Pd] ferromagnetic electrodes, since a low $\alpha$ is expected for the Co/Pd compared with Co/Pt.

All films are deposited on thermally oxidized Si substrates by dc/rf magnetron sputtering. The stack structures are, from the substrate side, Ta(5)/Pt(5)/synthetic-ferrimagnetic reference layer/MgO/Co$_{20}$Fe$_{60}$B$_{20}$(0.4)/[Co(0.4)/Pd($t_{Pd}$)/Ru(5)]. Pd thickness $t_{Pd}$ is varied from 0.4 to 1.2 nm and stacking number $n$ is varied from 4 to 6. For magnetization measurement, vibrating sample magnetometer is used. We fabricate MTJs by using electron beam lithography, reactive ion etching and Ar ion milling. All films are annealed at 300°C for 1 hour under a perpendicular magnetic field of 0.4 T.

Magnetization measurement reveals a perpendicular easy axis in the films with $t_{Pd} \geq 0.8$ nm and $n \geq 4$.

For MTJ with $t_{Pd} = 0.8$ nm and $n = 6$, we evaluate $\Delta$ by measuring switching probability ($P(\tau)$) as a function of the amplitude of pulse magnetic field. Fig. 1 shows $P(\tau)$ as a function of magnetic field of MTJ with the junction diameter of 31 nm. A high $\Delta$ of 218 is obtained.

This work was supported by the FIRST program of JSPS, R&D for Next-Generation IT of MEXT, and Grants for Excellent Graduate Schools of MEXT.