Influence of thermal treatment-induced atomic states on spin orbit torque in MgO/CoFeB/W stacks

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1. INTRODUCTION

Spin-orbit-torque (SOT) effect, which arises from in-plane current, has recently garnered considerable attention as a novel magnetization switching mechanism forlow power consumption, and new physical phenomenon [1,2]. The Rashba effect and the spin Hall effect have been considered to generate this kind of magnetic switching operated by SOT [3]. However, X. Qiu [4] has reported that there may be a new mechanism of spin-orbit torque associated with the oxidation states. Therefore, we examined the current-induced effective field related with SOT in W/CoFeB/MgO stacks with various post-annealing temperatures. SOT property has been investigated as atomic states and distribution at various annealing temperatures are changed.

2. EXPERIMENTAL DETAILS

MgO/$Co_{20}Fe_{60}B_{20}$/W stacks were prepared on thermally oxidized Si substrates utilizing a radio-frequency (RF) magnetron sputtering-system. Species were [Si/SiO_2] Substrate/MgO (2)/$Co_{20}Fe_{60}B_{20}$ (t_{CFB})/W (8), where numbers in parenthesis refer to layer thickness in nanometers. To show post-annealing influence on magnetic and atomic features, a post-annealing process was carried out at 325°C, 350°C, 375°C, and 400°C for 1 hour under vacuum conditions below ~1 x 10^{-6} Torr, with a 3T perpendicular magnetic field. Finally, these stacks were patterned into the width and length with 20 μm and 120 μm Hall bar by standard photolithography and Ar ion-milling techniques.

References

[1] Liu, L. Q. et al. Spin-torque switching with the giant spin Hall effect of tantalum. Science **336** (2012) 555-558.

[2] Miron, I. M. et al. Perpendicular switching of a single ferromagnetic layer induced by in-plane current injection. Nature **476** (2011) 189-193.

[3] Kim, J. et al. Layer thickness dependence of the current-induced effective field vector in Ta/CoFeB/MgO. Nature Mater. **12** (2013) 240-245

[4] Qiu. X. et al. Spin-orbit-torque engineering via oxygen manipulation. Nature nanotech. **10** (2015) 333-338