THEORETICAL PREDICTION ON THICKNESS TUNABLE MAGNETIC ANISOTROPY ENERGY AND ELECTRIC FIELD EFFECT ON Cr-BUFFERED Fe/MgO INTERFACE

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I. INTRODUCTION

Thin film containing Fe/MgO interface has unique magnetic characteristic, such as perpendicular magnetic anisotropy (PMA) and voltage controlled magnetic anisotropy (VCMA). By combining this novel properties, we try to create disruptive memory technologies with high density and low power consumption. Proposed technology seems to be mature, but there is still room for improvement. The current value of PMA in this interface is still below 1 mJ/m^2 [1]. This value needs to be improved to prevent the memory deterioration due to disturbance of external field.

II. METHOD AND SYSTEM

In search for superior features, systematic approach on the thickness variation of ferromagnet layer in Cr-buffered Fe/MgO interface has been performed by the current state-of-the-art of density functional theory (DFT). Generalized gradient approximation with high density of k-mesh, equipped with spin-orbit interaction [2], is employed to estimates the total energy difference of perpendicular and in-plane magnetizations. In addition to such energy of DFT, the magnetic dipole interaction energy (MDI) correction was carried out to estimate the total magnetic anisotropy energy (MAE).

III. RESULTS

Figure 1 shows the theoretical prediction in thinner layer compared to the experimental ones. Two calculation result of MAE are presented, the first MAE contribution comes only from spin-orbit interaction (SOI), the latter from SOI and MDI. As decreasing the thickness of ferromagnet layer, the PMA increases. In the other side, electric field effect (EFE) is decreasing until the sign finally reaches to negative one. Theoretical prediction at ultrathin configuration (2 monolayers) shows improvement of PMA and the negative of sign of EFE. This change may be related to the large change in electronic structure.

Basic mechanism of PMA based on second order perturbation theory is used to explain the positive contribution to MAE. Different way of electron filling mechanism of the iron at the interface in 2 ML configuration may relate to the change of its sign. The large peak of electron density of states just above the Fermi level may relate to the formation of interface resonant state (IRS). Non-rigid band filling mechanism of such IRS is observed at ultrathin configuration starting from 2 to 5 MLs. But the detail mechanism of this abrupt change in MAE and EFE may be attributed to electron filling of the local 3d orbitals on the interface Fe.

III. DISCUSSIONS

It has been predicted previously that the buffer modification (from Pd to Pt) in the 2-dimensional ferromagnet interface could provide change of EFE [3]. But currently we discuss that the ferromagnet thickness modification in this theoretically perfect Fe/MgO interface could lead to the similar physical properties, without the need of heavy metals [4] in the thin film stacking. This negative sign of EFE is interested for device application, because its consume less energy to modify the magnetization of each

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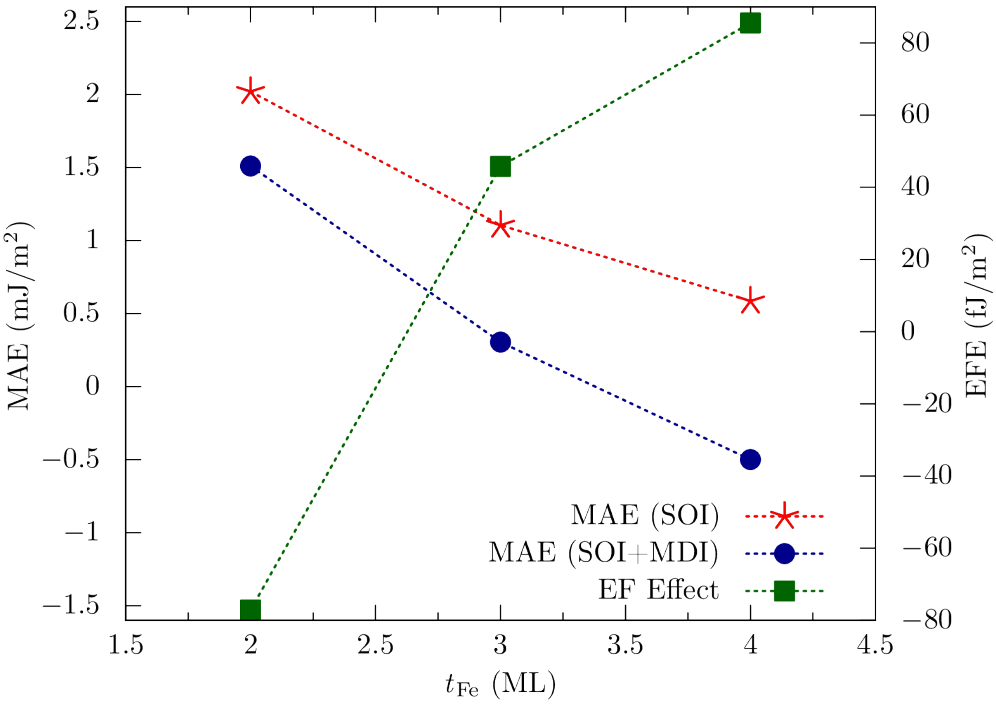

Figure 1. Theoretical prediction on magnetic anisotropy energy and electric field effect in ultra-thin ferromagnet configuration

magnetic tunnel junction (MTJ) cell. Also supported with larger PMA, theoretically this thin film configuration has huge potential for the high density and low power memory cell device. Continues development toward accurate prediction on searching for superior characteristic in this interface are still performed.

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