Modification of magnetism in transition-metal thin films by external electric field

Kohji Nakamura*
Department of Physics Engineering, Mie University, Japan

Electric-field (E-field) induced modification of magnetism in transition-metal thin films has received much attention as a potential approach for controlling magnetism at the nano-scale with the promise of ultra-low energy power consumption. It was originally reported that the coercivity of thin films, FePt and FePd, was reversibly varied by the application of a voltage, and the magnetocrystalline anisotropy (MCA) of the 3*d* transition-metal thin films with MgO interfaces was controlled by a voltage, thus opening a new avenue towards MgO-based magnetic tunnel junction electronics. However, continuing challenges still remain for understanding an E-field modification of the Curietemperature (T_C) and, more recently, for the Dzyaloshinskii-Moriya interaction (DMI) of thin film ferromagnets. Here, from first-principles calculations by using the full-potential linearizedaugmented plane wave method, the E-field-induced modifications of magnetism, namely the MCA, T_C and DMI, were demonstrated for prototypical transition-metal thin films with perpendicular magnetic easy axis, a freestanding Fe monolayer and a Co monolayer on Pt(111).[1] The resultspredict that a change in the screening charge density at surfaces/interface due to the E-field, which causes a small change in band structures around the Fermi energy, gives rise to the modification of the MCA energy. The applied E-field further modifies the magnon (spin-spiral formation) energy, which leads to modification of the Heisenberg exchange parameters, i.e., the T_C. The DMI, calculated by the second variation SOC method, was modifed by the E-field.

[1] K. Nakamura et.al., PRL102, 187201 (200); M. Oba et. al., PRL114, 107202 (2015).