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Single Domain Spin Manipulation by Electric Fields in Strain Coupled Artificial Multiferroic Nanostructures

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The continuously increasing demand for data storage systems that exhibit both high-speed and low energy consumption has encouraged researchers to look for novel ways of manipulating and recording information. One promising and viable solution is to couple a magnetostrictive ferromagnet to a ferroelectric piezoelectric creating an artificial multiferroic, a material whose magnetization configuration can be manipulated by applying an electric field [1, 2]. In this work we demonstrate the first experimental evidence of an electric field-induced 90 uniform magnetization reorientation between two single domain states in 200×100 nm2 Ni nanoislands. Artificial magnetoelectric coupling is achieved depositing the Ni nanoellipses on a Pb(Mg0.66Nb0.33)O3-PbTiO3 (PMN-PT) ferroelectric single crystal [3]. Imaging of the magnetic domain configuration was obtained by photoemission electron microscopy (PEEM) using the X-ray magnetic circular dichroism (XMCD) effect at the Ni L3 edge. By applying an electric field that drives the polarization reversal of the ferroelectric, the magnetization in the nanoislands rotates uniformly from the in-plane easy axis defined by the shape anisotropy, to the perpendicular in-plane easy axis, defined by the converse magnetoelectric interaction. Our experimental findings correlate well with micromagnetic simulations and the observed electric field-induced magnetization reorientation can be explained by strain mediated magnetoelectric coupling which causes the magnetization to reorient as a result of the competition of shape anisotropy and magnetoelastic contributions induced by the ferroelectric distortions. We believe that our results constitute an important step not only towards the realization of magnetoelectric memory devices containing an artificial multiferroic film stack with low power consumption and high switching reliability but also for a greater understanding of the physics related to strain coupled nanostructured artificial multiferroics.

[1] C. A. F. Vaz, J. Phys.: Condens. Matter 24 333201 (2012)
[2] R. V. Chopdekar, et al., Phys. Rev. B 86 014408 (2012)
[3] M. Buzzi, et al., Phys. Rev. Lett. 111 027204 (2013)

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