Magnetostrictive-piezoelectric coupling of $CoFe_2O_4$ nanopillars embedded in a $BaTiO_3$ matrix

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Multiferroic materials showing both magnetic and electric ordering allow an additional degree of freedom in the design of actuators, transducers and storage devices and thus have attracted scientific interest from the technological perspective as well as from basic research. Because the choice of single-phase multiferroic materials being suitable at room temperature is limited, the use of magnetoelectric two-phase composites has proven to be more promising [1]. Here we study ferrimagnetic $CoFe_2O_4$ (CFO) nanopillars embedded in a ferroelectric $BaTiO_3$ (BTO) matrix (Fig. 1). They operate at room temperature and are free of any resource-critical rare-earth element, which makes them interesting for potential applications. Prior studies succeeded in showing strain-mediated coupling between the two subsystems. In particular, the electric properties can be tuned by magnetic fields and the magnetic properties by electric fields. Here we take the analysis of the coupling to a new level utilizing soft X-ray absorption spectroscopy and its associated linear dichroism [2]. We demonstrate that an in-plane magnetic field breaks the tetragonal symmetry of the (1,3)-type $CoFe_2O_4$/$BaTiO_3$ structures and discuss it in terms of off-diagonal magnetostrictive-piezoelectric coupling (Fig. 1). This coupling creates staggered in-plane components of the electric polarization, which are stable even at magnetic remanence due to hysteretic behaviour of structural changes in the $BaTiO_3$ matrix. The competing mechanisms of clamping and relaxation effects are discussed in detail. The effect in the electric in-plane polarization of BTO obtained in this work extends over a large area. These concepts can be extended towards ceramic composites [3].

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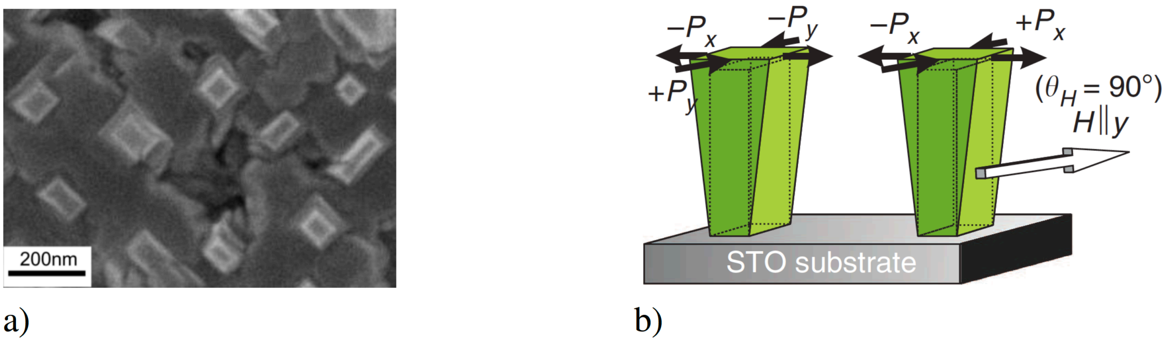

Figure 1: a) Scanning electron microscopy image of the sample corresponding to a top view on the nanopillar structure. b) Schematic presentation of the strained CFO nanopillars in the BTO matrix (not shown) when applying a magnetic field perpendicular to the pillars [2].

References

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