E controlled Magnetism

2018-07-27

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Mechanisms

- Ions displacement
- Magnetostriction
- Interface atoms displacement
- Hole mediated magnetization
- Surface magnetism

Ion displacement

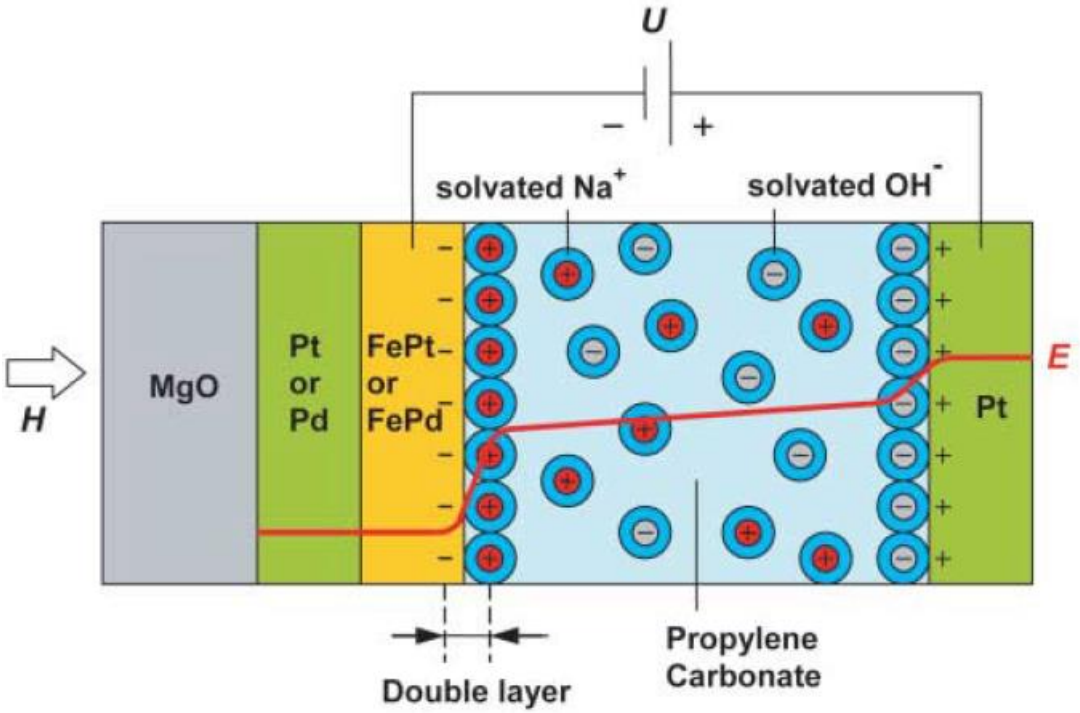
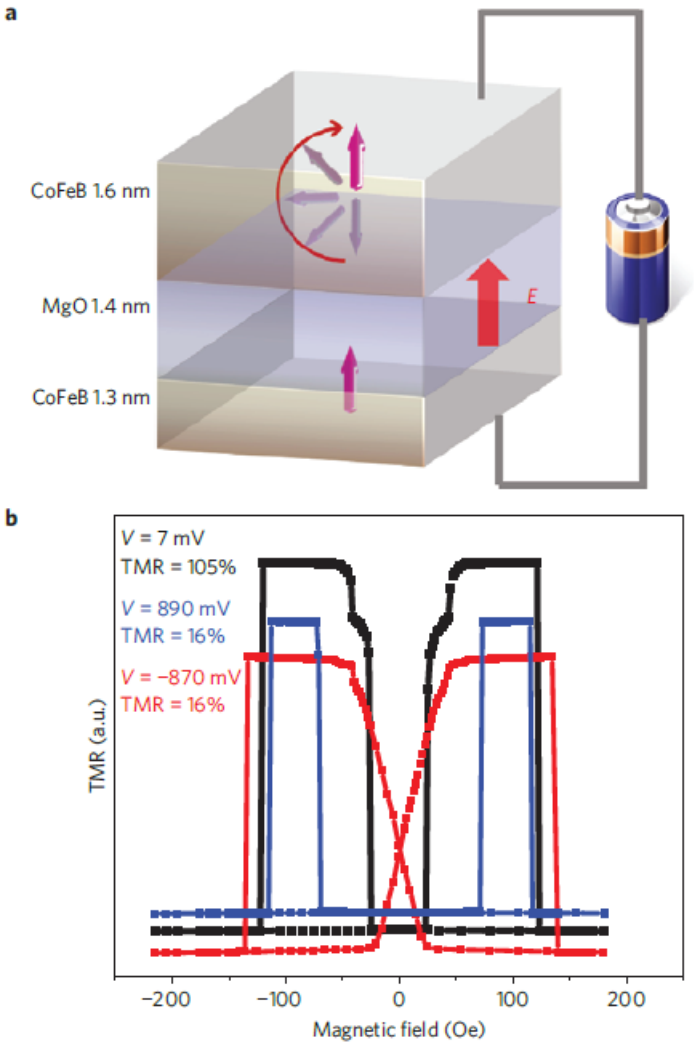


Fig. 1. Schematic of the electrolytic cell containing the FePt or FePd film within an applied magnetic field *H*. The potential profile *E* due to the applied potential *U* is indicated by the red line. The potential drop at the Pt electrode side is much lower (as compared to that of the sample surface) as a result of the Pt electrode's large surface area.



Ions penetrate through electrolyte under E field, leads potential difference between electrodes, so the magnetization in two electrodes is different.

Martin Weisheit., science, 315, 349-351 (2007)

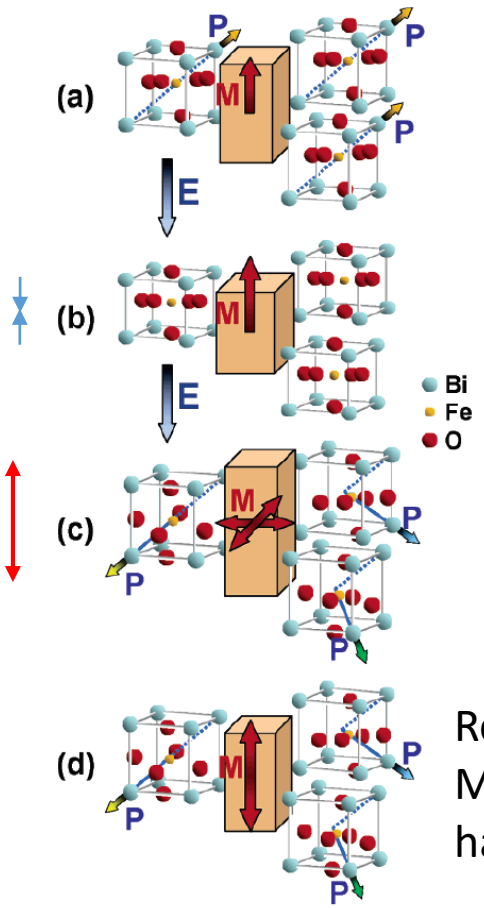
Wei-Gang Wang, NMAT3171 (2011)

Magnetostriction

F. Zavaliche., nano letter, 7, 1586-1590, 2007

BFO/CFO nanopillars

Magnetostriction factor for CFO λ(100)=-350e-6

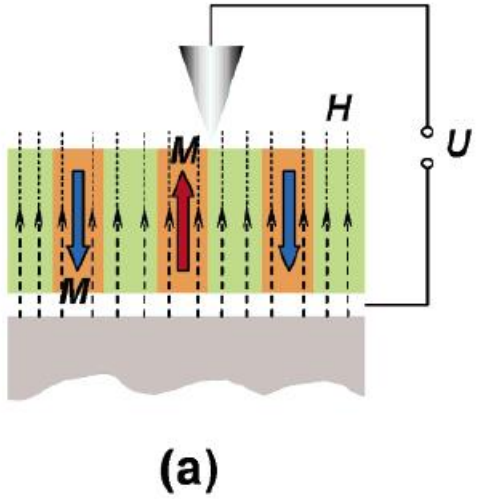


Initial

Before switching

After switching

Relax
M up or down
has 50% chance.



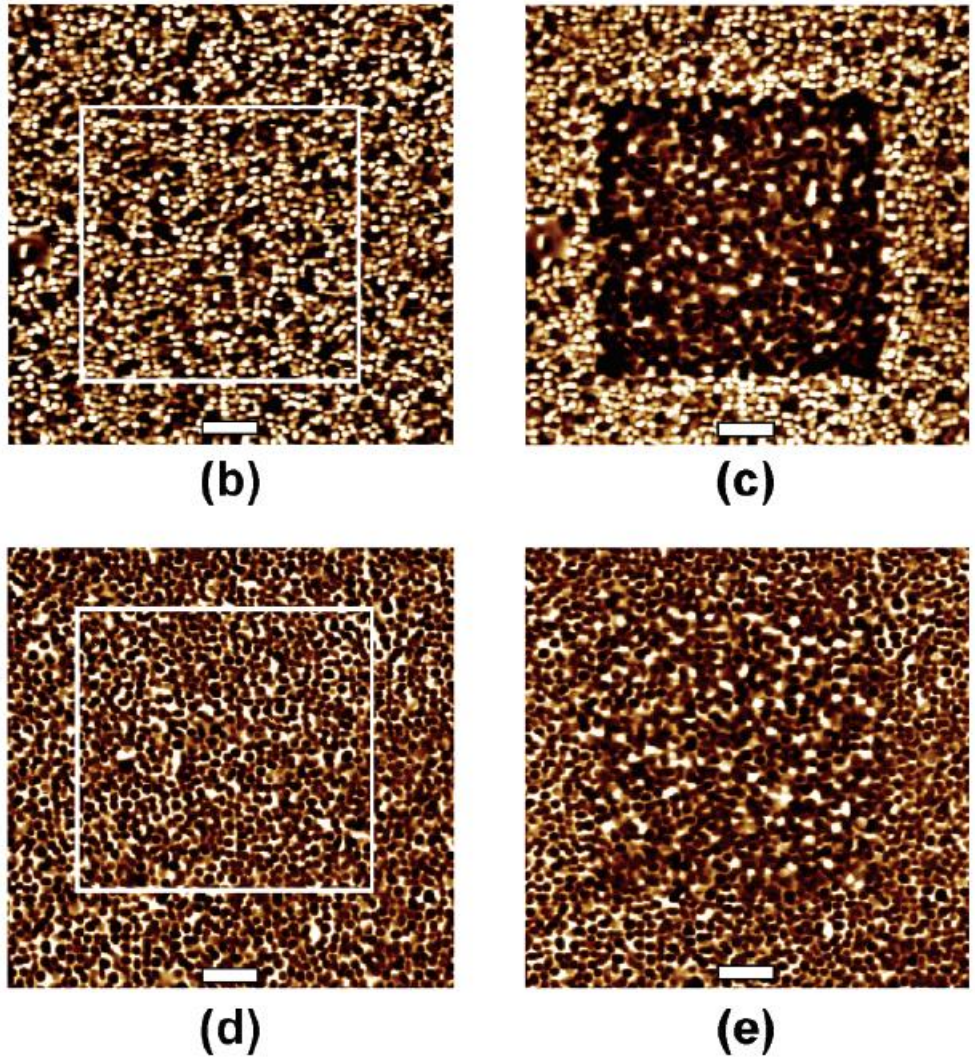
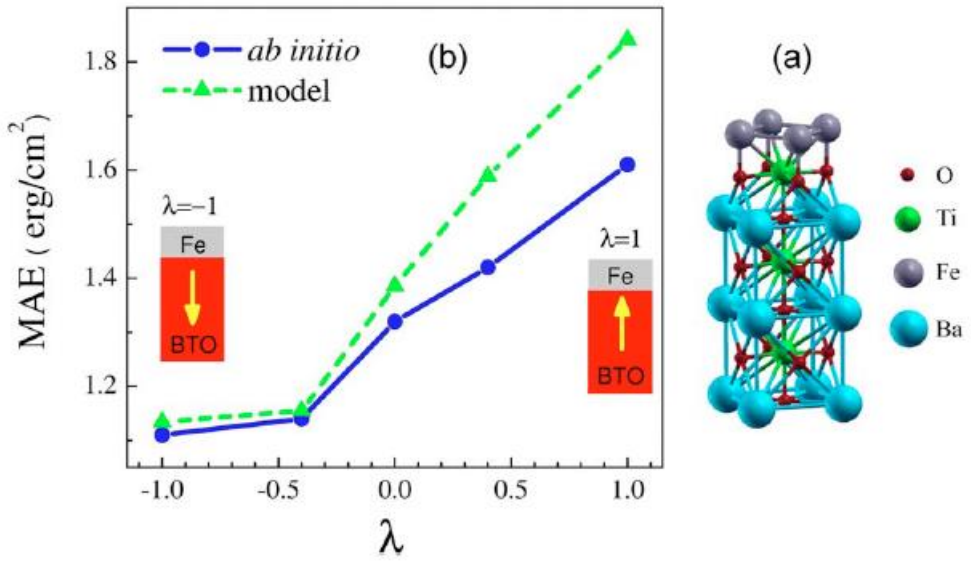


Figure 3. The principle of EAMR in $(BiFeO_3)_{0.65}-(CoFe_2O_4)_{0.35}$ multiferroic nanostructure. (a) Sketch of the experimental setup. (b) MFM after magnetization in a down 20 kOe field before and (c) after poling at −16 V in a 700 Oe up-magnetic field. (d) MFM after magnetization in an up 20 kOe field before and (e) after poling at −16 V in a 700 Oe up-magnetic field. The bars are 1 μm.

Interface atoms displacement



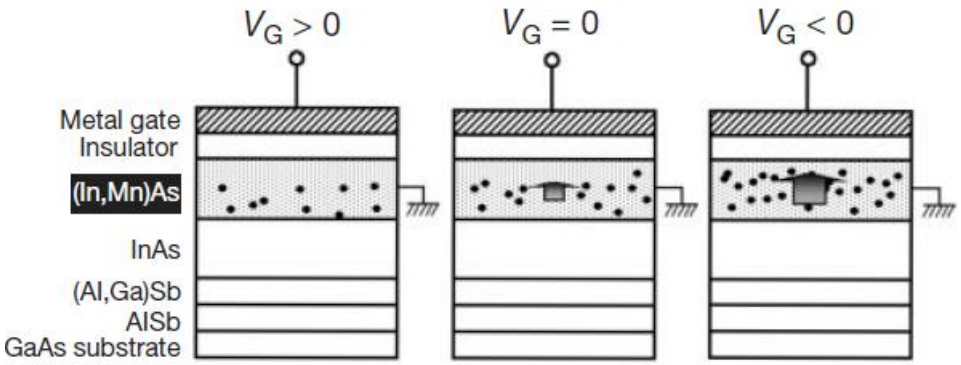
Due to polarization switch, the interfacial bonding length is changed. The bonding length affects hybridization between Fe-Ti, which changes spin population.

TABLE II. Calculated spin and orbital magnetic moments (M_S, M_L, in units of μ_B) of Fe and interfacial Ti atoms at the Fe/$BaTiO_3$ interface. Results are listed for different magnetization orientations n_M and ferroelectric polarization orientations n_P. $\Delta M_L = M_L(100) - M_L(001)$ is the anisotropy of the orbital moment. The results of monolayer Fe on the same square lattice are also listed for comparison.

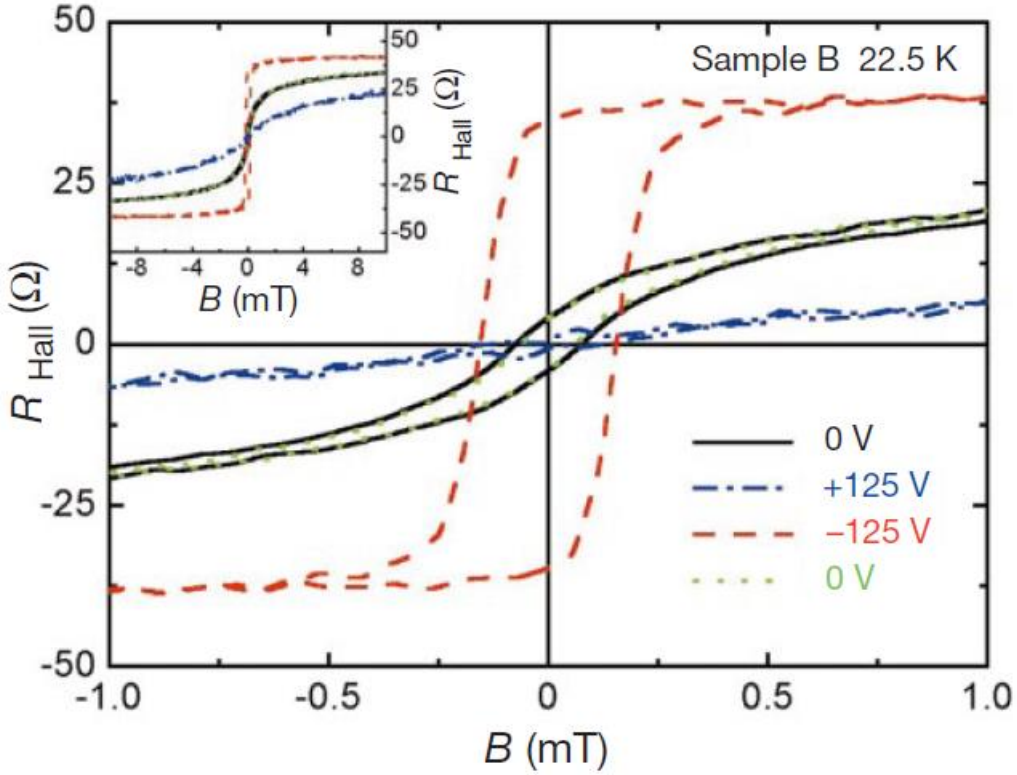
n_P	Atom	n_M	M_S	M_L	AM_L
	Fe	(100)	3.033	0.073	
		(001)	3.032	0.108	−0.035
↑	Ti	(100)	−0.416	0.012	
		(001)	−0.416	0.003	0.009
	Fe	(100)	3.096	0.082	
		(001)	3.095	0.103	−0.021
↓	Ti	(100)	−0.232	0.012	
		(001)	−0.232	−0.001	0.013
Fe monolayer		(100)	3.192	0.114	
		(001)	3.192	0.153	−0.039

C. G. Duan., APL 92, 122905 (2008)

Hole mediated FM

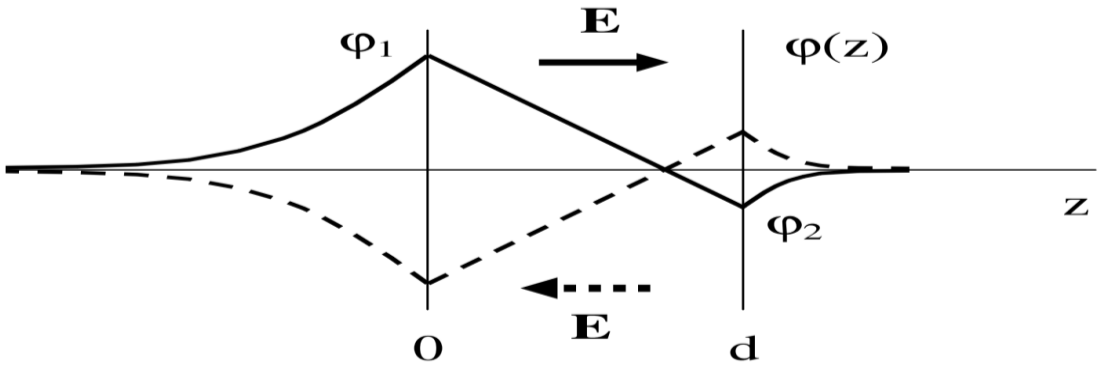


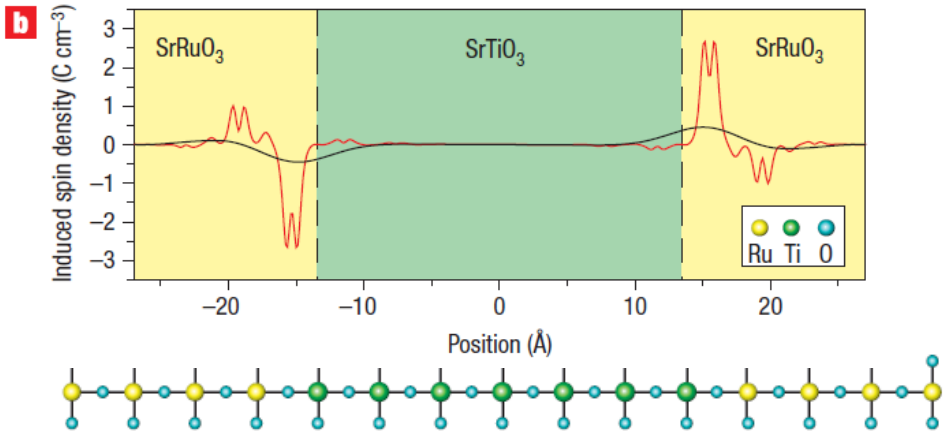
E field can reduce or increase hole population, and cause magnetization change in hole-mediated ferromagnetic material.



H. Ohno, nature 408, 944-946 (2000)

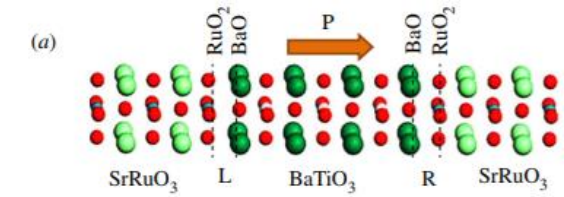
Surface magnetism

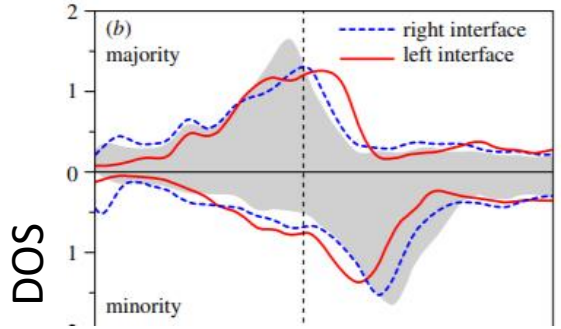




Majority and minority wavefunction is different near Fermi level, by applying E field, the spin population in screening charges will be changed, which leaves net magnetization changed.

James M. Rondinelli, nnano.2007.412





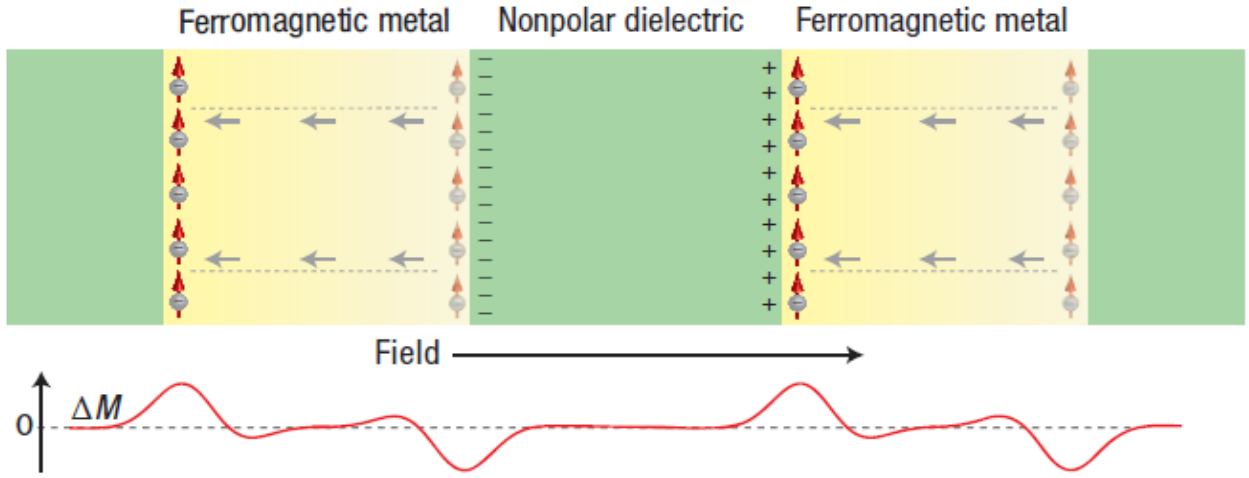


Figure 2 Schematic of the carrier-mediated magnetoelectricity mechanism. The accumulation of up-spin electrons adjacent to the positive face of the dielectric, and their depletion from the negative face, leads to the net magnetization change, ΔM, shown in red.