Design of functional nanopatterned porous ferroic metal oxides

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Perovskites and ferrites materials are important ferroic materials which may find application in several fields including ultrafast data reading, enhanced storage capacity, laser-assisted electronic data recording in ferroelectric memories, catalytic materials, and sensor devices. Nanopatterning porosity may be a tool to modify the properties of metal oxide thin films. In CICECO - Aveiro Institute of Materials, we have been focused on the understanding of the porosity effect on the piezoelectric properties of thin films. Nanoporous thin films of lead titanate [1,2] and bismuth ferrite [3], as examples of oxides with perovskite and ferrite structures, were prepared by block-copolymer self-assembly (Figure 1). Films with different thicknesses and pore organizations were also prepared. The films were characterized in relation to the structure and morphology by X-rays diffraction, scanning electron microscopy and atomic force microscopy. The electric properties were measured at nanoscale by piezoelectric-response force microscopy and are compared with dense counterparts with similar thickness. Nanopatterned PbTiO3 films present higher switchable polarization and $(d33)_{eff}$ piezoelectric coefficient than dense thin films (137.6 ± 6.7 pm/V and 49.6 ± 0.7 pm/V versus 85.1±2.0 pm/V and 35.7±0.8 pm/V, respectively), demonstrating the positive effect of porosity on the enhancement of the ferroelectric properties. Nanopatterned $BiFeO_3$ layers with 66 nm of thickness and average pore diameter of 100 nm at 600 °C were prepared. The large vertical porosity markedly enhances the local electric and macroscopic magnetic properties when compared with the dense counterparts. The vertical porosity orients the piezoelectric domains and reduces the energy necessary to reorient the dipoles. The induced instability in the dipole-dipole interactions results in the increase of the effective piezoelectric coefficient.

References

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Figures

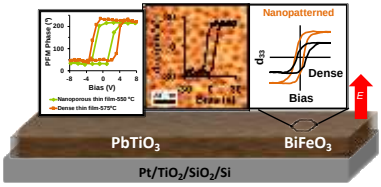

Figure 1. Nanoporous $PbTiO_3$ and $BiFeO_3$ thin films.

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