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Electric and magnetic properties of multiferroic $BiFeO_3$, $YMnO_3$ and $BiMnO_3$ thin films

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Abstract – We have grown $BiFeO_3$, $BiMnO_3$ and $YMnO_3$ thin films on $Pt/TiO_2/SiO_2/Si$ substrates by using a magnetron sputtering technique assisted by radio frequency in a pure oxygen atmosphere. Polarization as a function of electric field in capacitor structures showed for all samples hysteretic behavior. Magnetization measurements on all samples evidence weak magnetization, corroborating the behavior of the magnetoelectric coefficient observed in BFO bulk material

Multiferroic materials exhibit both ferromagnetic and ferroelectric polarizations along with coupling between them. The magnetic polarization can be switched by applying an electric field; likewise, the ferroelectric polarization could be switched by applying a magnetic field. Consequently, multiferroics offer rich physics and novel device concepts, which have recently become of great interest to researchers. Perovskite $BiFeO_3$ (BFO) has attracted much attention given the coexistence of ferroelectric and magnetic orders. It possesses a rhombohedrally distorted perovskite structure at room temperature, an antiferromagnetic (AF) and ferroelectric (FE) phases with high Curie (T_C ≈1100 K) and Neel (T_N ≈673 K) temperatures, in bulk. $YMnO_3$ (YMO) exhibits two stable crystallographic modifications; orthorhombic and hexagonal, magnetic ordering occurs in both phases, while ferroelectric ordering occurs only in hexagonal, besides displaying a ferroelectric transition with Curie temperature, T_C ≈ 914 K, and a rather low AF Neel temperature T_N ≈ 80 K.

Here, we report the growth of BFO, BMO and YMO thin films on Pt/TiO_2 $/SiO_2/Si$ substrates by using a magnetron sputtering technique assisted by radio frequency in a pure oxygen atmosphere. We investigated the effects of deposition temperature and crystallization on morphology, magnetization, and polarization. The crystalline phases of the films were determined by X-ray diffraction (XRD); surface morphology was obtained by atomic force microscopy (AFM), polarization electric field (*P*–*E*) measurements were performed by using the Ferroelectric Testing system (RT66a). We used a VSM technique on the Physical Property Measuring System (Quantum Design™) for magnetic measurements.

By X-ray diffraction (XRD) pattern we detected the presence of a bismuth oxide ($Bi_2O_{2,75}$) impurity phase in addition to the major $BiFeO_3$ phase; and, the presence of major yttrium manganese oxide (YMO) in hexagonal phase. Surface morphology of YMO films is improved when deposition temperature increases from 750 ºC to 850 ºC. Polarization as a function of electric field in capacitor structures based on our BFO and YMO films shows hysteretic behavior with a coercive field of 90 kV/cm and 2.69 kV/cm and a remnant polarization of 37.2 $\mu C/cm^2$ and 1.39 $\mu C/cm^2$, respectively. Magnetization measurements of the BFO samples evidence weak magnetization, corroborating the behavior of the magnetoelectric coefficient observed elsewhere [1], for bulk material. YMO films grown at 850 ºC showed saturation polarization of 4.17 $\mu C/cm^2$ [2].

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