Dielectric relaxation and magnetodielectric response in epitaxial thin films of La$_2$NiMnO$_6$

P. Padhan, H. Z. Guo, P. LeClair, A. Gupta

MINT Center and Department of Physics and Astronomy, The University of Alabama, Tuscaloosa, Alabama 35487-0209

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Abstract: Frequency-dependent dielectric measurements have been carried out on epitaxial thin films of the double perovskite La$_2$NiMnO$_6$ in the presence of a magnetic field at different temperatures. The results clearly show a dielectric relaxation behavior and an associated magnetodielectric effect. The films used for the measurements are grown on conducting 0.5 wt% Nb doped (100) SrTiO$_3$ (STO) and on SrRuO$_3$ coated (100) SrTiO$_3$ substrates using the pulsed laser deposition technique. The observed magnetodielectric effect is explained in terms of the influence of magnetic ordering and fluctuations on the dynamics of the electric dipolar relaxation.

Introduction

• The ferromagnetic order in double perovskites is a consequence of Goodenough-Kanamori rules arising from a 180° superexchange interaction between two transition metal cations. The La-based ferromagnetic double perovskite oxides are insulating or semiconducting, and show a magnetodielectric effect.

• Our aim is to grow and characterized La$_2$NiMnO$_6$ (LNMO) thin film on (100) STO substrates. Then study the dielectric response of LNMO grown on conducting 0.5 wt% Nb doped STO(STNO) and on SrRuO$_3$ coated STO substrates in presence of magnetic field.

• The field cooled temperature dependent magnetization indicate the presence of ferromagnetic order with $T_c = 270$°C.

• The hysteresis loop shows 335 Oe coercive field with 4.63 μB/f.u. saturation magnetization. The rectangular hysteresis loop shape indicates relatively low contribution of domain wall pinning and magnetically homogeneous film.

Atomic Force Microscopy

Tunneling Electroscution Microscopy

• The ~3.4 nm rms roughness and grains with a diameter in the range of 40-170 nm indicate smoother surface.

• The sharp and coherent interfaces with no major defects or dislocations indicates high interface quality between the STO and LNMO.

Electronic transport

The temperature dependent resistivity of LNMO on STO shows thermally activated electronic transport with 78 meV activation energy.

Magnetic and transport

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Impedance Spectroscopy

• Divergence of semicircular shape of the Cole-Cole plot indicates the presence of complex capacitance spectroscopy.

• The characteristic RC time varies negligibly above 120 K.

• The change of slope of log(τ) vs. inverse temperature in presence of magnetic field from that of its zero field slope indicates the influence of the magnetic ordering and fluctuation on the dynamics of the dipolar relaxation.

• The presence of magnetodielectric constant at measurement frequencies faster than the RC time constant, and the presence of positive magnetodielectric constant and loss, suggest that the observed relaxation process and the magnetodielectric constant are intrinsic properties of LNMO.

• The insulator like ferromagnetic La$_2$NiMnO$_6$ exhibits dipole relaxation and magnetodielectric effect.

• The magnetodielectric effect is due to the influence of magnetic ordering and fluctuation on the dynamics of dipolar relaxation.

Conclusions