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Lattice Distortions in Very Thin Films of Mn Compounds

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Introduction: We report on the structure of a 600Å thick film of $La_{1-x}Ca_xMnO_3$ (LCMO) with x~1/3, epitaxially grown on a $NdGaO_3$ substrate (mismatch ~1.2%) by pulsed laser ablation. The orientation of the substrate is <110>.

The LCMO compound in this doping region is a ferromagnet with Curie temperature T_C~280K, and the phenomenon of Colossal Magneto-Resistance renders it particularly attractive for applications. The physical properties of the film, however, are very different from the bulk. In-plane resistivity measurements (fig.1) and SQUID measurements, give clear evidence of a strong suppression of T_C, which is ~100K (instead of 280K in the bulk). Moreover, the non-linearity of the IV characteristic in the out-of plane direction indicates the presence of an insulating state. It is very interesting, then, to understand the influence of the thin film structure on the physical properties.

One of the characteristics of the manganite compounds of the type $La_{1-x}D_xMnO_3$ (D = Ca, Ba, Sr), is the strong correlation between their physical and structural properties. Most importantly, lattice distortions arising from the tilting of the oxygen octahedra (MnO_6) surrounding the Mn atoms, and also Jahn-Teller distortions, are associated with the onset of ferromagnetism and orbital ordering. The role of the lattice distortions becomes even more important in thin epitaxial films, due to the lattice mismatch with the substrate. The presence of the substrate either enlarges the effect of the distortions intrinsic in the perovskite structure, or induces new lattice deformations. The resulting strain and additional structural deformations give rise to film transport properties, which are frequently different to those of the bulk. Few recent experiments have shown the occurrence of such changes in the physical properties of very thin films, strongly correlated with structural deformations, but there is not a unique model, which explains the role of the distortions on the other physical properties of these perovskites.

The film is well registred on the substrate, and it has large domains, which are coherent along the entire thickness, as measured from the Laue oscillations around Bragg peaks. A very peculiar domain relationship exists between film and substrate. The mosaicity is very low, the FWHM, measured on the (002) Bragg peak, is 0.02^o. Tilting peaks have been found at the positions (+/- 0.5 +/- 0.5 4) (fig.2), they show a temperature dependence which needs to be further analyzed.

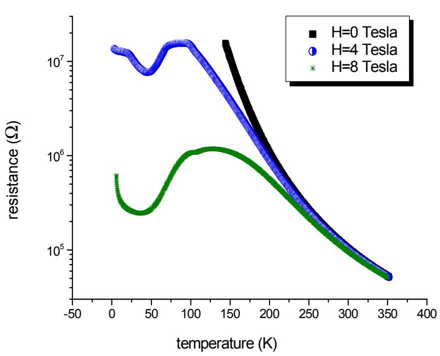

Fig1. In-plane resistivity measurements in external magnetic field

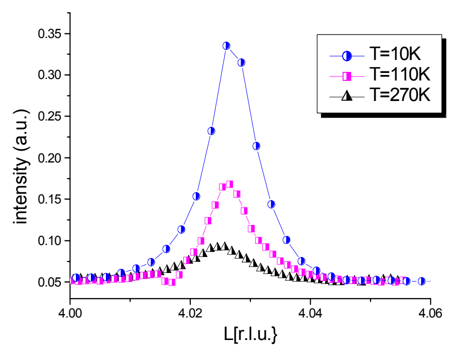

Fig2. The intensity of the tilting peak (-0.5 -0.5 4) changes drastically in the range of temperature [10-300]K