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Long Range Structure of Ultrathin CMR Films

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Introduction: Due to the large (colossal) magnetoresistance exhibited by perovskite manganites they have attracted a great deal of interest for the potential applications [1]. Many experiments have now show that the complex phase diagrams of CMR magnanites are driven by the close interplay between the charge, spin, and orbital degrees of freedom in the system, although the details of an active area of research. It is evident the lattice strain plays an important role in the properties of these materials, which opens up the possibility of optimizing the properties of CMR oxides for specific applications by growing thin CMR films on substrates with different lattice spacing [2, 3].

Methods and Materials: Epitaxial $La_{1-x}MnO_3$ (x ~ 0.8) films were grown on (001) $LaAlO_3$ substrates by metalorganic chemical vapor deposition (MOCVD) using a liquid-injection source delivery system [4]. Synchrotron XRD experiments were performed on the Oak Ridge National Laboratory's X-Ray beamline X14A at the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory (BNL). The x-ray energy was set to 8.0468 keV (λ=1.5406 Å).

Results: In Fig. 1 (a) and (b), we show the diffraction profiles for two in-plane orthogonal reflections: (4 0 0) and (0 4 0). These measurements correspond to near 90° rotations relative to the (0 0 4) sample normal. Below, we call these reflections in-plane. For the 60 Å film (solid dots) a pair of lines (Table I) occurs at high angle (lower d-spacing) relative to a pair lines found in the 1600 Å film (solid line) at lower angle (higher d-spacing). While the corresponding pair of diffraction lines in the 300 Å film are significantly closer to those of the 1600 Å film than those of the 60 Å film. The 300 Å film has an additional peak (C_2) with d-spacing similar to those of the 60 Å film.

The substrate peak appears for all orientations at higher angle indicating that the substrate has a smaller lattice constant than the films. Consequently, the two-peak structure is consistent with at film composed of two regions one near the substrate (A peaks) which is highly constrained by the substrate lattice and a more relaxed region away from the substrate (B peaks) with significant lattice relaxation (expansion). Notice that the peak corresponding to the top layer (B) is lower in intensity (and effective area) than the peak corresponding to the layer near the substrate (A).

Conclusions: The 300 and 1600 Å film are composed mainly of a strained A layer with a slightly smaller amount of covering metallic B layer.

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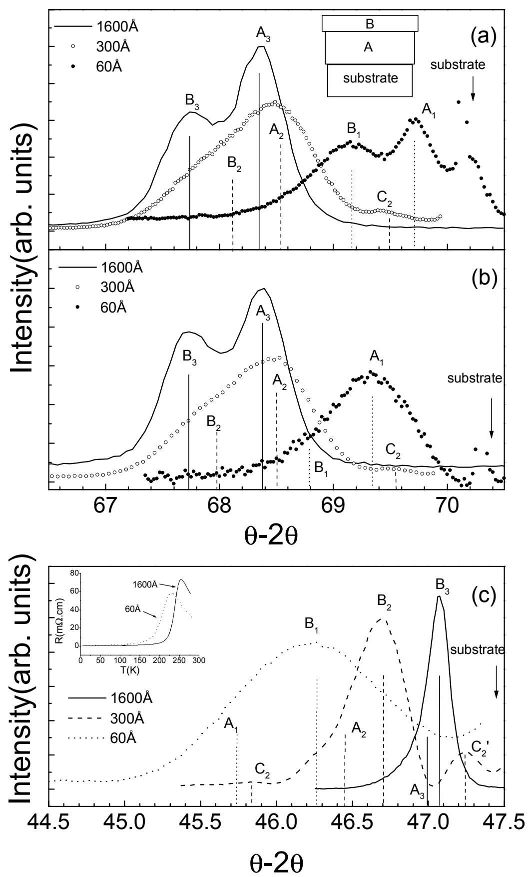

Fig. 1. X-ray diffraction θ-2θ scans of $La_{0.8}MnO_3$ film with the scattering plane approximately parallel and normal to surface. Diffraction peaks for (a) measurements along the direction (4 0 0) and (b) along the direction (0 4 0) are shown as two in-plane scans and (c) along the out-of-plane direction (0 0 4). The solid line is from the 1600 Å film, opened dot is from the 300 Å film and closed dot is from the 60 Å film. Each pattern is fit by a set of Gaussian peaks and the vertical bars show the approximate peak positions. The inset in (a) displays two layer film depositing model. Inset in (c) shows resitivity profile.