Low temperature high magnetic field magnetic force microscopic study in epitaxial $La_{5/8-y}Pr_yCa_{3/8}MnO_3$ thin film.

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Understanding of micrometer sized phase separation (PS) in $La_{5/8-y}Pr_yCa_{3/8}MnO_3$ (LPCMO) system has been debated and thought to arise from disorder broadened first order phase transition (FOPT) separating high temperature antiferromagnetic insulating (AFI) phase to low temperature ferromagnetic metal (FMM). However, some researcher believed that strain interaction between magnetically contrasting phases shapes micrometer length scale PS.

In epitaxial LPCMO thin film, magnetic force microscopy (MFM) measurement following novel paths in H-T space has been performed. The MFM study shows that ferromagnetic regions in an antiferromagnetic matrix grow well above the metal insulator transition temperature determined from resistivity measurement. During field cooling, the FMM regions grow with subhundred-nanometer nuclei and coalesce together to micrometer size with reducing temperature. From MFM images, the metal insulator transition is found to be percolative in nature. From MFM images it is also shown that the nucleation and growth of the FMM phase is different for the temperature and the magnetic field induced transition, and the glassy nature of the AFI state is dominant even up to 100 K. The glasslike arrested AFI state around 100 K (obtained after zero field cooling) results in larger size FMM regions with the application of magnetic field as compared to the field cooled state. Importantly, our MFM results directly show that the AFI- FMM transition in the LPCMO thin film cannot be explained solely in terms of broad first order phase transition due to quench disorder. Such a behavior may arise due to distribution of strain in the thin film.

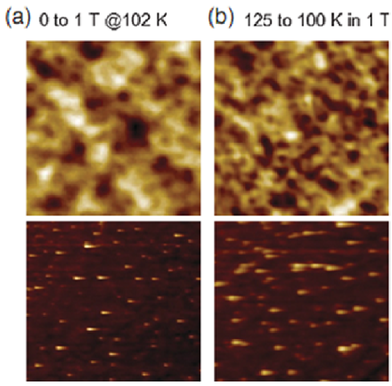

Figure: Magnetic (top panel) and topographic (bottom panel) images at 1 T (a) after zero field cooling to 102 K and (b) after field cooling to 100 K.