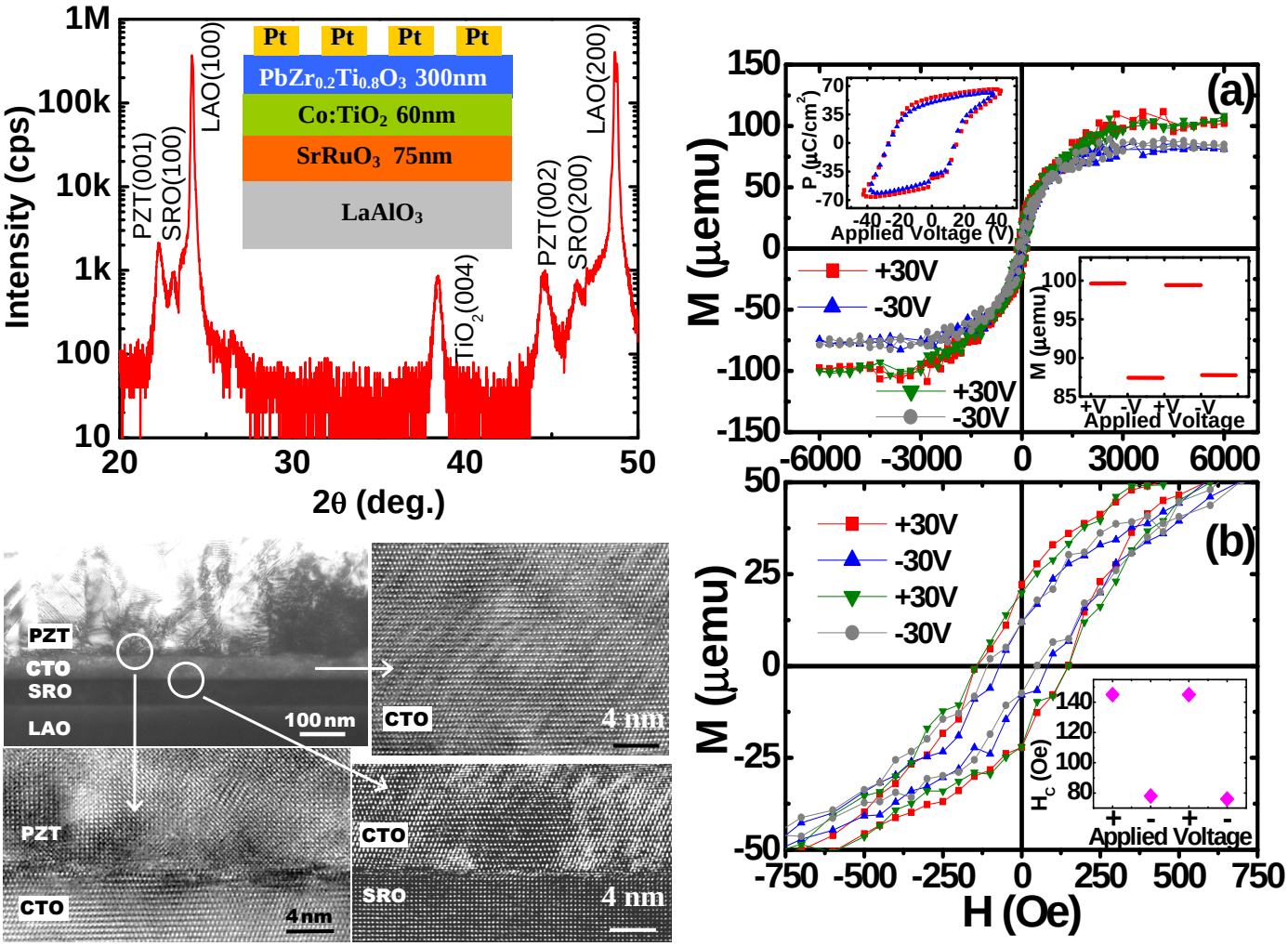
Electric Field Effect in Diluted Magnetic Insulator Anatase Co:TiO_2

An external electric field induced reversible modulation of room temperature magnetic moment and coercive field is achieved in an epitaxial and insulating thin film of dilutely cobalt-doped anatase TiO_{2-d}. This first demonstration of electric field effect in any oxide-based diluted ferromagnet is realized in a high quality epitaxial heterostructure of $PbZr_{0.2}Ti_{0.8}O_3/Co:TiO_2/SrRuO_3$ grown on (001) $LaAlO_3$. The observed effect, which is about 15% in strength in a given heterostructure (shown below), can be modulated over several cycles. The lower left panel shows the good interfacial quality of the heterostructure grown by pulsed laser deposition (PLD) and cluster free nature of $Co:TiO_2$ (CTO). The right panel below shows the modulation of saturation magnetization and coercive field, the latter modulation being almost 50%.



Observation of electric field effect strongly favors intrinsic (i.e. carrier-induced) nature of ferromagnetism in the high temperature grown insulating $Co:TiO_2$ films. Our finding is also the first report of field effect on ferromagnetism in an *insulating* diluted magnetic system. Given the highly insulating nature of the samples no itinerant electron based picture is feasible, and therefore the RKKY-type scenario discussed extensively in the context of GaMnAs magnetization simply does not apply here. Other physical pictures which could conform naturally to the attendant insulating magnetic state may thus be relevant. These include the bound magnetic polaron (BMP) percolation picture discussed in the context of strongly insulating DMS materials (Das Sarma and coworkers), and the defect (F-center) state percolation model discussed by Coey et al.

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