Electric Field Modulation of Ferromagnetism in Diluted Magnetic Insulating Co:TiO$_2$

T. ZHAO, Univ. of Maryland, College Park; Univ. of California, Berkeley, S.R. SHINDE, S.B. OGALE, H. ZHENG, Univ. of Maryland, College Park, T. VENKATESAN, S. DAS SARMA, Univ. of Maryland, College Park, J. MISEWICH, Brookhaven National Laboratory, R. RAMESH, Univ. of California, Berkeley — In this work we report the first successful implementation of an external electric field modulation of ferromagnetism in an oxide-based diluted magnetic system. An anatase TiO$_2$ layer with 7% Co doping and a ferroelectric PbZr$_{0.2}$Ti$_{0.8}$O$_3$ (PZT) layer were epitaxially grown on a conducting SrRuO$_3$ buffered LaAlO$_3$ substrate by pulsed laser deposition. The Co:TiO$_2$ channel grown in this case at a high temperature of 875 °C is insulating in nature. The magnetic hysteresis loops of the Co:TiO$_2$ were measured by SQUID after positive or negative electric poling on PZT. A 15% difference in the room temperature saturated magnetic moment as well as the coercive filed of Co:TiO$_2$ is observed according to the two polarization states of PZT, which can be modulated over several cycles. This first demonstration of electric field effect in an oxide based diluted ferromagnetic insulator system provides evidence of its intrinsic nature. Possible mechanisms for insulating ferromagnetism and its modulation by an electric field are discussed. This work was supported by DARPA SpinS program (through US-ONR) and the NSF-MRSEC (DMR 00-80008) at Maryland and by a grant from Brookhaven National Laboratory.