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Realizing Half Metallicity in Sr_2FeMoO_6 Epitaxial Films: Roadblocks and Successes[1]

FENGYUAN YANG, The Ohio State University

Half-metallic Sr_2FeMoO_6 has attracted much attention due to its high Tc of 420 K for magnetoelectronic applications. However, the potential of its half metallicity is far from being realized due to the unusual challenges in the fabrication of Sr_2FeMoO_6 films. In this talk, I will discuss a number of hurdles that troubled the deposition of Sr_2FeMoO_6 films, some of which have been largely ignored to date. We have succeeded in overcoming some of the dominant problems in the epitaxial film growth and obtained phase-pure, fully epitaxial, and stoichiometric Sr_2FeMoO_6 films on $SrTiO_3$ with high structural and magnetic ordering using off-axis ultrahigh vacuum sputtering. First, by precisely controlling the growth environment, we achieved pure double perovskite phase and complete epitaxy in Sr_2FeMoO_6 films without any detectable secondary phases (such as $SrMoO_4$) as confirmed by Bragg-Brentano and triple-axis X-ray diffraction (XRD) and aberration-corrected TEM. Secondly, we discovered using Rutherford backscattering (RBS) that the films have much more Mo than Fe under typical growth conditions (high sputter pressure) for complex oxides. The optimal pressure for obtaining stoichiometric films is around 10 mTorr at certain off-axis geometry. Next, we focused on improving the Fe/Mo ordering by tuning growth rate, substrate temperature and sputtering pressure. To date, the highest Fe/Mo ordering parameter we have is around 90% obtained by Rietveld refinements on epitaxial Sr_2FeMoO_6 (111) films with ordered double perovskite XRD peaks. More importantly, the Sr_2FeMoO_6 films exhibit strong magnetic shape anisotropy, i.e. the in-plane hysteresis loops are fairly square and the out-of-plane loops are perfectly slanted lines with a saturation filed of $\sim$3800 Oe. The clear shape anisotropy, which has never been seen before in Sr_2FeMoO_6 films, indicates strong magnetic coupling across the films. We are pursuing further improvement of the Sr_2FeMoO_6 film quality and incorporating it into magnetic heterostructures for magnetotransport studies.

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