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Exchange Interactions in $La_{0.7}Sr_{0.3}MnO_3$ / $La_{0.7}Sr_{0.3}FeO_3$ Superlattices

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Perovskite-structured oxides possess a wide range of technologically relevant functional properties including ferromagnetism, ferroelectricity, and superconductivity. Furthermore, the interfaces of perovskite oxides have been shown to possess unexpected functional properties not found in the constituent materials. These functional properties arise due to structural and chemical changes as well as electronic and/or magnetic interactions occurring over nanometer length scales at the interfaces. Gaining a fundamental understanding of these interfacial effects requires a comprehensive approach of state-of-the-art growth techniques as well as detailed characterization of their structural, chemical, and functional properties. In this work, we studied exchange interactions in perovskite oxide superlattices consisting of the ferromagnet (FM) $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) and the G-type antiferromagnet (AFM) $La_{0.7}Sr_{0.3}FeO_3$ (LSFO). Resonant x-ray reflectivity measurements show that due to the isostructural nature of these superlattices, extremely smooth FM/AFM interfaces can be obtained with an absence of uncompensated spins.[1] Therefore, these interfaces have been shown to exhibit spin-flop coupling characterized by a perpendicular orientation between the FM moments and the AFM spin axis.[2] Furthermore, an applied magnetic field was able to reorient the AFM spin axis while maintaining this perpendicular orientation. Using soft x-ray photoemission electron microscopy, the local FM/AFM domain patterns in each layer were selectively imaged as a function of temperature.[3] These images confirm the perpendicular alignment between the AFM spin axis and Mn magnetization such that each micrometer-sized AFM domain corresponds to two types of smaller FM domains. The locations of the AFM/FM domains move together with changes in temperature up to the Curie temperature of the FM LSMO layer, proving that the strength of the spin-flop coupling can overcome the anisotropy of LSFO and pinning effect of the structural defects that typically define the location of AFM domains. These results have the potential to lead to the development of device designs that harness the ability to reorient the AFM spin axis.

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