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Abstract

Perovskite oxides possess intriguing and technologically important physical properties such as ferromagnetism, superconductivity, and ferroelectricity. In particular, interfacial effects in superlattice structures resulting from structural distortions as well as band and charge discontinuities, can introduce enhanced or completely unexpected properties compared to the individual constituent materials. In this work, the structural, magnetic, and electronic properties of an all perovskite oxide superlattice consisting of alternating layers of the antiferromagnetic insulator $La_{0.7}Sr_{0.3}FeO_3$ (LSFO) and the ferromagnetic metal $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) were studied as a function of the superlattice period. With decreasing superlattice period, the ferromagnetic properties of the LSMO layers gradually approach the case of the LSMO/LSFO solid solution, i.e. decreasing saturation magnetization and Curie temperature as well as increasing resistivity are observed. By contrast, the orientation of the antiferromagnetic axis in all the superlattices differs from that of the solid solution and single LSFO layers. Moreover, the Néel temperature is nearly independent of the LSFO layer thickness. Anisotropic x-ray linear and circular dichroism was utilized to obtain information on the coupling between the LSFO and LSMO layers in the superlattices. For six unit cell thick sublayers, a strong magnetic LSFO/LSMO coupling exists. The orientation of the antiferromagnetic axis of the LSFO layer lies perpendicular to the magnetic axis of the LSMO layer and can be controlled by an applied magnetic field. Below a sublayer thickness of six unit cells, the LSMO layer does not exhibit ferromagnetic order down to the lowest measurement temperature of 10 K. For greater superlattice periods, it appears that the anisotropy of the LSMO and LSFO layers dominate over the exchange coupling and a weak parallel orientation of the Mn and Fe moments is observed. This superlattice period dependence of the relative orientation of the LSFO/LSMO easy axes provides a unique way to control the magnetic properties of perovskite oxide superlattices, which may have potential applications in next generation magnetic sensors and spintronic devices.

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