Hybrid Spin-Filter / Magnetic Tunnel Junction Heterostructures with Room Temperature Ferrimagnetic Barrier Layers.

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Magnetic tunnel junctions (MTJ) with ferrimagnetic barrier layers exhibit both spin filtering and MTJ device characteristics, providing a promising means to enhance spin transport over conventional MTJs. In such all-magnetic devices, the magnetic coupling behavior at the electrode-barrier interfaces is crucial to successful device operation. We have investigated the interfacial magnetism of this novel device architecture in the presence of a barrier layer with long-range magnetic order at room temperature. Heterostructures of highly spin polarized $La_{.7}Sr_{.3}MnO_3$ (LSMO) and Fe_3O_4 electrodes sandwiching an insulating $NiFe_2O_4$ (NFO) (T_C = 850 K) barrier layer were grown by pulsed laser deposition on (110) $SrTiO_3$ substrates. This heterostructure incorporates an isostructural spinel-spinel (NFO-Fe_3O_4) interface and a non-isostructural perovskite-spinel (LSMO-NFO) interface. X-ray diffraction in the 2θ-θ geometry shows only (110)-oriented peaks for both the perovskite and spinel crystal structures, indicating that the films grow epitaxially on one another with high crystallinity. Bulk-sensitive hysteresis loops taken at both 300K and 5K show sharp, independent magnetic switching of both the LSMO and Fe_3O_4 electrodes, creating well-defined parallel and antiparallel states despite the presence of a robust ferrimagnetic barrier layer between them. X-ray magnetic circular dichroism (XMCD) was used to probe the magnetic structure at each electrode-barrier interface with elemental specificity and surface sensitivity by total electron yield. Using various truncated heterostructures to probe the two different electrode-barrier interfaces separately, we have found independent magnetic switching between the Mn in LSMO and the Ni and Fe in NFO at the non-isostructural perovskite-spinel interface. However, we have found strong magnetic coupling and coincident switching of the magnetic cations across the isostructural spinel-spinel interface. The decoupled perovskite-spinel interface is crucial for independent electrode switching as observed in magnetotransport, while the isostructural spinel interface helps preserve interfacial spin polarization of Fe_3O_4, which has shown to be less robust when using non-isostructural barrier layers. The combination of a magnetically-coupled isostructural interface and a magnetically-decoupled non-isostructural interface is a key feature of this new hybrid device architecture whose room temperature operation is possible with $NiFe_2O_4$ barrier layers.

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