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Synthesis and Characterization of $CuCr_2O_4$ Thin Films for Spin-Based Devices.

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The complex spinel oxides have been of recent renewed interest due to their potential in spin-based devices. It has been shown that magnetic junctions with an isostructural interface between half-metallic Fe_3O_4 electrodes and a magnetic barrier layer can give rise to significant junction magnetoresistance while also allowing us to probe magnetism at these interfaces. $CuCr_2O_4$ is an electrically insulating, magnetic material that is promising as a magnetic barrier. It is a tetragonally distorted normal spinel crystal with Cr^{3+} and Cu^{2+} cations occupying octahedral and tetrahedral interstitial sites, respectively. We report the first synthesis of $CuCr_2O_4$ thin films that have significant potential as a magnetic barrier layer due to its close lattice match with Fe_3O_4.

$CuCr_2O_4$ films were grown by pulsed laser deposition on insulating (110) $SrTiO_3$ (STO), (110) $MgAl_2O_4$ (MAO), and (001) MgO substrates. We have found that depositing $CuCr_2O_4$ films at 500°C in 15mTorr of O_2 at an energy density of 1 J/cm^2 followed by cooling in 100 Torr O_2 yields films with magnetic properties similar to those of the bulk. X-ray diffraction of $CuCr_2O_4$ films on (110) MAO, and (001) MgO reveal single-phase films with epitaxial strain of -4.2% and -3.5%, respectively. Rutherford backscattering spectroscopy confirms the stoichiometry of our $CuCr_2O_4$ films. X-ray absorption spectroscopy (XAS) shows the presence of divalent Cu and trivalent Cr at the film surface indicating that bulk cation valence charge is preserved throughout the film. The consistent cation valence charge also suggests that in thin film form, like bulk $CuCr_2O_4$, Cr^{3+} continues to exist in octahedral interstices while Cu^{2+} occupies tetrahedral interstices.

Magnetic properties were investigated using SQUID magnetometry. The $CuCr_2O_4$ thin films exhibit a Curie temperature, T_C, of 125K and a magnetic moment of 0.78 μ_B/f.u, closely resembling bulk values(T_C = 135K and magnetic moment between 0.4-0.8μ_B/f.u)[2,3]. The low magnetic moment is surprising as Hund's rule calculations show that Cr^{3+} and Cu^{2+} are magnetic which suggests a magnetic moment of 5μ_B for $CuCr_2O_4$. However, the discrepancy in magnetization can be accounted for by the triangular cation configuration proposed by Yafet and Kittel in which Cr^{3+} cations are aligned anti-parallel to each other, and the Cu^{2+} cations are perpendicular, thus sitting along the axis of magnetization [3]. Finally, the insulating nature of bulk $CuCr_2O_4$ is preserved in thin film form as all films displayed highly insulating electronic behavior, thus making it appropriate as a magnetic barrier layer material [4].

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