Resistivity and tunnel magnetoresistance in double perovskite strontium ferromolybdate ceramics

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$Sr_2FeMoO_{6-\delta}$ (SFMO) double perovskite is a promising candidate for room-temperature spintronic applications since it possesses a half-metallic character (with theoretically 100% spin polarization), a high Curie temperature of about 415 K, and a low-field magnetoresistance (LFMR) [1]. However, due to different synthesis conditions of ceramics as well as thin films, different mechanisms of electrical conductivity and magnetoresistance prevail.
The intrinsic resistivity of SFMO obeys a temperature dependence $\rho_0 = \rho_D + AT^{\nu}$, where ρ_D is the inverse of the Drude conductivity, A a constant defined by the mean free path of spin waves in SFMO [2], and $\nu \approx 2.5$. Ceramic grain boundary oxidation leads to the appearance of spin-polarized tunneling via an oxide barrier. Increasing the barrier width beyond the limit of thin tunneling barriers, inelastic hopping occurs via localized states within the barrier. Here, second and third order hopping conductances are characterized by $T^{4/3}$ and $T^{5/2}$ conductivity terms, respectively. With further increase of the barrier width, the metallic-like conductivity disappears totally accompanied by an increase of the resistivity by about six orders of magnitude. The samples now exhibit a negative temperature coefficient of resistivity in the whole temperature region. Its resistivity behavior can be described in terms of the fluctuation-induced tunneling model, which converts near room temperature to a variable-range hopping conductivity mechanism [4]. Here, the electron transport occurs through a thick barrier via more conductive chains of localized states in series with nanosized tunnel barriers between the grains. In the bulk limit and at high temperatures, inelastic hopping changes to variable range hopping [3] as obtained experimentally [4].
The magnetic flux dependence of the tunneling barrier height was modeled by a series expansion, with empirical coefficients determined up to the second order.
The different mechanisms of magnetoresistance in SFMO are: (i) tunneling resistance across intergrain barriers in granular ceramics [6], (ii) tunnel resistance across intergrain nanocontacts in cold pressed and intermediate temperature annealed, granular ceramics [5], and (iii) intragrain tunneling across antiphase boundaries [7]. The magnetoresistance due to inelastic tunneling is not suitable for application.
We discuss consequences for a controlled SFMO ceramic fabrication and thin film deposition for the purpose of designing spintronic devices with advantageous magnetic properties, in particular, magnetic field sensors and magnetoresistive random access memories.

References:
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