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Investigation of tunneling effects in magnetic nanostructures using short pulsed electric and magnetic field fields

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Magnetic Tunnel Junctions (MTJs) are increasingly utilized in various applications, including hard drive read heads, magnetic field sensors and high-frequency devices [1]. While most MTJs are fabricated layer by layer, they also occur naturally in polycrystalline manganite films, where grain boundaries can act as barriers. The Colossal Magnetoresistance (CMR) effect is observed in these films, allowing for applications such as isotropic magnetic field sensors, known as CMR-B-Scalar sensors. Beyond the magnetoresistive (MR) effect, which causes significant changes in resistance with an applied magnetic field, these films also exhibit negative electroresistance (ER). An applied electric potential can align energy levels between the magnetic layers separated by the insulator modulating the tunneling currents.

Polycrystalline La-Ca(Sr)-Mn-O manganites are intensively studied for their CMR and ER effects and applications for the development of new electronic devices. To enhance the properties of polycrystalline films, it is essential to comprehend the mechanisms governing charge carrier transport through the grain boundaries (GBs) between crystallites. In this study, we explore the electrical conductivity behavior of vertically aligned $La_{1-x}Ca(Sr)_xMnO_3$ nanocolumn films with disordered grain boundaries (GBs) by subjecting them to synchronized strong pulsed electric and magnetic fields. Nanosecond electric field pulses allow us to analyze the intrinsic properties of the junctions within the film, avoiding any adverse thermal effects.

When subjected to high electric fields, the current-voltage (I-V) characteristics of the films become nonlinear. These nonlinearities can be explained by the Glazman – Matveev model [2]. At low electric fields, the electrical conductivity is mostly determined by elastic tunneling and tunneling through one localized state in the barrier, while at high fields inelastic tunneling through two or more states becomes dominant. It was found, that the nonlinearity of the *I-V* can be tuned by the application of magnetic field. The obtained results on magnetic field-tunable tunneling effects will be presented and discussed.

REFERENCES

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