Tunneling Magnetoresistance in La$_{0.67}$Sr$_{0.33}$MnO$_3$/organic molecule/Co Junctions

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Abstract

Organic-based spintronics devices have been receiving increasing attention over the past several years.\textsuperscript{1} We have studied the injection, transport, and detection of a spin-polarized current in ultra-thin organic films of tetraphenyl porphyrin (TPP). Also Impedance Spectroscopy was utilized to investigate the frequency dependent transport phenomena. Possible mechanism(s) that leads to the observed magnetoresistance and the nature of the spin polarized transport through the TPP layers will be presented.

\textsuperscript{1} Z. H. Xiong, et al. Nature \textbf{427}, 821 2004

Sample preparation

La$_{1-x}$Sr$_x$MnO$_3$ made by pulsed laser deposition

Optical lithography and wet etching

Vapor deposition of Co (~3.5 nm) and Al (~30 nm) through shadow mask

“Cross-bar” devices

Vapor deposition of organic (~10-20 nm)

I-V curves of Co (5nm)/TPP(20nm)/LSMO

The symmetric I-V curves (at 11K) is consistent with the fact LSMO and Co have similar work function. The inset shows conductance behavior of junction at 0.5K.

MR and bias voltage dependence

Negative MR and bias asymmetry can be understood from DOS of LSMO and Co.\textsuperscript{(Taken from P.R.L. 82, 4288 1999)}

Cole-Cole Diagram of Co (5nm)/TPP(20nm)/LSMO

Plot of imaginary vs. real part of Z shows characteristic of a parallel RC circuit.

Temperature dependence of the MR

LSMO surface spin polarization dominate the MR decrease with $T$.

Frequency dependence measurement

$C_{\text{effective}} = 1.2 \text{ nF}$ (fit from data), using the equation for geometrical capacitance, we calculated $d=2.64$nm.

Conclusions

• The injection, transport, and detection of a spin-polarized current was realized based on ultra-thin films of TPP and Alq$_3$.

• Nonlinear I-V response, temperature and bias dependent MR, and resistance-temperature characteristic indicate that the possible mechanism for MR is electron tunneling through the organic layer.

AFM data indicate thin TPP films have an island structure with RMS roughness about 4nm on the smooth LSMO surface. The TPP junction resistance increase with temperature, which is the most reliable criterion to rule out the present of pinholes.

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