# Spin Polarized Transports Through a Polymer Using Half Metallic Manganites as Spin Injectors

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**Abstract:**

The research focus is on spin polarized transport through thin polymer spacers using manganite electrodes in lithographically patterned nanostructures. The giant magnetoresistance (GMR) effect can be observed in magnetic thin films, which are composed of ferromagnetic layers and nonmagnetic (spacer) material. The ferromagnetic material being used in our research is $La_{0.7}Sr_{0.3}MnO_3$ (LSMO), which is nearly half metallic with very high spin polarization at Fermi Surface. When the ferromagnetic layers are parallel, they have a low resistance as opposed to when they are antiparallel. With an applied magnetic field, the direction of the magnetization can be altered.

## Introduction:

Most if not all electronics are still based on a system that is driven by the charge of the electron rather than its spin characteristics. This quantum property known as the spin has lead to an emerging field of electronics called spintronics. The orientation of the spin of the electrical carriers allows spintronics to read, write and store information [1].

Spintronics plays an important role in Magnetic Random Access Memory (MRAM), which is an avenue for the future of electronic devices. MRAM is believed to be a fast, nonvolatile memory device and is suppose to have a high density of dynamic RAM (DRAM). Some of the flaws seen in DRAM is that it loses data when the power is turned off, which will be remedied with the incorporation of MRAM into technologies. MRAM is an application to this project.

The current research is mainly focused on developing new materials for the next generation of spin-polarized (SP) carriers and on the exploration of new materials able to transport a coherent spin to distances up to $10^2$-$10^3$ nm [2]. The aims of this project were to have a SP transport through a polymer using a half metallic manganite as a spin injector and to observe a magnetoresistance (MR) effect at room temperature.

## Experimental Procedures:

The half metallic materials we used in this project was LSMO grown on $SrTiO_3$ substrates using pulse laser deposition. Our devices were fabricated by using a standard photolithography process and then focus ion beam patterning.

We first spun Micro-Chem LOR 5A lift-off resist over the substrate at 4000 rpm for 45.0 seconds. The substrate was then baked at 180°C for 10 minutes. Afterwards, we spun SPR 3012 photoresist at 4000 rpm for 45.0 seconds, which was followed by a soft bake at 110°C at 60 seconds. We then used a Karl Suss MA-6 contact aligner to expose the photoresist through a chrome mask for 3.2 seconds, followed by a post exposure bake (PEB) at 110°C at 30 seconds. The substrate was then developed in Shipley's CD-26 developer for 60 seconds.

Next, we used a Lesker Evaporator to deposit 20 nm of Ag and 300 nm of Au. A second photolithography process followed the deposition, where the Au was now patterned. We were able to complete the lift-off process by putting the device in acetone, which aided in the removal of the leftover resist. Then we did a reactive ion etch (RIE) of the Au over the LSMO film using an applied materials cluster tool with a high-density decoupled plasma source (DPS).

The next step in the device process was the use of a focus ion beam (FIB) to mill away segments of the film varying in width. Our smallest cut was at ~ 500 nm.

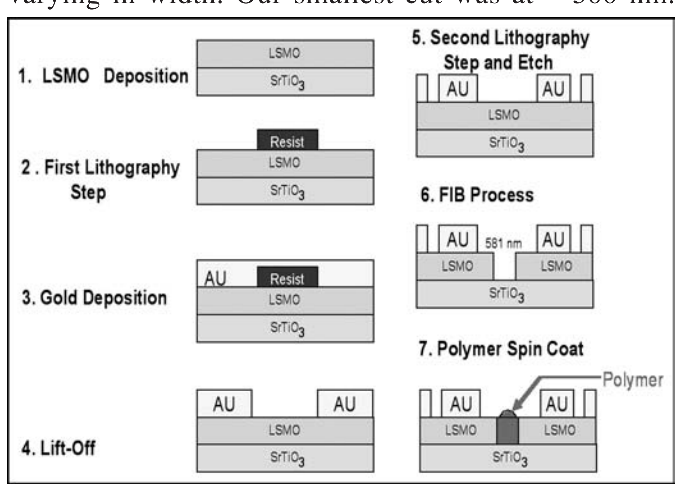



*Figure 1: Device fabrication.*

After the segments of the film had been milled away, we then spin coated a poly-3 hexyl-thiophene polymer over our device.

## Results and Conclusions:

After its completion, we measured the difference in voltage by applying a current across the device and later, the same device coated with the polymer. Both of the measurements were taken at room temperature. We found out what the IV curve for the device alone was linear with, without and after removing the magnetic field (Figure 2).

When we computed the results of the IV curve for the device coated with polymer, we found that there was a slight curvature to the graph with and after the magnetic field was removed (Figure 3). By drawing the best fit line over Figure 3, the average resistance calculated for the device with polymer was 1.08 x $10^5$ Ω. From the data shown in Figure 4, we were able to deduct that the magnetic field has an effect on the resistance of the material, which means that we had observed an MR effect and also a spin dependent effect. We were able to calculate a small MR in between the curves to be. Although we were able to receive results for the device, we felt that these results could have been better if we would have had more time to make and test more samples and try different conditions.

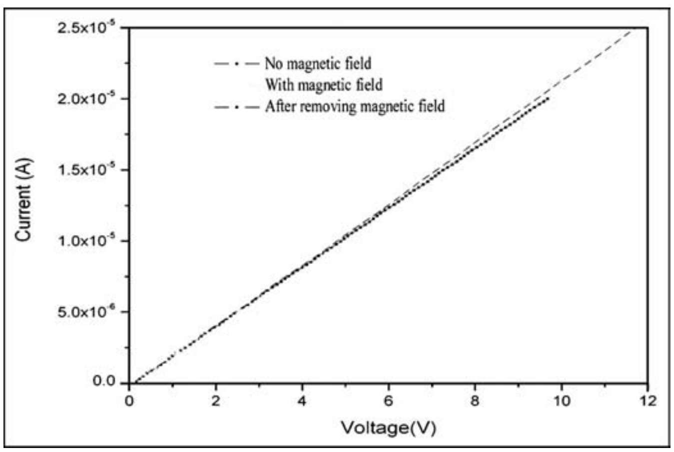
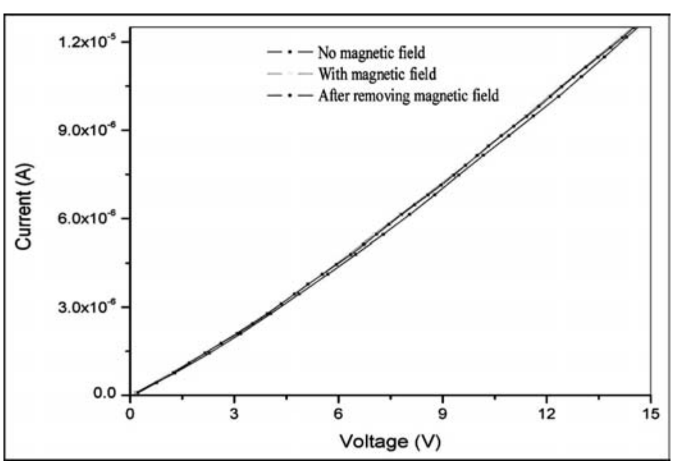



*Figure 2, above: The data was linear for the IV curve of the device.*

*Figure 3, below: The IV curve for the device with polymer had a slight curvature.*




## Future Work:

We would like to conduct more MR measurements with varying the temperature and vary the dimensions of the cut on the LSMO film. We would also like to try is to use alternative spacer materials in between the ferromagnetic layers.

## Acknowledgements:

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## References:

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[2] V. Dedu, M. Murgia, F.C. Matacotta, C.Taliani, S. Barbanera, et al., Solid State Communications 122 (2002) 181.

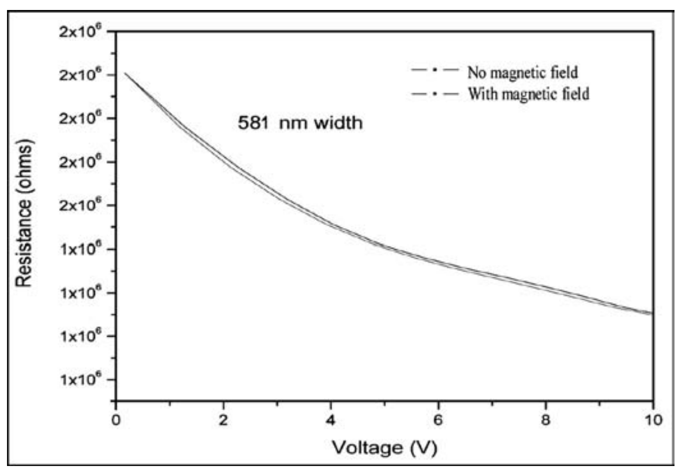


*Figure 4: The MR measurement for the device.*