Tunnel junctions and memristive microdevices were made using magnetoelectric interactions present in materials with a perovskite structure, grown as thin films. These materials are of great interest due to the strong correlation between their magnetic, mechanic and electrical properties.

A complete basic characterization of the used materials was also made through multiple techniques, like piezoelectric atomic force microscope, electric transport measurements or X-ray diffraction, among others. Some of these techniques were improved during this thesis.

Among the technological applications that can take advantage of the properties of these materials and the interactions between them are memristors, tunel junctions, electric and magnetic field sensors, ferroelectric memories, and others. In many cases the applications are based on being able to manufacture composite multiferroic systems, that is, multilayer systems where the magnetic properties of some materials are combined with electrical properties of others taking advantage of magnetoelectric coupling phenomena.

In a first stage a basic characterization of the properties of ferroelectric and ferromagnetic films was made. During this stage an atomic force microscope (AFM) was used and optimized for obtaining ultra-low current conductivity maps (CAFM or TUNA) and piezo-electric response measurement (PFM). Finally, in a second stage of the work interactions between materials were studied, tunnel junctions were made and composite multiferroics based memristores were developed, via a new process developed for the occasion.

The ferroelectric response of $BaTiO_3$ films grown over a Nb doped $SrTiO_3$ substrate was characterized. Then a new method to characterize ferroelectricity locally in a thin film was used called piezoelectric atomic force microscopy, and by using it hysteresis curves of the piezoelectric response of the films could be obtained for different film thicknesses, also piezoresponse maps could be written and read on the surfaces. This response is intimately related with the material ferroelectric remanence, by being the local deformation of the film sensitive to the electrical polarization.

Then the dielectric constant of the material in a film form was measured as a function of temperature in search of phase transitions. None was measured. In the material in bulk form were detected so it’s reasonable to think that the transitions are locked with the substrate. Finally, we analyzed the structural growth mode of the material, exhibiting an epitaxial growth.

Measurements of resistivity, Hall effect, magnetoresistance and magnetization were made as a function of magnetic field, temperature and thickness on $La_{0.8}Ba_{0.2}MnO_3$ films. The ferromagnetic response was also measured at 5K. The behavior of the electric transport was analyzed including the metal-semiconductor phase transition as a function of the film thickness, finding correlations between the resistivity, magnetoresistance and topographic measurements. Also some phenomenological models of manganite electrical transport were adjusted (Double exchange model and Anderson) over the resistivity data obtaining critical parameters of the material. The topographical analysis infers a terraced growth of some microns in size. This kind of growth implies a lack of complete percolation in films thinner than 10nm and degradation in the electrical properties.

Ferroelectric and ferromagnetic response measurements were made on a 50nm film of Bi_2FeTiO_6. A paraelectric and paramagnetic behavior was detected, without hysteresis.

The lattice parameter of all the used materials was measured via X-Ray diffraction.

Magnetization and resistivity measurements suggest that when 4.5nm of Bi_2FeTiO_6 are deposited over 30nm of $La_{0.8}Ba_{0.2}MnO_3$ the LBMO transition temperature increases 25K compared to the LBMO film alone, possibly because of the structural strain in the LBMO lattice caused by the BFTO.

Bilayers of Bi_2FeTiO_6 on top of $La_{0.8}Ba_{0.2}MnO_3$ were made with different BFTO thicknesses. Then C-AFM microscopy was used to obtain tunnel current images and IV curves through the top barrier. A fenomenological model based on Simons's was applied and parameters were obtained, including the attenuation length $\lambda = (1.19 \pm 0.3)nm$, the energy of the barrier $\phi = (0.52 \pm 0.09)eV$ and the voltage exponent on IV curves: $\alpha 0 = 2.7 \pm 0.6$, different from the value 2 predicted by the Simmons model. Also tunnel current was measured depositing metallic electrodes of different sizes over the barrier.

A new technique for manufacturing memristores was invented using the studied films. An LBMO film is used as a sensor material below BTO and a conduction channel with both elements is manufactured. Then, if a grounded metallic pad is deposited on top of the system and an electric current is introduced on the channel the voltage drop on the LBMO can polarize the BTO film (auto-polarized mode). If simultaneously there is an interaction between the BTO polarization and the LBMO conductivity, a memristor like IV curve should be measured. A patent based on this idea was published in INPI with the endorsement of Conicet.

These devices were manufactures with some extra connections to make measurements of magnetoelectric interactions and to obtain 4-wire IV curves. A change in the LBMO resistivity of up to ten times due to the BTO polarization was found when an external electric field was applied. Hysteresis was detected on this change. This appears to imply some remanence in the effect, at least temporarily.

Then the device was connected in the auto-polarized mode and IV curves were measured. A clearly memristive behavior was detected with a 5-10% effect in the IV curve. With this the device is proven to work as intended.