Electric-control of the orbital degree of freedom for oxide-based Orbitronics

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Ferroelectric field effect devices (FeFEDs) rely on the non-volatile electric field generated onto the channel material by an adjacent ferroelectric layer (*cf.* to Figure 1). Recent studies on prototypical manganites-based FeFEDs[1] have shown that beyond the pure electrostatic doping of charge carriers, intrinsic polar distortions at the manganites interfacial unit cells, triggered by the ferroelectric displacement of ions, can affect the hierarchy of the Mn-3*d* orbitals[2] (*i.e.* $3dz^2$ and $3dx^2$-y^2).

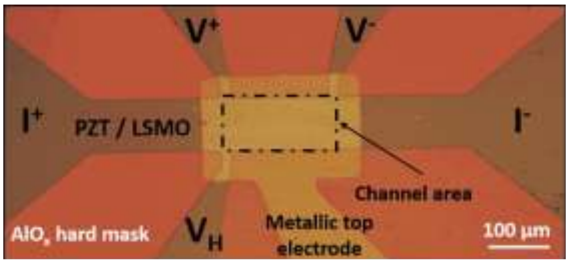

Figure 1 Optical microscopy image of an Hall bar patterned FeFEDs. Channel: $La_{0.825}Sr_{0.175}MnO_3$ (LSMO) mainly characterized by a band filling-controlled MIT. Ferroelectric gate: $Pb(Zr,Ti)O_3$ (PZT).

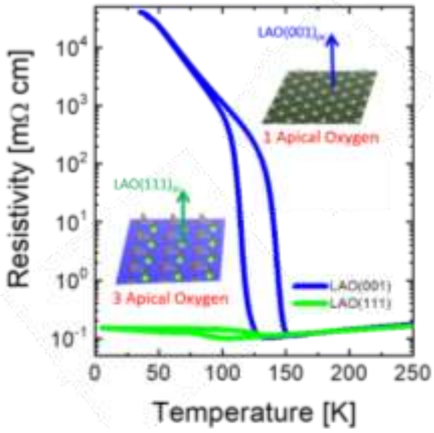

Figure 2 Temperature dependence of resistivity curves acquired for 4 nm thick $NdNiO_3$ films grown onto $LaAlO_3$ single crystals with different orientations, in order to (statically) induce different Ni-O-Ni

Here, for this project, the **candidate will prepare and study FeFEDs** based on oxide material where intrinsic structural distortions play an important role in the physics of the system (*cf.* to Figure 2). Since the intimate crosstalk between *e-e* correlations and lattice distortions underscores the rich phase diagram displayed by the rare-earth nickelates[3] ($RNiO_3$), the **ferroelectric field-effect approach can be very promising**. Indeed, $RNiO_3$ exhibit a bandwidth-controlled MIT where the Ni-O-Ni bond angle governing to which extent the Ni-3d orbitals overlap represents a key parameter to manipulate the MIT, hence, granting a route to exploit the aforementioned polar distortions in prototypical nickelates-based FeFEDs.

The propagation of the ferroelectric polar distortions in the channel layer is a genuine interfacial effect. Therefore, the growth of high quality $RNiO_3$/ferroelectric heterostructures (HTs) is a crucial step for the success of this project. The ideal candidate will master the growth of the HTs through **Pulsed Laser Deposition** to experimentally realize atomically abrupt nickelate/ferroelectric interfaces. **X-ray Diffraction, Scanning Force Microscope and Ferroelectric/Transport techniques** will be used for the standard characterization of the HTs. Afterwards, the FeFEDs will be engineered in the Clean-room to perform dedicate experiments by means of synchrotron radiation to study the orbital polarization in $RNiO_3$ system as a function of an external switchable and remnant electric field.

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[1] Preziosi, D. *et al.* Tailoring the interfacial magnetic anisotropy in multiferroic field-effect devices. *Phys. Rev. B* **90,** 125155 (2014).
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[3] Medarde, M. L. Structural, magnetic and electronic properties of $RNiO_3$ perovskites (R=rare earth). *J. Phys. Condens. Matter* **9,** 1679–1707 (1997).