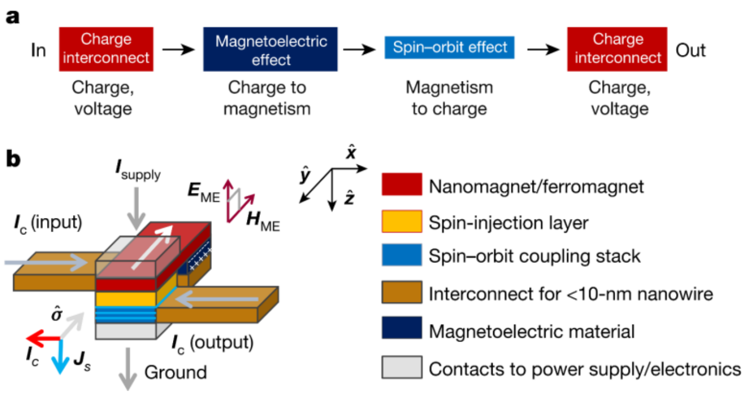
Unité Mixte de Physique CNRS/Thales – Oxitronics Group

Post-doctoral Fellowship

Giant spin-charge conversion at oxide interfaces for future spin-based logic

BACKGROUND AND OBJECTIVES. The current technology based on CMOS devices is getting close to its limits, both in terms of scaling and power needs, and new concepts based on entirely different physics principles must emerge[1]. The **MESO transistor proposed by INTEL**[2] (cf. Figure) aims to provide such a paradigm shift in information processing. Unlike conventional transistors that operate on charge, **MESO operates on spin** and therefore qualifies as a **spintronics device**. Exploiting the electron's spin degree of freedom rather than its charge bestows a number of advantages, including non-volatility when using ferromagnetic elements and high processing speed. The heart of MESO is a ferromagnetic element able to store a non-volatile binary information encoded by its magnetization direction. Information is written by applying a voltage to a magnetoelectric element in contact with the ferromagnet, which switches the magnetization direction. **The proposed project will focus of the read-out of the information** stored by the ferromagnet. **Spin-orbit coupling** will be used to convert a spin-based current from the ferromagnet (carrying spin-based information corresponding to the magnetization direction) into a charge-based voltage whose sign will depend on the magnetization direction. The amplitude of this voltage must be sufficient to drive the magnetoelectric input of the next MESO element. Following previous results in our group[3], the project will focus on **oxide interfaces as efficient spin-charge converter**[4] and its objective will be to achieve large output voltages at low and room temperatures.



a. Transduction of state variables for a cascadable logic device. The magneto-electric effect transduces the input information to magnetism, and a spin-orbit material transduces the magnetic state variable back to charge. **b.** MESO device formed with a magnetoelectric capacitor and a spin-orbit material. The device comprises a layer for spin injection from the ferromagnet to the spin-orbit material, an interconnect made of a conductive material, and contacts to the power supply and ground. The white arrow represents the magnetization direction of the ferromagnet. Grey arrows represent electric currents at the input and output, power supply and ground[2].

ACTIVITIES. For this project, the candidate will perform the following activities:

- Growth of heterostructures combining ferromagnets and oxide two-dimensional electron gases (2DEGs) using pulsed laser deposition and sputtering.
- Spectroscopic (XPS), magnetometry and magnetotransport characterization of the heterostructures
- Ferromagnetic resonance and spin-pumping experiments
- Data analysis and modeling
- Report and paper writing

EXPECTED COMPETENCES. The candidate is expected to have the following competences:

- Magnetism and spintronics (required)
- Growth experience in pulsed laser deposition and/or sputtering (recommended)
- Ferromagnetic resonance and magnetization dynamics (recommended)
- XPS and photoemission spectroscopy (optional)
- Optical and/or electron beam lithography (optional)
- Programming in Matlab, Labview, etc (optional)
- Excellent organization and scientific writing skills (required)
- Good communication skills (recommended)

WORK ENVIRONMENT. The project will be performed mostly at the **Unité Mixte de Physique CNRS/Thales** laboratory (UMPhy) located in Palaiseau on the Université Paris-Saclay campus. UMPhy is the cradle of spintronics, with the discovery of giant magnetoresistance in 1988 for which its Scientific Director, Prof. A. Fert, received the Nobel Prize in Physics in 2007. FMR and spin pumping experiments will be performed in the **Spintec laboratory in Grenoble** (group of L. Vila and J.P. Attané) with whom UMPhy has a long-standing collaboration. **This project is financed by INTEL** within a FEINMAN proposal. It will involve regular (every two weeks) skype meetings with INTEL staff and face-to-face meetings once or twice a year.

ADDITIONAL INFORMATION. The contract is for 12 months and is renewable. Salary is 2600-3000 € per month depending on experience. The position is to be filled as soon as possible.

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[1] S. Manipatruni et al., Nature Phys. **14**, 338 (2018); [2] S. Manipatruni et al., Nature 10.1038/s41586 (2018); [3] E. Lesne et al., Nature Mater. **15**, 1261 (2016); [4] J. Varignon et al., Nature Phys. **14**, 322 (2018).