# Master 2 Internship Proposal 2023-2024

## Electrical Characterization and Analysis of Ferroelectric Memories based on Hafnium-Zirconium oxide ($HfZ_rO_2$)

**Laboratory:** INL (Institut des Nanotechnologies de Lyon) : inl.cnrs.fr
**Keywords:** emerging memories, ferroelectric memories, electrical characterization
**Location :** INL, UMR CNRS 5270, 1 rue Enrico Fermi, 69622 Villeurbanne Cedex

## Subject:

*Background, Context:*

There is today a crucial need for **emerging memory technologies** to enable the development of **energy-efficient computing paradigms** like neuromorphic architectures and other types of hardware accelerators **[1]**. Among all emerging technologies, **ferroelectric memories** based on hafnium oxide are highly appealing because of their ultra-low power consumption (0.1-1pJ/bit) **[2]** and high endurance (>$10^{14}$) making them ideal candidate to implement either multi-bit memories as well as analog synapses (Figure 1).

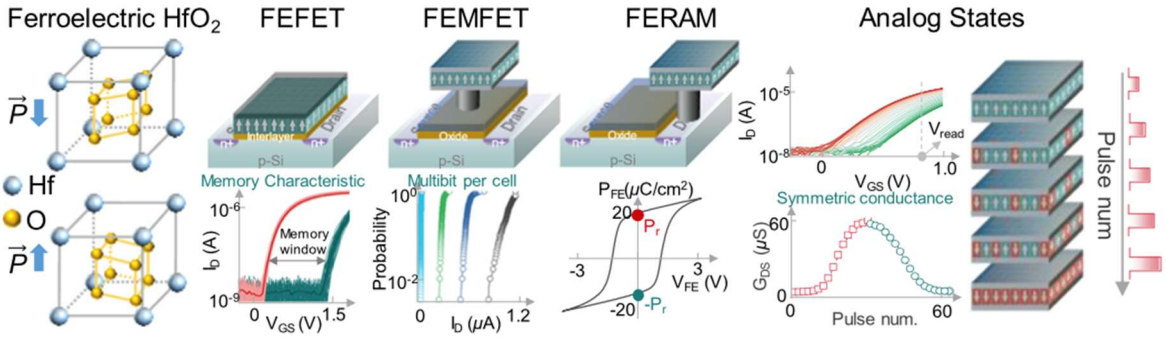


**Figure 1. Ferroelectric $HfO_2$ can be embedded as gate oxide to achieve ferroelectric transistors (FeFET) or within capacitors to achieve FeMFET/FeRAM or analog synapses. From [3]**

*Research Subject and work plan:*

INL is conducting research activities on the development of ferroelectric memories based on Hafnium oxide and is involved various research programs both with academia (European projects FVLLMONTI, NANOx4estor...) or industrial partners (STMicroelectronics, CEA-Leti, …) **[4-6]**.

The internship will focus on the **electrical characterization** of devices issued from our cleanroom facilities (Nanolyon) using probe station measurements. The objective is to **analyze** their electrical **performances** (polarization window, programming voltages, …) and **reliability** (endurance, wake up, imprint, leakage current…) and their evolution against different technological parameters. This work will provide indications for **optimizing** the device fabrication process along with a detailed analysis of selected physical phenomena.

**Candidate Profile:** The candidate should have a solid background in physics, material science and/or electrical engineering with a strong motivation for experimental work. Besides, fluency in English (spoken and written) together with good communications skills will be highly appreciated.

## References :


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[3] K. Ni *et al.*, *IEEE International Electron Devices Meeting (IEDM)*, p. 13.2.1-13.2.4., 2018, doi: 10.1109/IEDM.2018.8614496
[5] J. Bouaziz et al., APL Materials, 7, 081109, 2019 doi: 10.1063/1.5110894
[6] J. Bouaziz et al., ACS Appl. Electron. Mater., 9(1), 1740, 2019. doi: 10.1021/acsaelm.9b00367
[7] B. Manchon *et al.*, *Physica Status Solidi (RRL)–Rapid Research Letters 2100585* (2022). doi : 10.1002/pssr.202100585
[8] G. Segantini *et al.*, *Physica Status Solidi (RRL)–Rapid Research Letters*, 2100583 (2022). doi : 10.1002/pssr.202100583


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