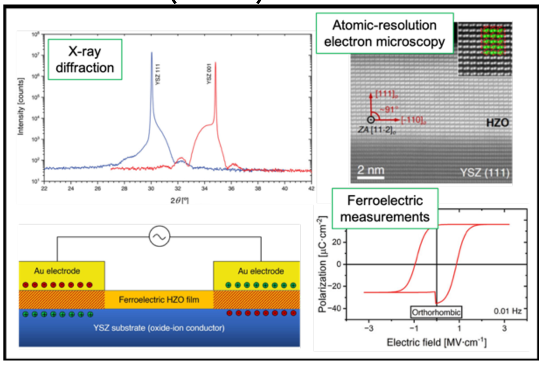
INMA INSTITUTO DE NANOCIENCIA Y MATERIALES DE ARAGÓN | EXCELENCIA SEVERO OCHOA | MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES | AGENCIA ESTATAL DE INVESTIGACIÓN

4-year contract offer for PhD @ INMA (Zaragoza, Spain)

Project: “Engineering FerroElectric HfO2-based epitaxial films FOR new MEmory Devices” (FE4MED) - PID2023-147211OB-C22

Electronics has become a ubiquitous and indispensable technological reality in 21st century, with an **increasing electricity consumption** will soon become technically unmanageable and unsustainable for the environment. Most of this electrical power is used in storage, transmission and processing of data. To tackle this tremendous challenge, a key industrial strategy is the development of **faster, low-power memory devices**, which in many cases rely on discovering new materials. The ground-breaking finding of **ferroelectricity in CMOS-compatible doped hafnium oxide (HfO2)** films in 2011 has placed non-volatile ferroelectric memories in the spotlight of all Semiconductor companies.



This PhD project aims at gaining an in-depth knowledge of the **science and engineering of the ferroelectric properties of HfO2-based epitaxial thin films**, to improve their functional properties and pave the way towards a new generation of CMOS compatible faster and energy-efficient memory devices.

Training plan: The candidate will acquire specialized training in thin film growth, vacuum technologies, electrical characterization, and nanocharacterization by transmission electron microscopy techniques. He/she will have access to the research facilities of INMA, including the Advanced Microscopy Laboratory (LMA, http://lma.unizar.es/). He/she will complement this local training with research stays at world-class research laboratories in the field, participation in conferences and outreach and dissemination activities. The candidate will enroll in the Physics Program at University of Zaragoza’s Doctorate School.

Requirements for the candidate: **Master's degree** (or equivalent) in **Physics, Materials Science, Materials Engineering, Nanoscience and Nanotechnology**, or a related field. **Fluent in English with good writing skills. Previous experience** with thin film growth, electrical characterization, electron microscopy, scripting/programming (python, MATLAB…) will be highly valued.

Details of the position:
Salary according to the **PhD fellowship program of the Spanish MICINN**.
Tentative **starting date: January-March 2025.**

Application Deadline: 8th November 2024

Contact before 8th November 2024 **to:**
César Magén (cmagend@unizar.es, https://cesarmagen.weebly.com/)
José Ángel Pardo (jpardo@unizar.es)

Electronics has become a ubiquitous and indispensable technological reality in our 21st century daily lives. Countless desktop, portable and wearable devices for communication, productivity and entertainment did not exist a few years ago. Electronic systems integrated in everyday hardware (automobiles, home appliances, etc.) are boosting. The proliferation of wireless 5G (soon 6G) communications, data centers for cloud computing and Artificial intelligence is rapidly increasing the huge amount of data that must be stored, transmitted and processed. Furthermore, their increasing electricity consumption will soon become technically unmanageable and unsustainable for the environment. To tackle this tremendous challenge, a key industrial strategy is the development of faster, low-power memory devices, which in many cases rely on discovering new materials. The ground-breaking finding of ferroelectricity in CMOS-compatible doped hafnium oxide (HfO_2) films in 2011 has placed non-volatile ferroelectric memories in the spotlight of all Semiconductor companies. However, the use of HfO_2-based materials in commercial memories needs a deeper understanding and an improvement of their functional properties.

The objective of FE4MED aims at gaining an in-depth knowledge of the science and engineering of the ferroelectric properties of HfO_2-based epitaxial thin films, to improve their functional properties and pave the way towards a new generation of CMOS compatible faster and energy-efficient memory devices.
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- We will apply a recently developed chemical method to produce epitaxial HfO_2 films: polymer-assisted deposition (PAD), exploring the use of different polymer solutions, substrates (such as yttria-stabilized zirconia -YSZ- and corundum -Al_2O_3-), doping (Zr, Y, Al), and annealing conditions to obtain the ferroelectric phase in epitaxial films. The successful implementation of this synthesis route can open new opportunities for low-cost scalable growth of large-area epitaxial HfO_2 ferroelectric films for memories, which is the Objective B of the coordinated project.
- We will explore the epitaxial growth of $Hf_{1-x}Zr_xO_2$ (HZO) films with new compositions (different from $x = 0.5$), directly deposited on YSZ and Al_2O_3 substrates without a conducting buffer layer, to obtain single-phase and single-textured HZO ferroelectric thin films. This will contribute to a deeper understanding of the microscopic mechanisms inducing ferroelectricity in HfO_2, which is the Objective C of the coordinated project.
- We will investigate the growth of HZO epitaxial films on novel electrodes presenting different types of conduction. Fully epitaxial HfO_2-based capacitors will be designed using the electron (or hole) doped GaN semiconductor on Al_2O_3, and the mixed ionic-electronic conductor Gd-doped CeO_2 on YSZ as buffer layers. We will focus on the functional properties of heterostructures combining a ferroelectric and an ion- or mixed conductor, which could have potential applications in ionotronics.