INTERNSHIP PROPOSAL

Laboratory name: Laboratory for the Study of NanoStructures and Surface Imaging
CNRS identification code: UMR 3680 (SPEC)
Internship director'surname: Lucia PEREZ RAMIREZ
e-mail: lucia.perezramirez@cea.fr Phone number: 01 69 08 47 27
Web page: https://iramis.cea.fr/en/spec/lensis/
Internship location: SPEC-LENSIS, CEA Saclay 91190 Gif sur Yvette

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Local control and imaging of ferroelectric domains in $HfZrO_2$ layers using piezoelectric force (PFM) and electron microscopy (LEEM-PEEM) techniques

Ferroelectric materials are characterized by the presence of a spontaneous polarization, whose orientation can be reversed by the application of an external electric field. This property finds an important application in information technologies, notably in non-volatile memories (NVM) where information can be encoded in the form of a ferroelectric domain, i.e. a region of the material with a certain orientation of the polarization ($P\uparrow$ or $P\downarrow$) corresponds to an information state (1 or 0).

Currently, hafnium zirconium oxide ($HfZrO_2$) is the most promising material for NVM fabrication thanks to its proven compatibility with standard CMOS processes and very low power consumption. HZO paves the way for very high-density mass storage (>10 Tbit/in²) because it retains its ferroelectric properties at very low layer thicknesses (< 10 nm), which allows more polarized domains per unit area.

The size of a domain in a HZO ferroelectric layer is about a few nm, which makes their study complex. We propose to use piezoelectric force microscopy (PFM) to examine them, due to its nanometric resolution and high sensitivity. We will use a particular mode of the technique that allows local writing of the domains and their subsequent imaging. This will allow us to study the phenomena of charge injection and polarization switching. In parallel, the student will use Low-Energy Electron Microscopy (LEEM) and PhotoEmission Electron Microscopy (PEEM) to characterize the surface potential, an inherent property of the material. We expect to elucidate the influence of the presence (absence) of a metal electrode above the ferroelectric layer in the mentioned electrostatic mechanisms.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: NO