Postdoctoral position at Laboratoire GREMAN (Tours, France)

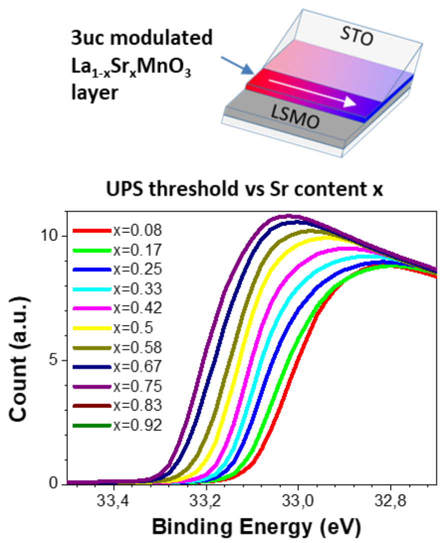
Controlling polarization and Schottky barrier height at metal/ferroelectric junctions through interfacial chemical bonding modulation

General information

Workplace: Laboratoire GREMAN / STMicroelectronics (Tours, France)
Contract: ANR project BePolar
Duration: 12 months extendable to 24 months
Expected date of employment: 1 June 2021
Salary: around 2650€ per month (gross income, before tax)
Advisors: Jerome Wolfman, Béatrice Négulescu
Contact: wolfman@univ-tours.fr

Context: (Ba,Sr)TiO_3 ferroelectric (BST FE) film capacitors, a.k.a. varactors, exhibit a voltage tunable capacitance used e.g. for dynamic impedance matching or phase shifting in telecommunication applications[1,2]. Emerging 5G or Near Field Communications standards call for higher frequencies or lower driving voltage, thus requiring varactors with reduced FE thickness. Unfortunately, two interfacial limiting phenomena impede this evolution. The first one is the existence, close to the electrodes, of FE "dead-layers" with degraded permittivity and spontaneous polarization.[3] The second one is an insufficient Schottky barrier height (SBH) to compensate for the bulk-limited high leakage current. Recent encouraging ab initio calculations showed the importance of the chemical bonding, polar discontinuity and distortion mismatch at electrode/FE interfaces for polarization stabilization[4,5] and SBH adjustment.[6,7] The challenge then is to tailor the interface to enhance both SBH and interface polarizability.

To meet this challenge, we propose to incorporate *a perovskite Interface Control Layer* (ICL) consisting of a few nm of conductive or dielectric films between the metal electrodes and BST. The isomorphism of the perovskite oxide structure allows to chemically tune the electronic properties using e.g. rumpling, polar discontinuity, BO_6 octahedral rotations as potential levers.[8,9] A systematic interface engineering using Combinatorial Pulsed Laser Deposition (ICPLD)[10] will produce heterostructures with continuously modulated interface composition and FE thicknesses (see figure). Advanced spectroscopy and microscopy methods, implemented within the consortium (laboratory and synchrotron photoemission, aberration corrected TEM techniques, UHV-SPM), coupled with first-principles calculations, will be used to investigate the chemical, structural and electronic mechanisms controlling band alignment and polarization at the interface. Optimized interfaces will then be tested in TRL 6 industrial prototype varactors.



Activities: The postdoctoral fellow will be in charge of the heterostructures synthesis (ICPLD) as well as their chemical (WDS), structural (XRD, AFM, SEM) and electrical characterization (IS). He / She will strongly interact with the consortium members to help correlating the TEM, XPS/UPS, SPM and DFT available data. The consortium includes CEA-SPEC (Saclay) for XPS/UPS/PEEM, CEMES (Toulouse) for HR-TEM/STEM-HAADF/EELS and DFT calculation and STMicroelectronics (Tours) for high TRL prototypes production.

Suitable profile: A PhD in condensed-matter physics or materials science with an expertise in oxide thin films synthesis and characterization. Experience with photoemission would be a plus. Strong inter-personal skills is a must.

Bibliography:

[1] M. Tiggelman et al., trans. Elec. Dev., 56, 2128 (2009)
[2] E. Bouyssou et al., ECS Transactions, 61, 155 (2014)
[3] C. Lichtensteiger et al., Chap.12 of “Oxide Ultrathin Films: Science and Technology”, Ed.G. Pacchioni, WYLEY 2012
[4] N. Sai et al., Phys. Rev. B 72, 020101(R) (2005)
[5] M. Stengel et al. Nat. Mater. 8, 392 (2009)
[6] R. Tung, Appl. Phys. Rev. 1, 011304 (2014)
[7] M. Nuñez and M. B. Nardelli, Phys. Rev. B 73, 235422 (2006)
[8] Z. Wang et al., Phys. Rev. B 94, 155307 (2016)
[9] S. Koohfar et al. Phys. Rev. B 96, 024108 (2017)
[10] J. Wolfman, B. Negulescu, A. Ruyter, N. Niang and N. Jaber in “Laser Ablation”, ed. Dr. Dongfang Yang, IntechOpen Ltd, Londres, 2020 http://dx.doi.org/10.5772/intechopen.94415