



HAL
open science

Bottom electrodes impact on Hf_{0.5}Zr_{0.5}O₂ ferroelectric tunnel junctions

Greta Segantini, Pedro Rojo Romeo, Benoit Manchon, Nicolas Baboux, Ingrid C Infante, Rabei Barhoumi, Cosmin M Istrate, Lucian Pintilie, Damien Deleruyelle, Bertrand Vilquin, et al.

► To cite this version:

Greta Segantini, Pedro Rojo Romeo, Benoit Manchon, Nicolas Baboux, Ingrid C Infante, et al.. Bottom electrodes impact on Hf_{0.5}Zr_{0.5}O₂ ferroelectric tunnel junctions. EMRS Spring Meeting 2021, May 2021, Virtual, France. . hal-03275569

HAL Id: hal-03275569

<https://hal.science/hal-03275569>

Submitted on 1 Jul 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Bottom electrodes impact on $\text{Hf}_{0.5}\text{Zr}_{0.5}\text{O}_2$ ferroelectric tunnel junctions

Greta Segantini¹, Pedro Rojo Romeo¹, Benoit Manchon², Nicolas Baboux²,
Ingrid C. Infante², Rabei Barhoumi², Cosmin M. Istrate⁴, Lucian Pintilie⁴,
Damien Deleruyelle², Bertrand Vilquin¹, Sharath Sriram³

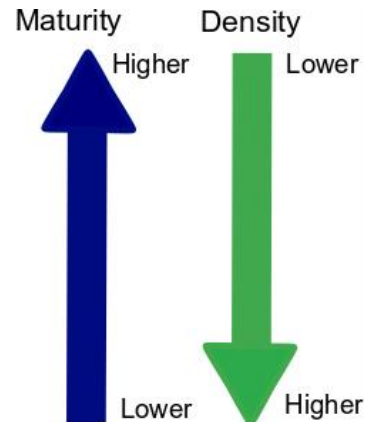
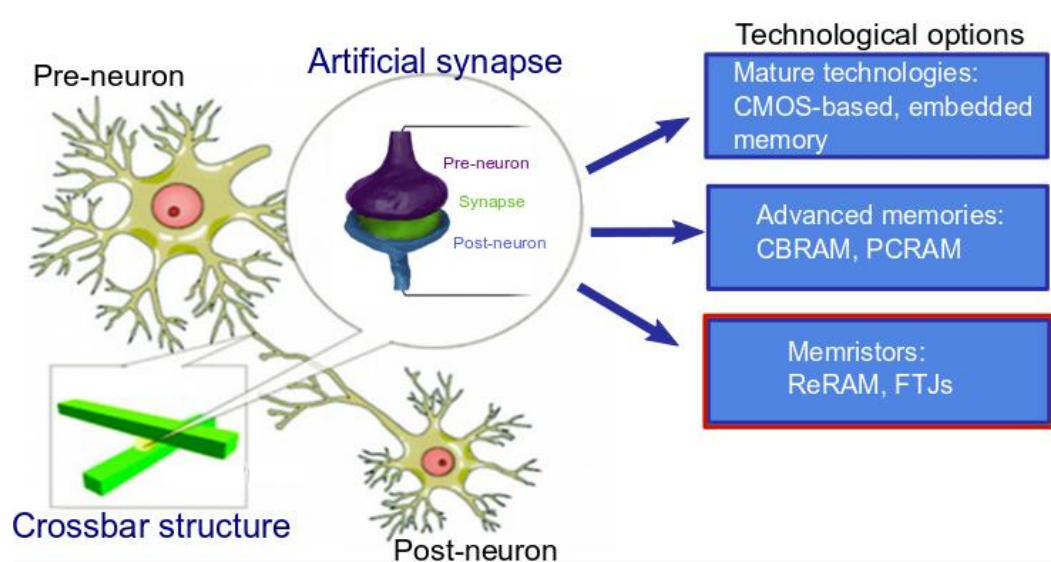
¹Université de Lyon, Ecole Centrale de Lyon, Institut des Nanotechnologies de Lyon, CNRS UMR5270

²Université de Lyon, INSA de Lyon, Institut des Nanotechnologies de Lyon, CNRS UMR5270, 7
avenue Capelle, 69621 Villeurbanne cedex, France

³Functional Materials and Microsystems Research Group and Micro Nano Research Facility, RMIT
University, Melbourne, VIC, 3001, Australia

⁴National Institute of Materials Physics, Atomistilor 405A, Magurele, 077125, Romania

Introduction



- Emulation of synaptic plasticity
- Parallel process of data
- High energy efficiency



Memristor

- ReRAM
- Ferroelectric tunnel junction (FTJ)

- CMOS Compatibility
- Stable orthorhombic phase at low thickness
- Optimisation of electrical performances



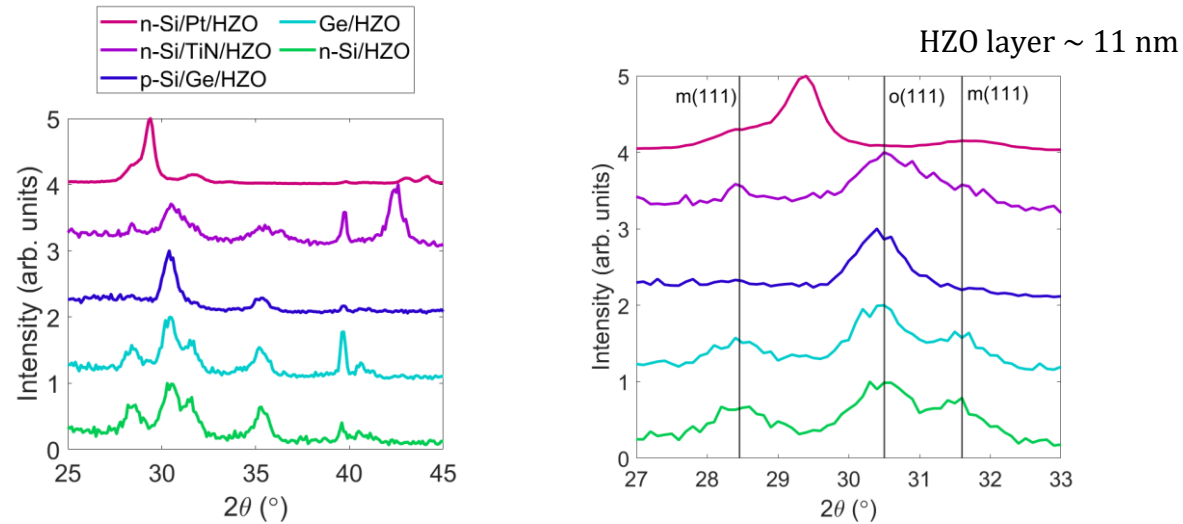
Impact of:

- Bottom electrode (BE)
- Ultra-thin buffer layer the electrode/HZO interface

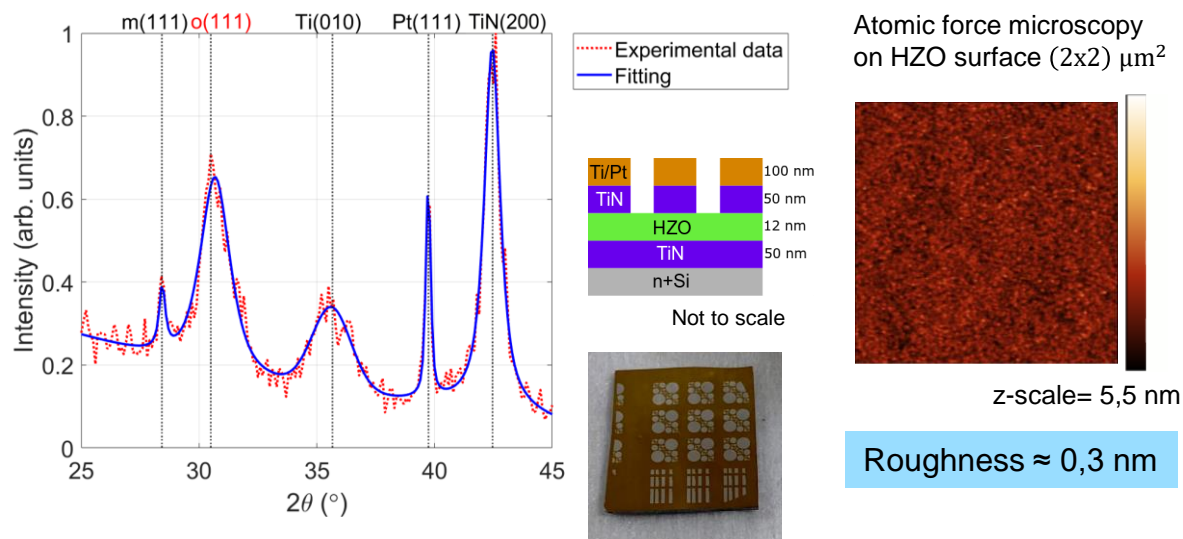


Experimental Results

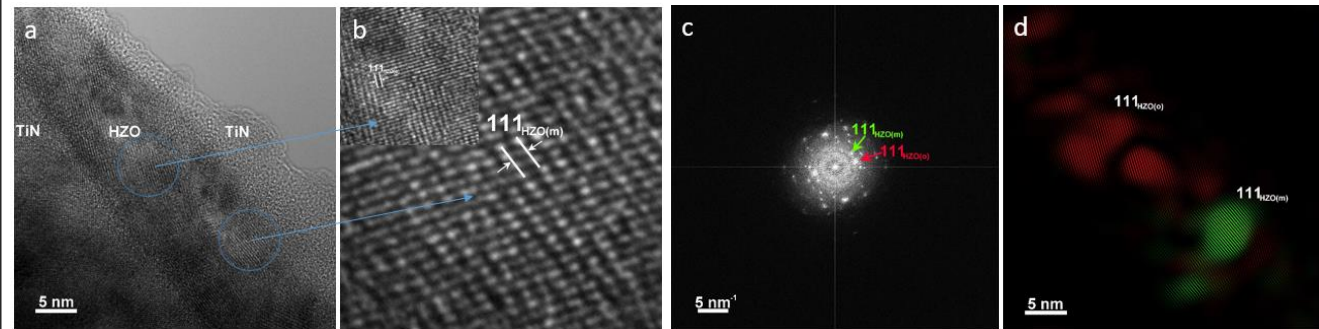
Post-annealing Grazing Incidence X-Ray Diffraction Characterisation:



TiN Bottom Electrode:



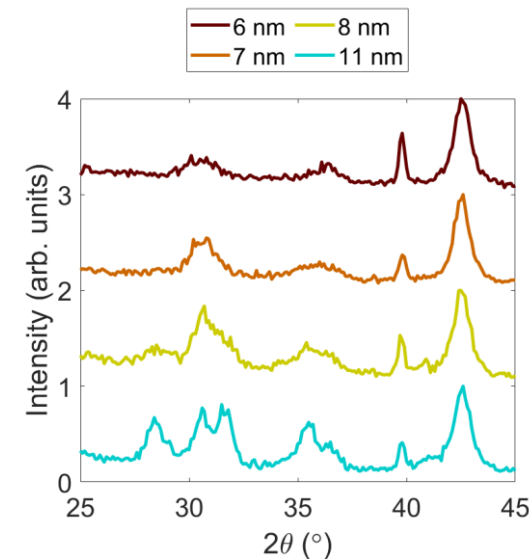
Transmission Electron Microscopy (TEM)



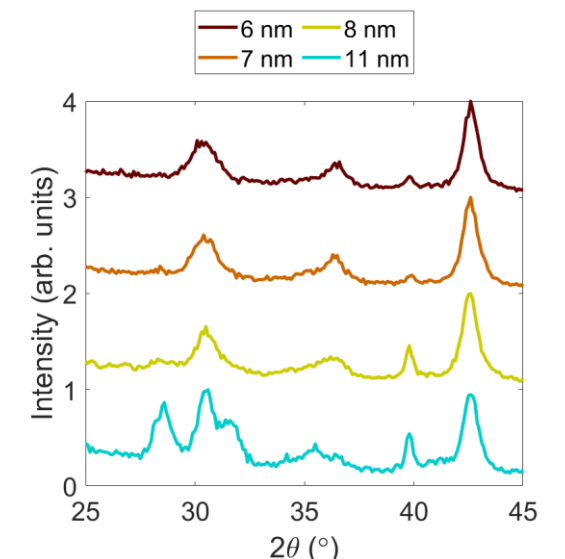
(a) HRTEM image of the TiN/HZO/TiN multistructure, (b) magnified view of two HZO crystallites with different crystalline structures from an area marked by the two blue circles from the HRTEM image, (c) Fast Fourier Transform picture performed on the HRTEM image, (d) reconstructed image of the two HZO crystallites using the two different spots marked on the FFT picture.

Impact of an ultra-thin Ti buffer layer: analysis for different thickness of HZO

n^+ Si(001)/TiN/HZO/TiN/Ti/Pt



n^+ Si(001)/TiN/Ti/HZO/TiN/Ti/Pt



Impact of an ultra-thin Ti buffer layer: analysis for different thickness of HZO:

Post-annealing the Ti turns into **TiO₂** which:

- Stabilize ferroelectric layer in HZO
- Increase oxygen vacancies in the HZO barrier
- Creates defects at the electrode/HZO interface

HZO layer ~ 11 nm

| Ti layer | $2P_r$ ($\mu\text{C}\cdot\text{cm}^{-2}$) | Cycling voltage (V) | Endurance (cycles) |
|----------|--|---------------------|--------------------|
| No | 13.68 | 4.5 | 10^6 |
| Yes | 28.12 | 4.5 | 10^6 |

TiN Bottom Electrode:

- Prevents degradation of ferroelectric phase
- Provides large ferroelectric polarization

- Increase of remnant polarisation
- No impact on endurance
- Decrease of wake up effect

Conclusions

- ✓ Realisation of thin ferroelectric layers by magnetron sputtering
- ✓ Ultra-thin buffer layer to promote ferroelectricity at low thickness
- ✓ Positive impact of the buffer layer on the electrical performances

References:

- [1] L. Chen *et al.*, “Ultra-low power Hf_{0.5}Zr_{0.5}O₂ based ferroelectric tunnel junction synapses for hardware neural network applications,” *Nanoscale*, vol. 10, no. 33, pp. 15826–15833, 2018, doi: 10.1039/c8nr04734k.
- [2] J. Bouaziz, P. R. Romeo, N. Baboux, and B. Vilquin, “Huge Reduction of the Wake-Up Effect in Ferroelectric HZO Thin Films,” *ACS Appl. Electron. Mater.*, vol. 1, no. 9, pp. 1740–1745, 2019, doi: 10.1021/acsaelm.9b00367.

The I3E ECLAUSion project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 801512