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## Bottom electrodes impact on Hf<sub>0.5</sub>Zr<sub>0.5</sub>O<sub>2</sub> ferroelectric tunnel junctions

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

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Ingrid C. Infante<sup>2</sup>, Rabei Barhoumi<sup>2</sup>, Cosmin M. Istrate<sup>4</sup>, Lucian Pintilie<sup>4</sup>,  
Damien Deleruyelle<sup>2</sup>, Bertrand Vilquin<sup>1</sup>, Sharath Sriram<sup>3</sup>

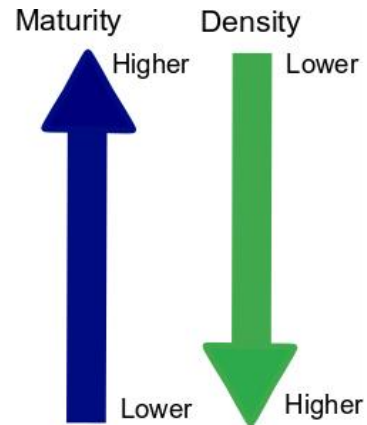
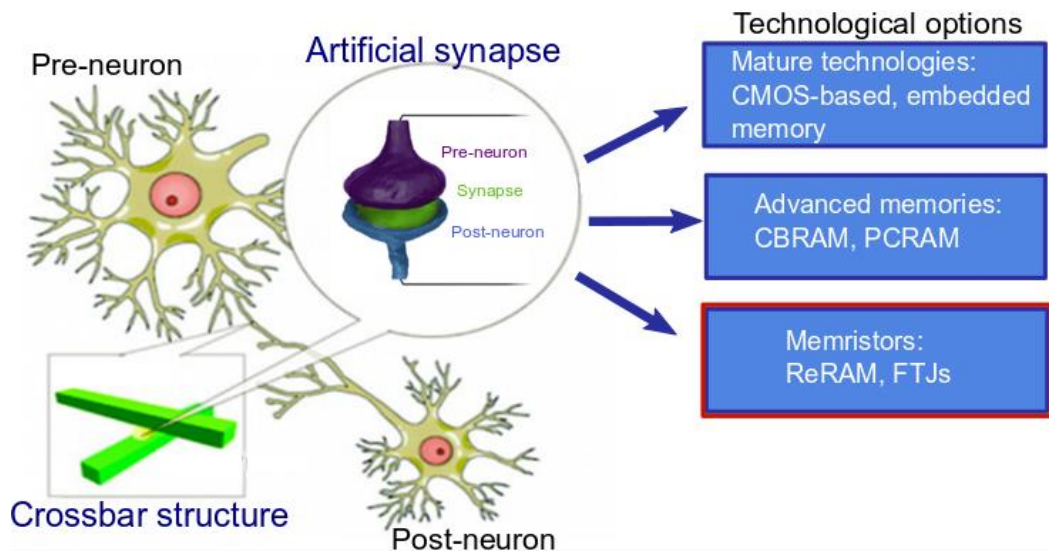
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# Introduction



- 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



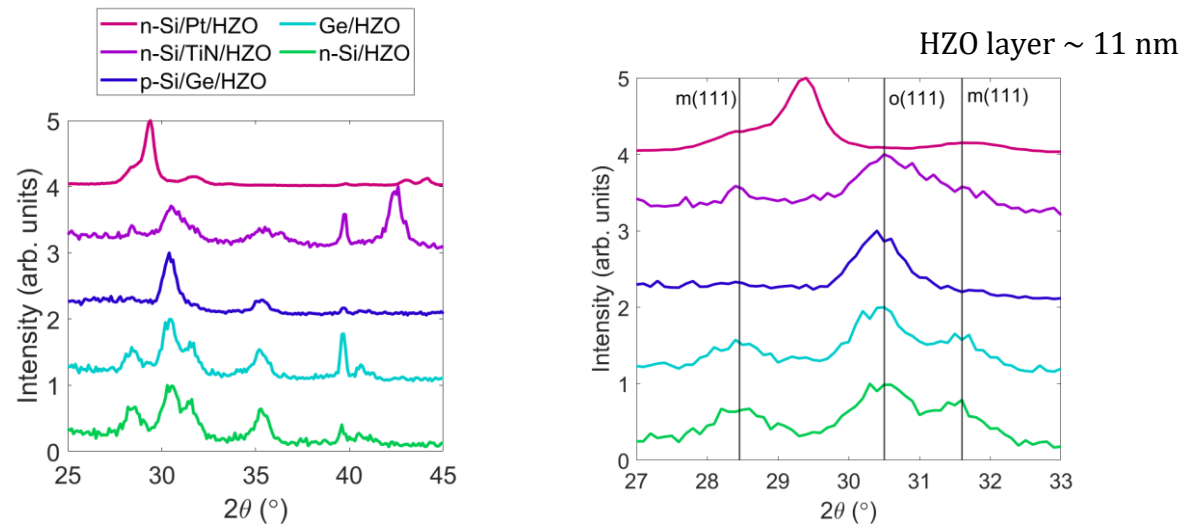
### Impact of:

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

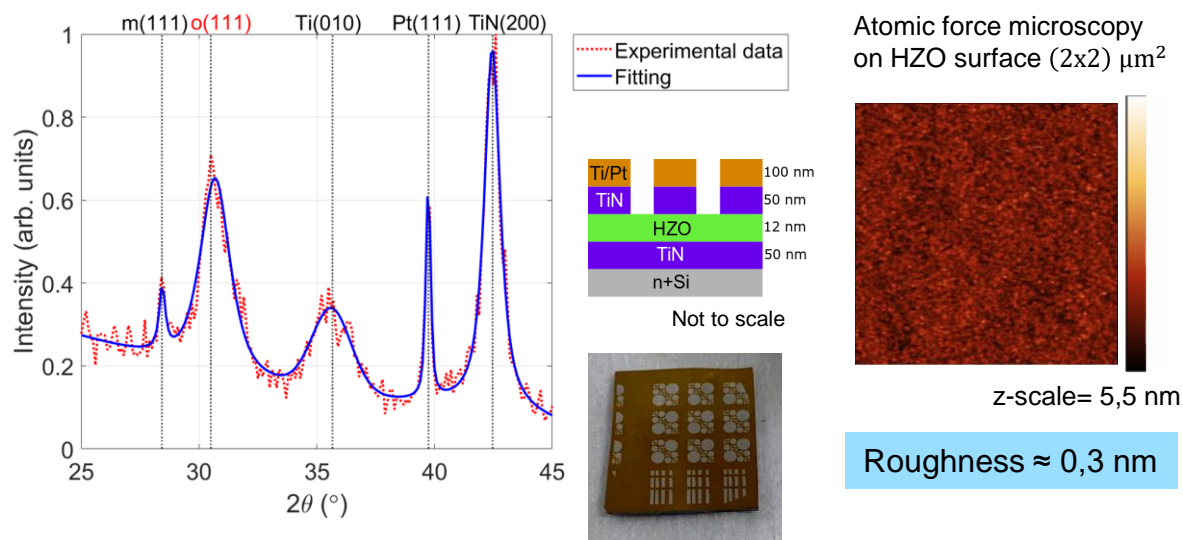


# Experimental Results

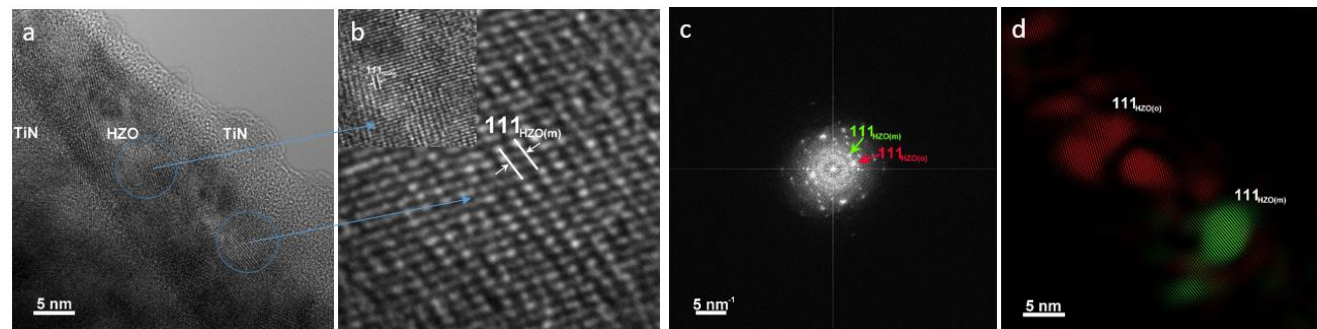
## Post-annealing Grazing Incidence X-Ray Diffraction Characterisation:



## TiN Bottom Electrode:



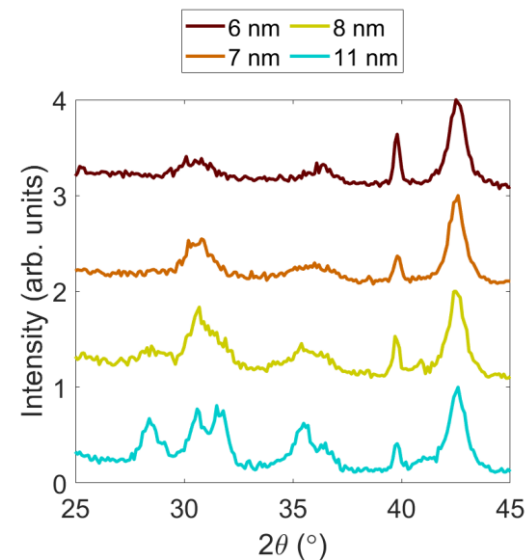
## Transmission Electron Microscopy (TEM)



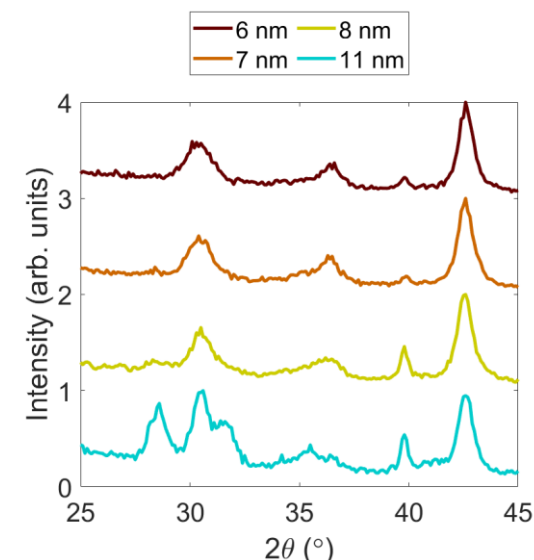
(a) HRTEM image of the TiN/HZO/TiN multistructure, (b) magnified view of two HZO crystallites with different crystalline structures from an area marked by the two blue circles from the HRTEM image, (c) Fast Fourier Transform picture performed on the HRTEM image, (d) reconstructed image of the two HZO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

### $n^+ \text{Si}(001)/\text{TiN}/\text{HZO}/\text{TiN}/\text{Ti}/\text{Pt}$



### $n^+ \text{Si}(001)/\text{TiN}/\text{Ti}/\text{HZO}/\text{TiN}/\text{Ti}/\text{Pt}$



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

Post-annealing the Ti turns into **TiO<sub>2</sub>** 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<sub>0.5</sub>Zr<sub>0.5</sub>O<sub>2</sub> 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.

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