Influence of bottom electrodes on HZO thin film features

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Influence of Bottom Electrodes on HZO Thin Films Features

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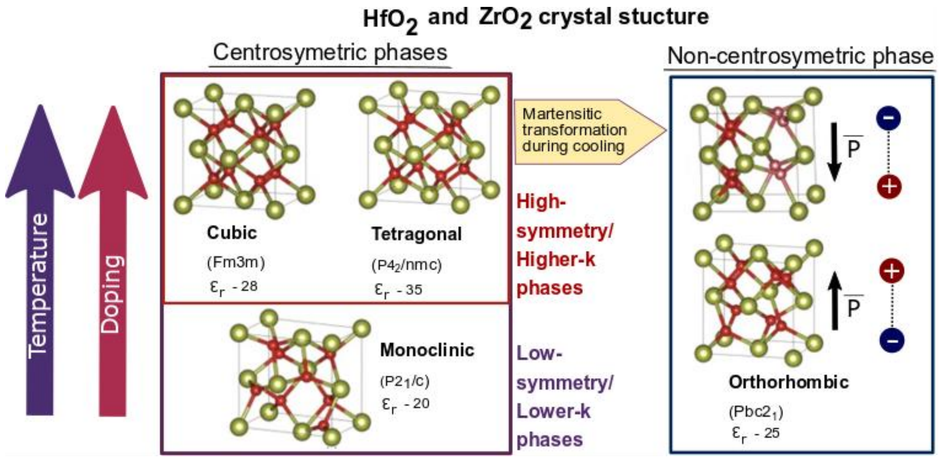
Neuromorphic computing is promising for the processing of massive data with an extremely low power consumption. After the discovery of memristors the research has been focused on the study and development of novel artificial neuromorphic devices, including ferroelectric-based ones.

Ferroelectric Tunnel Junction (FTJ) type memristors based on zirconium-doped hafnium oxide ($HfZrO_2$ or HZO) have shown synaptic learning capabilities. HZO processes are already integrated in Si CMOS industry and its ferroelectric properties allow to obtain oxide layers thinner than 10 nm. Nevertheless the endurance properties should be improved for industrial applications and the nucleation and stabilization of the ferroelectric phase (f-phase) is not yet well understood.

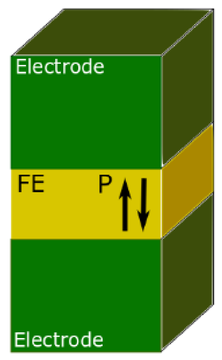
Motivations and Objectives



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

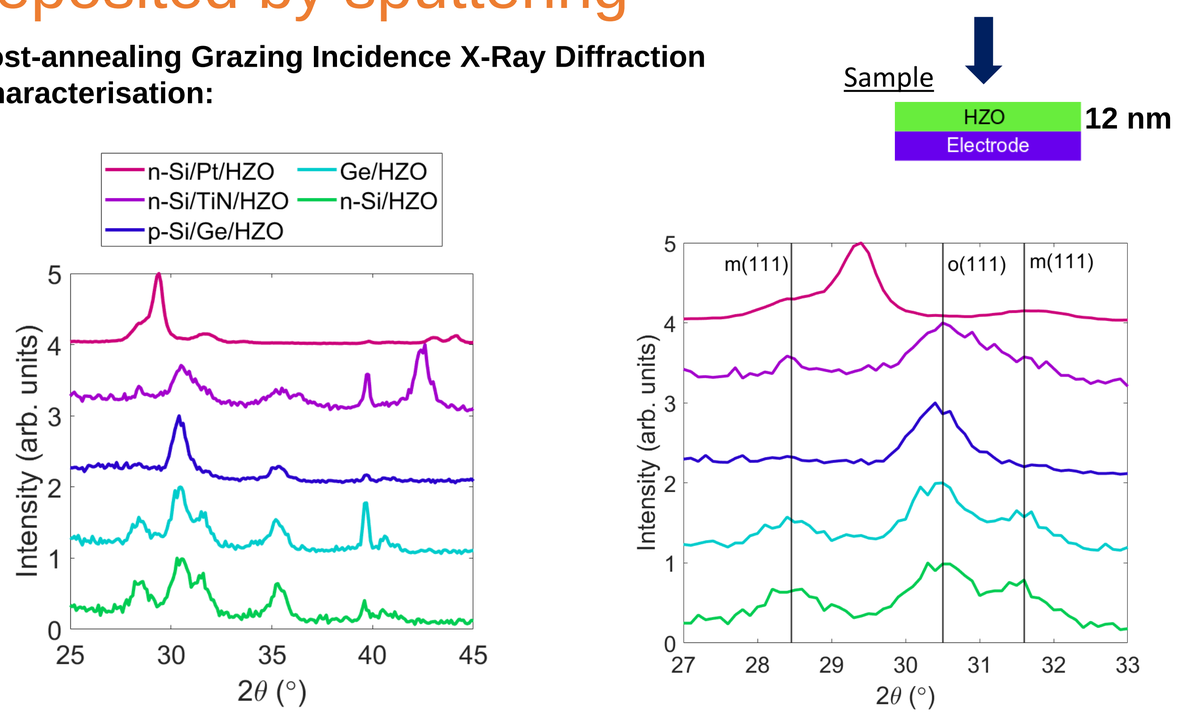
Impact of:

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



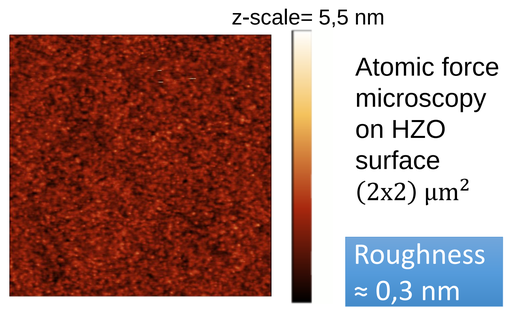
Structural characterisation of HZO films deposited by sputtering

Post-annealing Grazing Incidence X-Ray Diffraction Characterisation:

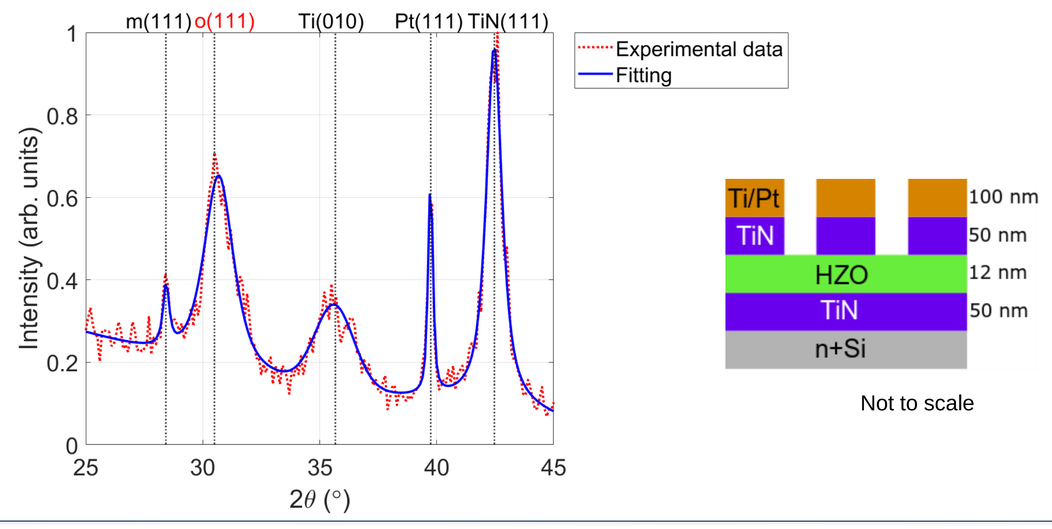


TiN bottom electrode (BE):

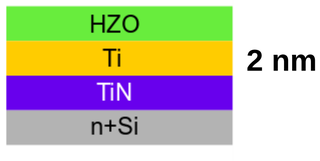
- Prevents degradation of ferroelectric phase
- Provides large ferroelectric polarization



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



Impact of ultra-thin Ti buffer layer: structural analysis for different thicknesses of HZO



Post-annealing the Ti turns into TiO_2 which:

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

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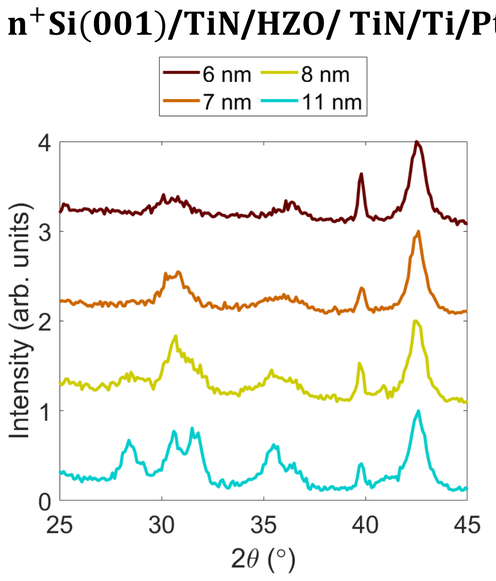
Increase of leakage current

Ferroelectricity confirmed by electrical characterisation: PUND (Positive Up Negative Down) technique

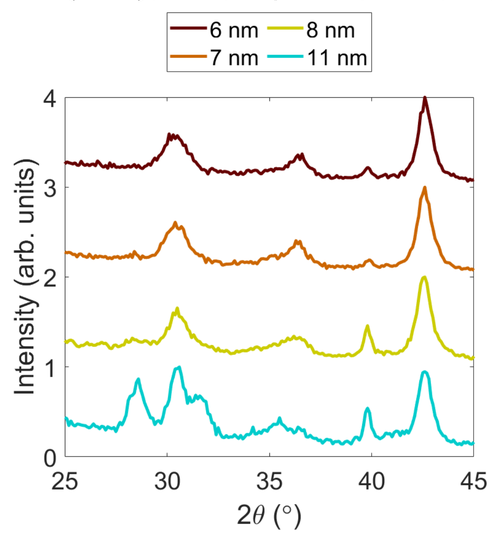
$HZO \sim 11$ nm

Ti layer	$2P_r$ ($\mu C.cm^{-2}$)	Cycling voltage (V)	Endurance (cycles)
No	20.33	4.5	10^6
Yes	28.12	4.5	10^6

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



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



Conclusions

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

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