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# New class of polar $HfO_2$-based materials sputter-deposited with a novel thin-film growth design concept

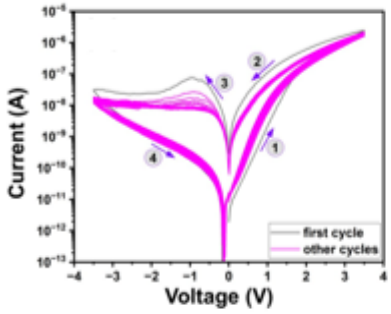
For enhanced uniformity in neuromorphic resistive-switching  Case Ref: BAK-10926-24

**The problem:** Artificial intelligence has emerged as one of the defining technologies of the 21st-century, however the rapid growth of AI presents a major challenge in sustainability. Neuromorphic computing overcomes this challenge by combining computation and memory, analogous to biological systems. However, such bio-inspired devices presently face a major challenge in achieving high cycle-to-cycle and device-to-device uniformity, owing to the stochastic nature of the resistive switching mechanism.

**The Solution**

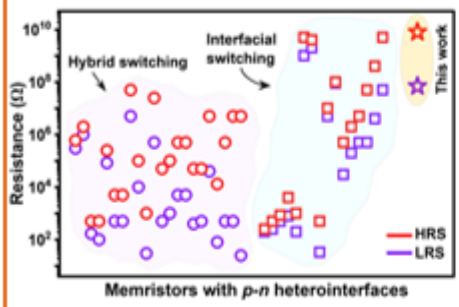
1. New class of co-doped polar $HfO_2$-based materials with a unique core shell structure
2. CMOS compatible materials and simple, scalable fabrication process
3. No initial electroforming process
4. Exceptional cycle-to-cycle and device-to-device uniformity
5. 6000 reproducible resistance levels from ~2.5 × $10^{-9}$ to ~1.4 × $10^{-7}$ S

## Memristive behaviour




- No need for initial electroforming process
- Exceptional cycle-to-cycle uniformity
- Memory windows ≥ 10
- Stable resistance states up to 5 × $10^4$ cycles

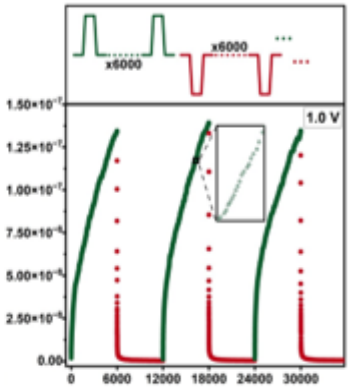
## P-type Conductivity




Memristors with *p-n* heterointerfaces

- Exhibit bipolar diode-like characteristics with pure interfacial conductance changes
- Highest resistance states and largest interfacial-memristive memory window of any memristor with p-n heterointerfaces

## Neuromorphic characteristics




- Remarkable reproducibility of the 6000-spike training scheme confirmed for several different devices
- Levels ranging from 2.5×$10^{-9}$ to 1.4×$10^{-7}$ S with Wmax/Wmin ratio > 50
- High linearity in conductance modulation from 6000-spike scheme after applying ~500 spikes

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