

Architectural Control of Ferroelectric and Memcapacitive Behavior in PLD-Grown HZO–ZrOY Thin Films for Neuromorphic Applications

I. Spinu⁽¹⁾, A.G. Boni⁽¹⁾, C.F. Chirila⁽¹⁾, P. Tsipas^(1,2), D. Popescu⁽¹⁾, L. Pintilie⁽¹⁾
and A. Dimoulas^(1,2)

(1) National Institute of Materials Physics, Atomistilor 405A, Magurele 077125, Romania, (2) Institute of Nanoscience and Nanotechnology, National Center for Scientific Research DEMOKRITOS, Neapoleos 27 and Patriarchou Gigoriou Str, Athens, Attiki 15341, Greece

HfO₂-based ferroelectric oxides are promising for neuromorphic hardware because their electrically accessible states can support both non-volatile switching and history-dependent response. In this work, thin-film structures based on HZO (Hf:Zr = 1:1), 3 at.% Y-stabilized ZrO (ZrOY), and HZO/ZrOY heterostructures were grown by pulsed laser deposition and investigated to clarify how layer architecture, substrate orientation, and interface design affect their ferroelectric and memcapacitive behavior. All structures were deposited at the relatively low temperature of 400 °C and crystallized directly during growth, without any post-deposition thermal treatment, highlighting the potential of PLD for low-thermal-budget integration [1]. Structural and electrical characterization show clear differences between single-layer and multilayer configurations. Single-layer films exhibit ferroelectric signatures, but often with pronounced internal fields and incomplete polarization stabilization, leading to mixed ferroelectric–memcapacitive behavior. By contrast, ZrOY/HZO/ZrOY multilayers show improved switching, larger remanent polarization, and better stability, especially on Si(111). The thickness of the ZrOY interlayers further tunes the response, with intermediate values giving the best ferroelectric performance, while thinner interlayers favor a more dominant memcapacitive character. These results show that PLD-enabled architectural tuning provides an effective route to access distinct operating regimes in HfO₂-based oxide films. The studied HZO–ZrOY multilayers therefore represent a versatile platform for further development of ferroelectric and memcapacitive elements relevant to future neuromorphic devices.

[1] C.F. Chirila et al., *Ceramics International*, 26, 50941-50950, 2025