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Negative Capacitance Ferroelectric Devices for Radiation Detection Applications

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The negative capacitance (NC) feature exhibited by doped high-k dielectric HfO2 has emerged as a crucial technological advancement in CMOS nanoscale electronic devices. The revelation of ferroelectricity in HfO2 opens up new possibilities for manufacturability and scalability across various domains, and the design of low-power, sharply switching transistors. The resilience of ferroelectricity in thin HfO2 films to thickness scaling underscores its exceptional miniaturization capabilities.
The voltage amplification induced by the unique properties of ferroelectric materials further pushes their use in almost every low-power application. The NC concept holds the promise of achieving sub-60 mV/decade subthreshold swing in FET devices at room temperature. The integration of a negative capacitor in the gate stack of a transistor introduces an amplified internal potential (step-up voltage), potentially overcoming the fundamental limit of 60 mV/decade subthreshold swing in FET devices at room temperature of conventional transistors. The theory of "capacitance matching" ensures hysteresis-free operation while maximizing the amplification of the internal potential. This breakthrough could have profound implications for advancing the landscape of electronic device design and performance.
This work introduces the HiEnd (Development of High Energy Efficient Electronic Devices Based on Innovative Ferroelectric Materials) projects, focusing on applying the NC working principle in High Energy Physics experiments detection systems for future colliders. The overarching goal is to advance the fabrication of tracking devices characterized by high spatial resolution, extremely thin layers, and the capability to discern signals from noise in challenging radiation environments. A pioneering aspect of the project involves a preliminary study of the radiation hardness of this innovative technology under irradiation conditions.
Advanced Technology CAD (Computer Aided Design) modeling will be used to investigate the potentiality of NC devices in unconventional application domains. Numerical simulations, capable of verifying experimental results, enhance predictive power, reducing time and cost in detector design and testing.

Collaboration

Role of Submitter

I am the presenter

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