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Negative Capacitance Ferroelectric Devices for Radiation Detection Applications

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The negative capacitance (NC) feature of doped high-k dielectric HfO2 has emerged with important technological applications in CMOS nanoscale electronic devices. The discovery of ferroelectricity in HfO2 reveals a new perspective for manufacturability and scalability in multiple fields, with groundbreaking implications in the design of low power, steep switching transistors. Ferroelectricity in thin HfO2 films does not degrade with the thickness scaling, showing excellent miniaturization properties. The voltage amplification triggered by the ferroelectric material properties, further pushes its use in almost every low-power application. The NC concept promising to provide room temperature sub-60 mV/decade subthreshold swing in FET devices. The presence of a negative capacitor in the gate stack of a transistor can provide an amplified internal potential (step-up voltage), which can potentially overcome the fundamental limit in the subthreshold swing of conventional transistors. The theory of "capacitance matching"is of utmost importance for obtaining a hysteresis-free operation with maximum amplification of the internal potential.
In this contribution, the INFN-CSN5 NegHEP (NEGative capacitance field effect transistors for the future High Energy Physics applications) project will be presented. The project proposes the use of the NC working principle in the framework of High Energy Physics experiments detection systems at future colliders, fostering the fabrication of tracking devices with high spatial resolution, extremely thin layers and capable of detecting signals from noise in harsh radiation environments. The project intends to study, for the first time ever, the radiation hardness of this innovative technology to irradiation.
Advanced TCAD (Technology Computer Aided Design) modeling will be used aiming at investigating the potentiality of Negative Capacitance (NC) devices in non-conventional application domains (e.g., radiation detection). When numerical simulations are capable of verify experimental results, they will also gain predictive power, resulting in reduced time and cost in detector design and testing.

Collaboration

INFN CSN5 NegHEP project

Primary authors: PASSERI, Daniele (University and INFN Perugia); MOROZZI, Arianna (Istituto Nazionale di Fisica Nucleare)

Presenter: PASSERI, Daniele (University and INFN Perugia)

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