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TCAD modeling of Ferroelectric Materials for Enhanced Electronic Device Efficiency

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The integration of negative capacitance (NC) into field-effect transistor (FET) devices, offers a promising solution to overcome the fundamental limitations in power dissipation, commonly referred to as Boltzmann tyranny. NC, characterized by a voltage increase with decreasing charge, has long been a theoretical concept but presents practical challenges in electronic device implementation. Recent advancements have demonstrated the feasibility of integrating NC with FET devices, thereby opening pathways for enhanced device performance and marking a significant milestone in semiconductor innovation.

In this context, the HiEnd project aims to assess the suitability of innovative NC devices in High Energy Physics experiments, particularly in self-amplified segmented, high-granularity detectors. The NC working principle will be applied in the non-conventional scenario of detection systems, to exceed the limits imposed by actual CMOS technology in terms of power consumption, signal detectability and switching velocity. Advanced TCAD (Technology Computer Aided Design) modeling have been used to develop numerical models describing the intricate behavior of ferroelectric materials, providing insights into their switching dynamics. Simulation outcomes and measurements from test structures will be presented.

The overarching goal is to advance the fabrication of tracking devices characterized by high spatial resolution, thin layers, and the ability to discern signals from noise in challenging radiation environments. A key aspect of the project involves a preliminary study of the radiation hardness of this innovative technology under irradiation conditions, aiming to enhance knowledge in the field and enable the design of innovative devices capable of addressing current challenges in power consumption and heat dissipation.

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