Tutorial 2: CMOS+X: Functional Augmentation of CMOS for Next Generation Electronics

Sayeef Salahuddin, University of California, Berkeley

Abstract:

Despite ominous foretelling of a slowdown, over the last decade the computational throughput has increased by orders of magnitude. Energy efficiency is critical not only to maintain this incessant advancement, but also to ensure that electronics does not become a drag on the finite energy resources of the world. This will need a radical rethinking of the basic building blocks that constitute the electronic hardware. In this talk, I shall briefly present how integrated ferroelectric devices offer a new pathway in this context. First, I shall discuss the phenomenon of negative capacitance in ferroelectric materials. A fundamentally new state in the ferroelectric materials, negative capacitance promises to reduce power consumption in electronic devices significantly. I shall discuss our current understanding of negative capacitance derived from numerous experimental works done over the last few years. We shall further discuss the material science that is enabling the integration of negative capacitance into advanced transistors. Going beyond transistors, the insight gained from physics and materials could also lead to advanced, low power memory devices. Additionally, I shall present integrated magnetic devices. Beyond memory applications, these devices are showing promise for neuromorphic computing and sensing applications. These examples underscore how functional augmentation of CMOS by harnessing new physical phenomena, we are calling it CMOS+X, could offer opportunities that are otherwise not available through conventional means.

Bio:

Prof. Sayeef Salahuddin is the TSMC Distinguished Professor of Electrical Engineering and Computer Sciences at the University of California Berkeley. His work has focused on emerging electronics and spintronics phenomena for energy efficient computing. He is attributed for discovering the Negative Capacitance phenomenon in Ferroelectric materials and for demonstration of ferroelectricity in atomically thin ferroelectric films on silicon. His most notable awards include the Presidential Early Career Award for Scientist and Engineers (PECASE) from President Obama, Young investigator awards from the

NSF, ARO and AFOSR and the IEEE George E Smith Award. He currently serves as the Editor in Chief of the IEEE Electron Devices Letters. Salahuddin is a Fellow of the IEEE and the APS.