TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Physics

PHYSICS COLLOQUIUM

Speaker: **Prof. Sourav De**
National Tsing Hua University

Topic: **Hafnium Oxide Based Ferroelectric Field Effect Transistor as Next Generation Embedded Storage-Class Memory: A Material-Device-Co-Optimization Approach**
Introduction for habilitation

Time and place: Tuesday, November 5, 2024, **2:50 pm**
The colloquium will be held as online-only event.
Online access:
Zoom-Meeting: Meeting-ID: 631 3817 8900 / passcode: PC-WiSe24
https://tu-dresden.zoom-x.de/j/63138178900?pwd=E3ujrdyvlnABCPexxEhG5XErr7Cv5B.1

Host: Prof. Lukas Eng

Abstract: The application of hafnium oxide (HfO_2) in ferroelectric memory has garnered significant interest, particularly for its potential as storage class memories (SCM) that bridge the gap between dynamic random access memories and flash memories. This is largely due to its excellent scalability and compatibility with complementary metal-oxide-semiconductor (CMOS) technology and back-end-of-line processes. Although FeFETs have demonstrated the potential to act as standalone SCM, several challenges must be addressed before full commercialization is achievable and also implementation of embedded-SCM (eSCM). The primary hurdles include reducing the operational voltage to be on par with logic transistors used in eSCM and mitigating charge trapping and de-trapping, which adversely affect the endurance cycles of these devices. Our investigation begins with state-of-the-art silicon channel ferroelectric field-effect transistors (FeFETs), where we analyze low-frequency noise characteristics. This analysis reveals fluctuations in carrier mobility and the impact of doping on noise behavior. We demonstrate the array-level operations of these devices before exploring various scaling issues for eSCM integration. This section of our research focuses on the thermal budget and ferroelectric properties of ultra- thin HfO_2 in metal-ferroelectric-metal structures. Our findings indicate that 4 nm thick hafnium zirconium oxide (HZO) devices can achieve significant ferroelectric properties without experiencing polarization degradation. Additionally, we examine the wake-up behavior through various field

cycling methods, confirming that these devices primarily exhibit interfacial layer soft breakdown mechanisms.

Bio: Professor Sourav De, an IEEE senior member, directs his scholarly pursuits at the confluence of physics and technology, with a specific emphasis on scrutinizing the fundamental characteristics and attributes of hafnium oxide-based thin films. His research involves the meticulous application of physical and electrical characterization methodologies such as XPS/HAXPES, low-frequency noise analysis, charge pumping, and other established techniques. The overarching objective of these endeavors is to enhance the system-level performance of these thin films through procedural and modus-operandi refinement. Professor De's scholarly contributions were recently distinguished with the "George E. Smith" award in 2022, a significant milestone in the annals of Fraunhofer IPMS. Beyond his scholarly achievements, he has been actively engaged with the IEEE Electron Device Society, assuming roles such as a Technical Program Committee member at prominent conferences like EDTM and delivering keynote addresses at conferences such as the Non- volatile Memory Symposium. Additionally, Professor De has been an assiduous contributor to academic discourse through his participation in paper reviews for esteemed journals including Nature Communication, Scientific Reports, Advanced Science, Journal of Applied Physics, Applied Physics Letters, IEEE Electron Device Letters, and IEEE Transactions on Electron Devices. His primary scholarly pursuit revolves around hafnium oxide-based resistive and ferroelectric memories, underscoring his unwavering commitment to advancing the frontiers of technology and physics.