Department of Materials Science and Engineering Seminar Series 2025

EMERGING NON-VOLATILE MEMORY ARCHITECTURES FOR NEXT-GENERATION NEUROMORPHIC AND IN-MEMORY COMPUTING SYSTEMS

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Date and time: Wednesday, 18th November 2026, 10:00 am

Venue: E7-03-08

Abstract

The rapid growth of AI, autonomous systems, and IoT demands low-energy, low-latency hardware for sensory data processing. Conventional von Neumann architectures are limited by data-transfer bottlenecks. This thesis develops a materials-device-array-system approach that exploits controllable internal states of emerging memory materials for sensing, encoding, storage, and computation.

A photonic ReFET based on a defect-engineered HZO-HSO superlattice and IGZO channel integrates optical sensing, non-volatile memory, and analog computation, delivering forming-free 8-bit multilevel switching and endurance beyond 10^{10} cycles. A 20×20 array enables in-sensor optical convolution with 94.45% accuracy on Fashion-MNIST. Ultrathin AlScN ferroelectric tunnel junctions, stabilized by Hf electrode engineering, retain operation up to 250 °C and support a 20×20 crossbar for hyperdimensional computing with high tolerance to bit errors in bearing-fault classification.

An 8×8 array of Nb:STO/$YFeO_3$/Pt memristors provides a homogeneous multi-timescale platform: short-term depression, analogue weight storage, and oscillatory spiking. The same cells form a reservoir-computing system that classifies EEG signals at 91.2% accuracy. These studies establish a unified materials-to-functions route toward robust edge-intelligence hardware.

Biography

Kaixuan Sun received his B.Eng. degree in Microelectronics Science and Engineering from Xiangtan University and his M.Eng. degree in Electronic Science and Technology from Hebei University. He is currently pursuing his Ph.D. in Materials Science and Engineering at the National University of Singapore (NUS) under the supervision of Professor Jingsheng Chen. His research focuses on memristive devices, ferroelectric AlScN, and neuromorphic computing architectures for next-generation edge intelligence.

Please join us!

HOST: Asst Prof Zhong Peichen