ME Seminar

Molecular Neuromorphic Building Blocks for Artificial Intelligence

Dr. Sreetosh Goswami, CeNSE, IISc, India

ABSTRACT

Artificial Intelligence (AI) has long been a subject of fascination, oscillating between grand promises and inevitable disillusionment. While remarkable milestones, like AI outperforming human champions in complex games, suggest we are entering a new era of computing, a deeper look reveals that these breakthroughs come at a steep cost — demanding vast amounts of energy and intensive, expensive training process. In areas like cognition, decision-making, and intelligence, even our most advanced computing machines fall far short of the brain's unparalleled efficiency and compact design. The core of this challenge lies in the limitations of conventional circuit elements and computing architectures, which struggle to replicate the brain's complex, nonlinear dynamics operating at the edge of chaos. In this seminar, I will introduce a new class of molecular circuit elements designed to capture the intricate, reconfigurable logic that mimics brain-like behaviour at the nanoscale. These devices can be operated as analog or digital elements, or could be poised on the verge of instability, offering a unique potential to emulate neural functions in ways that traditional computing hardware cannot. Our journey explores these molecular systems from their foundational physics and chemistry, all the way to integrated circuit design and on-chip applications [1-7] with the aim of laying the groundwork for AI and machine learning platforms that can transcend the limitations of Moore's Law and lead to a new era of energy-efficient computing.

References:

[1] Sharma, D., Rath, S.P., Kundu, B., Korkmaz, A., Thompson, D., Bhat, N., Goswami, S., Williams, R.S. and Goswami, S. Linear symmetric self-selecting 14-bit kinetic molecular memristors. ***Nature*** 633, 560–566 (2024).

[2] Sreebrata Goswami, Williams, R. Stanley, and Sreetosh Goswami. "Potential and challenges of computing with molecular materials." ***Nature Materials*** (2024): 1-11.

[3] Rath, S. P., Deepak, Goswami, S., Williams, R. S., & Goswami, S. Energy and Space Efficient Parallel Adder Using Molecular Memristors. ***Advanced Materials*** (2023), 2206128.

[4] Rath, Santi Prasad, Thompson, Damien, Goswami, Sreebrata, & Goswami, Sreetosh. "Many-body molecular interactions in a memristor." ***Advanced Materials*** (2023): 2204551.

[5] Goswami, Sreetosh, et al. "Decision trees within a molecular memristor." ***Nature*** 597.7874 (2021): 51-56.

[6] Goswami, Sreetosh, et al. "Robust resistive memory devices using solution-processable metal-coordinated azo aromatics." ***Nature Materials*** 16.12 (2017): 1216-1224.

[7] Goswami, Sreetosh, et al. "Charge disproportionate molecular redox for discrete memristive and memcapacitive switching." ***Nature Nanotechnology*** 15.5 (2020): 380-389.

ABOUT THE SPEAKER

Dr. Sreetosh Goswami is an Assistant Professor and Pratiksha Trust Young Investigator Chair at the Centre for Nanoscience and Engineering (CeNSE), Indian Institute of Science. He obtained his Ph.D. from the National University of Singapore. His graduate research was recognized with the Graduate Student Awards (Gold Medal) from both the Materials Research Society (MRS) and the European Materials Research Society (EMRS). In 2024, he was named a Young Member of the Indian Academy of Sciences. Sreetosh's research is dedicated to advancing energy-efficient neuromorphic hardware for AI, with a focus on developing accelerators for deep learning, signal and image processing, as well as bioinformatics.

October 25, 2024, 4:00 pm, AR Auditorium, Mechanical Engineering, IISc