

*Stephenson School of Biomedical Engineering and
The School of Computer Science
Seminar Series Presents*



**ULTRA-LOW SWITCHING ENERGY MEMORIES
TO ARTIFICIAL NEURONS**

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11 - 12 pm | Tuesday, Oct. 8, 2019 | Gallogly Hall, Room 126

SHORT BIO – T. Venkatesan

T. Venkatesan is the Director of the Nano Institute at the National University of Singapore (NUSNNI) where he is a Professor of ECE, Physics, MSE and NGS. As the inventor of the pulsed laser deposition (PLD) process, he has over 760 papers and 30 patents and is globally among the top one hundred physicists (ranked at 66 in 2000) in terms of his citations (~45,368 with a hirsch Index of 109-Google Scholar). He has graduated over 50 PhDs, 35 Post Docs and over 35 undergraduates.

Venkatesan is founder and chairman of Neocera, a company specializing in the area of PLD and magnetic field imaging systems. Close to 14 of the researchers (PhD students and Post Docs) under him have become entrepreneurs starting over 20 different commercial enterprises. He is a Fellow of the APS, winner of the Bellcore Award of excellence, Guest Professor at Tsinghua University, Winner of the George E. Pake Prize awarded by APS (2012), President's gold medal of the Institute of Physics Singapore, Academician of the Asia Pacific Academy of Materials, Fellow of the World Innovation Forum, was a member of the Physics Policy Committee (Washington DC), the Board of Visitors at UMD and the Chairman, Forum of Industry and Applications of Physics at APS. He was awarded the outstanding alumnus award from two Indian Institute of Technologies- Kanpur (2015) and Kharagpur (2016), India. He has been awarded the 2020 APS Distinguished Lectureship Award on the Applications of Physics. He has the following start-ups in Singapore- Cellivate, Breathonix and CLEOME Photonics.

ABSTRACT:

Memory devices are responsible for a significant fraction of the energy consumed in electronic systems- typically 25% in a laptop and 50% in a server station. Reducing the energy consumption of memories is an important goal. For the evolving field of artificial intelligence the compatible devices must simulate a neuron. We are working on three different approaches towards these problems- one involving an organic metal centred azo complex, the other involving oxide based ferroelectric tunnel junctions and the last involving real live neuronal circuits.

In the organic memristors that we have built on oxide surfaces the device performance exceeds the ITRS roadmap specification significantly demonstrating the viability of this system for practical applications. More than that, these organic memories exhibit multiple states arising from interplay of redox states, counter ion location (studied by in-situ Raman and UV-Vis measurements) and molecular self-assembly leading to the possibility of neuronal systems. These molecular devices are extremely stable and reproducible- a significant departure from conventional organic electronics.

On the oxide- front the significant results are that ferroelectric tunnelling is seen even in barriers with single and two atomic layers of BaTiO₃ or BiFeO₃. Oxygen vacancy motion can also play an important role in changing the device characteristics leading to synaptic characteristics. Last but not the least, oxide surfaces can be utilized to force neurons to grow at specific places on a surface giving the potential for fabricating live neuronal circuits.