Microelectronics and **I**ntegrated-Systems with **N**euro-centric **D**evices (**MIND**) Lab
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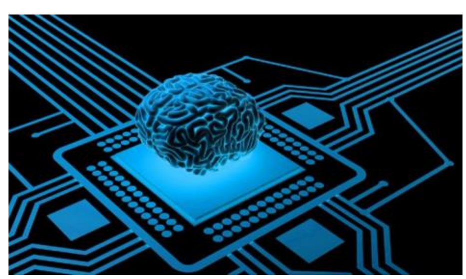
Primary Research Areas:

- **Emerging Logic and Memory Devices beyond CMOS**: Metal Oxide Semiconductor (CMOS) devices serve as the backbone of all processors and memory technologies. The continued scaling of CMOS devices, well known as Moore's Law of Scaling, has instigated all major innovations in the areas of computing and data storage in the last few decades. The versatility of CMOS devices have also served as a launch pad for several new technologies ranging from smartphones, notebooks, tablets, and high performance computing, to MEMs technologies, and point of care devices. It is fascinating that CMOS devices today are as small as just 22 nm in gate length and semiconductor industry has roadmap for few mores generations of scaling the size of the transistor to around 5 nm by the year 2020. However, conventional scaling of Silicon based CMOS devices will approach fundamental limits and new technologies are needed to meet the computational demands of the future applications. My research group is focusing on emerging Logic and Memory devices that can address these bottlenecks. In particular, we are investigating transition metal oxide (TMO) based Resistive Random Access Memory (ReRAM) devices for high density data storage and in-memory computing architectures.

Application of novel low-power data storage devices. Image source: Google

- **Neuromorphic Devices and Computing**: Albert Einstein famously said, "Look deep into nature, and then you will understand everything better". A biological brain is an excellent computing machine. While today's digital computers are extremely good at general purpose computing, they fail when it comes to solving a subjective computing problems. For example, a human brain can easily make decisions based on surrounding environmental conditions. A similar decision-making would be a daunting task for digital computers. Additionally, as CMOS devices are approaching their fundamental scaling limits, it becomes important to explore alternative ways of computing that are power efficient and scalable. To this end, people have traditionally explored Neural Networks. In fact, Deep Neural Networks (DNN) based machine learning is becoming increasingly important



Developing brain inspired components such as neurons and synapses for cognitive computing. Image source: LinkedIn.

these days where cloud is getting inundated with massive amount of data generated by various sources. However, DNN still runs on digital computers that uses fundamentally different components and architecture than those found in a biological brain. Therefore, to address this challenge, our research group focuses on understanding the components and circuits in a biological brain and develops nanoelectronic neuromorphic devices and circuits that can match the energy-efficiency, scalability, and robustness of a biological brain for biomimetic learning-based computing and decision making. This research aligns closely with the recent grand challenge announcement from white house in the areas of brain inspired computing: https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

For both projects, students will be involved in:

1. Microfabrication of selector diodes in cleanroom.
2. Testing of selector diodes on state of the art electrical testing equipment available in MIND lab at UC
3. Data analysis and device modeling
4. Working with Dr. Jha in a research of highly motivated graduate and undergraduate students.
5. Exploration of Artificial Neural Network Circuits and interfacing with artificial synapses for Neuromorphic Architectures.