"Live, Free, Democratized Electronics: Bridging Catalyst of Multi-Disciplinary Research."

We live in the age of the information where electronics play critical role in our daily life. Traditional approaches for innovation in electronics have been inspired by Moore's Law: performance with affordability. By leveraging suitable material properties of silicon, we have perfected complementary metal oxide semiconductor (CMOS) technology to achieve high performance, energy efficiency and ultra-large scale integration density in CMOS electronics. Moving forward as we embrace the Internet of Everything (IoE) where people, process, device and data will be connected – what would be the attributes of the electronics? What potential applications can augment the quality of our life which do not exist today? Is it possible to bring tomorrow's applications to today's society?

My research has been influenced by these questions. My continuing exploration suggests electronics in future will be ubiquitous in our life and seamlessly connected through internet. The attributes of the future generation of physical electronics will include: dynamic performance, ultra-low to self-powered operation (i.e. co-integration of energy harvesters), robust communication, live (data acquisition through sensors, data processing, storage, communication and decision execution through actuators will be heterogeneously integrated), democratized (easy to understand, simple to implement, use and affordable) and free form (physically flexible, stretchable and reconfigurable to conform to the soft tissue, irregular contour and asymmetric skin surfaces of living beings: from human and plants to animals).

While traditional CMOS industries have been advancing the classical features of performance, power consumption and scaling, the academic community has specifically focused on materials based innovation and low-cost fabrication processes. Ironically traditional CMOS materials like silicon, silicon germanium, germanium, III-V, gallium nitride, etc. are rigid and bulky; conversely emerging materials are still in the exploration phase and far from manufacturability for broad range of electronics. Thus, a balanced blend of scientific discovery and engineering innovation is an absolute necessity today. Therefore, our research is focused on hybrid integration of heterogeneous materials, processes and devices to build free form (flexible, stretchable, reconfigurable in shape and size) interactive and high-performance electronics and systems for smart living and a sustainable future focusing on healthcare, water, food and environment. For scientific exploration, we develop integration strategy to make collective use of the materials, processes and device architecture leveraging multidisciplinary tracks of electrical engineering, material science, bioengineering, computer science and engineering, mechanical engineering, environmental engineering (focusing plants and marine science) and health science. As engineering tool, we use CMOS technology extensively due to its industrial relevance, maturity and reliability for rapid tech transfer. In my talk, I will discuss the advances we have made which are under active commercialization by industries who are giants in their respective fields but not in the area of electronics. My examples will include: (i) advanced electronic systems for personalized healthcare; and (ii) frebonics: physically reconfigurable geometry electronics for fundamental design change in infotainment gadgets and electronic appliances.

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