Intelligent Nanosystems

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The integrated circuit industry has been steadily investing in technologies to fabricate at ever-smaller nodes, and is predicted to achieve sub-10 nm feature sizes within a decade. This inexorable push by a US$300B industry creates opportunities in other semiconductor device disciplines to realize new, powerful, self-contained, ultra-miniature systems capable of autonomously sensing, transducing, processing, and communicating information. We refer to this new opportunity as enabling "Intelligent Nanosystems."

Realization of such nanosystems will enable unique capabilities and benefits, but require overcoming significant challenges. This talk focuses on technical challenges of the four key nano-based components that comprise a fully-integrated, self-contained intelligent nanosystem-on-a-chip: 1) N/MEMS physical sensors, 2) mixed signal circuits, 3) communication linkages, and 4) on-chip power. Many classical sensing methods benefit greatly from scaling size to nanometer dimensions, and new modalities become available at quantum-scale dimensions. Most properties of transistors benefit from smaller node sizes, but analog performance often suffers. Nanometer-scale features put a lower limit on the wavelength of communication methods, requiring the use of THz and optical transduction. Power is a serious concern, as it scales to smaller system volumes. New approaches to minimizing standby power dissipation will be needed.

The practical integration of these four essential nano-scaled components into a compact chip stack represents a significant "More-than-Moore" challenge. The Intelligence Advanced Research Projects Activity (IARPA) has begun an investment in this future electronics direction including forming strategic world-wide partnerships among industry, government, and academia. Two case examples of aggressive dimensional scaling in both physical and biochemical sensing will be presented as a new pathway forward in enabling future intelligent nanosystems.

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