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Room 119A, ZEC

April 23, 2013 3:55-5:10 P.M.

Johns Hopkins on the Chip: A Metaphor for Medicine and Health Care Delivery in the 21st Century

by
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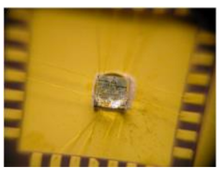
Abstract: Since the invention of the integrated circuit -the chip in short- in the 1950's, the microelectronics industry has seen a remarkable evolution from the centimeter scale devices created by Jack Kilby millimeter scale integrated circuits fabricated by Robert Noyce to today's 8nm feature size MOS transistors. During this time, not only have exponential improvements been made in the scaling of size and the density of devices, but CAD and workstation technologies have advanced at a similar pace enabling the design of complete truly complex Systems On a Chip (SOC). The advances in the microelectronics industry have also enabled the proliferation of computational fields for bio-informatics, systems biology imaging and multi-scale multi-domain modeling. Micro-fabrication and integration has paved the way to highly integrated electronic components through rapid, low-cost techniques that yield highly accurate and reproducible structures. Adaptation of the traditional silicon based technologies together with advances in new biomaterials are now applied to biotechnology to produce high-throughput microarray structures for genes and proteins.

Semiconductor technology is contributing to the advancement of biotechnology, medicine and health care delivery in ways that it was never envisioned; from scientific grade CMOS imagers to silicon photomultiplier and ion sensing arrays. The advent of microarray technologies, DNA chips, gene chips and protein chips is revolutionizing medical diagnosis and disease treatment. The stunning convergence of semiconductor technology and life science research is transforming the landscape of the pharmaceutical, biotechnology, and healthcare industries, signaling the arrival of personalized and molecular-level imaging diagnosis and treatment therefore speeding up the pace of scientific discovery, and changing the practice and delivery of patient care. Whether through

tissue and organ imaging, Labs-on-Chip or genome sequences, biotechnology and modern medical diagnostics are generating a staggering amount of data!

Every endeavor that relies on an exponential growth of knowledge and technology and rapidly advancing multi-disciplinary fields is inevitably going to offer challenges, but at the same time opportunities. These challenges often go beyond the traditional scientific and technological issues and into regulatory, financial and policy matters that often transcend single nation and individual society and patients safety, privacy concerns and ethical issues which are of course of paramount importance. In an era where semiconductor industry will be fueled by applications in health care and biotechnology where devices are “consumed” very quickly, the “chip” must be produced in more efficient, environmentally sound and sustainable manufacturing process. Furthermore the vast amount of “big variety”, “big volume” data that needs to be “consumed" i.e. processed by “cognitive machines” to extract the relevant information. In my talk I will discuss challenges and point to opportunities for future technological advances (i) in the sustainable manufacturing of future bio-chips and (ii) computing architecture in the era of exponential data growth.



A. G. Andreou, “Johns Hopkins on the chip: microsystems and cognitive machines for sustainable, affordable, personalized medicine and health care (invited paper),” *IEE Electronics Letters (special supplement on semiconductors for personalized medicine)*, pp. s34–s37, Dec. 2011.

Andreas G. Andreou is a professor of electrical and computer engineering, computer science and the Whitaker Biomedical Engineering Institute, at Johns Hopkins University. Andreou is the co-founder of the Johns Hopkins University Center for Language and Speech Processing. Research in the Andreou lab is aimed at brain inspired microsystems for sensory information and human language processing. Notable microsystems achievements over the last 25 years, include a contrast sensitive silicon retina, the first CMOS polarization sensitive imager, silicon rods in standard foundry CMOS for single photon detection, hybrid silicon/silicone chip-scale incubator, and a large scale mixed analog/digital associative processor for character recognition. Significant algorithmic research contributions for speech recognition include the vocal tract normalization technique and heteroscedastic linear discriminant analysis, a derivation and generalization of Fisher discriminants in the maximum likelihood framework. In 1996 Andreou was elected as an IEEE Fellow, “for his contribution in energy efficient sensory Microsystems.”