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An Intel Perspective on Silicon, Nanotechnology and Microelectronics

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ABSTRACT

The history of silicon microelectronics is best summarized by Moore's law, which predicted that the number of devices on an integrated circuit would double every 18th months. Sub-100nm technology is already a production reality at Intel, and it continues to follow Moore's Law. Equally important, the cost of each transistor continues to decrease, driving additional investments in research, development and new factories. But what does the future hold? Predictions are difficult to make, but we do believe that silicon nanotechnology is extendable through 2015.

The generally accepted industry consensus on the future of microelectronics scaling is the ITRS roadmap. This document is prepared under the auspices of the Semiconductor Research Corporation (SRC) and high lights potential risks to the continued scaling of microelectronic devices. In this document we can see some of the key technology gaps that will be encountered, and solved, in the coming 5-10 years. These short term issues, such as low power logic, reduction of gate oxide thickness, lithography costs, and factory integration are hard problems, but healthy robust business systems are in place to bring the focused talent of industry, government, and universities to bear on them, making success a reasonable expectation. In addition to these short term gaps, there are fundamental quantum and thermal limits based on the nanoscale device physics. These fundamental physical limits pose obstacles to further scaling of CMOS devices significantly below 5nm.

What is "Nanotechnology" for the microelectronics industry? Taking the lead from the US National Nanotechnology Initiative (NNI), structures having "….novel properties and functions because of their small and/or intermediate size…." in the range of 1 to 100 nm. This working definition is being increasingly accepted in the electronics industry, with a focus on those novel properties that influence the electrical characteristics of the device functionality, and the long term reliability of our products.

What will happen beyond 10 nm? Intel is open-minded about the technical options beyond 2015, but any new profitable products based on molecular, spin or quantum devices must be able to compete with mature silicon. This will require an unprecedented level of collaboration between industry, governments and universities. What is the "best" way for industry, government and universities to work together on the key issues of technology? What are the needs for government support and investment? While there are not yet definitive answers to these questions, these organizational challenges are starting to be recognized as critical to the long term health of the technology.