

SIA Updates National Technology Roadmap for Semiconductors

The National Technology Roadmap for Semiconductors (NTRS) was created by the U.S. Semiconductor Industry Association (SIA) to provide the semiconductor community with a common vision of the future technology needs of the silicon-based semiconductor integrated circuit (IC) industry. As such, the NTRS provides technical performance targets for the semiconductor equipment, materials, and software suppliers as well as well-defined technology needs for the research and development community. First published in 1991 and updated in 1994, the NTRS has become the common reference for the semiconductor industry worldwide. The underlying guide for the Roadmap is Moore's Law, which states that the number of transistors per square centimeter will quadruple every three years, or double every 18 months. The IC industry has been able to increase the IC functionality per unit cost by 25–30%/year by following Moore's Law. The enormous increase in performance of silicon-based ICs over the past three decades provides the base technology for the Information Age. The decreasing cost of high performance ICs has also led to ubiquitous use of semiconductors in all aspects of modern technology and commerce, from kitchen appliances to banking.

Under the leadership of the SIA, the semiconductor community has been working for the past year to update the NTRS. Technical experts from industry, universities, national laboratories, and government associated with advanced semiconductor research, development, and manufacturing are engaged in the effort.

The 1997 update started with a meeting of the Roadmap Coordinating Group (RCG) in April 1996. The RCG, chaired by Owen Williams (Motorola) and co-chaired by Paolo Gargini (Intel) appointed a separate working group for each major aspect of the technology. Each Technology Working Group (TWG) contained repre-

sentatives from the semiconductor device manufacturing and supplier industries as well as representatives from universities and government laboratories. These 11 TWGs addressed each of the technology areas required to keep the industry on Moore's Law and to maintain its historical productivity growth rate. The results of the year-long work of the TWGs were presented to the semiconductor community at a Roadmap Workshop in Austin, Texas, May 28–29, 1997. The workshop was attended by over 300 scientists and engineers who provided feedback for the final reports from the TWGs. These reports will provide the heart of the 1997 NTRS update.

The result of this industry-wide process will be a set of unified industry requirements obtained by industry-wide consensus. In addition to providing a consensus view of the direction of future technology, the Roadmap will highlight critical areas (potential "show stoppers") that could prevent the industry from sustaining its historical productivity growth.

Some major trends were evident in the TWG reports at the Workshop. Although many have debated the ability of the industry to continue to decrease the feature size of the ICs at the rate required to follow Moore's Law, currently we are observing the opposite trend. Technology nodes are being accelerated compared to the 1994 Roadmap, with 0.25 μm technology in high volume production in 1997 rather than 1998 as indicated in the 1994 NTRS. Other anticipated changes are the introduction of new materials and the end of conventional refractive optical lithography. Although the end of optical lithography has been predicted before, new approaches to through-the-lens photolithography will clearly be required as the feature size requires exposure wavelengths that are beyond the transmission cut-off of all optical materials. While sev-

eral approaches for lithography beyond optical are being explored, it is not yet known which technology will ultimately be used for high volume manufacture of ICs at feature sizes at 0.1 μm and below.

As presently envisioned, implementation of low-*k* interlayer insulators through the 100 nm technology generation will require introduction of a new material with each new generation of technology. Introduction of new materials into silicon IC manufacture at this rate is unprecedented in the history of the industry. Additional technology generations will either require materials beyond normal metals and dielectrics or conceptually new approaches to interconnect.

Major research efforts and new as yet unknown approaches will be required to address these changes. For the first time, the semiconductor industry cannot see a clear path to continue to follow Moore's Law for the next decade. The magnitude of the challenges will be detailed in the 1997 version of the NTRS. This update is scheduled for publication by SIA in November 1997, entitled *The National Technology Roadmap for Semiconductors: Technology Needs* (SEMATECH: Austin, 1997). Copies will be available from the SIA, 181 Metro Drive, Suite 450, San Jose, CA 95110; 408-436-6600; or fax 408-436-6646.

Because of the rapid changes in the industry, and because industry leaders frequently attempt to execute programs on schedules which exceed the NTRS projection, the industry decided that the Roadmap should be updated every two years instead of every three years. The next revision is therefore scheduled for 1999.

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U.S. Department of Energy

1998

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Application Deadline: December 5, 1997

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