Towards a new scale

Work on a new technology roadmap and an exceptional wave of consolidation hint at fundamental changes in the micro- and nanoelectronics industry, as **Christian Martin** explains.

Technology roadmaps are powerful tools to structure research and development. By laying out mid- and long-term goals for functionalities and technological capabilities, they provide important guidance to industry strategists, academic researchers and funding bodies alike. When unprecedented developments in the marketplace occur, however, hard work may be required to appropriately react to the new situation at hand.

One eminent case of a roadmap that is currently undergoing such profound revision is the International Technology Roadmap on Semiconductors (ITRS), which has been the central technology strategy document for the worldwide micro- and nanoelectronics industry since 1999, when it emerged from the national roadmap of the US Semiconductor Industry Association. Over the years, the ITRS has served as a key catalyst for a circle of innovation, growth, and investment in research and development as well as in fabrication facilities in the semiconductor industry.

At the core of progress in the industry, and the first versions of the ITRS, was the geometrical scaling of semiconductor logic and memory devices, which enabled integrated device manufacturers (IDMs) to regularly double the density of integrated circuits according to Moore's Law[1]. Although physical limitations soon required engineers to turn to so-called equivalent scaling and research new materials and device architectures to achieve further improvements in performance, the combination of the two different techniques guaranteed a constant improvement of processing power as well as enduring economic success in the world of servers and personal computers. With wireless communications and mobile devices emerging, however, this established approach eventually turned out to be too narrow. After several updates of the original document, the industry therefore started a roadmapping exercise towards a thoroughly revised ITRS 2.0 (ref. 2).

These efforts coincided with a year of exceptional mergers and acquisitions in the semiconductor industry[3]. By the end of 2015, a wave of transactions with a total volume of more than US$100 billion had swept the market. IDMs such as Intel, NXP and Infineon all successfully closed deals during the course of the year, though the biggest case, the US$37 billion merger of Broadcom and Avago, remains to be finalized in early 2016.

This wave of consolidation is more than a concentration process aimed at the creation of economies of scale; rather, many of the 2015 mergers indicate a strategic adjustment to the changes in the market that have also prompted the revision of the ITRS.

After decades of double-digit annual growth, the semiconductor industry has recently entered maturity. To keep costs in the manufacturing of integrated circuits in check while scaling integrated circuit production to technology nodes of 10 nm or less, the transition to larger silicon wafers had long been promoted as a necessary step[4]. However, owing to technical challenges the transition to 450-mm wafers has now been pushed back several times. At the same time, device prices are continuing the downward trend they have followed over the past decades. For companies, this means even more pressure to stay ahead of the competition, or to accept shrinking margins in the manufacture of commodity devices.

Against this backdrop, the exploration of new high-growth areas of nano- and microelectronics represents a welcome path towards diversification and risk mitigation. Segments such as automotive and industrial electronics as well as communications still show projected growth rates of up to 10%[3], but they often require flexible chip architectures that allow for the implementation of embedded systems in smaller volumes, as well as a combination of computational power with sensing and communication capabilities — expertise that some of the traditional IDMs did or do not have. And indeed, it is in these segments that many of the companies that went through mergers in 2015 have acquired new expertise and market share.

The revision of the ITRS mirrors this trend towards diversification. Whereas the original version of the document took a scaling-centred approach, the miniaturization of integrated circuits in its strictest sense – dubbed 'More Moore' — is only covered by one of seven focus teams drafting the ITRS 2.0 (ref. 5). Instead, emerging technology areas such as connectivity and the heterogeneous integration of different materials and components have moved into the scope of the roadmapping committees.

So what will be the role of nanotechnology as the ITRS 2.0 is evolving? Undoubtedly, nanoscale devices and nanofabrication technologies will still be crucial in satisfying the miniaturization targets set by the roadmap. For example, advanced device architectures such as the gate-all-around field-effect transistor[6] are still in the running for sub-10 nm technology nodes[7], and carbon nanomaterials continue to be considered for new devices[8]. Likewise, memory that relies on nanostructural material changes is likely to remain on the roadmap. Probably the most unexplored territory, however, is in sensors. While the motion sensors prevalent in today's cars and smartphones are based on microelectromechanical systems, new sensing capabilities might emerge from fundamental research on nanosensors. In comparison to the scaling of logic and memory devices, however, technology roadmapping in emerging areas such as sensing and heterogeneous integration poses a very different and arguably more complex challenge. Few agreed-upon figures of merit exist, and rapidly emerging applications will cause technology requirements to be far less predictable than in the past. Nevertheless, nanotechnology researchers should make every effort to make their mark on the changing landscape of electronics. ❐

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References

1. Moore, G. E. *Electronics* **38**, 114–117 (1965).
2. The International Technology Roadmap for Semiconductors; http://www.itrs2.net/itrs-news.html
3. PwC Technology Institute *Evolving landscape of technology deals: semiconductor industry* (August 2015); http://go.nature.com/EAwy4H
4. Martin, C. *Nature Nanotech.* **9**, 89–90 (2014).
5. Gargini, P. *ITRS past, present and future* (February, 2015); http://www.itrs2.net/itrs-reports.html
6. Kuhn, K. J. *IEEE Trans. Electron. Dev.* **59**, 1813–1828 (2012).
7. Badaroglu, M. *ITRS 2.0 - More Moore update* (July, 2015); http://www.itrs2.net/itrs-reports.html
8. ERD Group *"Beyond CMOS" update* (July, 2015); http://www.itrs2.net/itrs-reports.html