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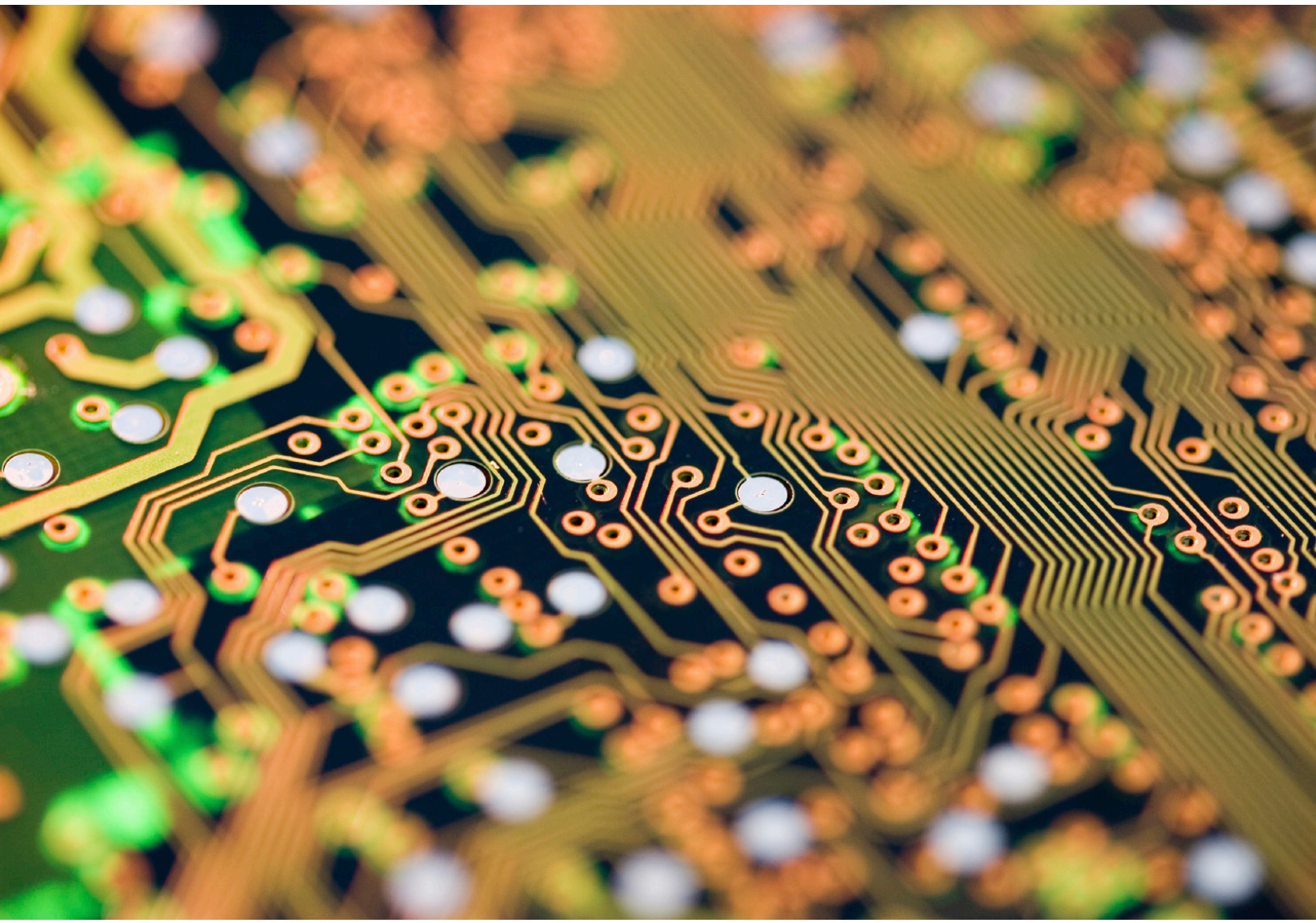
Knowledge@Wharton – Wipro Future of Industry Series: Semiconductors Innovation

Collaborative Innovation Holds Key to Semiconductor Industry Growth



Knowledge@Wharton – Wipro Future of Industry Series: Semiconductors Innovation

Collaborative Innovation Holds Key to Semiconductor Industry Growth

The market opportunity for semiconductor manufacturers is riding on the coattails of the exploding growth of Internet-enabled devices. By 2015, more than 15 billion devices, or twice the world population, will have Internet connections, according to a Cisco forecast. "Smart, connected products" are at or near a tipping point for semiconductor innovation, says Morris Cohen, Wharton professor of manufacturing & logistics. However, innovation by semiconductor makers must overcome technological and commercial hurdles to provide lower cost chips with more features, says Ramadurai Ramalingam, vice president and head of the semiconductor, computing and storage division at Wipro Technologies. Chipmakers are "critically dependent" on the industry's ecosystem to create value in their offerings, says Rahul Kapoor, Wharton management professor. Ganesh Iyer, practice head of Wipro's semiconductor, computing and storage division, points out that adjacent industry segments, emerging geographies and innovative business models are shaping up the next generation trends in the semiconductor industry. Ramadurai, Iyer, Cohen and Kapoor explore the semiconductor industry's challenges and opportunities in this 'Future of Industries' series white paper produced by Knowledge@Wharton and sponsored by Wipro Technologies.

"The semiconductor industry is at the beginning of its value chain," according to Ramadurai Ramalingam, vice president and head of the semiconductor, computing and storage division at Wipro Technologies. He points out that most users of smartphones, laptops, tablets and other such devices are not fully aware of the power of the semiconductor chips that enable the various features they use. In enterprises, these chips make possible everything from conventional computers to newer technologies like machine-to-machine computing, remote monitoring, smart sensors, etc., he adds. Innovation in semiconductors now commands higher visibility than ever before with the explosive growth in the user base of equipment and devices that chips power, he feels. "Smartphones and tablets are two areas that most semiconductor makers are currently focusing on."

Morris Cohen, Wharton Panasonic professor of manufacturing & logistics and co-director of its Fishman-Davidson Center for Service and Operations Management offers a peek into the future. "One area that is at or near a tipping point is that of 'smart, connected products,' i.e. embedding computing, communication and data storage/retrieval into every day products," he says. "The implications of this for after-sales service and new product development will be especially interesting." Cohen is a professor of

operations and information management at Wharton and is the co-founder of MCA Solutions, a Philadelphia-based firm that provides service supply chain software for semiconductor equipment firms, among others. (MCA recently merged with PTC Corporation, a provider of CAD and service support software systems.)

Cohen identifies two other areas where current and future developments are especially important to the semiconductor industry. One is the adoption of "performance-based contracting" for after-sales product support "where suppliers of equipment are incentivized to maintain products based on the actual value customers realize from product use," he says. "[The other area is] integration of product development systems with planning systems for optimal resource management to support product support services."

Industry watchers point to the explosive growth in the number of Internet users worldwide and forecast a rise in the use of electronic devices. Cisco expects worldwide devices and connections to grow to almost US$19 billion by 2016. According to OECD, by 2022, the average American household with two teenage children will own roughly 50 Internet-connected devices. Research firm IDC estimates that the global market for connected devices will touch $814.3 billion by 2017.

According to Wharton management professor Rahul Kapoor, in order to maximize their opportunities, semiconductor companies must strike collaborative relationships across their industry value chain. Kapoor's research specialties include innovation, technology management and strategy. "The ability of a semiconductor company to create value from its own products and technologies is critically dependent on its business ecosystem comprised of suppliers, customers and complementors (suppliers of complementary products)," says Kapoor in a report of the Wharton-ATREG Semiconductor Ecosystem Study released last November. (ATREG is a semiconductor advisory services firm in Seattle, Washington.)

The Wharton-ATREG study was part of a two-year research on the nature of challenges and opportunities that integrated device manufacturers (IDMs), or semiconductor companies, face. The study based its findings on detailed responses from senior executives at 23 publicly listed IDM companies, including 11 of the 20 largest IDMs by 2011 revenues.

TECHNOLOGICAL AND COMMERCIAL CHALLENGES

In 1965, Intel co-founder Gordon Moore had predicted that the number of transistors on a chip would roughly double every two years. Innovation in semiconductors to increase the processing power of chips has thus far been faithful to Moore's Law. Semiconductor firms are making transistors progressively smaller so that they can pack more of them on each silicon wafer chip. At present, they have the technology to design and manufacture chips of 14 nm (nanometers, or one-billionth of a meter). Going ahead, this will become 10 nm and 7 nm before reaching 5 nm by 2017, says Ramalingam.

However, even as Moore's Law holds firm, technological obstacles loom large. Take for instance the light sources used to carve circuits on silicon wafers. Chip manufacturers currently using conventional optical light wave technologies will be unable to use the same for smaller sizes, says Ramalingam. Newer technology like extreme ultraviolet (EUV) lithography will be needed, but the technology to make this commercially viable is still evolving, he adds.

Using advanced materials for chip manufacture and increasing the energy efficiency in devices to keep pace with increased processing power poses another challenge. Chipmakers are

exploring the possibility of replacing silicon with graphene, a so-called "wonder material" that promises superior conductivity, but here again the technology is still in development and not yet commercially viable, says Ramalingam.

The main problem with energy efficiency is that battery power technology has not kept pace with increase in processing power. Users cannot concurrently run multiple processes beyond a point to optimize power consumption. "While we can all say Moore's Law will continue, we have to seriously start looking at the economic benefits of the law due to the phenomenon termed as 'dark silicon,' which forces a portion of the chip to be powered down (dark) in order to conserve battery power," says Iyer.

WHERE COLLABORATIVE MODELS COULD HELP

Ramalingam outlines several options for semiconductor firms. For instance, to offset rising R&D and manufacturing equipment costs, they could use existing equipment more efficiently with tools like "predictive maintenance and yield improvement using advanced analytics." In collaboration with partners, semiconductor makers could extract synergies from the data generated by processes for product lifecycle management, manufacturing and enterprise resource planning. They could also address energy efficiency with design changes through partnerships.

Collaborative development projects could certainly be one way to achieve those, according to Cohen. "One approach is to adopt performance based customer-supplier relationships where payment is not for ownership of the product, but for the value that the product creates," he says. "This could be applied, in particular to semiconductor equipment, as well as to end products."

On the design side, Iyer suggests that semiconductor firms must also direct their innovation to expand their user base both by finding newer applications and by focusing on emerging economy markets. According to him, applications designed for smartphones or tablets may find uses in health care, such as for patient monitoring. "Semiconductor companies need to derive from an existing portfolio and build it for different industry segments."

Redesigning products for emerging markets is another opportunity where external partners could help, according to Iyer. "Users in different geographies have different needs. For example, users in one market may want features of a smartphone but may not necessarily need, say, a high-end camera," he says. "Semiconductor makers are creating derivative platforms for the development and prototyping of new products and features." Adds Iyer: "Third party vendors could be roped in with risk- and revenue-sharing models for both design of derivatives as well as realization of the product; such partnerships help shrink the time to market for new offerings."

Cohen feels such partnership models are in their early stages. "The [semiconductor] industry is still based on somewhat adversarial relationships with suppliers and customers," he says.

According to the findings of a survey led by Kapoor, a preferred strategy among semiconductor makers is to use existing intellectual property for new versions of existing products and for new products. The 2010 Wharton-GSA Semiconductor Ecosystem Survey found that on average, a semiconductor maker reuses about 73% of the intellectual property in revising existing product designs and about 44% in new product designs.

The Wharton-GSA survey also found that collaborative innovation could prove especially

beneficial in shortening the time-to-market for new products. According to this survey, the average time-to-market for semiconductor companies (defined as the period from design start to mass production), is about 11 months for revision of an existing product design, but about 17 months for a new product design. "The results reaffirmed that the ecosystem provides a rich set of opportunities for semiconductor companies to create value," it concluded.

FRUITS OF SHARING

According to a 2013 paper by Kapoor and Wharton doctoral student Patia McGrath, the key motivations for collaboration are "learning, technology integration, and resource pooling." Kapoor and McGrath focused on the interplay between technology evolution and the organization of R&D in the global semiconductor industry. Their research covered trends between 1990 and 2010.

In the emerging innovation model the consumer will be the prime driver, says Ramalingam. "As we move forward, consumer-led applications will be the trend. Innovation is increasingly consumer-led and is no longer completely enterprise-driven." He advises chipmakers to create platforms for users to create applications. Here, Cohen sees opportunities for developers to work on technologies such as 3-D printing and open-source software, adding that they "encourage social networking throughout the development process."

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