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22

Decoupling Platform

Collaborative development between OEMs and platform specialists can reduce internal R&D funding resources while speeding new equipment time-to-market.

The semiconductor industry faces a growing challenge in keeping up with the high pace of IC development mandated by the International Technology Roadmap for Semiconductors (ITRS) and Moore's Law. While there is little doubt that the industry can continue to push critical dimensions to even lower design nodes, there's a growing concern on how long transistor costs will keep on dropping. Each new design node and wafer size is becoming increasingly costly to implement, and such costs are falling more heavily on the equipment manufacturers.

In part, these rising costs are driven by what can be characterized as a "cottage industry" approach to tool development. By and large, each semiconductor OEM, whether start-up or established manufacturer, expends a considerable portion of its R&D dollars to development of equipment platforms rather than core technologies. Often the greatest stumbling blocks to bringing the next-generation technology to market involve not only critical improvements in tool process capability, but also required improvements in tool platform performance.

This article describes a paradigm shift in the way semiconductor tool development and manufacture is conducted. It focuses on collaborative innovation and leveraging economies of scale to enable OEMs to lower tool development costs, while enhancing their ability to reduce the time required to bring production-worthy tools to market.

Growing R&D crisis

For more than 40 years, the semiconductor industry has experienced significant and relatively steady growth by relentlessly following the "faster, smaller, cheaper" dictum that is at the heart of Moore's Law. Today, as we approach the 45 nm node, this steady pace of growth and innovation is being threatened as the industry pushes the boundaries of key scientific disciplines such physics, chemistry and materials science. Not only is it becoming scientifically more challenging, but a gap has emerged between the pace of innovation required by Moore's Law and the cost of funding that innovation.

Industry analyst Ron Leckie has estimated that R&D funding required by the semiconductor equipment and materials industry by 2010 for continued scaling will reach $16.2B — a figure that could swell to $19.7B if the industry transitions to 450 mm wafers. Unfortunately, as shown in the Figure, the industry's projected R&D budget for 2010 is only $10.4B, leaving a potential funding gap of $9.3B just two years from now.[1]

This situation is exacerbated by changing industry dynamics. Traditionally, the semiconductor equipment industry revenue growth has been faster than that of the device sector, but is now approximately equal. Between 1981 and 2005, semiconductor revenue growth slowed from 17 to 7%, while equipment revenue growth slowed from 20 to 5%.[2] As was seen with the 300 mm transition, however, the equipment industry is now being expected by its customers to carry an ever growing share of the R&D burden required to develop the new tools. This has forced the industry to continue investing in R&D at an unsustainable rate, creating a problem that is not limited to small companies. Speaking to *Electronic News* (April 1, 2005), Applied Materials' CEO Mike Splinter stated, "R&D spending averages between 15% and 18% overall, but there's hardly ever an average year. It's difficult for us and our competitors to fit in all that's required. I believe there is an R&D crisis in the equipment industry."

Cottage industry approach

Ten to 15 years ago, competition among semiconductor equipment manufacturers was framed in terms of throughput, process reliability, repeatability and innovation. Although all of these factors remain important, tool cost of ownership (CoO) has become an increasingly important competitive advantage. Device manufacturers are pressuring equipment companies to provide the latest process technology at ever lower costs, yet equipment companies require adequate revenues to support the R&D needed to develop new processes. Clearly, what is needed is an effective means of lowering the cost of developing and deploying new process technology.

The semiconductor equipment industry is, of course, not the only industry to have encountered this kind of R&D challenge. About seven years ago, Proctor & Gamble was experiencing a similar crisis. The company realized that its old business model, in which all R&D was conducted internally, would not support the product development required to meet future revenue growth targets. It found that there were at least 200 researchers doing similar work for every researcher employed internally. The company decided to change its development strategy and tap into these outside resources. Today, 35% of the company's new ideas come from outside consultants, R&D productivity is up ~60% and R&D cost as a percentage of revenue is down.[3]

R&D spending by semiconductor equipment companies is 4-6× higher than in any other manufacturing sector.[4] Although the industry has successfully squeezed the waste out of most other operational functions, R&D is one of the last key controllable expenses that the industry has yet to optimize. Certainly, the industry has made some efforts in this direction, such as the formation of consortia and alliances such as Sematech (Austin, Texas). Although this has helped to slow the R&D growth rate,[5] it has not proven to be the complete answer to the problem.

It is estimated, for example, that as much as 80% of the work that equipment engineers perform is not directly related to development of core technology.[6] Some of these tasks include generic platform design, translating prototypes to production, upgrading mature products, qualifying vendors, quality testing, documentation and manuals — many of which could be easily and effectively outsourced. Performing these tasks takes away time that could and should be devoted to the key reason for R&D investment: to develop the next-generation technology needed to keep the company competitive.

This generalist, or cottage industry, approach to new tool develop-

& Tool Development for Lower CoO

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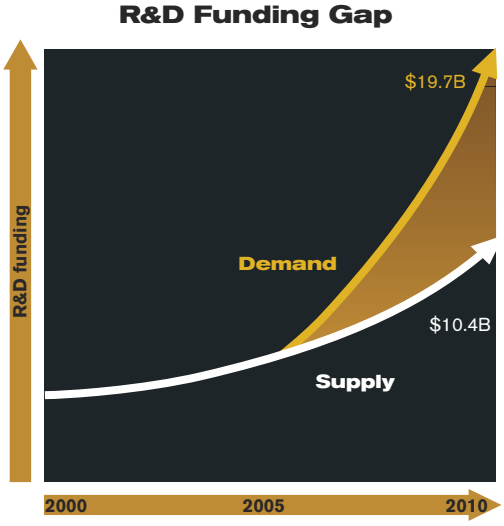
ment not only makes less than efficient use of the tool development engineer's valuable time, it also requires a higher level of staffing than would otherwise be required, which drives up costs. It has a further downside in what is a very cyclical industry: layoffs during down cycles, followed by hiring binges during up cycles. These cycles are hard on employee morale and frequently leave equipment companies scrambling to meet customer demands during upturns.

More efficient development

Collaborative development, an emerging tool development approach, offers semiconductor equipment companies an opportunity to reduce their tool development costs, minimize technical risk, optimize platform performance and speed time to market. It also focuses the OEM's internal resources on core technology improvement. The OEM works closely with an outside design and manufacturing company that is an expert in semiconductor platform development. The OEM is responsible for the core technology; the outsource platform design and manufacturing company is responsible for integrating this new core technology onto a generic equipment platform. The OEM provides the outsource company with its desired platform performance specifications concerning footprint, particle and contamination, electrical and controls architecture, software architecture, factory interface and general tool construction.

The platform design company optimizes all of these subsystems and ensures that they will integrate correctly with the process hardware developed by the OEM. It also focuses on resolving key platform issues such as maintainability, serviceability and manufacturability, while the process engineers resolve key process challenges. The platform design house has several significant advantages that enable it to perform these tasks much more effectively and cost-efficiently than the OEM. These include engineering experience, methodology and partnerships.

The average OEM will typically design a new platform every three to four years, while a platform design house will design five to seven platforms a year. This higher level of platform design activity allows the design house to streamline the platform development process. Its engineering and manufacturing teams have developed proven tools that are optimized for performance and manufacturability, resulting in accelerated time-to-market. Platform design houses also have close partnerships with subsystem manufacturers, such as the developers of factory-level automation software. As a result, they are very aware of the available subsystem options and can more quickly determine which are best suited for a particular platform's requirements.



1. The projected R&D budget for equipment and materials suppliers falls >$9B short of what is expected to be required to stay on the technology curve. *(Source: Ron Leckie, Infrastructure Advisors)*

For this collaborative approach to succeed, it's critical for both the platform engineering design company and the OEM to take a long-term strategic approach. To be effective, collaborative development must be addressed from a company or product roadmap perspective. Decisions must be made to determine which areas will be focused on by the OEM's engineers and which will be focused on by the design partner. It's necessary to determine which additional technologies and skill sets will be required and who will be tasked with providing them.

In addition to speeding the time to market for new process tools, an established OEM can use this approach to reduce the CoO of existing process tools, while adding new platform functionality. Working with an OEM on the redesign of an existing platform, we were able to reduce the cost of one tool platform by 30%, while simultaneously helping to integrate improvements in process technology.

Conclusion

The rising cost of process technology development, coupled with tight margins, is making it more and more challenging for semiconductor equipment companies to rapidly and cost-effectively develop the technology needed to meet the continuing innovation demanded by Moore's Law. Traditionally, process tool manufacturers have expended a considerable portion of their R&D dollars and engineering time on platform and process development. Partnering with an engineering design house to collaboratively develop new tool platforms can help speed time-to-market and reduce overall system costs. **SI**

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