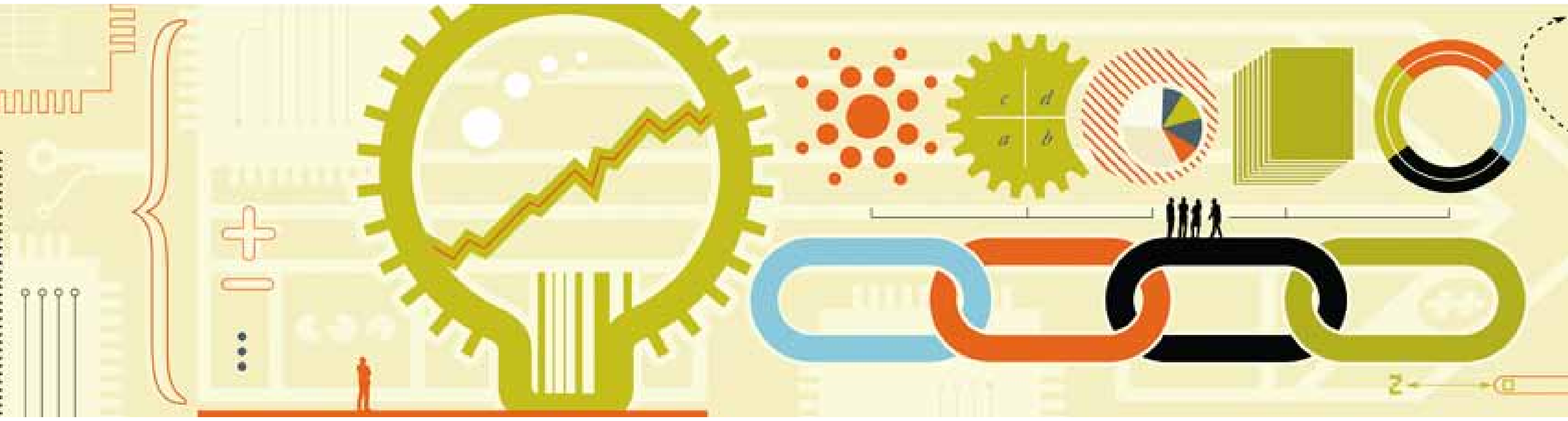

The evolution of business models in a disrupted value chain

The progress predicted by Moore's Law has slowed in recent years. Players across the semiconductor value chain must adjust their approaches to compete as the industry continues to evolve.

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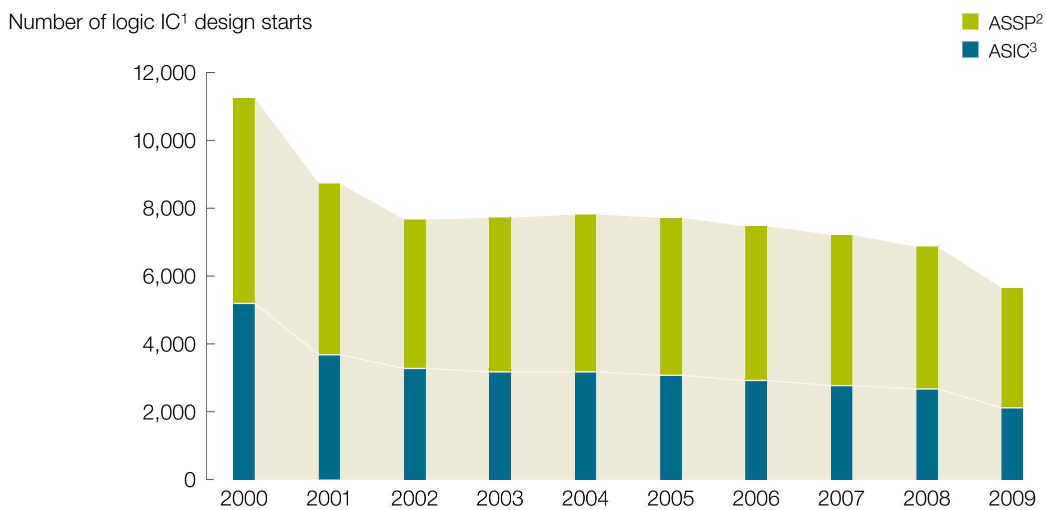
Over the past decade, the growing importance of specialization and scale in semiconductors has led to a breakup of the value chain and the establishment of a "winner take all" dynamic in many market segments, as noted in "Creating value in the semiconductor industry" (p. 5). Scale has become essential, as technical evolution in line with Moore's Law requires larger and larger investments in R&D each year. Specifically, the pursuit of smaller gate sizes, larger wafers, and competitive scale has resulted in an increase of about 20 percent in investment per year in leading-edge technology nodes. As a result, only a handful of companies—such as Intel, Samsung, and Taiwan Semiconductor Manufacturing Company (TSMC)—can keep up in the technology race.

Design costs, measured on a project basis, have exploded as well, resulting in a reduction of new designs (Exhibit 1). It is no surprise that Intel stands out as the winner in microprocessor units (MPUs), Texas Instruments in diversified integrated device manufacturers (IDMs), and TSMC in foundry; Samsung and Toshiba are arguably the winners in memory. All other players, including most IDMs, net out with either zero or negative cumulative economic profits from 1996 to 2009. Across the industry, semiconductor players destroyed a combined $140 billion in value.

However, not every segment conforms to this Darwinian model; fabless players and segments

Exhibit 1

There are fewer design starts, particularly on newer advanced technology.



[1]Integrated circuit.
[2]Application-specific standard product.
[3]Application-specific integrated circuit.

Source: Global Semiconductor Alliance; Morgan Stanley; McKinsey analysis

such as analog IDMs are two examples of businesses that are less ruthlessly competitive. In fact, the progress predicted by Moore's Law has slowed in many segments of the semiconductor industry. Given this context, we examined ways in which the semiconductor value chain might evolve and explored how current players might adapt in order to compete.

We begin by looking at the changes occurring in the fabless segment. Next, we turn to front-end fabrication, the segment that drove the technical developments that enabled the kind of advances predicted by Moore's Law. Finally, we address back-end fabrication, where the miniaturization race seems to be shifting the assembly-and-test segment.

Fabless design: Players adopt a range of successful models

Over the last decade, fabless players have continued to gain ground, outpacing IDMs and claiming more than 20 percent of the market. Despite some scale in high-end design, there is no overarching winner-takes-all dynamic in this corner of the industry. In fact, as noted in "Creating value in the semiconductor industry" (p. 5), there are far more fabless companies generating economic profits than there are profit-generating companies in manufacturing-related business domains. At first glance, one might conclude that fabless players create value because they require less capital investment. However, we find these companies win by establishing dominance in specific applications rather than across applications. Overall, three distinct business models have succeeded in the fabless space: innovators, fast followers, and mature-market attackers.

The innovator model is exemplified by leading players such as Qualcomm. These companies invest in continuous innovation for new applications, and they constantly expand their core intellectual property. Their efforts focus on unmet needs in the marketplace that come with large potential demand, and their explicit aim is to provide targeted semiconductors at the scale required to recoup R&D costs.

But being first to the market is not a must for fabless players. Broadcom is a good example of a fast follower. Instead of gambling on untested market potential, fast followers pick large, rapidly growing markets and quickly develop intellectual property to enter certain segments. They position themselves as presenting an integrated solution that is a lower-cost alternative to the market leader, with a streamlined business structure.

The third model, the mature-market attacker, is best illustrated by MediaTek. It may appear quite similar to a fast follower at first glance. However, such companies wait until an application area has reached significant global volume before entering the fray. At that point, they attack the market with a simplified value-for-money product offering. Execution excellence—that is, efficient development and speedy production—is crucial for these players. Other companies in this category include Monolithic Power Systems, Richtek Technology, MStar Semiconductor, and RDA Microelectronics.

With the ongoing commoditization of manufacturing services and better access to leading-edge intellectual property, the fabless industry will profit from its focused business system. We expect these players to dominate more and more successful applications, especially in consumer electronics and some areas of IT. IDMs and even established microcontroller and microprocessor players will continue to cede ground to fabless competitors. The compound annual growth rate of the fabless segment, which currently outperforms the overall semiconductor industry by more than 5 percentage points a year, seems sustainable over the longer term.

A more interesting model that may be reemerging is that of the integrated original-equipment manufacturer (OEM). In the past 30 years, many OEMs, such as Motorola and Hewlett-Packard, divested their semiconductor arms due to the high capital intensity of these businesses and the need for scale. Today, a new generation of OEMs that are tied neither to in-house process technologies nor to software development are taking more ownership of integrated-circuit design. Apple and Google may indicate the emergence of a larger trend, in which we see that the intellectual property for functional design may not belong fully to the chip maker but to a new kind of integrated OEM. With valuable functional designs in hand, such players may in-source or outsource chip design based on cost. Companies such as Apple and Google have sufficient scale and capability to become fabless for both the box and the chips. Because these OEMs tend to be market leaders, they can compete with innovator and fast-follower companies for share in the overall profit pool. Of course, OEMs without the scale or skills will continue to rely on mature-market attackers to sustain their businesses.

Front-end manufacturing: What are the limits of vertical disintegration?

Over the past several years, many semiconductor companies have decided to go “fab lite,” or step out of some aspects of the capital-intensive, leading-edge front-end technology-development and fabrication part of the value chain. Nearly all IDMs have outsourced some of their production to foundries. Even the Japanese, who are known for their reluctance to give up in-house capabilities, are going asset light, at least in part. Examples include Fujitsu, Renesas Electronics, and Toshiba. As a result, the foundry business has surged over the last decade, outperforming IDMs by an average of about 5 percentage points each year (Exhibit 2).

In the longer term, the foundry business has evolved over the last 20 years. Although it earlier competed on factor cost advantages, productivity gains, and operational excellence, it now depends on true technology leadership, scale advantages, and a superior ecosystem for product design. Modern foundries can provide every type of support: for example, developing intellectual property, offering photomasks, and offering access to networks of third-party design centers. Services even include competence in testing and packaging. More recently, foundries have started to offer 3D expertise, interposers, and back-end integration as a means of differentiating themselves from competitors.

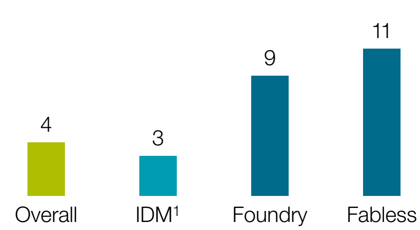
As noted above, in the early days, the foundry model generated profits primarily through low costs. Analysis of manufacturing costs that pitted European IDMs against Taiwanese foundries in the 1990s indicated that the cost advantages of the foundries were close to 50 percent. By the mid-2000s, leading foundries' process technology reached parity with other leading-edge players in standard complementary-metal-oxide-semiconductor (CMOS) technologies. By the end of the 2000s, foundries became the core of new technology clusters. They no longer had to compete on price.

Despite the fanfare, foundry volumes occupy only 20 percent of current manufacturing capacity

Exhibit 2

Fabless and foundry businesses have grown above the industry average, whereas IDMs have grown below it.

Revenue growth by value-chain slices,
% compound annual growth rate, 2005–10

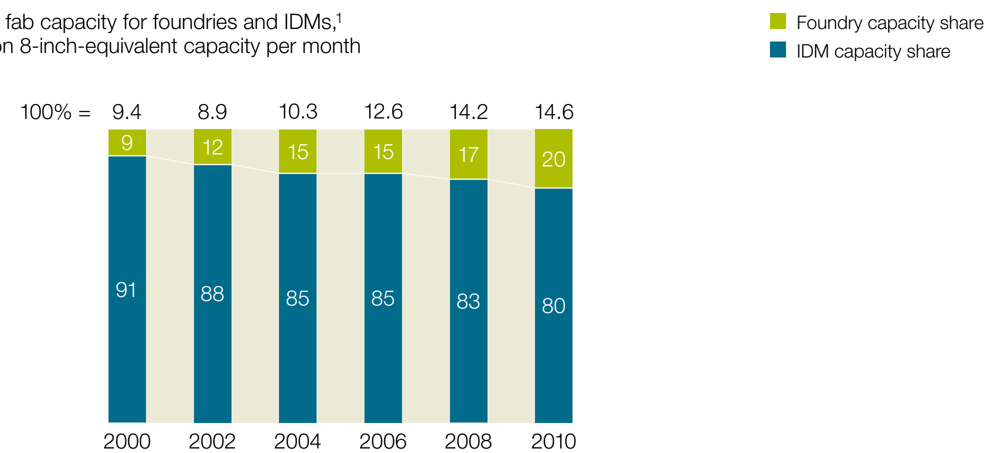


[1] Integrated device manufacturer.
Source: iSuppli; IC Insights; Gartner

Exhibit 3

Despite early fanfare, foundry volumes remain low relative to IDMs.

Semiconductor fab capacity for foundries and IDMs,[1]
%, total in million 8-inch-equivalent capacity per month



[1] Integrated device manufacturers.
Source: iSuppli, Q4 2010; World Semiconductor Trade Statistics, Q4 2010; McKinsey analysis

(Exhibit 3). With the expertise that many foundries currently possess, when will this business model truly take off? The reality is that there probably will not be any great jump in market share.

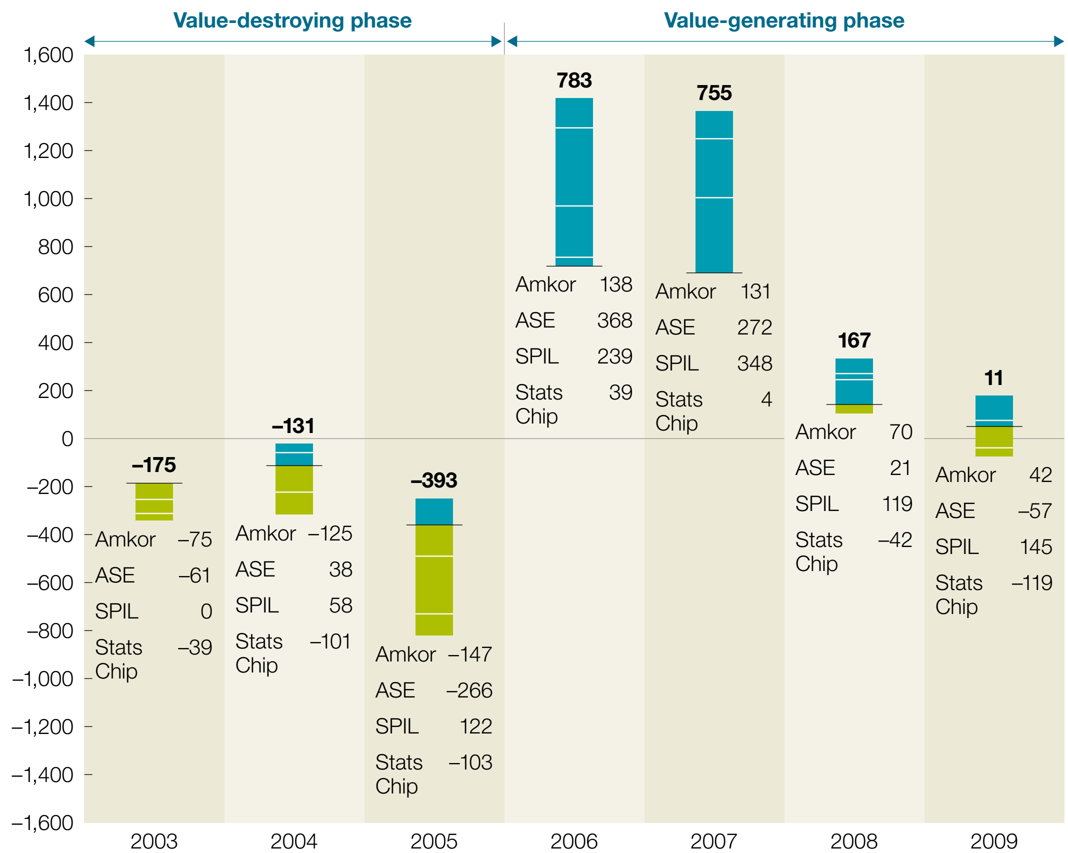
Growth in the foundry business has rested on three pillars: first, leading-edge fabless companies such as Qualcomm and Nvidia rely on foundries to produce their designs, including hot products such as application-specific integrated circuits (ASICs) and application-specific standard products (ASSPs), all of which are sold into the global semiconductor market. A second pillar of growth has come as a result of IDMs looking to go fab lite; examples include NXP, Texas Instruments, Freescale, Fujitsu, and Renesas. The third growth driver has been increasing share among existing customers due to foundries' ability to produce chips for cutting-edge and trailing products at a lower cost.

In our market model, we expect most new ASIC or ASSP capacity to be built within the foundry ecosystem. In addition, all the new leading-edge capacity for nonmemory applications will end up at foundries or Intel. Nevertheless, we assume it will be difficult for foundries to gain share at the lagging edge of the chip market because IDMs are producing them based on sunk-cost economic models. It will be equally challenging for them to move in on the specialty technology businesses of IDMs, which also thrive due to depreciated assets (and which display relatively low portability across fabs precisely because of the level of specialization in these products). Given these assumptions, the slowdown of Moore's Law node migration and the fact that most IDMs have already turned asset light will impede foundry growth. In total, we expect the segment to grow 5 to 10 percent a year, rather than the 10 to 15 percent it grew in years past.

Exhibit 4

Four leading OSAT players adjusted their business models and are generating economic profits.

Economic-profit generation[1] for the top 4 OSAT[2] players, $ billion



[1]Calculated as (return on invested capital – weighted average cost of capital) × invested capital.
[2]Outsourced semiconductor assembly and test; the 4 players referenced in the chart are Amkor Technology (Amkor), STATS ChipPAC (Stats Chip), Siliconware Precision Industries Co. Ltd. (SPIL), and ASE Global (ASE).

Source: McKinsey Corporate Performance Analysis Tool

While foundry demand may be growing less quickly, a great deal of capacity is coming online. As a consequence, we expect leading foundry players such as TSMC, Samsung, Global Foundries, and United Microelectronics Corporation to compete for customers more aggressively than they have in the past, as capital expenditure and process-technology development costs skyrocket. Second-tier players from China and Malaysia will also try to operate at capacity. In addition, Japanese IDMs might give away surplus capacity to potential customers at “cash cost,” hurting the foundries’ price points. All in all, price competition in this sector will likely intensify.

More recently, the earthquake and tsunami in Japan brought the need for supply-chain diversification to the forefront. Specialization and geographic concentration, which helped drive success in foundries in the past, are now becoming risks. Will foundry companies be able to provide risk diversification from natural or man-made disasters? Will OEMs be willing to bear the infrastructure costs associated with having multiple suppliers on fragmented campuses manufacturing interchangeable and commoditized technologies? The answers to these questions are unclear at this time. However, continued business-model innovation is needed to enable multisourcing with minimal cost impact, if not further cost reduction. If this evolution can be achieved, it will likely drive continued disintegration in the semiconductor value chain.

All in all, it does not look as if the foundries' current 20 percent market share will grow appreciably anytime soon. Indeed, in addition to interfoundry competition, these players are quite likely to face competition from other players along the value chain such as Intel and Samsung.

Given these facts, and the implications of deceleration with regard to Moore's Law, how will foundries capture a fair, if not disproportionate, share of the profit pool? From the other side, how will customers capture more value from the foundries? Naturally, the big foundries would favor fewer foundry players. At the same time, OEMs, IDMs, and fabless players would prefer to have multiple leading-edge foundries. Investment for capacity, partnerships, alliances, and distribution of orders across foundries over the next three to five years will be crucial in determining the competitive dynamics of the industry.

Back-end manufacturing:

The race for miniaturization brings success to OSAT players

Chip packaging has shifted to an outsourcing model more quickly and more extensively than front-end processes have. In fact, many expect that the outsourced share of this segment could reach 50 percent of the market by 2013.

In the not-too-distant past, outsourced semiconductor assembly and test (OSAT) companies were regarded as low-end, commoditized service businesses, and the competitive dynamics of the business were driven by price competition. This had a negative impact on the economics of the industry. Between 1996 and 2006, the sector, cumulatively, delivered no significant economic profit. However, the same analysis for the past three years shows a very different result (Exhibit 4). Part of the OSAT industry has undergone a transformation, and there are now two profitable subsegments: the very profitable high-end players and the less successful mainstream OSAT players.

As the pace of innovation slows in the front-end segment of the semiconductor market, the pressure on back-end companies is increasing; these players are expected to offer sophistication and technical differentiation in a bid to increase chip performance. Technological differentiation will continue to drive the two-tier market structure: there will be oligopolistic high-end players and commoditized mainstream players. The OSAT industry can stay profitable at the high end as long as the top players have the technical skills required to differentiate the degree to which the chips they receive from foundries can be tuned to the needs of different products—and if they are able to avoid price wars.

Four leading OSAT players have redefined their businesses models successfully and are generating economic profits. Amkor Technology, STATS ChipPAC, Siliconware Precision Industries Co. Ltd., and ASE Global are the four high-end OSAT companies, and each has significantly improved its profitability since 2006, leaving aside some turmoil caused by the Lehman Brothers collapse and resulting economic downturn.

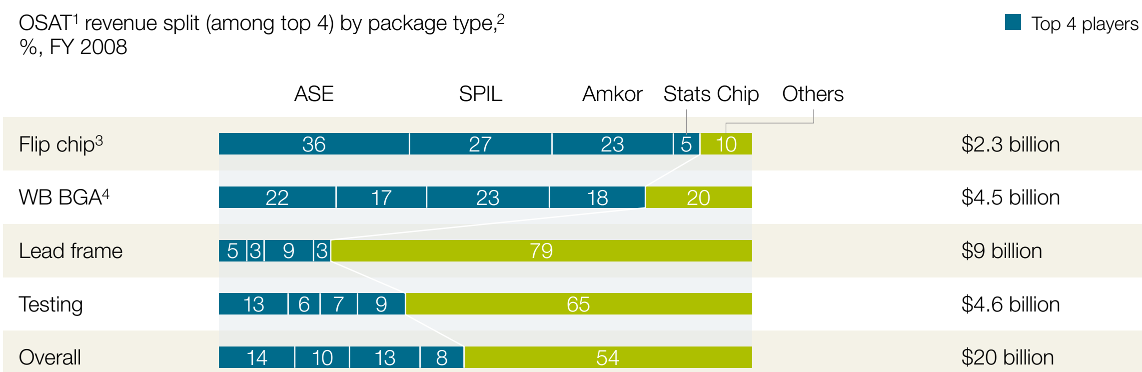
These companies successfully migrated from value destruction to value creation by focusing on improved capital productivity through careful management of investments and by introducing more sophisticated pricing models. Furthermore, they invested in advanced packaging technologies and improved miniaturization technologies, such as ball grid array (BGA) and flip-chip BGA, and shifted their product portfolio to those categories. The top four OSAT companies account for 80 to 90 percent of all outsourced substrate-based packaging services (Exhibit 5). On the other hand, lead-frame packaging services have become essentially a commoditized market. Technology-based differentiation allows certain players to access more specialized markets. In those narrower niches, pricing pressures are much lower than they are in the more commoditized packaging segments. Companies thus want to be in the substrate rather than the lead-frame packaging-services game.

These four companies avoided the vicious price competition of the early 2000s, and they also improved their cost position, reducing capital expenditure by planning capacity more carefully and by avoiding unnecessary capacity buildup. One way they have done this is by maintaining leadership in technology,

Exhibit 5

Revenues can be broken down by package type.

OSAT[1] revenue split (among top 4) by package type,[2]
%, FY 2008



[1]Outsourced semiconductor assembly and test; the 4 players referenced in the chart are Amkor Technology (Amkor), STATS ChipPAC (Stats Chip), Siliconware Precision Industries Co. Ltd. (SPIL), and ASE Global (ASE).
[2]Figures may not add up to 100% because of rounding.
[3]Includes bumping.
[4]Wire-bonded ball grid array.

Source: Company filings; expert interviews; McKinsey analysis which has allowed them to establish equipment-consignment agreements with key accounts, thus avoiding overproduction and reducing the need for capital investment.

As the technology race shifts to OSAT players, the industry will find itself at a turning point. For the leading high-end OSAT players, the lifeline has been the industry's increasing need to package smaller, advanced-node chips. Will those leading-edge players be able to break away and maintain a comfortable and profitable oligopoly? Or will mainstream players also enter the advanced-packaging technology race, creating price competition that will likely take value away from the current players in the OSAT sector? The deciding factor may be the advantage that accrues to companies that lock in the limited external resources that allow them to maintain differentiability or to play catch-up. Those limited resources might include capital investment from leading-edge foundries seeking to provide integrated solutions, or the advanced-packaging technologies held by players in high-cost countries, such as the Japanese IDMs.

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The deceleration in progress along Moore's Law has changed the rules—from a strong and almost sole focus on process-technology development to a more diverse set of success factors, such as additional value-added services, operational performance and responsiveness, intellectual property, and cost management. This industry, which had represented the essence of advanced technology, is becoming more commoditized, and competition within any given slice of the semiconductor value chain will continue to escalate in the years ahead. The competitive arsenal is expanding to include a number of management skills—such as strategies for mergers and acquisitions—that will help companies battle other players' strengths, securing intellectual property and locking in market share. Operational excellence is yet another imperative. Those that can get the mix right and adjust their business models to the changing landscape will be well positioned to break the boom-and-bust cycle and generate strong economic profits in the years to come. ○

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