

SHIFTING SANDS

NEW CHALLENGES IN SEMICONDUCTORS

By Philipp Jung and Guy Gilliland

As we have argued elsewhere, the rise of the post-PC era is ushering in a period of profound change throughout the technology industry. Semiconductors have enabled many of the changes taking place: the “consumerization” of technology, the rise of mobile ecosystems, and the paradigm shift from power to portability in computing and connectivity. Now the semiconductor sector itself is being reshaped by new technology ecosystems and changing consumer and enterprise needs. Companies at every stage of the value chain need to rethink how they compete and create value going forward. This article, the first in a series on the challenges facing semiconductor companies, examines the structural trends in the sector and their impact on the opportunities for value creation in the coming years.

THE SEMICONDUCTOR SECTOR IS entering what we believe will be a seminal transition period. The historical determinants of success have included scale, the skill to manage market volatility, and the ability to innovate at the speed of Moore’s Law. These will continue to be significant factors going forward, but new

determinants are moving fast to the fore. Among other things, these include the ability of companies to meet the demands of the growing mobile-device market by shifting from improving speed and processing power to reducing power consumption. Companies must also design and manufacture for a fragmenting universe of products and devices that often have shorter product life cycles. In addition, providing support for integrated and advanced graphics is increasingly important.

The semiconductor sector is far from monolithic; trends vary across its complex value chain. Still, companies’ attempts to meet the sector’s challenges could cause technological prowess and market share to concentrate among a handful of the largest players, intensifying competitive pressure on smaller companies. Factors such as innovation and technological development, manufacturing efficiency, and effective pricing, as well as having a sizable footprint in Asia, will become increasingly important to competitive dynamics. The sector may undergo a wave of consolidation as compa-

nies seek to maintain or increase their economies of scale through mergers, acquisitions, alliances, and joint ventures.

Value: Past and Future

According to Gartner, the semiconductor market will continue to experience above-average growth of about 6 percent a year, reaching approximately \$500 billion in 2016. This rate is about twice that of world GDP growth and on par with other technology sectors, such as software and services and telecommunications. Growth in semiconductors will be driven by the proliferation of smart devices, the automation of everything from automobiles to zoos, and the need to process and store an explosion of data.

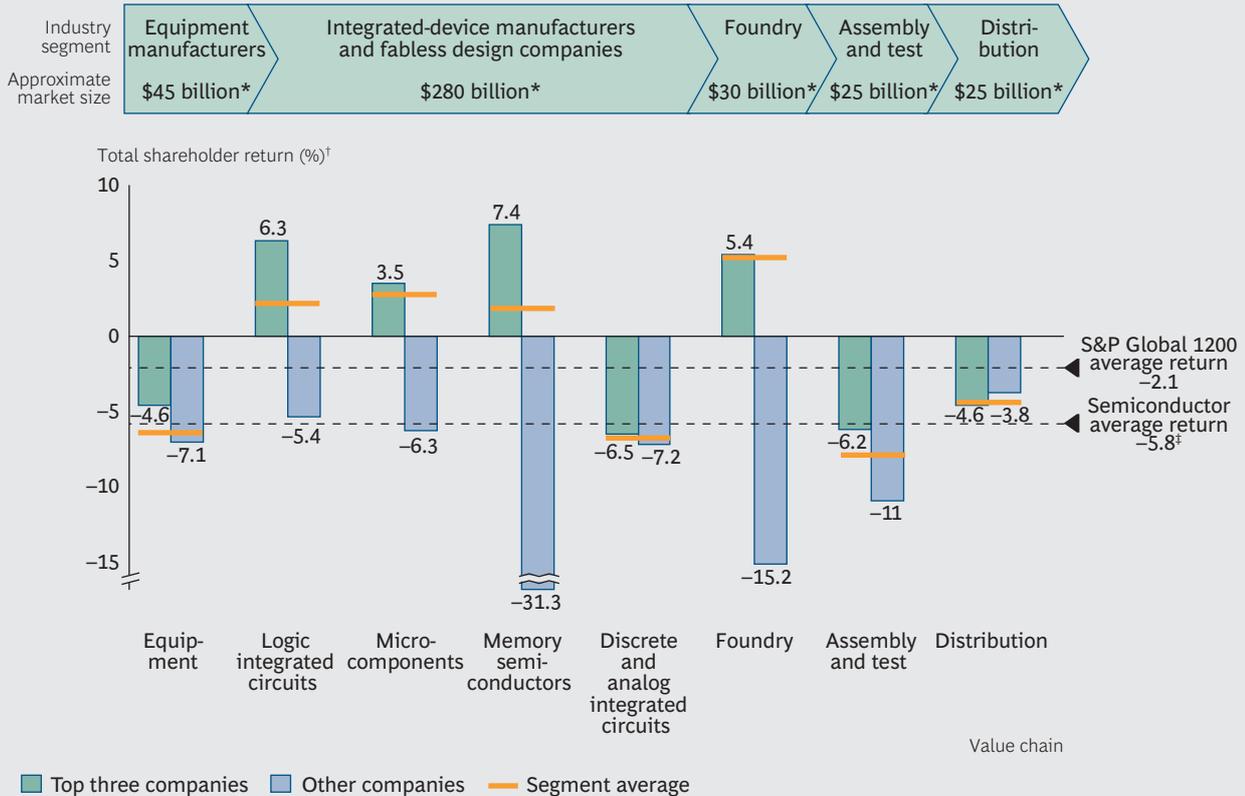
In this sense, the outlook is auspicious. But it is worth bearing in mind three factors.

The first is that the semiconductor sector historically has experienced extended periods of growth interrupted by sharp downturns that last 12 to 18 months. As a result, the sector has suffered from revenue and earnings volatility, and companies have had varied success returning value to shareholders.

The second and more significant factor is that not all companies have had sufficient scale to create value for shareholders. In the past, it has generally been the biggest players that have succeeded, although some companies—such as Qualcomm and ARM—have developed new business models and approaches to scale, also creating value. Most of the rest have underperformed. (See Exhibit 1.)

The third factor is that Moore’s Law is increasingly straining balance sheets and

EXHIBIT 1 | Top Three Companies in Each Segment Have Generally Outperformed Smaller Players



Sources: Capital IQ; Gartner; BCG ValueScience Center; BCG analysis.

Note: The segment average is weighted by 2006’s year-end market capitalization.

*Market size for 2011, as measured by Gartner.

†Five-year weighted average by market capitalization. Total shareholder returns from June 2007 through June 2012.

‡Semiconductor average return includes approximately 240 public semiconductor companies, some of which have meaningful revenues in multiple segments.

income statements and affecting the ability of companies to play in multiple markets. The physical constraints of silicon real estate and the sheer cost of increasingly sophisticated R&D are threatening the financial viability of continued investment.

To create value going forward, companies must, as they have in the past, have the ability to manage volatility and address issues of scale. However, they must also determine whether and how to pursue Moore's Law and how to differentiate their products to meet new market demands. At the same time, companies will face other challenges from a handful of big and far-reaching trends that are converging now.

Evolving Sources of Demand and Shorter Life Cycles. The semiconductor value chain has always been complex and fragmented. (See Exhibit 2.) Now, it is in significant flux owing to broader market trends. Chief among them is an end-user customer base that is evolving from predominantly business users to consumers

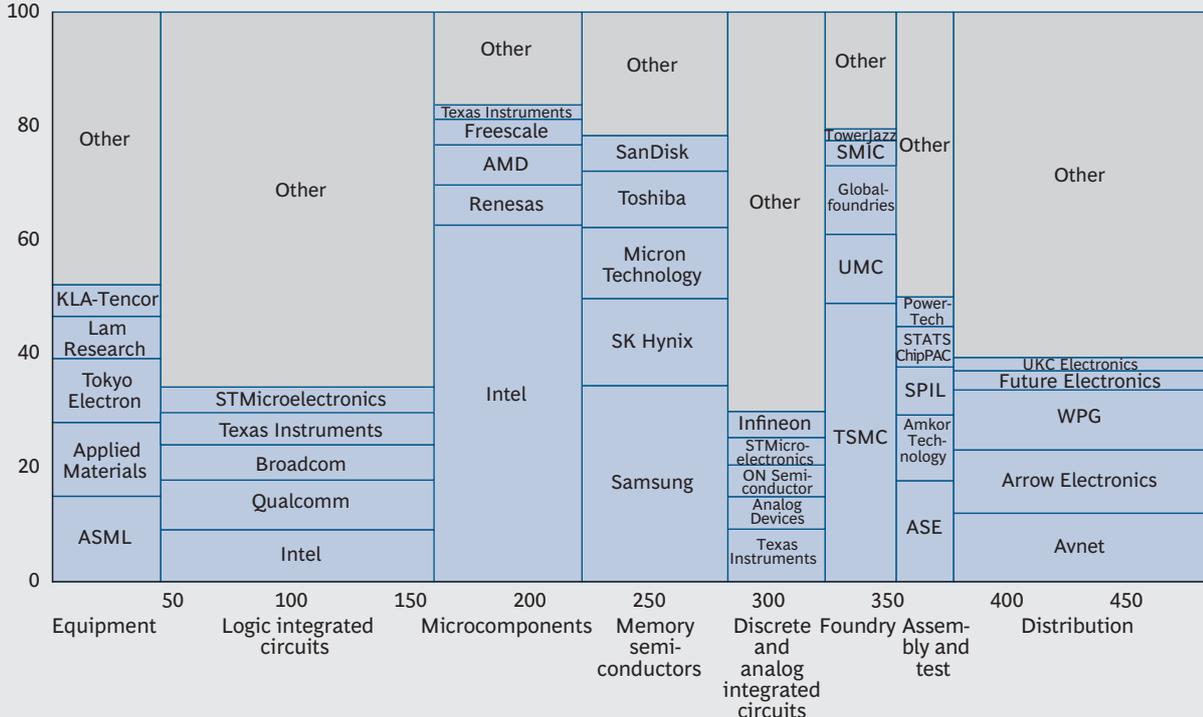
and that is buying an expanding variety of primarily mobile devices. According to iSuppli, for example, the number of smartphones shipped worldwide will exceed 1 billion in 2015, more than double the total number shipped in 2011.

Another significant trend is that more and more semiconductors are being used in a wider variety of devices and products. For example, Strategy Analytics expects the global automotive semiconductor market, worth \$23.7 billion in 2011, to grow at a rate of more than 9 percent per year through 2016. The market for purpose-built consumer devices is also rapidly expanding.

These evolving sources of demand are leading to continued growth in the sector, but they are also changing it. Consumer and customer requirements for continuous improvement and innovation have exerted pressure on semiconductor designers and manufacturers, particularly when it comes to producing chips that require less power.

EXHIBIT 2 | The Industry's Value Chain Is Complex and Fragmented

Market share, 2011 (%)



Sources: Gartner; BCG ValueScience Center; BCG analysis.
 Note: Value chain excludes the materials, optical, and sensor segments.

Revenues (\$billions)

At the same time, these requirements have led to shorter product life cycles, making the longevity of demand for any particular chip increasingly uncertain.

Such changes are calling long-standing business models into question.

Industry giants such as Intel and Samsung have built fortress-like positions through vertical integration, controlling all aspects of their design and manufacturing process. This model made sense when the largest customers for semiconductors were computer hardware manufacturers, which built PCs and laptops according to specifications that had evolved into industry standards, driving down costs dramatically. As PC and laptop growth slows, and the proliferation of mobile devices increases, the demand for a wider selection of chips with varying functionality is challenging large semiconductor companies to manage issues of step changes in manufacturing technology, product complexity, and manufacturing capacity utilization.

Although we do not expect the integrated model to disappear, it is coming under sustained attack from the fast-growing “fabless foundry” approach, which breaks down the design and manufacturing process and involves different companies concentrating on distinct functions or intellectual property blocks. Fabless designers (such as Avago Technologies, Broadcom, Marvell, MediaTek, Qualcomm, and Xilinx) and high-efficiency, low-cost foundries (such as Globalfoundries, Taiwan Semiconductor Manufacturing Company [TSMC], and United Microelectronics Corporation [UMC]) have staked out large and growing positions, attempting to flank their vertically-integrated competitors (such as Intel, Samsung, and Toshiba). The trend toward deconstruction is most pronounced in the digital segment, where product life cycles are short, capital requirements are high, and scale matters. Vertically integrated manufacturers remain especially strong in the analog segment, where product life cycles are significantly longer and proprietary manufacturing processes have been developed.

Regional Market Concentration. The semiconductor sector is global, with design and manufacturing taking place in multiple Asian, European, and North American locations. Nevertheless, in recent years, as more original-design manufacturers have opened facilities in Asia, so, too, have more chip makers, particularly those seeking skilled labor, low costs, and proximity to customers. As a result, Asia has become the largest regional market for semiconductors by a substantial margin, a position we expect it will continue to hold. Semiconductor companies without a significant presence in the region will find it increasingly difficult to compete. And equipment manufacturers will find themselves facing new low-cost competitors from the region.

A Focus on the User Experience. Since the PC was introduced, the high-tech industry has largely focused on chips—their speed and power. However, the technological and financial challenges of keeping pace with Moore’s Law have caused the industry to shift away from this obsession toward advancing the end-user experience. This has helped usher in the post-PC era.

Smartphones and especially tablets are the new focus of consumer demand. Gartner expects sales of tablets to reach 370 million units by 2016, a much faster ramp-up than any other consumer-electronics or mobile device. Intel’s announcement that year on year, its 2012 third-quarter revenue declined by \$700 million or 5 percent, which includes an 8 percent revenue drop in the company’s PC Client Group, is evidence of the move away from PCs to purpose-built devices.

With these new devices in hand, users are fast embracing digital ecosystems built around operating systems such as Apple’s iOS and Google’s Android. Although task-based applications, such as word processing, have been—and will continue to be—popular uses, these new ecosystems provide an enhanced and broader user experience. The applications that run in these environments are increasingly interactive and give users the ability to share information in real time. And the

devices that host them incorporate a wide variety of technologies that enable richer human-computer interfaces, such as voice and handwriting recognition. Companies such as Amazon.com, Apple, Baidu, Google, Microsoft, and Samsung are responding by creating and presiding over content- and capability-rich environments. As the ecosystems and applications continue to evolve, the devices that access them will need an ever-expanding variety of chips that can interface with software, supporting integrated solutions.

Increasing Pressure on Equipment

Manufacturers. Semiconductor equipment companies face particularly complex challenges as financial and technological constraints lead their customers to pursue different strategies. Some designers and manufacturers are pursuing new technologies, such as extreme ultraviolet (EUV) lithography, fin field-effect transistor or FinFET, and through-silicon via interposer. Others are reluctant to invest in new technologies and equipment absent widespread demand, which has failed to develop partly because their customers are doing more with existing technologies (adding multiple layers, for example) and partly because they doubt that new technologies can be delivered and scaled quickly enough in a world of shortening product life cycles. At the same time, equipment manufacturers continue to struggle with the highly volatile nature of the sector, with its large swings in revenues and, more important, margins, over time.

Changes and Challenges

Big structural changes often lead to shakeouts, especially in fragmented industries. Given the importance of scale and the essential benefits it conveys, we believe the semiconductor sector may be due for a period of consolidation. Size matters, but size alone will not guarantee success. Companies need to decide where and how to innovate and where to invest so they can continue to create value. The challenge going forward will be for semiconductor companies of all stripes to

develop business models that will help to:

- Meet the need for accelerated speed to market
- Fulfill the requirements of purpose-built devices
- Address issues of manufacturing scale and capacity utilization
- Function in an environment with increasing development and manufacturing costs
- Rise to the financial and technical challenges of continuing to pursue Moore's Law
- Pursue an active corporate-development and M&A agenda, including forming alliances and joint ventures, if necessary, to gain needed expertise, build R&D scale, or access capital

The companies that create value going forward will possess a wide variety of capabilities, several of which we plan to explore in future articles in this series. Some of these capabilities include:

- Working closely with customers that can help inform and drive product innovation, increasing the likelihood of success from development investments and from clearly differentiated products
- Effectively pricing products, a discipline long underappreciated among semiconductor companies
- Achieving manufacturing efficiency as the traditional value chain breaks down and new ones are formed around the foundry model
- Pursuing new and innovative manufacturing technologies in the face of a consolidating customer base—a strategic imperative for equipment manufacturers
- Funding continued innovation and finding new applications beyond mobile devices; new business models

will increase in importance as the relevance of the Wintel model declines in the face of post-PC ecosystems

- Realizing higher R&D productivity by making more deliberate bets and exploring new forms and models of collaboration, such as coinvesting to develop technologies
- Attracting the necessary talent to a mature sector and retaining it when competing with younger sectors, such as social media
- Building global organizations that align operations with customer needs—especially in Asia

Recent high-profile litigation has also led to a heightened focus on intellectual property rights as a critical competitive weapon. Technologically, financially, and competitively, semiconductors have always been a complex and challenging business. The sector's most challenging and rewarding days lie ahead.

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