

# SHIFTING SANDS

## THE FUTURE FOR SEMICONDUCTOR FOUNDRIES

By Enrique Duarte Melo and David Michael

*New dynamics are combining with historical determinants of success to reshape the semiconductor sector. The first article in our series on these “shifting sands” explored how the challenges of managing scale, dealing with market volatility, and innovating at the speed of Moore’s law increasingly share space on the strategic priority list with the demands of the growing mobile-device market, a fragmenting universe of devices with short life cycles, and new technologies to support sophisticated applications such as advanced graphics. Nowhere are these challenges coming together in a more concerted fashion than for foundries. The long-term revenue outlook is strong for foundry companies as a group. Individually, however, they face major shifts in both technology and marketplace demand, necessitating a comprehensive reexamination of strategies and business models if they are to perpetuate the same levels of growth that have propelled their rapid rise.*

**S**EMICONDUCTOR FOUNDRIES WERE BORN out of the need for the fast-growing semiconductor sector to construct and manage manufacturing capacity more

efficiently. Companies such as Taiwan Semiconductor Manufacturing Company (TSMC), Global Foundries, and UMC have grown into major players alongside integrated device manufacturers (IDMs) such as Intel, Samsung, and Texas Instruments (TI). As we move further into the post-PC era, however, foundries—as well as design companies and IDMs—face big changes and choices in how they do business. Major shifts in product mix, big technology challenges, and increasingly demanding economics will cause foundries to rethink their basic value proposition.

Foundries face broader strategic options and imperatives than ever before in terms of the products they manufacture and the technologies they employ. At the same time, the mushrooming cost of constructing new, advanced technology capacity heightens the financial pressure to make the right bets. Only the biggest companies, such as TSMC, will have the ability to serve a wide array of customer segments. For others, new capabilities, in addition to scale and utilization, will rise in impor-

tance, especially as large, deeply resourced competitors, such as Intel and Samsung, seek footholds in the foundry market. Intel, for example, has recently contracted to manufacture Altera's field-programmable gate array chips using its 14-nanometer tri-gate transistor technology. These dynamics have ramifications for the entire value chain, from design companies to original equipment manufacturers.

Foundries will have to develop the ability to assess end-user—often meaning consumer—demand and needs. Which products will generate new sources of revenue? Which technologies are the best fit? Which design customers and IDMs can a foundry best work with in order to meet this demand?

This is no small challenge. Big, integrated companies such as Intel and TI have very different strategies, priorities, and needs from those of younger designers such as Broadcom, Qualcomm, Marvell, and MediaTek. Companies that straddle much of the value chain, such as Apple and Samsung, have their own competitive dynamics. Working hand in glove with the right partners to establish a strategy and vision for the future will become critical in creating value for many foundries.

## From Standardization to Proliferation

As the PC era took off, rising demand for faster, more powerful computers and more and more memory put a premium on scale and high rates of capacity utilization in the chip-manufacturing process. PC architecture converged around a few design standards, and foundries enjoyed rapid and profitable growth as a result. In recent years, however, the sources of demand have proliferated to include sophisticated new consumer devices such as smartphones and tablets, as well as industrial applications such as embedded processors in automobiles. These devices and applications have different processor needs from those of PCs, a phenomenon that has resulted in the increased use of architectures such as ARM-based design. As a result, the device pie has

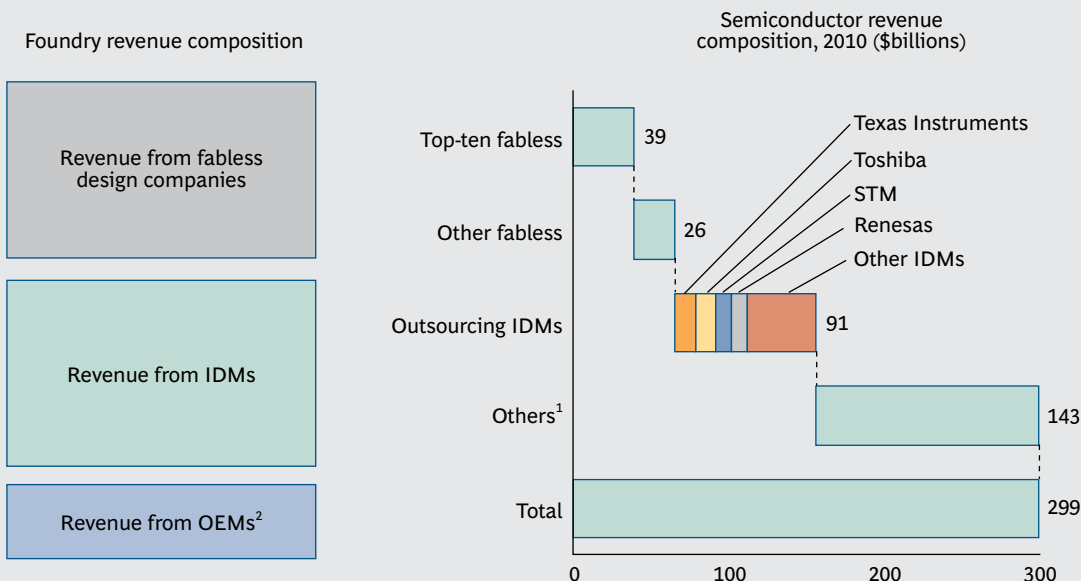
grown in size and has also been carved into a greater number of slices.

The long-term outlook remains strong, but it will continue to be fueled by varied forces: the explosion in digital devices with differing power consumption needs, the rising demand for low-cost systems and devices in emerging markets, the need to process ever more vast quantities of data, and the continuing penetration of semiconductors throughout other major sectors of the economy. Gartner projects the semiconductor market will grow at about 6 percent a year—approximately twice the rate of GDP growth—to more than \$400 billion in 2016. Demand at foundries will increase even faster. Revenues grew more than 7 percent from 2011 through 2012 and are expected to increase more than 7.5 percent in 2013 to some \$37 billion.

Fabless design companies, long the biggest customer segment, will drive some three-quarters of demand at foundries, but increased outsourcing at IDMs will also be responsible for a significant share. The top ten fabless design companies and the five largest outsourcing IDMs are expected to generate approximately half of foundry revenues. This customer concentration will become an increasingly important industry dynamic. (See the exhibit “Foundries Face a Significant Concentration of Revenues.”)

Managing scale and productivity and keeping pace with Moore's law are still key strategies for foundries. So, too, are meeting demand for a widening array of semiconductors with varying features and capabilities, such as sophisticated graphics and power management, and adapting to longer R&D timeframes and shorter product life cycles. The biggest driver of demand will be the exploding number, and changing nature, of digital devices. Computing and consumer electronics represent 60 percent of the end-user market for chips. Recent BCG research in the U.S. found that consumers today own an average of 2.9 digital devices (including computers, smartphones, and tablets), almost twice as many as three years ago, and they are likely to own 4.1 such devices in three years' time.

## Foundries Face a Significant Concentration of Revenues



Sources: Gartner; BCG analysis.

Note: IDMs = integrated device manufacturers; OEMs = original equipment manufacturers.

<sup>1</sup>Includes Intel (\$42 billion), memory companies (\$33 billion), IDMs that run foundry services (\$31 billion), and IDMs with minimal outsourcing (\$38 billion).

<sup>2</sup>Includes a small contribution to the foundry segment and is not a focus of this analysis.

## The Shifting Economics of Power

Technology issues and financial constraints complicate the strategic choices further.

The market continues to expect process technology advances (such as decreases in size from 45 nanometers to 32 nanometers to 22 nanometers and beyond) that simultaneously consume less power and provide increased performance. This puts a premium on precision tooling (particularly lithography) and yield optimization, which is leading to exponential growth in capital costs for advanced technology nodes.

Most companies cannot keep up with market leader Intel, which already has 22-nanometer chips in production and is working toward the production of 14-nanometer chips in the near future. Three of the next-largest players trail significantly. At the same time, the rising cost of investment in each new generation of technology makes it harder to create the necessary returns. In addition, while the market expects faster ramp-up cycles to meet the introduction of new products, the time from “tape out” to initial production for foundries expands with advanced nodes—from 12 months for 65 nanometers and 45

nanometers to an estimated 18 months for 28 nanometers and beyond.

The inevitable result is diminishing pay-back on ever-bigger investments—a difficult prescription for value creation. Foundries also face increasing complexity in design with the advent of 3-D integrated circuits and the transition to larger wafer diameters (from 200 millimeters to 300 and 450 millimeters). Several key technologies are approaching the limits that physics places on further advancement.

A new, big bottom line looms: as the amount of capital required to fund development of advanced nodes grows, only a few of the biggest players have the balance sheet capacity to lead in process development. Some current leaders soon will become followers, and companies used to winning on technological edge will need to look for new sources of competitive advantage.

## New Capabilities for an Evolving Marketplace

The net impact for just about all foundry companies will be the need to rethink

options and magnify bets. Not all foundries have evolved equally, of course. With 2012 revenues of \$16 billion, TSMC is the market leader by a considerable margin; the next two largest players, Global Foundries and UMC, and are about one-quarter its size. Each company has its own strengths in technology and manufacturing, but most do not have the resources to serve every design company or IDM or to develop the intellectual property necessary to meet the increasingly varied technological demands of a fragmenting market. They will have to make choices, based on their current market position, technological capabilities, financial strength, and customer relationships. Not the least of these decisions will be choosing where to commit constrained resources and how companies will position themselves for the future. For example, do they want to be technology leaders or to focus on niche segments? China's SMIC, for example, has decided to focus on second- and third-generation technology applications.

As this process plays out, design companies and IDMs will likely find themselves with fewer manufacturing partners from which to choose. They will be pushed toward working more closely with a few companies that can consistently meet their needs from a technology and capacity point of view. All players will need to think about new questions of strategy, competitive advantage, and operations.

Foundries need to decide—first, foremost, and quickly—which segments of the market they can most profitably serve. Their next challenge is to build close working relationships with those targeted customers. They need to gain an intimate understanding of their strategies and needs—and get embedded into each customer's product roadmap. They also need to determine where to place bets on technologies and how to build (or acquire) the capabilities required to serve the market segments that they target.

Developing a successful segmentation strategy requires an in-depth understand-

ing of customer needs, which include the following:

- Process technology needs (technology nodes and transistor characteristics such as gate materials)
- Intellectual property needs (such as specific input-output or I/O, physical design or PHY, and analog technologies)
- Markets served—such as logic, embedded software (including all its subcategories), and memory
- Business interface needs, including technical assistance with yield analysis and design impact, high-priority “hot lots” for rapid testing, volume of chips, cost pressure, geographic location needs, manufacturing diversity, pricing models, and investment needs
- A customer's propensity for outsourcing throughout the design and manufacturing process

In areas that lack scale or process technology leadership, foundries also need to determine if there is an opportunity to serve as a second source of supply. This raises a different series of challenges, including organizing to perform at similar levels of service as the primary supplier, managing functions such as inventory and variation in manufacturing volume, maximizing facility utilization, and pricing.

Design companies need to consider their options as well. They'll need a foundry strategy that can deliver the technology base, product capability, investment capacity, volume capacity, flexibility, and pricing they require. One big question is whether a sole supplier will be adequate (and advantageous) or if the design company can generate sufficient volume to benefit from a second source. In addition to competition, of course, secondary suppliers can provide potentially useful geographic or product fits as well as insurance against difficulties for, or interruptions from, the primary supplier.

In structuring their supplier relationships, design companies will also need to carefully consider goals and objectives—for example, whether they are looking to eliminate fixed costs and move to a more variable cost structure, to free up their balance sheets, to focus on innovation rather than utilization, and so forth. Contracts need to align with these objectives, and pricing will inevitably be a key consideration. Does the design company pay per wafer, die, premium die, yield, or on some other basis? Design companies should motivate foundry partners to get embedded in their product and technology roadmaps, which is something, as already noted, that foundries will be looking to do. Both sides will have to address tough financial questions such as who pays for inventory during a market downturn. There should be adequate incentives on both sides to develop close, integrated relationships that can facilitate getting up

the yield curve quickly, speeding time to market, and lowering development costs.

**T**HE FABLESS FOUNDRY model has served semiconductor customers and investors well for almost three decades—a near-eternity in the technology sector. Continuing to create value will be a more complex challenge as structural changes in the market combined with the cost and technological challenges of ongoing advances bring new pressures on foundries and design companies alike. We believe the foundry model can continue to produce significant value, but doing so will require finding new sources of competitive advantage for a changed environment. The need to place costly bets makes it all the more essential for foundries to work even more closely with their customers in meeting the needs of a rapidly segmenting, increasingly complex market.

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