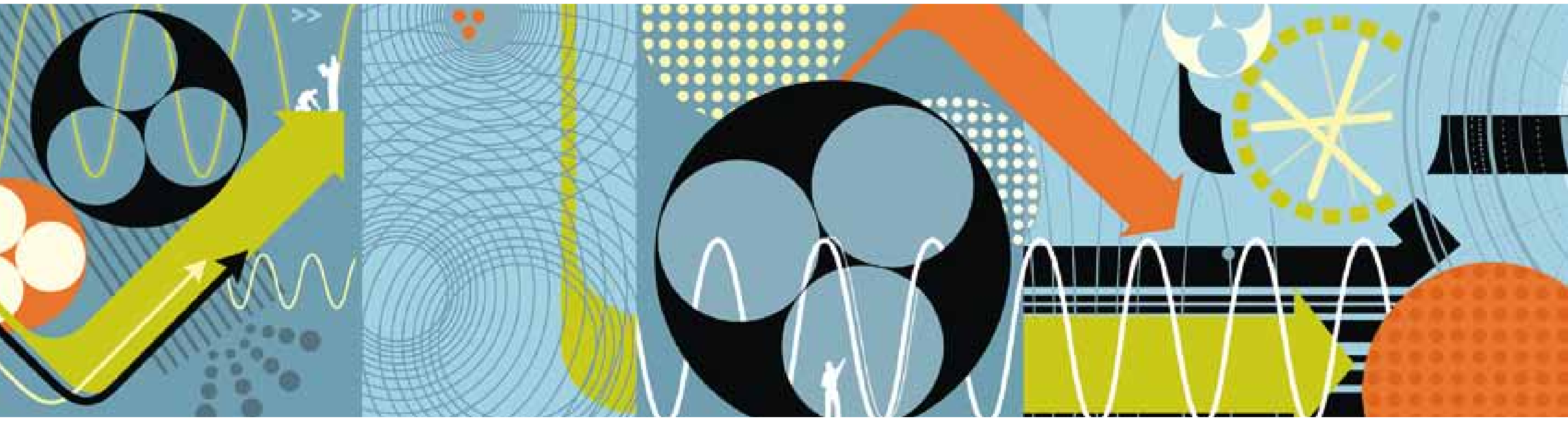


Will analog be as good tomorrow as it was yesterday?

Many worry that 300mm manufacturing capacity will destabilize pricing across the analog semiconductor market. We argue that only a few segments have reason to be concerned.

Abhijit Mahindroo, David Rosensweig, and Bill Wiseman

Within the semiconductor industry, the analog segment has been remarkably profitable and stable in recent years, largely free from the punishing investment demands of Moore's Law that have beset its digital counterpart. Consider the following aspects of analog's recent performance.

Strong growth. Analysts project that the analog segment will grow twice as fast as the overall semiconductor market during the 2010–14 period (8.8 percent versus 4.3 percent compound annual growth rate[1]), primarily because of expected rapid growth in consumer and enterprise wireless devices. Already, the value of analog and mixed-signal content in the Apple iPhone 4 is 50 percent higher than that of the logic content.[2]

Healthy margins. Analog players exhibit gross margins of 40 to 70 percent—generally higher than margins obtained in the digital segment. The higher numbers are possible primarily because lower levels of capital expenditure are required. Other than the microprocessor segment, which is a duopoly, the analog segment has historically created the most value in the semiconductor industry when measured according to economic profit.[3]

Room to play. The heterogeneity of products, process technologies, and applications creates opportunities for various companies and prevents an oligopoly from forming. In 2009, the top 10 players had approximately 50 percent

[1] iSuppli AMFT 3Q 2010.
[2] Logic includes microprocessor, microcontroller, digital-signal processors, and general-purpose logic. iSuppli teardown of the iPhone 4, available at http://www.isuppli.com/Teardowns/News/Pages/iPhone-4-Carries-Bill-of-Materials-of-187-51-According-to-iSuppli.aspx.
[3] Defined as the profit generated over a company's cost of capital, that is, [NOPLAT / (WACC x invested capital)].

market share in the analog segment, compared with 80 percent share for the top 10 in logic and 90 percent in memory.

Stability. Market share for most analog players has remained relatively constant over the last decade. Analog design is an art as much as a science. Design talent remains a barrier to entry, as it takes 5 to 10 years to train strong designers.

The 300mm challenge

The most significant development within the industry over the past 18 months has been the move of several industry players to establish fabrication capacity for 300mm wafers. This development has proceeded from an understanding that a successful transition from 200mm to 300mm wafers could lead to a 20 to 30 percent reduction in front-end-manufacturing costs for analog and mixed-signal products, resulting in a 10 to 15 percent reduction in per-unit die costs. Many are now asking whether the development of 300mm capacity will alter the stability that analog has enjoyed, by triggering a new wave of capital investment as players seek to remain cost competitive. In our view, the effects of the transition to 300mm will be real, but they will be confined to selected segments and not affect the analog industry overall.

In late 2009, Texas Instruments (TI) announced the $172.5 million purchase from bankrupt DRAM-maker Qimonda AG of 300mm tools capable of producing approximately 20,000 12-inch wafer starts per month (WSPM). Once its bid gained approval, TI shipped these tools to its facility in Richardson, Texas, known as “RFAB,” targeting the manufacture of high-volume analog products. At approximately $550 million for 20,000 WSPM capacity, TI paid roughly 35 percent of greenfield costs (assuming greenfield costs of $80 million per 1,000 12-inch WSPM capacity). This is consistent with TI’s own statement that it expects RFAB to break even at 30 to 35 percent utilization.

A little over a year later, in mid-2010, TI acquired two fabs from bankrupt NOR-flash manufacturer Spansion in Aizu-Wakamatsu, Japan. One of these was a 300mm facility, from which TI shipped additional tools to RFAB.

Around the same time, in the summer of 2010, Maxim entered into a 300mm foundry alliance with Taiwan’s Powerchip Semiconductor Corporation. Maxim qualified a 180nm Bipolar-CMOS-DMOS process, used in power-management chips, in Powerchip’s 300mm fabrication facility and began shipping product in November 2010.

The advantages and limits of 300mm

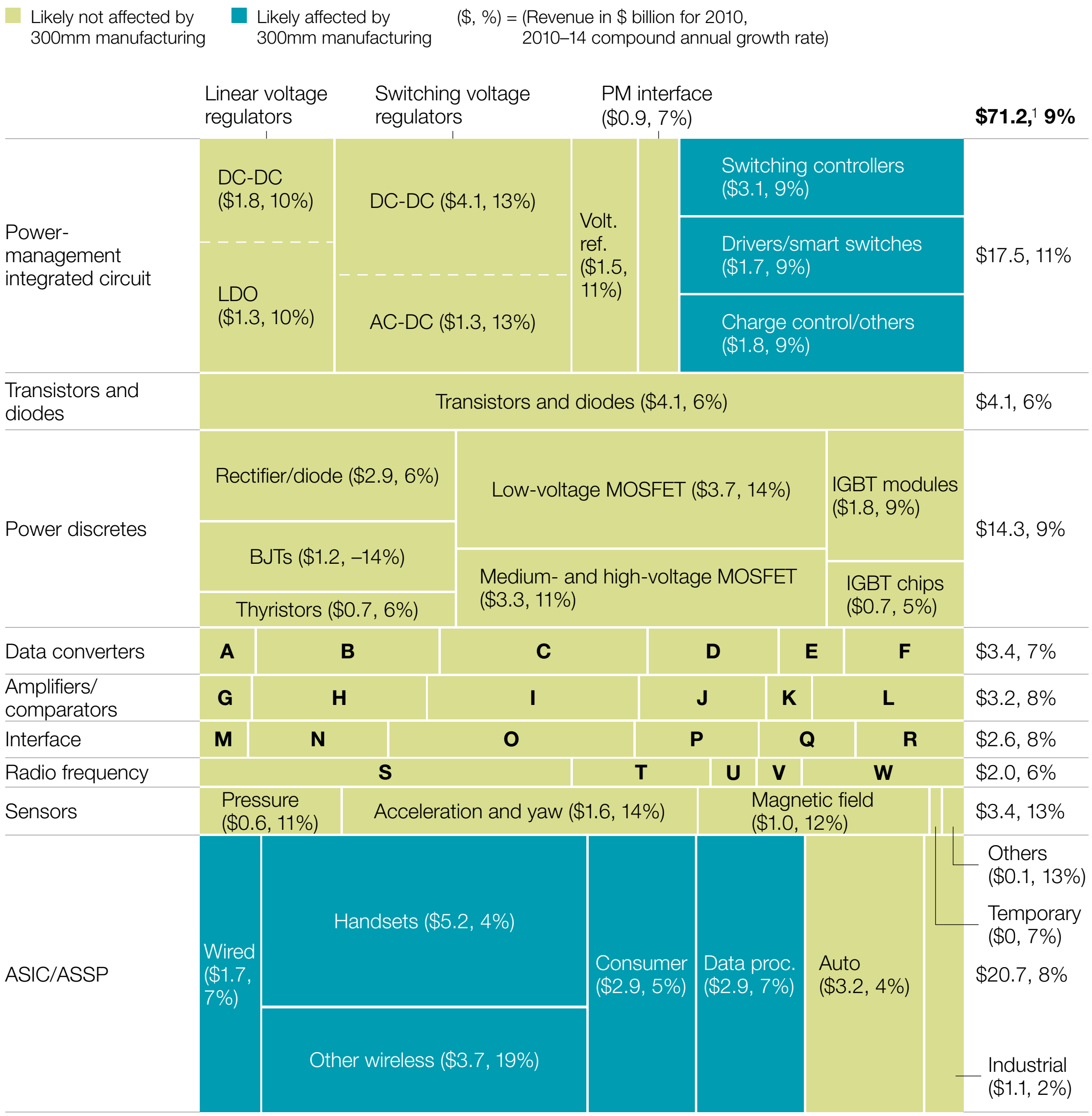
Advantages

Many are concerned that 300mm manufacturing in analog portends a costly and value-destroying cycle of large investments that the memory, microprocessor, and logic segments have already endured. Some players certainly have reason to watch these developments closely. As illustrated in Exhibit 1, the transition to 300mm manufacturing is most economical for high-volume products (such as analog application-specific standard products, power-management chips, and so on), which have sufficient revenue per stock-keeping unit to justify the nonrecurring engineering costs associated with requalifying the process on 300mm wafers.

The high volume requirement follows from the large number of die per wafer in 300mm manufacturing. For example, on a 250nm BiCMOS process (typically used for analog amplifiers)

Exhibit 1

The transition to 300mm manufacturing is most economical for high-volume products.



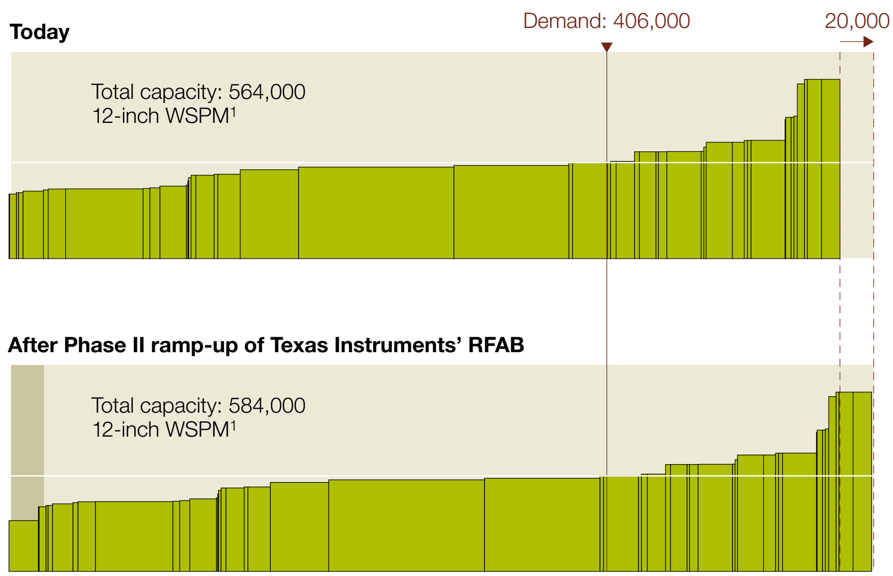
	Wired	Wireless	Consumer	Data proc.	Auto	Industrial
Data converters	**A** ($0.2, 3%)	**B** ($0.8, 15%)	**C** ($0.9, 3%)	**D** ($0.6, 4%)	**E** ($0.3, 5%)	**F** ($0.5, 7%)
Amplifiers/comparators	**G** ($0.2, 10%)	**H** ($0.7, 19%)	**I** ($0.9, 3%)	**J** ($0.5, 4%)	**K** ($0.2, 5%)	**L** ($0.7, 5%)
Interface	**M** ($0.2, 7%)	**N** ($0.5, 21%)	**O** ($0.8, 4%)	**P** ($0.4, 3%)	**Q** ($0.3, 3%)	**R** ($0.4, 7%)
Radio frequency		**S** ($1.0, 10%)	**T** ($0.4, 2%)	**U** ($0.1, –1%)	**V** ($0.1, 3%)	**W** ($0.4, 2%)

[1]Total may not sum due to rounding.

Source: iSuppli, 2010; McKinsey AMS database, 2008; *O-S-D report*, IC Insights, 2010; Gartner, 2010

Exhibit 2

The 2009 capacity cost curve for RFAB's relevant analog market shows that the increase in supply would not fundamentally alter pricing.



[1]Wafer starts per month.

Source: iSuppli Competitive Landscaping Tool 2010; SEMI World Fab Watch, May 2010; literature search; McKinsey analysis

used to manufacture a 4mm x 4mm die, a batch of 25 300mm wafers translates into 100,000 die, versus approximately 45,000 die for the same number of 200mm wafers. This factor increases further if 300mm manufacturing results in lower node width, which decreases die size.

The consumer and wireless segments are particularly attractive for 300mm manufacturing, since these segments traditionally have thinner margins due to higher competitive intensity and often use digital techniques to implement analog features, enabling these products to benefit substantially from the cost reductions that a transition to 300mm (and the node reduction that typically accompanies this transition) provides.

Limits

Industry segments or products outside these areas, however, are not likely to be significantly affected by 300mm manufacturing. Exhibit 1 shows that 300mm manufacturing could affect approximately one-third of the total analog and mixed-signal semiconductor revenue pool: in 2010 the potentially affected segments accounted for $22 billion of the $71 billion total. Furthermore, the existing 300mm players are not expected to fully exploit this potential anytime soon. Even after complete fitting out, TI's RFAB could drive approximately $3 billion in revenue—that is, less than 15 percent of the revenue for segments potentially affected by the shift to 300mm. Maxim is a significantly smaller player in this area.

A number of factors come into play that will define the limits of the transition to 300mm.

- First, at 20,000 WSPM capacity, RFAB will represent only 4 percent additional capacity in the high-volume analog market during the first phase of its ramp-up. The cost curve in Exhibit 2 suggests that a 4 percent increase in supply would not be enough in the near term to alter market pricing fundamentally across the potentially affected segments. Once RFAB is operating at full capacity, it will eventually be able to account for approximately 15 percent of overall capacity.

- Second, TI itself is not yet committed to a complete transition to 300mm manufacturing. Among the two fabs purchased from Spansion in mid-2010 is one 200mm facility that TI plans to continue running at 0.3 micron for high-performance products (such as data converters and power amplifiers).[4] In addition, in early 2010, TI agreed to acquire rival National Semiconductor in a $6.5 billion all-cash deal; 90 percent of National's product mix is high-performance 200mm analog chips.

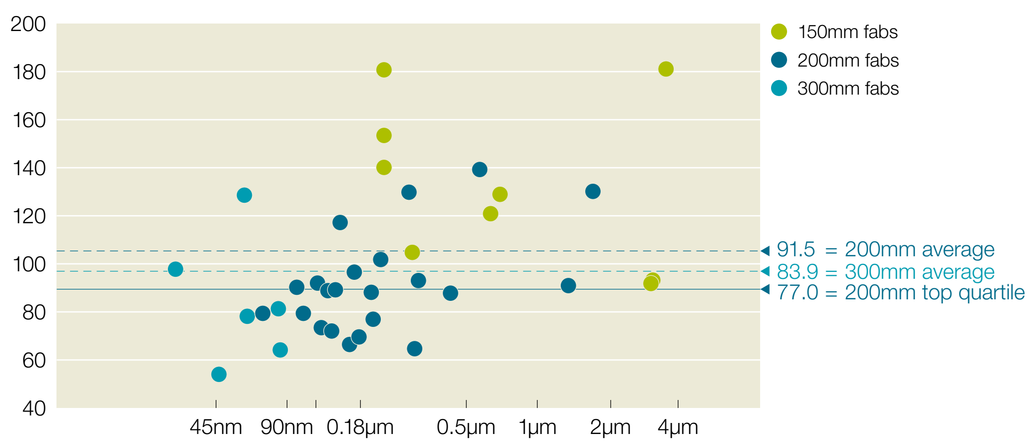
- Third, while larger-diameter wafers are typically more cost effective, individual fab performance matters. Exhibit 3 presents our analysis of cash costs per layer, revealing that while the best-performing 200mm fabs outperform 150mm fabs, 150mm fabs outperform the worst-performing 200mm fabs. We expect that a similar dispersion will emerge between 300mm and 200mm fabs, with the best 200mm fabs outperforming the less efficient among 300mm fabs.

[4] http://www.eetimes.com/electronics-news/4204587/TI-buys-two-fabs-from-Spansion-Japan.

Exhibit 3

An analysis of cash costs for a range of fabs demonstrates that individual fab performance matters.

Cash cost per layer,
index 100 = mean cost per layer (8")



Average line width,
log (line width, 10)

- Finally, improvements in wafer-manufacturing costs have a smaller impact on the gross margin of analog than of logic products. To begin with, as noted, analog products typically enjoy higher gross margins than memory and logic products. Analog products also have higher back-end costs as a proportion of total costs, as illustrated in Exhibit 4. Assuming an analog gross margin of 60 percent and an equal split between front-end and back-end costs, wafer costs will constitute approximately 20 percent of revenue for an analog product, versus 40 to 50 percent of revenue for typical logic products with gross margins of approximately 40 percent.

For affected players, a path to a successful response

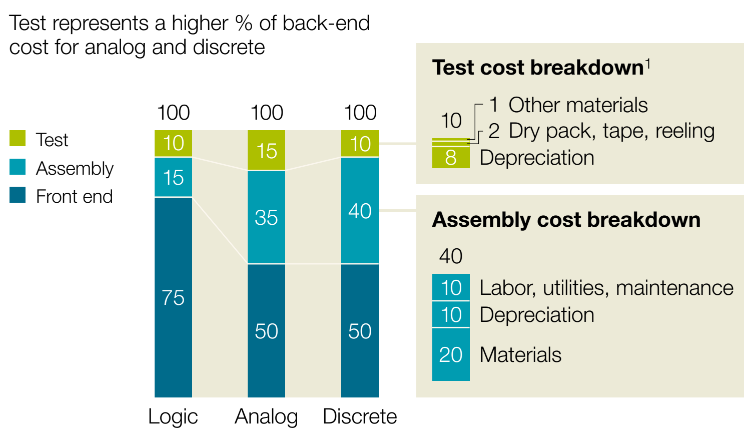
For affected analog players, it will be cold comfort that some of their colleagues do not need to worry about 300mm manufacturing. For integrated device manufacturers that play in products or segments affected by its introduction, the time has come to examine strategic options. We believe that a path to a successful response will involve three steps.

First, players must consider their high-volume analog portfolio and understand precisely what a transition to 300mm manufacturing will mean for them. Do they need to pursue a 300mm strategy? If so, can this best be done independently or in an alliance? A detailed cost-benefit analysis should assess potential benefits from larger wafer sizes, node shrinkage, and die-size reduction against the cost, schedule, and risk implications of a process transition.

Second, players must closely follow the market's evolution. In this area, a number of key questions

Exhibit 4

Analog products have higher back-end costs as a proportion of total costs.



"The ROI[2] on packaging improvements is higher than the ROI on front-end improvements . . . improved thermal dissipation in the packaging allows the supplier to shrink the die size (and save on the front end) while still dissipating an equivalent amount of heat in a smaller area"

—Vice president of packaging at an integrated device manufacturer

[1]Total may not sum due to rounding.
[2]Return on investment.

Source: Expert interviews

should be considered, including what options are available to competitors, how soon competitors might react, and which manufacturing partnerships might be possible.

A continuum of options

Finally, players must craft a response strategy, which must be both comprehensive and consistent with the company's overall manufacturing and sourcing strategy. The options span a wide continuum. At one end is independent 300mm fabrication, along the lines of the TI model. Accordingly, companies would purchase used 300mm tools to install in their own fabs. While in 2011, the supply of used 300mm equipment is tight, the eventual transition to 450mm wafers in microprocessors or memory will likely flood the market with used 300mm equipment. A second option resembles the model pursued by Maxim, in which an alliance is established to source idle DRAM capacity. Further along the spectrum of responses is a transition to a fabless or fab-lite model, in which a foundry partner is encouraged to manage the transition to 300mm. Outsourcing high-volume analog products alone to a foundry partner—that is, ones that benefit from node reduction and 300mm wafer scale—might be the next point along the continuum of options. Last, affected players might work to improve productivity and operational performance in their current 200mm fabs, so they can compete more effectively against new 300mm analog capacity.

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The effects of the transition to 300mm capacity on the analog universe will certainly be felt, but only in select segments rather than the industry as a whole. For players in the affected areas, it is not too early to begin tailoring their response to the 300mm challenge. The optimal approach to crafting a strategy is a carefully considered process that takes into account the specific features of a company's high-volume analog portfolio, the market's evolution, and the spectrum of viable responses, extending from "all-in" 300mm fabrication to none at all. o

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