Research Brief

1Q03 Capacity Update: Growth on the Horizon

Abstract: Semiconductor capacity expansions in the first half of 2003 will target selective increases in response to higher demand. Expect the first 90-nanometer production in early 2004.

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Recommendations

- Semiconductor equipment manufacturers must prepare for slow capacity growth through the first half of 2003 and accelerated growth after that.

- Fab management needs to monitor overall capacity trends closely so that they are not caught unprepared if demand for semiconductors surges unexpectedly.

- Equipment manufacturers must not assume that slow demand for 0.13-micron equipment in late 2002 and early 2003 will delay the initial demand for 90-nanometer (nm) equipment, which is scheduled for first pilot lines in late 2003 and first production in early 2004.

- Equipment manufacturers must be prepared for the 130-nm and 90-nm process generations to ramp in parallel throughout the next upcycle, ending in 2006.

- Equipment manufacturers must have new products targeted at the 65-nm generation ready for initial evaluation by manufacturers in 2004, first pilot production in 2005 and initial volume production in 2006.
Introduction

By the end of 2002, total worldwide semiconductor manufacturing capacity had reached the bottom point in the 2001 to 2002 downturn and was poised to return to growth in 2003. By mid-2002, incremental capacity additions throughout the semiconductor industry were beginning to appear, and a return to desirable levels of growth by the end of 2003 appeared certain. Then semiconductor demand softened, and projected demand growth for the third and fourth quarters of 2003 fell to anemic levels. Semiconductor manufacturers responded to the lackluster economic news by cutting back on capital spending in the near term and sliding out planned expansions. At the same time, the industry responded to the worst downturn in its history by closing obsolete and obsolescent fabs and moving as much production as possible toward more cost-effective smaller-geometry production.

In addition, investment in new technology continued throughout 2002, and the first 300-mm fabs achieved volume production status (albeit low volumes in most cases), and leading-edge producers debugged their 130-nm process to the point that most were reporting acceptable yields by the end of 2002. As we enter 2003, most of the fab closings have occurred, and the industry is poised to expand its 130-nm capacity aggressively once demand returns to the semiconductor industry. Although 130-nm capacity will account for the vast majority of spending in 2003, 90-nm production will first appear at pilot levels by the end of the year and will pick up steam in 2004.

The overall capacity picture will respond to increased semiconductor demand by resuming growth in 2003. This will start slowly during the first half of the year, then pick up speed in the second half. While the wafer fab equipment market will not show "robust" performance early in the year, equipment will still be sold, and the majority of that will go for incremental capacity increases as needed at fabs throughout the world. New fab construction will wait until the 2004 to 2005 time frame because unused space in existing fabs is sufficient to supply needed additional capacity well into 2004.

Business Trend

In the aftermath of the 2001 to 2002 semiconductor market collapse, we are beginning to see the magnitude of the actions taken by semiconductor manufacturers to preserve scarce resources and margins in the face of vanishing demand. We have recently completed our annual survey of fabs throughout the world, and the results were surprising. We had earlier identified slightly more than 50 fabs scheduled to close between 2000 and 2002. After we compiled the results of our survey, that number increased to more than 100 fabs, representing 103 million square inches (MSI) per quarter of capacity. To put this into perspective, it represents 18 percent of the total capacity that existed at the end of 1997, or capacity of more than 680,000 200-mm wafers per month. That capacity is the equivalent of 27
"standard" 200-mm fabs producing 25,000 wafers per month. However, the reality is that the overwhelming majority of these fabs were using older 5-inch or 6-inch technology and had outlived their useful lives.

In the meantime, semiconductor manufacturers had become more cautious with their capital spending plans and were investing selectively in advanced technology to provide a foundation for renewed growth. While the 1999 to 2000 boom focused on 180-nm technology, by the end of 2002, most leading-edge semiconductor manufacturers were solidly entrenched in the 130-nm process generation, with basic processes developed and debugged to the point that yields were becoming reasonable. As we begin 2003, the predominant strategy for capacity building is to wait for demand to materialize and then incrementally ramp capacity to meet demand. This approach is made easier because equipment manufacturers in almost all segments except implant and lithography have short lead times, so that commitments to incrementally increase capacity can be delayed until the last minute.

Consequently, Gartner Dataquest expects worldwide capacity to increase very slowly through the first quarter of 2003, then begin an upward trend that should extend through 2004. Figure 1 summarizes our estimates for total worldwide capacity on a quarterly basis by wafer size through 2004.

Figure 1
Worldwide Semiconductor Capacity by Wafer Size

As shown, significant 300-mm capacity began to come on line in the middle of 2001, and it has been growing slowly since. By now, most 300-mm fabs have reached minimal production volumes, with typical installed capacities in the 5,000-to-10,000-wafer-per-month range. Moreover, the
early adopters of 300-mm technology report that they are seeing the promised cost savings of about 30 percent below 200-mm costs for the same process. Gartner Dataquest estimates that the incremental costs of equipment to produce 1,000 300-mm wafers per month is about $55 million, compared with about $35 million for the same wafer volume at the 200-mm level. However, when the larger area of each 300-mm wafer is taken into account, the costs per square inch of capacity demonstrate the real savings. We estimate that the cost per quarter for 1 MSI of 300-mm capacity is $160 million, compared with $230 million for 200 mm.

Because of the improved cost-effectiveness of 300-mm manufacturing, we expect that it will account for almost 60 percent of all equipment purchases in 2003 and that this will increase to more than 80 percent of all purchases by 2007. The effects of this trend are illustrated in Figure 2, which shows worldwide capacity on an annual basis through 2007.

**Figure 2**

*Worldwide Semiconductor Capacity, 1997-2007*

As shown, Gartner Dataquest anticipates total capacity to ramp strongly through 2005, consistent with our present forecast scenarios. By the end of 2005 and into early 2006, we expect a return to an overinvestment condition, which will lead to the next cyclical downturn in the equipment business from 2006 through 2007. During that period, semiconductor manufacturers will respond much like they did in the last downturn, by closing marginal fabs and moving production to more cost-effective process nodes.

The other side of the fab capacity picture is fab process capability, measured in terms of the minimum feature size being produced in each
fab. Gartner Dataquest measures process capability by process nodes as defined by the International Technology Roadmap for Semiconductors (ITRS). While many semiconductor manufacturers report linewidths that are different from ITRS nodes, these typically represent slight shrinks of more-standard processes. Thus, for example, 110-nm production is considered a shrink of 130-nm processes and is therefore regarded as being at the 130-nm node. Figure 3 shows worldwide fab capacity by quarter through 2004 in terms of ITRS process nodes.

**Figure 3**  
Worldwide Fab Capacity by Linewidth

The term "leading edge production" is defined as the two most-recent process generations. Thus, through 2003, leading edge includes both 0.18- and 0.13-micron processes, but as 90 nm begins to come on line in 2004, the leading edge shifts, so that by the end of 2004, it includes only 130-nm and 90-nm production. This shift is illustrated in Figure 3. During the last upturn, 1999 to 2000, the 180-nm process generation was coming into the dominant leading-edge position. By the end of the boom, the first 130-nm production was coming on line. In the next upcycle, the majority of new capacity should be at the 130-nm node, but by 2004, the first 90-nm capacity will start to come on line. Moving forward, Figure 4 shows worldwide capacity by linewidth on an annual basis through 2007.
As shown, we expect 130-nm capacity to be the predominant driver of the next upturn, reaching a maximum level in 2006 and staying roughly constant through 2007. Starting in 2004, 90-nm production will gain steam and will continue to expand through the forecast horizon. In 2006, we anticipate the first low-volume 65-nm production to appear at a few fabs.

**Gartner Dataquest Perspective**

Fab operation managers are extremely cost-sensitive and, given the choice, they will delay fab additions as long as possible to minimize fixed costs and maximize margins. We expect them to do exactly that during the next six to 12 months as semiconductor demand slowly returns to a strong growth condition, and the need for more capacity becomes critical. However, the pace of technology development and implementation does not change, and those manufacturers that have adopted a technology leader strategy cannot, and do not, pause in the pace of new technology implementation.

However, while the few early adopters of each new technology node continue to adhere to a two-year schedule between nodes, much of the rest of the industry is slipping toward a three-year timetable. This division in the industry between early and late technology adopters means that the effective lifetime of each process generation increases and that the rate at which the industry shifts to the new processes will be more gradual. For equipment manufacturers, they will still have to be ready for the early adopters, or they will lose critical early placement of their most-advanced
tools. But they also must recognize that each new tool generation must address multiple process nodes or be faced with a slower ramp to acceptable sales volumes.

Finally, 300 mm has come of age. After a slow start in the late 1990s, growth in 300-mm fabs was poised to take off just as demand crashed at the end of 2000. Entering 2003, mainstream volume 300-mm fabs are poised to lead the next capacity expansion wave. While the total cost of a "typical" 300-mm fab is staggering by historical standards ($2.5 billion to $3 billion), it actually represents major cost savings in terms of cost per unit volume produced. However, a 300-mm fab can produce up to 2.5 times the number of chips compared with a 200-mm fab of the same wafer-per-month output. Therefore, expect to see ramp times of 300-mm fabs in terms of wafer-per-month capacity to be slower than preceding generations, as manufacturers respond to the need for output in terms of chips, not wafers.

**Key Issue**

What are the size and projected growth of the semiconductor manufacturing markets and supply chain elements?
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