A CLOSE-UP ON SEMICONDUCTOR EQUIPMENT MANUFACTURERS

By Michael Murphy

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This article is the first of several columns for the *AAII Journal* focusing on understanding and analyzing specific technology industries.

Why technology?

We are in a once-in-a-lifetime transition from an old economy to a new one, in which the driving force has become cheap semiconductors and the new prototypical product is the personal computer. The major social change is telecommuting over intranets. And that means great investment opportunities in semiconductors, computing, communications, and medical technology.

Many people think this terrific rate of advance is driven by the semiconductor industry. Not true. While that industry has the smarts to design great new chips, none of those designs would see the light of day without continuous advances in the semiconductor equipment industry. If semiconductors are "the oil of electronics," then the equipment to make semiconductors is the drilling rig, tool bit, and pipeline.

HOW FAST IS IT GROWING?

The semiconductor equipment industry grew 18% a year from 1987 through 1996. That included some slow years around the 1990-1991 recession and a boom year in 1995. Growth slowed in 1996 to about a 10% rate, and the industry topped out at about a $25 billion annual shipment rate. The second half of 1996 was weak, as was 1997, as semiconductor companies utilized the excess capacity they installed in 1994 and 1995. The equipment industry passed its trough at the end of 1998 and started a multi-year upturn.

There are over 100 major semiconductor fabrication factories scheduled to be built in the next three years alone. As computers and communications spread around the world to newly-affluent consumers, tremendous amounts of silicon will be sucked up. Those chips have to be built somewhere, so the equipment industry is likely to resume an 18% a year growth rate for the next seven to 10 years.

WHAT DRIVES THE CYCLES?

Semiconductor equipment is a major capital investment, often involving millions of dollars for one machine and $1 billion to $2 billion for an entire fabrication facility. That means money is allocated by the chip manufacturer's customers through a careful capital budgeting process, which takes some time. Consequently, orders for semiconductor equipment tend to lag conditions in the chip industry. Coming out of a slow period for chip sales, orders for new equipment will be low because chip makers will have plenty of unused capacity from the prior cycle of factory building.

As chip sales pick up, though, spot shortages will develop, and the prices of some chips will stop declining or even start to rise. All of a sudden the economics of making those chips will justify expanding production, and the chip makers will order more manufacturing lines for their current factories.

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This is when the semiconductor equipment industry feels the first benefit of the upturn, as in the second half of 1998, and their stocks start to outperform.

In the next stage their factories are nearing full capacity with no room for additional lines, so the manufacturers commit to new "greenfield" plants. These factory designs start with an empty plot of land—a green field—and take over a year to build, during which the manufacturers will evaluate and test all the latest semiconductor equipment and give out purchase orders. This is the time new manufacturers have their best chance to get a foot in the door, because rather than just duplicate existing production lines, chip makers will be looking for newer equipment that can cut costs or produce higher manufacturing yields.

After the factory is built it takes another six to nine months to bring in all the equipment and test the production process. This is the best of times for semiconductor equipment stocks. They often move on the announcement of orders won, and then move again when the equipment is shipped and revenues are booked. This period can go on for quite a while, depending on what is happening to end-user demand for computer and communications products. Eventually, though, too much production capacity is built, chip prices fall and the manufacturers back off from their expansion plans. They often even put projects on hold, pending the next up-cycle.

We used to say the top of the market always was marked by Intel, which would decide to build a huge factory right at the peak of activity. By the time the structure was built, the market would be headed down. Intel then would lock the doors before they equipped it. A year or so later, when they announced they were going ahead with the equipment orders, we knew the bottom of the market was behind us.

You can track this cycle by getting the monthly press release on equipment orders and shipments from the Semiconductor Equipment & Materials Institute (SEMI, 805 East Middlefield Road, Mountain View, CA 94043-4080; 650/964-5111, or visit their Web site at www.semi.org).

When monthly orders are larger than shipments, the ratio of orders to shipments is above 1-to-1. This ratio is called the *book-to-bill ratio*. Although the book-to-bill ratio for chips was more widely known until it was discontinued at the end of 1996, the book-to-bill ratio for equipment is in many ways more useful. It is reported in SEMI's monthly press release; the data can be found on their Web site (www.semi.org/mktstat/bobinessoutlook.htm/#book).

The best time to buy the stocks is when the ratio is below 1-to-1 but starting to rise, as at the end of 1998, and the best time to sell is when the ratio is at a cyclical high but starting to decline.

If the supply/demand cycle for semiconductors was the only force driving the semiconductor equipment cycle, it would not be a hard business to forecast. But there is another major force: the march of technology. The cost of making a semiconductor falls 50% every 18 months only if you have the latest equipment. Even in the middle of a downturn, manufacturing technology is advancing. Chip makers have to make constant trade-offs between adding to excess capacity today or being caught tomorrow with a high-cost process in an industry upturn. If a company decides to slide by without updating their technology, what will happen to them if a competitor does buy the new equipment?

HOW PROFITABLE IS IT?

Very. Semiconductor equipment is a manufactured product sold to a small number of customers. The big three of the industry, Applied Materials, Lam Research, and Novellus Systems, average gross profits of 50%. Out of that they spend a lot on research and development (R&D)—an average of 12%. They spend 18% on selling, general, and administrative expenses, which is not bad considering the long selling cycle and the extensive customer handholding required to get equipment installed and accepted in the customer's production process.

This leaves the three companies with average operating profits of 20%, superb by any standards. This financial model is typical for the industry, although smaller, newer companies may be using it as a target to grow toward.

WHAT COMPANIES WIN?

The most important strategy for the success of these companies is to have the best price/performance equipment, which usually means the latest technology. Equipment that can build the most advanced, complex chips is worth a premium price, because that price is amortized over the number of bits or wafers it will process in a given period of time.

An interesting corollary strategy is to deliberately *not* have the most advanced product, but to drive the cost out of the previous generation of products and then sell the customer a "mix and match" strategy—use the old process wherever you can and the new, expensive process only where you have to.

The second most important strategy is to offer global service and support. Of course, this can be difficult and expensive for a small company that may have the latest and greatest gear, but does not have the size to support it worldwide. The usual solution is to sell and service direct in the U.S. and possibly in Korea, where there are only four major customers, and then use well-known equipment distributors to sell and support in Europe and Japan. The downside is that the distributor takes a hefty cut of the profits, which leaves less to reinvest in new

TABLE 1. THE MAJOR SEMICONDUCTOR EQUIPMENT MANUFACTURERS

Ticker	Company	Sector	Revenues ($ million)	Market Cap ($ million)	Expected EPS Growth (%)	R&D as % of Sales (%)	Annual Sales Growth (%)	Pretax Profit Margin (%)	Price-to-Growth Flow* (X)
MASK	Align-Rite Int'l	photomasks	50	60	20	1.5	23.3	20.9	8.8
AMAT	Applied Materials	all	4,000	15,000	23	13.9	40.2	19.6	15.9
ASMLF	ASM Lithography	lithography	500	3,700	15	13.5	35.4	27.1	12.9
BRKS	Brooks Automation	robotics	100	160	17	16.4	58.4	8.0	10.0
CFMT	CFM Technologies	wet processing	75	60	50	12.3	68.2	8.2	4.3
CMOS	Credence Systems	testers	200	400	24	18.3	30.7	21.1	6.6
CYMI	Cymer	lithography	200	420	35	12.2	183.7	14.1	11.1
DPMI	DuPont Photomask	photomasks	270	610	20	4.7	19.2	18.4	14.6
EGLS	Electroglas	metrology	150	260	20	14.6	22.2	22.2	6.3
ESIO	Electro Scientific	test & repair	230	400	18	12.4	27.6	15.2	11.7
EMKR	EMCORE Corp.	wafers	50	140	35	18.8	62.3	9.0	15.3
ETEC	Etec Systems	photomasks	290	800	27	18.5	43.1	22.1	9.5
FSII	FSI International	photoresist	210	170	23	19.7	23.1	12.5	3.1
GSNX	GaSonics Int'l Corp.	strip	120	110	21	14.4	30.4	13.0	4.3
KLAC	KLA-Tencor Corp.	metrology	1,100	3,600	23	15.6	47.5	16.9	11.8
KLIC	Kulicke & Soffa Indus	assembly	500	410	18	9.2	39.5	10.3	7.1
LRCX	Lam Research Corp.	etch, CMP	1,050	700	19	19.6	31.8	15.7	3.5
LTXX	LTX Corp.	testers	200	110	22	17.5	2.6	5.3	3.0
MTSN	Mattson Technology	strip, RTP	75	100	17	19.2	32.4	15.4	4.9
WFR	MEMC Electronic	wafers	1,000	360	19	6.5	15.6	9.4	3.1
NANO	Nanometrics	metrology	35	70	23	8.2	19.2	21.9	10.5
NVLS	Novellus Systems	CVD, PVD	500	1,700	25	16.8	50.2	31.3	11.7
PLAB	Photronics	photomasks	220	600	22	5.4	36.7	21.1	19.1
PRIA	PRI Automation	robotics	200	450	30	14.5	86.6	15.3	11.2
SMTL	Semitool	spray process	180	80	16	10.9	45.8	10.4	3.8
SVGI	Silicon Valley Group	lithography	610	350	21	12.4	25.3	8.5	3.9
TGAL	Tegal Corp.	etch	40	40	30	26.6	2.2	7.3	2.8
TER	Teradyne	testers	1,500	3,200	20	12.8	19.1	15.3	12.5
SFAM	Speedfam Int'l	CMP	180	230	21	18.2	37.8	8.8	4.7
UTEK	Ultratech Stepper	lithography	150	360	28	17.9	28.4	18.0	8.5
VAR	Varian Associates	ion implant	1,400	1,100	15	7.8	2.1	11.5	5.5
WJ	Watkins-Johnson	CVD	300	150	11	17.2	2.0	9.3	2.6

**Share price divided by R&D per share plus EPS.*
Historical data from Bloomberg and company reports. Forecasts, including financial ratios, from California Technology Stock Letter.
Share prices as of 12/18/98.

R&D to stay ahead of the big boys. But if the equipment is good enough it will generate lots of revenues and a big installed base, whereupon the manufacturer can terminate the distributors and begin direct sales and support.

THE NEXT BIG CHANGE

The next big change in the semiconductor equipment industry is to move from today's 0.5 micron equipment to 0.25 micron and 0.18 micron equipment. This is the equivalent of going from 140 circuit lines in the width of a human hair to 280 lines and then to 400 lines.

Following a little behind, but essentially in parallel, is the move to 12-inch diameter silicon wafers, which should be well underway by the year 2000. These two changes will drive the next sharp drops in chip cost-per-bit, and essentially require that almost every semiconductor factory in the world be re-equipped by 2005.

THE SECTORS

Semiconductor equipment is broadly classified into two groups:

- The front-end equipment used to make the chip, and
- The back-end equipment used to assemble, package, and test it.

Table 1 provides a list of the major semiconductor equipment

manufacturers and the sector in which they operate. While you do not have to understand how semiconductors are made to be a successful semiconductor equipment investor, here is a brief description of the production process that serves as a guide to the primary sectors (in italics).

First, a single crystal cylindrical ingot is pulled from a vat of molten silicon, polished, and sliced into thin wafers. *Chemical-mechanical polishing (CMP)* gives them a mirror finish. The wafer is handled by *robotics* through a series of wet and dry processes that are repeated for each layer of the electronic circuit. *Rapid thermal processing (RTP)* is used as needed to heat the wafer to hundreds of degrees centigrade.

In a diffusion furnace, dopants are diffused into the surface of the wafer to change its conductivity. Then, the wafer is placed in a cloud of vaporized film using *chemical-vapor-deposition equipment (CVD),* which will deposit a thin film of material on the wafer.

This layer is covered with a *photoresist* layer, a light-sensitive coating. Next comes *lithography*. A picture of each layer of the desired electronic circuit has been transferred to a piece of glass, called a *photomask*. The photoresist layer is exposed to a light shining through the appropriate mask. Where the light hits the photoresist, the material can be hardened in the pattern of the mask.

After hardening, the wafer goes into *etch,* where the deposited vaporized film that is not protected by photoresist is stripped away, leaving the circuit lines on the wafer.

The wafer then may go to *ion implantation* to control the electrical conductivity in a selected region.

A photoresist *strip* machine then removes the developed photoresist.

The chip is then prepared for *metalization*, where a thin layer of aluminum or copper is sputtered onto the chip and connects the various components of the chips. The wafer is then *diced* into separate chips, and each chip is *bonded* to a package base, which contains the electronic leads that will connect the chip's electronic circuits to the outside world.

Finally, *encapsulation* provides a top to the package, sealing the chip.

Throughout this process, the wafers and die will be inspected visually by microscope for surface defects (*metrology*), and probed electronically for faults.

After the chip is manufactured, it is examined by a *tester*.

INVESTMENT STATISTICS

Table 1 provides a number of useful financial statistics on the major semiconductor equipment manufacturers. The technology industry changes fast, and these numbers will quickly be outdated; however the table will provide you with guidelines for the kinds of investment criteria you should first focus on when investing in semiconductor equipment manufacturers.

The *revenue* figures are my estimates of the current rate.

Expected earnings per share growth (provided by Bloomberg) is a consensus estimate from I/B/E/S with some of my own adjustments.

R&D relative to sales measures a firm's commitment to research and development. Dividing a company's R&D spending by annual sales tells you in percentage terms how much a company is spending on R&D. In this table, the figures are from the last fiscal year, although a few numbers are adjusted for companies that had unusual circumstances. In general, a technology company should spend a minimum of 7% of revenues on R&D spending.

Annual sales growth for the last three years (adjusted for unusual circumstances) provides an indication of how fast the business is growing. For technology companies, ideally you should seek companies with sales growth of at least 15% per year.

Pretax profit margin (net income divided by revenues, here a blend of historical averages and my forecast for 1999) provides an indication of how profitable the company is. In general, you should seek technology companies with pretax profit margins of 15% or better.

Return on equity (aftertax profits divided by shareholders equity) indicates how the firm makes use of its invested capital, and most importantly indicates whether a company is capable of financing its own growth without resorting to outside financings that dilute earnings. Ideally, semiconductor equipment manufacturers should have return on equity of 15% or more.

The *price-to-growth-flow ratio* provides a measure of relative valuation. Traditional valuation approaches are often misleading for technology companies because research and development spending directly cuts into a company's current earnings, so that the more a company spends on research and development, the worse its reported earnings will be. The price-to-growth-flow figure adjusts the price-earnings valuation approach by adding the last fiscal year's research and development spending per share to normalized earnings per share to determine growth flow; the stock's share price divided by the growth flow produces the price-to-growth-flow ratio. Technology stocks are fairly priced when price-to-growth-flow ratios are around 10 to 14; anything under 8 is cheap while ratios of 16 and over are too expensive.

While the list here provides an overview of the industry, any investment requires an in-depth analysis of the firm and its industry. And, of course, before buying any technology stock, recalculate these ratios using the most recent data and current prices. ✦