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Upstate New York

Assessing the Economic Impact of Attracting Semiconductor Industry

March 2008

NY Nanotech

Prepared by Semico Research Corp.

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INTRODUCTION

1. The revenue in this report is shown in current US Dollars (current). Revenue is not adjusted to a base year.

2. Revenue and shipments represent where semiconductors are shipped. This implies the site of assembly for the end products.

Executive Overview

The semiconductor industry since its inception has been an attractive industry to state and local governments around the world. The example of the growth of the economy in Silicon Valley in California is an enviable economic model. Not only do the semiconductor manufacturers themselves generate revenue, the spin-off companies and support structure spawn growth.

The employees of semiconductor fabs hold advanced degrees and possess skills necessary to grow the technology field. Semiconductor employers and support industries seek employees with specific scientific skills. Education is a priority for semiconductor companies and its employees. This fact focuses time and money on the educational system and results in more science and math emphasis.

The “clean industry” is how the semiconductor fabs are perceived. Emissions are controlled and water is reclaimed so both do not impact the environment negatively. The clean environment lifestyle is an attraction to the educated, skilled workers sought by the semiconductor fabs.

Semiconductor companies work hard to be good neighbors. Every community with a semiconductor company benefits from semiconductor company volunteers to local programs and from donations of equipment and resources to colleges and universities. The growth of amenities in the community is a plus for all the residents. The availability of cultural programs from orchestra to interesting speakers adds value to the community.

New York State has an enviable existing environment with the Albany NanoCollege, IBM and other semiconductor-related industries already in place. Very few new 300mm fabs are built every year. The cost is onerous and semiconductor companies face lower margins every year. Only through a partnership with the state can a semiconductor company afford to locate to an area in the US.

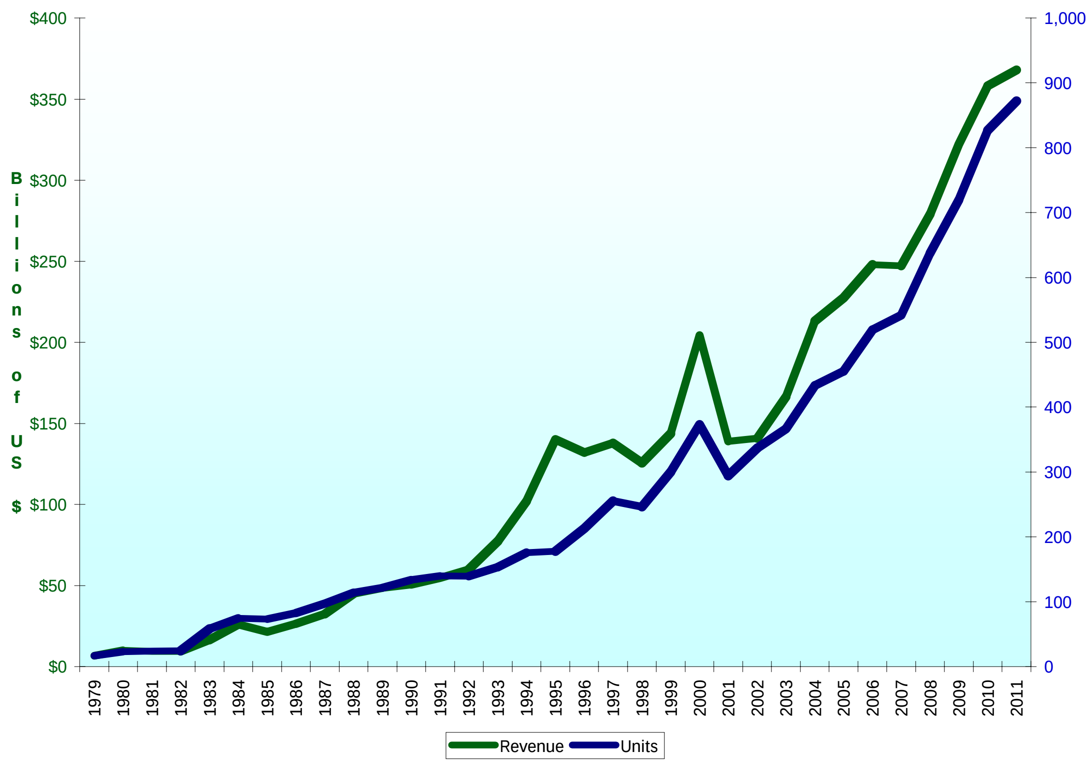
As discussed in this report, many geographic areas are willing to work with a company to attract it to an area. The site, the financial capacity, the educational facilities, the environment, and the team to accomplish the task of finalizing the building of a new 300mm fab all can work for upstate New York — and a semiconductor fab will generate in excess of a 200 percent ROI over a five year period.

Semiconductor Market Overview

The semiconductor market achieved a double-digit compound annual revenue growth rate (CAGR) of 13 percent over a 28-year period. This trend is anticipated to continue through the forecasted period.

The worldwide semiconductor industry generated $248 billion in revenue in 2006. This revenue was generated from the shipment of 519 billion units. The unit volume is forecast to increase at a CAGR of 10 percent over the next five years. The revenue compound annual growth rate for the industry in the past 5 years was 13 percent, and is forecast to achieve 9 percent in the next five years.

Figure 1. Semiconductor Revenue and Unit Shipments



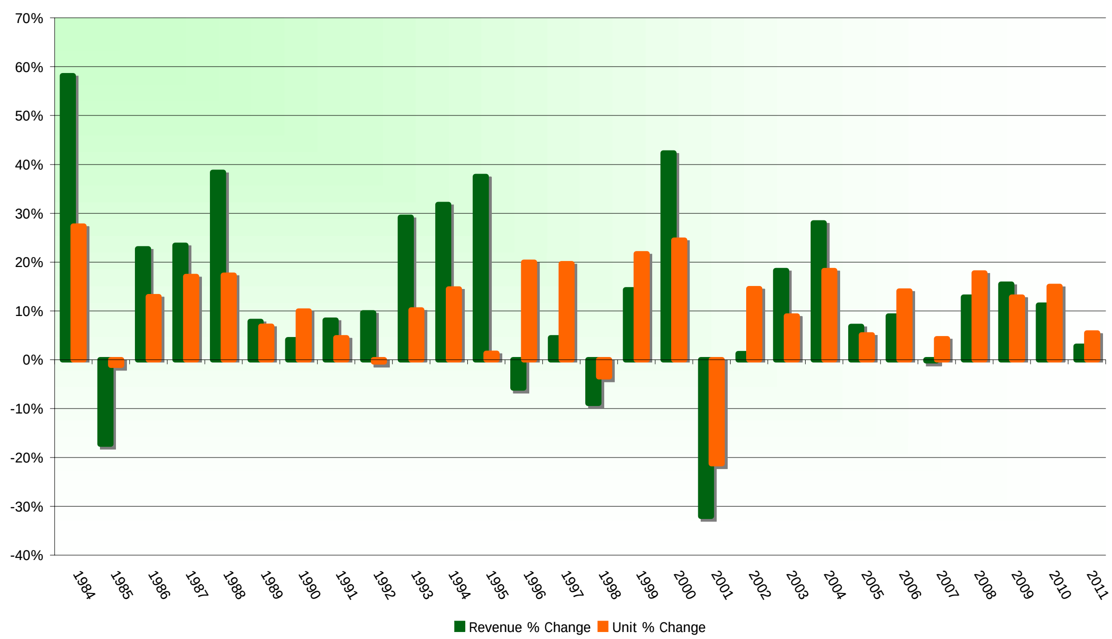
Source: Semico Research Corp.

As orderly as the increase in revenue and units appears, the semiconductor market has a fluctuating growth rate as illustrated in the next graph. The variation in revenue growth rates is attributed to the world economy, supply and demand, and manufacturing capacity. The unit changes are impacted by the same factors. In addition, technology advancement, integration, new markets and manufacturing availability are also important.

Following a down revenue year, the market typically rebounds with double-digit growth. Revenue decline makes an adjustment between supply and demand and enables well-positioned manufacturers to continue to grow.

No two consecutive years down.

Figure 2. Revenue and Unit Growth Rate



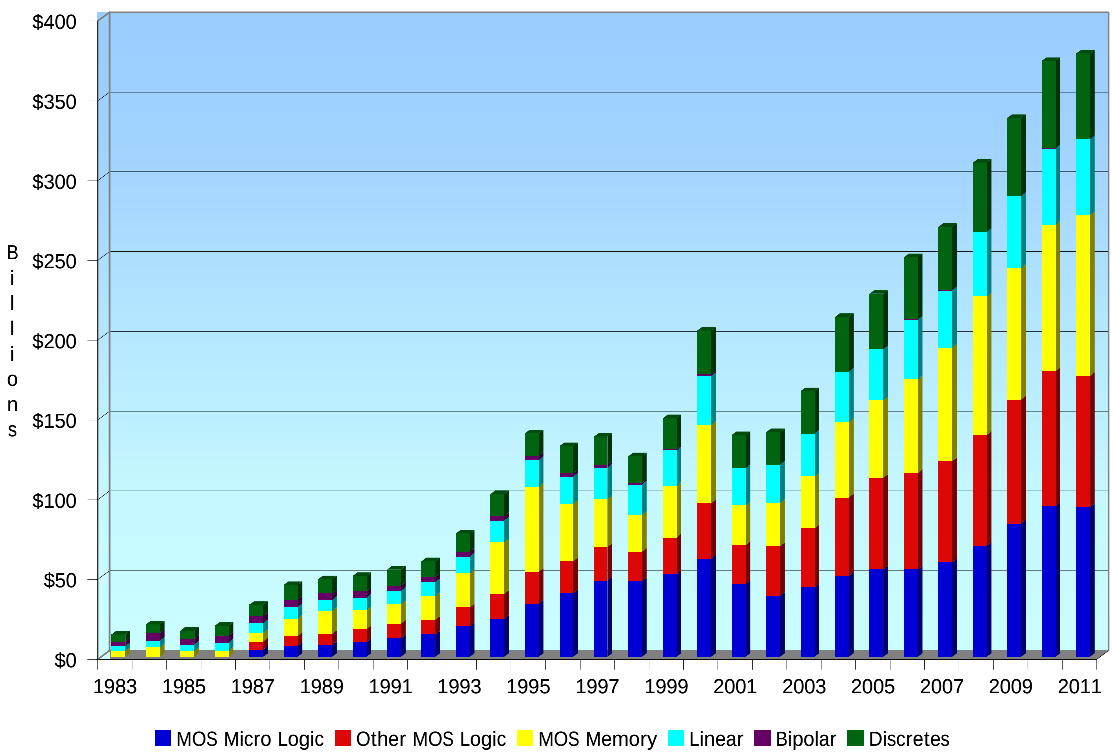
Source: Semico Research Corp.

Major Categories of Semiconductors

The semiconductor industry is divided into eight major semiconductor functions or product categories. The definitions of the categories are according to the WSTS/SIA (World Semiconductor Trade Statistics/Semiconductor Industry Association). The following graph shows the relative revenue relationship between the specific categories. These categories are included to provide a second level of detail that can be related to specific vendors involved in the production of the various products.

The MOS Micro Logic category contains the products manufactured by AMD and Intel. The CAGR for this category from 1987 through 2006 twenty years is 14 percent. The memory category had a similar CAGR over the same twenty-year period.

Figure 3. Revenue by Semiconductor Category



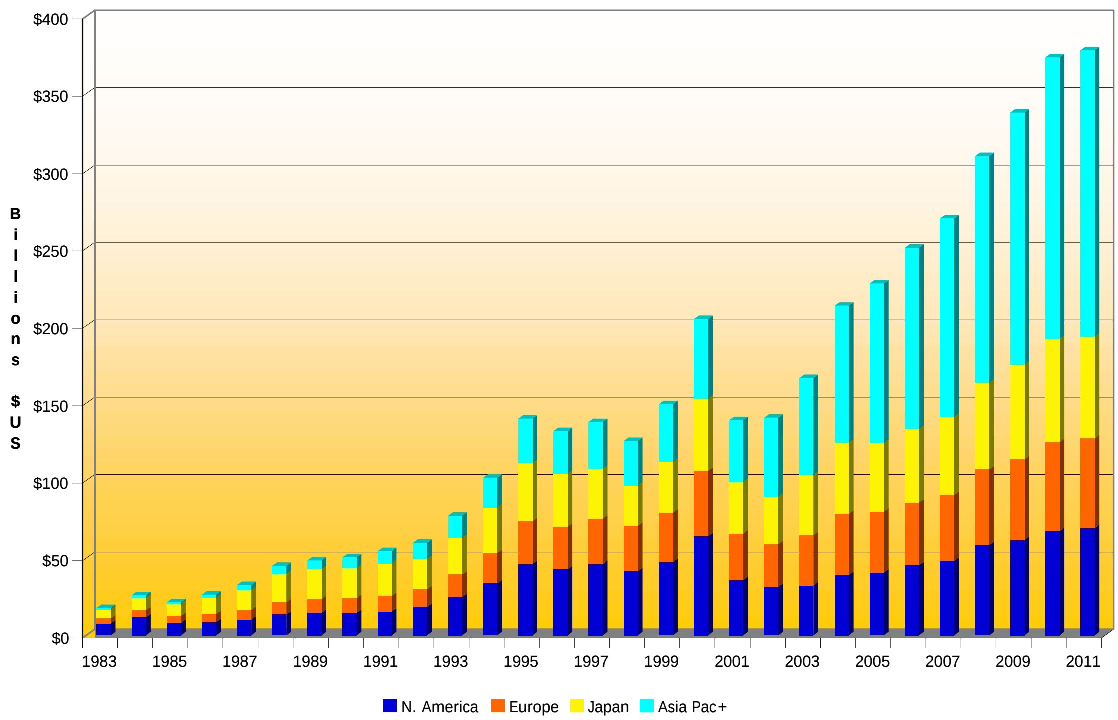
Source: Semico Research Corp.

Geographic Semiconductor Market

The chart by major geographic region: North America, Europe, Japan and Asia, presents the impact of changes in manufacturing site locations. Both the manufacturing site of semiconductors and the end product manufacturing have been affected. Since the acceptance by end product manufacturers of the no inventory or just in time delivery of semiconductors, semiconductor companies have been under great pressure to locate manufacturing facilities close to the end customer's manufacturing. While worldwide, much inventory is located in warehouses to service customer needs. In the case of Dell and Samsung, Samsung has a facility close to the old site of Dell's manufacturing.

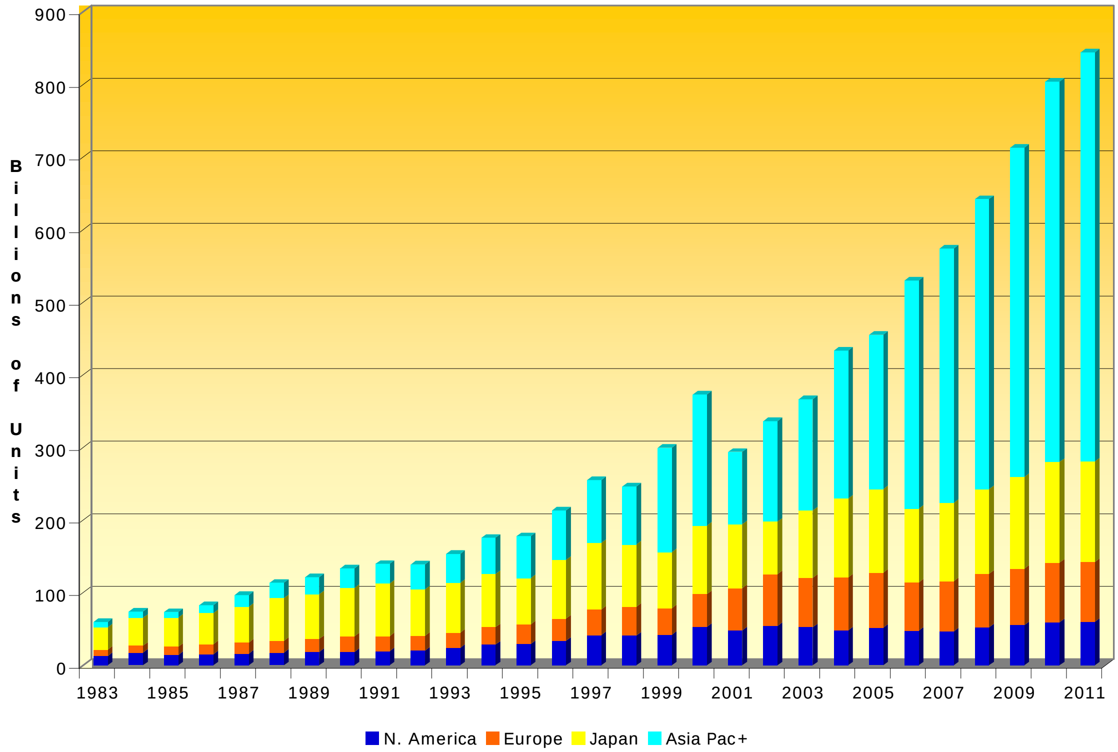
With the growth of manufacturing of end products in China and the growth of consumption of electronic products in China, the sales of semiconductor products has moved to the Asia Pacific area. The building of semiconductor fabs has followed.

Figure 4. Geographic Revenue Shipments



Source: Semico Research Corp.

Figure 5. Geographic Unit Shipments

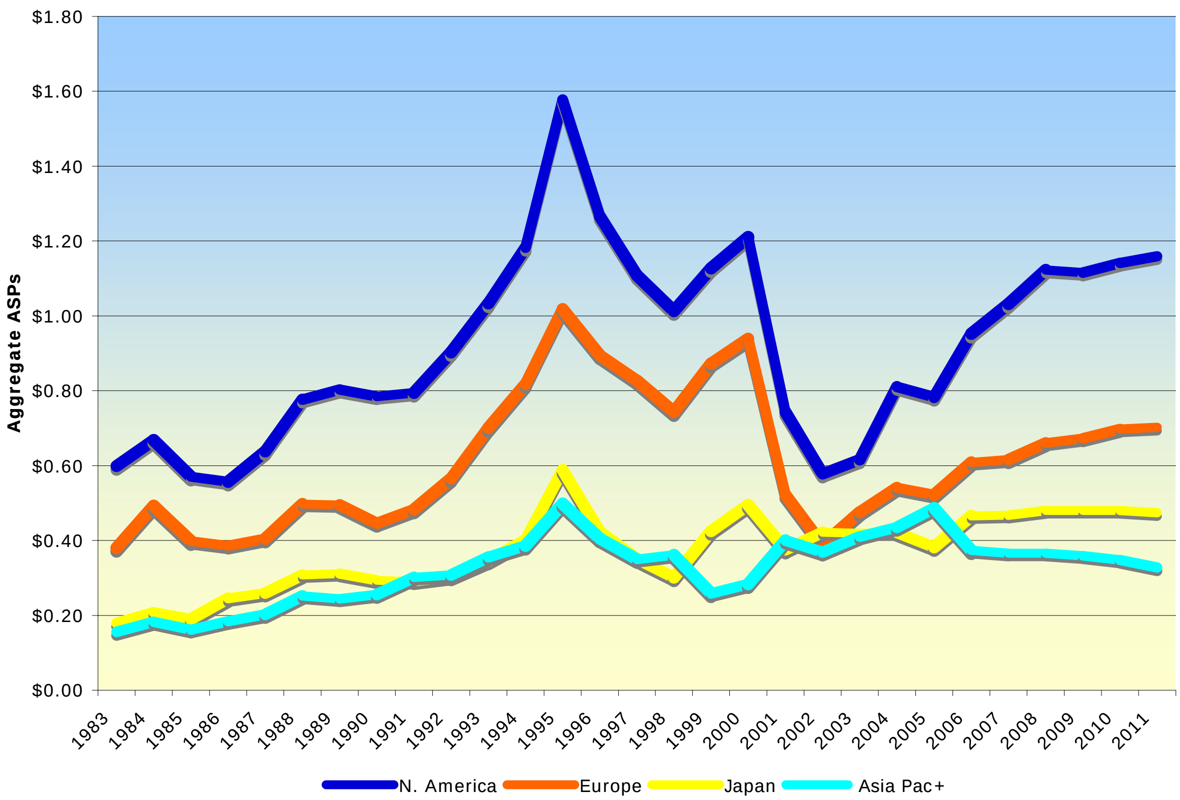


Source: Semico Research Corp.

While Asia Pacific is huge in terms of revenue and unit shipments, the average selling price (ASP) by region highlights a different trend that relates to leading technology. North America has the highest aggregate ASP.

PC motherboards manufactured in Asia normally are shipped to the US without the very expensive processor to avoid import tax. Because the processor is a high-priced component, it raises the overall ASPs for North America. Additionally, PC memory will be installed at the time of shipment by large US vendors to eliminate holding inventory on a product that can decline in value very quickly.

Figure 6. Geographic Aggregate ASPs

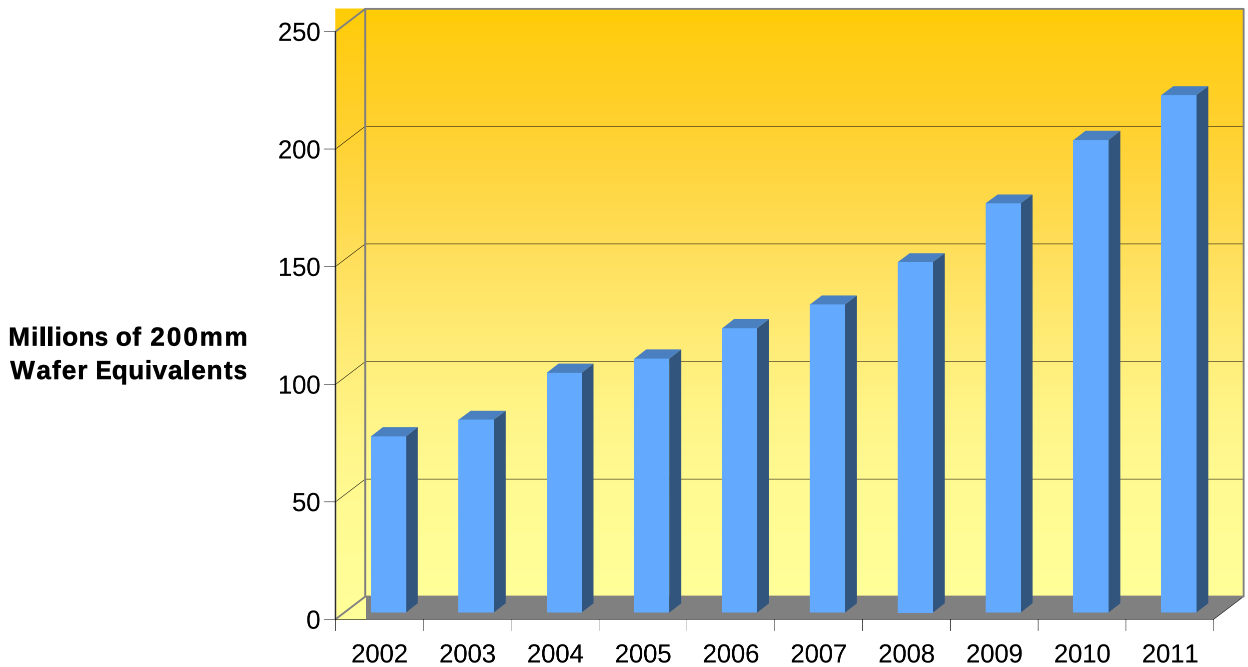


Source: Semico Research Corp.

Number of Fabs Required

The continual growth of unit demand assures that new fabs will be needed in the future. The unit demand is the result of growth in the end product market. New innovations continue to expand the application of semiconductors. With a compound annual growth rate of around 10 percent, Semico estimates the number of wafers needed to supply demand to experience a CAGR of 13 percent from 2006 through 2011.

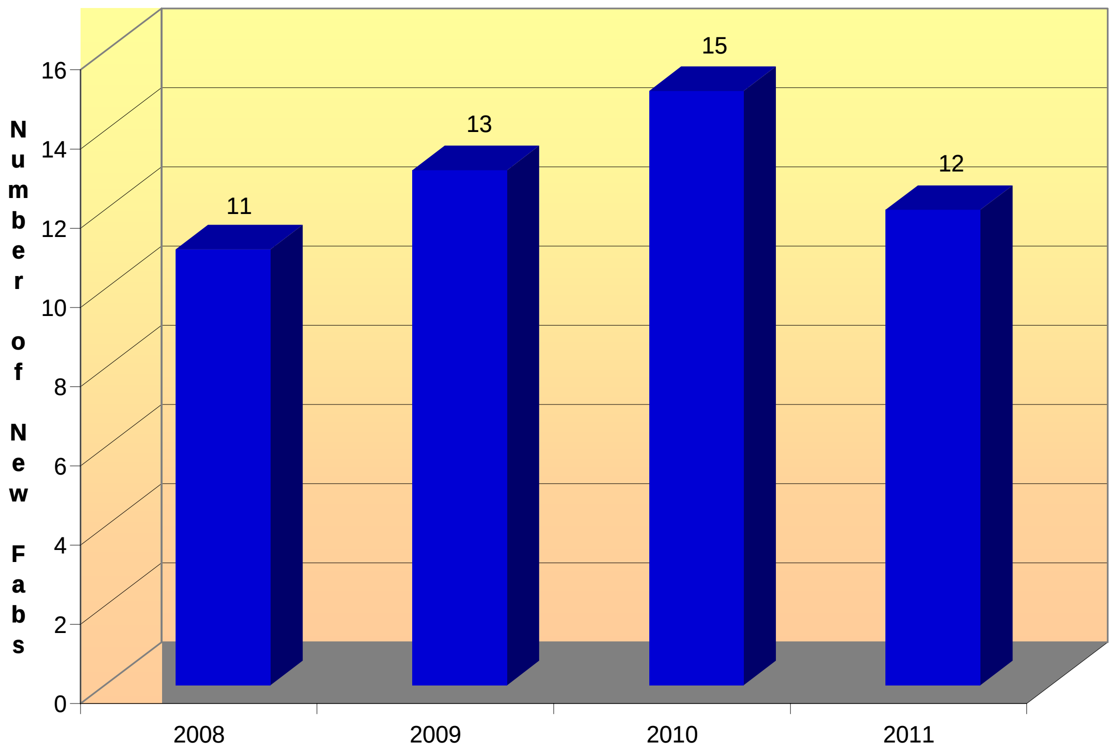
Figure 7. Wafer Demand of 200mm Equivalents



Source: Semico Research Corp.

The number of wafers required obviously relates directly to the number of fabs needed to produce those wafers. Semico's forecast takes into account the device type, technology and demand by semiconductor category. This point is important because different devices are manufactured at different technology nodes, wafer sizes and processes. It is leading edge technology that will require new 300mm fabs in most cases. Older fabs are then retrofitted to produce legacy product.

Figure 8. Number of New Fabs to be Built Yearly

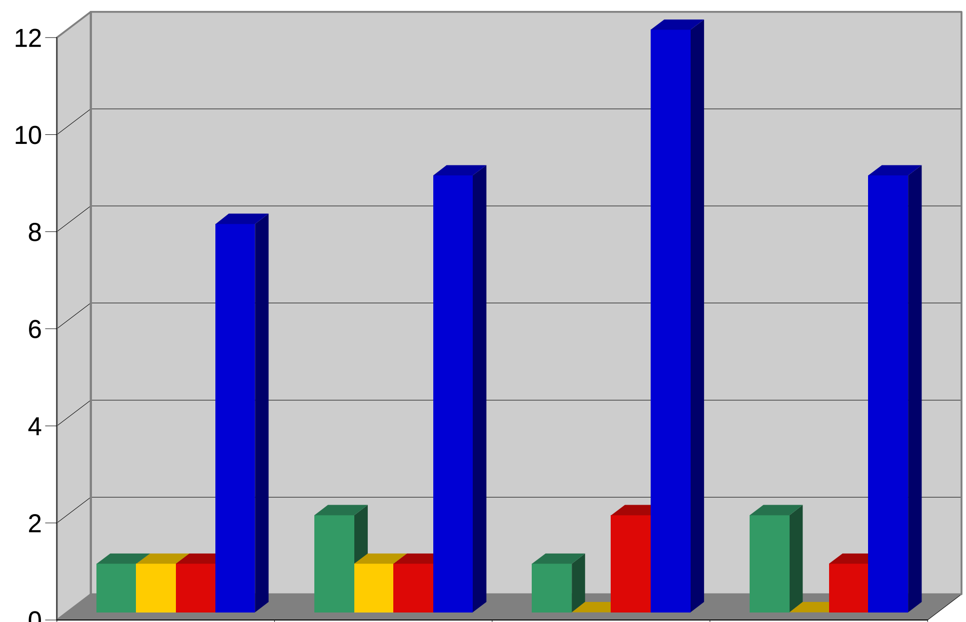


Source: Semico Research Corp.

The next question is where they will be built. The majority will be built in Asia where the greatest consumption of semiconductors occurs. During the next four years, between 60 and 80 percent of the new fabs will be in the Asia region. Many of these will be memory fabs. The major memory vendors are already located in that region, so it makes sense that most of the addition will be close to established facilities.

Even though the largest percentage of fabs will be built in Asia, there will be fabs constructed in the U.S., Europe and Japan. One is planned for 2008 and two more are tentatively planned for 2009.

__Figure 9. Geographic Location of New Fabs to be Built (Units)__



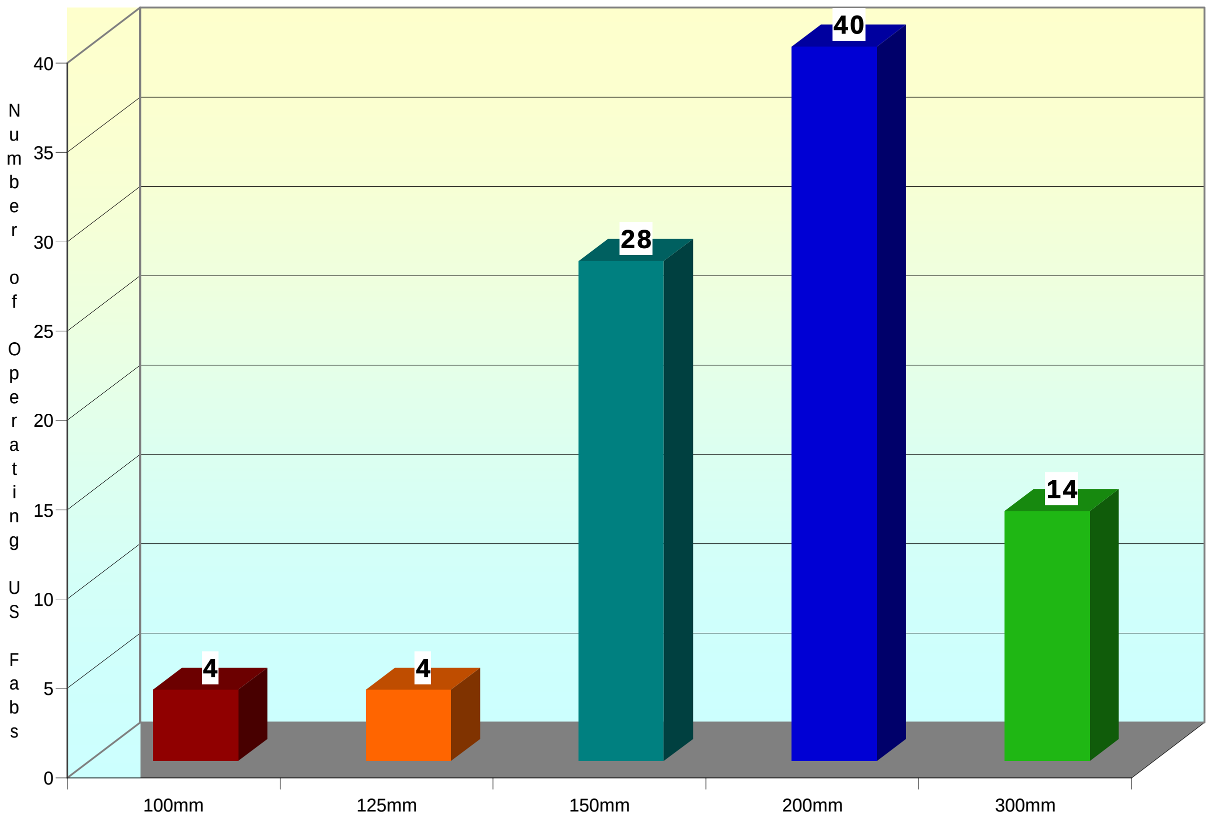
	2008	2009	2010	2011
US	1	2	1	2
Europe	1	1	0	0
Japan	1	1	2	1
Asia	8	9	12	9

Source: Semico Research Corp.

The U.S. has a number of established fabs ranging in technology from 100 to 300mm wafers. A total of ninety fabs are currently operating. The majority at this time are 150mm and 200mm. Some of these will continue to operate for a number of years, producing legacy and older technology products. There are fourteen 300mm fabs at present.

The following graph illustrates the fabs by wafer size.

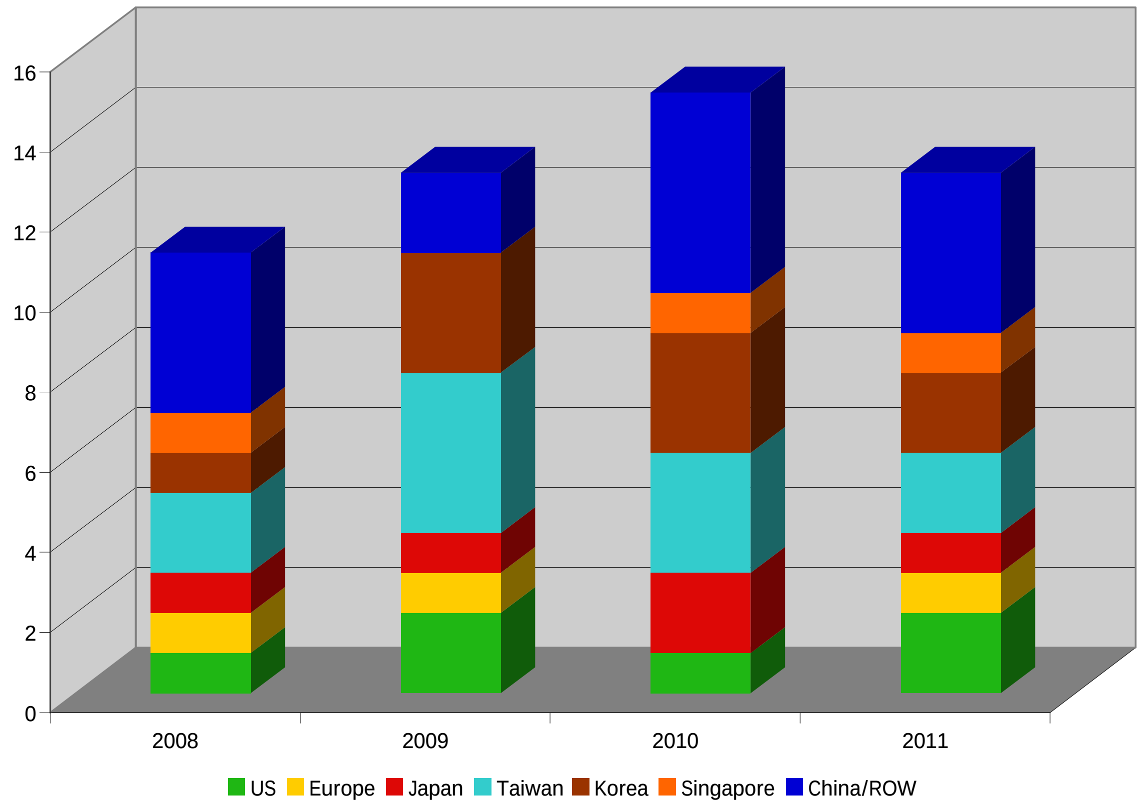
__Figure 10. U.S. Fabs by Technology (Units)__



Source: Semico Research Corp.

The new fabs that will be constructed are planned for a variety of regions and countries. The following figure illustrates that Asia encompasses a variety of countries and regions. The U.S., Japan, Korea, Taiwan and Singapore are shown with detail by country. Europe is the entire European Union. China/ROW (Rest of World) includes China, India, Brazil, Thailand, Russia and other countries outside the listed ones that may build semiconductor fabs.

Figure 11. Fabs to be Built by Region (Units)



Source: Semico Research Corp.

Top Semiconductor Vendors

Of the top twenty semiconductor companies in 2006, seventeen were IDMs (Integrated Device Manufacturers) and had dedicated fabs. Three of the companies follow the foundry model and do not have dedicated fabs. Most of the companies in the top twenty have maintained a spot on this portion of the list for a number of years.

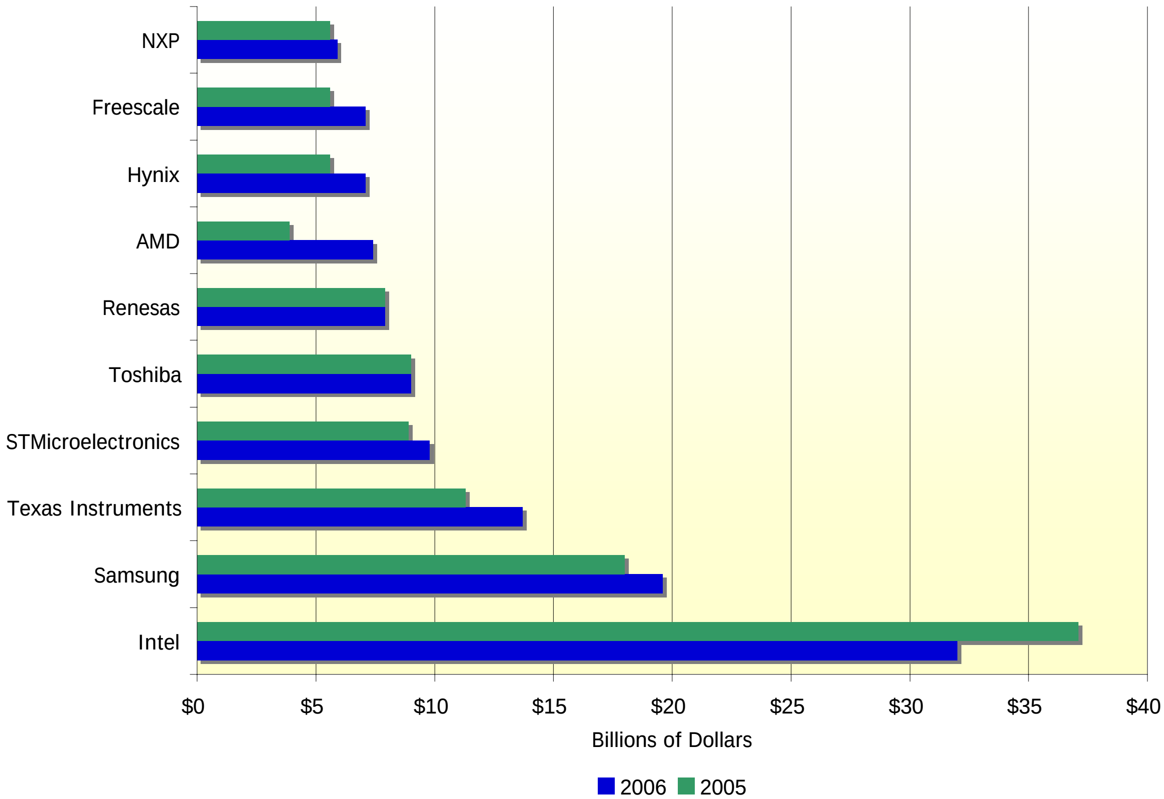
The following table shows rank, market share and change in market share percentage.

Table 1. Market Share for Top 20 Semiconductor Vendors

Rank 2005	Rank 2006	Vendor	B$ 2005	B$ 2006	% Chg	% Share 2005	% Share 2006	Share Delta
1	1	Intel	$37.1	$32.0	-13.7%	16.3%	12.9%	-3.4%
2	2	Samsung	$18.0	$19.6	8.6%	7.9%	7.9%	0.0%
3	3	Texas Instruments	$11.3	$13.7	21.2%	5.0%	5.5%	0.6%
5	4	STMicroelectronics	$8.9	$9.8	10.7%	3.9%	4.0%	0.1%
4	5	Toshiba	$9.0	$9.0	0.0%	4.0%	3.6%	-0.3%
7	6	Renesas	$7.9	$7.9	-0.3%	3.5%	3.2%	-0.3%
15	7	AMD	$3.9	$7.4	88.3%	1.7%	3.0%	1.3%
11	8	Hynix	$5.6	$7.1	26.4%	2.5%	2.9%	0.4%
12	9	Freescale	$5.6	$7.1	26.8%	2.5%	2.9%	0.4%
10	10	NXP	$5.6	$5.9	4.5%	2.5%	2.4%	-0.1%
8	11	NEC	$5.8	$5.2	-10.7%	2.6%	2.1%	-0.5%
13	12	Micron	$5.0	$5.1	3.0%	2.2%	2.1%	-0.1%
6	13	Infineon	$8.3	$4.9	-41.0%	3.7%	2.0%	-1.7%
14	14	Sony	$4.0	$4.6	16.4%	1.7%	1.9%	0.1%
16	15	Qualcomm	$3.5	$4.4	27.2%	1.5%	1.8%	0.3%
19	16	Broadcom	$2.7	$3.6	32.9%	1.2%	1.4%	0.3%
17	17	IBM	$2.8	$3.5	23.5%	1.2%	1.4%	0.2%
23	18	Elpida	$1.8	$3.3	83.3%	0.8%	1.3%	0.5%
18	19	Analog Devices	$2.8	$2.6	-7.3%	1.2%	1.0%	-0.2%
20	20	NVIDIA	$2.3	$2.5	5.3%	1.0%	1.0%	0.0%
		Other	$75.6	$88.7	17.3%	33.23%	35.80%	
		TOTAL	$227.5	$247.8	8.9%	100.00%	100.00%	

Source: Semico Research Corp.

__Figure 12. Market Share for Top 20 Semiconductor Vendors__



Source: Semico Research Corp.

Foundries

Foundries are important participants in the semiconductor manufacturing arena. They serve the segment of the semiconductor industry that designs product but do not have manufacturing fabs of their own.

TSMC is the world's largest dedicated semiconductor foundry. It is known for providing leading-edge process for its customers. Fabless semiconductor companies use the foundries to manufacture products. The fabless companies design to the process rules of the foundry they use. With the high cost of building dedicated fabs, more semiconductor companies move some segment of its products to a foundry each year embracing the "fab lite" model.

U.S. companies dominate the fabless market, accounting for about 70 percent of total market revenues in 2006, followed by Taiwan companies with 17 percent, according to data from the Fabless Semiconductor Association (FSA). China and Europe were in equal third place, each with 3 percent of the market.

The following table presents the primary location for the leading foundries.

Table 2. Top Foundries

Top Foundries	Location
TSMC	Taiwan
UMC	Taiwan
IBM	US
SMIC	China
Chartered Semiconductor	Singapore
X-Fab	Germany
Vanguard International	Taiwan
Dongbu HiTek	Korea
MagnaChip (Hynix)	Korea
Hahung/NEC	Korea
Tower	Israel
Jazz Semiconductor	U.S.
Grace Semiconductor	China
AMI	U.S.

Source: Semico Research Corp.

Profile of the U.S. Semiconductor Industry

The semiconductor industry is the leading manufacturing industry in the country. The chip industry is now America's largest manufacturing industry in terms of value added to the U.S. economy. The 2006 semiconductor industry provided direct and indirect employment in the U.S. for nearly 1.7 million people. Rising from the 17th position in 1987, the semiconductor industry's unparalleled expansion has created employment growth of 4.3 percent per year (since 1991), which is 8.6 times faster than the growth of all other manufacturing employment. The semiconductor industry's average annual wage is nearly twice the national average. High-tech companies, including companies using semiconductors as parts, employed over 4 million people.

U.S.-based semiconductor manufacturers are located all over the world; semiconductor companies have approximately 70 fabrication facilities in the U.S., and 68 in foreign countries.

- U.S. 2006 Sales = $112 billion
- Worldwide 2006 Sales = $247.7 billion
- 2006 World Market Share = 46 percent of $247 billion Market
- U.S. Jobs = 225,000
- World Jobs = 1,0223,000
- Percent of Sales Outside U.S. Market = 78 Percent
- Capital Equipment = $11 billion, 10 Percent of Sales
- R&D Investment = $18 billion, 17 Percent of Sales
- Historically 25-30 Percent of Revenues Invested in the Future

New York is an economic powerhouse for the United States. The state of New York is the third largest state economy behind California and Texas. Combining the three states accounts for nearly 8% of the U.S. GDP. These three states are also the leading technology centers for the U.S.

2006 World GDP

The top 15 countries account for over 77% of the world's GDP. The table below details the GDP ranking, dollar amount, percent of the world's GDP and semiconductor revenue as a percent of GDP. While the semiconductor industry represents just over one half of one percent of the world GDP; compared to the U.S. economy it is approaching 2% of the total U.S. GDP.

Table 3. World GDP and Semiconductor Revenue % or GDP

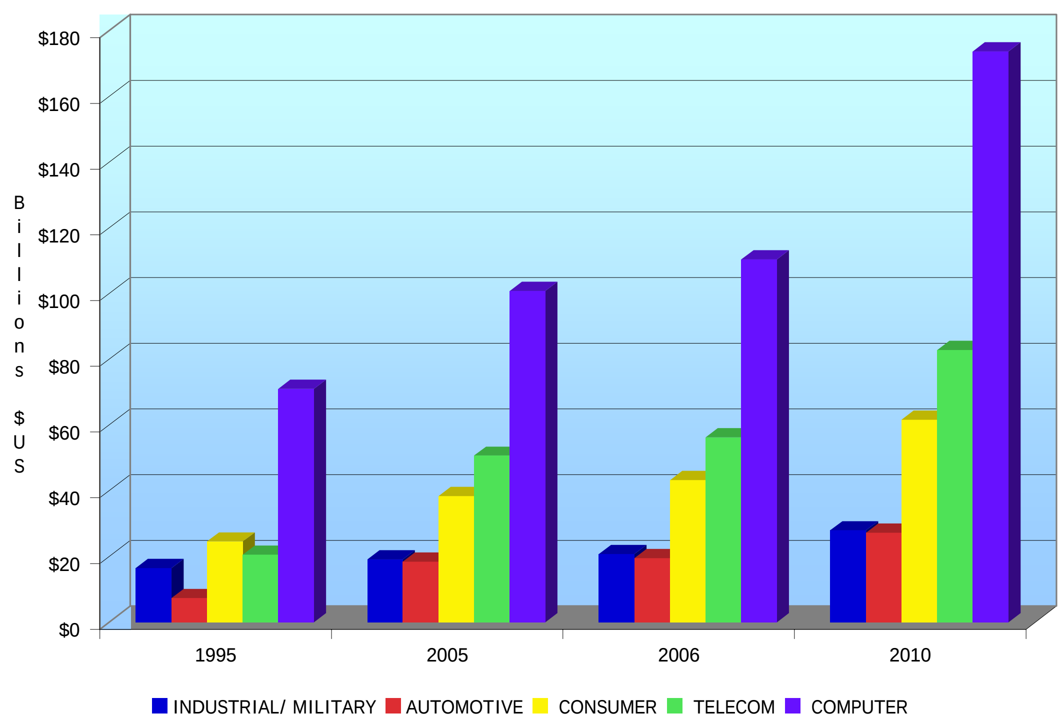
Country/Ranking	**GDP**	**% of Total**	**Semiconductors as % of GDP**
1 United States	13,201,819	27.4%	1.88%
2 Japan	4,340,133	9.0%	5.71%
3 Germany	2,906,681	6.0%	8.52%
4 China	2,668,071	5.5%	9.28%
5 United Kingdom	2,345,015	4.9%	10.56%
6 France	2,230,721	4.6%	11.10%
7 Italy	1,844,749	3.8%	13.43%
8 Canada	1,251,463	2.6%	19.79%
9 Spain	1,223,988	2.5%	20.24%
10 Brazil	1,067,962	2.2%	23.20%
11 Russian Federation	986,940	2.0%	25.10%
12 India	906,268	1.9%	27.33%
13 Korea, Rep.	888,024	1.8%	27.90%
14 Mexico	839,182	1.7%	29.52%
15 Australia	768,178	1.6%	32.25%
Sub Total top 15	37,469,194	77.7%	0.66%
Others	10,775,685	22.3%	2.30%
Total World	**48,244,879**	**100.0%**	0.51%

Source: Semico Research Corp.

End Markets Drive Semiconductor Demand

Without the demand for electronic end products, there would be no requirement for semiconductors. It is the success of the semiconductor industry to continuously reduce the cost of the functions of a semiconductor along with constantly adding new features that drives a robust electronics business.

Figure 13. Major End Market Segments



Source: Semico Research Corp.

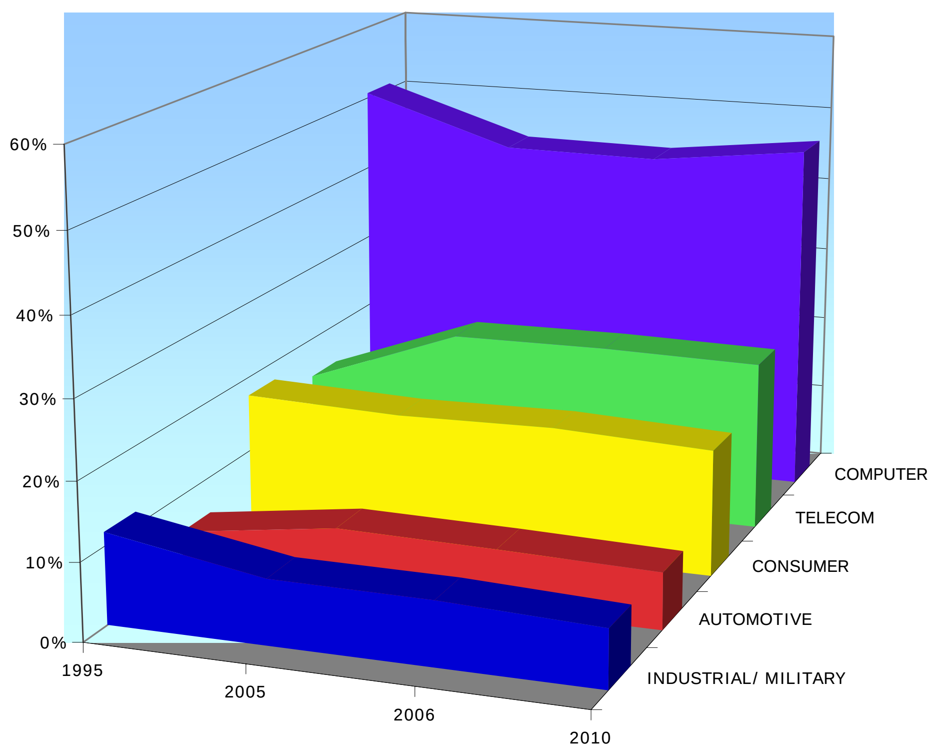
Table 4. End Market Segments Revenue

	1995	2005	2006	2010
INDUSTRIAL/ MILITARY	$16.5	$19.1	$20.8	$28.0
AUTOMOTIVE	$7.4	$18.4	$19.5	$27.3
CONSUMER	$24.6	$38.4	$43.3	$61.6
TELECOM	$20.6	$50.7	$56.3	$82.9
COMPUTER	$71.0	$100.8	$110.4	$173.7

Source: Semico Research Corp.

The continuing dominance of the computing sector confirms the point that even with all of the new end product, the established end products continue to have a share of market. Even as the computing sector is transitioning from desktop PC to notebook PC, the consumption of semiconductors is strong. Telecom, consumer and automotive are all important segments of the market for semiconductors.

Figure 14. Market Share for End Market Segments



Source: Semico Research Corp.

While the revenue is important, so is the growth in unit consumption. The four end products at the top of the list are considered to be the base products for the industry. The six products below those are products expected to have strong growth through 2011.

Table 5. End Product Five-Year CAGR

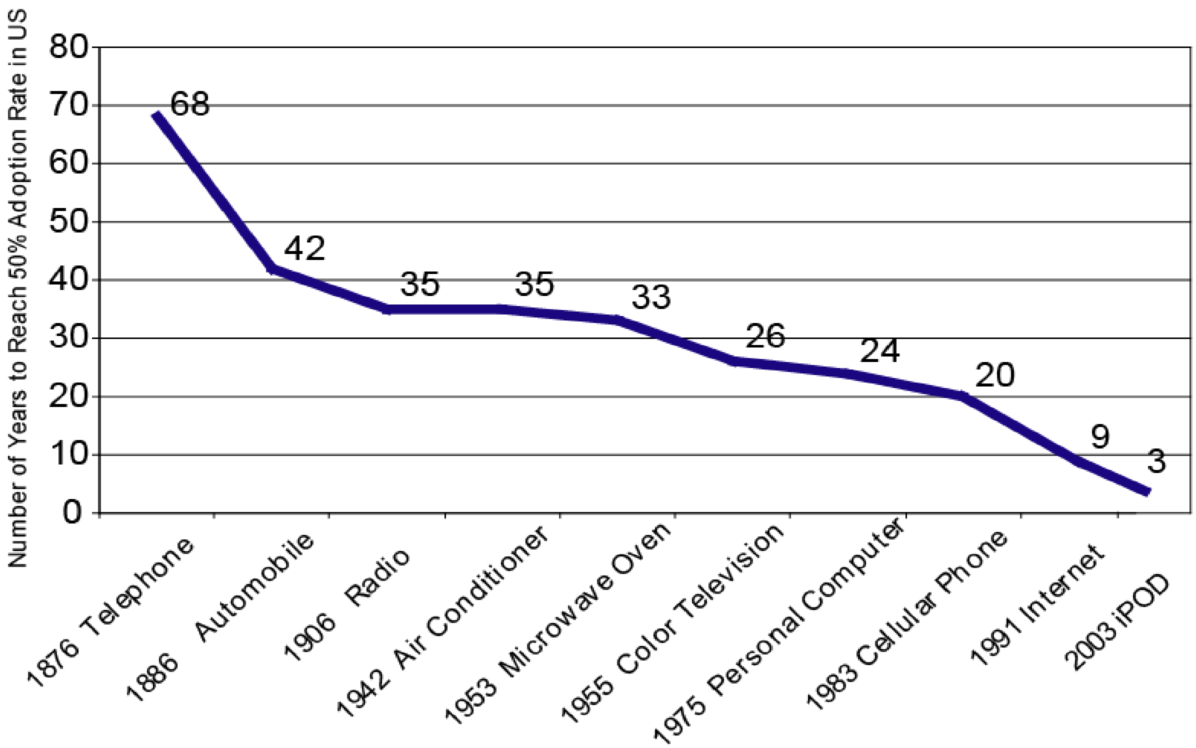
End Product	CAGR 2007 - 2011
Desktop	2%
Notebooks	12%
Basic Cell Phones	8%
High-end phones	17%
Integrated DTV	16%
DVD Recorders	27%
PMP (Portable Media Players)	27%
IP PBX	22%
WiMAX CPE (Customer Premise Equipment)	149%
Media Center PC	39%

Source: Semico Research Corp.

The major trend today is the portability and connectivity of end products. The emphasis on smaller, faster, cheaper semiconductors is requisite for the mobile or portable market. Portable devices such as notebooks, cell phones and portable media players will continue to be imports. Equally important will be the wireless capabilities and the infrastructure for interconnecting all of the wireless products.

The issue of how fast a new product is adopted has changed radically over the past thirty years. The following presents a look at some of the major end products that have changed the way we live and how long it took in the U.S. alone to achieve a 50 percent adoption rate. The period has declined until the industry now assumes major new product adoption in less than three years. Semico expects this adoption rate to contract to two years and less over the next five years.

Figure 15. Increasing Speed of New Product and Technology Adoption



Source: "Science, Technology and Business Innovation as Factors of Growth"/Ramon Marimon/ASU 2003/Semico Research Corp.

Semiconductor Equipment Market

Equipment manufacturers (OEM's) had a 23% growth in 2006 over 2005. The 2007 market growth is expected to be around 10%. Following is the information for equipment sales by geographic region for 2005 and 2006.

Table 6. Semiconductor Equipment Market by Region (Billions)

Region	2005	2006	% Change
China	1.3	2.3	74.5%
Europe	3.3	3.6	10.2%
Japan	8.2	9.2	12.5%
Korea	5.8	7.0	20.4%
North America	5.7	7.3	28.4%
Taiwan	5.7	7.3	27.7%
Rest of World	2.9	3.7	29.6%
	32.9	40.5	23.1%

Source: Semico Research Corp.

The equipment support is provided by a variety of manufacturers. The top vendors are listed in the following table with market shares for 2006. The top three vendors have been leaders for many years and account for 42 percent of the total and dominate their markets.

Table 7. Semiconductor Equipment Vendor 2006 Market Shares

Vendor	Revenue	Market Share
Applied Materials	$8.6	21%
Tokyo Electron	$4.7	12%
ASML	$3.9	10%
KLA-Tencor	$1.9	5%
Lam Research	$1.9	5%
Advantest	$1.9	5%
Nikon	$1.8	4%
Novellus Systems	$1.7	4%
Other	$14.1	35%
Total	$40.5	100%

Source: Semico Research Corp.

The four largest areas for semiconductor industry equipment sales are: Japan, Korea, North America and Taiwan. This trend is expected to continue in 2007 and beyond.

Table 8. Semiconductor Equipment Sales by Geographic Region

Region	2005	2006	% Change
China	1.3	2.3	74.5%
Europe	3.3	3.6	10.2%
Japan	8.2	9.2	12.5%
Korea	5.8	7.0	20.4%
North America	5.7	7.3	28.4%
Taiwan	5.7	7.3	27.7%
Rest of World	2.9	3.7	29.6%
TOTAL	32.9	40.5	23.1%

Source: Semico Research Corp.

The semiconductor equipment companies will be among the first to establish a presence in any location that builds a new fab. Equipment companies do not typically build a facility in the region, but it will have people assigned to the fab during the critical start-up phase. Those people will have offices in the semiconductor fab to provide 24/7 equipment support. The equipment support technical people will live in the area with their families and will contribute to the community. During the production phase equipment companies will set up satellite offices to support ongoing operations.

Additionally, Field Service Organizations (FSO) are located near a fab that implement a given equipment vendor's product. For instance, AMAT may have 60 to 80 percent of the equipment installed in a new fab. This involves complex software that operates, monitors and diagnosis problems. The FSO enables the equipment manufacturer to augment its revenues by maintaining spares and service close to a fab. The FSO has the knowledge and capability to reduce downtime. FSOs perform sophisticated monitoring and diagnostic solutions to optimize operation metrics, the mean time to diagnosis first-time fix rates, and work order completion rates.

Key Drivers of Semiconductor Investment

Semiconductor manufacturers are a sought-after industry for a region. The examples are the success of the DRAM industry, first in the United States, then Japan, then Korea and then Taiwan. Attracting and developing a semiconductor industry are well-documented ways to grow an economy. Semiconductor facilities bring educated, skilled workers. This is a relatively stable work force with families. The wage base for a region will increase with the profession salaries. New housing developments and service industries grow up around a fab community.

Capacity Utilization

Capacity utilization is a forward indicator of supply and demand. When capacity utilization reaches 95 percent, semiconductor manufacturers believe more capacity is needed. When capacity utilization is under 80 percent, there is no immediate need to increase capacity. The following lists the important points of capacity utilization and why it is key to planning new facilities.

- Capacity changes driven by supply and demand
- When ASPs (Average Selling Prices) decline, manufacturers cut back on output, if possible
- Inventory becomes a key component
- Inventory is held in different parts of the supply chain
- Lower capacity utilization results in cutback on capital expenditures

Supply and Demand were key issues in 2007. The following bullets highlight the key trends.

- Inventories correction 2007
- Shortages in 2008 into 2009
- Reduced capex in 2007 caused utilization to increase in 2H07
- ASPs stabilized in 2H07 setting growth potential for 2008
- Rising ASPs signal higher demand
- Capacity utilization rises as ASPs increase

Macro Economic Issues

The health of the world and U.S. economy contributes to the health of the semiconductor industry and visa versa. There are inflection points in the economy that trigger or influence the semiconductor industry. Overcapacity in the semiconductor industry destroys average selling prices and drags down revenue. The lower revenue can lead to shutting down facilities and worker layoffs.

However, it is typical that occurrences at the U.S. macro economic level impact the semiconductor vendors, electronic original equipment manufacturers and semiconductor equipment makers. Here is a list of items that are currently of concern on the macro economic level.

- Oil prices - Still rising
  - Currently over 40 percent above 2005 & over 90 percent above 2004
  - Drag on consumer spending
- Housing prices continue to decline
  - Bad for consumer confidence
- Rate Cuts
  - Good for consumer confidence
- Deficit
- Inflation worries
- Employment News Mixed
- Consumer Spending Slow

Global Concerns

Because the semiconductor industry is truly a global business, the health of all the geographic regions impacts the market. In addition to looking at regions, there are some global concerns that each region watches. Global competition impacts where, when and why manufacturing facilities, design centers and expansion are done.

- Holding down corporate profits through component pricing that must be competitive worldwide against manufacturers competing with a lower cost base than U.S. or Europe.
- Worldwide Markets Uncertain with U.S. Sub-prime loan fiasco
- How long this lasts and what impact it has on the world economy is still a question.
- Middle East conflict fuels uncertainty

  Iran - May be bad news

  Iraq – When does oil production restart?
- North Korea - May be good news
- Investments by Russia worldwide
- Is another region investing to become a major player in semiconductor?
- Investments in China and Taiwan
- Semiconductor is important to a region, but over-building capacity can lead to price wars and elimination of competitors.

The following presents the GDP percent change by region, another economic indicator used to gauge the health of the various economies.

Table 9. GDP Percent Change by Region

	2006	2007
China	9.6%	11.1%
Eastern Europe	4.9%	4.1%
Germany	1.3%	1.0%
Japan	2.5%	2.0%
Russia	6.0%	5.8%
South America	4.6%	4.3%
USA	2.9%	3.1%

Source: Semico Research Corp.

Positive Economic Trends

Some events have worldwide impact. Presidential elections in the U.S. always stimulate economic growth. Elections in Taiwan have the same affect. In 2008 both the U.S. and Taiwan have presidential elections.

Of great importance is the supply and demand balance for semiconductors. As stated previously, the industry builds new facilities or adds capacity when utilization is high and average selling prices are rising.

Here are some summarized indicators for the future economic growth forecast. U.S. and World Economy Improves in 2008.

Election Year in U.S. and Taiwan

Olympics in China

- Semiconductor Capacity Utilization Increases
  - Higher ASPs in 2008
  - Inventory under control
- Dollar value spurs international sales
- Housing market improved
- Reduced capex investments in 2007 result in tight capacity in 2008, thus:
  - Leads to stable ASPs
  - Industry revenue growth
  - Demand for new fabs
  - Good semiconductor revenue in 2008
  - Increased demand will roll into 2009

It is the end markets that drive the consumption of semiconductors. Established markets provide a base line, but it is the development of new end products that drive increased demand. It is interesting to note that established new products do not replace older products. The iPhone is a good example of a developing new market that does not replace the old. Cell phones continue while the iPhone expands the class of internet media devices.

The following list looks at new possibilities for 2008 and beyond.

- End markets improve in 2008 and 2009
- Innovation continues in the end product segment
  - New Applications in Automotive
  - New Applications in Medical
  - New Applications in Consumer
  - New Applications in Telecom
  - New Applications in Security
- iPhone stimulates new designs & spurs upgrades
  - New products imitating iPhone
  - Innovations beyond iPhone
- TV and Set Top Box improves as digital broadcasting emerges
  - Media server becoming a hot product at under $500
- Consumer adoption increases
- PC market experiences increased upgrade cycle
  - Important base market still growing
- Notebook PC becomes more competitive against smaller, cheaper consumer products.

Semiconductor Location Investment Decisions

The cost of building and facilitizing a semiconductor facility is over $4 billion. This fact alone makes it critical for semiconductor companies to develop a partnership with the government where they locate. In the United States there are 18 states actively competing to attract new technology businesses. However, New York State is the only state recently to have shown the ability and willingness to compete for semiconductor manufacturing. Attraction of new business to a region is very important to the revenue base and therefore is very competitive. Financial incentives are key for a semiconductor facility to build in a different location than where it is already established, especially considering the liability imposed by the federal tax code when it comes to capital depreciation.

There are some basic criteria that must be met before a region is considered for semiconductor manufacturing. Land desirability, adequate and reliable utilities and a robust infrastructure are key components to site selection. The establishment of one manufacturing facility will make the area more attractive to other manufacturers.

Availability of skilled workers and access to a continual stream of educated employees is necessary. It is too expensive for a company to relocate all of the engineers and specialized staff for a fab.

The network of universities can enable the development of interest in a locality. Universities are not only a source for future management and skilled workers, but also a source of consultation, R&D capabilities, graduate students and mentoring programs.

Secondary, but still important, is the standard of living for employees. Access to diverse cultural programs, schools, recreational areas, medical, environmental conditions and arts and sciences are key to families employed by a semiconductor fab.

Following is the checklist of items that are impacted by the location of a new facility in an area.

Telecommunications

- Infrastructure
  - Roads
  - Hospitals
  - Business environment
  - Taxes
  - Tariffs/barriers
  - Labor regulations
  - Legislative climate
  - Bureaucracies
- Land
  - Adequate for future expansion
  - Natural disaster threats
- Reliable Utilities
  - Water
  - Electric
  - Heating/Cooling Cost
- Fire Departments with HazMat capabilities
- Raw Materials Access
- Airports
  - International
  - Local
- Universities
  - Availability of scientists
- R&D centers
- Other similar businesses
- Investment appeal of area
- Cost of living
- Cultural amenities
- Recreational amenities
- Environmental restrictions or benefits
- Advantages over other locations

Reasons for Investment Choices

Overriding influences on site selection are the financial incentives and existing location of other semiconductor facilities. The availability of work force, materials and infrastructure is considered to be resolved if another company is in the area. An organization within the state must be dedicated to keeping the program progressing even after an agreement is reached.

Areas attracting new high tech industry investment must work to establish a positive business climate and embrace policies that reduce taxes, streamline procedures and clarify regulations, and provide high quality public services.

Direct assistance must be provided to businesses looking to relocate includes information on:

- Highways
- Education
- Public safety
- International trade
- Community development
- Technology transfer from universities
- Access to research capacity
- Subsidized higher education
- Special industry support
- Workforce assistance

Active participation by the universities in a given state is critical to assure an atmosphere of scientific development. Future workers come from science-based programs.

Programs such as Workforce Oregon were established to ensure the availability of trained workers with the pertinent skills. This is a combination of public and private organizations working to provide jobs or people as needed.

Resources came from:

- Oregon state government
- Oregon university system
- County organizations
- Numerous local employment consortiums

Financial incentives through direct program assistance are provided by some states when a new industry enters a region. A specialized incentive package is prepared depending upon the economic conditions, cost comparison of utilities with another region or a plethora of business issues. The packages are customized to a specific business.

Financial incentives can be:

- Direct financial incentives,
- Indirect financial assistance
- Tax-based incentives and rewards

Direct financial incentives are available to a business from a state through a state-funded organization.

Indirect incentives include grants and loans from local governments, and community organization or service providers to support investment. This could include special funding for community college classes to train workers, not a direct payment to the company, but payment to aid a specific business.

Tax incentives can be deductions or credits, abatements, exemptions, refunds, deferrals and other preferential tax treatment. This is the reward to companies for creating jobs, investing capital in equipment or research, training workers, recycling or providing special employee services.

The next table shows the types and number of incentives offered by the various states competing for high-tech business.

Enabling Environment

A company moving to a new region does not expect all of the requirements to do business to be in place at the beginning of the agreement; however, the presence of strategic planning, policy development and milestone accountability are required. The partnership with organizations in the state will enable roadblocks to progress to be resolved quickly and efficiently.

Benchmarking Global Competitors - Dresden, Oregon, and Taiwan

The key point to each of the regions examined is the existence of a regional group that champions the development of an area for new semiconductor business and continues to support that business as it grows in the region. Each region has state political support and local business support. There are secondary strengths and weaknesses that contribute to long-term growth, but initial strengths and weaknesses are included in the following regional benchmarks.

Dresden Germany SWOT Analysis

The Dresden site was a business boom to Siemens, the owner of Infineon. The infrastructure contracts awarded to Siemens were a critical feature of Infineon locating in the Dresden area. Additionally, the CEO of Infineon was a major driver within Siemens regarding building and expansion of the DRAM business for Siemens/Infineon. Companies with alliances or partnerships can be attracted to an area at the same time as the major manufacturer – in this instance, Infineon.

Strengths

- Strong educational institutions focusing on Microelectronics
- Used Equipment industry existing
- Local mask makers
- Good infrastructure in place to support semiconductor fabs
- Low wage rates (EU) for skilled work force
- Low wage rates (EU) for advanced degreed technical talent
- Existing large IDM production fabs
- EU allowed Germany to provide higher incentives
- Since the reunification, new infrastructure in Eastern Germany
- Supportive local population
- Recently attracted new state of the art facilities
- New infrastructure including international airport, roads, electric
- Cultural development – world famous opera house
- Historically significant buildings with major restoration program underway

- Existing fabs for two product technologies that are likely to continue to be IDM: micro logic and memory
- Active participation by political leaders to attract semiconductor jobs
- Pan-European organization with strong track record of developing microelectronic R&D in Europe
- EU Development Panel promotes three countries as part of expansion
- Attractive to global scientific community
- Established equipment support system available in other German location
- Modern infrastructure, telecommunication, and industrial landscapes.
- International airports in Dresden and Leipzig, exceptionally developed long-distance road and rail networks, and a location in the heart of large European markets all were strong prerequisites for locating a manufacturing fab
- Political stability and the reliability of the German legal system guarantee that investments in Saxony had a solid foundation
- The vicinity of Poland and the Czech Republic provides mixed, cross-border access and development

Weakness

- Weather lacks the appeal of warmer climates
- Restriction on clearing trees for further expansion
- High cost of moving trees for expansion
- High taxes
- Restrictive labor laws
- Strong unions with political power
- Employee benefits high compared to all other regions
- Limited manufacturing of end products in Germany
- Import PCB (printed circuit boards)
- Contract packaging and test not local

Opportunities

- German governments and EU known to provide good incentives
- Continued expansion of 300mm wafer technology and the desire to locate near an already existing facility
- Europe wants to stay in semiconductor industry
- EU desire to attract and develop more high tech centers
- Established support in Dresden for semiconductor manufacturers
- Need for EU to grow and become more competitive internationally in the semiconductor/new technology industry

Threats

- Asia offers competing incentives and low wage rates
- German companies have manufacturing and technology exchange alliances with Taiwan and Chinese companies
- Competitive market pressure on German-based manufacturers to reduce manufacturing costs making Asia more attractive
- Rising value of Euro against U.S. dollar makes goods from Europe very expensive to U.S.

Competitive Opportunities for Upstate New York versus Germany

- Weak dollar makes foreign investment in the U.S. more attractive
- European companies like East Coast locations to have a presence in the U.S.
- Total management change at Qimonda / Infineon from inception
- Former Infineon CEO key player in location of Infineon / Qimonda in Dresden

Portland Oregon SWOT Analysis

Intel established the importance of the semiconductor industry in Oregon. As land values in northern California started to increase, Intel looked for other locations to expand. Oregon had many attractive features at that time, including inexpensive land, cooperative local and state governments, attractive urban and outdoor lifestyle and convenient to Northern California and Japan.

Initially, Oregon's tech sector consisted of non-microprocessor businesses. The suitability of the area has increased to make Intel Oregon's largest private employer. Other electronics companies were already present in Oregon when Intel decided to establish a presence.

The very positive aspect is that Intel is not the only high-tech company in Oregon. New companies have moved in to support semiconductor manufacturing, and spin-offs have been established that provide further growth for Oregon and for the semiconductor industry.

Strengths

- Strong educational institutions
- Universities have a strong history of commercializing university-developed innovation
- Large venture capital community
- Large number of engineering graduates
- Headquarters of leading semiconductor companies
- Large number of semiconductor R&D facilities
- Good infrastructure in place to support semiconductor fabs
- Good skilled work force
- Attracts scientific talent from around the world
- Attractive lifestyle
- Still recognized as one of the areas for semiconductor talent
- State government support for Intel and other high-tech companies
- Convenient to travel to Asia
- Tax abatements for up to ten years

- Community reinvestment area to encourage local business to reinvest for longer tax abatements
- Foreign trade zone to import goods and then export them without paying duty or excise tax to all non-NAFTA countries
- Range of semiconductor – electronics firms located in area
- Two-hour commute to San Jose
- No Sales Tax

Weakness

- High taxes overall compared to other states in region
- Land is in short supply and very expensive
- Cost of housing has increased substantially with high-tech development
- High wage rates for advanced degreed technical talent
- High cost of living
- Area suffers from earthquakes
- Limited municipal transportation for current population
- Freeway system is old and inadequate
- High amount of rainfall annually
- Industry centered around one mega-large and influential vendor

Opportunities

- Continued upgrades and expansions of existing facilities
- New fab construction is promising for locations next to existing fabs
- Efforts by other states keeps active teams working to attract new businesses
- Committed support at state and local level
- Environment for start-ups based on companies currently in area – similar to spin-offs of new companies in Silicon Valley
- Intel cooperates to keep good working relationship with the state and local governments

Threats

- Other locations offer more incentives to locate a fab
- Trained engineering talent is a target for repatriation to newly-industrialized economies such as Singapore, Taiwan, Malaysia
- Large number of visas to foreign engineers to keep salary costs low
- Countries recruit and offer incentives to foreign-born engineers willing to return home to Taiwan, India, China, Russia, etc.
- Shortage of U.S.-educated science and engineering students

Competitive Opportunities for Upstate New York versus Portland

- Not dominated by Intel
- Scientific community developing next-generation technology and products
- Rural atmosphere – reminiscent of why many located in Oregon at the beginning
- Opportunity to build a new region for companies
- Association with Albany NanoCollege and Sematech

Taiwan Industrial Parks SWOT Analysis

Taiwan has established its role in the semiconductor industry with the development of industrial parks. The success of the foundry business drew attention to the benefits of high tech ventures. The industrial parks enabled Taiwan to quickly establish the necessary infrastructure in an area to assure semiconductor companies that the area could support manufacturing. Additionally, very generous tax programs for companies doing business and adding new facilities made the area very attractive to memory manufacturers and sub assembly contractors.

Strengths

- Good infrastructure in place to support semiconductor fabs in industrial parks
- Good skilled work force
- Land still available in the new science park
- Five-year tax-free environment
- Existing foundry base
- Large computer and consumer manufacturing base
- Already has two existing high technology industrial parks
- Building a $14 billion high-speed rail project between two science parks
- Developed industrial base and strong vertical integration in electronics sectors
- Largest venture capital industry in Asia – 231 venture capital firms operating in Taiwan
- Harbor infrastructure for shipping within Asia
- Emphasis on R&D – ranking fourth in patents behind the U.S., Japan and Germany
- Entrepreneurial spirit with majority of businesses medium to small
- Innovative and creative businesses created and sustained around semiconductor companies
- Taiwan a test market for companies looking to invest in Mainland China – offer help to international companies entering Chinese market
- Proximity to end-product manufacturers in Asia

- Commitment and investment will enable Taiwan to have mobile networks throughout the country in 2008
- Major investment in education – university level
- Rapid transit railway system expanding
- Desalinization project to ensure water sources
- Department of Investment Services (under the Ministry of Economic Affairs) provides assistance to starting a business in Taiwan
- Aggressive tax incentives for high-tech industry
- Schools for children provided in industrial park
- Housing provided in industrial park

Weakness

- Natural disasters common – earthquake and typhoon threats
- Rapid expansion of industrial parks challenge utility reliability
- Uncertain political tension with Mainland China
- Wages increasing
- Immigration a problem for work force – large influx of unskilled workers
- Costly incentives to attract skilled foreign engineers and scientists
- Relies upon international brand names to sell semiconductor output
- Lacks regional brand identification worldwide
- Jobs moving to mainland China – economic threat may be higher than military
- Island – limited land
- Manufacturing, not design, center of Asia – depends upon outside design innovations
- Require external access to oil and natural resources
- Does not attract scientific community from around the world
- High-density living conditions
- Poor air quality

Opportunities

- Site of world's leading foundry – key supplier to many U.S. (fabless) semiconductor companies
- Continued upgrades and expansions of existing facilities in industrial parks
- Existing foundries building 300mm production facilities to offer leading-edge technology
- Continued support from local government and existing businesses
- International companies have alliances or licenses with Taiwanese companies to provide them with design and product technology
- Hub of subcontracting companies in Asia
- Strong competitors in the memory segment of the market

Threats

- China and Singapore attracting new investments away from Taiwan
- Cost of operations continues to increase
- Malaysia foundry fabs succeed in attracting business away from Taiwan foundries
- 300mm wafers takes much longer to implement, allowing other foundries to gain market share
- IDMs lower usage of foundries causing excess foundry capacity
- Commitment to memory market makes country vulnerable to supply and demand swings as well as other countries being competitive on a worldwide basis

Competitive Opportunities for Upstate New York versus Taiwan

- Close to R&D technology development occurring on the East Coast
- Attractive rural life style
- More opportunities to attract skilled workers for lifestyle
- Prestige of working with Albany NanoCollege

New York SWOT Analysis

The Upstate New York area is potentially a prime location for a semiconductor facility. The current importance of establishing the area hinges on the start of construction by AMD. An important challenge to overcome is the perceived distance from other manufacturing sites for this company. Upstate New York is far from Austin, Texas, but the current AMD CEO (while employed by another firm) moved corporate headquarters from Arizona to Texas. The advantage of being a leader in establishing in a new area, with new opportunities can be a driver for the start of construction. The vision of establishing a strong future direction for a company in a new location is a powerful plus.

Strengths

- Strong educational institutions
- University at Albany has a state-of-the-art prototyping laboratory
- Albany NanoCollege Center known worldwide
- Albany and IBM attract scientists from international community
- International Sematech
- Established base of nanoelectronics development
- State government funded a $1 billion high-tech initiative for advanced university R&D and economic outreach
- NY ♥ Nanotech regional brand identity program
- Large number of engineering graduates
- Good infrastructure in place to support semiconductor fabs
- Good skilled work force
- Transportation infrastructure in place
- Reliable utilities infrastructure in place
- Attractive rural lifestyle – family friendly

Weakness

- Does not have a concentration of existing high technology companies
- Perceived as highly unionized, high cost location

Opportunities

- Continued upgrades and expansions of existing facilities
- Building a 300mm pilot line to train skilled technicians and engineers
- Continued support from local government and existing businesses, i.e. IBM

Threats

- Increased competition from other global locations such as Singapore, Taiwan, Japan, China and India, possibly even Russia.

Benchmark Summary

The following table summarizes some of the decision points of the various regions along with Upstate New York. There are, of course, additional subjective issues, but overall, Upstate New York fares very well in a comparison to other established areas.

In comparison to all of the listed areas, it has benefits accruing from the Albany NanoCollege, International Sematech and proximity to IBM that the other sites did not have at the time of their development. The advantage of the availability of access to Albany NanoCollege and International Sematech is a very big selling point for the region.

Table 10. Benchmark Comparison

	Upstate NY	Dresden, Germany	Taiwan Science Parks	Portland, Oregon
Urban Amenities	Travel to Urban Centers	Urban Setting	Urban Setting	Rural/Urban Setting
Outdoor Amenities	Rural Setting	Travel to Outdoor recreation	Travel to Outdoor recreation	Easy access to Outdoor recreation
Cultural	NYC	Dresden/International destinations	Taipei/International destinations	Portland/San Franciso
Universities	World Class -East Coast	Europe	Taiwan/International	Oregon/International
Transportation Infrastructure	Planned expansion	Modernized in mid-90's	Ongoing	Freeways inadequate for population growth
Science Education	East Coast Universities	Emphasized	Emphasized	State and West Coast Universities
R&D Centers	Albany NanoCollege /IBM/Cornell	European and German	Limited	Rely on Silicon Valley
Design Centers	Albany NanoCollege /IBM	International and Local	International	Local and Fabless Semiconductor Companies
Utilities Infrastructure	Developed and Planned	Modernized in mid-90's	Modernized in mid-90's	Developed and Planned
Natural Disasters	Winter Weather	Winter Weather	Earthquakes/Typhoons	Earthquakes/winter rains
Proximity to End Customers	Needs to be developed	European customers/close to Asian and African customers	Asian Customers	Easy transportation to Asia and US Customers
Foreign Scientist	Must attract	Easily attracted	Attract US-trained and American workers	Attract international workers
Government Assistance	Yes	Yes	Yes	Yes
Technology	Leading	Leading/Legacy	Leading/Legacy	Leading/Legacy
Other IC-related Companies	Need to be developed for region - present in state	Limited - continue development	Good support for leading Foundry	Good support for leading Semiconductor Company
Cost of Living	Moderate	Very High	High	Rising

Source: Semico Research Corp.

Economics: Upstate New York (Example County – Oneida)

New York State has an active program to attract new technology to the region. The semiconductor industry outreach and attraction efforts offer a unique opportunity to prospective companies.

Residential Market

- Mohawk Valley represents 0.1% of the nation's households
- Cost of living 9% below national average
- Median income is 97% of the national average, while the median home cost is 62% of the average
- Average 2 bedroom apartment rent is 86% of the national average
- Water quality is one of the highest in the nation ranking 60% above the national average based on EPE water quality index
- K-12 Pupil/Teacher Ratio is 91% of the national average
- 5 higher education schools, two 4-year and three 2-year institutions

Business

- Downtown and suburban lease rates are 69% of the national average
- Industrial lease rates and 67% on the national average
- Construction cost for industrial space is 98% of the national average
- Construction cost of office space is 93% of the national average

The upstate New York counties involved in this project do not have a developed electronics/semiconductor base; however, during the past 10 years the State of New York has established a significant foothold in nanoelectronics with a 300-acre NanoCenter at the State University of New York Institute of Technology. The state program, NY ♥Nanotech, has given New York world recognition as premier center for the development of innovative technology.

Upstate New York can capitalize on the success of New York's nanoelectronics program and the synergy with the semiconductor industry with the building of a 300mm wafer fab.

Overview of the Economic Impact

A semiconductor manufacturing fab will have a financial impact on the state from the planning start date of construction. Following is a high level list of impact of the fab itself. The impact of the construction is covered under construction issues.

Impact on New York State and Local Areas

Following is a list of some of the positive aspects of the location of a semiconductor fab to Upstate New York. Additional jobs at higher wage rates are the immediate benefit.

- Employment of entry level personnel
  - Skill set required
  - One year's experience
- Salaries
  - Wafer operators (staring salaries) $40,000
- Skill set salaries for fab workers
  - Engineers 80% or 352 moving to area
  - Management 70% or 69 moving to area
  - Support Staff 40% or 26 moving to area
  - Fab operators 30% or 148 moving to area
- Salaries
  - Engineers average salary $75,000
  - Management average salary $110,000

The construction of a manufacturing plant will bring construction laborers to the area along with families for the one to three years required to build. Because additional construction of new homes and businesses will be required for the increased population, a large percentage of the construction people will stay in the area. Additional employment of people moving/migrating to the area will also include support for the fab.

Support jobs for the fab include the following list. Jobs are not limited to this list.

- Fab garment cleaning
- Computer sales maintenance
- Warehousing
- Delivery service
- Chemical disposal
- Satellite equipment offices
- Specialty products
- Maintenance
- Training
- Private security

Additional jobs revolving around the fab are the suppliers of equipment, materials and services. Included in this number are jobs for spouses and work age children.

Table 11. Additional Jobs Created by Fab

Direct Jobs	435
Direct earnings	$17.4 million
Multiplier Effect Jobs	634
Multiplier Earnings	$25.4 million

Source: Semico Research Corp.

With increased population come increases in the services area. Doctors, teachers, lawyers, accountants, sanitation workers, etc are added to the required job support base. Real estate demand is projected to increase about 15% in two to three years.

This all equates to an increase in the tax base (property, sales, income, etc.). Direct state generated revenue and additional business per year is represented below.

Table 12. Additional State Generated Revenue

Income Taxes	$14.4 million
State Sales taxes	$19.2 million
County Sales taxes	$20.3 million
Added business to economy	$370.1 million

Source: Semico Research Corp.

Table 13. Additional Jobs Created in the Community

Additional Jobs	2,419
Additional Earnings	$98 million
State Sales Tax	$2.1 million
County Sales Tax	$2.2 million
Additional State Income Tax	$6.7 million

Source: Semico Research Corp.

New jobs and growth would stimulate local area schools and healthcare expansion. Assuming 1.5 children per household, 894 new children would need to attend local schools.

Workforce education and retraining programs would be needed to provide a long-term supply of skilled workers for the manufacturing jobs. In order to only recruit 30 to 60 percent of employment from out-of-area there will need to be workforce education and retraining. This will come from local schools and local company programs. Some counties in Oregon specialize in cooperative retraining programs to keep jobs in Oregon.

Synergies with educational institutions and universities (R&D) such as SUNY need to be coordinated to achieve increased employment levels.

Private company and small business investment is a gradual incremental increase. This ranges from the expansion of chains to new shopping centers. Other investment, of course, is with the support business from the fabs that were listed previously.

Expansion of infrastructure such as transportation (highways, airport, etc.), utilities (water, sewer, electric, gas, telecommunications, etc.), public services (police, fire, etc.), education (schools, universities), R&D centers – are all part of the expansion of employment and revenue generation for the area. Some of this expansion will be accomplished with companies and organization present in other locations in New York.

The following is the ROI for the State of New York on the investment to attract a semiconductor manufacturing plant.

The state investment is estimated at $650 million.

Benefits to the state are defined as the following:

- Additional State taxes
- Additional County taxes
- Jobs from the attracted manufacturing company
- Jobs to support the manufacturing process
- Jobs to support workers of the manufacturing company and the support businesses
- Added value to the community in the form of:

    Stronger real estate market

    More economic opportunities for the citizens

Significant manufacturing operations tend to stimulate the cultural aspects of a community like:

    Performing arts

    Museums

    Charities

Summary of Economic Benefits

Jobs head the list driving economic improvement to the state. Building and operating a semiconductor manufacturing facility was examined in two phases. The construction phase impact comes first.

Phase 1 Construction

The number of jobs for construction is based on statistics from other 300mm fab construction projects.

Table 14. Additional Jobs Created in the Community

Job Definition	Number Employed
Construction jobs 1.4 years	1500
Additional jobs for the multiplier affect	2550 (1.7 employment multiplier used)

Source: Semico Research Corp.

The fab construction will add jobs up to two years before the manufacturing fab is opened. These are commercial firms with first-class operations. Union workers will be employed and salaries will be at scale or above for the region. These are construction firms that comply with all federal and state regulations. Construction workers are experienced and qualified for their jobs. Salaries are commensurate with the level of expertise.

Building - Brick and Mortar Trades = $300 million, 1-2 years (The shell plus wages)

Masons

Electricians

Plumbers

Communication technicians

Following the completion of the fab shell, the addition of equipment is the next step. This is a lengthy process that leads to the full production capabilities of the manufacturing facility. The following lists the number of people estimated to accomplish this step.

Facilitizing with semiconductor fab equipment = $3 billion, 1-2 years

Company technicians = 100

Company Process engineers = 75

Company facility engineers = 25

Support company technicians = 50

Employments During Construction

Brick and Mortar

1500 trades workers for 1.4 years

$135 million in W2 earnings

Multiplier affect from construction spending is $353 million

State income tax from labor W2 = $16.3 million

State sales taxes = $7.5 million

County sales taxes = $8.0 million

Incremental state and local sales and income tax is $31.9 million

One typical semiconductor fabrication plant uses

- Greater than or equal to the amount of power as 7500 houses
- Nearly 1 billion gallons of water per year

Phase II Fab Job Generation

The construction job phase generates employment for workers who will probably leave the area at the completion of the fab. Some may be employed in the area to build new houses and businesses. The jobs generated by the fab itself will be long-term and permanent jobs. The following table presents the number of jobs for a full production fab.

Table 15. Manufacturing Jobs

On Site Jobs	Number of Jobs
Wafer Fab Operators	495
Engineers	440
Management	99
Support Staff	66
Outside Vendors on-site	60
Total on-site Jobs	**1160**
Jobs Multiplier from Fab	894
Total Jobs	**2054**

Source: Semico Research Corp.

There is also an outside support industry that generates jobs including, but not limited to: fab garment cleaning, computer sales/maintenance, warehousing, delivery service, chemical disposal, satellite equipment office, specialty products, training, private security.

Table 16. Support Industry Jobs

Offsite Jobs	Number of Jobs
Support industry jobs	435
Multiplier for offsite jobs	634
Total Jobs	**1069**

Source: Semico Research Corp.

Looking at the numbers, it becomes obvious that the impact of a manufacturing fab will have a very positive effect on the employment of the Upstate New York region as well as for the state as a whole. The following table shows jobs by project phase.

Table 17. Jobs by Project Phase

	Base Jobs	Potential Upside Jobs
Total Jobs Phase I	1500	2550
Total Jobs Phase II	4014	634
Total Jobs	**5514**	**3184**

Source: Semico Research Corp.

Potential upside jobs are dependent upon a number of unpredictable variable situations. Construction can be expedited and that adds more jobs. Condition of the infrastructure and availability of existing services impacts potential job upside.

Tax Revenues

The two phases of the project will generate revenue from the beginning of construction in the area. Again, the revenue numbers are presented by phase of the project. The brick and mortar or Phase I is expected to last 1.4 years.

Table 18. Phase I Brick and Mortar

Income Tax Revenues	Revenue
State Income Tax for Labor	$14.4 Million
State and Local Sales Tax	$19.2 Million
County Sales Taxes	$20.3 Million
Added Business to the Economy	**$370.1 Million**

Source: Semico Research Corp.

Phase II of the project begins with the installation of equipment in the fab and the addition of personnel. Following is the tax generation from Phase II.

Table 19. Phase II Production

Source	Revenue
Annual Taxes on Consumed Materials	$14,150,453
Income Tax on Fab Jobs/Support Industry	$ 7,696,660
Sales Taxes from W2 Spending	$20,093,319
Multiplier Job Sales Tax	$ 4,300,169
Multiplier Income Tax	$ 6,732,836
Total Tax Revenue	**$52,973,437**

Source: Semico Research Corp.

Additional Economic Value to the State

Phase I and Phase II have additional impact on the economy from salaries and materials. The following table shows that revenue impact.

Table 20. Labor and Materials for Phase I and II

Phase/Item	Revenue
Phase I Brick and Mortar	
Labor	$135,000,000
Multiplier Effect	$353,480,000
State Income Tax from Labor	$16,339.305
Sales Tax W2 labor and Multiplier Effect	$15,534.225
Phase II Production	
Multiplier affect	$370,104,749
Income Taxes from W2's	$7,696,660
State & County Sales Taxes	$39,558,455

Source: Semico Research Corp.

Fab Economics When Operational

The cost to build and facilitize a 300mm fab is $3 billion. Assuming Empire Zone benefits, this amount is being treated as if it were tax exempt as it pertains to property taxes. Following are employment and material consumption numbers for the fab when it is in full production.

Table 21. Fab Labor

	Jobs	Revenue
Total Direct Employment	1100	$66,396,000
Industry Infrastructure Support	60	$3,200,000
Total Labor	1160	$69,596,000

Source: Semico Research Corp.

Table 22. Materials Consumption per Year

Material	Quantity	Unit Cost	Revenue
Wafers	360,000	$150	$54,000,000
Chemical/Gases	360,000	$225	$81,000,000
Power to Process Wafers kWh/cm2	1.25	$.08	$25,446,900
Water Gallons/year	986,486,486	$0.00075	$739,865
Waste Water	394,594,595	.00135	$532,703
Total Material Costs			$161,719,468

Source: Semico Research Corp.

The materials consumed and labor all equate to revenue generated for the state. The following table shows the yearly income that will be generated by the above when the facility is in full production.

Summary of Data

The numbers show that the addition of a semiconductor manufacturing plant would generate revenue for the state. Based on a state outlay of time, payback occurs within the first 12 months. There is an upside to this number should upstate New York be successful in adding other companies to the list in the immediate future.

Table 23. Five Year ROI

	Revenue
5-Year Direct Tax Increase	$532,296,675
5-Year Addition to Local Economy	$2,840,249,119
Total	$3,372,545,793

Source: Semico Research Corp.

An ROI is calculated in the following manner:

(Gain from investment – Cost of investment)/ Cost of Investment

Additionally, Semico has provided a 6-year Net Present Value of the investment compared to added benefits to the economy and increase in taxes. The NPV assumes a 4% interest rate and a $1 billion investment from the government for incentives and infrastructure. Semico presents a 6-year Net Present Value (NPV) of the investment compared to added benefits to the economy and increase in taxes

The ROI for five years and ten years is:

- 5-yr = 466%
- 10-yr = 609%

Alternatively, one can look at in a Net Present Value Analysis where the investment outlay is assumed to be in the beginning of the project and the returns occur over time and a discount rate is applied to the future stream of benefits to adjust the dollar value back to constant dollars. In this analysis a discount rate of 4% is use over the 6-year time frame.

The NPV calculation assumes a $650 million inflow from the state and an offsetting economic benefit of $300 million from construction followed by 4 years of economic benefit from plant production. The five-year NPV of the state's $650 million investment from additional revenue is $129 million. Adding in increased economic value to the region the NPV jumps up to $1.88 billion.

The cost of jobs for New York State assuming $650,000,000 investment would be as follows.

- The cost per job of $117,884 includes:
    - Construction Personnel
    - Fab
    - Support Industry
    - Local Business Jobs

Table 24. Ten-Year ROI

	Revenue
10 year State direct tax* revenue increase:	$711,773,111
10 year County direct tax* revenue increase:	$414,028,530
10 year additional GDP from multiplier effect:	$5,678,840,086

Source: Semico Research Corp.

*sales/income tax for consumables in the fab and increased purchases by new consumers

Yearly Return on Investment

The state does not wait until Year Five or more to see a return on investment. Benefits of the location and start of construction on the semiconductor fab begin in Year One. The following table presents the State Revenue and added GDP. Over a ten year period, close to $4 billion is generated in New York state revenue. The yearly detail is presented in the following table.

Table 25. Yearly Return on Investment

	State Revenue	Added GDP	Total
Year 1	$23,884,500	$353,480,000	$377,364,500
Year2	$40,516,680	$537,990,331	$578,507,012
Year 3	$41,732,181	$554,130,041	$595,862,223
Year 4	$42,984,147	$570,753,943	$613,738,089
Year 5	$44,273,671	$587,876,561	$632,150,232
Year 6	$45,601,881	$605,512,858	$651,114,739
Year 10	$51,325,318	$681,510,056	$732,835,375

Source: Semico Research Corp.

Breakeven

The breakeven period for the investment that the State of New York would be required to attract a semiconductor fab to Upstate New York begins in the first 12 months. The breakeven calculation is based upon the following:

- Summing the value of additional taxes
- Plus the additional value added to local economy
  - Similar to calculating value additions to GDP
- Includes the value of construction and the fab starting operation and moving to full production

This report presents substantial and necessary statistics and facts about the semiconductor industry. The number of jobs that can be created by the establishment of a semiconductor facility in the Upstate New York area is impressive. Additionally, the enhanced levels of employment and income would be a definite plus to the tax coffers of the state.

As noted in the SWOT analysis, all areas have advantages. It is the commitment of the area that attracts a company. New York needs and deserves to have a 300mm semiconductor facility built in the Upstate area.

APPENDIX

APPENDIX TABLE 1. Top Semiconductor Manufacturers and Primary Products

IDM	
Company	Primary Product
Intel	Logic, Memory
Samsung	Memory
TI Logic, Analog	
Toshiba	Memory
STMicroelectronics	Logic, Memory
Infineon	Logic
Qimonda	Memory
Renesas	Logic
NEC Logic	
NXP Logic	
Hynix	Memory
Freescale	Logic, Analog
Micron	Memory, Opto
Sony	Logic
AMD	Logic, Memory
Analog Device	Logic, Analog
Fujitsu	Logic
Spansion	Memory
National Semiconductor	Analog
Elpida	Memory
Sharp	Memory
Maxim	Analog
Atmel	Logic, Memory
Fairchild	Analog
On Semiconductor	Analog
Nanya	Memory
Powerchip	Memory
ProMos	Memory
MicroChip	Logic
OKI Logic	
Matsushita	Logic
RFMD	Analog
Foundry	
TSMC	Logic
IBM Logic	
SMIC	Memory, Logic
Chartered Semiconductor	Logic
First Silicon	Logic
Siltera	Logic
Tower	Specialty Logic, Analog
Jazz Semiconductor	Analog
Grace Semiconductor	Memory, Logic
Hahung/NEC	Logic
AMI Specialty Logic	

Source: Semico Research Corp.

Semiconductor Glossary of Acronyms

Courtesy of Applied Materials

200mm A size of silicon wafer approximately 8-inches in diameter.
300mm A size of silicon wafer approximately 12-inches in diameter.
Abatement A process where toxic or other hazardous substances are removed from a liquid or gas. (e.g. removing copper particles from CMP slurry)
ADC Automatic Defect Classification. Defects found by wafer inspection systems are classified by the system into several categories based on their physical and optical properties.
Advanced Patterning Films (APF) A strippable hardmask (an amorphous carbon/DARC stack film) that is designed to replace the spin-on ARC in typical trim procedures.
Aluminum Chemical Vapor Deposition (ALCVD) A CVD process that results in deposited aluminum on a substrate.
Aluminum Interconnect Aluminum pathways within a microchip that connect the transistors.
Aluminum Low Pressure Seed (ALPS) ALPS was originally an aluminum process, now also used for other metal PVD processes.
Ambient Control Chamber (ACC) A Synexis chamber that stores and pressurizes in-process wafers. The chamber attaches to the side of the factory interface and is fed by the FI robots.
Amorphous silicon A type of silicon deposited on a variety of surfaces (rigid and flexible) with thin homogenous layers. Amorphous silicon absorbs light more effectively than crystalline silicon, so the cells can be thinner. For this reason, amorphous silicon is also known as a "thin film" photovoltaic technology.
Angstrom (Å) A unit of length; one ten-billionth of a meter.
Anneal A high-temperature processing step (usually the last one) designed to repair defects in the crustal structure of the wafer.
Anti-Reflective Coating (ARC) A light-absorbing metal layer (typically titanium nitride), deposited on top of metal or polysilicon, to improve photolithography performance.

APCVD Atmospheric Pressure CVD refers to systems whose deposition environments operate at or near atmospheric pressure. Typically, wafers are placed horizontally on belt-driven flat susceptors that move through the deposition zone. Belt speed and gas flow determine the film thickness.

Aspect ratio The ratio of depth to width of a via or contact structure.

Atomic Layer Deposition (ALD) A specialized CVD process required for <100nm deposition.

Automated Process Control (APC) A computer controller for gas panels used within semiconductor manufacturing.

Back-end of Line (BEOL) The series of process steps from contact through completion of the wafer, prior to electrical test. Also known as the back-end of semiconductor manufacturing.

Barrier A physical layer designed to prevent intermixing of the layers above and below the barrier layer.

Bunny Suit Special clothing worn by people working in clean rooms that reduce the amount of particles that could damage a semiconductor.

Capacitor A device used to store electrical charge in a circuit and smooth out irregular current.

CD Critical Dimension is the width of a patterned line or the distance between two lines of the sub-micron sized circuits in a chip.

Chemical Mechanical Planarization (CMP) is a process that uses an abrasive, corrosive slurry to physically grind the microscopic topographic features on a partly processed wafer flat (planarization) so that subsequent processes can begin from a flat surface.

Chemical Vapor Deposition (CVD) is a process for depositing thin films from a chemical reaction of a vapor or gas.

Chip A small piece of a silicon wafer that contains a complete integrated circuit.

Circuit The combination of many connected electrical elements to accomplish a desired function.

Cleanroom The portion of a fab where semiconductors are manufactured. These rooms are strictly monitored to ensure successful manufacturing of semiconductors.

Color Filter (CF) The section of a flat panel display that is broken into areas of red, green and blue. Using a transistor, varying amounts of lights are transmitted through the color filter to create millions of colors.

Complimentary Metal Oxide Semiconductor (CMOS) Any MOS device that incorporates both p-channel and n-channel transistors within the same silicon substrate. CMOS devices are noted for low power requirements, high immunity to electrical noise, and relatively slow speed.

Computer Integrated Manufacturing (CIM) is manufacturing supported by computers. It is the total integration of Computer Aided Design/Manufacturing and also other business operations and databases.

Conductor A material that conducts current.

Contact The portion of a microchip that is between the copper or aluminum interconnect and the transistor. This area is often filled with tungsten.

Contact diameter The diameter of the metal structure used to connect the doped contact area formed in the silicon base material to the metal interconnect.

Copper Interconnect Copper pathways within a microchip that connect the transistors. Copper interconnects provide better microchip performance when compared to aluminum interconnects.

Copper seed layer A thin copper layer deposited by physical vapor deposition over the barrier layer. It acts as a wetting and nucleation layer for growth of the subsequent copper film deposited by electroplating.

Critical Dimension Scanning Electron Microscopy (CD-SEM) A type of Scanning Electron Microscope used to measure critical dimensions.

Crystalline A material that has atoms arranged in an ordered periodic array.

Damascene An integrated circuit process where a metal conductor pattern is embedded in a dielectric film on the silicon substrate, resulting in a planar interconnection layer. The creation of a damascene structure most often involves chemical mechanical planarization of a nonplanar surface resulting from multiple process steps.

Decoupled Plasma Nitridation (DPN) A method for creating an advanced oxynitride gate dielectric with high nitrogen incorporation at the oxynitride/poly interface and low nitrogen at the Si/oxynitride interface.

Decoupled Plasma Source (DPS) A technology used within conductor etch that separates the management of plasma density and bias power, resulting in the ability to provide a uniform high ion density over a large process window, maintain a linear plasma density dependence on the inductive RF power and apply a minimum bias power.

Deep ultraviolet (DUV) The portion of the ultraviolet light spectrum with wavelengths below 300nm.

Defect Inspection A process where defects are located on a patterned wafer.

Defect Review Scanning Electron Microscopy (DR-SEM) DR-SEMs classify defect types during the wafer manufacturing process at a very high magnification and determine whether these defects will affect chip yields. DR-SEMs are typically used in the critical layers of the device structure at 0.25 microns and below.

Deposition A process used to deposit a thin layer of insulating or conductive material onto the wafer.

Design rules Rules that outline the allowable dimensions of features used in the design and layout of integrated circuits, such as limits for feature size, and layer-to-layer overlap.

Dielectric A material that conducts essentially no current when it has a voltage across it: an insulator. Two dielectrics commonly used in semiconductor processing are silicon dioxide (SiO_2) and silicon nitride (SiN).

Dielectric Anti-Reflective Coating (DARC) A non-reflective, non-energy-absorbing, inorganic dielectric layer deposited on top of metal or polysilicon to improve photolithography performance. DARC layers make it possible to accurately transfer the mask pattern onto the photoresist and are typically used in advanced devices such as 256Mb DRAMs and beyond.

Dielectric Anti-Reflective Layer (DARL) Another name for dielectric anti-reflective coating (DARC).

Dielectric Film A non-conducting film. In integrated circuits usually $Si0_2$ (Silicon Dioxide)

Dopants An impurity added in controlled amounts to a material in order to modify some intrinsic characteristic, such as resistivity/conductivity or melting point.

Doping Adding a controlled amount of impurities to a material in order to modify some intrinsic characteristic, e.g., resistivity/conductivity, melting point.

Double-layer Metal (DLM) The number of metal layers used to personalize an ASIC die.

Electochemical Plating (ECP) A deposition process in which metals are removed from a chemical solution and deposited on a charged surface.

Epi or Epitaxy A process technology used in some semiconductor designs where a pure silicon crystalline structure is deposited or "grown" on a bare wafer, enabling a high-purity starting point for building the semiconductor device.

Equivalent Oxide Thickness (EOT) A number used to compare performance of high-k dielectric MOS gates with performance of SiO_2 based MOS gates.

Etch A process for removing material in a specified area through a chemical reaction.

Etch Stop Layer (ESL) A layer of film used to identify a place for etching to stop. For example, a nitride layer can be deposited over a poly layer to signal the etch process to stop before etching the poly layer.

Fab A facility for manufacturing semiconductors.

Flat Panel Display (FPD) A consumer display device that uses advanced technologies to create televisions and computer monitors. Flat panel displays can be created using thin-film transistors, organic light emitting diodes or plasma technologies.

Flexible Printed Circuit Boards (FPCB) A flexible dielectric substrate having circuit lines attached to one or more surfaces. The flexible printed circuit board is widely used and can be divided into four types according to function: lead line, printed circuit, connector, and integration function system.

Front-end of Line (FEOL) Front-end processes include: Thermal Processes, Implantation, Chemical Vapor Deposition (CVD), Photolithography, Etching, Physical Vapor Deposition (PVD), Polishing, Process Diagnostics and Control (Metrology), and Cleaning.

FSG Fluorine-doped Silicate Glass is a reduced dielectric constant (k=approximately 3.5) material made by doping SiO_2 with fluorine.

Gate An electrode that adjusts the flow of current in a metal oxide semiconductor transistor.

Gate Stack The gate/oxide structure in a MOSFET/CMOS.

Geometry A circuit line or etched feature on a chip.

Hard Mask A hard nitride layer deposited on top of a polysilicon gate, increasing the adhesion of the resist at edges.

High Density Plasma (HDP) A plasma featuring a high concentration of free electrons, and hence, a high concentration of ions.

High Density Plasma Chemical Vapor Deposition (HDPCVD) A CVD process that incorporates high-density plasma.

High Temperature Oxide (HTO) A high temperature process that deposits an oxide layer on a wafer.

Implant An abbreviation for ion implantation

Indurium Tin Oxide (ITO) A transparent, conductive material often used when creating thin-film solar cells.

Insulator Nonconductive dielectric films used to isolate electrically active areas of the device or chip from one another. Some commonly used insulators are silicon dioxide, silicon nitride, boro-phospho-silicate glass (BPSG), and phospho-silicate glass (PSG).

Integrated Circuit (IC) A fabrication technology that combines components of a circuit on a wafer.

Interconnect The wiring in an integrated circuit that connects the transistors to one another.

Interlayer Dielectric (ILD) Films used between metal layers of an IC for insulation.

Intermetal Dielectric (IMD) Insulating films used between adjacent metal lines; typically silicon dioxide.

Ion Implantation A process technology in which ions of dopant chemicals (boron, arsenic, etc.) are accelerated in intense electrical fields to penetrate the surface of a wafer, thus changing the electrical characteristics of the material.

Junction The interface between two semiconductor regions of differing dopant types. Usually refers to a p-n junction, at which the conductivity semiconductor changes from p-type to n-type.

Lattice An orderly arrangement of atoms in the crystal wafer.

Layering A process of depositing thin layers of metal or insulators onto a wafer during the wafer fabrication process using deposition and oxidation techniques.

Linewidth The width of a metal interconnect.

Liquid Crystal Display (LCD) A type of flat panel display that uses an array of backlit thin film transistors to control a display process.

Litho Enabling A set of processes that enhance the lithography process.

Lithography The transfer of a pattern or image from one medium to another, such as from a wash to a wafer.

Load Locks Isolation chambers that allow a process chamber to be protected from ambient conditions.

Low k A dielectric material having relatively greater insulating ability than silicon dioxide (SiO_2), usually with a $k<3.5$.

LPCVD Low Pressure CVD refers to systems that process wafers in an environment with less than atmospheric pressure. LPCVD systems may be furnaces that process wafers in batches, or single-wafer systems.

Mask A flat plate that is used to transfer desired geometries for one process layer onto the surface of a wafer.

Material Control System (MCS) A computer-controlled system that controls the flow of physical items in a manufacturing environment.

Metallization The deposition of a layer of high-conductivity metal (such as aluminum) used to interconnect devices on a chip by CVD or PVD. Metals typically used include aluminum, tungsten and copper, etc.

Metrology The science of measurement to ascertain dimensions, quantity, or capacity; the techniques and procedures for using sensors and measurement equipment to determine physical and electrical properties in wafer processing.

Micron (µm or micrometer) A unit of length; one-millionth of a meter or about forty-millionths of an inch. A human hair is approximately 100 microns wide.

Microprocessor An integrated circuit that contains the basic arithmetic, logic and control circuitry required for processing.

Monocrystalline silicon A type of silicon that has a single and continuous crystal lattice structure with almost no defects or impurities.

Multicrystalline silicon A type of silicon that is cast into ingots using grains of monocrystalline silicon. The ingots are then sliced into wafers and used in the manufacturing of mircrochips and photovoltaic cells.

Nanomanufacturing Technology Solutions for the semiconductor manufacturing industry that are focused on dimensions smaller than 100nm.

Nanometer (nm) A unit of length; one billionth of a meter.

NMOS An n-channel MOS transistor; in an NMOS device the channel is negative during conduction.

Nucleation Layer A thin layer of film that promotes the growth of the subsequently deposited film.

Organic Light Emitting Diode (OLED) A mechanism of light emission where radiation is emitted as a result of electron-hole interactions in a thin film organic semiconductor, leading to the formation of exciton; de-excitatipon of excitons results in photon emission.

Passivation The final layer in a semiconductor device that forms a hermetic seal over the circuit elements. Plasma nitride and silicon dioxide are the materials primarily used for passivation.

PECVD Plasma Enhanced Chemical Vapor Deposition is a process where plasma is used to lower the temperature required to deposit film onto a wafer.

Perflourocompound (PFC) A class of gas byproducts created in the manufacturing of semiconductors. PFCs are most commonly seen in CVD processes and can be reduced by an abatement solution.

Phase Shift Mask (PSM) A conventional mask that phase shifts the light passing through transparent portion of the mask. Phase shifting increases resolution of the pattern transfer with destructive interference, preventing resist exposure in the regions in which it should not be exposed.

Photolithography A process by which a mask pattern is transferred to a wafer, usually using a "stepper."

Photoresist A light-sensitive organic polymer that is exposed by the photolithography process, then developed to produce a pattern, which identifies some areas of the film to be etched.

Photovoltaic A process where sunlight is converted to electricity.

Planarization The process by which an uneven wafer surface is made relatively flat using a low-selectivity etch.

Plasma Display Panel (PDP) A type of flat panel display where visible light is created by phosphors excited by the discharge of an inert mixture of noble gases (typically neon and xenon).

Plasma Ionized gases that have been highly energized—for example, by a radio frequency energy field.

PMD and Contact The area of a semiconductor transistor that is made up of the pre-metal dielectric and contact plug.

PMOS P-channel MOS transistor where the active carriers are holes flowing between p-type source and drain regions in an electrostatically formed p-channel in an n-type silicon substrate. The channel, the source, and the drain are made of a p-type semiconductor material. (HWDI series)

Polycide A material formed by reaction of polysilicon with a metal.

Polysilicon (Poly) Polycrystalline silicon; extensively used as conductor/gate materials in a highly doped state. Poly films are typically deposited using high-temperature CVD technology.

Post Nitridation Anneal (PNA) An RTP process used within the creation of the gate stack.

Pre-metal Dielectric (PMD) Films that insulate between the wafer and first metal layer.

Process A group of sequential operations in the manufacturing of an integrated circuit.

Process chamber An enclosed area in which a process-specific function occurs during wafer manufacturing.

Process Integration Optimizing each process step to work correctly with the prior and subsequent steps in a sequential process flow.

PVD Physical Vapor Deposition (also called sputtering) is a process technology in which molecules of conducting material (aluminum, titanium nitride, etc.) are "sputtered" from a target of pure material, then deposited on the wafer to create the conducting circuitry within the chip.

Radio Frequency (RF) Electromagnetic energy with frequencies ranging from 3 kHz to 300 GHz.

Reactive Ion Etch (RIE) A combination of chemical and physical etch processes carried out in a plasma.

Reticle A flat, transparent plate, used in a stepper that contains the photographic image of wafer patterns to be reproduced on a wafer.

RF generator A device that creates radio frequency, often used to create plasma within the semiconductor industry.

RTP Rapid Thermal Processing is a process in which a wafer is heated to a specified temperature for short periods of time.

SEM A scanning electron microscope is a device that displays an electronically scanned image of a die or wafer for examination on a screen or for transfer onto photographic film.

Semiconductor A material whose electrical conductivity is intermediate between that of metals (conductors) and insulators (non-conductors) and can be modified physically or chemically to increase or decrease its conductivity from a "normal" state by "dopants."

Shallow Trench Isolation (STI) The STI isolates each transistor from its adjacent transistor in order to prevent current leakage. Traditionally this isolation was accomplished with a LOCOS (localized oxidation of silicon) field oxide process.

Silane (SiH_4) A gas that readily decomposes into silicon and hydrogen, silane is often used to deposit silicon-containing compounds. It also reacts with ammonia to form silicon nitride, or with oxygen to form silicon dioxide.

Silicide A film compound of silicon with a refractory metal. Common silicide semiconductor films (used as interconnects) include tantalum, tungsten, titanium and molybdenum.

Silicon A brownish crystalline semi-metal used to make most semiconductor wafers.

Silicon Dioxide (SiO_2) The silicon/oxygen film most often used for dielectric applications; can be deposited via silane or TEOS; often called "oxide."

Silicon Nitride (SiN) A silicon/nitrogen film dielectric deposited using plasma-enhanced or LPCVD.

Silicon-on-Insulator (SOI) A silicon wafer with a thin layer of oxide (SiO_2) buried in it. SOI substrates provide superior isolation between adjacent devices in an integrated circuit as compared to devices built into bulk wafers.

Sputtering A method of depositing a film of material on a desired object.

Stepper Equipment used to transfer a reticle (mask) pattern onto a wafer.

Strain Engineering Processes used in semiconductor manufacturing that introduce stress into the underlying silicon structure by either compressing or expanding the silicon lattice structure, enabling electricity to move more easily through the transistor, increasing transistor performance.

Substrate A wafer that is the basis for subsequent processing operations in the fabrication of semiconductor devices.

Thin-Film Transistor (TFT) A metal-oxide-semiconductor field effect transistor manufactured with thin film technology. It typically uses thin films such as polycrystalline or amorphous silicon with a variety of insulating substrates. Used primarily in the manufacturing of active matrix LCDs.

Throughput The number of wafers per hour through a machine, assuming 100% equipment uptime and a fully-loaded machine.

Topography Refers to the layering of features on a device structure causing contours on the surface. The degree of flatness and/or smoothness is very important in wafer fabrication.

Track A track-like set up which integrates several instruments needed to process photoresist (deposition, soft bake, exposure, developing, hard bake) in advanced semiconductor manufacturing.

Transistor An electronic device that controls current flow and serves as the basic element of a computer chip. It consists of three terminals: a source, a gate, and a drain. Applying a voltage to the gate controls current flow between the source and the drain.

Trench A groove etched in a wafer to be used as part of a device structure.

Trench Capacitor A capacitor built into an etched trench on the semiconductor substrate. The capacitance can be increased without increasing the area on the wafer needed to form the capacitor.

Tungsten A refractory metal used as an interconnect material.

Ultra-shallow Junction (USJ) An area of semiconductor manufacturing that is focused on reducing the junctions on the silicon substrate through ion implantation and rapid thermal processing.

Ultraviolet (UV) The invisible part of the light spectrum with wavelengths between 250 to 400 nanometers.

Vias Holes through dielectric layers, opened by etching. Metal will be deposited in the via to form a plug and create an interconnect between two metal lines.

Wafer The thin, circular slice of pure silicon on which semiconductors are built.

Wafer and Mask Metrology An area of semiconductor manufacturing that is focused on ensuring the consistency and success of a microchip through automated systems.

Wet Clean A process for cleaning patterned wafers using a liquefied cleaning solution between process steps.

Yield The percentage of wafers or die produced in a process that conforms to specifications.