

## **1.0 EXECUTIVE SUMMARY**

### **CONSOLIDATION**

*Consolidation continues to drive the semiconductor industry.*

- *In terms of silicon wafer consumption - the top 10 customers consume over 57% of the silicon wafer area.*
- *In terms of silicon wafer supply - the top 3 companies supply over 79% of the silicon wafer area.*
- *In terms of wafer diameter - the 2 largest diameters comprise almost 87% of the wafer area produced and over 92% of the revenue.*

### **POLYSILICON SITUATION**

*The biggest problem in the silicon world had previously been the shortage of polysilicon. After seven years of silicon glut (oversupply), the polysilicon supply had become inadequate to supply, both its traditional customer (the semiconductor market) and its new customer (the photovoltaic market).*

*However through massive new investment by new polysilicon suppliers combined with a global economic downturn, the supply of polysilicon has returned to an oversupply situation once again. While most of the new polysilicon supply is not of sufficient quality to serve the semiconductor industry, it will be sufficient to serve the solar industry and thus relieve the pressure on the traditional high quality polysilicon suppliers.*

*The photovoltaic (solar) demand for polysilicon increased from 72,121 metric tons in the year 2009 to 120,826 metric tons in 2010. The combined demand (solar + semiconductor+ solar inventory build) was  $(120,826 + 28,028 + 11,042) = 159,896$  metric tons in 2010. This demand was less than the polysilicon manufacturing capacity of the polysilicon suppliers of 172,400 metric tons by some 12,504 metric tons. New polysilicon supplies contributed 68,000 metric tons of capacity. This adequacy of supply resulted in average polysilicon prices staying constant at \$55/kg.*

*There were some polysilicon supply problems in 2010. Two Japanese polysilicon suppliers were shut down for a period of 6 months for factory improvements demanded by the Japanese government. On the semiconductor side Osaka Titanium Technology and Mitsubishi Materials Polysilicon were out of operation for a period of approximately six months. On the solar side Hemlock shut down one of its newer solar facilities for improvements and REC Silicon required a few months to optimize production from their new fluidized bed reactors. However, once supply and demand for polysilicon came back into balance, all consumers of semiconductor and solar polysilicon are able to obtain all the polysilicon that they need.*

*Similarly the largest photovoltaic manufacturers are able to obtain all of their polysilicon needs, and even the many smaller producers will not have problems obtaining all of the polysilicon that they need over the next few years. However because of the shortage mentality and the strong influence of take-or-pay contracts much more polysilicon was sold in 2010 than was consumed as inventories built some 11,042 metric tons.*

*The effects of the easing of the tight polysilicon market on the semiconductor industry will be:*

- lower polysilicon prices for all semiconductor wafer producers*
- no lack of raw material for the smaller wafer manufacturers*
- decreased demand for reclaim wafers (more competition from test wafers)*

## 1.1 KEY FINDINGS

- *Semiconductor silicon is becoming a niche product, only 5.9% of the silicon wafer area produced is for semiconductor production and only 17.6% of the polysilicon produced goes to semiconductor industry.*
- *Twelve inch (300 mm) wafer demand increased from 3036 million square inches in 2009 to 4876 million square inches in 2010.*
- *Eight inch (200 mm) wafer demand increased from 2.6 billion square inches in 2009 to 3.2 billion square inches in 2010.*
- *Semiconductor revenue increased from \$205.9 billion in 2009 to \$271.4 billion in the year 2010, a 31.8% increase.*
- *Intel once again ranked as the world's leader in semiconductor revenue. The Korean company, Samsung Semiconductors is in second position and the American company, Texas Instruments, was in third position.*
- *Wafer consumption was 9342 million square inches in the year 2010, up 38.5% from 2009.*
- *SiGe epitaxy on silicon and SOI silicon wafers are destined to remain niche markets, although they are holding their own.*
- *Polysilicon consumption increased 38.6%, from 20,216 metric tons in 2009 to 28,028 metric tons in the year 2010, a increase of over 7812 metric tons.*
- *Foundry production of semiconductor devices has increased from 28.5% to the 29.5% level, but still only one of the top 10 wafer consuming companies is a pure play foundry.*

## ***PLANT EXPANSIONS***

*Wafer expansions for 12" (300 mm) in 2010 were:*

- *Siltronic at Freiberg, Germany*
- *Siltronic at Singapore (JV with Samsung)*
- *SUMCO at Imari, Japan*
- *SEH at Shirakawa, Japan*
- *SEH at Orchards, Washington*
- *SUMCO Techxiv at Nagasaki, Japan*
- *LG Siltron at Gumi, South Korea.*

## ***PLANT CLOSURES***

*Some 6" (150 mm) and many 8" (200 mm) plants have been closed and the work moved to more cost effective sites. These sites have been closed:*

- *Siltronic facility at Burghausen, Germany*
- *Siltronic facility at Portland, Oregon*
- *MEMC plant at Sherman, Texas*
- *MEMC plant at St. Peters, Missouri*
- *SUMCO plant at Maineville, Ohio*

## **CORPORATE CHANGES**

*No new changes. These represent changes for the recent past.*

- *Topsil acquired Cemet Silicon, a Cz wafer producer located in Poland*
- *Komatsu sold 75% interest in its Butte, Montana, polysilicon plant to the Norwegian solar company, REC.*
- *Komatsu sold 51% interest in Komatsu Electronic Metals to SUMCO, ex-Komatsu now operates as SUMCO Techxiv*
- *Dongbu sold its 50% interest in LG Siltron to a Korean investment group*
- *Covalent Materials is looking for some new investors*

## **MARKET SHARES**

*Top 6 polysilicon producers' semiconductor market shares are:*

• Hemlock	36.4%	Mitsubishi	11.4%
• Tokuyama	18.0%	REC Silicon	10.0%
• Wacker	16.0%	MEMC	6.0%

*In the year 2010 the market shares of Tokuyama and Mitsubishi decreased slightly. The shares of the others increased slightly.*

*On an area basis the top 6 silicon wafer producers' market shares are:*

• SEH	33.1%	MEMC	9.2%
• SUMCO	30.9%	LG Siltron	7.7%
• Siltronic	15.1%	Others	3.9%



## 1.2 INTRODUCTION

*This report is the twenty fifth (25<sup>th</sup>) in a series of annual reports on the silicon industry prepared by Sage Concepts. Sage Concepts analyses range from the macroeconomics of the developed world, down through the electronics industry, to the semiconductor industry, to the silicon wafer industry, and ultimately to the polysilicon industry. Business revenues begin at the low end with the \$1.5 billion semiconductor polysilicon industry, up through the \$9.7 billion silicon wafer industry, to the \$271.4 billion semiconductor industry.*

*This Executive Summary began with a bulletized presentation of the report's key findings. Listings of the top participants at the various levels of the integration chain are presented next. The facts and figures presented in this report are derived from an overall database of the semiconductor industry, the silicon wafer industry, and the polysilicon industry.*

*While the levels at the upper end of the vertical integration chain are not directly linked, history has proven a strong correlation between GNP and electronics consumption, and between electronics consumption and semiconductor consumption. The linkage between semiconductor consumption and silicon wafer consumption, and the linkage between silicon wafer consumption and polysilicon consumption, can be technologically defined.*

*Since there are virtually no substitutes for polysilicon, except remelt, in the manufacture of silicon wafers and there are almost no substitutes for silicon wafers, except, wafer reclamation, in the manufacture of semiconductor devices; these consumption linkages can be well defined.*

*This executive summary continues with a forecast of the future of the following industry strata:*

- *Semiconductor Industry*
- *Silicon Wafer Industry*
- *Polysilicon Industry*

*These forecasts are followed by a description of the key players at the various levels of the silicon vertical integration chain.*

### 1.3 INDUSTRY FORECASTS

Forecasts for three different levels of the vertical integration chain are provided as follows:

- *Semiconductor Industry*
- *Silicon Wafer Industry*
- *Polysilicon Industry*

#### 1.3.1 SEMICONDUCTOR INDUSTRY FORECAST

A history and forecast of semiconductor sales is provided in Figure 1-1. The semiconductor industry has grown from \$21.3 billion in 1979 to \$271.4 billion in the year 2010. This over twelve-fold (12.8x) increase represents an average annual growth rate of 8.8%. Sage Concepts' previous forecast predicted the year 2010 semiconductor sales of \$270 billion, compared to the actual sales of \$271.4 billion. The earlier forecast was too low by 0.5%. The small discrepancy was caused by the faster than expected recovery in the last half of 2010.

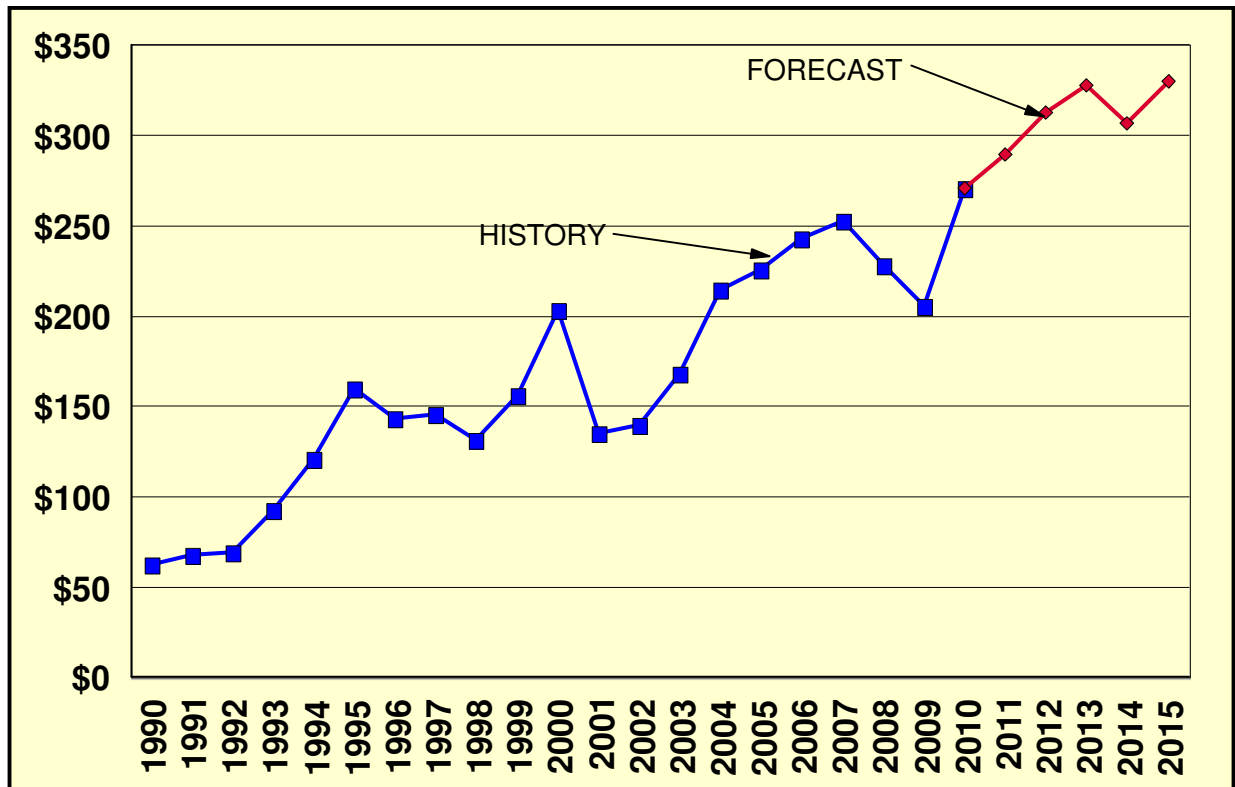
The new forecast calls for the following sales levels:

- 2010            \$271 billion
- 2011            \$290 billion
- 2012            \$313 billion
- 2013            \$328 billion
- 2014            \$307 billion
- 2015            \$330 billion

The forecast calls for a 7.0% increase in the year 2011. This rate reflects the slow recovery from the global financial crisis of 2009. Future years call for a continued more moderate growth pattern. Sage Concepts' forecast calls for a 7.4% increase in 2011, a 7.9% increase in 2012, a 4.5% increase in 2013, a 6.4% decrease in 2014 and a 7.5% increase in 2015.

It would appear that the elusive \$300 billion level, first predicted by DataQuest for the year 2000, may finally arrive in 2012, some 12 years late.

FIGURE 1-1  
SEMICONDUCTOR INDUSTRY FORECAST



GLOBAL SEMICONDUCTOR FORECAST IN BILLIONS OF US DOLLARS

### 1.3.2 SILICON WAFER FORECAST

The forecast for the silicon wafer industry is provided in Figure 1-2. The silicon wafer industry has grown from 2281 million square inches in 1990 to 9342 million square inches in the year 2010. This factor of 4.1x growth represents a compound annual growth rate of 7.3%. Thus, despite changing chip sizes and increasing efficiencies, the monetary growth of the semiconductor industry is greater than the growth in surface area of the silicon wafer industry.

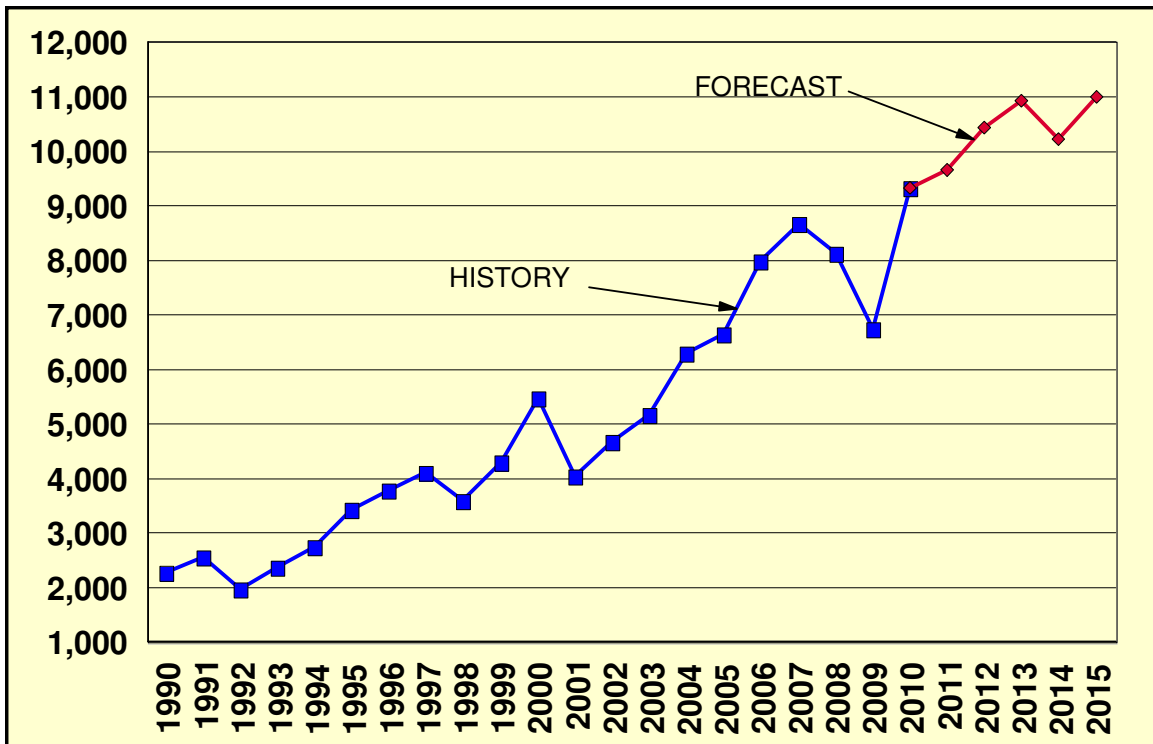
The previous forecast called for 9000 million square inches of prime plus test wafers. The actual the year 2010 number was 9342 million square inches, some 3.8% above the forecast. The previous Sage Concepts' forecast was low because of the faster than expected steady recovery.



*This 2010 forecast calls for the following growth:*

- 2010 9342 MSI
- 2011 9667 MSI
- 2012 10,433 MSI
- 2013 10,933 MSI
- 2014 10,233 MSI
- 2014 11,000 MSI

**FIGURE 1-2**  
**SEMICONDUCTOR SILICON WAFER FORECAST**



GLOBAL SILICON WAFER SALES FORECAST IN MILLIONS OF SQUARE INCHES

*The forecast calls for a 3.5% increase in 2011, followed by 7.9% increase in 2012. This is followed by a 4.8% increase in 2013. For the year 2014 the forecast calls for a reduction of 6.4%, followed by a 7.5% increase. The 12" (300 mm) wafers were the only diameter to increase*

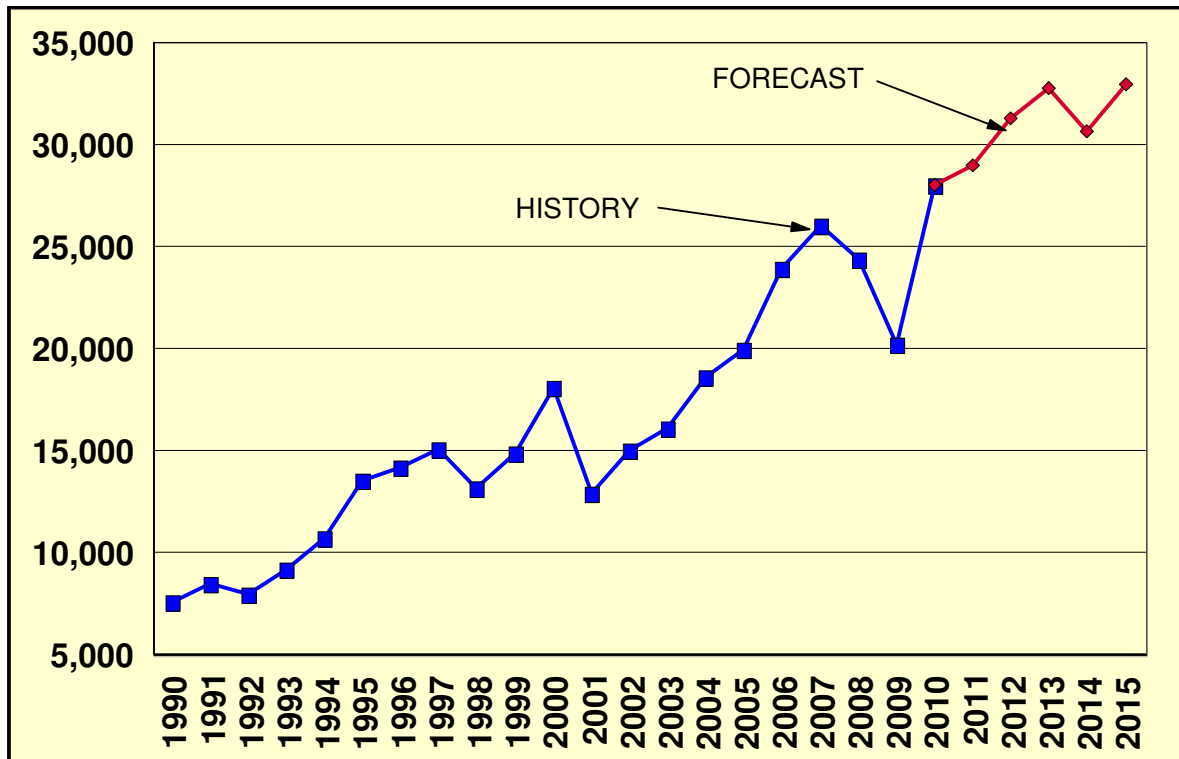


share in 2010. They are anticipated to account for over 58.6% of the total wafer volume in 2010. A 12" (300 mm) wafer forecast is provided in section 1.5 of this chapter.

### 1.3.3 SEMICONDUCTOR POLYSILICON FORECAST

Figure 1-3 contains the forecast for the polysilicon industry. The semiconductor polysilicon industry has grown from 7588 metric tons in 1990 to 28,028 metric tons in the year 2010. This growth represents an annual growth rate of 6.7%. The polysilicon growth rate is typically slightly lower than the silicon wafer growth rate, but because the industry's increases in silicon wafer manufacturing efficiencies more than offset the demand for ever increasing wafer thickness.

FIGURE 1-3  
SEMICONDUCTOR POLYSILICON FORECAST



GLOBAL POLYSILICON FORECAST IN METRIC TONS

*This year's sales were 28,028 metric tons. The sales and the consumption were equal, because almost the entire inventory in the industry has been consumed to meet the additional demand of the photovoltaic industry. The previous forecast called for the consumption of 27,000 metric tons in 2010. This forecast was low by 3.8% because of the more steady recovery from the global financial crisis.*

*The 2010 polysilicon forecast takes into account the use of reclaim wafers (lowers wafer usage and therefore polysilicon), the use of remelt (a substitute for polysilicon), and the use of wire saws (which increases wafer material yields and therefore decreases polysilicon usage).*

*The line of demarcation between semiconductor silicon use and solar silicon use is somewhat blurred. In 2007 the price being paid for semiconductor silicon scrap is higher than the price of semiconductor polysilicon. Under these conditions some semiconductor silicon wafer producers are selling their scrap and consuming more of the lower cost polysilicon, rather than recycling their scrap. This situation has reversed as the price of scrap is much lower than the price of polysilicon.*

*The forecast calls for 3.3% compound average growth rate between the year 2010 and the year 2015. The following semiconductor polysilicon production levels are forecast:*

- 2010 28,028 metric tons
- 2011 29,000 metric tons
- 2012 31,300 metric tons
- 2013 32,800 metric tons
- 2014 30,700 metric tons
- 2015 33,000 metric tons

## 1.4 KEY PLAYERS

*The leading producers discussed in this section include:*

- *Semiconductor Companies (silicon devices only)*
- *Silicon Wafer Companies*
- *Polysilicon Companies*

### 1.4.1 SEMICONDUCTOR COMPANIES

*The top 20 semiconductor manufacturers (based solely on their manufacture of semiconductors on silicon wafers – no compound semiconductors) are presented in Table 1-1. The leading semiconductor manufacturer is Intel. In second (2<sup>nd</sup>) place is Samsung Semiconductors. In third (3<sup>rd</sup>) position is Texas Instruments. Fourth (4<sup>th</sup>) position is held by Toshiba. In fifth (5<sup>th</sup>) position is the Japanese company, Renesas. Renesas is a new joint venture company between the old Hitachi and Mitsubishi Electric partners and NEC Electron Devices. In sixth (6<sup>th</sup>) position is the South Korean company, Hynix Semiconductor. In seventh (7<sup>th</sup>) position is held by the European company, ST Microelectronics. In 2010 Micron Technology ranked 8<sup>th</sup> largest. In 9<sup>th</sup> position is the fabless company, Qualcomm. Rounding out the top ten companies is another fabless company, Broadcom.*

*Seven of the top ten semiconductor companies (Intel, Texas Instruments, Renesas, ST Microelectronics, Hynix, Infineon, and Qualcomm) do not manufacture electronic systems. However, Renesas, and Infineon were previously spun-off from electronics system manufacturing companies.*

*In 11<sup>th</sup> position is the American fables company, AMD. Next is the European company Infineon. Infineon is followed by the Japanese company, Elpida. In 2010 the American company, Freescale Semiconductor, was in 14<sup>th</sup> position.*

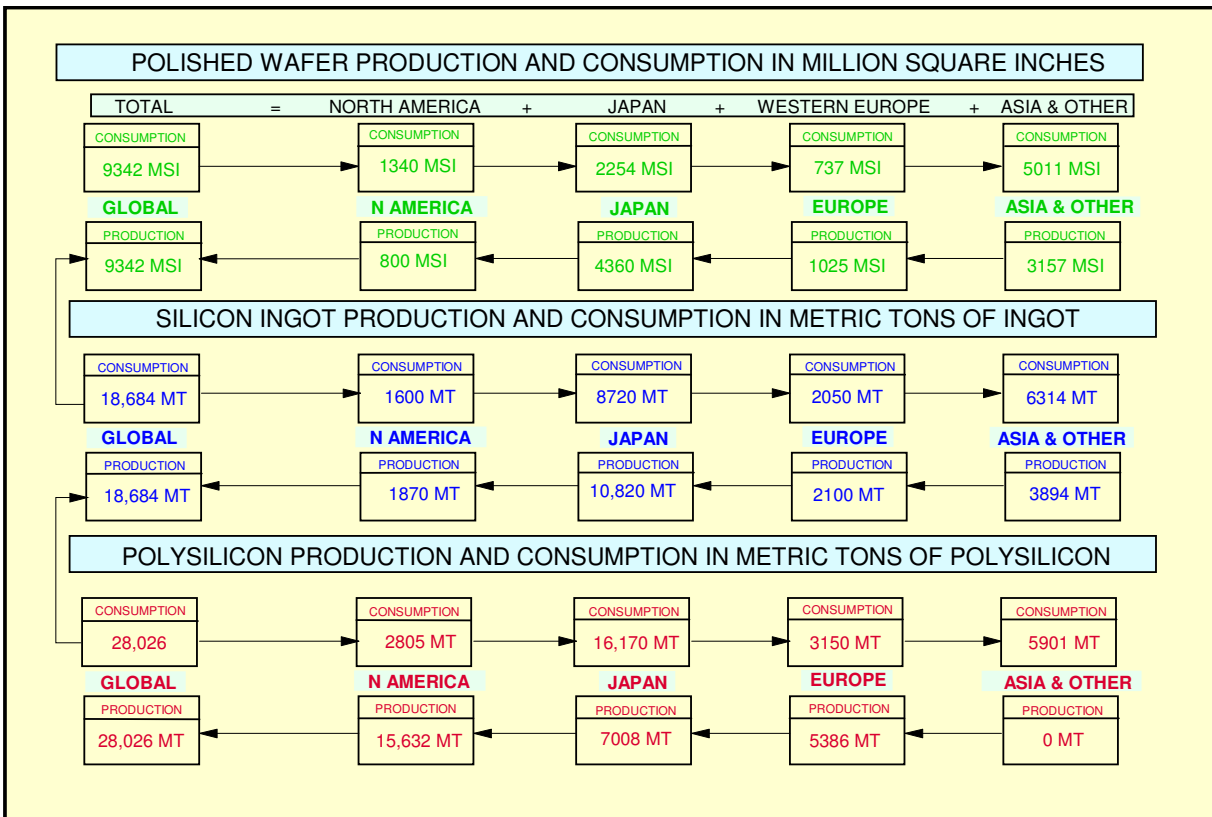
**TABLE 1-1**  
**TOP 20 SEMICONDUCTOR COMPANIES**

RANK #	COMPANY NAME	DEVICE SALES (IN US DOLLARS)	MARKET SHARE (IN PERCENT)	CUMULATIVE SHARE (IN PERCENT)
1	INTEL	\$41,682,000,000	15.4%	15.4%
2	SAMSUNG SEMICONDUCTORS	\$29,875,000,000	11.0%	26.4%
3	TI	\$13,947,000,000	5.1%	31.5%
4	TOSHIBA	\$13,684,000,000	5.0%	36.5%
5	RENESAS NEW	\$12,160,000,000	4.5%	41.0%
6	HYNIX SEMICONDUCTOR	\$10,820,000,000	4.0%	45.0%
7	ST MICROELECTRONICS	\$10,392,000,000	3.8%	48.8%
8	MICRON TECHNOLOGY	\$8,467,000,000	3.1%	52.0%
9	QUALCOMM-QTC	\$6,980,000,000	2.6%	54.5%
10	BROADCOM	\$6,820,000,000	2.5%	57.0%
11	AMD	\$6,500,000,000	2.4%	59.4%
12	INFINEON	\$6,255,000,000	2.3%	61.7%
13	ELPIDA	\$5,800,000,000	2.1%	63.9%
14	FREESCALE SEMICONDUCTOR	\$4,508,000,000	1.7%	65.5%
15	SONY	\$4,496,000,000	1.7%	67.2%
16	SANDISK	\$4,460,000,000	1.6%	68.8%
17	NXP SEMICONDUCTORS	\$4,443,000,000	1.6%	70.5%
18	PANASONIC SEMICONDUCTOR	\$3,683,000,000	1.4%	71.8%
19	MEDIATEK	\$3,680,000,000	1.4%	73.2%
20	MARVELL TECHNOLOGY	\$3,610,000,000	1.3%	74.5%
	TOP 20 SUBTOTAL	\$202,262,000,000	74.5%	
	REMAINING COMPANIES	\$69,172,000,000	25.5%	
	TOTAL	\$271,434,000,000	100.0%	

*In 15<sup>th</sup> position is the Japanese company, Sony Semiconductor. Sony is followed the fabless company, Sandisk, in 16<sup>th</sup> place. After Sandisk, comes the European company, NXP Semiconductor. After NXP, come Panasonic, and fabless companies, Mediatek and Marvell Technology.*

*Qualcomm, Broadcom, Mediatek, and Sandisk are fabless semiconductor companies that use foundries to manufacture their devices. In total, the top 20 semiconductor companies accounted for 74.5% of the total semiconductor sales in the year 2010. The production of semiconductors stimulates the consumption of silicon wafers. In the year 2010, the production of semiconductors valued at \$271.4 billion stimulated the consumption of 9342 million square inches of silicon wafer. Figure 1-4 is a summary graphic providing the overall consumption and production numbers for the silicon wafer, the monocrystalline ingot, and the polysilicon industries.*

FIGURE 1-4  
POLYSILICON TO WAFER INTEGRATION CHAIN



The consumption (at each of these levels of the vertical integration chain figure) is driven by the production of semiconductors, as discussed above. The quantities used in the graphic are presented in physical units rather than monetary units as used for the macroeconomic, electronic, and semiconductor industries. The consumption of 9342 million square inches of silicon wafer stimulated the production of an equal amount of silicon wafer production. The production of 9342 million square inches of silicon wafer consumed 18,684 metric tons of silicon ingot. This silicon ingot is a cylinder of single crystal silicon from which the wafers are sliced. In the production of this ingot 28,026 metric tons of polysilicon were consumed. The polysilicon is consumed in a melting and seeding process, which feeds the growth of the silicon ingot. To meet the polysilicon consumption demands 28,026 metric tons of semiconductor grade polysilicon were produced. The balance between production and demand kept polysilicon inventories at near zero.

A study of Figure 1-4 indicates that while the flow of material up the vertical integration chain is relatively dovetailed, the flow within the various regions of the different levels is far from smooth. These regional differences are compensated by large flows of material between regions at each of the levels. The largest percentage flows (see Figure 8-19) are at the polysilicon level where there are many international transactions between companies. At the ingot level, there remains a significant flow of material; however, most of the flow is between divisions of the same company, as shown in Chapter 7.

#### 1.4.2 SILICON WAFER COMPANIES

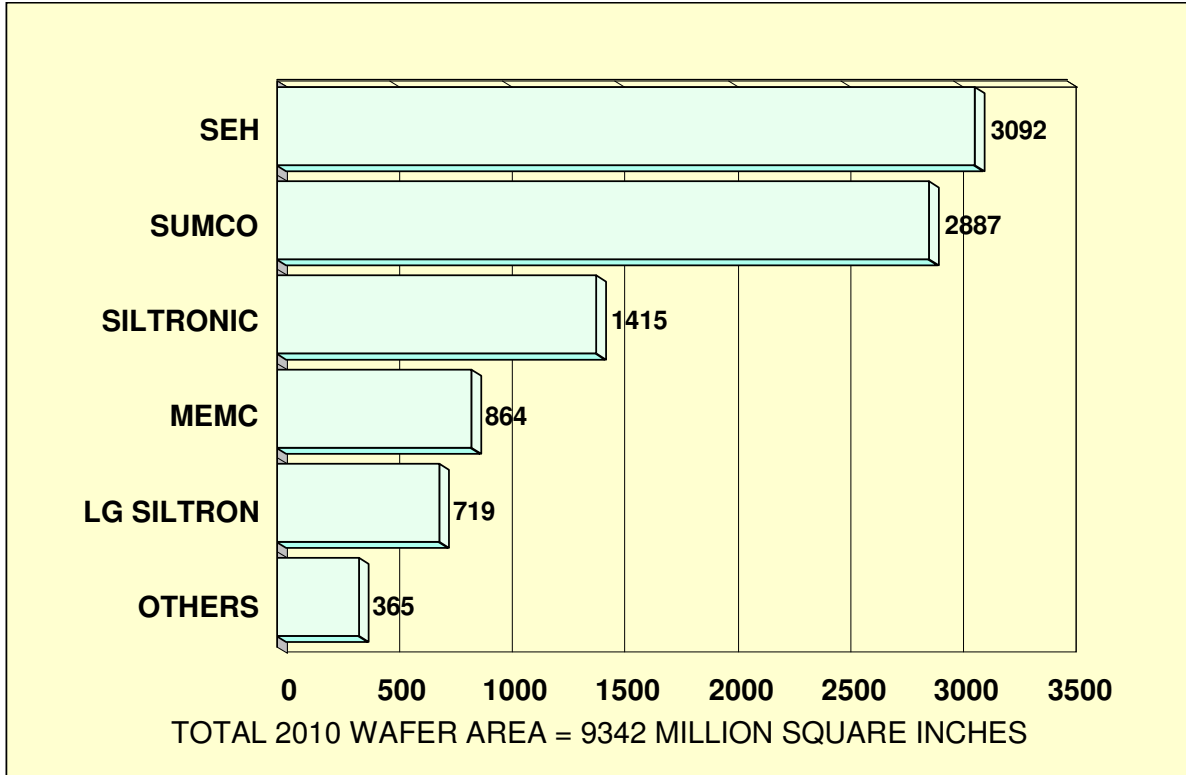
The leading silicon wafer manufacturers are presented in Figure 1-5. These wafer manufacturers have the following market shares:

- SEH 33.1%
- SUMCO 30.9%
- Siltronic 15.1%
- MEMC 9.2%
- LG Siltron 7.7%

*Shin-Etsu Handotai (SEH) is the world's leading silicon wafer producer with a year 2010 production of 3092 million square inches. In second place (2<sup>nd</sup>) is SUMCO, with sales of 2887 million square inches. SUMCO is derived from the merger of the former Sumitomo Sitix, Mitsubishi Materials Silicon, and Komatsu Metals. In third (3<sup>rd</sup>) position is Siltronic with sales of 1415 million square inches in 2010.*

*The fourth (4<sup>th</sup>) largest silicon wafer manufacturer is MEMC. In the year 2010, MEMC had combined sales of 864 million square inches. In fifth (5<sup>th</sup>) position was LG Siltron with sales of 719 million square inches. Others, including Covalent Materials (the former Toshiba Ceramic), account for 365 million square inches of silicon wafer sales.*

**FIGURE 1-5**  
**SEMICONDUCTOR SILICON WAFER SUPPLIERS**



*The prices for the silicon wafers sold are presented in Table 1-2. This table lists the average prices for wafers sold globally. These prices are presented in three currencies, including:*

- *U.S. dollars (\$)*
- *Japanese Yen*
- *Euros (€)*

*The prices are provided by wafer diameter and by wafer type. The diameters range from three inches (75 mm) to twelve inches (300 mm) and the wafer types include test, unpolished float zone (FZ), polished, annealed, and epitaxial wafers.*



TABLE 1-2  
SILICON WAFER PRICES

DIA	TYPE	\$	YEN	EURO
3	TEST	\$4.31	¥366	€3.08
3	FZ	\$5.75	¥489	€4.11
4	TEST	\$3.41	¥290	€2.44
4	FZ	\$7.56	¥643	€5.40
4	CZ	\$4.55	¥387	€3.25
4	EPI	\$5.79	¥492	€4.14
4	SOI	\$23.88	¥2,030	€17.06
5	TEST	\$6.05	¥514	€4.32
5	FZ	\$9.07	¥771	€6.48
5	CZ	\$8.07	¥686	€5.76
5	ANNEAL	\$10.25	¥871	€7.32
5	EPI	\$12.53	¥1,065	€8.95
5	SOI	\$34.29	¥2,915	€24.49
6	TEST	\$9.73	¥827	€6.95
6	FZ	\$19.77	¥1,680	€14.12
6	CZ	\$12.97	¥1,102	€9.26
6	ANNEAL	\$16.90	¥1,437	€12.07
6	EPI	\$22.03	¥1,873	€15.74
6	SIGE	\$28.99	¥2,464	€20.71
6	SOI	\$49.30	¥4,191	€35.21
8	TEST	\$23.63	¥2,009	€16.88
8	CZ	\$31.51	¥2,678	€22.51
8	ANNEAL	\$38.09	¥3,238	€27.21
8	EPI	\$41.60	¥3,536	€29.71
8	SIGE	\$60.90	¥5,177	€43.50
8	SOI	\$105.80	¥8,993	€75.57
12	TEST	\$103.37	¥8,786	€73.84
12	CZ	\$137.87	¥11,719	€98.48
12	ANNEAL	\$155.84	¥13,246	€111.31
12	EPI	\$187.41	¥15,930	€133.86
12	SOI	\$510.87	¥43,424	€373.87

*Sales in terms of wafer area sold are illustrated in Table 1-3. Shin-Etsu is the largest producer overall with worldwide sales of 3092 million square inches for an overall market share of 33.1%. It was the largest seller in the Asia Pacific. Shin-Etsu's Asia Pacific sales have increased to the point where they are more than triple (3.4x) their domestic Japanese sales.*



**TABLE 1-3**  
**SUPPLIER WAFER AREA / REGION MATRIX**

COMPANY NAME	WAFER SALES BY GEOGRAPHIC REGION - IN SQUARE INCHES					TOTAL	COMPANY PERCENT
	ASIA PACIFIC	JAPAN	N AMERICA	EUROPE	OTHER		
SHIN-ETSU	2,090,083,188	608,371,810	281,126,836	105,721,839	6,232,737	3,091,536,409	33.1%
SUMCO	1,105,478,404	1,185,255,267	448,183,805	142,512,044	5,658,982	2,887,088,502	30.9%
SILTRONIC	633,085,142	187,532,434	240,536,959	321,713,853	31,681,761	1,414,550,150	15.1%
MEMC	533,561,761	36,240,578	177,575,595	105,650,554	11,027,739	864,056,227	9.2%
LG SILTRON	529,628,116	32,746,405	124,173,656	33,199,471		719,747,649	7.7%
OTHER	63,564,127	203,865,851	68,674,990	28,426,589		364,531,557	3.9%
REGIONAL SUBTOTALS	4,955,400,737	2,254,012,347	1,340,271,842	737,224,351	54,601,219	9,341,510,494	100.0%
REGIONAL %	53.0%	24.1%	14.3%	7.9%	0.6%	100.0%	

The 2<sup>nd</sup> largest global producer is SUMCO with sales of 2887 million square inches. It is the 2<sup>nd</sup> largest silicon wafer seller in the Asia Pacific, and Europe and largest in Japan and the United States. The third (3<sup>rd</sup>) largest silicon wafer producer in the world is Siltronic with 2010 sales of 1415 million square inches or 15.1% of the world total. It is the largest seller in Europe and the 3<sup>rd</sup> largest in the United States. MEMC is the 4<sup>th</sup> largest worldwide wafer manufacturer. It is the 4<sup>th</sup> largest seller in United States and the Asia Pacific, and Europe.

The largest seller in the Asia Pacific, SEH, is followed in 2<sup>nd</sup> place by SUMCO. In 3<sup>rd</sup> place is the German company, Siltronic. After Siltronic are LG Siltron and MEMC.

In the United States, SUMCO is the largest, followed by SEH and Siltronic. In 4<sup>th</sup> place is MEMC followed by LG Siltron and Others.

In Europe Siltronic is the leader, followed by SUMCO, SEH, and MEMC.

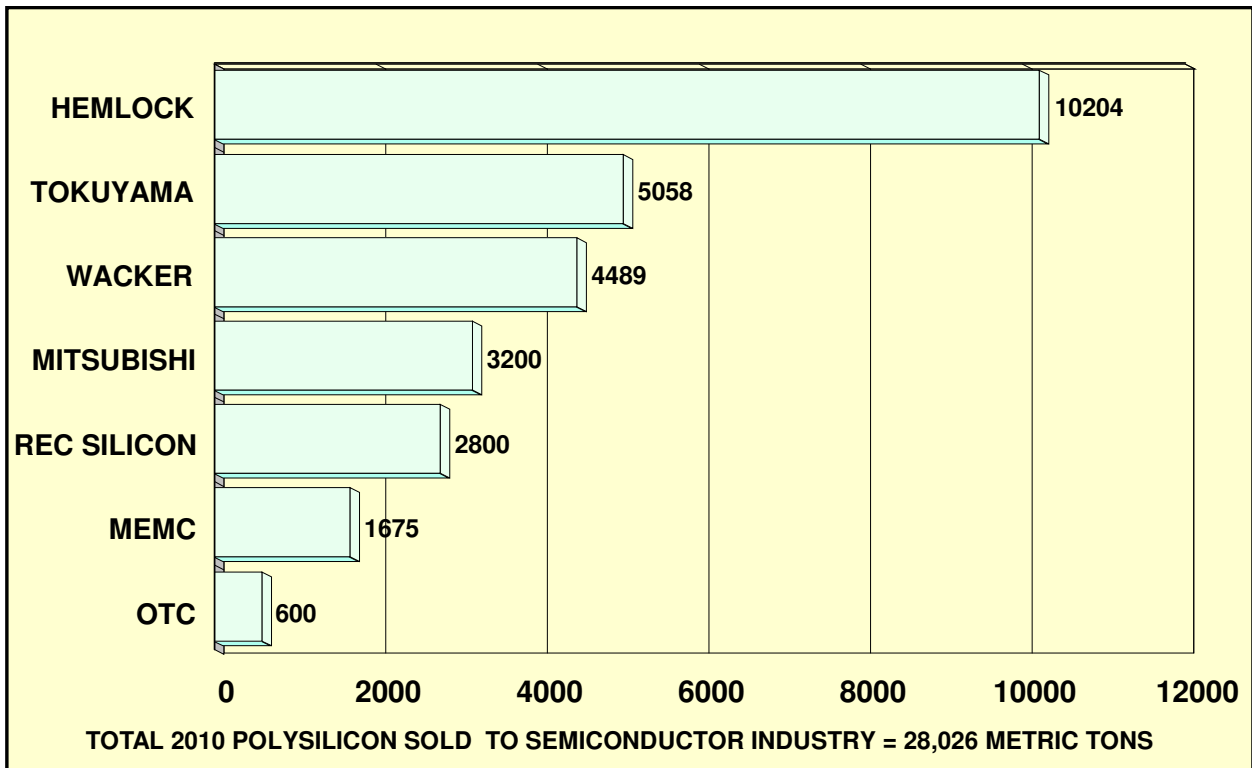
In Japan SUMCO is the largest supplier followed by SEH in 2<sup>nd</sup> place. The Other category, including Covalent Materials (ex-Toshiba Ceramic), is in 3<sup>rd</sup> place. Siltronic is in 4<sup>th</sup> place in Japan.

**1.4.3 SEMICONDUCTOR POLYSILICON COMPANIES**

The key semiconductor polysilicon producers are listed in Figure 1-6. The market share of the leading producers is as follows:

- Hemlock 36.4 %
- Tokuyama 18.0%
- Wacker Chemie 16.0%
- Mitsubishi (Japan & USA) 11.4%
- REC Silicon 10.0%
- MEMC (USA & Italy) 6.0%
- OTC (ex-Sumitomo) 2.1%

**FIGURE 1-6  
SEMICONDUCTOR POLYSILICON SUPPLIERS**



*The leading producer was Hemlock Semiconductor. Hemlock produced 10,204 metric tons of semiconductor polysilicon from its Hemlock, Michigan, complex. Tokuyama was the 2<sup>nd</sup> largest supplier of semiconductor polysilicon. In the year 2010 this company sold 5058 metric tons of semiconductor polysilicon. The 3<sup>rd</sup> largest production came from Wacker Chemie. In the year 2010, Wacker supplied 4489 metric tons of semiconductor polysilicon.*

*After Wacker, the next largest semiconductor polysilicon production came from Mitsubishi Materials Polycrystalline Silicon. Its Yokkaichi plant produced 1350 metric tons and its newer plant in the United States produced 1850 metric tons for a total semiconductor polysilicon production of 3200 metric tons. Next is the REC Silicon plant located in Butte, Montana. This plant produced 2800 metric tons of semiconductor polysilicon in the year 2010. After REC is MEMC. Their facility, located in Merano, Italy had a the year 2009 semiconductor polysilicon production of 897 metric tons and their facility located in Pasadena, Texas, produced 778 metric tons for a total of 1675 metric tons of semiconductor polysilicon.*

*The seventh (7<sup>th</sup>) largest polysilicon production was from Osaka Titanium Technology Corporation's (formerly STC) Amagasaki facility. This facility produced 600 metric tons of semiconductor polysilicon in the year 2010. Due to the abundance of high quality polysilicon no semiconductor purchases from others, primarily located in Korea and China.*

*If the semiconductor market were the only market for polysilicon then there would be an enormous oversupply situation in the polysilicon industry. In 2010 the total production of polysilicon was 159,896 metric tons and the demand of the semiconductor industry was 28,028. Thus semiconductor demand was only 17.6% of the total production capacity of the polysilicon industry. There is however a second market for polysilicon. This market is the photovoltaic (solar) market. This market also uses silicon wafers made from silicon ingots.*

*As contrasted with the semiconductor market these ingots do not have to be ultrapure monocrystalline material. Silicon wafers produced for the photovoltaic market have to be pure (99.9999%) pure, but not ultrapure (99.99999%). They also have to be crystalline, but not monocrystalline. The non monocrystalline material for the photovoltaic industry is typically defined as multicrystalline. Multicrystalline ingots for the production of solar cells for the photovoltaic industry typically have multiple areas of single crystal material separated by very thin grain boundaries. The multi crystalline ingots can be produced in traditional Czochralski*

*crystal pullers (used by the semiconductor industry) or they market produced in casting machines. Photovoltaic silicon ingots produced in Cz pullers are circular in cross-section and those produced in casting machines are rectangular in cross-section. In some solar photovoltaic wafer processes the ingot step is eliminated and the wafer sheet material is produced directly from the silicon melt. This type of process is typically referred to as a ribbon process.*

*Because of the lessened purity requirements, photovoltaic material can be made from start material that is somewhat less pure than semiconductor grade polysilicon. Typically it is made from a mixture of semiconductor grade polysilicon and scrap material from the semiconductor industry. This scrap includes crucible leavings, ingot croppings, wafer breakage, and polysilicon rod rejects and fines.*

*In 2010 the photovoltaic industry consumed 120,826 metric tons of silicon raw material. Combined with the semiconductor industry the total consumption was 148,854 MT. However in 2010, due to inventory buildups 159,896 metric tons was sold. Thus 11,042 metric tons went into inventory to promote future growth and to protect against shortages. Over 100,896 metric tons of this 159,896 metric tons came from traditional semiconductor polysilicon producers (see Table 8-6) and the 59,000 metric tons came from polysilicon newcomers, semiconductor scrap, and supplies of upgraded metallurgical silicon.*

*In 2010 the traditional semiconductor polysilicon suppliers supplied the following amounts of polysilicon to the photovoltaic industry:*

- *Hemlock*                    25,796 metric tons
- *Wacker*                    24,211 metric tons
- *REC Silicon*            10,800 metric tons
- *MEMC*                    8421 metric tons
- *Tokuyama*                3642 metric tons
- *Mitsubishi*              0 metric tons
- *OTC*                        0 metric tons

*The total is 72,870 metric tons, which when added to the semiconductor demand of 28,028 produced a traditional supplier amount of 100,898 metric tons. In addition newcomers produced an additional 59,000 metric tons of polysilicon for total polysilicon sales of 159,898 metric tons.*

## 1.5 300 MILLIMETER FORECAST

*The diameter some once thought would commence in 1997 now is dominant in the industry. The new 12" (300 mm) fabs have proven to be very cost effective. Since the year 2004, 8" (200 mm) diameter wafer consumption decreased from 57.1% of the total demand to 34.4% in 2010. Eight inch diameter (200 mm) wafer usage dropped to 2<sup>nd</sup> place in year 2008. Twelve inch (300 mm) wafers are now the dominant wafer diameter accounting for 52.2% of the total wafer area.*

*The 12" (300 millimeter) fabs have proven to be 30% cheaper than 8" (200 mm) fabs. However one has to fab many wafers to pay back the \$3 billion investment needed construct a 12" (300 mm) fab. The fab yields of these new 12"(300 mm) fabs are high enough to be attractive. In 2003 there were 13 12"(300 mm) fabs operation around the world. By 2009 this number increased to 71 fabs, A list of the these and additional planned 12" (300 mm) diameter fabs is provided in of Volume II in Table 10-4. The list contains fab announcements from most of the world's top semiconductor manufacturers and foundries.*

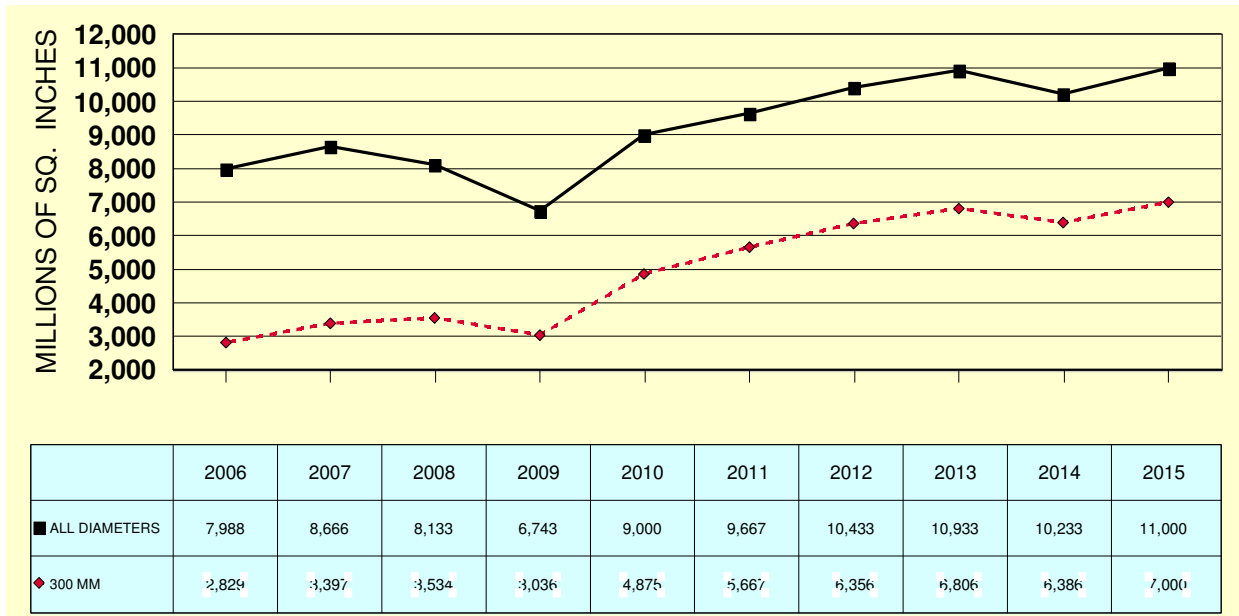
*Today's leaders include:*

- *Samsung*
- *Toshiba*
- *TSMC*
- *Hynix Semiconductor*
- *Micron Technology*
- *TI*
- *Elpida*
- *Intel*
- *PowerChip*
- *UMC*

*The Sage Concepts forecast for twelve (12") inch diameter wafers is provided in Figure 1-7. The figure illustrates that total silicon wafer area grew from 6.6 billion square inches in the year 2005 and is expected to grow to 11 billion square inches by the year 2015. In the year 2005 the 12" (300 mm) share was only 25.7% of the total. In 2008 the share increased to 43.4% and overtook 8" (200 mm) as the dominant wafer diameter. In 2015 the 300 mm share is anticipated*

to grow to 63.6%. In this forecast 450 mm is not anticipated to be in production and 200 mm is anticipated to hold steady as the transfer work out of 200 mm fabs and into 300 mm fabs is offset by the transfer of work out of small diameter fabs into 200 mm fabs.

**FIGURE 1-7**  
**300 MM FORECAST**



*In terms of wafers per month the forecast is as follows:*

- 2009            3036 MSI                    2,308,000 wafers per month
- 2010            4875 MSI                    3,707,000 wafers per month
- 2011            5667 MSI                    4,309,000 wafers per month
- 2012            6356 MSI                    4,833,000 wafers per month
- 2013            6806 MSI                    5,175,000 wafers per month
- 2014            6386 MSI                    4,856,000 wafers per month
- 2015            7000 MSI                    5,322,000 wafers per month



## 1.6 REPORT OUTLINE

*The remainder of the report, entitled "Silicon Industry - 2011" is organized accordingly:*

- Chapter 2.0 Electronics Industry*
- Chapter 3.0 Semiconductor Industry*
- Chapter 4.0 Silicon Wafer Consumption*
- Chapter 5.0 Wafer Fabs by Diameter*
- Chapter 6.0 Silicon Wafer Sales*
- Chapter 7.0 Polysilicon to Wafer Integration*
- Chapter 8.0 Polysilicon Industry*
- Chapter 9.0 Specialty Silicon and Database*
- Chapter 10.0 Potential Silicon Shortages*
- Chapter 11.0 Wafer Consumers*
- Chapter 12.0 Semiconductor Database*

*In a move to better understand the business pyramid that drives the silicon wafer and polysilicon markets, Chapter 2.0 discusses the producers of Electronic Systems. Each of the top 20 producers is analyzed. Chapter 3.0 highlights the activity of the semiconductor industry. The chapter describes the semiconductor manufacturers of the worldwide industry.*

*Chapter 4.0 describes the consumption of silicon wafers by the semiconductor industry during the fabrication of its semiconductor devices. The consumption of silicon wafers by diameter and by wafer type is presented, as well as wafer consumption maps for Japan and the United States. The discussion includes a ranking of the semiconductor fabs by region and country.*

*Chapter 5.0 groups the companies that produce semiconductors by the various wafer diameters. Lists are provided for each of the various diameters by region, country, city, and company; as well as wafers started per month and the wafer area consumed in the year 2010 for each fab.*

*Chapter 6.0 provides a discussion of the sales of silicon wafers. Wafer price information is provided by region, and market shares are presented by wafer area sold. Chapter 7.0 presents the polysilicon to silicon wafer integration chart. The chapter continues by describing the production and consumption of wafers, ingots, and polysilicon for each of the major regions. A*



*material flow chart is presented for each of the largest wafer producers showing the production of polysilicon, the production, transfer, and consumption of monocrystalline ingot, and the production, transfer, and sale of silicon wafers. The regional production and consumption of silicon wafers, ingot and polysilicon is also illustrated with tables and maps.*

*The second volume of this report begins with Chapter 8.0, which provides a description of the polysilicon industry. This chapter contains a discussion of the regional polysilicon demand generation, as well as a discussion of the demands of the leading polysilicon consumers. The customers of each of the leading polysilicon suppliers are presented and the chapter ends with the polysilicon buyer/seller matrix for 2010 and a regional polysilicon flow chart.*

*Chapter 9.0 provides a look at areas of special interest including: float zone, annealed, epitaxial, SiGe epitaxial, and SOI wafers. The chapter concludes with a discussion of 12" (300 mm) wafer supply and demand and the presentation of the silicon manufacturers' database.*

*Chapter 10.0 discusses the tight markets for both 8" (200 mm) and 12" (300 mm) wafers. It then discusses the polysilicon shortage. The photovoltaic market and their demand for polysilicon are discussed. Then the combined semiconductor and photovoltaic demand are compared to the polysilicon industry's ability to produce.*

*Chapter 11.0 continues with a description of the top 20 wafer consumers. These company descriptions include tables of wafers consumed by city, sales by diameter, and finally a pie chart indicating wafer supplier shares. The chapter concludes with a presentation of the silicon wafer buyer / seller matrix.*

*Chapter 12.0 contains a description and presentation of the 55 page Semiconductor Manufacturers Database. This database has been heavily updated from previous years.*

*This page concludes the introduction.*