

REPORT I SILICON INDUSTRY 2008 SUMMARY

CONSOLIDATION

Consolidation is the key indicator driving the semiconductor industry.

- *In terms of silicon wafer consumption - the top 10 customers consume nearly 56% of the silicon wafer area.*
- *In terms of silicon wafer supply - the top 3 companies supply over 78% of the silicon wafer area.*
- *In terms of wafer diameter - the 2 largest diameters comprise over 82% of the wafer area produced and almost 90% of the revenue.*

POLYSILICON SHORTAGE

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

The polysilicon consumption for semiconductor production increased from 23,964 metric tons in 2006 to 26,041 metric tons in the year 2007, an increase of 8.7%. The use of polysilicon per square inch of silicon wafer remained constant at 3.0 grams per square inch in 2007. Since 12" (300 mm) wafers are thicker, their increased production tends to increase the average consumption. For the consumption rate to hold constant, wafer manufacturers had to increase their yields (which decreases grams per square inch). This decrease indicates that the silicon wafer industry has made slight yield increases in their 12" (300 mm) wafer production processes.

The photovoltaic (solar) demand for polysilicon increased from 3000 metric tons in the year 2000 to 24,975 metric tons in 2007. The combined demand (solar + semiconductor) was $(24,975 + 26,041) = 51,016$ metric tons in 2007. This demand exceeded the polysilicon manufacturing capacity of 43,800 metric tons by some 7216 metric tons.

While no semiconductor wafer manufacturers went without polysilicon in 2007, this lack of polysilicon supply resulted in an increase in the average price from \$62 per kilogram to \$73 per kilogram. Some semiconductor prices have now hit \$100 per kilogram and solar spot prices have hit the \$300 to \$450 per kilogram level.

With photovoltaic polysilicon demand expected to continue growing at a 15% to 30% pace, and the semiconductor polysilicon market expected to grow at a 7% pace, the combined demand will exceed capacity for the next several years. The polysilicon industry can expand polysilicon manufacturing capacity at their existing plants by 7000 to 8000 metric tons over the next two years. Expansion beyond this point will require the construction of new sites. The earliest production from these new plants would not be available until 2008. A fully balanced market will probably not occur until the year 2010.

In the interim only customers with long term contracts will receive the polysilicon that they require. It would appear that major semiconductor polysilicon consumers like SEH, SUMCO, Siltronic, and MEMC will not run short of polysilicon. Probably long term consumers of semiconductor polysilicon such as Covalent Materials (ex-Toshiba Ceramic), LG Siltron, and Okmetic will be able to purchase polysilicon quantities at least at their 2004 levels for the next few years. Semiconductor growth at these companies will be limited by lack of polysilicon. Other smaller consumers of semiconductor polysilicon may not be able to obtain additional polysilicon during the 2007 to 2010 time frame.

Similarly the largest photovoltaic manufacturers will be able to obtain the majority of their polysilicon needs, but many smaller producers will not have their polysilicon demands met over the next few years.

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

- *higher polysilicon prices for all semiconductor wafer producers*
- *lack of raw material for the smaller wafer manufacturers*
- *increased demand for reclaim wafers (need no polysilicon)*

1.1 KEY FINDINGS

- *Construction of new 12" (300 mm) fabs is on the rise. There are 58 fabs now operating and 15 new ones under construction.*
- *Twelve inch (300 mm) wafer demand increased from 2829 million square inches in 2006 to 3397 million square inches in 2007.*
- *Eight inch (200 mm) wafer demand increased from 3.6 billion square inches in 2006 to 3.7 billion square inches in 2007.*
- *Semiconductor revenue was up from \$243.3 billion in 2006 to \$253.9 billion in the year 2007, a 4.4% increase. This is a record for semiconductor revenues.*
- *Intel once again ranked as the world's leader in semiconductor revenue. The Korean company, Samsung Semiconductors is in second position and a Japanese company, Toshiba was in third position.*
- *Wafer consumption was 8667 million square inches in the year 2007, up 8.5% over 2006. This consumption was also an historical peak.*
- *SiGe epitaxy on silicon and SOI silicon wafers are destined to remain niche markets, although they are growing.*
- *Polysilicon consumption increased 8.7%, from 23,964 metric tons in 2006 to 26,041 metric tons in the year 2007, an increase of over 2077 metric tons.*
- *Foundry production of semiconductor devices has increased from 22.5% to the 25.4% level, but still only one of the top 10 wafer consuming companies is a pure play foundry.*

MARKET SHARES

Top 6 polysilicon producers' semiconductor market shares are:

• Hemlock	32.7%	REC Silicon	11.3%
• Tokuyama	16.8%	Mitsubishi	10.9%
• Wacker	15.9%	MEMC	8.2%

In the year 2007 the market shares of Hemlock and REC increased slightly. The shares of the others decreased slightly.

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

• SEH	32.1%	MEMC	10.4%
• SUMCO	31.5%	LG Siltron	4.9%
• Siltronic	14.7%	Others	6.3%

The top 2 producers all held their market share. With the purchase of 51% in Komatsu by SUMCO, the SUMCO market share increased from 21.8% to 31.5%. Siltronic's market share decreased from 14.9% to 14.7% and MEMC's market share decreased marginally from 11.7% to 10.4%. LG Siltron increased from 3.6% to 4.9%.

1.4.2 SILICON WAFER COMPANIES

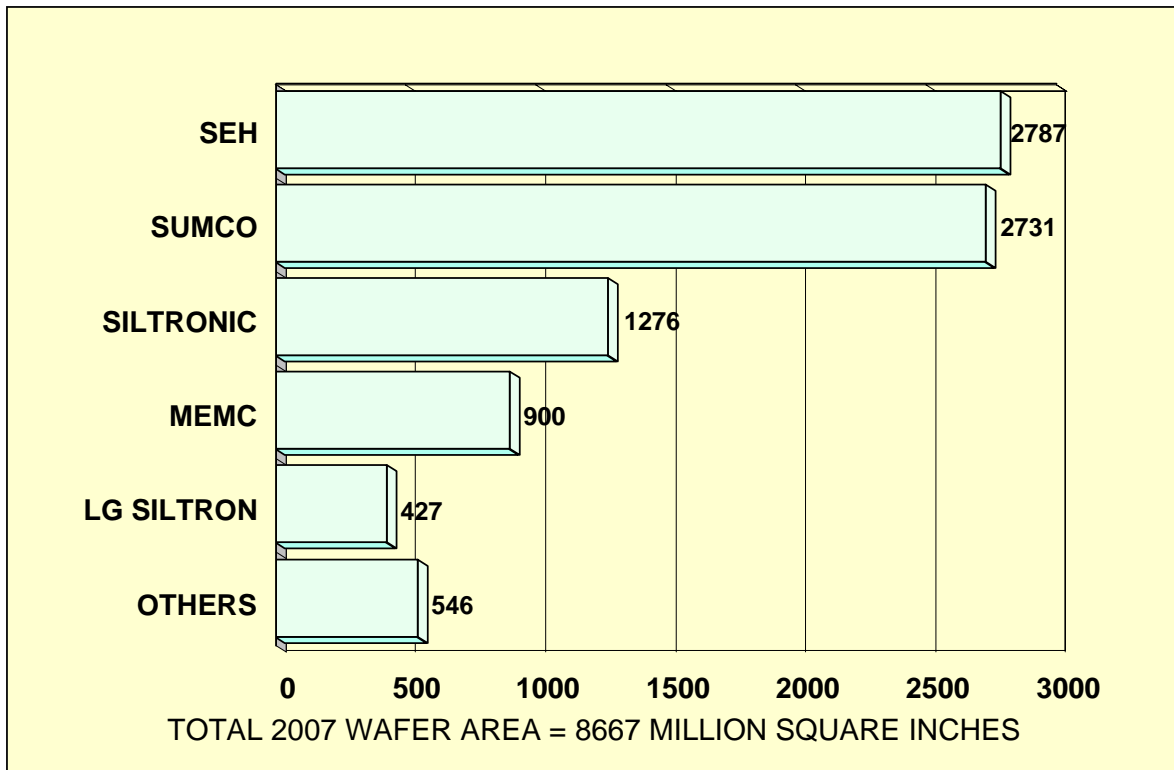
The leading silicon wafer manufacturers are presented in Figure 1-5. These wafer manufacturers have the following market shares:

• SEH	31.9%
• SUMCO	31.7%
• Siltronic	14.8%
• MEMC	11.7%
• LG Siltron	3.6%

Shin-Etsu Handotai (SEH) is the world's leading silicon wafer producer with a year 2007 production of 2787 million square inches. In second place (2nd) is SUMCO, with sales of 2731 million square inches. SUMCO is the result of a merger of the former Sumitomo Sitix, Mitsubishi Materials Silicon, and Komatsu. In third (3rd) position is Siltronic with sales of 1276 million square inches in 2007.

The fourth (4th) largest silicon wafer manufacturer is MEMC, whose sales figures include the sales of the joint venture operations; Taisil, MEMC Korea, and Texas Instruments. In the year 2007, MEMC had combined sales of 900 million square inches. In fifth (5th) position was LG Siltron with sales of 427 million square inches. Others, including Covalent Materials (the former Toshiba Ceramic), account for 546 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	\$4.24	¥492	€2.84
3	FZ	\$5.65	¥655	€3.79
4	TEST	\$6.04	¥701	€4.05
4	FZ	\$7.40	¥858	€4.96
4	CZ	\$8.05	¥934	€5.39
4	EPI	\$9.42	¥1,093	€6.31
4	SOI	\$26.50	¥3,074	€17.76
5	TEST	\$9.68	¥1,123	€6.49
5	FZ	\$11.88	¥1,378	€7.96
5	CZ	\$12.90	¥1,496	€8.64
5	ANNEAL	\$16.16	¥1,875	€10.83
5	EPI	\$18.10	¥2,100	€12.13
5	SOI	\$46.88	¥5,438	€31.41
6	TEST	\$14.88	¥1,726	€9.97
6	FZ	\$19.08	¥2,213	€12.78
6	CZ	\$19.84	¥2,301	€13.29
6	ANNEAL	\$20.15	¥2,337	€13.50
6	EPI	\$28.79	¥3,340	€19.29
6	SIGE	\$35.20	¥4,083	€23.58
6	SOI	\$68.00	¥7,888	€45.56
8	TEST	\$36.55	¥4,240	€24.49
8	CZ	\$48.73	¥5,653	€32.65
8	ANNEAL	\$65.13	¥7,555	€43.64
8	EPI	\$66.37	¥7,699	€44.47
8	SIGE	\$77.17	¥8,952	€51.70
8	SOI	\$209.35	¥24,285	€140.26
12	TEST	\$153.67	¥17,826	€102.96
12	CZ	\$240.31	¥27,876	€161.01
12	ANNEAL	\$286.40	¥33,222	€191.89
12	EPI	\$299.50	¥34,742	€200.67
12	SOI	\$748.50	¥86,826	€501.50

Sales in terms of wafer area sold are illustrated in Table 1-3. Shin-Etsu is the largest producer overall with worldwide sales of 2787 million square inches for an overall market share of 32.2%. 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 twice (2x) 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	EUROPE	JAPAN	N AMERICA	OTHER		
SHIN-ETSU	1,584,415,716	91,701,860	743,494,066	352,489,034	14,698,293	2,786,798,970	32.2%
SUMCO	896,973,418	256,043,013	1,176,387,895	395,208,597	6,035,636	2,730,648,559	31.5%
SILTRONIC	535,754,694	299,975,197	97,501,601	317,542,092	25,569,391	1,276,342,975	14.7%
MEMC	490,620,833	115,958,656	68,433,261	216,503,039	8,749,550	900,265,339	10.4%
LG SILTRON	373,169,280	5,697,187	15,944,231	31,757,679		426,568,377	4.9%
OTHER	120,737,389	89,772,204	226,483,169	108,919,384		545,912,147	6.3%
REGIONAL SUBTOTALS	4,001,671,329	859,148,117	2,328,244,223	1,422,419,825	55,052,872	8,666,536,366	100.0%
REGIONAL %	46.2%	9.9%	26.9%	16.4%	0.6%	100.0%	

The 2nd largest global producer is SUMCO with sales of 2731 million square inches. It is the 2nd largest silicon wafer seller in the Asia Pacific and Europe and largest in Japan and the United States. The third (3rd) largest silicon wafer producer in the world is Siltronic with 2007 sales of 1276 million square inches or 14.7% of the world total. It is the largest seller in Europe and the 3rd largest in the United States. MEMC is the 4th largest worldwide wafer manufacturer. It is the 3rd largest seller in Europe and the 4th largest seller in the Asia Pacific and the United States.

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

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

In Europe Siltronic is the leader, followed by SUMCO, with MEMC in 3rd position.

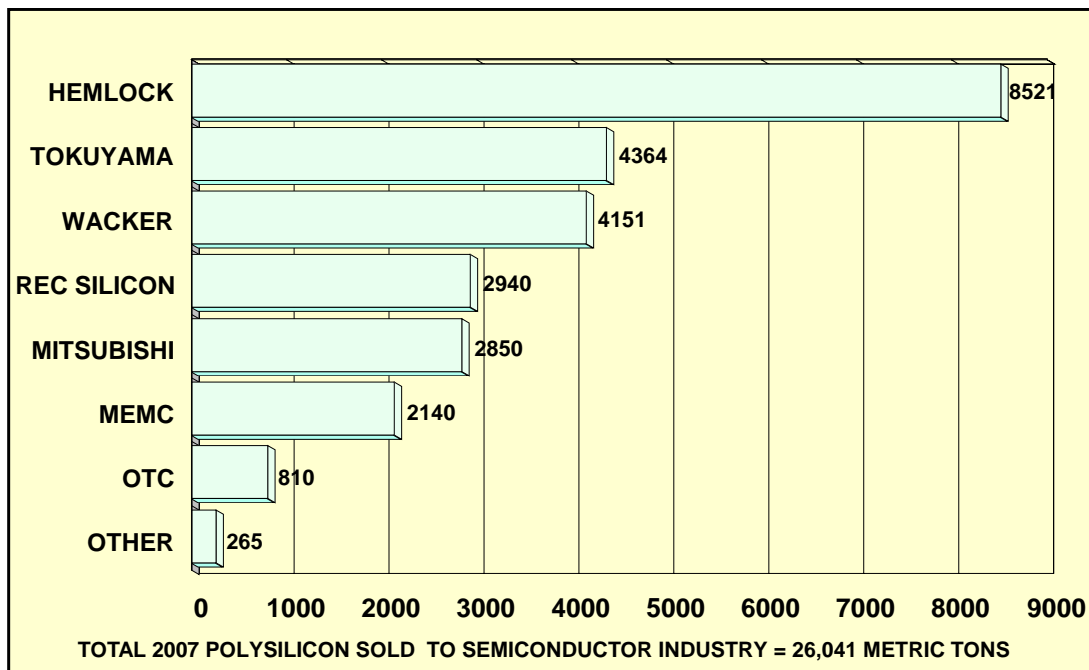
In Japan SUMCO is the largest supplier followed by SEH in 2nd place. Siltronic is in 3rd place followed by MEMC. Others, including Covalent Materials (ex-Toshiba Ceramic), contribute a significant share.

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 28.6 %
- Tokuyama 18.2%
- Wacker Chemie 17.5%
- Mitsubishi (Japan & USA) 11.9%
- REC Silicon 10.1%
- MEMC (USA & Italy) 9.4%
- Sumitomo Sitix 3.2%

FIGURE 1-6
SEMICONDUCTOR POLYSILICON SUPPLIERS



The leading producer was Hemlock Semiconductor. Hemlock produced 8521 metric tons of semiconductor polysilicon from its Hemlock, Michigan, complex. Tokuyama was the 2nd largest supplier of semiconductor polysilicon. In the year 2007 this company sold 4363 metric tons of semiconductor polysilicon. The 3rd largest production came from Wacker Chemie. In the year 2007, Wacker supplied 4151 metric tons of semiconductor polysilicon.

Next is the REC Silicon plant located in Butte, Montana. This plant produced 2940 metric tons of semiconductor polysilicon in the year 2007. After REC, the next largest semiconductor polysilicon production came from Mitsubishi Materials Polycrystalline Silicon. Its Yokkaichi plant produced 1500 metric tons and its newer plant in the United States produced 1350 metric tons for a total semiconductor polysilicon production of 2850 metric tons. After Mitsubishi is MEMC. Their facility, located in Merano, Italy had a the year 2007 semiconductor polysilicon production of 800 metric tons and their facility located in Pasadena, Texas, produced 1340 metric tons for a total of 2140 metric tons of semiconductor polysilicon.

The seventh (7th) largest polysilicon production was from Osaka Titanium Technology Corporation's (formerly STC) Amagasaki facility. This facility produced 810 metric tons of semiconductor polysilicon in the year 2007. There were an additional 265 metric tons for others, primarily located in China.

If the semiconductor market were the only market for polysilicon then there would be an oversupply situation in the polysilicon industry. In 2007 the total production of polysilicon was 43,800 metric tons and the demand of the semiconductor industry was 26,041. Thus demand was only 59.4% of the total production capacity of the polysilicon industry. There is however a second market for polysilicon. This market is the photovoltaic market. This market 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 2007 the photovoltaic industry consumed 24,975 metric tons of silicon raw material. Over 17,759 metric tons of this material came from traditional semiconductor polysilicon producers and the remainder comes from semiconductor scrap and supplies of upgraded metallurgical silicon.

In 2007 the traditional semiconductor polysilicon suppliers supplied the following amounts of polysilicon to the photovoltaic industry:

- *Hemlock* 5979 metric tons
- *Wacker* 3949 metric tons
- *REC Silicon* 3460 metric tons
- *MEMC* 1560 metric tons
- *Tokuyama* 1236 metric tons
- *Mitsubishi* 200 metric tons
- *OTC* 90 metric tons
- *Others* 300 metric tons

The total is 17,759 metric tons, which when added to the semiconductor demand of 26,041 produced a total demand of 43,000 metric tons totally consuming nearly all of the polysilicon that could be produced in 2007.

1.6 REPORT OUTLINE

The remainder of the report, entitled "Silicon Industry - 2007" 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 2005 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 2005 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 65 page Semiconductor Manufacturers Database. This database has been heavily updated from previous years.