SILICON

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Silicon is a light chemical element with metallic and nonmetallic characteristics. Silicon is not found free in nature. Silicon combines with oxygen and other elements to form silicates, which comprise more than 25% of the Earth's crust. Silica (SiO_2) as quartz or quartzite is used to produce silicon ferroalloys for the iron and steel industries and silicon metal for the aluminum and chemical industries. Silicon metal that is refined into semiconductor-grade metal for use in making computer chips is crucial to modern technology, but the quantity is less than 5% of total silicon metal demand (Roskill's Letter from Japan, 2000). The only information that this report contains about this highest purity silicon is as it appears in the foreign trade statistics and from published sources.

In 2004, overall domestic silicon production increased for the first time in 7 years. At 275,000 metric tons (t) of contained silicon, production was 9% higher than that of 2003 (table 1). On a gross-weight basis, production increased by 8% from the revised figure of 335,000 t in 2003 (table 2).

On the basis of contained silicon, U.S. exports of silicon products decreased by 5%, while imports increased by 7%. The decrease in exports was associated with decreases in the "99.00% to 99.99% silicon" and "other" silicon metal trade categories (table 5). The increase in imports was attributable to increases in all grades of silicon metal, which offset decreases in ferrosilicon imports (table 6).

Apparent consumption for ferrosilicon remained essentially flat from 2002 through 2004, while that of silicon metal increased by 22% compared with that in 2003. Year-average import prices for silicon metal increased 34%, and those for each ferrosilicon grade increased by 22% compared with those in 2003 (table 1).

Legislation and Government Programs

Silicone Gel Breast Implants.—On January 13, the U.S. Food and Drug Administration (FDA) issued a revised draft guidance document entitled "Saline, Silicone Gel, and Alternative Breast Implants; Guidance for Industry and FDA" for public review and comment. In the revised draft, the FDA clarifies the type and amount of scientific data that should be submitted by industry to allow FDA evaluation of whether the devices are safe and effective. Comments on the latest revised document were due to the FDA by April 12 (U.S. Food and Drug Administration, 2004). As of mid-July 2005, the FDA had yet to publish a final version of the document.

In June, the FDA published its "FDA Breast Implant Consumer Handbook—2004." In the handbook, the FDA emphasized that because no company had premarket approval authority yet to sell silicone gel-filled breast implants, consumers could only get them if enrolled in either an investigational device exemption or adjunct study (U.S. Food and Drug Administration, 2004§[1]).

Silica Fume.—On April 30, the U.S. Environmental Protection Agency amended the Comprehensive Procurement Guideline IV (CPG) by adding silica fume as a recovered material that can be used to make cement and concrete. Silica fume (microsilica) is a byproduct from furnaces making silicon metal or ferrosilicon with a silicon content of at least 75%. It is obtained by capturing furnace offgases and fines. The CPG requires any agency that uses appropriated federal funds to procure $10,000 or more of a designated item (for example, concrete) in a given year to purchase the item containing the highest percentage of recovered materials practicable (U.S. Environmental Protection Agency, 2004).

Production

Silicon Ferroalloys[2] and Metal.—In terms of gross weight and in comparison with those of 2003 (revised), overall domestic gross production and net shipments of silicon products increased by 8% and 10%, respectively, whereas stocks decreased by 7%. The most pronounced year-to-year changes were in the 75% ferrosilicon category, for which production and shipments increased by 15% and 20%, respectively. Production and shipments for 50% ferrosilicon increased by 4% and 8%, respectively. Silicon metal production and shipments rose by 8% and 6%, respectively (table 2).

Domestic production data for silicon are derived from monthly and annual voluntary surveys and estimates for nonrespondents by the U.S. Geological Survey (USGS). The data in table 2 were obtained from all operations listed in table 3 that are canvassed by means of the USGS Silicon Alloys survey.

Globe Metallurgical, Inc. emerged from Chapter 11 bankruptcy protection on May 10 after securing a $16 million term loan from Fortis Bank and MI Capital Corp., who will receive a significant portion of Globe's common stock. MI Capital is a member of the Marco International Group, which has a tolling contract for Globe's production (Ryan's Notes, 2004c). On May 28, Globe reported an "eruption" at its silicon metal plant located near Selma, AL, which fatally injured one worker and shut down one of two furnaces (Platts Metals Week, 2004a). The furnace was restarted on June 8, with the company reporting about 360 t in lost production (Platts Metals Week, 2004b). No cause for the outage was given.

Consumption

Silicon Ferroalloys and Metal.—As reported in table 4, the majority of ferrosilicon was used to produce steel (68%) and cast irons (29%). Silicon metal was used mainly to produce

[1]References that include a section mark (§) are found in the Internet References Cited section.

[2]There are two standard grades of ferrosilicon—50% and 75%. For a more detailed explanation of these grades, see table 2.

chemicals—silicones, silanes, and other—and silica fume (76%). Metallurgical-grade silicon carbide can substitute for ferrosilicon, especially in iron foundries. Data on North American production and U.S. imports of silicon carbide are reported in the Manufactured Abrasives chapter of the 2004 USGS Minerals Yearbook.

Total U.S. apparent consumption of silicon ferroalloys and metal in 2004 increased by 9% to 594,000 t from the revised estimate of 544,000 t in 2003 (contained silicon). Apparent consumption increased by 22% to 293,000 t for silicon metal, and decreased marginally to 301,000 t for ferrosilicon and miscellaneous silicon alloys. Decreases in net imports for consumption contributed to the slight decrease in ferrosilicon apparent consumption. Increases in production and net imports for consumption led to the rise in silicon metal apparent consumption. Ferrosilicon and miscellaneous silicon alloys accounted for 51% of the total demand.

Reported to apparent consumption on a content basis is 41% for ferrosilicon, which includes miscellaneous silicon alloys, and 90% for silicon metal. These percentages were derived based on the typical silicon contents of the materials noted in table 4.

Consumption of ferrosilicon and silicon metal was estimated by CRU International Ltd. to have increased in 2004 throughout the Western World. In terms of contained silicon, ferrosilicon consumption increased to 1.97 million metric tons (Mt) from 1.91 Mt in 2003, and silicon metal consumption increased to about 1.28 Mt from 1.13 Mt. Areas having the largest year-to-year increase in consumption were, for ferrosilicon, Japan and Western World countries (excluding Cuba, the United States, and Western Europe), and for silicon metal, Asian countries (excluding China, Japan, and North Korea) and the United States. In decreasing order of consumption, Western Europe, Japan, and other Asian countries accounted for 72% of the ferrosilicon consumption in 2004. Also in decreasing order of consumption, Western Europe, the United States, and Japan accounted for 77% of the silicon metal consumed in 2004 (CRU Bulk Ferroalloys Monitor, 2005a, b).

Semiconductor Grade Silicon.—Global demand for silicon wafers made from polycrystalline silicon increased by 22% as shipments rose to 6,260 million square inches from 5,149 million square inches in 2003. The corresponding value of the shipments increased by 26% to $7.3 billion from $5.8 billion (Roskill's Letter from Japan, 2005).

Silica Fume.—The global market for fumed silica is estimated to exceed 230,000 metric tons per year (t/yr) (Interfax Mining & Metals Report, 2002).

Prices

Ferrosilicon and silicon metal prices tend to vary in response to changes in demand and supply by the aluminum, chemical, ferrous foundry, and steel industries. Year-average import prices given by Platts Metals Week were, in cents per pound, 55.4 for 75% ferrosilicon and 81.9 for silicon metal; these prices were 22% and 34% higher, respectively, than those of 2003. The year-average North American transaction price for 50% ferrosilicon as calculated from Ryan's Notes listings was 58.2 cents per pound, a 22% increase from that of 2003. The year-average prices for these materials were at their highest level since 1996. Prices for both grades of ferrosilicon rose based on increased demand from the domestic steel sector and reduced import levels from those of 2002. Higher silicon metal prices in the United States were attributed to the rising production costs and demand (CRU Bulk Ferroalloys Monitor, 2004a, b).

Foreign Trade

Trade volumes discussed below are based on gross weight. While U.S. ferrosilicon exports decreased slightly (1%), their value increased by 13% to $11.7 million from those of 2003. In decreasing order of amount, Canada and Mexico accounted for 98% of the total 2004 ferrosilicon exports (table 5). Exports of silicon metal decreased by 7%, while their value increased by 33% from those of 2003. In decreasing order of amount, Japan and China accounted for 47% of silicon metal exports. Shipments of high-purity silicon containing more than 99.99% silicon accounted for 62% of total silicon metal exported and 94% of the total value of combined ferrosilicon and silicon metal exports.

U.S. ferrosilicon imports decreased by 8%, but increased by 10% in value to $2.01 million compared with those in 2003. Imports decreased for all significant categories, with the exception of magnesium ferrosilicon imports, which increased slightly by 1% from those in 2003. Imports of standard 75% ferrosilicon (ferrosilicon category of "55% to 80% silicon, other") accounted for 83% of total ferrosilicon imports by gross weight and value (table 6). They also had the largest year-to-year decrease (9%) of ferrosilicon imports. China was the leading source of ferrosilicon imports at 24%, followed by Venezuela at 17%.

Silicon metal imports rose by 30% to 167,000 t from 128,000 t, and 43% in value to $314 million from $220 million compared with those in 2003. Imports increased in all silicon metal categories, the largest amount of which was in the "99.00% to 99.99% silicon" category. Brazil was the leading source of the "99.00% to 99.99% silicon" import category at 41%, followed by South Africa at 24%. This category accounted for 55% of the total value for silicon metal imports, an increase of 36% from those in 2003.

The estimated U.S. net import reliance for ferrosilicon in 2004 decreased to 58% from 62% in 2003 (revised), while that of silicon metal increased to 50% from 44%. The overall import reliance for silicon was estimated to be the same level (54%) as it was in 2003.

The general rates of duty that applied to U.S. imports during 2004 were the same as in 2003. These were, on an ad valorem basis, 1.5% for standard 75% ferrosilicon; 1.1% for nominal 75% ferrosilicon that contains more than 3% calcium; 1.9% for ferrosilicon containing 80% to 90% silicon; 5.8% for ferrosilicon containing more than 90% silicon; free for magnesium ferrosilicon and other ferrosilicon; and 5.3% or 5.5% for metal exclusive of the high-purity grade, which is free (U.S. International Trade Commission, 2003).

Silicon Metal Imports from Brazil (July 1, 1998, through June 30, 1999).—On April 15, the U.S. Court of International Trade (CIT) remanded the antidumping duty margin rate for

these imports to the International Trade Administration (ITA) of the U.S. Department of Commerce (Elkem Metals Co. v. United States, Consol. Court No. 01-00098, CIT Slip Opinion 04-36). The CIT instructed the ITA to recalculate the antidumping duties for Companhia Brasileira Carbureto de Calcio (CBCC) based on the company's home market credit expense and for Eletrosilex, S.A. based on a more relevant "adverse facts available" rate. On July 14, the ITA changed the antidumping duty margins for CBCC to zero from 0.63% and for Eletrosilex to 61.58% from 93.2% (International Trade Administration, 2004§). As of mid-July 2005, the CIT had yet to decide on the ITA determination.

Ferrosilicon Imports from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela (1989 through 1993).—On May 12, the CIT remanded for the third time the U.S. International Trade Commission's (ITC) determination that U.S. ferrosilicon producers were not materially injured by these imports (Elkem Metals Co. v. United States, No. 99-10-00628, CIT Slip Opinion 04-99). The third remand required the ITC to provide additional evidence supporting the negative determination it made on August 18, 2003 (U.S. International Trade Commission, 2003§). In June, the ITC filed a motion for reconsideration with the CIT on certain portions of the recent opinion (U.S. International Trade Commission, 2004a). On December 3, the CIT clarified and modified the opinion, but denied the ITC's motion for reconsideration. As a result, the matter continues to be remanded to the ITC (Elkem Metals Co. v. United States, No. 99-10-00628, CIT Slip Opinion 04-152).

Silicon Metal Imports from Brazil (July 1, 1994, through June 30, 1995).—On May 13, the CIT upheld ITA's revised dumping margin of 0.37% (de minimis) for the subject imports (American Silicon Technologies v. United States, No. 97-02-00267, Slip Opinion 04-50). The ITA revised the dumping margin in response to the U.S. Court of Appeals for the Federal Circuit's remand that upheld CBCC's appeal of the 67.93% duty rate the ITA assessed in 1999 and the CIT sustained on August 27, 2001 (U.S. Court of Appeals for the Federal Circuit, 2003§).

Silicon Metal Imports from Russia (July 2001 through December 2001).—On June 22, the CIT upheld part of the ITC's final determination that the U.S. silicon industry was injured by these imports, but remanded the case to the ITC to explain how spot market prices effected annual contract prices and how secondary aluminum-grade silicon prices effected other silicon product prices (Bratsk Aluminum Smelter v. United States, Consol. Court No. 03-00200, CIT Slip Opinion 04-75). This remand was a result of appeals by U.S. silicon consumer General Electric Company and Russian silicon producers Bratsk Aluminum Smelter and SUAL-Kremny-Ural, Ltd. In September, the ITC found once again that the U.S. silicon industry was injured by silicon imports from Russia in its determination (U.S. International Trade Commission, 2004d). As of mid-July 2005, the CIT had yet to decide on the ITC determination.

In a related matter, the CIT remanded the appeals case by U.S. silicon producers Globe Metallurgical, Inc. and Simcala, Inc. to the ITA on September 24 (Globe Metallurgical Inc. v. United States, Consol. Court No. 03-00202, CIT Slip Opinion 04-123). The U.S. silicon producers appealed the antidumping margin rates set by the ITA in March 2003 on silicon metal imports from Russia on the basis that they were too low (Platts Metals Week, 2003). In its remand, the CIT asked the ITA to clarify why Russian post-nonmarket-economy prices and recycled silicon metal fines were not factored into production costs. On January 5, 2005, the ITA made its final determination where the treatment of recycled silicon metal fines was revised in concurrence with arguments made by the U.S. silicon producers (International Trade Administration, 2005§). As a result of the redetermination, the ITA recalculated the dumping margin rates for Bratsk Aluminum Smelter to 87.08% from 79.42%, and for ZAO Kremny/Sual-Kremny-Ural Ltd. to 56.2% from 56.11%. The Russian-wide rate remained unchanged at 79.42%. As of July 18, 2005, the CIT had yet to decide on the ITA determination.

Silicon Metal Imports from Brazil (July 1, 1999, through June 30, 2000).—On November 16, the CIT remanded the 0.35% duty margin rate the ITA calculated for the subject imports from Rima Industrial S.A. (Elkem Metals Co. v. United States, Consol. Court No. 02-00232, CIT Slip Opinion 04-145). The CIT told the ITA to recalculate the antidumping duty based on the value-added taxes paid by Rima.

Pending U.S.-Southern African Customs Union Free Trade Agreement.—In December, the United States Trade Representative (USTR) met with trade ministers from the member nations of the Southern African Customs Union (Botswana, Lesotho, Namibia, South Africa, and Swaziland) to continue negotiations on the pending U.S.-Southern African Customs Union Free Trade Agreement (FTA) (Office of the United States Trade Representative, 2004§). The USTR launched negotiations for the FTA on June 2, 2003 (Office of the United States Trade Representative, 2003§). The FTA could result in the elimination of the 5.5% ad valorem duty on imports of less than 99.00% silicon metal from South Africa.

Antidumping Duty Administrative Reviews.—On June 13, 2003, the ITA announced the final results of its administrative review of silicon metal imports from China for Groupstars Chemical Co., Ltd., covering the period June 1, 2001, through May 31, 2002 (International Trade Administration, 2003a). The ITA retained the antidumping margin rate of 139.49% preliminarily issued on March 10, 2003.

On December 23, 2003, the ITA rescinded the antidumping duty review of silicon metal imports from Brazilian producers CBCC and Companhia Ferroligas Minas Gerais-Minasligas (Minasligas) for the period July 1, 2002, through June 30, 2003. The ITA terminated the review, which it began on August 22, 2003, after the petitioners (Elkem Metals Company and Globe Metallurgical Inc.) withdrew their request for one on November 19, 2003 (International Trade Administration, 2003b).

On April 7, 2004, the ITC announced the beginning of a countervailing duty investigation on silicon metal imports from Brazil and an antidumping duty investigation on silicon metal imports from South Africa in 2003. ITC started the investigations because of a petition filed on March 31 by Globe Metallurgical Inc. and others (U.S. International Trade Commission, 2004b). On April 28, the ITC discontinued the investigations because the organizations withdrew their petition on April 16 (U.S. International Trade Commission, 2004c). The groups withdrew their petition because Elkem, the largest silicon metal producer in the United States, would not support the investigations (Ryan's Notes, 2004d).

On August 30, 2004, the ITA announced the start of an antidumping duty administrative review for silicon metal imports from Brazilian producer Camargo Correa Metals, S.A. (CCM) for the period of July 1, 2003, through June 30, 2004 (International Trade Administration, 2004a). The ITA also began an antidumping duty administrative review of silicon metal imports during the same period from Brazilian producers Minasligas and Ligas de Aluminio S.A. (LIASA) on September 22 (International Trade Administration, 2004b). On November 19, 2004, the ITA rescinded the administrative review for LIASA and Minasligas because neither company had sales or exports of the subject merchandise during the period of review (International Trade Administration, 2004c).

World Review

Data on annual world production of ferrosilicon and silicon metal by country during 2000 to 2004 are given in the Ferroalloys chapter of the 2004 USGS Minerals Yearbook. World production of ferrosilicon was estimated to have been 5.63 Mt in 2004 compared with 4.90 Mt in 2003. The major ferrosilicon producers in 2004 were, in decreasing order, China, Russia, Norway, Ukraine, the United States, South Africa, Brazil, Iceland, and Kazakhstan; they accounted for 88% of total production as listed in table 1. World production of silicon metal, excluding that from China, was estimated to have been 686,000 t in 2004 compared with 642,000 t in 2003. Firm data on China's production of silicon metal are lacking, although one source reported it at 520,000 t/yr in 2004 (Ryan's Notes, 2004e). At this rate, China is by far the largest producer of silicon metal in the world. Other major producers of silicon metal in 2004 were, in decreasing order, the United States, Brazil, Norway, France, Russia, and South Africa; they accounted for about 84% of total production as listed in table 1.

European Union.—In March, the European Union imposed an antidumping duty rate of 49% on silicon metal imports from China for the period October 1, 2001, through September 30, 2002 (Official Journal of the European Union, 2004).

Brazil.—Brazilian ferroalloy producer Companhia de Ferro Ligas da Bahia-Ferbasa began construction of a ferrosilicon furnace with a production capacity of 15,000 t/yr at its Pojuca plant in Bahia State. The company expected construction to be completed by August 2005 (TEX Report, 2004e).

Canada.—In October, Timminco Limited acquired Becancour Silicon Inc., a Quebec-based company that produces high-quality chemical and electronic-grade silicon metal and specialty ferrosilicon, for approximately Can$34 million (US$26 million) (Metal-Pages, 2004f§, g§).

China.—In 2004, China's exports of ferrosilicon containing more than 55% silicon rose 10% to an alltime high of 908,000 t from that of 2003, while those containing 55% or less silicon fell about 32% to 22,800 t from that of 2003. China exported an estimated 550,000 t of silicon metal in 2004, an increase of 11% from 497,000 t in 2003 (TEX Report, 2005a, b).

On May 1, the Central Government of China (the State Council) announced new measures to stem investment in, and expansion of, ferroalloy facilities throughout the country (TEX Report, 2004c). The Chinese Government was concerned about the potential adverse impact the continued rapid growth by the country's ferroalloys industry would have on its "bubbling" economy; the Government estimated that ferroalloy production capacity would double to 10 million metric tons per year (Mt/yr) by yearend 2005 if left unrestricted. The Government indicated concern that such expansion would further compromise the already strained electricity supply and further degrade environmental conditions (TEX Report, 2004b, d).

The new measures included: 1) immediately closing all electric furnaces and blast furnaces with capacities less than 3,200 kilovolt-amperes (kVA) and 100 cubic meters, respectively; 2) closing electric furnaces with capacities below 5,000 kVA before 2005; 3) eliminating favorable policies for ferroalloy producers including discounted electricity rates, reduced tax rates, and benefits regarding land usage; and 4) tightening enforcement of environmental regulations (Metal Bulletin Research Ferro-alloys Monthly, 2004). Financial institutions were prohibited from offering financing to closed plants or illegal producers (TEX Report, 2004c).

In June, the Inner Mongolia Electric Power Metallurgy Co. Ltd. of the ERDOS Group expanded ferrosilicon production at its new ferrosilicon plant in the city of Wuhai, Inner Mongolia Autonomous Region by constructing 16 electric furnaces in addition to the 4 completed in 2003. Design capacity for the facility was estimated to be 180,000 t/yr by yearend 2004 rather than the 500,000 t/yr projected last year. The ERDOS expansion was approved because it complied with the Government's May 1 restrictions on ferroalloy facilities (TEX Report, 2004d).

In November, Ordins Trading Company announced plans to bring a new 10,000-t/yr silicon metal plant located in Jingyu, Jilin Province online by yearend 2004. The cost of the facility was reported at rmb30 million (US$3.6 million) (Metal-Pages, 2004d§).

In December, China's Ministry of Finance revoked the 8% export tax rebate on ferrosilicon starting January 1, 2005. The Government did so to reduce metal exports in 2005 following shortages in the country's energy and transport sectors (Metal-Pages, 2004b§).

France.—On December 15, 2003, Canadian aluminum producer Alcan Inc. acquired Pechiney Electrometallurgie (PEM) (Alcan Inc., 2003§). In late December 2004, Alcan reported it was discussing the sale of PEM's ferroalloy division with Spanish ferroalloy producer Ferroatlantica Group (Metal-Pages, 2004a§). On April 5, 2005, Ferroatlantica purchased PEM for 140 million euros (US$180 million) (Yahoo! Finance [France], 2005§). PEM's ferroalloy division includes ferrosilicon and silicon metal producer Invesil with four plants in France and one in South Africa.

Iceland.—In November, Elkem ASA announced plans to add up to two ferrosilicon furnaces at its Icelandic Alloys Ltd. facility to offset lost ferrosilicon production when the company converts its large ferrosilicon furnace to silicon metal production at its Thamshavn, Norway, plant. The company expected to first spend NOK23.5 million (US$3.76 million) to enlarge storage facilities before adding the furnaces, but did not provide additional details on the expansion (Ryan's Notes, 2004b).

India.—Nava Bharat Fero Alloys Ltd. announced plans to expand its ferroalloys plant at Paloncha in Andrha Pradesh State

by installing a new 25 megavolt-amperes (MVA) furnace at a cost of Rs280 million (US$6.3 million). The new furnace will increase ferroalloy output (unspecified product mix) to 122,000 t/yr from 75,000 t/yr in 2005 (Mining Journal, 2004).

Norway.—In October, Elkem began converting furnace 2 at its Thamshavn, Norway, plant to silicon metal production from that of ferrosilicon at a cost of NOK110 million (US$16.7 million) (Elkem ASA, 2004b§). Once completed, the plant will be wholly dedicated to silicon metal production, with furnace 2 the largest silicon metal furnace in the world. Following the switch, it will be able to produce 50,000 t/yr of silicon metal and 20,000 t/yr of microsilica (Metal-Pages 2004c§). Also in October, the company acquired a 23% share in Norwegian-based Renewable Energy Corporation AS for NOK450 million (US$70.2 million) (Elkem ASA, 2004a§). By doing so, the company continued its expansion into high-purity silicon production for the solar energy industry (Elkem ASA, 2005§). In December, the company announced it would be dropping ferrosilicon production at its Salten, Norway, plant to less than 50% of capacity during the first half of 2005, citing higher raw material prices, stagnant metal prices, and a soaring euro. As a result, it will lose about 10,000 t of 75% ferrosilicon (Ryan's Notes, 2004g).

Norwegian producer Fesil ASA reported the following for 2004: its Holla Metall silicon metal plant was in full production (51,000 t/yr); its Rana Metall ferrosilicon plant operated close to capacity (95,000 t/yr of 75% ferrosilicon); and the Lilleby Metall ferrosilicon and silicon metal plant remained shutdown with no plans to restart in 2005 (Fesil ASA, 2005§).

Russia.—In the spring of 2004, Kuznetsk Ferroalloy Works (KFZ) purchased Yurga Abrasives, a Russian abrasive materials manufacturer, from SUAL Holding to expand ferroalloy production in the Kemerovo region of Russia. KFZ expected construction of the new ferroalloy line at the Yurga plant, up to 70,000 t/yr of 75% ferrosilicon, to begin later in 2004 upon completion of a feasibility study (Interfax Mining & Metals Report, 2004a).

Chelyabinsk Electrometallurgical Integrated Plant acquired the right to manage KFZ sometime during the year (TEX Report, 2004a). KFZ is owned by the Russian Joint Ferroalloy Industrial Group, comprised by Chelyabinsk and KFZ. The group plans to transfer all ferrosilicon production at Chelyabinsk to KFZ. Ferrosilicon production at KFZ is expected to increase to 460,000 t by 2006, up from 410,000 t in 2004 and 344,000 t in 2003 (Ryan's Notes, 2004a).

In April, Russian Aluminum (RUSAL) sold its Bratsk, Russia, silicon ferroalloy plant to the JSC Investment, Construction, Technologies consortium. Production capacity at the plant is 40,000 t/yr of ferrosilicon and 10,000 t/yr of silicon metal (RUSAL, 2004§).

South Africa.—More information can be found under "France" in this section about Ferroatlantica's acquisition of PEM, including Silicon Smelters Ltd. located in Polokwane near Pietersburg, South Africa, owned by PEM subsidiary Invesil.

Sweden.—In October, Vargon Alloys AB decided to restart the no. 8 furnace at its ferroalloys plant in Vargon, Sweden and switch production to 25,000 t/yr of ferrosilicon from ferrochrome. The 48-MVA furnace was closed on September 1 (Ryan's Notes, 2004f).

Ukraine.—Nikopol Ferroalloys Plant (NFZ) invested 63 million hryvnia (US$12.2 million) in 2004 to modernize the plant. Major projects included an overhaul of the no. 12 furnace to produce 65% ferrosilicon, a new product for NZF. After modernization, the company expected to produce more than 9,000 t of ferrosilicon in 2004 and 13,700 t in 2005 (Interfax Mining & Metals Report, 2004b).

Current Research and Technology

Silicon in Computer Chips.—Toyota Central Research & Development Laboratory and Denso Corp. announced a new method of making silicon carbide crystals that could lead to its replacement of silicon in electronic and other applications. Silicon carbide is cheaper than silicon, and more robust than silicon wafers, which can malfunction at high temperatures (Industrial Minerals, 2004). Silicon Genesis Corporation received a patent on September 14 for technology that transfers films of stressed silicon onto silicon-on-insulator substrates, which results in defect- and germanium-free substrates. The company believes these silicon substrates will find application in "next-generation" semiconductor applications (Metal-Pages, 2004e§).

Silicon in Solar Cells.—Several companies are developing new solar cell technologies that eliminate the need for crystalline silicon. Konarka Technologies, Inc., Lowell, MA, has developed films comprised of tiny semiconducting particles of titanium dioxide coated with light-absorbing dyes, bathed in an electrolyte, and embedded in plastic film. Nanosolar, Inc., Palo Alto, CA, continued to test titanium compounds and conductive plastic that can be sprayed on surfaces to form solar cells. Siemens AG, Erlangen, Germany, recently increased the power output of electrically conducting buckyball-plastic cells (Fairley, 2004).

Nanotechnology.—Researchers at Bringham Young University reported a new method that allows silicon to be patterned with functional organic chemical groups through selective deposition of alcohol, amines, and proteins on silicon surfaces. Such layering could find applications in nanotechnology and sensors (Freemantle, 2004). Scientists at Harvard University devised a method for making electrical contacts to nanometer-sized semiconductor circuit elements using metallic wires of the same dimensions of the semiconductor. The nanosized entities are brought together by selectively converting segments of a silicon nanowire (a semiconductor) to metallic nickel silicide. The researchers believe this technology will enable the fabrication of multifunctional, complex nanoscale electronic and optoelectronic devices (Jacoby, 2004).

Silanes.—The performance of several filler minerals used in plastics could be greatly enhanced by surface modification with silanes. Silanes act as molecular bridges between these fillers and the plastic to promote adhesion, cross-linkage, and water scavenging (Weissenbach, 2004).

Outlook

Demand for ferrosilicon follows trends in the iron and steel industries, for which the combined annual growth rates (CAGRs) have been typically in the range of 1% to 2% in the United States. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2004 USGS

Minerals Yearbook. Raw steel production in 2004 increased by 6% in the United States and about 9% globally. According to the International Iron and Steel Institute (IISI), apparent consumption of finished steel products increased by 9% to 968 Mt in 2004 from that in 2003 (International Iron and Steel Institute, 2005§). This increase was primarily attributed to steel consumption in Asia, particularly in China. Asia accounted for 50% of steel consumed worldwide in 2004, up 10% to 487 Mt from that in 2003. China alone consumed 265 Mt, a 13% increase from the prior year. Steel consumption in 2004 was also up in all other regions of the world.

Demand for silicon metal comes primarily from the aluminum and chemical industries. The American Chemistry Council estimated a 4.5% gain in domestic chemical volumes in 2004, moderating to 3.8% in 2005, as a result of improving economic recovery in 2004 within the United States. Globally, chemical output volumes were expected to increase 5.0% and 4.3% in 2004 and 2005, respectively (Chemical & Engineering News, 2004). Demand for silicon by the U.S. aluminum castings industry was expected to mirror the 6.4% increase in aluminum casting shipments forecasted in 2005 (Kirgin, 2005§).

As a rough indicator of high-purity silicon demand, world production of polycrystalline silicon was forecasted to increase by 16% to 27,000 t in 2004. Output of semiconductor-grade material was expected to rise by 19% to 19,350 t and that of solar battery-grade material by 13% to 7,650 t (Roskill's Letter from Japan, 2004).

Demand for microsilica comes from the cement industry. Worldwide demand for cement was projected to rise 4.1% annually through 2006 to 2.1 billion metric tons, although advances were expected to be less robust in more developed areas such as Japan, the United States, and Western Europe (Mining Engineering, 2002).

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TABLE 1
SALIENT SILICON STATISTICS[1]

(Thousand metric tons of silicon content unless otherwise specified)

	2000	2001	2002	2003	2004
United States:					
Production	367	282	261	253	275
Exports:					
Ferrosilicon	22	10	7	6	6
Silicon metal	19	12	15	20	18
Imports for consumption:					
Ferrosilicon	231	115	140	189	173
Silicon metal	130	116	145	126	165
Apparent consumption:					
Ferrosilicon	397	258	301	304 r	301
Silicon metal	292	244	240	240 r	293

See footnotes at end of table.

TABLE 1—Continued
SALIENT SILICON STATISTICS[1]

(Thousand metric tons of silicon content unless otherwise specified)

	2000	2001	2002	2003	2004
United States—Continued:					
Price, average, cents per pound of Si:					
Ferrosilicon, 50% Si[2]	45.00	42.80	41.10	47.70	58.16
Ferrosilicon, 75% Si[3]	35.40	31.90	32.90	45.30	55.35
Silicon metal[4]	54.80	50.50	53.20	61.30	81.92
World, production, gross weight:[e]					
Ferrosilicon	4,240	4,030	4,220	4,900	5,630
Silicon metal[5]	729	629	615	642	686

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits.
[2]Ryans Notes North American transaction prices based on weekly averages.
[3]Platts Metals Week mean import prices based on monthly averages.
[4]Platts Metals Week dealer import prices based on monthly averages.
[5]Excluding China.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES[1, 2]

(Metric tons, gross weight, unless otherwise specified)

	Silicon content (percentage)		2003, producers' stocks,	2004		
Material	Range	Typical	December 31	Gross production[3]	Net shipments	Producers' stocks, December 31
Ferrosilicon[4]	25-65 [5]	48	14,300 [r]	120,000	88,300	10,400
Do.	56-95	76	13,400 [r]	92,300	93,600	13,100
Silicon metal (excluding semiconductor grades)	96-99	98	5,520	150,000	141,000	7,530

[r]Revised.
[1]Data are rounded to no more than three significant digits.
[2]Data for silvery pig iron (less than 25% silicon) are withheld to avoid disclosing company proprietary data.
[3]Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.
[4]Includes miscellaneous silicon alloys, which formerly was listed separately.
[5]25% to 55% for ferrosilicon; 32% to 65% for miscellaneous silicon alloys.

TABLE 3
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND/OR SILICON METAL IN THE UNITED STATES IN 2004

Producer	Plant location	Product[1]
CC Metals and Alloys, Inc.	Calvert City, KY	FeSi.
Elkem Metals Co.	Alloy, WV	FeSi and Si.
Globe Metallurgical, Inc.[2]	Beverly, OH	Do.
Do.	Selma, AL	Si.
Oxbow Carbon and Minerals LLC[3]	Bridgeport, AL	FeSi.
Simcala, Inc.	Mt. Meigs, AL	Si.

[1]FeSi, ferrosilicon (includes miscellaneous silicon alloys); Si, silicon metal.
[2]Globe's silicon ferroalloys plant located in Niagara Falls, NY, was idle in 2004.
[3]Formerly Applied Industrial Minerals Corp.

TABLE 4

REPORTED CONSUMPTION, BY END USE, AND STOCKS OF SILICON FERROALLOYS AND METAL IN THE UNITED STATES IN 2004[1, 2]

(Metric tons, gross weight, unless otherwise specified)

End use	Silvery pig iron[3]	Ferrosilicon, 50%[4]	Ferrosilicon, 75%[5]	Silicon metal[6]	Miscellaneous silicon alloys[7]	Silicon carbide[8]
Steel:						
Carbon and high-strength, low-alloy	--	(9)	15,200	(10)	857	(9)
Stainless and heat-resisting	--	(9)	51,400	343	(9)	3,160
Full alloy	--	(9)	7,680	(10)	(9)	--
Electric and tool	--	--	29,100	--	(9)	(9)
Unspecified	--	32,100	(10)	(10)	713	4,910
Total	--	32,100	103,000	343	1,570	8,080
Cast irons	4,720	28,900	28,600	(10)	12,100	27,200
Superalloys	--	(11)	(10)	261	--	--
Alloys (excluding superalloys and alloy steel)	(11)	4,010	(10)	56,100 [12]	--	--
Miscellaneous and unspecified	--	--	825	176,000 [13]	--	--
Grand total	4,720	65,100	133,000	233,000	13,700	35,200
Consumers' stocks, December 31	333	2,540	8,590	2,120	895	1,520

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes U.S. Geological Survey estimates.

[3]Typically 18% silicon content but ranges from 5% to 24% silicon content.

[4]Typically 48% silicon content but ranges from 25% to 55% silicon content; includes briquets.

[5]Typically 76% silicon content but ranges from 56% to 95% silicon content; includes briquets.

[6]Typically 98% silicon content but ranges from 96% to 99% silicon content.

[7]Typically 48% silicon content. Primarily magnesium-ferrosilicon but also includes other silicon alloys.

[8]Typically 64% silicon content but ranges from 63% to 70% silicon content. Does not include silicon carbide for abrasive or refractory uses.

[9]Included with "Steel: Unspecified."

[10]Included with "Miscellaneous and unspecified."

[11]Included with "Cast irons."

[12]Primarily aluminum alloys.

[13]Primarily silicones, silanes, fumed silica, and other chemicals.

TABLE 5

U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2004[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
More than 55% silicon:			
Canada	5,430	3,260	$5,000,000
Chile	1	1	7,020
Colombia	11	8	15,800
Dominican Republic	19	14	38,700
France	16	10	25,500
Jamaica	2	1	3,240
Japan	1	(2)	2,780
Malaysia	22	17	33,100
Mexico	1,610	977	2,170,000
United Kingdom	2	1	2,690
Total	7,110	4,280	7,300,000
Other ferrosilicon:			
Australia	5	2	4,810
Canada	2,850	1,430	2,810,000
Colombia	7	3	7,650
France	75	38	120,000

See footnotes at end of table.

TABLE 5—Continued

U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2004[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon—Continued:			
Other ferrosilicon—Continued:			
Germany	32	14	$33,700
Italy	33	17	52,600
Korea, Republic of	27	14	42,800
Mexico	1,310	652	1,330,000
Spain	12	6	10,800
Other	12	6	22,600
Total	4,360	2,180	4,430,000
Grand total ferrosilicon	11,500	6,460	11,700,000
Metal:			
More than 99.99% silicon:			
China	1,540	XX	45,100,000
Finland	140	XX	3,970,000
France	213	XX	5,760,000
Germany	1,420	XX	45,400,000
Italy	145	XX	13,500,000
Japan	5,230	XX	231,000,000
Korea, Republic of	647	XX	28,000,000
Norway	1,110	XX	29,800,000
Taiwan	332	XX	13,300,000
United Kingdom	297	XX	20,800,000
Other	482	XX	34,200,000
Total	11,600	11,600 [e]	471,000,000
99.00% - 99.99% silicon:			
Brazil	763	755	1,860,000
China	56	56	120,000
Colombia	85	84	120,000
France	185	184	509,000
Germany	24	24	34,300
Hong Kong	53	53	75,200
Japan	420	417	1,050,000
Mexico	156	155	229,000
Panama	23	23	33,200
United Kingdom	79	78	111,000
Other	83	82	150,000
Total	1,930	1,910	4,290,000
Other silicon:			
Canada	386	375	454,000
China	270	262	357,000
Indonesia	83	81	110,000
Japan	1,150	1,120	3,670,000
Korea, Republic of	1,010	981	1,380,000
Mexico	581	564	1,250,000
Netherlands	555	530	4,460,000
Norway	478	464	631,000
Taiwan	164	159	220,000
United Kingdom	171	166	491,000
Other	257	250	668,000
Total	5,110	4,950	13,700,000
Grand total silicon metal	18,600	18,400	489,000,000

[e]Estimated. XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2004[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
55% - 80% silicon, more than 3% Ca:			
Argentina	30	18	$42,200
Brazil	542	370	588,000
China	30	17	40,700
France	608	391	1,020,000
Total	1,210	796	1,690,000
55% - 80% silicon, other:			
Brazil	1,570	1,660	1,390,000
Canada	13,300	10,000	10,200,000
China	56,000	42,500	39,800,000
France	4,310	2,880	7,020,000
Iceland	24,600	18,400	16,300,000
Kazakhstan	12,100	9,210	10,500,000
Norway	11,200	8,360	11,900,000
Russia	33,800	25,600	27,500,000
South Africa	2,600	1,970	1,800,000
Venezuela	41,200	31,500	35,000,000
Other	2,990	2,290	4,490,000
Total	204,000	154,000	166,000,000
80% - 90% silicon:			
Brazil	5	4	3,230
Canada	18	14	9,430
Germany	17	12	73,600
Total	40	31	86,300
More than 90% silicon, Italy	21	20 [2]	48,700
Magnesium ferrosilicon:			
Argentina	3,770	1,750	2,990,000
Brazil	3,570	1,610	2,990,000
Canada	2,090	966	1,680,000
China	4,160	1,910	3,010,000
France	38	18	35,900
India	174	197	188,000
Japan	328	156	486,000
Netherlands	900	416	711,000
Norway	15,300	7,040	12,300,000
South Africa	58	20	68,500
Other	71	35	90,700
Total	30,500	14,100	24,500,000
Other ferrosilicon:			
Brazil	457	192	511,000
Canada	11,100	3,490	7,230,000
China	72	37	122,000
France	42	21	74,700
India	141	85	136,000
Italy	4	2	3,670
Russia	7	4	5,990
Slovenia	59	41	70,000
Ukraine	5	3	4,030
Venezuela	4	2	3,270
Total	11,900	3,870	8,160,000
Grand total ferrosilicon	247,000	173,000	201,000,000

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2004[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal:			
More than 99.99% silicon:			
Belgium	75	XX	$104,000
China	23	XX	524,000
Germany	503	XX	48,700,000
India	17	XX	108,000
Italy	393	XX	15,900,000
Japan	464	XX	31,300,000
Korea, Republic of	56	XX	1,280,000
Mexico	16	XX	111,000
Philippines	214	XX	306,000
Taiwan	29	XX	346,000
Other	19	XX	1,090,000
Total	1,810	1,810 [e]	99,800,000
99.00% - 99.99% silicon:			
Australia	3,490	3,470	5,060,000
Brazil	55,700	55,300	66,100,000
Canada	19,400	19,200	26,500,000
China	20	20	23,900
France	7,880	7,800 [2]	12,200,000
Germany	44	44 [2]	67,400
Norway	8,200	8,180	15,500,000
Philippines	567	561 [2]	759,000
South Africa	37,400	37,000 [2]	45,300,000
Spain	400	397	637,000
Other	134	116	799,000
Total	133,000	132,000	173,000,000
Other silicon:			
Belgium	402	108	493,000
Brazil	13,200	13,000	16,800,000
Canada	4,490	4,310	6,690,000
China	2,830	2,780	3,170,000
France	2,400	2,310	3,060,000
Germany	244	234	636,000
Norway	2,820	2,780	4,130,000
South Africa	3,060	2,980	3,340,000
Ukraine	1,360	1,330	1,670,000
United Kingdom	652	640	1,010,000
Other	205	136	257,000
Total	31,700	30,600	41,300,000
Grand total silicon metal	167,000	165,000	314,000,000

[e]Estimated. XX Not applicable.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]All or part of these data have been referred to the U.S. Census Bureau for verification. Data were adjusted by the U.S. Geological Survey to the minimum silicon content level.

Source: U.S. Census Bureau.