



# 2007 Minerals Yearbook

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## GALLIUM

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Gallium metal and gallium arsenide (GaAs) wafer imports continued to account for most of the U.S. gallium consumption. Metal imports were 38% higher than those in 2006, with Germany, Canada, and Ukraine, in descending order, as the leading sources of imported gallium. Doped GaAs wafer imports were 4% lower than those in 2006; Germany and Japan were the principal sources. Almost all the gallium consumed in the United States was in the form of GaAs and gallium nitride (GaN) and was used in integrated circuits (ICs) and optoelectronic devices [laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells]. Gallium consumption increased by 24% from that in 2006. The increase in consumption was less than the increase in imports because a large portion of the U.S. imports was estimated to be low-purity material that was refined in the United States and shipped to other countries.

In 2007, estimated world crude gallium production was 95 metric tons (t), 32% higher than that in 2006. Principal producers were China, Germany, Japan, Kazakhstan, and Ukraine. Plants in Hungary, Russia, and Slovakia also recovered gallium. Refined gallium production was estimated to be about 135 t, which included some new scrap refining. Refined gallium was produced in China, Japan, and the United States.

## Legislation and Government Programs

In May, the U.S. Department of Energy (DOE) awarded \$13.3 million for eight solid-state lighting (SSL) research and product development projects. These projects continued the DOE's public-private partnership to advance state-of-the-art SSL used for general lighting applications. Five of these projects involved improvements in LEDs. Of the five, the goals of Carnegie Mellon University, Cree Inc., Inlustra Corp., and Yale University were to increase LED device efficiency. Sandia National Laboratory's proposal seeks to improve InGaN epitaxial quality (LEDs Magazine, 2007c).

Velox Semiconductor Corp. was awarded \$2 million from the U.S. Department of Commerce's National Institute of Science and Technology to develop a GaN replacement for silicon-based automotive power switching transistors. It is thought that the GaN switching devices will significantly increase the fuel efficiency of hybrid vehicles, as well as increase the efficiency and reduce the size of power supplies used in laptop computers, telecommunications applications, and other consumer and industrial applications (Semiconductor Today, 2007n).

Raytheon RF Components was awarded \$8.85 million from the U.S. Department of Defense's Defense Production Act (DPA) Title III Program to develop a dedicated, long-term domestic foundry source for atomic layer deposition (ALD) hermetic coating of monolithic microwave integrated circuits (MMICs) at the wafer level. The MMICs are used in radar

systems, and the atomic layer deposition will allow better quality control (Semiconductor Today, 2007h).

Goodrich Corp. was selected by the Defense Advanced Projects Agency to develop next-generation night vision sensor technology for helmet-mounted and microvehicle applications. The indium gallium arsenide-night vision sensors were expected to significantly reduce the size and weight of vehicle-mounted imaging cameras and head-mounted monoculars by eliminating the cooling systems used in current night vision technologies (Goodrich Corp., 2008).

## Production

No domestic production of primary gallium was reported in 2007 (table 1). Recapture Metals Inc. in Blanding, UT, recovered gallium from scrap materials, predominantly those generated during the production of GaAs. Recapture Metals' facilities have the capability to produce about 40 metric tons per year (t/yr) of high-purity gallium. The company recovered gallium from its customers' scrap on a fee basis and purchased scrap and low-purity gallium for processing into high-purity material.

In 2007, drilling was completed at Gold Canyon Resources Inc.'s Cordero gallium property in Humboldt County, NV. Based on an updated estimate, indicated resources reportedly increased to 713,930 kilograms (kg) of gallium and inferred resources decreased to 334,590 kg. Gold Canyon plans to collect a bulk sample for metallurgical testing in preparation for a prefeasibility study (Gold Canyon Resources Inc., 2008).

## Consumption

Gallium consumption data were collected by the U.S. Geological Survey from a voluntary survey of U.S. operations. In 2007, there were 11 respondents to the consumption of gallium survey, representing 61% of the total canvassed. Data in tables 2 and 3 were adjusted by incorporating estimates to reflect full industry coverage. Many of these estimates were based on the companies' 2007 10-K reports submitted to the U.S. Securities and Exchange Commission.

More than 95% of the gallium consumed in the United States was in the form of GaAs or GaN. GaAs was used to manufacture optoelectronic devices (laser diodes, LEDs, photodetectors, and solar cells) and ICs. ICs accounted for 65% of domestic consumption, optoelectronic devices accounted for 29%, and 6% was used in research and development and other applications (table 2). GaN principally was used to manufacture LEDs and laser diodes.

**Gallium Arsenide.**—In September, RF Micro Devices Inc. (RFMD) announced plans to expand its compound semiconductor manufacturing capacity with the construction

of a \$103 million 6-inch post-epitaxial processing plant at the company's Greensboro, NC, facility. This would be the company's sixth expansion in its 16-year history. The plant will be RFMD's second 6-inch post-epitaxial wafer processing operation, and it was expected to produce additional GaAs power amplifier chips for cellular telephones (Compound Semiconductor.net, 2007h). In November, RFMD completed its \$900-million acquisition of radio-frequency (RF) component supplier Sirenza Microdevices Inc. The acquisition would allow RFMD to apply its cellular-focused RF expertise across Sirenza's markets, which include aerospace, broadband, defense, wireless, and worldwide interoperability for microwave access (WiMax) (Semiconductor Today, 2007g).

In December, RFMD agreed to purchase Filtronic Compound Semiconductors Ltd. for \$25 million. The acquisition included Filtronic's 6-inch GaAs wafer fabrication facility in Newton Aycliffe, United Kingdom, and its microwave and millimeterwave RF semiconductor business. It was expected that the purchase will increase RFMD's GaAs capacity by 30% (Semiconductor Today, 2008b).

In October, Skyworks Solutions Inc. began conversion of its internal GaAs heterojunction bipolar transistor fabrication facility in Newbury Park, CA, from 4-inch wafers to 6-inch wafers. The conversion was a result of demand for Skyworks' products from tier-one handset original equipment manufacturers and other customers. Increased GaAs content per handset for new, third-generation (3G) cellular telephones also added to demand. Skyworks also expanded its partnerships with several leading Taiwanese foundries to meet the need for extra capacity (Compoundsemi Online, 2007b). Skyworks agreed to purchase Freescale Semiconductor Inc.'s GaAs power amplifier (PA) business. The agreement included Freescale's GaAs PA designs, intellectual property, inventory, and product lines, but it did not include Freescale's GaAs wafer fabrication facility, located in Tempe, AZ (Compound Semiconductor.net, 2007e).

AXT Inc. (Fremont, CA) increased GaAs wafer production capacity in China by 40% during the third quarter of 2007. The company cited increased interest from bipolar field effect transistor power amplifier (BiFet PA) and solar cells manufacturers and expectations of continued strong demand as the reasons for the capacity increases (Compound Semiconductor.net, 2007b). In December, AXT was awarded a production order from IQE plc for its 2008 worldwide GaAs substrate requirements. The substrates were primarily 6-inch GaAs, and the agreement was worth approximately \$15.1 million, with an option for IQE to purchase an additional \$3.5 million of substrates (AXT Inc., 2007).

In September, Anadigics Inc. (Warren, NJ) acquired Fairchild Semiconductor Inc.'s RF design team. The acquisition provided Anadigics with an additional 23 RF designers and engineers to further develop the company's 3G cellular, WiFi (a wireless networking technology), and WiMax semiconductor devices (Compound Semiconductor.net, 2007a).

Also in September, TriQuint Semiconductor Inc. (Hillsboro, OR) announced the acquisition of RF transistor supplier Peak Devices Inc. (Boulder, CO). Peak Devices had developed a silicon-based technology that allows a single power amplifier device to operate over multiple octaves, including the range in

which most wireless networks operate. TriQuint claimed that the technology can be incorporated into its GaAs and GaN designs. TriQuint's goal had been to diversify beyond mobile handsets, and think its acquisition of Peak Devices will probably strengthen its position among multiple RF power markets including base-station products, broadband solutions, and military communications (Semiconductor Today, 2007l).

**Gallium Nitride.**—Companies continued to try to improve the substrate material on which GaN is grown to improve the quality of the GaN material. In March, Hitachi Cable Ltd. (Tokyo, Japan) announced it had successfully developed an easily reproducible 3-inch diameter GaN substrate. The diameter enlargement was made possible by a newly developed technology for separating the base substrate. The technology, called void-assisted-separation, created a low-strength "sacrifice layer" by generating a microscopic void between a layer of GaN film and the base substrate to allow for easier separation. The sacrifice layer enables the GaN film to separate from the base substrate owing to thermal stress generated at the time of temperature drop after Hydride Vapor Phase Epitaxy growth. The process allows for easily reproducible substrates (Tadashi, 2007).

Sandia National Laboratories demonstrated the growth of GaN on the A-GaN substrates of Aonex Technologies Inc. (a subsidiary of Arrowhead Research Corp). Aonex claimed the A-GaN substrates provide a way to reduce the cost of GaN-based devices while improving performance. The company described its A-GaN wafers as effective veneers of bulk GaN wafers, with the thin GaN layer providing the high-quality surface for device fabrication, while the aluminum nitride support material is chosen for its low cost, fracture resistance, process compatibility, and ease of removal following device growth (Semiconductor Today, 2007i).

In response to growing demand for its low-defect-density nonpolar native GaN substrates, Kyma Technologies Inc. announced that it had partnered with Caracal Inc. and the Pennsylvania State University's Electro-Optics Center to increase effective manufacturing capability and capacity. Demand for nonpolar native GaN had grown rapidly because of its promise to enable better performance electronic and optoelectronic devices (Compoundsemi Online, 2007a).

RFMD completed the technical qualification of its first generation 48 volt (V) GaN process technology and began preproduction volume shipments of the technology to customers. RFMD claimed the electrical properties of its GaN technology delivered higher efficiency, wider operating bandwidth, and greater ruggedness than currently available technologies. The applications targeted by RFMD included high-linearity cable television line amplifiers, military radar applications, power modules for high-lumen light generation applications, and wide bandwidth wireless infrastructure power amplifiers (RF Micro Devices Inc., 2007).

To address the requirements driving the emerging standards of 3G cellular telephones and WiMax, Nitronex Corp. introduced its first 48V GaN-on-Silicon RF power transistors for high-power broadband operation. The 48V power transistors take advantage of thermal enhancements in wafer processing and transistor design and allow devices to operate with reduced

memory effects and wider RF output bandwidth (Nitronex Corp., 2007a, b). Nitronex also completed its new 7,900 square-meter research and development facility, which increases Nitronex's manufacturing capacity and provides additional space for expanding research and development efforts (Nitronex Corp., 2007c).

Sony Corp. increased its production capacity of GaN-based blue semiconductor lasers to 1.7 million per month. Owing to an increase in blue-violet laser diode demand, Sony installed wafer processing equipment capable of producing 5 million blue-violet laser diodes and was to expand its assembly capacity when demand increases. Sony claimed that demand for Blu-ray disc players, high-definition DVD recorders, and high-end games consoles would ensure that GaN lasers are a major component of market growth (Compound Semiconductor.net, 2007j).

In October, Toshiba Corp. developed a GaN power field-effect transistor (FET) for the Ku-band [12 gigahertz (GHz) to 18 GHz] frequency range that achieved output power of 65.4 watts (W) at 14.5 GHz, the highest level of performance yet reported at this frequency band. Mass production of the FET was expected to begin by April 2008. The FET will be used mainly in base stations for satellite microwave communications, which carry high capacity signals, including high definition broadcasts. At high microwave frequencies, GaN devices offer advantages over GaAs devices in heat dissipation and high power performance characteristics (Toshiba Corp., 2007). Toshiba also developed the first high-power semiconductor weather radar based on its GaN FET technology. The FETs allow Toshiba to manufacture systems without the electron tubes that had previously been used in weather radar transmitter modules. The GaN-based weather radar was made possible because the GaN FETs offer twice the power output of similar-sized silicon devices. The GaN transistors also allow the weather radar to make more efficient use of the radio spectrum by narrowing the frequency range scanned (Compound Semiconductor.net, 2007f).

**Light-Emitting Diodes.**—Many LED manufacturers introduced new LEDs based on GaAs and GaN technology that offer improvements from current LEDs. In many cases, the new LEDs are brighter, last longer, and can be used in new applications. These new products have applications that include automotive lighting, cellular telephones, entertainment and decorative lighting, and signage.

BluGlass Ltd. (Sydney, Australia) announced that it had developed the world's first blue light emission from the uniform deposition of GaN on a 6-inch-diameter coated glass wafer, which it thinks will yield much cheaper blue, green, and white LEDs for general lighting applications (Semiconductor Today, 2007b). BluGlass awarded Irish epitaxy equipment vendor EMF Semiconductor Systems Ltd. a contract to supply components forming the basis of the first commercial-scale prototype GaN-on-glass reactor. The manufacturing process is based on BluGlass' processing technique called remote plasma chemical vapor deposition, which uses nitrogen gas rather than ammonia as the source of nitrogen in the compound semiconductor films (Compound Semiconductor.net, 2007d). BluGlass was also awarded \$5 million from the Australian Government to assist in the commercialization of its technology. Independent analysis

indicated that the technology could achieve GaN cost savings of more than 48% at the wafer level and 10% at the LED device level compared with production systems in current use (LEDs Magazine, 2007a).

To strengthen its leadership position in the SSL market, Koninklijke Philips Electronics N.V. acquired several prominent SSL manufacturers. The manufacturers included Belgium-based Partners in Lighting International, Canada-based TIR Systems Ltd., and the United States-based firms Color Kinetics Inc. and Genlyte Group Inc. Philips claimed the acquisitions of PLI and Color Kinetics would strengthen its LED portfolio, technology base, and intellectual property position, while the acquisitions of TIR Systems and Genlyte would provide Philips with a strong line of fully integrated SSL modules used to deliver integrated lighting products to fixture manufacturers (Koninklijke Philips Electronics N.V., 2007).

Further consolidation in the LED lighting industry took place when Cooper Industries Ltd. acquired two companies with commercial LED expertise. United Kingdom-based Clarity Lighting and United States-based Io Lighting LLC, which specialize in white light and red/green/blue LED color-changing technical lighting applications and advanced indoor/outdoor architectural lighting respectively, would enhance Cooper Industries' position in the LED market by strengthening the company's global offerings in LED solutions (LEDs Magazine, 2007b).

Because of growing demand for ultrabright LED applications in automotive parts and outdoor displays, Showa Denko K.K. (SDK) announced that it would increase the production capacity of its aluminum gallium indium phosphide (AlGaInP) blue LED chips from 100 million units per month to 200 million units per month by yearend 2008. The expansion is in addition to an earlier expansion from 30 million units per month to 100 million units per month completed in October 2007 (LEDs Magazine, 2007d).

**Solar Cells.**—Sustained high energy prices sparked renewed interest in solar energy. Most of the solar cells that are being manufactured for terrestrial applications are multijunction cells, with a substrate of germanium and layers of indium gallium arsenide and other gallium compounds.

To meet increasing demand for terrestrial solar power systems, EMCORE Corp. added two additional production MOCVD systems to its chip fabrication facility in Albuquerque, NM. The additional systems increased EMCORE's solar cell manufacturing capacity to 75 megawatts (MW) per year (Compound Semiconductor.net, 2007c, k).

In May, EMCORE announced it had achieved a record conversion efficiency of 30.9% for a new class of multijunction solar cells optimized for space applications. The new cell architecture reduced the number of lattice defects seen in previous designs and allowed sunlight to be absorbed more effectively. The company claimed the new solar cells would enable a new class of lightweight, high-efficiency solar arrays to power the next generation of spacecraft and satellites (Semiconductor Today, 2007d).

In July, WIN Semiconductors Corp. (Taiwan, China) announced it was diversifying into multijunction solar cell production and had ordered a production MOCVD tool from

German equipment vendor Aixtron AG. The MOCVD tool is typically designed to handle either twelve 4-inch or seven 6-inch wafer configurations (Compound Semiconductor.net, 2007l).

SolFocus Inc. (Mountain View, CA) received venture funding of \$52 million to provide expansion of concentrator photovoltaic systems (CPV) at its manufacturing site in India. SolFocus announced that the CPV expansion would support the company's first commercial deployment—the Castilla La Mancha project in Spain, an installation earmarked for 3 MW photovoltaic energy generation using CPV systems (Compound Semiconductor.net, 2007i).

## Prices

Since 2002, producer prices for gallium have not been quoted in trade journals. Data in table 4 represent the average customs value of gallium imported into the United States. Reports in Mining Journal indicated that low-grade gallium prices increased considerably in 2007. At the beginning of the year, the low-grade gallium price was reported to be about \$330 per kilogram. By August, the price had increased to about \$600 per kilogram. By December, the price had fallen to about \$550 per kilogram.

From U.S. Census Bureau import data, the annual average value for low-grade gallium was estimated to be \$314 per kilogram, 10% higher than the estimated average value for 2006. For high-grade gallium, the annual average estimated value increased to \$530 per kilogram, about 20% higher than that in 2006. Import data reported by the U.S. Census Bureau do not specify purity, so the values listed in table 4 are estimated based on the average value of the material imported and the country of origin.

## Foreign Trade

In 2007, U.S. gallium imports were 38% higher than those in 2006 (table 5). Germany (30%), Canada (27%), and Ukraine (17%) were the leading sources of imported gallium. One reason for the increase in gallium imports was that after Recapture Metals and Mining & Chemical Products Ltd. (MCP) purchased a gallium recovery facility in Germany, some of the gallium produced in Germany was refined in the United States rather than in France, where it had previously been refined.

In addition to gallium metal, GaAs wafers were imported into the United States (table 6). In 2007, 178,000 kilograms (kg) of doped GaAs wafers was imported. Approximately 3,300 kg of undoped GaAs wafers was also imported; however, this quantity was an estimate owing to apparently inaccurate U.S. Census Bureau import data from China and Taiwan. The data listed in table 6 may include some packaging material and, as a result, may be higher than the actual total weight of imported wafers.

## World Review

Imports of gallium into Japan and the United States, the two leading consuming countries, were used as the basis for estimating world gallium production. Estimated crude gallium production was 95 t in 2007. Principal world producers were China, Germany, Japan, Kazakhstan, and Ukraine. Gallium

also was recovered in Hungary, Russia, and Slovakia. Refined gallium production was estimated to be about 135 t; this included some new scrap refining. China, Japan, and the United States refined gallium. Gallium was recycled from new scrap in Germany, Japan, the United Kingdom, and the United States.

**China.**—To support anticipated growth beyond its primary wafer fabrication located in Warren, NJ, Anadigics began construction of a new 6-inch GaAs integrated circuit wafer fabrication plant in Jiangsu Province of China in July. The company planned to supply the fast-growing wireless and wireline broadband markets in China and the larger Asia-Pacific Region. Total investment during the plant's lifetime was expected to be \$50 million, and construction was expected to be completed by mid-2008 (Anadigics Inc., 2007).

Cree Inc. acquired Hong Kong-based COTCO Luminant Device Ltd., a leading supplier of high brightness LEDs. The company announced plans to significantly increase white LED manufacturing capacity at its plant in Guangdong, China, tripling Cree's existing capacity for packaging lighting-class LEDs (Semiconductor Today, 2007c).

In October, Century Epitech Company, Ltd. completed construction of the first stage of an extensive compound semiconductor epitaxial wafer and chip production facility in Shenzhen. The initial priority for the facility will be production of epitaxial wafers for GaAs-based RF components, lasers, and LEDs. Century Epitech claimed that the total investment planned for the Shenzhen base will be \$4.3 billion, and will, in time, become the largest single compound semiconductor facility in the world (Hatcher, 2007).

**Japan.**—Mitsubishi Chemical Corp. announced plans to expand production capacity of its 2-inch GaN wafers 10-fold at the company's Tsukuba plant. A capital investment of \$46 million was to be spent on specially built equipment for Mitsubishi's GaN production processes, and the new equipment was expected to produce 1,000 2-inch wafers per month when at full capacity (Compound Semiconductor.net, 2007g).

**Malaysia.**—In May, Osram GmbH announced that its subsidiary (Osram Opto Semiconductors) would significantly expand LED production capacity at its assembly plant in Penang by building its second LED chip fabrication plant. The new plant was expected to open by spring 2009. Osram announced it would also expand the capacity of the existing LED assembly line in Penang by 50% (Semiconductor Today, 2007f).

**Taiwan.**—In March, the Taiwan Optoelectronic Semiconductor Industry Association was formed by the Government-sponsored Industrial Technology Research Institute and 14 Taiwanese LED manufacturers with the goal of strengthening Taiwan's LED industry. The association would attempt to bolster cooperation and exchanges among companies and researchers involved in the optoelectronics and semiconductor industries. In addition, Taiwan's Ministry of Economic Affairs and the Department of Industrial Technology have established an alliance for research and development on LED lighting standards and quality, involving seven Taiwanese LED lighting-related member companies. The alliance's goal was to integrate technologies within the LED and lighting industries and develop the first complete LED lighting measurement standard in Taiwan (Semiconductor Today, 2007j, k).

**United Kingdom.**—The Department of Trade and Industry awarded a 3-year, \$5.96 million contract to a consortium to develop high-quality GaN-based LEDs on 6-inch silicon substrates. The project's goal was to enable large-scale production of low-cost LED lamps for solid-state white lighting. The consortium planned to reduce costs and improve consistency by applying mature large-scale semiconductor processing methods to grow GaN-based light-emitting structures on large-diameter silicon substrates (Semiconductor Today, 2007m).

## Outlook

The research and consulting firm Strategy Analytics Inc. predicted in 2008 that the GaAs market for digital cable networks would reach \$109 million by 2012—compared with the \$72 million recorded in 2007—as operators strive to deliver high-definition television signals to homes. The company forecast that continued rollout and upgrade of networks would result in infrastructure applications such as line amplifiers and hybrid amplifiers to account for 57% of the GaAs device market from digital cable in 2007, growing to 67% by 2012 (Compound Semiconductor.net, 2008).

In a separate report, Strategy Analytics predicted that the market for 4-inch semi-insulating (SI) GaAs bulk substrates would decline by more than 20% by 2009, with demand shifting to 6-inch material. Bulk 6-inch substrates would account for 76% of total market revenues in 2012, up from 63% in 2007. The company indicated that the market for GaAs devices was driven primarily by cellular handset and other wireless markets, and forecast that the overall SI GaAs substrate market would increase by an annual growth rate of 5%, with merchant demand accounting for 95% by 2012 (Compoundsemi Online, 2008).

Strategy Analytics predicted that market revenues for GaN-based laser diodes would increase by an annual growth rate of 103% through 2011. It projected that the consumer-based optical data storage market would dominate all other applications, driven by use in game consoles, home theater, and personal computers, with home theater eventually gaining dominance as Blu-Ray achieves mass market acceptance (Semiconductor Today, 2007e).

According to a report by Strategies Unlimited (a unit of PennWell Corp.), the largest market for packaged high-brightness LEDs in 2007 was mobile appliances, with 44% market share. The company forecast that the high-brightness LED market would increase by 12% in 2008. With growth accelerating as applications outside the mobile telephone market become more prominent, an annual growth rate of 20% in the next 5 years was predicted, to a total market of \$11.4 billion in 2012. The largest application in 2012 was expected to be signs and displays, including backlighting for large computer monitor and television LCD screens (Semiconductor Today, 2008a).

Strategy Analytics predicted that the automotive LED market was expected to increase to \$1 billion by 2014. New performance capabilities are expanding their use beyond simple switch illumination applications into automotive LCD backlighting and exterior lighting, including fully LED-based front headlights (Semiconductor Today, 2007a).

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TABLE 1  
SALIENT U.S. GALLIUM STATISTICS<sup>1</sup>

(Kilograms unless otherwise specified)

	2003	2004	2005	2006	2007
Production	--	--	--	--	--
Imports for consumption	14,300	19,400	15,800	26,900	37,100
Consumption	20,100	21,500	18,700	20,300	25,100
Price <sup>2</sup> dollars per kilogram	411	550	538	443	530

-- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Estimate based on average value of U.S. imports of high-purity gallium.

TABLE 2  
U.S. CONSUMPTION OF GALLIUM, BY END USE<sup>1,2</sup>

(Kilograms)

End use	2006	2007
Optoelectronic devices:		
Laser diodes and light-emitting diodes	3,670	2,450
Photodetectors and solar cells	303	4,790
Integrated circuits:		
Analog	12,000	14,700
Digital	1,400	1,760
Research and development	2,840	1,360
Other	77	75
Total	20,300	25,100

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes gallium metal and gallium compounds.

TABLE 3  
STOCKS, RECEIPTS, AND CONSUMPTION OF GALLIUM, BY GRADE<sup>1,2</sup>

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
2006:				
99.99% to 99.999%	503	131	--	634
99.9999%	1,160	2,970	2,900	1,230
99.99999% to 99.999999%	136	496	602	30
Total	1,800	3,590	3,500	1,890
2007:				
99.99% to 99.999%	634	2,900	--	3,530
99.9999%	1,230	8,450	7,260	2,420
99.99999% to 99.999999%	30	457	436	51
Total	1,890	11,800	7,700	6,010

-- Zero.

<sup>1</sup>Consumers only.

<sup>2</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4  
ESTIMATED AVERAGE GALLIUM PRICES

(Dollars per kilogram)

Gallium metal	2006	2007
Purity $\geq$ 99.9999%; average value of U.S. imports	443	530
Purity $\leq$ 99.99%; average value of U.S. imports	285	314



TABLE 5  
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM (UNWROUGHT, WASTE, AND  
SCRAP), BY COUNTRY<sup>1</sup>

Country	2006		2007	
	Quantity (kilograms)	Value <sup>2</sup>	Quantity (kilograms)	Value <sup>2</sup>
Canada	2,410	\$593,000	10,000	\$5,420,000
China	5,780	1,820,000	5,270	2,290,000
France	1,120	593,000	44	42,800
Germany	4,600	1,380,000	11,000	4,090,000
Hungary	2,200	676,000	1,280	410,000
Japan	1,960	584,000	1,300	624,000
Russia	718	187,000	341	128,000
Singapore	354	26,300	247	104,000
Slovakia	1,710	671,000	108	38,200
Ukraine	5,380	1,450,000	6,380	1,790,000
United Kingdom	387	133,000	509	216,000
Other	298 <sup>r</sup>	89,400 <sup>r</sup>	577	370,000
Total	26,900	8,210,000	37,100	15,500,000

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Customs value.

Source: U.S. Census Bureau.

TABLE 6  
U.S. IMPORTS FOR CONSUMPTION OF  
GALLIUM ARSENIDE WAFERS, BY COUNTRY<sup>1</sup>

Material and country	2006		2007	
	Quantity (kilograms)	Value <sup>2</sup>	Quantity (kilograms)	Value <sup>2</sup>
Undoped:				
China <sup>3</sup>	1,140	\$354,000	850 <sup>e</sup>	\$360,000 <sup>e</sup>
Hungary	200	60,000	--	--
Singapore	--	--	102	20,200
Taiwan <sup>3</sup>	2,160	260,000	1,700 <sup>e</sup>	283,000 <sup>e</sup>
Ukraine	--	--	586	152,000
Other	50	36,400	30	19,000
Total	3,550	711,000	3,300 <sup>e</sup>	834,000 <sup>e</sup>
Doped:				
China	19,500	20,000,000	15,100	15,600,000
Finland	11,000	6,470,000	14,300	8,530,000
France	12,600	28,400,000	10,900	7,860,000
Germany	36,500	40,200,000	30,300	44,900,000
Japan	53,500	61,300,000	57,600	55,800,000
Korea, Republic of	26,400	24,100,000	15,400	11,100,000
Russia	318	743,000	4,050	1,240,000
Singapore	5,400	6,810,000	3,890	5,610,000
Taiwan	8,730	10,900,000	12,400	15,800,000
United Kingdom	1,050	799,000	3,240	3,620,000
Other	10,100 <sup>r</sup>	1,570,000 <sup>r</sup>	11,000	4,850,000
Total	185,000	201,000,000	178,000	175,000,000

<sup>e</sup>Estimated <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Customs value.

<sup>3</sup>The U.S. Census Bureau's undoped gallium arsenide wafers quantity and value data for China and Taiwan in 2007 appear to be inaccurate. The data have consequently been estimated by the USGS for 2007 based on previous years' imports for consumption patterns and 2007 pricing data.

Source: U.S. Census Bureau.

TABLE 7  
ESTIMATED WORLD ANNUAL PRIMARY GALLIUM  
PRODUCTION CAPACITY, DECEMBER 31, 2007<sup>1</sup>

(Metric tons)

Country	Capacity
China	59
Germany	35
Hungary	8
Japan	20
Kazakhstan	25
Russia	19
Slovakia	8
Ukraine	10
Total	184

<sup>1</sup>Includes capacity at operating plants as well as at plants on standby basis.