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GALLIUM [ADVANCE RELEASE]

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Gallium

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Primary crude gallium is recovered globally as a byproduct of processing bauxite and zinc ores. No domestic primary crude gallium was recovered in 2013, and imports of gallium metal and gallium arsenide (GaAs) wafers continued to account for most of U.S. gallium consumption. Metal imports were 39% lower than those in 2012. The leading sources of imported gallium, in descending order of imports by gallium content, were Germany, China, Ukraine, and the United Kingdom. Doped GaAs wafer (a wafer with intentionally modified electrical properties) imports were substantially higher than those in 2012—Japan, by far, was the leading source, while China, Germany, and Taiwan were other principal sources. Undoped GaAs wafer imports also were substantially higher than those in 2012—Canada, Taiwan, and the United Kingdom were the principal sources. Almost all gallium consumed in the United States was for the production of GaAs and gallium nitride (GaN), which along with imported wafers, were used in integrated circuits (ICs) and optoelectronic devices [laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells]. U.S. gallium consumption increased about 10% from that in 2012. A significant portion of imports was estimated to be low-purity gallium that was refined in the United States and shipped to other countries. Data on refined gallium exports were not available.

In 2013, estimated world primary crude gallium production was 350 metric tons (t). Principal producers were China, Germany, Japan, Russia, and Ukraine. Plants in Hungary and the Republic of Korea also recovered gallium. Kazakhstan, previously a major producer of primary gallium, reported no production in 2013. Production of primary refined gallium was estimated to be about 170 t, about one-half of crude gallium production. Refined gallium from primary material was produced in China, Japan, Slovakia, the United Kingdom, and the United States.

Legislation and Government Programs

Several companies received U.S. Department of Energy (DOE) funding in 2013 for development of bulk GaN wafers used in LEDs and power electronics applications. Soraa (Fremont, CA) was awarded $3.2 million by the DOE's Advanced Research Projects Agency-Energy (ARPA-E) SWITCHES program to develop a U.S.-based technology for large-area, low-cost, high-quality bulk GaN substrates and to validate their performance in state-of-the-art power switches (Soraa, 2013). Kyma Technologies, Inc. (Raleigh, NC) was awarded $3.2 million by the ARPA-E SWITCHES program to use its proprietary high-growth-rate GaN crystal growth technology to advance the technology for manufacturing GaN substrates (Kyma Technologies, Inc., 2013).

Production

No domestic production of primary crude gallium was reported in 2013 (table 1). Molycorp Inc. (Greenwood Village, CO) recovered gallium from scrap materials, predominantly those generated during the production of GaAs. Molycorp's facility in Blanding, UT, had the capability to produce about 50 metric tons per year (t/yr) of high-purity gallium. The company refined high-purity gallium from its customers' scrap and purchased scrap and low-purity primary crude gallium. In 2013, the company purchased 25.7 t of primary crude gallium and 3.6 t of gallium scrap materials. Molycorp's other gallium investments included an 80% interest in a gallium trichloride production facility in Quapaw, OK; a 50% interest in a primary gallium facility in Stade, Germany; a gallium recycling facility in Peterborough, Ontario, Canada; and an 80% interest in a new gallium trichloride production facility in the Hyeongok Industrial Zone in the Republic of Korea. Gallium trichloride is a precursor for many gallium compounds, including the organic gallium compounds used in epitaxial layering (Molycorp Inc., 2014, p. 11, 44, 45, 59).

Consumption

Domestic Consumption

Gallium consumption data were collected by the U.S. Geological Survey from a voluntary survey of U.S. operations. In 2013, 61% of the canvassed respondents replied to the gallium consumption survey. Data in tables 2 and 3 were adjusted by incorporating estimates for the nonrespondents to reflect full industry coverage. Many of these estimates were based on company reports submitted to the U.S. Securities and Exchange Commission.

Approximately 80% of the gallium consumed in the United States was contained in GaAs and GaN wafers. Trimethylgallium (TMG) and triethylgallium (TEG), metalorganic sources of gallium used in the epitaxial layering process for the production of LEDs, accounted for most of the remainder. GaAs was used to manufacture ICs and optoelectronic devices (laser diodes, LEDs, photodetectors, and solar cells). GaN principally was used to manufacture LEDs and laser diodes. ICs accounted for 74% of domestic gallium consumption, optoelectronic devices accounted for 25%, and research and development accounted for 1% (table 2).

In 2013, U.S. consumption of gallium for use in ICs increased by 21% from that in 2012 owing to an increased demand for GaAs-rich "smartphones" (cellular telephones with advanced personal computer-like functionality) and strong demand in military applications. Gallium consumed in the production of domestic LEDs and laser diodes decreased by 19% from that in 2012 owing to increased competition from China's rapidly

growing LED industry. Gallium supplied to the photodetector and solar cell industry increased by 44% from that in 2012 owing to increased installation of copper-indium-gallium-diselenide (CIGS) solar cells worldwide.

Global Consumption

GaAs applications accounted for about 80% of the worldwide gallium market, while GaN and CIGS applications accounted for about 7% and 5% respectively. Various other applications accounted for the remaining 8% (Riecken, 2013).

Gallium Arsenide.—The value of worldwide GaAs devices consumed increased by 11% in 2013, to $5.9 billion from $5.3 billion in 2012. Developments in cellular telephone technology, particularly sophisticated third-generation (3G) and fourth-generation (4G) smartphones, continued to drive the GaAs device industry, accounting for more than 50% of the GaAs device market in 2013. Fourth-generation smartphones use up to 10 times more GaAs than a standard cellular telephone. Worldwide sales of smartphones in 2013 totaled approximately one billion units, an increase of 42% from that of 2012. The proportion of smartphones sold worldwide increased to 54% of total handset sales in 2013, and exceeded sales of standard cellular telephones for the first time. Growth in wireless infrastructure in Asia and growth in military radar and communications applications also contributed to increased consumption of GaAs devices (Gartner, Inc., 2014; Higham, 2014).

Worldwide GaAs bulk substrate consumption decreased slightly in 2013 owing to cellular radio architecture migrating from multiple single-band power amplifiers to a single less-GaAs-intensive multi-band power amplifier and the conversion of cellular telephone switches from GaAs to silicon-on-insulator technology. GaAs bulk substrate consumption was anticipated to increase less than 1% per year through 2018 (Compound Semiconductor, 2014b).

Gallium Nitride.—Increased demand for GaN devices, namely laser diodes, power electronics, and radio frequency (RF) electronics, provided significant growth for advanced GaN-based products. The key driver of non-LED GaN-based technology in 2013 was military and defense applications, which accounted for about 75% of the total market. The technology also was used in automotive, industrial, medical, and commercial applications such as cable television, power electronics, and wireless infrastructure. The value of the worldwide non-LED GaN device market was estimated to be approximately $95 million in 2013 (Higham, 2014).

In 2013, owing to increased development of advanced power applications in information and communications technology and industrial power markets worldwide, the worldwide GaN power semiconductor market was estimated to have doubled in value from approximately $12.6 million in 2012 (MarketsandMarkets, 2012, 2014). GaN power transistors operate at higher voltages and with a higher power density than existing GaAs devices. The major applications for GaN power semiconductors were inverters, motor drives, power supply modules, and RF devices.

Light-Emitting Diodes.—In 2013, the worldwide high-brightness light-emitting diode (HB-LED) market increased by 4% to $14.2 billion, and had increased by an average of 21% per year from $1.2 billion in 2000 (Strategies Unlimited, 2014a). HB-LEDs account for the leading end use of all GaN-based devices. GaN HB-LEDs were valued at $12.4 billion in 2013, and accounted for an estimated 87% of total revenues in the HB-LED industry. GaN HB-LED unit shipments in 2013 increased by 17.3% from that of 2012. GaN LEDs dominate key HB-LED backlighting applications such as televisions, computer monitors, notebook computers, and tablet computers, and have experienced growing demand in general lighting applications (IHS Inc., 2014).

Owing to significant HB-LED capacity expansion in 2011 and the resulting HB-LED surplus, prices for HB-LEDs decreased in 2012 and remained low in 2013. The lower prices were beneficial to the HB-LED general lighting sector, where HB-LED consumption increased from that of 2012 and more than offset the decline in HB-LED revenue from the backlighting sector. HB-LEDs for general lighting applications remained the largest segment of the HB-LED market and, according to research and consulting firm Strategies Unlimited, accounted for about 30% of HB-LED sales, an increase from 23% of sales in 2012. Additional HB-LED market segments in 2013, in decreasing order of market share, included television and monitor backlighting, mobile display applications (such as cellular telephones, computer notebooks and tablets, eBooks, and MP3 players), signage, automotive, and other uses (Strategies Unlimited, 2013, 2014a).

The United States supplied 31% of the $4.4 billion HB-LED general lighting segment in 2013, followed by Japan, 21%; Taiwan, 18%; the Republic of Korea, 15%; China, 11%; and Europe, 4% (Smallwood, 2014). Supply for all segments of the worldwide HB-LED market, however, was led by Japan and the Republic of Korea, at 30% and 28%, respectively, as of 2012 (the latest year with available data), followed by the United States and Europe, 19%; Taiwan and Southeast Asia, 15%; and China, 8%. China's HB-LED market share quadrupled from 2% in 2010 owing to large investments in its domestic solid-state lighting industry (Strategies Unlimited, 2013).

In 2013, an estimated total of 170 LED fabrication plants were in operation worldwide, up from 64 plants in 2006. China's LED fabrication plants accounted for 27% of global capacity, followed by Taiwan (23%), Japan (20%), the Republic of Korea (16%), North America and South America (11%), and Europe and the Mideast (3%) (Morrow, 2014).

As HB-LED demand increased throughout 2010 and the first half of 2011, materials suppliers began adding more capacity for TMG, the metal-organic chemical used to fabricate HB-LED epiwafers. When TMG and nitrogen gas are fed into the metal-organic chemical vapor deposition (MOCVD) reactor and heated, a GaN layer is formed on the epiwafer. TMG's purity and quality determine an HB-LED's brightness and reliability. In 2013, an estimated 47 t of TMG was consumed worldwide, an increase of about 57% from that of 2012, with 80% consumed by China, the Republic of Korea, and Taiwan (IHS Inc., 2013). Albemarle Corp. (Baton Rouge, LA) continued the construction of its TMG and TEG production facility in the Republic of Korea. Commercial production was expected to begin in mid-2014 (Albemarle Corp., 2014, p. 10).

Solar Cells.—The solar cell market continued to be dominated by crystalline silicon solar cells, which accounted for about 90% of the market. In 2008, industry experts had thought that CIGS technology would eventually be able to compete with conventional silicon-based photovoltaic technology. CIGS technology, however, has been slow to enter the commercial market owing to a decline in prices of silicon-based solar cells, a complicated manufacturing process that has impeded commercial mass production of CIGS panels, and financial instability among many of the research-based startup CIGS companies. In 2013, however, world production of CIGS solar cells increased to 1,050 megawatts (MW), a 36% increase from the 770 MW produced in 2012. To keep CIGS technology competitive, CIGS manufacturers have trimmed production costs, increased production capacities, improved module conversion efficiencies, and increased CIGS adoption in commercial rooftops. Several large corporations acquired select small startup companies and increased utilization of their production capacities. China's Hanergy Holding Group Ltd., Japan's Solar Frontier K.K., and the Taiwan Semiconductor Manufacturing Co. Ltd. were the three predominant CIGS manufacturers (NanoMarkets, LC., 2014, p. 4–6; Roskill's Letters from Japan, 2014b).

In October, scientists at the Center for Solar Energy and Hydrogen Research (ZSW) in Baden-Wurttemberg, Germany, achieved a record 20.8% efficiency for their CIGS solar cell on a glass substrate (Gifford, 2013).

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 Metal Bulletin indicated gallium price decreases during 2013. At the beginning of the year, the low-grade (≤99.99%-pure) gallium price in China was reported to be about $280 per kilogram (a decrease of 46% from that in January 2012) as significant increases in China's low-grade gallium production continued to exceed increases in worldwide consumption. By July, the price had decreased to about $260 per kilogram, and by December, the price decreased to about $250 per kilogram.

From U.S. Census Bureau data, the annual average value for imported low-grade gallium in 2013 was estimated to be $276 per kilogram, about 21% less than that in 2012. For high-grade (≥99.9999%-pure) gallium, the annual average estimated import value decreased by 5% to $502 per kilogram. Import data reported by the U.S. Census Bureau do not specify purity, so the values listed in table 4 were estimated based on the average value of the material imported and the country of origin.

Foreign Trade

In 2013, U.S. gallium metal imports were 39% less than those in 2012 (table 5). Germany (35%), China (30%), Ukraine (21%), and United Kingdom (10%) were the leading sources of imported gallium. Reduced imports were most likely due to the stockpiling of excess gallium metal imported in 2011, as well as the outsourcing of some LED production overseas.

In addition to gallium metal, GaAs wafers were imported into the United States (table 6). Doped GaAs wafer imports were substantially higher than those in 2012 based on a large increase in wafer imports from Japan. Undoped GaAs wafer imports were also substantially higher than those in 2012 based on increased imports from Taiwan and the United Kingdom. The data listed in table 6 may include some packaging material weight and, as a result, quantities may be higher than the actual total weight of imported wafers.

World Review

Imports of gallium into Japan and the United States, two leading consuming countries, and an updated gallium production estimate for China, were used as the basis for estimating world gallium production. Metal Bulletin (2013b) reported that China may have decreased production of primary crude gallium in 2013 despite substantial capacity increases throughout the year. Estimated worldwide primary crude gallium production was 350 t in 2013. Principal world producers were China, Germany, Japan, Russia, and Ukraine. Gallium also was recovered in Hungary and the Republic of Korea. Kazakhstan, which had been a leading producer in 2012, did not produce any primary crude gallium in 2013, most likely owing to the worldwide surplus of primary crude gallium. Production of primary refined gallium in 2013 was estimated to be about 170 t, 51% lower than the year's primary crude production. China, Japan, Slovakia, the United Kingdom, and the United States refined gallium from primary material. Updated primary refined gallium production estimates by the USGS for 2010, 2011, and 2012 were estimated to be 140 t, 150 t, and 160 t, respectively.

Roskill Information Services Ltd. (2014a) estimated worldwide gallium consumption to be between 250 t and 300 t in 2013. Japan's DOWA Electronics Materials Co., Ltd. (Tokyo) estimated 2013 worldwide gallium consumption to be about 280 t (Roskill's Letters from Japan, 2014a). Approximately 40% to 45% of total consumption was estimated to come from recycled material (Spicer, 2013). Gallium was recycled from new scrap in Canada, Germany, Japan, the United Kingdom, and the United States. By 2020, Roskill expected worldwide gallium consumption to increase to approximately 420 t, with LED general lighting applications accounting for 33% of demand (Roskill Information Services, Ltd., 2014b).

Canada.—Orbite Aluminae Inc. (Montreal, Quebec) (formerly known as Exploration Orbite V.S.P.A. Inc.) announced that construction of its high-purity alumina plant, located in Cap-Chat, Quebec, experienced significant delays in 2013. The plant was now expected to begin commercial operation in early 2015. A separation facility was to be built at the alumina plant to recover 4N purity (99.99%) gallium and other rare metals and rare-earth elements. Preliminary engineering for the separation facility was expected to commence in the third quarter of 2014. Production capacity was reported to be 90 t/yr of primary crude gallium (Orbite Aluminae Inc., 2012, 2014).

China.—Beginning in 2011, China's Government passed a series of domestic policies to stimulate LED lighting demand and production, and began investing substantially in the country's LED manufacturing infrastructure. In 2013, for the first time, a Chinese company [MLS Electronics Co. Ltd.

(Shenzhen, Guangdong Province)] entered the top 10 ranking of global packaged LED manufacturers, which included leading companies in Germany, Japan, the Republic of Korea, Taiwan, and the United States (Semiconductor Today, 2014a). Subsidies from local governments were instrumental in helping increase LED production capacity. General lighting was the driving force for China's LED market growth in 2013, accounting for 45.1% of the country's packaged LED revenues, followed by signage, 19%; backlighting, 15.7%; and other applications, 20.2% (Compound Semiconductor, 2014c). China was reported to have produced 300 t of primary crude gallium in 2013, and increased its primary crude gallium manufacturing capacity to 450 t in 2013 from 350 t in 2012 (Metal Bulletin, 2013a, 2014).

In 2013, Chinese gallium producers began to sell excess inventories of primary crude gallium to the country's Fanya Metal Exchange. At yearend, the Exchange's gallium inventory totaled 97 t and had a gallium inventory capacity of 200 t (Roskill's Letters from Japan, 2014a).

China's primary crude gallium producers were Aluminum Corporation of China, Ltd. (Beijing); Beijing JiYa Semiconductor Material Co., Ltd. (Beijing); China Crystal Technologies, Ltd. (Beijing); East Hope Mianchi Gallium Industry Co. (Shanghai); and Zhuhai Fangyuan Inc. (Roskill Information Services Ltd., 2011, p. 21–26). China's primary refined gallium producers include Beijing JiYa Semiconductor Material Co., Ltd.; 5N Plus Inc. (Shenzhen, Guangdong Province); Nanjing Jinmei Gallium (Nanjing, Jiangsu Province); and Zhuzhou Keneng New Material (Zhuzhou, Hunan Province) (Shen, 2014).

Japan.—DOWA Electronics Materials estimated that Japan consumed 97 t of gallium in 2013. DOWA also estimated that Japan's gallium supply in 2013 totaled about 140 t, with 51% of the gallium supply sourced from recovered scrap, and 43% from imports. The remaining 6% was primary crude gallium produced by Japan as a byproduct of its zinc refining process (Industrial Rare Metals, 2013). Japan was, by far, the largest producer of commercial GaN wafers in the world, accounting for approximately 85% of worldwide production (Compound Semiconductor, 2014a).

Korea, Republic of.—5N Plus invested in a new gallium chemicals facility located near key South Korean LED manufacturing facilities. The new chemicals facility was built to meet the increasing demand for gallium in LED manufacturing in northeast Asia (5N Plus Inc., 2013).

United Kingdom.—In January 2013, IQE completed the acquisition of the Kopin Wireless compound semiconductor epiwafer manufacturing division of Kopin Corp. (Taunton, MA), plus a 90.2% controlling interest in subsidiary Kopin Taiwan Corp. in Hsinchu, Taiwan. Kopin Wireless was a global manufacturer of heterojunction bipolar transistors, which are used in power amplifiers, a key wireless component in mobile devices. The devices are produced using MOCVD epitaxial wafer technology (Compound Semiconductor, 2013b).

Outlook

Smartphones represent a fundamental structural shift in mobile communications, offering services not available on standard cellular telephones such as internet access, video-streaming, computer program applications ("apps"), and global positioning systems. Smartphones, which use up to 10 times the amount of GaAs-rich RF content than standard cellular telephones, are expected to account for 65% of all worldwide handset sales by 2014 (Market Intelligence & Consulting Institute, 2014). Installation of 3G and 4G mobile networks in India and the Republic of Korea is expected to further increase sales of smartphones. Additional increases in GaAs demand will also result from new applications for wireless fidelity (WiFi), such as point-to-point communications, smart meters, and tablet personal computer technologies. Market research firm Strategy Analytics forecast that while the commercial GaAs device market would increase by less than 5% per year through 2018, the military GaAs device market is expected to increase by approximately 13% per year through 2018 owing to increasing use of GaAs technologies in radar, electronic warfare, communications, and other military applications. The leading use of military GaAs devices is expected to come from radar applications, accounting for approximately 60% of GaAs military market revenue (Semiconductor Today, 2014b).

Yole Développement forecast that RF GaN-based devices could reach more than 18% of the overall RF device market by 2020, increasing by 9% per year between 2013 and 2020. High frequency RF applications over 3.5 gigahertz, including military radar and electronic warfare systems, commercial wireless telecommunications, and cable television (CATV) applications, require the high voltage and high power capabilities of GaN-based devices. GaAs and silicon devices cannot operate at such high frequencies (Yole Développement, 2014).

Owing to significant expansion of LED manufacturing capacity, reduced prices, and government incentives, the LED industry is expected to expand its general lighting applications for the rest of the decade. The highest growth is forecast to be in LED-based tubes that replace fluorescent tubes used in commercial applications, LED street lights, and LED luminaires of varying sizes. Strategies Unlimited predicted that global unit shipments of LED street lights would increase by 31% per year between 2012 and 2017, from 2 million units in 2012 to approximately 8 million units in 2017 (Strategies Unlimited, 2014b).

Since 2011, Japan's producers have held the largest market share for LED lighting applications and are expected to continue leading the market through 2016 (Compound Semiconductor, 2013c). China's LED lighting market is forecast to more than double from $3.1 billion in 2013 to $7.4 billion in 2017 owing to the country's ongoing urbanization, policy support, energy goals, and reduced LED prices. The LED share of the lighting market in China is predicted to increase from 9.6% to 18% during the same timeframe. The country's residential LED market is expected to show the fastest growth, increasing from $23 million in 2013 to $310 million in 2017, an average annual growth rate of 92% (Lux Research, 2013).

As the market for general LED lighting increases, global demand for the precursors TMG and TEG is expected to more than double by 2016. China is forecast to consume up to 45% of the precursors in 2016. MOCVD system shipments are forecast to increase an average of 14% per year between 2013 and 2018 owing to increasing LED use (Compound Semiconductor, 2013a; Semiconductor Today, 2014c).

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TABLE 1
SALIENT U.S. GALLIUM STATISTICS[1]

(Kilograms unless otherwise specified)

	2009	2010	2011	2012	2013
Production, primary crude	--	--	--	--	--
Imports for consumption	35,900	59,200	85,700	58,200	35,400
Consumption	24,900	33,500	35,300	34,400	37,800
Price,[2] dollars per kilogram	449	600	688	529	502

-- Zero.
[1]Data are rounded to no more than three significant digits.
[2]Estimate based on average value of U.S. imports of high-purity gallium.

TABLE 2
U.S. CONSUMPTION OF CONTAINED GALLIUM, BY END USE[1, 2]

(Kilograms)

End use	2012	2013
Optoelectronic devices:		
Laser diodes and light-emitting diodes	10,400	8,460
Photodetectors and solar cells	642	922
Integrated circuits:		
Analog	20,600	23,900
Digital	2,730	4,200
Research and development	32	312
Total	34,400	37,800

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes gallium metal and gallium contained in compounds produced domestically.

TABLE 3
STOCKS, RECEIPTS, AND CONSUMPTION OF GALLIUM METAL, BY GRADE[1, 2]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
2012:				
99.99% to 99.999%	5,150	-217 [3]	--	4,930
99.9999%	1,340	-242 [3]	2	1,090
99.99999% to 99.999999%	367	655	828	194
Total	6,850	195	829	6,220
2013:				
99.99% to 99.999%	4,930	-735 [3]	--	4,200
99.9999%	1,090	-244 [3]	64	786
99.99999% to 99.999999%	194	957	660	491
Total	6,220	-22 [3]	724	5,470

-- Zero.
[1]Consumers only.
[2]Data are rounded to no more than three significant digits; may not add to totals shown.
[3]Reshipments exceeded receipts.

TABLE 4
ESTIMATED AVERAGE GALLIUM PRICES

(Dollars per kilogram)

Gallium metal	2012	2013
Purity ≥ 99.9999%; average value of U.S. imports	529	502
Purity ≤ 99.99%; average value of U.S. imports	349	276

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM (UNWROUGHT, WASTE, AND SCRAP), BY COUNTRY[1]

	2012		2013	
Country	Quantity (kilograms)	Value[2]	Quantity (kilograms)	Value[2]
Canada	199	$55,500	89	$19,300
China	22,700	9,200,000	10,700	3,090,000
France	319	163,000	112	43,700
Germany	23,900	8,230,000	12,500	4,020,000
Japan	1,130	529,000	619	415,000
Korea, Republic of	1,130	231,000	--	--
Singapore	48	20,500	56	23,600
Ukraine	2,170	632,000	7,510	2,000,000
United Kingdom	6,500	3,610,000	3,700	1,210,000
Other	130	56,000	67	28,600
Total	58,200	22,700,000	35,400	10,800,000

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

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF
GALLIUM ARSENIDE WAFERS, BY COUNTRY[1]

Material and country	2012 Quantity (kilograms)	2012 Value[2]	2013 Quantity (kilograms)	2013 Value[2]
Undoped:				
Austria	117	$78,000	81	$31,800
Canada	2,980	25,100	5,870	49,400
Japan	460	80,600	--	--
Taiwan	6	19,600	34,000	329,000
United Kingdom	5	13,600	39,000	51,800
Other	42 r	31,400 r	15	5,540
Total	3,610	248,000	79,000	467,000
Doped:				
Belarus	6,700	719,000	7,830	2,080,000
Belgium	3,390	600,000	643	449,000
China	20,700	20,200,000	36,900	27,300,000
Finland	7,650	5,160,000	10,100	5,570,000
France	8,620	12,000,000	7,980	13,100,000
Germany	44,900	28,600,000	60,500	25,100,000
Italy	1,050	431,000	564	245,000
Japan	71,000	77,300,000	443,000	59,700,000
Korea, Republic of	12,900	1,290,000	9,170	1,250,000
Malaysia	3,240	276,000	420	233,000
Mexico	430	54,000	1,350	53,500
Poland	557	453,000	404	320,000
Singapore	9,200	13,400,000	2,580	3,810,000
Taiwan	24,800	47,400,000	46,500	70,300,000
United Kingdom	1,800	2,500,000	5,500	3,320,000
Other	1,320 r	915,000 r	906	1,410,000
Total	218,000	211,000,000	635,000	214,000,000

rRevised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Customs value.

Source: U.S. Census Bureau.

TABLE 7
ESTIMATED WORLD ANNUAL PRIMARY GALLIUM
PRODUCTION CAPACITY, DECEMBER 31, 2013[1]

(Metric tons)

Country	Capacity
China	450
Germany	40
Hungary	8
Japan	10
Kazakhstan	25
Korea, Republic of	16
Russia	10
Ukraine	15
Total	570

[1]Includes capacity at operating plants as well as at plants on standby basis.