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2019 Minerals Yearbook

GALLIUM [ADVANCE RELEASE]

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Gallium

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Low-grade primary gallium was recovered globally as a byproduct of processing bauxite and zinc ores. No domestic low-grade primary gallium was recovered in 2019. Imports of gallium metal, gallium arsenide (GaAs) wafers, and domestically refined and recycled gallium continued to account for all U.S. gallium consumption (gallium metal and gallium in GaAs). The quantity of gallium metal imports was 82% lower than that in 2018 (tables 1, 4), most likely owing to the introduction of higher import tariffs on gallium from China and a 300% increase of gallium imports from China in 2018 before the tariffs were introduced. Gallium metal and powder imports from China (including Hong Kong) decreased by 94% from those in 2018. The value of all gallium metal and powder imports was 79% lower than that in 2018 (table 4). The leading sources of imported gallium metal and powders were, in descending order, Germany, China (including Hong Kong), and Russia. Some of the imports were thought to be low-grade gallium that was refined in the United States and shipped to other countries. Data on refined gallium exports, however, were not available. Doped GaAs wafer (a wafer with intentionally modified electrical properties) imports decreased by 39% from those in 2018 (table 5). Germany was the leading source, followed by France, Taiwan, Japan, and China, in descending order of quantity. The U.S. Census Bureau stopped reporting undoped GaAs wafer imports in 2017. Almost all gallium consumed in the United States was for the production of GaAs, gallium nitride (GaN), and gallium phosphide (GaP), which, along with imported wafers, were used in integrated circuits (ICs) and optoelectronic devices [laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells]. In 2019, U.S. gallium consumption for the production of analog and digital ICs decreased slightly but increased slightly for the production of laser diodes and LEDs (table 2). U.S. gallium consumed for the production of photodetectors and solar cells decreased by 7%. Refined gallium metal consumption decreased by 16% (table 3). In total, U.S. gallium consumption was essentially unchanged in 2019 (table 1). The 82% decrease in gallium metal imports and 39% decrease in doped GaAs wafer imports suggest that the consumed gallium was sourced from previously stockpiled gallium metal and GaAs wafers. About 98% of the gallium metal consumed in 2019 was at a purity level of 99.99999% to 99.999999% (table 3).

In 2019, estimated world low-grade primary gallium production was 351 metric tons (t), a decrease of 16% from the estimated production of 420 t (revised) in 2018 (table 6). China, which accounted for 83% of global low-grade primary gallium capacity (fig. 1, table 7), produced 96% of the global low-grade primary gallium (table 6). Japan, the Republic of Korea, and Russia accounted for the remaining production in 2019. Ukraine was believed to have stopped production of low-grade primary gallium in 2019. The estimated global compound annual growth rate (CAGR) of low-grade primary gallium production was 16% from 2009 through 2019 (fig. 2), primarily owing to China's large annual increases in production beginning in 2010. Globally, about 210 t of low-grade primary gallium was processed to high-grade refined gallium; the remaining low-grade primary gallium produced in 2019 was most likely stockpiled. High-grade primary refined gallium was produced in China, Japan, the United States, and possibly Slovakia. The United Kingdom stopped production of high-grade primary refined gallium in 2018. The global CAGR of high-grade primary refined gallium production was 6% from 2009 through 2019. Global high-grade secondary refined gallium production increased at a CAGR of 8%. Global gallium consumption, which increased at a CAGR of 7% from 2009 through 2019, was estimated to have been 385 t in 2019 (fig. 2).

Production

No domestic production of low-grade primary gallium was reported in 2019. Neo Performance Materials Inc. (Canada) purchased low-grade primary gallium and recovered gallium from new scrap materials, predominantly those generated during the production of GaAs ingots and wafers. Neo's facility in Blanding, UT, had the capacity to refine 50 metric tons per year (t/yr) of high-grade gallium from low-grade primary gallium. The company also had the capacity to recycle 30 t/yr of new scrap and refine it into high-grade gallium. Neo's other gallium facilities included a gallium trichloride production facility in Quapaw, OK (80% ownership); a gallium recycling facility in Peterborough, Ontario, Canada; and a gallium trichloride production facility in the Hyeongok Industrial Zone in the Republic of Korea (80% ownership). Gallium trichloride is a precursor for many gallium compounds, including the organic gallium compounds used in epitaxial layering. Neo announced that their Blanding, UT, facility would close in mid-2020 (Neo Performance Materials Inc., 2020, p. 18–21). Indium Corp. (Clinton, NY) refined high-grade gallium from low-grade primary gallium and recycled gallium from new scrap at its facilities in Rome and Utica, NY (Indium Corp., 2020).

Consumption

U.S. Consumption

Gallium consumption data were collected by the U.S. Geological Survey from a voluntary survey of U.S. operations. In 2019, 21 operations were canvassed and 62% responded to the gallium consumption survey. Data in tables 2 and 3 incorporated 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.

GaAs, gallium arsenide phosphide (GaAsP), and gallium phosphide (GaP) were used to manufacture ICs and optoelectronic devices. GaN was used principally to manufacture LEDs and laser diodes. ICs accounted for 72% of domestic gallium consumption, optoelectronic devices accounted for 25%, and research and development accounted for the remainder (table 2). Approximately 80% of the gallium consumed in the United States was contained in GaAs, GaN, and GaP wafers. Gallium metal, trimethylgallium (TMG), and triethylgallium (TEG) used in the epitaxial layering process to fabricate epiwafers in the production of LEDs and ICs accounted for most of the remainder.

In 2019, reported gallium consumption in the United States was 14.9 t, a slight decrease from 15 t in 2018 (table 1) owing to little change in gallium consumption for the production of analog and digital ICs, laser diodes, and LEDs, which together accounted for 95% of total gallium consumption (table 2). Doped GaAs wafer imports decreased by 39% from those in 2018 (table 5). Refined gallium metal consumption decreased by 16% from that in 2018 (table 3). About 98% of the gallium metal consumed was at a purity level of 99.99999% to 99.999999%. U.S. gallium consumers opening new GaAs wafer production facilities in Asia to be closer to the Asian-dominated optoelectronics industry were thought to be a leading cause for the continued decrease in U.S. gallium consumption and gallium wafer imports since 2015.

Global Consumption

Gallium Arsenide.—Yole Développement (2018, p. 21, 267, 296; 2020b) estimated that global GaAs substrate consumption, by wafer volume, was approximately 2.4 million 6-inch equivalent units in 2019, an increase of 17% from 2.06 million units in 2018, owing mostly to a 23% increase in consumption by optoelectronics (laser diodes, LEDs, photonics) manufacturers. The LED market consumed 41% of GaAs substrates by volume in 2019, and the photonic market consumed 5%. Consumption of GaAs substrates by radio frequency (RF) cellular, power, and wireless manufacturers was approximately 895,500 6-inch equivalent units, an increase of 8% from 832,500 units in 2018. RF applications consumed 33% of GaAs substrates by volume in 2019. The rate of increase for RF applications was lower than that for optoelectronics consumption owing to a gradual saturation of the smartphone market and the reduction in component size. Global GaAs epiwafer consumption, by wafer volume, was approximately 892,000 6-inch equivalent units in 2019, an increase of 14% from 783,000 units in 2018.

Wireless applications continued to drive the RF GaAs device market in 2019. The value of RF GaAs devices consumed globally was $8.55 billion, a 4% decrease from $8.9 billion in 2018 owing primarily to a decline in third- and fourth-generation (3G and 4G) "smartphone" shipments (Higham, 2019, 2020).

Owing to global market saturation, longer replacement cycles, and high prices delaying the purchase of fifth-generation (5G) smartphones, worldwide shipments of smartphones from device vendors in 2019 decreased slightly to 1.37 billion units from 1.4 billion units shipped in 2018 (IDC Corp. USA, 2020). China, Asia and the Pacific (other than China), North America, and Western Europe, in descending order, were the principal regions and (or) countries of smartphone growth in 2019; China accounted for 27% of smartphone sales; Asia and the Pacific (other than China), 26%; North America, 10%; and Western Europe, 9% (Gartner Inc., 2020).

Gallium Nitride.—GaN substrates, where GaN is grown epitaxially on sapphire, silicon, silicon carbide, or GaN wafers, were produced and consumed mostly in the Asia and the Pacific region, where China constituted a significant share of the market. Prominent GaN technology companies occupied the Asia and the Pacific region, and significant investments were made in research and development of innovative GaN technologies. North America emerged as the second-largest market for GaN substrates owing to increased use of the substrates in the production of white light LEDs and electric vehicles. Europe was the third-largest market owing to the increasing use of GaN substrates in the automotive industry and the rapid industrialization of the region (Semiconductor Today, 2019).

Increased demand for GaN RF devices provided significant growth for advanced GaN-based products. In 2019, the value of GaN RF devices consumed globally was approximately $740 million. GaN RF technology was developed originally for military use and expanded to cable television, communications base station transceivers, radar, and very small aperture terminal (VSAT) satellites, among other end uses. In 2019, military applications accounted for 46% of sales; telecommunications infrastructure, 43%; satellite communications, 6%; wired broadband applications, 2%; commercial radar and avionics applications, 1%; RF energy applications, 1%; and other uses, 1% (Yole Développement, 2020a).

GaN power devices operate at higher voltages, power densities, and switching frequencies, and offer greater power efficiency than existing GaAs and silicon devices. Increased demand from the military for enhanced battlefield performance stimulated demand for GaN power devices. In 2018, defense and aerospace applications accounted for 31% of sales; information and communication applications, 27%; industrial and medical applications, 15%; consumer electronics applications, 12%; automotive applications, 10%; and other uses, 5% (Gaurav, 2019, p. 41).

Laser Diodes and Light-Emitting Diodes.—Gallium is a primary component of many laser diodes and LEDs. Various gallium compounds, including aluminum gallium indium phosphide, GaAs, GaAsP, GaN, and GaP, produce variously colored light when exposed to an electric current.

Yole Développement reported that laser diode applications were driving growth in the GaAs wafer and epiwafer market, more than established GaAs RF applications, owing primarily to Apple Inc.'s introduction in 2017 of the iPhone X smartphone with three-dimensional (3D) sensing function. Using three GaAs-based vertical-cavity surface-emitting lasers (VCSELs) working simultaneously, the iPhone X recognizes the smartphone owner's face and unlocks the phone. Global GaAs substrate consumption for laser diode applications was estimated to be 367,000 6-inch equivalent units in 2019, an increase of 49% from 247,000 units in 2018. Global GaAs epiwafer consumption for laser diode applications was estimated

to be 119,000 6-inch equivalent units in 2019, an increase of 76% from 67,500 units in 2018. The introduction of the 3D sensing function using GaAs VCSELs attracted much interest and Yole Développement expected multiple Android smartphone manufacturers and autonomous vehicle manufacturers to adopt this technology, further driving the GaAs wafer and epiwafer market (Yole Développement, 2018, p. 21, 169, 267, 296).

Worldwide LED consumption decreased in 2019 owing to a combination of the trade dispute between the United States and China, increased production capacity, and stagnant demand. According to TrendForce Corp., packaged LED market sales revenue was valued at $16.6 billion in 2019, a decrease of 10% from $18.4 billion in 2018 (Chu, 2019, 2020). LED prices in 2019 decreased by 1% to 5% from those in 2018, which were already about 20% lower than those in 2017. Significant LED capacity expansion began in 2011, mostly brought about by the creation of Government-subsidized LED companies in China. The LED market was in surplus since 2012 and prices for packaged LEDs decreased continuously since then (Wright, 2016, 2018; LEDinside, 2019).

The Asia and the Pacific region was the leading consumer of LED material in 2019, followed by North America and Europe. The demand for LED material in the Asia and the Pacific region was driven mainly by the large number of LED-chip manufacturing facilities located in China, Japan, the Republic of Korea, and Taiwan. China had the largest LED industry in the world and accounted for about 54% of LED-chip production capacity in 2017 (Chu, 2017).

As LED demand increased beginning in 2010, producers began expanding capacity for TMG, the metal-organic chemical used to fabricate the GaN epitaxial layer on 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 LED's brightness and reliability. There were five major TMG producers globally in 2019: Akzo Nobel N.V. (Netherlands) manufactured TMG in Texas; Albemarle Corp. (Baton Rouge, LA) manufactured TMG in the Republic of Korea; the Dow Chemical Co. (Midland, MI) manufactured TMG in Massachusetts and the Republic of Korea; Jiangsu Nata Opto-electronic Material Co., Ltd. (China) manufactured TMG in Jiangsu Province, China; and SAFC Hitech Inc. (a subsidiary of Sigma Aldrich Corp., St. Louis, MO) manufactured TMG in Taiwan and the United Kingdom (QYR Chemical and Materials Research Center, 2016, p. 22).

Prices

Since 2002, producer prices for gallium have not been quoted in trade journals. From U.S. Census Bureau data, the average unit value for imported low-grade gallium in 2019 was estimated to be $150 per kilogram, a decrease of 19% from that in 2018 (table 1). The estimated average unit value for imported high-grade (≥99.9999%-pure) gallium increased by 12% to $570 per kilogram. Import data reported by the U.S. Census Bureau do not specify purity, and the estimated price distinction between gallium grades was based on the average customs value of the material and the country of origin.

According to Asian Metal Ltd. (2019a, b, 2020), the low-grade gallium price in China was $150 per kilogram in January 2019. By June, the price had decreased to $145 per kilogram. By December, the price decreased to $140 per kilogram.

Foreign Trade

In 2019, gallium metal imports were 82% lower than those in 2018 (table 4), most likely owing to the introduction of higher import tariffs on gallium from China and a 300% increase of gallium imports from China in 2018 before the tariffs were introduced. Gallium stockpiling in the United States in 2018 may have been prompted by the discussion of potential tariffs on imports from China. Gallium metal imports from China (including Hong Kong) decreased by 94% from those in 2018. Germany (30%), China, including Hong Kong (26%), and Russia (17%) were the leading sources of imported gallium metal in 2019. U.S. gallium export data were not available.

In addition to gallium metal, GaAs wafers were imported into the United States (table 5). Doped GaAs wafer imports decreased by 39% from those in 2018. Germany was the leading source, accounting for 46% of imports. France (19%), Taiwan (15%), Indonesia (8%), and Japan (5%) were the other main sources of doped GaAs wafers. The data listed in table 5 may include some packaging material weight, and as a result, the quantities reported for 2019 may be higher than the actual total weight of imported wafers.

World Review

Reported gallium production for China and Japan and imports of gallium into Japan and the United States, two leading gallium-consuming countries, were used initially as the basis for estimating world gallium production. China decreased its production of low-grade primary gallium in 2019 by approximately 16% (Asian Metal Ltd., 2020) and was estimated to account for 96% of worldwide low-grade primary gallium production. Estimated global low-grade primary gallium production was estimated to be 351 t in 2019, a decrease of 16% from that in 2018 (table 6). Principal world producers, in order of production, were China, Russia, Japan, and the Republic of Korea. Ukraine was believed to have stopped production of low-grade primary gallium in 2019. Production of high-grade primary refined gallium (sourced from current and stockpiled low-grade primary gallium) in 2019 was estimated to be 210 t, 40% less than low-grade primary production. China, Japan, the United States, and possibly Slovakia refined high-grade gallium from low-grade primary material. The United Kingdom stopped production of high-grade refined gallium in 2018 (5N Plus Inc., 2019, p. 7).

Worldwide gallium consumption was estimated to be 385 t in 2019, an increase of 4% from that in 2018. Based on historic consumption patterns, an estimated 40% to 45% of gallium consumed was from recycled material (Spicer, 2013). Therefore, about 210 t of high-grade primary refined gallium and 175 t of recycled gallium were estimated to have been consumed in 2019. Gallium was recycled from new scrap in Canada, China, Germany, Japan, Slovakia, and the United States. The United Kingdom stopped recycling gallium in 2018 (5N Plus Inc., 2019, p. 7).

China.—China produced a reported 338 t of low-grade primary gallium in 2019 (Asian Metal Ltd., 2020) and

consumed an estimated 125 t of gallium, approximately 32% of worldwide consumption. China's share of worldwide consumption was forecast to increase to 35% in 2020 owing to the rapid growth of the country's LED industry (Business Wire, Inc., 2016). Approximately 95% of China's gallium was sourced as a byproduct from bauxite during alumina production. The remaining 5% was sourced from the refining of lead and zinc ores (Juncong, 2017, p. 6).

China's major low-grade primary gallium producers included Aluminum Corp. of China Ltd. (Beijing); Beijing JiYa Semiconductor Material Co., Ltd. (Beijing); East Hope Mianchi Gallium Industry Co., Ltd. (Shanghai); Shanxi Jiahua Tianhe Electronic Materials (Shanxi Province); Shanxi Zhaofeng Gallium Industry Co. (Shanxi Province); Xiaoyi Xingan Gallium Co., Ltd. (Guangxi Province); and Zhuhai Fangyuan Inc. (Guangdong Province) (Huy and Liedtke, 2016, p. 34). China's high-grade primary refined gallium producers included Beijing JiYa Semiconductor Material Co., Ltd.; 5N Plus Inc. (Shenzhen, Guangdong Province); Nanjing Jingmei Gallium Co., Ltd. (Nanjing, Jiangsu Province); and Zhuzhou Keneng New Material Co., Ltd. (Zhuzhou, Hunan Province) (Shen, 2015).

Japan.—Japan Oil, Gas and Metals National Corp. (JOGMEC) reported that Japan's gallium supply in 2019 totaled 174 t, essentially unchanged from that in 2018; 57% of the gallium supply was sourced from imports, 41% from recovered scrap, and 2% from low-grade primary gallium produced in Japan as a byproduct of zinc refining. Of Japan's 76.5 t of imported gallium, 72% came from China. Japan remained the leading gallium-consuming country and consumed 132 t of gallium in 2019, approximately 34% of worldwide consumption (Kazuhiro Kojima, Director General, Rare Metals Stockpile Department, JOGMEC, written commun., November 5, 2020). Production of GaN wafers was concentrated in Japan with more than 85% of sales held by three Japan-based companies: Mitsubishi Chemical Corp., Sciocs Co. Ltd., and Sumitomo Electric Industries, Ltd. (Yole Développement, 2017).

Outlook

Gallium consumption is expected to increase as the use of GaN technology in defense applications and wireless infrastructure increases, as well as the implementation of new fifth generation (5G) networks globally. High-frequency RF applications over 3.5 gigahertz, including cable television applications, commercial wireless telecommunications, and military electronic warfare systems and radar, require the high voltage and high power capabilities of GaN devices. GaAs and silicon devices cannot operate at such high frequencies. The consumption of GaAs wafers for laser diode applications is expected to increase, as driven by devices with 3D sensing function.

Owing to significant expansion of LED-manufacturing capacity, reduced prices, and Government incentives, global LED sales are expected to increase by a CAGR of more than 16% between 2018 and 2022. General lighting is expected to remain the largest segment of the LED market, accounting for 77% by 2021, and the Asia and the Pacific region is expected to account for 52% of the market by 2022. The Asia and the Pacific region is expected to remain the leading consumer of LED material owing to rapid development in many Asian countries, Government incentives to encourage use of energy-efficient lighting, and the presence of the majority of the LED industry (Semiconductor Today, 2017; Technavio, 2018).

Annual production of TMG is forecast to be 60 t on average from 2018 to 2020 and to increase to 64 t by 2022 (QYR Chemical and Materials Research Center, 2016, p. 91, 95).

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

(Kilograms, unless otherwise specified)

	2015	2016	2017	2018	2019
Production, primary crude	--	--	--	--	--
Imports for consumption:					
Metal	28,600	10,500	20,200	32,000	5,740
Gallium arsenide wafers (gross weight)[2]	2,690,000	1,290,000	803,000 r	444,000 r	272,000
Consumption, reported	29,700	18,100	17,900	15,000	14,900
Price,[e, 3] dollars per kilogram:					
Purity ≥99.9999%	317	690	477	508	570
Purity ≤99.99%	188	125	124	185	150

[e]Estimated. [r]Revised. -- Zero.
[1]Table includes data available through September 23, 2020. Data are rounded to no more than three significant digits.
[2]Data include imports of undoped and doped wafers from 2015 and 2016, but only doped wafers since 2017.
[3]Source: U.S. Census Bureau. Estimate based on average value of U.S. imports of gallium metal.

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

(Kilograms)

End use	2018	2019
Optoelectronic devices:		
Laser diodes and light-emitting diodes	3,300	3,380
Photodetectors and solar cells	395	369
Integrated circuits:		
Analog	9,060	9,340
Digital	1,830	1,430
Research and development	425	376
Total	15,000	14,900

[1]Table includes data available through September 23, 2020. 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
2018:				
99.99% to 99.999%	1,870	--	--	1,870
99.9999%	604	2	11	595
99.99999% to 99.999999%	370	649	564	455
Total	2,840	651	575	2,920
2019:				
99.99% to 99.999%	1,870	--	--	1,870
99.9999%	595	12	12	595
99.99999% to 99.999999%	455	400	469	386
Total	2,920	412	481	2,850

-- Zero.
[1]Tables includes data available through September 23, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Consumers only.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT GALLIUM AND GALLIUM POWDERS, BY COUNTRY OR LOCALITY[1]

Country or locality	2018 Quantity (kilograms)	2018 Value[2]	2019 Quantity (kilograms)	2019 Value[2]
Belgium	--	--	47	$20,100
China	19,300	$3,430,000	494	70,200
Czechia	--	--	3	3,010
Estonia	140	30,800	--	--
France	417	334,000	109	75,100
Germany	1,240	306,000	1,750	289,000
Hong Kong	5,400	1,250,000	1,000	140,000
Japan	1,070	390,000	400	220,000
Korea, Republic of	1,280	176,000	11	2,350
Russia	507	112,000	1,000	148,000
South Africa	23	23,000	--	--
Taiwan	--	--	500	74,800
Ukraine	2,560	315,000	--	--
United Kingdom	50	10,600	428	294,000
Total	32,000	6,380,000	5,740	1,340,000

-- Zero.
[1]Table includes data available through July 30, 2020. 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 5
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM ARSENIDE WAFERS, BY COUNTRY OR LOCALITY[1]

Material and country or locality	2018 Quantity (kilograms)	2018 Value[2]	2019 Quantity (kilograms)	2019 Value[2]
Doped:				
Austria	12	$5,690	39	$41,300
Belarus	1,030	238,000	--	--
Belgium	3,590	1,720,000	1,730	48,000
Canada	212 r	605,000 r	20	126,000
China	265,000	32,600,000 r	6,770	7,090,000
Denmark	389	286,000	402	195,000
Finland	5,650 r	5,570,000 r	5,600	8,950,000
France	22,900	28,200,000	52,800	64,000,000
Germany	32,700	22,900,000 r	125,000	20,100,000
Indonesia	--	--	21,000	32,700
Israel	12	62,800	28	64,500
Italy	474	152,000	485	198,000
Japan	35,400	29,700,000	12,400	22,200,000
Korea, Republic of	8,630	4,030,000	2,410	1,440,000
Malaysia	561	184,000	108	91,200
Netherlands	2	19,600	5	12,400
Poland	347	278,000	175	121,000
Singapore	756	408,000	441	277,000
Taiwan	65,200	83,900,000 r	41,100	44,600,000
United Kingdom	1,400	2,530,000	635	2,080,000
Other	171 r	278,000 r	202	186,000
Total	444,000 r	214,000,000	272,000	172,000,000

rRevised. -- Zero.
[1]Table includes data available through July 30, 2020. 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
GALLIUM: PRIMARY WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Kilograms)

Country or locality	2015	2016	2017	2018	2019
China	444,000	171,000 [r]	319,000 [r]	404,000 [r]	338,000
Germany, crude	11,000	16,000	--	--	--
Japan	5,000	3,000	3,000	3,000	3,000
Korea, Republic of [e]	2,500	3,000	3,000	3,000	2,000
Russia [e]	1,000	9,000	7,000	6,000	8,000
Ukraine	9,400	9,000 [e]	4,000 [e]	4,000 [e]	-- [e]
Total	473,000	211,000 [r]	336,000 [r, e]	420,000 [r]	351,000

[e]Estimated. [r]Revised. -- Zero.
[1]Table includes data available through September 3, 2020. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
ESTIMATED WORLD ANNUAL PRIMARY GALLIUM
PRODUCTION CAPACITY, DECEMBER 31, 2019[1, 2]

(Metric tons)

Country or locality	Capacity
China	600,000
Germany	40,000
Hungary	8,000
Japan	10,000
Kazakhstan	25,000
Korea, Republic of	16,000
Russia	10,000
Ukraine	15,000
Total	724,000

[1]Table includes data available through May 21, 2020. Data are rounded to no more than three significant digits.
[2]Includes capacity at operating plants as well as at plants on standby basis.

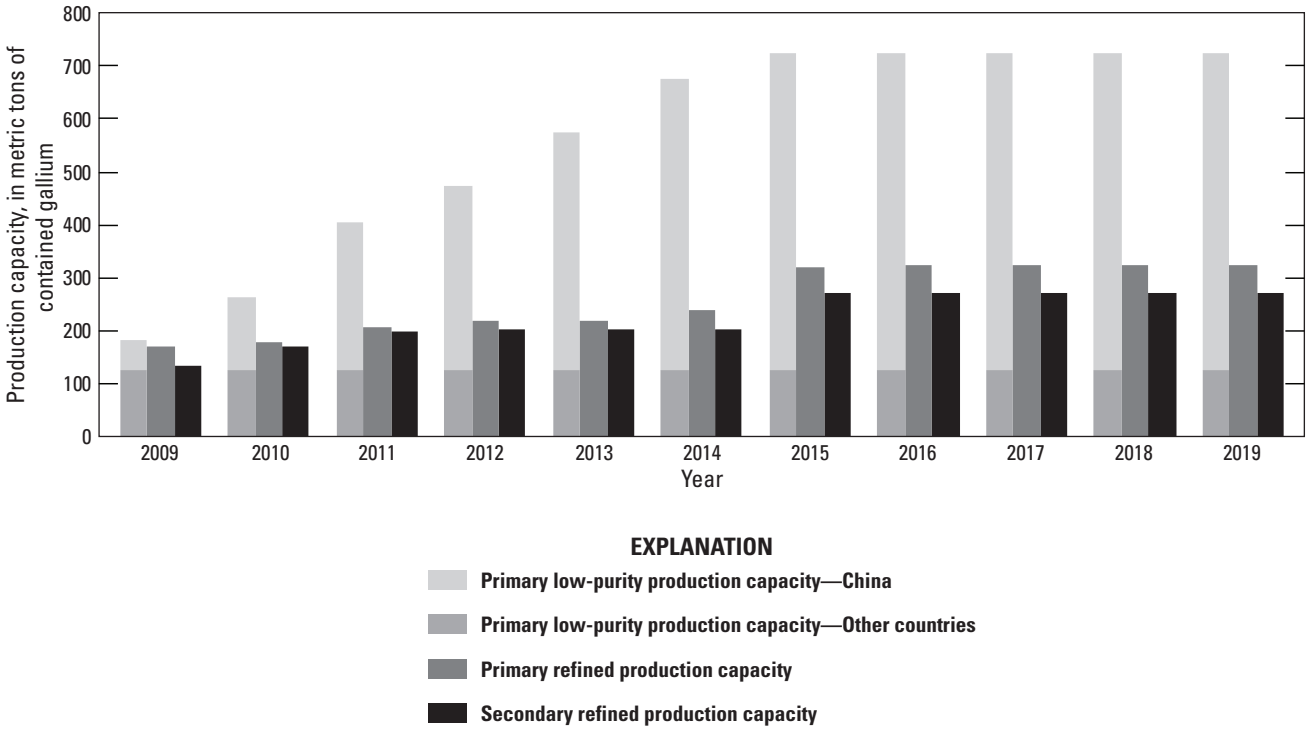

Figure 1. Estimated worldwide gallium production capacity from 2009 through 2019.

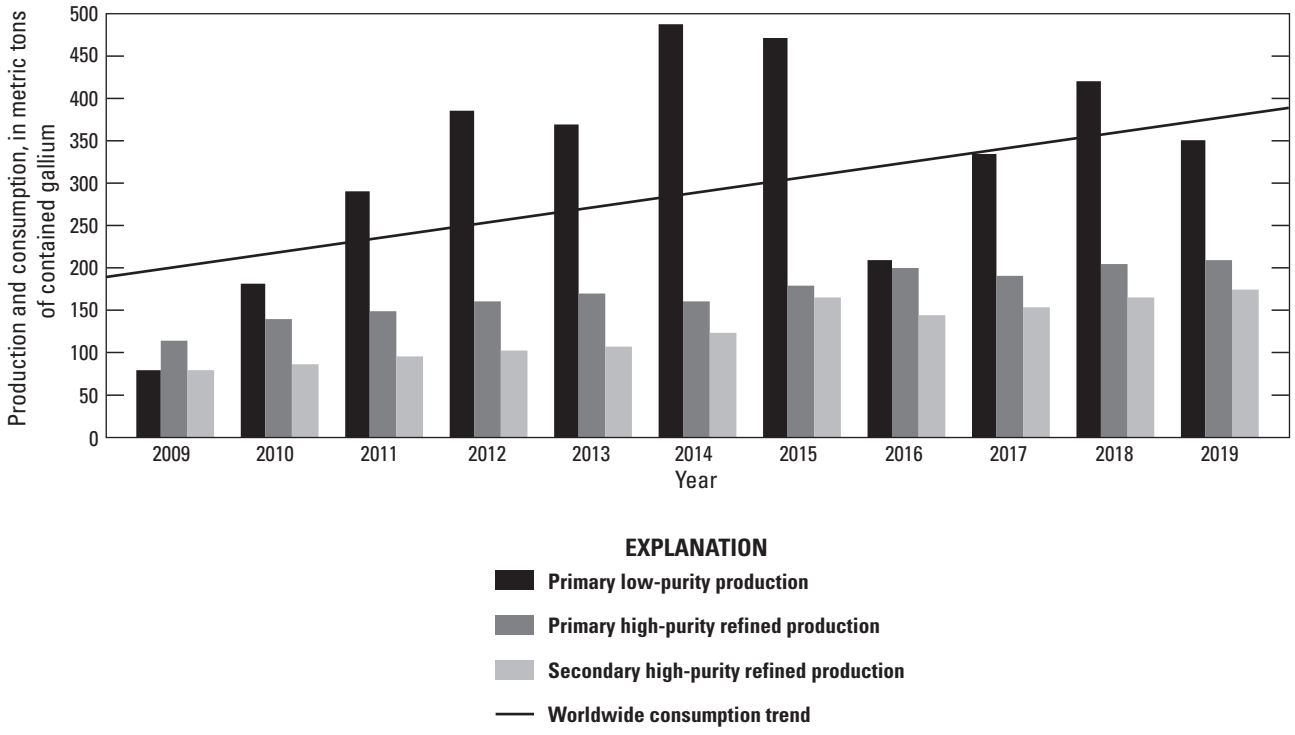

Figure 2. Estimated worldwide gallium production and consumption from 2009 through 2019.