GALLIUM

(Data in kilograms of gallium content unless otherwise noted)

Domestic Production and Use: No domestic primary (low-grade, unrefined) gallium has been recovered since 1987. Globally, primary gallium is recovered as a byproduct of processing bauxite and zinc ores. One company in Utah recovered and refined high-purity gallium from imported low-grade primary gallium metal and new scrap. Imports of gallium metal and gallium arsenide (GaAs) wafers were valued at about $4 million and $225 million, respectively. GaAs was used to manufacture integrated circuits (ICs) and optoelectronic devices, which include laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells. Gallium nitride (GaN) principally was used to manufacture optoelectronic devices. ICs accounted for 60% of domestic gallium consumption and optoelectronic devices accounted for 40%. Approximately 70% of the gallium consumed in the United States was contained in GaAs and GaN wafers. Gallium metal, trimethyl gallium, and triethyl gallium used in the epitaxial layering process to fabricate epiwafers for the production of LEDs and ICs accounted for most of the remainder. Optoelectronic devices were used in aerospace applications, consumer goods, industrial equipment, medical equipment, and telecommunications equipment. Uses of ICs included defense applications, high-performance computers, and telecommunications equipment.

Salient Statistics—United States:	**2012**	**2013**	**2014**	**2015**	**2016[e]**
Production, primary	—	—	—	—	—
Imports for consumption,					
Metal and scrap	58,200	35,400	53,900	28,600	11,000
Gallium arsenide wafers, gross weight	222,000	714,000	391,000	2,690,000	1,400,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	34,400	37,800	35,800	29,700	22,000
Price, yearend, dollars per kilogram[1]	529	502	363	317	400
Stocks, consumer, yearend	6,220	5,470	3,980	3,280	2,300
Net import reliance[2] as a percentage of reported consumption	100	100	100	100	100

Recycling: Old scrap, none. Substantial quantities of new scrap generated in the manufacture of GaAs-based devices were reprocessed to recover high-purity gallium at one facility in Utah.

Import Sources (2012–15): China, 34%; Germany, 28%; United Kingdom, 20%; Ukraine, 13%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–16**
Gallium arsenide wafers, undoped	2853.00.0010	2.8% ad val.
Gallium arsenide wafers, doped	3818.00.0010	Free.
Gallium metal	8112.92.1000	3.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Imports of gallium metal and GaAs wafers continued to account for all U.S. consumption of gallium. Owing to U.S.-based gallium consumers opening new facilities in Asia to be closer to the Asian-dominated optoelectronics industry in 2015 and 2016, gallium metal imports in 2016 were about 60% lower than those in 2015 and 80% lower than those in 2014.

Primary low-grade (99.99%-pure) gallium prices decreased throughout 2016, continuing the more than 4-year decline, as China's primary low-grade gallium production continued to exceed worldwide consumption. The average monthly price for low-grade gallium in Asia decreased to $120 per kilogram in October from $130 per kilogram in January. China's primary low-grade gallium production capacity has expanded tremendously to approximately 600 tons per year in 2016 from 140 tons per year in 2010 on the expectations of increases in LED-based backlighting and general lighting demand. China accounted for more than 80% of worldwide low-grade gallium capacity. In 2016, the average price of U.S. imports of high-grade (99.9999%- and 99.99999%-pure) refined gallium increased, despite an estimated worldwide high-grade refined-gallium capacity utilization rate of less than 60%.

Owing to primary low-grade gallium prices decreasing to below the operating costs of many producers, China's low-grade gallium production decreased in 2016 to approximately 350 tons, a 20% decrease from the country's estimated production of 440 tons in 2015. An electronic metals producer closed its low-grade gallium plant in Germany owing to low prices.

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The value of worldwide GaAs device consumption increased by about 7% to $7.5 billion in 2015 owing to a growing wireless telecommunications infrastructure in Asia; growth of feature-rich, application-intensive, third- and fourth-generation (3G, 4G) "smartphones," which employ up to 10 times the amount of GaAs as standard cellular handsets; and robust use in military radar and communications applications. Cellular applications accounted for approximately 53% of total GaAs device revenue and wireless communications accounted for 27%. Various automotive, consumer, fiber-optic, and military applications accounted for the remaining revenue.

Owing to their large power-handling capabilities, high-switching frequencies, and higher voltage capabilities, GaN-based products, which historically have been used in defense applications, have begun to be used in cable television transmission, commercial wireless infrastructure, power electronics, and satellite markets. By yearend 2016, the GaN radio frequency device market was expected to reach $340 million, a 13% increase from that of 2015, and was forecast to increase at an average annual rate of 17% to reach $630 million in 2020.

General lighting was the leading sector among LED applications and was expected to be the major share of the LED market for the rest of the decade. The other main LED sectors include backlighting and automotive lighting, in decreasing order of sales. During 2015, significant expansion of LED manufacturing capacity in Asia took place, much of it owing to China's Government-instituted incentives to increase LED production. Owing to increased LED production and lower than expected consumption from the general lighting and backlighting sectors in 2015, LED prices decreased by up to 40%, causing many LED manufacturers to exit the market. The LED market was valued at $14.3 billion in 2015, a decrease of 8% from $15.6 billion in 2014. Owing to overproduction, only 22% of the LED chips produced in 2015 were consumed. Prices were expected to stabilize by yearend 2016 owing to limited room for further price cuts given the high cost of materials.

World Production and Reserves:[3] In 2016, world low-grade primary gallium production was estimated to be 375 tons—a decrease of 20% from 470 tons in 2015. Low-grade primary gallium producers outside of China most likely restricted output owing to a large surplus of primary gallium. China, Germany, Japan, and Ukraine were the leading producers; countries with lesser output were Hungary, the Republic of Korea, and Russia. Kazakhstan, which was a leading producer in 2012, has not reported any production since then. Primary refined high-purity gallium production in 2016 was estimated to be about 180 tons. China, Japan, the United Kingdom, and the United States were the known principal producers of high-purity refined gallium. Gallium was recovered from new scrap in Canada, China, Germany, Japan, the United Kingdom, and the United States. World primary low-grade gallium production capacity in 2016 was estimated to be 730 tons per year; high-purity refinery capacity, 320 tons per year; and secondary capacity, 270 tons per year.

Gallium occurs in very small concentrations in ores of other metals. Most gallium is produced as a byproduct of processing bauxite, and the remainder is produced from zinc-processing residues. Only a portion of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of reserves is not possible.

World Resources: The average gallium content of bauxite is 50 parts per million (ppm). U.S. bauxite deposits consist mainly of subeconomic resources that are not generally suitable for alumina production owing to their high silica content. Recovery of gallium from these deposits is therefore unlikely. Some domestic zinc ores contain up to 50 ppm gallium and could be a significant resource, although no gallium is currently recovered from domestic ores. Gallium contained in world resources of bauxite is estimated to exceed 1 million tons, and a considerable quantity could be contained in world zinc resources. However, only a small percentage of the gallium in bauxite and zinc resources is potentially recoverable.

Substitutes: Liquid crystals made from organic compounds are used in visual displays as substitutes for LEDs. Silicon-based complementary metal-oxide semiconductor power amplifiers compete with GaAs power amplifiers in midtier 3G cellular handsets. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and helium-neon lasers compete with GaAs in visible laser diode applications. Silicon is the principal competitor with GaAs in solar-cell applications. GaAs-based ICs are used in many defense-related applications because of their unique properties, and no effective substitutes exist for GaAs in these applications. GaAs in heterojunction bipolar transistors is being replaced in some applications by silicon-germanium.

[e]Estimated. NA Not available. — Zero.

[1]Estimated based on the average values of U.S. imports for 99.9999%- and 99.99999%-pure gallium.

[2]The United States has not produced gallium since 1987 and recovers no gallium from old scrap. All domestic consumption is assumed to originate from imported gallium.

[3]See Appendix C for resource and reserve definitions and information concerning data sources.