

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 \$700,000 and \$170 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 73% of domestic gallium consumption, optoelectronic devices accounted for 25%, and research and development accounted for 2%. About 81% of the gallium consumed in the United States was contained in GaAs, GaN, and gallium phosphide (GaP) wafers. Gallium metal, triethyl gallium, and trimethyl 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:	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019^e</u>
Production, primary	—	—	—	—	—
Imports for consumption:					
Metal	28,600	10,500	20,200	32,000	3,000
Gallium arsenide wafers (gross weight)	2,690,000	1,290,000	804,000	446,000	340,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	29,700	18,100	17,900	15,000	15,000
Price, imports, dollars per kilogram:					
High-purity, refined ¹	317	690	477	508	570
Low-purity, primary ²	188	125	124	185	150
Stocks, consumer, yearend	3,280	2,720	2,840	2,920	1,920
Net import reliance ³ 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 (2015–18): Metal: China⁴, 50%; United Kingdom, 18%; Germany, 10%; Ukraine, 9%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12-31-19
Gallium arsenide wafers, doped	3818.00.0010	Free.
Gallium metal	8112.92.1000	3.0% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Imports of gallium metal and GaAs wafers continued to account for all U.S. consumption of gallium. In 2019, gallium metal imports decreased by about 90% from those of 2018, most likely owing to the introduction of higher import tariffs on gallium from China and the 300% increase of gallium imports from China in 2018 before the tariffs were introduced. Gallium stockpiling in 2018 may have been prompted by the discussion of China's potential tariffs.

Primary low-grade (99.99%-pure) gallium prices in China decreased by about 7% in 2019. Low-grade gallium prices worldwide continued to decline as China's primary low-grade gallium production continued to exceed worldwide consumption despite reduced production. The average monthly price for low-grade gallium in China decreased to \$145 per kilogram throughout 2019 from approximately \$155 per kilogram at yearend 2018. China's primary low-grade gallium production capacity has expanded to approximately 600 tons per year since 2016 from 140 tons per year in 2010. China accounted for more than 80% of worldwide low-grade gallium capacity.

GALLIUM

Low-grade primary gallium producers outside of China most likely restricted output owing to a large surplus of primary gallium. These producers included Japan, the Republic of Korea, Russia, and Ukraine. Germany and Kazakhstan ceased primary production in 2016 and 2013, respectively.

Primary high-purity refined gallium production in 2019 was estimated to be about 205 tons. China, Japan, Slovakia, and the United States were the known principal producers of high-purity refined gallium. The United Kingdom ceased high-purity gallium production in 2018. Gallium was recovered from new scrap in Canada, China, Germany, Japan, Slovakia, and the United States. World primary low-grade gallium production capacity in 2019 was estimated to be 720 tons per year; high-purity refinery capacity, 330 tons per year; and secondary capacity, 270 tons per year.

In 2018, the value of worldwide radio frequency (RF) GaAs device consumption increased slightly to \$8.9 billion owing to a growing wireless telecommunications infrastructure in Asia; growth of third- and fourth-generation (3G and 4G) “smartphones,” which employ up to 10 times the amount of GaAs in standard cellular handsets; and robust use in military radar and communications applications. Global GaAs wafer consumption by volume increased by 17% in 2019, with an estimated 50% and 40% of wafers used in LED and RF applications, respectively. Countries within the Asia and the Pacific region dominated the GaAs wafer market. 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, continued to be used in cable television transmission, commercial wireless infrastructure, power electronics, and satellite markets. The GaN RF device market was estimated to be \$750 million in 2019, an increase of 15% from the revised \$650 million in 2018.

The global high-power LED market was estimated to be \$13.3 billion in 2019, an increase of 5.3% from that in 2018. LED manufacturing capacity in Asia increased significantly in 2018 and 2019 owing to China’s Government-instituted incentives to increase LED production. China’s increased LED production outpaced worldwide consumption and LED prices declined.

World Production and Reserves:

	Primary production		Reserves⁵
	<u>2018</u>	<u>2019^e</u>	
United States	—	—	Quantitative estimates of reserves are not available.
China	397,000	310,000	
Japan	3,000	3,000	
Korea, Republic of	3,000	3,000	
Russia	6,000	4,000	
Ukraine	<u>4,000</u>	<u>4,000</u>	
World total (rounded)	413,000	320,000	

World Resources: 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. The average gallium content of bauxite is 50 parts per million. U.S. bauxite deposits consist mainly of subeconomic resources that are not generally suitable for alumina production owing to their high silica content. Some domestic zinc ores contain up to 50 parts per million 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, less than 10% 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.

^eEstimated. NA Not available. — Zero.

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

²Estimated based on the average values of U.S. imports for 99.99%-pure gallium.

³Defined as imports – exports. Excludes gallium arsenide wafers.

⁴Includes Hong Kong.

⁵See Appendix C for resource and reserve definitions and information concerning data sources.