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 $6 million and $230 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 68% of domestic gallium consumption, optoelectronic devices accounted for 30%, and research and development accounted for 2%. About 75% of the gallium consumed in the United States was contained in GaAs and GaN 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:	2014	2015	2016	2017	2018[e]
Production, primary	—	—	—	—	—
Imports for consumption:					
Metal	53,900	28,600	10,500	20,200	33,000
Gallium arsenide wafers (gross weight)	391,000	2,690,000	1,290,000	804,000	630,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	35,800	29,700	18,100	17,900	23,000
Price, imports, dollars per kilogram:					
High-purity, refined[1]	363	317	690	477	350
Low-purity, primary[2]	239	188	125	124	160
Stocks, consumer, yearend	3,980	3,280	2,720	2,840	2,940
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 (2014–17): China, 32%; United Kingdom, 28%; Germany, 15%; Ukraine, 14%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12–31–18
Gallium arsenide wafers, doped	2853.90.9010	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: In May 2018, the U.S. Department of the Interior, in coordination with other executive branch agencies, published a list of 35 critical minerals (83 FR 23295), including gallium. This list was developed to serve as an initial focus, pursuant to Executive Order 13817, ‘‘A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals” (82 FR 60835).

Imports of gallium metal and GaAs wafers continued to account for all U.S. consumption of gallium. In 2018, gallium metal imports increased by about 60% from those of 2017. However, owing to U.S.-based gallium consumers opening new facilities in Asia to be closer to the optoelectronics industry in that region, gallium metal imports in 2018 were still 39% lower than those in 2014.

Primary low-grade (99.99%-pure) gallium prices in China increased by about 40% in 2018, most likely due to restocking by consumers. Low-grade gallium prices worldwide increased after a more than 5-year decline as China’s primary low-grade gallium production continued to exceed worldwide consumption. The average monthly price for low-grade gallium in China increased to $200 per kilogram throughout 2018 from approximately $140 per kilogram in 2017. 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.

Prepared by **Brian W. Jaskula [(703) 648–4908, bjaskula@usgs.gov]**

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 2018 was estimated to be about 205 tons. China, Japan, Slovakia, 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 2018 was estimated to be 730 tons per year; high-purity refinery capacity, 320 tons per year; and secondary capacity, 270 tons per year.

In 2017, the value of worldwide radio frequency GaAs device consumption increased by 7% to $8.8 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. The value of worldwide GaAs wafer consumption increased by 13% to $790 million. Countries within the Asia and the Pacific region dominated the GaAs wafer market, with cellular, optoelectronics, and wireless manufacturers consuming an estimated 61% of the GaAs wafers. 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. In 2018, the GaN radio frequency device market was estimated to have increased by 23% to $467 million.

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. LED manufacturing capacity in Asia increased significantly owing to China's Government-instituted incentives to increase LED production. In 2017, China accounted for 54% of global LED manufacturing capacity. In the first 9 months of 2018, China's LED production outpaced worldwide consumption and LED prices declined. The global LED market was estimated to be $18.8 billion in 2018, an increase of 4% from that in 2017.

World Production and Reserves:

	Primary production		Reserves[4]
	2017	2018[e]	
United States	—	—	Quantitative estimates of reserves are not available.
China	300,000	390,000	
Japan	3,000	3,000	
Korea, Republic of	3,000	3,000	
Russia	7,000	6,000	
Ukraine	4,000	6,000	
World total (rounded)	320,000	410,000	

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.

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

[3]Defined as imports – exports.

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