GALLIUM

(Data in kilograms of gallium content unless otherwise noted)

<u>Domestic Production and Use</u>: No domestic primary gallium recovery was reported in 2011. One company in Utah recovered and refined gallium from scrap and impure gallium metal. Imports of gallium, which supplied most of U.S. gallium consumption, were valued at about \$66 million. Gallium arsenide (GaAs) and gallium nitride (GaN) electronic components represented about 99% of domestic gallium consumption. About 61% of the gallium consumed was used in integrated circuits (ICs). Optoelectronic devices, which include laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells, represented 38% of gallium consumption. The remaining 1% was used in research and development, specialty alloys, and other applications. Optoelectronic devices were used in areas such as aerospace, consumer goods, industrial equipment, medical equipment, and telecommunications. Uses of ICs included defense applications, high-performance computers, and telecommunications.

Salient Statistics—United States:	<u>2007</u>	<u>2008</u>	2009	<u>2010</u>	<u>2011^e</u>
Production, primary					
Imports for consumption	37,100	41,100	35,900	59,200	95,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	25,100	28,700	24,900	33,500	57,000
Price, yearend, dollars per kilogram ¹	530	579	449	600	700
Stocks, consumer, yearend	6,010	3,820	4,100	4,970	6,000
Employment, refinery, number	20	20	20	20	20
Net import reliance ² as a percentage					
of reported consumption	99	99	99	99	99

Recycling: Old scrap, none. Substantial quantities of new scrap generated in the manufacture of GaAs-base devices were reprocessed.

Import Sources (2007–10): Germany, 27%; Canada, 20%; United Kingdom, 19%; China, 17%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations		
		<u>12-31-11</u>		
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 and GaAs wafers continued to supply almost all U.S. demand for gallium. Gallium prices increased sharply in the first and second quarters of 2011 owing to the exceptional demand for GaN-LEDs in mobile display and backlighting applications. Prices decreased during the third quarter when rapidly rising gallium production exceeded the declining demand from LED producers. In January, the price for low-grade (99.99%-pure) gallium in Asia and Europe averaged \$645 per kilogram. By June, the average low-grade price had increased to \$970 per kilogram. By early October, the average low-grade price had decreased to \$740 per kilogram.

Market conditions continued to improve for GaAs- and GaN-based products in 2011. GaAs demand, while still driven mainly by cellular handsets and other high-speed wireless applications, increased owing to rapid growth of feature-rich, application-intensive, third- and fourth-generation "smartphones," which employ considerably more GaAs content than standard cellular handsets. Smartphones were estimated to account for 28% of all handset sales in 2011. Analysts estimated that the smartphone market's sales volume will grow at an annual rate of 15% to 25% for the next several years. Owing to the large power handling capabilities of GaN technology, GaN-based products, which historically have been used in defense and military applications, have recently begun to gain acceptance in cable television transmission, commercial wireless infrastructure, power electronics, and satellite markets.

The high-brightness LED industry was a significant driver for GaN-based technologies. In 2011, the worldwide GaN-LED market increased by 36% in unit volume from that of 2010. GaN-LED sales volume, however, increased by only 1%, to \$8.7 billion, from that of 2010. Reduced revenue growth was attributed to slower-than-expected growth in LED backlighting and to LED supply outpacing demand. The backlighting of computer notebook screens, flat-screen computer monitors, and flat-screen televisions was the driving force for high-brightness LED consumption in 2011. The market share of LED-backlit computer notebooks was estimated to have increased to 100% in 2011 from 89% in 2010, while LED-backlit flat-screen televisions increased to 43% in 2011 from 23% in 2010.

GALLIUM

In response to the unprecedented demand for high-brightness LEDs, several trimethylgallium (TMG) producers expanded their TMG production capacities worldwide in 2010 and 2011. TMGs are metalorganic precursors used in the production of LEDs. One producer announced plans to build an additional TMG production plant in the United States, which would bring its total TMG capacity to 100 metric tons per year. Construction of the plant was expected to begin in late 2011, with completion in 2012.

In 2011, the parent company of a Utah-based gallium refiner purchased an Oklahoma-based producer of gallium trichloride, which is used in the production of LEDs. The company announced plans to expand its gallium trichloride production operations into the Republic of Korea. A new facility was expected to commence operations in late 2012.

The value of the copper-indium-gallium diselenide (CIGS) market, a thin-film photovoltaic technology, was estimated to be \$613 million in 2011, and had been forecast by one analyst to increase to \$5.4 billion by 2018. CIGS technology, however, had been slow to enter the commercial market owing to a complicated manufacturing process that had impeded commercial mass production of CIGS panels. Decreased prices of silicon-based solar cells also slowed demand for the more expensive CIGS technology. These two factors resulted in a large oversupply of CIGS modules that caused prices to be reduced by 20%.

Asian Governments invested heavily in LED technologies in 2010 and 2011. The Republic of Korea initiated a LED lighting program that aimed to achieve a 100% adoption rate for LED lighting in the Korean public sector and a 60% adoption rate for all lighting applications nationwide by 2020. In China, significant incentives were established by its Government to build a dominant LED industry. The Chinese Government also implemented a large street-lighting program that was expected to create strong domestic demand for LED-based lighting. To meet the large gallium demand for LEDs, Chinese gallium capacity and production was believed to have expanded tremendously in 2011.

World Production and Reserves: In 2011, world primary gallium production was estimated to be 216 metric tons, 19% greater than the revised 2010 world primary production of 182 tons. China, Germany, Kazakhstan, and Ukraine were the leading producers; countries with lesser output were Hungary, Japan, the Republic of Korea, and Russia. Refined gallium production was estimated to be about 310 tons; this figure includes primary gallium production and some possible scrap refining. China, Japan, the United Kingdom, and the United States were the principal producers of refined gallium. Gallium was recycled from new scrap in Canada, Germany, Japan, the United Kingdom, and the United States. World primary gallium production capacity in 2011 was estimated to be between 260 and 320 tons; refinery capacity, 270 tons; and recycling capacity, 198 tons.

Gallium occurs in very small concentrations in ores of other metals. Most gallium is produced as a byproduct of treating bauxite, and the remainder is produced from zinc-processing residues. Only part of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of current reserves comparable to the definition of reserves of other minerals cannot be made. The world bauxite reserves are so large that much of them will not be mined for many decades; hence, most of the gallium in the bauxite reserves cannot be considered to be available in the short term.

<u>World Resources</u>: The average content of gallium in 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 as much as 50 ppm gallium and, as such, could be a significant resource. World resources of gallium in bauxite are estimated to exceed 1 billion kilograms, and a considerable quantity could be present in world zinc reserves. The foregoing estimate applies to total gallium content; only a small percentage of this metal in bauxite and zinc ores is economically recoverable.

<u>Substitutes</u>: Liquid crystals made from organic compounds are used in visual displays as substitutes for LEDs. Researchers also are working to develop organic-based LEDs that may compete with GaAs in the future. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and GaAs competes with helium-neon lasers 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 there are no effective substitutes for GaAs in these applications. GaAs in heterojunction bipolar transistors is being challenged 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 99.9999%-pure gallium.

²Defined as imports – exports + adjustments for Government and industry stock changes.

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