

GERMANIUM

(Data in kilograms of germanium content unless otherwise noted)

Domestic Production and Use: The value of domestic refinery production of germanium, based upon an estimated 2006 producer price, was \$4.0 million. Germanium production in the United States comes from either the refining of imported germanium compounds or industry-generated scrap. The production series for refined germanium was revised significantly downward to avoid double-counting of material imported in chemical form and directly consumed or consumed in the production of other germanium compounds. Germanium was recovered from zinc concentrates produced at two domestic zinc mines, one in Alaska and the other in Washington, that were exported to Canada for processing. Another mine in Tennessee produced germanium-rich zinc concentrates until its closure in mid-2003.

A germanium refinery in Utica, NY, produced germanium tetrachloride for optical fiber production. Another refinery in Oklahoma produced refined germanium compounds for the production of fiber optics, infrared devices, and substrates for electronic devices. Six companies account for most of the U.S. germanium consumption. The major end uses for germanium, worldwide, were estimated to be polymerization catalysts, 31%; fiber-optic systems, 24%; infrared optics, 23%; electronics/solar electric applications, 12%; and other (phosphors, metallurgy, and chemotherapy), 10%. Domestically, these end uses varied and were estimated to be fiber-optic systems, 40%; infrared optics, 30%; electronics/solar electric applications, 20%; and other (phosphors, metallurgy, and chemotherapy), 10%. Germanium is not used in polymerization catalysts in the United States.

| Salient Statistics—United States: | 2002 | 2003 | 2004 | 2005 | 2006^e |
|---|-------------|-------------|-------------|-------------|-------------------------|
| Production, refinery ^e | 4,900 | 4,700 | 4,400 | 4,500 | 4,600 |
| Total imports ¹ | 19,900 | 15,500 | 24,400 | 28,500 | 38,000 |
| Total exports ¹ | 20,100 | 6,200 | 13,800 | 10,100 | 7,100 |
| Shipments from Government stockpile excesses | 681 | 1,760 | 7,190 | 4,510 | 4,000 |
| Consumption, estimated | 28,000 | 20,000 | 25,000 | 27,000 | 38,000 |
| Price, producer, yearend, dollars per kilogram: | | | | | |
| Zone refined | 620 | 380 | 600 | 660 | 880 |
| Dioxide, electronic grade | 400 | 245 | 400 | 405 | 760 |
| Stocks, producer, yearend | NA | NA | NA | NA | NA |
| Employment, plant ^c number ^e | 85 | 65 | 65 | 65 | 65 |
| Net import reliance ³ as a percentage of estimated consumption | NA | NA | NA | NA | NA |

Recycling: Worldwide, about 35% of the total germanium consumed is produced from recycled materials. During the manufacture of most electronic and optical devices, more than 60% of the germanium metal used is routinely recycled as new scrap. Little domestic germanium returns as old scrap because there is a low unit use of germanium in most electronic and infrared devices. Because new European directives on Waste Electrical and Electronic Equipment (WEEE) mandate the recycling of electronics, the supply of old scrap within the European Union is expected to increase.

Import Sources (2002-05):⁴ Belgium, 40%; Canada, 21%; China, 12%; Russia, 6%; and other, 21%.

| Tariff: Item | Number | Normal Trade Relations 12-31-06 |
|---------------------|---------------|--|
| Germanium oxides | 2825.60.0000 | 3.7% ad val. |
| Waste and scrap | 8112.30.0000 | Free. |
| Metal, unwrought | 8112.30.6000 | 2.6% ad val. |
| Metal, wrought | 8112.30.9000 | 4.4% ad val. |

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: The Defense National Stockpile Center (DNSC) started the Basic Ordering Agreement (BOA) sales program for germanium using weekly postings on Thursdays on the DNSC Web site. BOA sales began on July 20, 2006.

Stockpile Status—9-30-06⁵

| Material | Uncommitted inventory | Committed inventory | Authorized for disposal | Disposal plan FY 2006 | Disposals FY 2006 |
|-----------------|------------------------------|----------------------------|--------------------------------|------------------------------|--------------------------|
| Germanium | 23,728 | — | 23,728 | 8,000 | 4,302 |

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Events, Trends, and Issues: For 2006, an estimated 100 metric tons of germanium was produced worldwide, with an estimated U.S. production of 4,600 kilograms. Total domestic imports of germanium in 2006 were 38,000 kilograms, with Belgium and Canada being the leading import sources. The supply deficit evident in 2005 increased in 2006 owing to a further growth in demand and resulting in price increases. This deficit was expected to shrink in 2007 as output is raised and recycling increases. Recycling of new scrap continued to increase and remained a significant supply factor, but the primary supply of germanium was well below the level of consumption. Supply capacity, defined as availability of primary material and recyclable waste material, was expected to meet future demand. Also, there has been some renewed interest in the recovery of germanium from coal fly ash in areas outside of China and Russia. The current high prices of germanium metal should provide incentive for the collection of flue dusts by zinc smelters and ash from the combustion of coal.

Demand for germanium increased in 2006 because of the growth of fiber-optic production, the increased use of germanium-base infrared devices for night-vision applications in luxury cars, and the continued demand for military security and surveillance equipment. Germanium consumption in catalysts for polyethylene terephthalate (PET) production remained stable.

Silicon-germanium (SiGe) is beginning to replace gallium arsenide (GaAs) in wireless communications devices. SiGe chips, with high-speed properties, can be made with low-cost, well-established production techniques of the silicon-chip industry. A tarnish-proof sterling silver alloy, trademarked Argentium, requires 1.2% germanium. The recent rise in energy cost has improved the economics of solar panels, a potential major new use of germanium. Research continued on germanium-on-insulator substrates as a replacement for silicon on miniaturized chips, and on germanium-base solid-state light-emitting diodes (LEDs).

Germanium has little or no effect upon the environment because it usually occurs only as a trace element in ores and carbonaceous materials and is used in very small quantities in commercial applications.

World Refinery Production, Reserves, and Reserve Base:

| | Refinery production ^e | | Reserves ⁶ | Reserve base ⁶ |
|-----------------|----------------------------------|---------------|-----------------------|---------------------------|
| | <u>2005</u> | <u>2006</u> | | |
| United States | 4,500 | 4,600 | 450,000 | 500,000 |
| Other countries | <u>85,500</u> | <u>95,400</u> | <u>NA</u> | <u>NA</u> |
| World total | 90,000 | 100,000 | NA | NA |

World Resources: The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores. Significant amounts of germanium are contained in ash and flue dust generated in the combustion of certain coals for power generation. Reserves and reserve base figures exclude germanium contained in coal ash.

Substitutes: A new titanium-base catalyst for PET production was used in Asia at the beginning of 2005. Silicon is less expensive and can be substituted for germanium in certain electronic applications. Although some metallic compounds that contain gallium, indium, selenium, and tellurium can be substituted for germanium, it is more reliable than competing materials in many high-frequency and high-power electronics applications and is more economical as a substrate for some LED applications. Zinc selenide and germanium glass substitute for germanium metal in infrared applications systems but often at the expense of performance.

^eEstimated. NA Not available. — Zero.

¹In addition to the gross weight of wrought and unwrought germanium and waste and scrap, this series was revised to include estimated germanium dioxide metal content. This series does not include germanium tetrachloride and other germanium compounds for which data are not available.

²Employment related to primary germanium refining is indirectly related to zinc refining.

³Defined as imports – exports + adjustments for Government and industry stock changes.

⁴Imports are based on the gross weight of wrought and unwrought germanium and waste and scrap; includes estimated germanium dioxide, metal content; does not include germanium tetrachloride and other germanium compounds for which data are not available.

⁵See Appendix B for definitions.

⁶See Appendix C for definitions.