science for a changing world

2005 Minerals Yearbook

GERMANIUM

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In 2005, germanium was produced at two refineries and recovered from zinc concentrates produced at two zinc mines in the United States. The two domestic zinc-mining operations in Alaska and Washington produced germanium-containing zinc concentrates that were exported to Canada for processing. Another zinc mine that had produced germanium-rich zinc concentrates in Tennessee closed in May 2003.

The U.S. Geological Survey (USGS) estimated domestic germanium reserves, factored from zinc reserves, to be 450,000 kilograms (kg). Data for worldwide reserves were not available. Worldwide germanium resources were associated with zinc and lead-zinc-copper sulfide ores. Germanium was also recovered to a lesser extent from coal ash and cobalt-copper ores.

Germanium is a hard, brittle semimetal that first was used about one-half century ago as a semiconductor material in radar units and as the material for the first transistors. Today, it is used principally as a polymerization catalyst for polyethylene terephthalate (PET), a commercially important plastic; a component of glass in telecommunications fiber optics; in infrared night-vision devices; and as a semiconductor and substrate in electronics circuitry.

Legislation and Government Programs

As a strategic and critical material, germanium was included in the National Defense Stockpile (NDS) in 1984. All the material purchased for the stockpile was zone-refined polycrystalline germanium metal.

According to the Defense Logistics Agency (DLA), sales began 2005 at $605 per kilogram and ended the year at $676 per kilogram. The DLA reported that sales for calendar year 2005 were 4,512 kg compared with 7,186 kg in 2004 and that, as of December 31, 2005, the NDS inventory of germanium metal was 28,851 kg, all of which has been authorized for sale. Germanium was offered for sale on the fourth Monday of each month, and the DLA was authorized to sell up to 8,000 kg during fiscal year 2006 (Defense Logistics Agency, 2005).

Production

Domestic refinery production for germanium was estimated by the USGS based on data provided by North American producers. The USGS estimated that U.S. refinery production of germanium from fly ash, imported primary material and germanium compounds, and new scrap increased in 2005 to 4,500 kg from 4,400 kg in 2004. Production of refined germanium in 2004 and preceding years was revised significantly downward to avoid counting material imported in chemical form and directly consumed or consumed in the production of other germanium compounds.

In July 2003, Umicore Optical Materials USA Inc. (a subsidiary of Umicore NV/SA, Brussels, Belgium) acquired certain assets of EaglePicher Technologies' germanium operations based in Quapaw, OK, which remained the leading domestic producer of germanium in 2005. Umicore produced germanium from fly ash, germanium concentrates (typically containing 5% germanium or more), scrap, and imported germanium compounds. About 10% of Umicore's germanium and cobalt was produced from scrap. This facility also produced germanium-base products used in fiber-optics, infrared devices, and substrates for electronic devices (Umicore NV/SA, 2006, p. 13).

Germanium Corporation of America (a subsidiary of Indium Corporation of America) produced germanium products including germanium tetrachloride, germanium dioxide, and germanium metal at its facility in Utica, NY.

Teck Cominco Limited produced germanium-containing zinc concentrates at its Red Dog zinc-lead open pit mine in Alaska and its Pend Oreille zinc-lead underground mine in Washington State. Concentrates produced at the Red Dog and Pend Oreille Mines were shipped to the company's metallurgical complex in Trail, British Columbia, Canada, where the zinc concentrates were treated in roasters or pressure leach facilities to extract germanium coproducts. Approximately 25% of the zinc concentrate produced at Red Dog was shipped to the Trail facility (Teck Cominco Limited, 2006, p. 8).

Consumption

The USGS estimated that domestic consumption of germanium increased to 27,000 kg in 2005 from 25,000 kg in 2004. Worldwide, the end-use pattern was estimated to be as follows: catalysts for PET, 31%; fiber optics, 24%; infrared optics, 23%; electrical/solar applications, 12%; and other uses (such as phosphors, metallurgy, and chemotherapy), 10%. The domestic end-use pattern was significantly different, however, with fiber optics accounting for 40%; infrared optics, 30%; electronics/solar electrical applications, 20%; and other uses (phosphors, metallurgy, and chemotherapy), 10%. Germanium was not used in PET catalysts in the United States.

In the fiber optics sector, germanium was used as a dopant (a substance added in small amounts to the pure silica glass core to increase its refractive index while not absorbing light) within the core of optical fibers used by the telecommunications industry.

Germanium lenses and windows are transparent to infrared radiation, which allows them to be used in infrared optical systems in the same way that ordinary glass lenses and windows are used in visible-light optical systems. These germanium-base optical systems have been used principally for military guidance and weapon-sighting applications, including satellite systems and personnel detection equipment for poor visibility environments. Germanium optical glass also is used for nonmilitary purposes in monitoring systems, night-vision applications for luxury vehicles, and surveillance equipment.

In the polymerization catalysts sector outside the United States, germanium consumption as a catalyst for PET production has remained stable.

Germanium-base devices have become well established for analog and digital functions. Silicon germanium (SiGe) enables manufacturers to produce smaller transistors with less electronic noise interference. Germanium-base transistors, referred to also as chips, are more energy efficient than traditional silicon-base chips, extending the life of the battery in wireless devices. Other benefits include more stability over a wider range of temperatures and the ability to operate at ultrahigh frequencies (IBM Research, 2004§[1]).

Prices

Free market prices for germanium dioxide, published by Metal Bulletin, remained in the range of $360 to $430 per kilogram during 2005. Based on NDS sales, the price of zone-refined metal averaged $621.39 per kilogram during 2005 (Defense Logistics Agency, 2005§).

Trade

The U.S. Census Bureau (2006§) reported that imports of germanium (wrought, unwrought, and waste and scrap material) increased to approximately 16,700 kg in 2005 from 9,130 kg in 2004. Belgium, China, Germany, and Russia, in descending order of quantity, accounted for 95% of imports into the United States in 2005 (table 1). In addition, the estimated germanium content of the germanium dioxide imported in 2005 was 11,800 kg, compared with 15,200 kg in 2004. When metal imports and estimated metal content of germanium dioxide imports are added together, Belgium accounted for 49.5%; Canada, 20.9%; China, 11.5%; Germany, 11.2%; and Russia, 6.10% of imports of contained germanium metal into the United States.

Exports of germanium and articles thereof, including waste and scrap, were 10,100 kg in 2005 according to the U.S. Census Bureau. Low-value waste exported to Belgium accounted for about 90% of exports of germanium from the United States in 2005. The estimated germanium content of germanium dioxide exported in 2005 was 732 kg. When metal exports and estimated metal content of germanium dioxide exports were added together, Belgium was the destination for 88.5%; Canada, 4.8%; Germany, 1.9%; Russia, 1.5%; and China, 1.4% of exports of contained germanium metal from the United States.

World Industry Structure

In 2005, the world's total estimated supply of germanium was 90 metric tons (t), including 4,500 kg released from the NDS. The recycling level remained about the same and supplied about 31 t of the world's total supply of germanium.

Starting in 2001 and continuing through 2002, there had been a growing surplus of germanium owing to a major downturn in the fiber optics market. The bottom of this recent cycle was in 2003, and by yearend 2003, supply and demand were in close balance. Lower production and moderate demand growth resulted in a tight supply in 2004. In 2005, the germanium market remained tight with little change in supply and demand (Metal-Pages, 2005a§).

Current Research and Technology

Germanium continued to be used for thermal imaging in night-vision systems. The germanium lens focuses the infrared (IR) rays from the observed object to a detector. Umicore introduced germanium arsenic selenium IR (GASIR), a new material used in the far-infrared night vision system produced by Autoliv Inc., a German automotive safety equipment manufacturer. GASIR lenses have excellent IR transmission properties while containing only 20% germanium. Also, through an efficient molding technique, Umicore was able to minimize waste production and reduce production costs. IR radiation can be transmitted through the GASIR lens system from up to 300 meters away (Umicore NV/SA, 2006, p. 16).

Consumer demand for night-vision systems in automobiles dropped in 2004, prompting General Motors Corp. (GM) to drop the option from its 2006 model Cadillac vehicles. GM continued to offer night-vision as a dealer-installed option in its Hummer models. Toyota Motor Corporation reported that the percentage of Lexus models sold with night-vision fell to less than 5% by yearend from 26% in early 2004 (Business Week, 2004§).

In August, IBM announced that it had developed the 130-nanometer SiGe bipolar complementary metal oxide semiconductor (BiCMOS) technology, allowing for higher performance and efficiency in wireless applications than the prior SiGe technology. Some of the products that can be integrated with this new technology include safety systems for automobiles (blindside detection and collision warning), 60-gigahertz (GHz) Wi-Fi chips, software defined radios for cellular devices, and high-speed analog-to-digital (A/D) and digital-to-analog (D/A) converters (IBM Corp., 2005§).

Research conducted by the Georgia Tech Research Institute through its Silicon-Germanium Transmit-Receive Module Project was aimed at developing SiGe technology for future phased-array radar systems. Researchers were investigating SiGe chips that are less expensive and hold a significantly larger number of high-speed circuits on a single chip than do gallium arsenide or indium phosphide compound semiconductors. SiGe technology generates much less radio frequency (RF) power than gallium arsenide devices, making SiGe amplifiers a better match for radar compared with other applications that require more power output (Georgia Institute of Technology, 2005§).

A new tarnish-resistant sterling silver alloy was developed that contained about 1.2% germanium. Any tarnish that develops on the alloy can easily be removed with a wet sponge. The alloy is free from firescale when heated, eliminating the need to strip off oxidation with hazardous chemicals. It is also stronger and more dent-resistant, allowing for larger silver designs (Silver Institute, The, 2005§).

[1]References that include a section mark (§) are found in the Internet References Cited section.

Researchers at Riken Corp., one of Japan's leading institutes for science and technology, have developed a new product that exhibits negative thermal expansion with higher electric and thermal conductivities than other metals. Negative thermal expansion allows the product to shrink significantly with rising temperature. The properties of the product are the result of replacing select zinc and gallium atoms with germanium in an anti-perovskite-structure manganese nitride (Mn3XN). Possible applications are in precision devices and components that have to avoid any thermal expansion (Metal-Pages, 2005b§).

Outlook

Nearing the end of 2005, hazardous environmental conditions forced more than a dozen zinc smelters in China to shut down; however, this did not disrupt the germanium market (Metal-Pages, 2005c§). Zinc mine closures in Australia, Canada, and the United States and smelting facilities closures in Europe have lowered the output of byproduct germanium. However, germanium production capacity and the availability of primary and secondary material are projected to be sufficient to overcome a near-term deficit of germanium metal (Wilson, 2005).

Higher recycling rates of PET catalyst material and replacements of germanium as a catalyst in PET plastics manufacturing will erode the consumption of germanium in Asia. Titanium-base catalyst for PET production was preferred over antimony, germanium, and other rare earth metals owing to the availability and lower cost of titanium (Metal-Pages, 2005d§).

Reduced catalyst demand in Asia could be partially offset by domestic growth in optical fiber production. A continued recovery in the telecommunications sector as phone and cable companies improve access to metropolitan areas, the new innovation fiber-to-home, and an upgrading of telecommunications networks in Asia could mean a strong surge in demand for germanium along with continued increase in fiber optics use. The use of germanium was expected to continue to increase moderately along with the growth of new services in the telecommunications market. Growing industry segments [such as voice over internet protocol (VoIP), streaming media, and wireless networking (Wi-Fi)], and fiber-optic innovations have increased demand. Fiber-optic use in the Far East has been predicted to increase.

Another growth area is in the IR optics area owing to increased interest for IR devices by the military, in security and surveillance equipment, and the automobile market. Germanium consumption in the thin-film application for DVDs, germanium-base semiconductors, and other electronic uses for germanium also show growth potential.

SiGe technology could launch more affordable systems for communication, aircraft weather radar, and mobile uses for electronic system developments, such as those used in space programs.

In addition, germanium substrates for solar electronic applications are expected to increase in the short term because of increased demand for satellite communication. Overall, the demand for germanium is expected to moderately increase in conjunction with a tightening supply.

References Cited

Defense Logistics Agency, 2005, Revised annual materials plan for FY 2006: Fort Belvoir, VA, Defense Logistics Agency news release, November 14, 2 p.

Teck Cominco Limited, 2006, 2005 annual information form: Vancouver, British Columbia, Canada, Teck Cominco Limited, 45 p.

Umicore NV/SA, 2006, 2005 report to shareholders and society: Brussels, Belgium, Umicore NV/SA, 127 p.

Wilson, Robert, 2005, Indium, germanium and cadmium market overview: Minor Metals 2005, Lisbon, Portugal, June 2, 2005, Presentation, [unpaginated].

Internet References Cited

Business Week, 2004 (September 14), A dark start for night vision in autos, accessed June 15, 2005, via URL http://www.businessweek.com.

Defense Logistics Agency, 2005, Stock accepts germanium bids, News release, accessed May 20, 2006, via URL https://www.dnsc.dla.mil.

Georgia Institute of Technology, 2005 (December 10), Nanoengineered silicon-germanium improves chips, accessed May 15, 2006, at URL http://www.gatech.edu/news-room/release.php?id=717.

IBM Corp., 2005 (August 5), IBM announces next generation silicon germanium technology, accessed May 15, 2006, at URL http://www-03.ibm.com/press/us/en/pressrelease/7819.wss.

IBM Research, 2004, What is silicon-germanium, accessed May 20, 2004, at URL http://www.research.ibm.com/sigetech/describe.html.

Metal-Pages, 2005a (December 9), Germanium gives out mixed signals, accessed December 8, 2005, via URL http://www.metal-pages.com.

Metal-Pages, 2005b (December 22), Germanium replaces zinc and gallium in 'shrinking' product, accessed December 23, 2005, via URL http://www.metal-pages.com.

Metal-Pages, 2005c (December 22), Major Chinese zinc and minor metals smelter closed for pollution breach, accessed December 23, 2005, via URL http://www.metal-pages.com.

Metal-Pages, 2005d (January 6), Titanium catalysts to nudge out antimony, germanium and rare earths, accessed January 7, 2005, via URL http://www.metal-pages.com.

Silver Institute, The, 2005, Argentium sterling silver introduced, Silver News, accessed July 16, 2005, at URL http://www.silverinstitute.org/news/1q05.pdf.

U.S. Census Bureau, 2006, United States International Trade Commission, USITC Interactive Tariff and Trade DataWeb, accessed July 7, 2006, via URL http://dataweb.usitc.gov/scripts/user_set.asp.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Germanium. Ch. in Mineral Commodity Summaries, annual.

Gallium, Germanium, and Indium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Other

Germanium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

TABLE 1

U.S. IMPORTS OF GERMANIUM, BY CLASS AND COUNTRY[1, 2]

Class and country	2004 Gross weight (kilograms)	2004 Value	2005 Gross weight (kilograms)	2005 Value
Wrought, unwrought, waste, and scrap:				
Belgium	2,710	$2,850,000	9,060	$4,930,000
Canada	521	335,000	282	191,000
China	2,660	1,520,000	3,110	2,080,000
Germany	1,140	1,130,000	2,300	2,350,000
Hong Kong	50	30,600	--	--
India	--	--	184	134,000
Israel	66	61,800	16	17,700
Japan	--	--	45	32,100
Russia	1,950	1,310,000	1,740	1,490,000
Switzerland	9	2,350	--	--
United Kingdom	25	19,400	1	5,810
Total	9,130	7,260,000	16,700	11,200,000

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Does not include germanium dioxide imports.

Source: U.S. Census Bureau.