GERMANIUM

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Germanium is a hard, brittle semimetal that first came into use a 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 component of glass in telecommunications fiber optics; as a polymerization catalyst for polyethylene terephthalate (PET), a commercially important plastic; in infrared night-vision devices; and as a semiconductor and substrate in electronics circuitry.

In 2004, germanium was produced at two refineries in the United States, which processed manufacturers' scrap, some post consumer scrap, and imported germanium compounds. Germanium was recovered from zinc concentrates produced at two domestic mines, one in Alaska and the other in Washington. The germanium-bearing concentrates were exported to Canada for processing.

Domestic refinery production and consumption for germanium were estimated by the U.S. Geological Survey (USGS) based on data provided by North American producers and consumers. Production decreased in 2004 to 4,400 kilograms (kg) from 4,700 kg in 2003 and estimated consumption increased to 25,000 kg from 20,000 kg. The increased demand was met by an increase in imports, sales from the National Defense Stockpile (NDS), and a drawdown in unreported industry stocks.

The USGS estimated domestic germanium reserves to be 450,000 kg, equivalent to about an 18-year supply at the 2004 domestic rate of consumption. 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.

Legislation and Government Programs

As a strategic and critical material, germanium was included in the NDS in 1984. All the material purchased for the stockpile was zone-refined polycrystalline germanium metal. The amount designated for annual sales from the NDS was a significant portion of the domestic and world supply. According to the Defense Logistics Agency (DLA), sales began 2004 at $480 per kilogram and ended the year at $610 per kilogram. The DLA reported that sales for calendar year 2004 were 7,186 kg (compared with 1,760 kg in 2003), and that as of December 31, 2004, the NDS inventory of germanium metal was 32,776 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 2005 (Defense Logistics Agency, 2004).

Production

The USGS estimated that U.S. refinery production of germanium from imported primary material and germanium compounds and from new scrap decreased in 2004 to 4,400 kg from 4,700 kg in 2003. Umicore Optical Materials USA Inc. (a subsidiary of Umicore NV/SA, Brussels, Belgium) in Quapaw, OK, remained the leading domestic producer in 2004. Umicore produced germanium from fly ash, germanium concentrates (typically containing 5% germanium or more), reprocessed scrap, and imported germanium compounds. Germanium Corporation of America (a subsidiary of Indium Corporation of America) produced germanium products at its facility in Utica, NY.

Teck Cominco Limited produced germanium-containing zinc concentrates at its Red Dog Mine in Alaska and its Pend Oreille Mine in Washington. The concentrates were shipped to the company's Trail, British Columbia, Canada, facility for smelting and refining (Teck Cominco Limited, 2005, p. 17).

Consumption

The USGS estimated that domestic consumption of germanium increased to 25,000 kg in 2004 from 20,000 kg in 2003. The world-use pattern was estimated to be as follows: polymerization catalysts, 31%; fiber optics, 24%; infrared optics, 23%; electrical/solar applications, 12%; and other uses (such as phosphors, in metallurgy and chemotherapy), 10%. World germanium use shifted a bit more towards fiber optics in 2004 because of increased demand for satellite television and high-speed internet (Umicore NV/SA, 2005, p. 10). The domestic use pattern was significantly different; there fiber optics accounted for 40%; infrared optics, 30%; electronics/solar electrical applications, 20%; and other uses (phosphors, metallurgy, and chemotherapy), 10%.

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. The use of germanium is expected to continue to increase with the recent recovery of the telecommunications market. This increased demand is being propelled by phone and cable companies improving access to metropolitan areas and the new innovation fiber-to-home.

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, and surveillance equipment.

In the polymerization catalysts sector outside the United States, PET consumption weakened primarily owing to

economic conditions in Asia. New materials are expected to replace the relatively expensive germanium as a catalyst and will reduce its overall growth for this end use.

Germanium-base devices have become well established for analog and digital functions. Silicon germanium (SiGe) enables manufacturers to produce smaller chips with less electronic noise interference from the chip itself. The germanium-base chips are more energy efficient than traditional silicon-base chips; and therefore, extend the life of the battery. Other benefits include more stability over a wider range of temperatures and operation 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 $400 per kilogram all year. The price of zone-refined metal averaged $550.33 per kilogram during 2004 (U.S. Department of Defense, 2005, p. 11).

Trade

The U.S. Census Bureau in 2004 reported that imports of germanium wrought, unwrought, and waste and scrap material increased to approximately 9,130 kg from 8,380 kg in 2003. Of these metal imports, Belgium, China, Russia, and Germany, in descending order of value of receipts, accounted for approximately 90% of U.S. imports in 2004 (table 1). The estimated germanium content of germanium dioxide imported in 2004 was 15,200 kg compared with 7,090 kg in 2003. When metal imports and metal content of estimated germanium dioxide imports are added together, Canada represents 44.5%, Belgium 25.4%, China 11.6%, Russia 8.1%, and Germany 7.0% of U.S. imports of contained germanium metal. Germanium export data were not available.

World Review

In 2004, world refinery production of primary germanium was estimated to be 50 metric tons (t), lower than the 58 t produced in 2003. The recycling level remained about the same and supplied 30 t of germanium worldwide. The world's total estimated market supply was 87 t in 2004, including 7,186 kg released from the NDS.

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 close to a balance. Lower production and moderate demand growth resulted in a continued tight supply in 2004; world demand was estimated to be about 88 t, slightly higher than supply (Wilson, 2005).

Current Research and Technology

Germanium continued to be used for thermal imaging in night-vision systems. The germanium lens focuses the infrared rays from the observed object to a detector. All objects emit heat to some degree, but humans, animals, and moving vehicles are quite visible in the infrared spectrum because of the large amount of heat emitted, which contrasts with the cooler background.

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. Some drivers reported that the GM and Toyota systems were distracting because the drivers were required to discern objects themselves. Other manufacturers, such as BMW Group and Ford Motor Company, as well as Toyota were developing advanced systems that would alert drivers to objects in the field of view (Business Week, 2004§).

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, thus 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§).

Outlook

Higher recycling rates of PET and replacements for germanium as a catalyst in PET plastics will erode the consumption of germanium in Asia. The closures of zinc mines in Australia, Canada, and the United States and of smelting facilities in Europe have lowered the output of byproduct germanium.

The leading domestic use for germanium in 2004 was for optical fiber production, which had declined considerably during the preceding few years. A recovery in the telecommunications sector as phone and cable companies improve access to metropolitan areas, the new innovation fiber-to-home, and a predicted upgrading of telecommunications networks in Asia could mean a strong surge in demand for germanium. Significant growth potential exists in the infrared optics area owing to increased demand for infrared devices by the military, in security and surveillance equipment, and in private automobiles. Germanium substrates for solar electronic applications are expected to increase in the short term because of increased demand for satellite communication. Germanium alloyed tarnish-proof sterling silver is a potential new market. There is also potential growth in germanium consumption in the thin-film application for DVDs, SiGe chips, germanium-base semiconductors, and other electronic uses for germanium.

Germanium production capacity and the availability of primary and secondary material are projected to be sufficient to overcome a near-term deficit of metal (Wilson, 2005).

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

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

Class and country	2003 Gross weight (kilograms)	2003 Value	2004 Gross weight (kilograms)	2004 Value
Wrought, unwrought, waste, and scrap:				
Belgium	3,120	$3,310,000	2,710	$2,850,000
Brazil	2	4,680	--	--
Canada	691	388,000	521	335,000
China	2,650	1,190,000	2,660	1,520,000
Germany	555	476,000	1,140	1,130,000
Hong Kong	--	--	50	30,600
Israel	93	98,000	66	61,800
Latvia	3	4,410	--	--
Russia	1,260	830,000	1,950	1,310,000
Switzerland	--	--	9	2,350
United Kingdom	6	10,900	25	19,400
Total	8,380	6,310,000	9,130	7,260,000

-- 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.