

GERMANIUM

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Germanium is a grayish-white, metallic element with the properties of a semiconductor, i.e., electrical characteristics between those of a metal and an insulator. It is commercially available as a tetrachloride, a high-purity oxide, and in the form of zone-refined metal ingots, single-crystal bars, castings, doped semiconductors, optical materials, optical blanks, and other specialty products. Germanium is extensively used to make elements for infrared optical devices. Its excellent mechanical, optical, and electrical properties, as well as its moderate cost and availability in large sizes make it attractive in many aerospace applications. The end use pattern for germanium in 1996 was estimated to be as follows: fiber-optic systems, 40%; polymerization catalysts, 20%; infrared optics, 15%; electrical/solar applications, 15%; other uses, 10%.

The domestic germanium industry consisted of two zinc mining operations in Alaska and Tennessee, which supplied byproduct germanium concentrates to the domestic and export markets, and three refineries, in New York, Oklahoma, and Pennsylvania. The refineries processed manufacturer's scrap, along with imported concentrates; very little old (postconsumer) scrap was available for recycling. Domestic refinery production, which amounted to about one-third of the world refinery production in 1996, was estimated to be worth \$30 million to \$40 million. Domestic refinery production and consumption for germanium are estimated by the U.S. Geological Survey (USGS) on the basis of discussions with domestic producers. Domestic refinery production of germanium was estimated to have increased significantly in 1996, while U.S. consumption was judged to have decreased slightly.

The USGS estimated domestic germanium reserves at 450,000 kilograms, equivalent to 18 years of domestic consumption at the 1996 rate; figures for worldwide reserves were not available. Worldwide, germanium resources are associated with zinc and lead-zinc-copper sulfide ores.

As a strategic and critical material, germanium was included in the National Defense Stockpile (NDS) in 1984, with an initial goal of 30,000 kilograms of germanium metal. In 1987, a new NDS goal of 146,000 kilograms was established; this was later adjusted downward in 1991 to 68,198 kilograms. At yearend 1996, the actual inventory was 68,207 kilograms of germanium metal. The Defense Logistics Agency, which maintains the NDS, made plans to sell germanium at a rate of 4,000 kilograms per year through 2005. All of the material to be offered is zone refined polycrystalline germanium metal (U.S. Department of Defense, 1997).

Production

The USGS estimated domestic refinery production from both primary and secondary materials in 1996 to be 18,000 kilograms, much more than in any of the prior 3 years. In 1996, Eagle-Picher Industries Inc.'s Quapaw, OK, Electro-Optic Materials Department remained the largest producer in the United States, but is no longer recovering primary germanium from zinc smelter residues. Eagle-Picher produced germanium from reprocessed scrap, fly ash, and germanium concentrates.

Cabot Corp., Revere, PA, and Atomergeric Chemetals Corp., Plainview, NY, produced germanium from reprocessed scrap and semirefined foreign material. The zinc refinery at Clarksville, TN, which Savage Resources Ltd. acquired in 1994, continued to produce germanium-rich residues as a byproduct of processing zinc ores from the associated Elmwood-Gordonsville Mine. The new operating company, Savage Zinc, Inc., continued the established practice of shipping these residues to Union Minière's Germanium Business Unit in Belgium for germanium recovery and refining.

Consumption

The USGS estimated domestic consumption of germanium in 1996 at approximately 25,000 kilograms, down somewhat from the 1995 level. The estimated world consumption pattern in 1996 was as follows: fiber optics, 40%; polymerization catalysts, 20%; infrared-optical systems, 15%; electrical/solar applications, 15%; and other applications (phosphors, metallurgy, and chemotherapy), 10%.

Fiber optics and infrared optical systems continued to be the principal industrial end uses for germanium in the United States. In the fiber optics sector, germanium was employed as a dopant within the core of many optical fibers used by the telecommunications industry. In addition, germanium-containing lenses and windows are transparent to infrared radiation, a property that has led to their use in infrared optical systems. These optics are employed principally for military guidance and weapon-sighting applications. Germanium glass was also used for nonmilitary surveillance and monitoring systems in fields such as satellite systems and fire alarms.

Prices

In 1996, domestic producer prices for germanium metal and dioxide increased over the long-standing price levels first established in late 1981 (\$1,060 and \$660 per kilogram, respectively). Throughout this 1981-96 period, significant

discounting by producers was evident because of competition from imported materials. In 1996, producer prices for zone refined metal reportedly reached \$2,000 per kilogram and germanium dioxide producer prices were at \$1,300 per kilogram.

Free market prices for germanium dioxide, published by Metal Bulletin (London), started 1996 at \$860 to \$960 per kilogram and ended the year in the \$1,200 to \$1,280 per kilogram range. The price for Belgian-produced germanium dioxide, published by Metal Bulletin (London), started the year at about \$850 per kilogram, rose to approximately \$935 at the end of February, and maintained that level until the close of the year.

Prices continued to increase dramatically through the summer as the world production was not sufficient to meet growing demand, and promised sales from Russia, Ukraine, and the United States stockpile did not materialize. High prices have resulted in increased production of germanium by existing producers, the development of new sources of supply, and increased recycling (Roskill's Letter from Japan, 1996).

Foreign Trade

In 1996, the estimated germanium content of imports was approximately 27,500 kilograms, about 70% higher than in 1995. Russia, the United Kingdom, Belgium, China, and Germany, in descending order of shipments, accounted for approximately 96% of U.S. germanium imports for 1996. (*See table 1.*) Imports directly attributable to countries of the former Soviet Union amounted to 15,200 kilograms, about a 300% increase from the previous year's level. Increased shipments from Russia accounted for the sharp rise in imports.

World Review

World refinery production was estimated at 53,000 kilograms in 1996, an increase of about 18% from 1995 production levels. The sales from Ukrainian stockpiles totaled 6,500 kilograms, while 12,000 kilograms was recycled worldwide. Hence, 71,500 kilograms of germanium was available for consumption in 1996. The total world germanium refinery capacity was judged to have declined in 1996 and was estimated at approximately 150,000 kilograms.

Japan.—The Japanese market for PET (polyethylene terephthalate) containers continued to grow at about 3.1% per year (Roskill's Letter from Japan, 1996). This growth represents an equivalent increase in the consumption of germanium owing to its use as a catalyst in making PET.

Russia.—Stocks as high as 8,500 kilograms of germanium and 29,000 kilograms of germanium dioxide reportably were available for immediate disposal (Metal Bulletin, 1997b).

Spain.—Asturiana de Zinc produced 6,500 kilograms of germanium grading 66% at its Arnao powder plant from concentrates taken from the Reocin zinc and lead mine (Metal Bulletin, 1997a).

Ukraine.—Ukraine's Zaporozhya titanium-magnesium plant

planned to sell 4.33 metric tons of germanium from government reserves to raise money for modernization. The time frame for the sale was unspecified, but the value of the material was estimated at \$7 million (American Metal Market, 1996).

Current Research and Technology

A controversy exists on the toxicity of "organic germanium" found in certain dietary supplements. The proponents of "organic germanium" claim that it increases the flow of oxygen to the bloodstream, relieves pain, and strengthens the immune system. On the other hand, the Food and Drug Administration and the National Council Against Health Fraud have linked "organic germanium" to kidney failure and dispute that any health benefits can really be derived from the product (Pilat, William, Indiana School of Business, written commun., 1997). On October 10, 1989, the British government warned all doctors in England of health risks from germanium compounds widely sold in health-food stores. Persons with AIDS and chronic fatigue are especially likely to use germanium (James, 1989).

The task of accurately aligning and affixing fibers or lenses, commonly known as "pigtailling," to the photonic devices such as fiber optic cables or laser diodes remains one of the most difficult and expensive in the manufacturing process. Automation is finding wide acceptance as a solution for lowering costs and providing improved performance in high-volume applications. Recent increases in production have driven the need for complete "align-and-attach" automation solutions. In a recent demonstration at Lawrence Livermore National Laboratory, an automated fiber-pigtailling machine automatically loaded, aligned, and epoxy-bonded conveyor-loaded trays of multichannel waveguides without operator assistance (Photonics Spectra, 1997).

Outlook

In 1996, germanium supplies were sufficient on a worldwide basis to meet the demand for this specialty metal and its related products. The 1995 shortage of production and increased demand for virgin germanium that had led to a very tight world supply of germanium was moderated by increased production from North American sources, releases from various national stockpile holdings, and increased shipments from China. However, future germanium supplies could remain tight if the increased demand from the fiber optics sector continues as has been projected (Fiberoptic Product News, 1997) and new or expanded sources of supply are not brought on-line in the very near future. In fact, if the prevailing supply-demand situation remains in place, prices of processed germanium may be expected to continue at elevated levels. In this environment, competition from alternative materials will become an increasingly significant factor in germanium markets, especially if prices reach and maintain extremely high levels for extended periods of time.

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SOURCES OF INFORMATION

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- Germanium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675.
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TABLE 1
U.S. IMPORTS OF GERMANIUM, BY CLASS AND COUNTRY 1/

Class and country	1995		1996	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Unwrought and waste and scrap:				
Austria	--	--	6	\$6,170
Belgium	3,620	\$3,870,000	3,960	6,700,000
Canada	--	--	1	4,430
China	2,420	1,470,000	2,860	4,490,000
Estonia	18	11,700	169	254,000
Finland	--	--	64	70,500
France	25	27,400	26	36,300
Germany	171	66,300	493	306,000
Hong Kong	97	102,000	50	45,800
Israel	182	126,000	106	229,000
Japan	232	135,000	96	180,000
Korea, Republic of	269	26,200	--	--
Latvia	--	--	96	95,600
Lithuania	185	29,700 r/	--	--
Netherlands	--	--	108	75,400
Romania	--	--	39	19,000
Russia	2,960	1,940,000	14,600	13,100,000
Ukraine	651	373,000	296	447,000
United Kingdom	5,380	2,120,000	4,550	4,720,000
Total	16,200	10,300,000	27,500	30,800,000

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1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.