INDIUM

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There was no known production of indium at domestic mines, and none was recovered from ores in the United States in 1997. Domestic indium production was confined to the upgrading of imported metal and the recycling of scrap. Two refiners, one each in New York and Rhode Island, were the major producers of indium metal and indium products in 1997. Several smaller firms also produced high-purity indium alloys, compounds, solders, sputtering targets, and related products.

Domestic consumption increased from about 45 metric tons to an estimated 50 tons. Estimated uses were slightly different from those in 1996: coatings, 50%; solder and alloys, 33%; batteries and electronic uses, 12%; and research and other uses, 5%. The main change was an increase in coatings applications at the expense of all other applications. The estimated value of primary metal consumed in the United States in 1997 was $13.7 million, at an average producer price of $8.51 per troy ounce.

World consumption was believed to have increased slightly in 1997. World refinery production was estimated at 230 tons, a 15% increase compared with the 1996 figure. There were eight major producing countries; the top four, Canada, China, France, and Japan, accounted for 76% of the total. Recycling of indium, which became important for the first time in 1996, decreased significantly, as did prices. Strong demand and concern over supply had caused a corresponding price increase in 1995, which provided the incentive to increase recycling. In 1996, although total consumption increased, the demand for primary metal actually decreased as a result of the dramatic increase in recycling. In 1997, with adequate supply and lower prices, ranging from $6.53 per ounce to $9.85 per ounce, the amount of metal provided through recycling decreased as rapidly as it had increased in 1996.

World reserves are sufficient to meet anticipated demand for the next decade. Canada has greater resources of indium than any other country—about 27% of the world reserves of 2,600 tons and 35% of the world reserve base of 5,700 tons. For the United States, the corresponding shares are 12% and 11%, respectively.

Legislation and Government Programs

The National Defense Stockpile inventory of indium on December 31, 1997, was 443 kilograms (14,231 troy ounces). The original stockpile goal was 41,990 kilograms for indium, but this was reduced to 7,740 kilograms in 1992, when the first purchase of indium was made. According to the Annual Materials Plan for fiscal year 1996, indium was to be eliminated from the stockpile, but congressional authority allowed only 1,090 kilograms (35,000 troy ounces) to be offered for sale during any one fiscal year. No sales were made in 1996, but sales of indium from the stockpile amounted to 1,118 kilograms (35,956 troy ounces) in 1997.

Production

U.S. production of primary metal consisted of upgrading lower grade and standard-grade indium (99.97% or 99.99%) into higher purity metal. Indium can be refined to purities up to 99.99999%. All the indium to be upgraded was imported. Domestic secondary production was mainly from new scrap and spent sputtering targets. The amount of indium produced from scrap decreased significantly as the price fell. Indium was available in various forms, such as ingot, foil, powder, ribbon, shot, and wire.

Consumption

Domestic consumption was estimated at about 50 tons, nearly an 11% increase from the 1996 level. Consumption in the various end uses increased. Thin-film coatings on glass, which included indium oxide and indium-tin-oxide (ITO), constituted one-half of total domestic indium use in 1997. The coatings, produced by sputtering the material onto a glass substrate, have been the largest area of research and growth for indium in the past several years.

There are two kinds of indium-containing coatings, electrically conductive coatings and infrared-reflecting coatings. Electrically conductive coatings, the more commercially significant group, are used primarily in liquid crystal displays (LCD's) for watches, television screens, portable computer screens, video monitors, etc. They are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost-free. Infrared-reflecting coatings on window glass limit the transfer of radiant heat through windows, helping to make the heating and cooling of buildings more energy efficient.

About 33% of the indium consumed was used as an addition to combinations of bismuth, cadmium, lead, and tin to form low-melting-point alloys. These alloys are used in such applications as electrical fuses, fusible links, or as gripping material for the grinding of optical glass. Indium is used as a strengthening agent for lead solders and also as the base material for many low-melting-point solders. Indium-based solders have a number of advantages over ordinary solders: lower melting points, flexibility over a greater temperature range, and negligible leaching of gold components from electronic assemblies. Lead-free solders can be developed starting with indium-based alloys.

Indium is used in alkaline batteries to prevent the buildup of hydrogen gas in the sealed container. These batteries are available in popular small consumer sizes, and together with electronic uses, including semiconductors, accounted for about 12% of the indium consumed domestically.

Prices

The domestic producer price as reported by Platt's Metals Week for 99.97%- to 99.99%-pure indium fluctuated "normally" in 1997. Prices for higher grades of metal were not published. The producer price was $6.53 per troy ounce at the beginning of the year. It increased by $1 in March and $2 more in April. It fell by $1 in July and recovered about one-half of that decline in September. The price remained steady after a slight increase in October, finishing the year at $9.41 per troy ounce.

Foreign Trade

Trade returned to normal levels in 1997 after a precipitous drop in 1996. The increase corresponds to a decrease in recycling and a return to reliance on imports. Imports increased 160% by weight and 70% by value. These increases brought imports back to the levels typical of recent years before 1996. Canada retained its position as the top supplier by a wide margin, providing more than one-half of the total. Next, in order of importance, were China, Russia, France, and Belgium. The top three countries provided 81% of U.S. imports, and the top five provided 91%. China rose from sixth to second rank in exports to the United States. Data for
exports from the United States were unavailable.

World Review

Japan remained the world's largest consumer of indium. Its trade pattern was similar to that of the United States in that 1997 Japanese imports were more than double those of 1996: 101 metric tons vs. 44 metric tons. France, China, and Russia are the leading suppliers of indium to Japan. Since 1995, more than one-half of the indium consumed in Japan has been used for ITO coatings. In 1997, two-thirds of it went into these coatings (Roskill's Letter from Japan, 1998).

Current Research and Technology

Researchers from several academic, industrial, and government laboratories reported on various approaches to developing lead-free solders for electronic applications. This work was driven by the need to protect the environment from toxic lead-containing alloys and by the improved properties obtained with indium alloys. The studies included indium-base systems in general as well as the specific systems tin-indium, tin-zinc-indium, tin-silver-indium (-antimony), and tin-bismuth-indium. Potential applications included computers and communications equipment as well as spacecraft and air and ground transportation vehicles (Mahidhara and others, 1997).

Outlook

Consumption of indium is expected to increase throughout the next decade, especially for LCD's, high-definition television, semiconductor materials, batteries, and low-temperature solders for military and electronic applications. For the near term, the main driving force for this increase will continue to be Japanese production of LCD's (Metal Bulletin, 1997; Tice, 1997). Demand for other uses, such as replacement nuclear control rods and fusible alloys, should remain steady. If indium prices rise significantly, research into substitutes for ITO for LCD's will be stimulated. Zinc-tin-oxide could possibly be used as a substitute, but currently its properties are not as good as those of ITO. If the price of indium is sufficiently high, recycling becomes economically attractive and will tend to limit upward movements in price as long as there is a supply of appropriate scrap. Stocks of scrap should increase when little recycling is occurring because the efficiency of the sputtering process for LCD's can be as low as 35%. World reserves, together with increases in production capacity achieved through increased yields in primary recovery and improvements in recycling technology, are expected to be sufficient to meet the demand for indium through the next decade.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF INDIUM, BY CLASS AND COUNTRY 1/

Class and country	1996 Quantity (kilograms)	1996 Value (thousands)	1997 Quantity (kilograms)	1997 Value (thousands)
Unwrought and waste and scrap:				
Belgium	2,600	$748	2,660	$690
Cameroon	112	29	--	--
Canada	13,000	3,780	44,900	9,810
China	1,700	768	14,100	3,690
Finland	21	10	20	5
France	5,420	2,360	5,630	1,510
Germany	202	24	479	96
Hong Kong	194	80	200	60
Israel	170	36	--	--
Japan	679	265	1,720	559
Netherlands	276	93	2,310	659
Peru	2,480	757	1,580	435
Russia	5,900	2,930	10,500	2,580
Singapore	--	--	97	17
United Kingdom	486	214	1,340	364
Total	33,200	12,100	85,500	20,500

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

Source: Bureau of the Census.