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 1998. 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 1998. A number of smaller firms also produced high-purity indium alloys, compounds, solders, sputtering targets for indium tin oxide (ITO) coatings, and related products.

Domestic consumption was estimated by the U.S. Geological Survey (USGS) to have remained steady at about 50 metric tons. Estimated uses were about the same as those in 1997—coatings, 50%; solder and alloys, 33%; batteries and electronic uses, 12%; and research and other uses, 5%.The value of primary metal consumed in the United States in 1998 was $15 million with an average producer price of $9.35 per troy ounce, calculated from prices published in Platt's Metals Week.

World consumption was believed to have decreased slightly in 1998. World refinery production was estimated to be 240 tons, a 4% increase compared with the 1997 figure. The eight major producing countries, in descending order of output, were China, Canada, France, Japan, Russia, Belgium, Italy and Peru. The top four accounted for 75% of the total. Recycling of indium, which became important for the first time in 1996, was not significant in 1998. The decrease in world consumption was due to substitution by ITO coatings that can be manufactured more efficiently and to the slightly lower production of liquid crystal displays (LCD's) using indium (Roskill's Letter from Japan, 1999).

World reserves were sufficient to meet anticipated demand beyond the first decade of the next century. Canada had greater resources of indium than any other country—about 27% of the world reserves of 2,600 tons. For the United States, the corresponding share is 12% of world reserves (Brown, 1999).

Legislation and Government Programs

The National Defense Stockpile inventory of indium on January 1, 1998, was 443 kilograms (14,248 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. No sales were made in 1996, but sales amounted to 1,118 kilograms (35,956 troy ounces) in 1997. On December 16, 1998, the last indium in the stockpile was sold, thus making the United States completely dependent on imports for primary indium (American Metal Market, 1998).

Production

According to industry sources, U.S. production of primary indium in 1998 consisted of upgrading low-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 (unused) scrap and spent sputtering targets. The amount of indium produced from new or used scrap was not significant. Indium was available in various forms, such as ingot, foil, powder, ribbon, shot, and wire.

Consumption

Domestic consumption in 1998 was estimated by the USGS to be about 50 tons, the same as that of 1997. Consumption in the various end uses held steady. Thin-film coatings on glass, which included indium oxide and ITO, constituted one-half of total domestic indium use in 1998. The coatings, produced by sputtering the material onto a glass substrate, have been the largest area of research, development, and growth for indium in the past several years.

The two kinds of indium-containing coatings are electrically conductive and infrared-reflecting. Electrically conductive coatings, the more commercially significant group, are used primarily in LCD's for watches, television screens, portable computer screens, and video monitors. They are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost-free. In addition, 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 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 within 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, which

are available in popular small consumer sizes, and electronic uses, including semiconductors, accounted for about 12% of the indium consumed domestically.

Prices

As reported by Platt's Metals Week, the domestic producer price for 99.97%- to 99.99%-pure indium was nearly constant in 1998. Prices for higher grades of metal were not published. The average producer price was $9.41 per troy ounce at the beginning of the year, fell to $8.63 per troy ounce in mid-October, and held steady the rest of the year. This was relatively stable compared with fluctuations of $3.00 per troy ounce during 1997, following a steady decrease of $10.00 per troy ounce in 1996 and a steady increase of $12.00 per troy ounce in 1995.

Foreign Trade

Imports decreased by 12% (weight) and 9% (value) (table 1). Canada retained its position as the top supplier by a wide margin, providing more than 41% of the total. Next, in order of importance, were China, Russia, France, and Belgium. The top three countries provided 77% of U.S. imports, and the top five provided 92%. China maintained its place of second rank in exports to the United States. Data for exports from the United States were not published by the Bureau of Census.

World Review

Total world consumption for ITO in 1998 was approximately 80 tons (Roskill's Letter from Japan, 1998).

Asia.—The world indium market was dominated by Japanese buyers and Chinese sellers. Japan remained the world's largest consumer of indium, with two-thirds of it going for ITO coatings. At midyear, the Chinese raised prices, but the Japanese were hesitant to buy, thus stabilizing the price (Metal Bulletin, 1998). At yearend, anticipating the possibility of a large sale from the Ukranian stockpile, the Chinese rushed to sell indium at low prices—just when the Japanese had decided to cut back on purchases (Mining Journal, 1999).

Ukraine.—The indium world market could be destabilized by the availability of 29 tons of indium from the Ukranian stockpile, but this material has been known for several years and was expected to be sold in many small lots over a long period of time, rather than all at once (Mining Journal, 1998).

Current Research and Technology

In 1998, the switch from one technology to another for the manufacture of LCD's accelerated. The older technology is the supertwisted nematic; the newer one is the thin film transistor (TFT) which requires only one-third as much indium per unit (Roskill's Letter from Japan, 1999). Because more than one-half of the world's indium consumption is for ITO coatings, this conservation by conversion to a more-efficient technology will have the same effect as reducing indium consumption by more than 15%.

Outlook

Consumption of indium is expected to increase throughout the next decade, especially for LCD's, batteries, high-definition television, low-temperature solders for military and electronic applications, and semiconductor materials. The driving force for this increase will continue to be Japanese production of LCD's, despite recent short-term cuts in production. International Business Machines Corp. (IBM) has forecast that world demand for ITO will increase from 80 tons in 1998 to more than 120 tons in 1999 and to more than 250 tons by 2002 (Roskill's Letter from Japan, 1998). Demand for other uses, such as replacement nuclear control rods and fusible alloys, should remain steady. If indium prices rise significantly, then conversion to TFT-LCD's will be further accelerated, and research into substitutes for ITO in LCD's will be stimulated. Zinc tin oxide could possibly be used as a substitute, but currently (1998) its properties are not as good as those of ITO. If the price of indium is sufficiently high, then recycling becomes economically attractive and will tend to limit upward movements in price as long as appropriate scrap is available. Stocks of scrap increase when recycling is not a high priority. World reserves and increases in production capacity (achieved through new plants and increased yields in primary recovery and improvements in manufacturing and recycling technology) are expected to be sufficient to meet the demand for indium through the first decade of the 21st century.

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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	1997 Quantity (kilograms)	1997 Value (thousands)	1998 Quantity (kilograms)	1998 Value (thousands)
Unwrought and waste and scrap:				
Belgium	2,660	$690	3,080	$795
Canada	44,900	9,810	31,100	7,060
China	14,100	3,690	15,500	3,690
Finland	20	5	--	--
France	5,630	1,510	7,610	2,030
Germany	479	96	207	60
Hong Kong	200	60	714	202
Japan	1,720	559	861	312
Netherlands	2,310	659	91	22
Peru	1,580	435	2,520	691
Romania	--	--	18	4
Russia	10,500	2,580	11,500	3,160
Singapore	97	17	360	99
United Kingdom	1,340	364	1,410	478
Total	85,500	20,500	75,000	18,600

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

Source: Bureau of the Census.