INDIUM

By Robert D. Brown, Jr.

Domestic indium production was confined almost entirely to the upgrading of imported metal. There was no known production at domestic mines. Two companies, one each in New York and Rhode Island, were the major producers of indium and indium products. Several smaller firms also produced high purity indium alloys, compounds, solders, sputtering targets, and related products.

Domestic consumption increased from 40 to 43 metric tons. The estimated use pattern was as follows: coatings, 45%; solder and alloys, 35%; electronic and semiconductor uses (including batteries), 15%; and research and other uses, 5%. The estimated value of primary metal consumed in the United States in 1995 was $16.1 million.

World refinery production was estimated at 239 tons, a 40% increase over the 1994 figure, which was revised from 145 tons to 170 tons. Ten countries produced indium; the top five producers accounted for 84% of the total. World consumption also increased significantly, driving the production increase and accounting for a price increase from below $5.00 per troy ounce at the beginning of the year to more than $16.00 per ounce at the end of the first three quarters of 1995.

Legislation and Government Programs

The Defense National Stockpile Center inventory of indium on December 31 was 1,560 kilograms (50,200 troy ounces), the same as it was in 1994. The original stockpile goal for indium was 41,990 kilograms. This was reduced to 7,740 kilograms in 1992. The first purchase was made in 1992. According to the Annual Materials Plan for Fiscal Year 1996 proposed by the Defense Logistics Agency (DLA), indium would be eliminated from the stockpile. But congressional authority has so far been granted only to offer 1,090 kilograms (35,000 troy ounces) for sale during the period 1996-2002.[1]

Late in 1992, telemarketing firms had begun selling indium to investors at highly inflated prices. To alert potential buyers, the Federal Trade Commission prepared a consumer information brochure entitled *Investing in Indium and other "Strategic Metals."*[2] At the end of 1994 and during 1995, several investors sold out at higher market prices, thereby reducing their losses.

Production

U.S. production consisted of upgrading standard grade indium (99.97% or 99.99%) into higher purity metal. Indium can be refined to purities up to 99.99999%. There was no known production at domestic mines; all the standard grade indium was imported. Domestic secondary production was mainly from new scrap and spent sputtering targets. Although the amount of indium produced from scrap is still fairly small compared with that produced from imported metal, it is increasing.

Consumption

Domestic consumption was estimated at 43 metric tons, an 8% increase from the 1994 level. Consumption in the diverse end uses increased proportionally. Indium was available in various forms, such as ingot, foil, powder, ribbon, shot, and wire.

Thin-film coatings on glass, which included indium oxide and indium-tin-oxide (ITO), constituted 45% of total domestic indium use in 1995. 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 and infrared reflecting. Electrically conductive coatings, the largest 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 are used to control energy losses by reflecting heat inward in winter and outward in summer.

About 35% of the indium was used as an addition to combinations of bismuth, cadmium, lead, or 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 solder and as the base material for many low-melting-point solders. Indium-based solders have the advantages of lower melting points, flexibility over a greater temperature range, and negligible leaching of gold components. Lead-free solders can be developed when starting with an indium-based alloy.

Indium can replace mercury in alkaline batteries, preventing the buildup of hydrogen gas in the sealed container. These batteries were available in popular small consumer sizes, and together with other electronic uses, including semiconductors, accounted for 15% of the indium consumed domestically.

Prices

The domestic producer price for 99.97% to 99.99% pure

indium rose rapidly during the first quarter of 1995 from $135.00 to $392.00 per kilogram. It increased gradually to $418.00 during the second quarter, and to $523.00 per kilogram during the third quarter, where it remained until the end of the year. Increases in consumption caused concern for supply, driving prices upward. Supply was adequate, but only enough to cause the price to level out at the high achieved in September. The price did not fall at any time during 1995. Prices for higher grades of metal were not available.

Foreign Trade

After a 4% drop in 1994 from the previous high in 1993, domestic imports of indium rose to a new record of 85.2 metric tons for 1995. This was a 21% increase over 1994 and a 16% increase compared with the old record. Canada remained the largest supplier, and China edged out Russia for the second rank. These three countries provided 72% of U.S. imports. Belgium and France rounded out the top five suppliers, which accounted for 84% of U.S. imports. Export data were unavailable.

World Review

Canada.—The reopening of the Mount Pleasant Mine in New Brunswick would firm up Canada's standing as an indium producer. The mine is now owned by the Adex Mining Corp. It was previously operated by Billiton Metals for tungsten and molybdenum. Proven reserves include 9 million tons grading 1 ounce of indium per ton and 5.1 million tons grading 2.6 ounces of indium per ton. Drilling and metallurgical research expenses totaled more than $500,000 for 1995. Reserves also include tungsten, molybdenum, tin, bismuth, zinc, and copper. Continuing feasibility studies anticipate an operating rate of 2,500 tons of ore per day.[3]

Japan.—Japan remained the world's largest consumer of indium and became the largest producer in 1995. Its consumption was estimated at 86 metric tons in 1995, compared with nearly 80 tons in 1994. In 1995, more than one-half of Japanese consumption was used for ITO.[4]

Current Research and Technology

In September 1995, Cleveland-based TRW, Inc., was awarded a $22 million contract by the Department of Defense's Advanced Research Projects Agency to developnew processes and procedures for automated assembly of integrated circuits and multichip assemblies. These devices are composed of gallium arsenide or indium phosphide and are used by military systems to transmit and receive high frequency signals. Gallium arsenide is currently the standard material, and indium phosphide is the challenger. Indium phosphide offers higher operating speeds and lower power consumption than gallium arsenide. Laboratory studies using indium phosphide prototypes have demonstrated an ability to carry twice as much information while consuming only one-fourth as much power. The current end-use applications of these devices include smart weapons systems, space communications systems, and avionics systems.[5]

Outlook

World reserves and increases in production capacity are sufficient to meet expected demand for indium through the next decade. Consumption of indium is expected to increase during this period, especially for liquid crystal displays, high definition television, semiconductor materials, batteries, and low temperature solders for military and electronic applications. Other uses, such as replacement nuclear control rods and fusible alloys, should remain steady. Apparent surges in demand or breaks in supply may cause increases in price. If indium prices go too high, 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. Also, whenever the price of indium remains high, recycling becomes more economically attractive.

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[1]Metal Bulletin. DLA Receives Extra Sales Authority. No. 8032, Nov. 23, 1995, p. 9.

[2]Federal Trade Commission
Bureau of Consumer Protection
Office of Consumer & Business Education
Washington, DC 20580
Telephone: (202) 326-3650
To register a complaint, the FTC recommends calling the National Fraud Information Center at 1-800-876-7060 or a local office of the Federal Bureau of Investigation.

[3]Metal Bulletin. Canada's Mount Pleasant Tungsten Mine Dusted off. No. 7952, Sept. 6, 1995, p. 9.

[4]Roskill's Letter from Japan. Indium: Lower Prices in 1996. No. 246, Oct. 1996, p. 2.

[5]TRW, Inc., Redondo Beach, CA. Press Release, Reuter's Business Wire, Sept. 11, 1995.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publications

Indium. Ch. in Mineral Commodity Summaries, annual.

Weeks, R.A., 1973, Gallium, Germanium and Indium, *in* Brobst, D.A., and Pratt, W.P., eds., United States Mineral Resources: U.S. Geolgical Survey Professional Paper 820, p. 237-246.

Other Sources

Indium. Ch. In U.S. Bureau of Mines Bulletin 675, Mineral Facts and Problems, 1985 edition.

American Metal Market .

Mining Journal.

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

Class and country	1994		1995	
	Quanity (kilograms)	Value (thousands)	Quanity (kilograms)	Value (thousands)
Unwrought and waste and scrap:				
Belgium	2,880	$338	4,030	$1,120
Canada	39,500	5,030	32,800	12,700
China	--	--	14,500	6,390
Estonia	91	10	--	--
Finland	78	8	--	--
France	5,130	750	4,770	2,020
Germany	160	16	2,670	537
Hong Kong	--	--	1,450	555
Italy	3,750	392	--	--
Japan	1,930	643	3,620	1,370
Lithuania	--	--	75	18
Peru	2,660	279	1,630	705
Russia	11,600	1,220	14,300	5,420
Spain	--	--	1,450	465
Switzerland	--	--	2,000	884
United Kingdom	2,470	258	1,810	809
Total	70,200	8,950	85,200	32,900

1/ Data are rounded by the U.S. Geological Survey to three significant digits; may not adds to totals shown.

Source: Bureau of the Census.