



2005 Minerals Yearbook

INDIUM

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All refined indium production in the United States during 2005 came from the refining of lower grade imported indium metal and from refining of scrap. Two refineries, one in New York and the other in Rhode Island, produced the majority of indium metal and indium compounds in 2005. A number of small companies produced specialty indium alloys and other indium products.

Domestic consumption of indium in 2005 was estimated by the U.S. Geological Survey to have remained stable at about 100 metric tons (t), based on import levels of unwrought indium and indium powder. Domestic consumption distribution for 2005 was estimated to be 70% for coatings, 12% for solder and alloys, 12% for electrical components and semiconductors, and 6% for other uses. The value of indium consumed in the United States in 2005 was about \$90 million at an average New York, NY, dealer price of \$816 per kilogram, as calculated from prices published in Platts Metals Week.

World primary refined production increased by 25%, compared with production in 2004. Most of the increase was attributed to China, with 59% of world production in 2005 compared with 49% in 2004. The other two major producing countries of refined indium recovered from domestic or imported concentrates or residues were Japan, with 14%, and Canada, with 10% of world production. Several other countries in Europe and one in South America produced smaller quantities (table 2). Higher prices for indium in 2005 spurred increased recycling activity as well.

World consumption increased owing to a continuation of strong demand for consumer electronics such as laptop computers, flat-panel televisions, and other devices containing flat-panel displays (FPDs) such as cell phones, as well as growth in the use of other technologies that used indium-tin oxide (ITO) coatings and indium metal. While some indium is used in electronic components such as capacitors, the bulk of the indium is used in the FPDs, either in liquid crystal displays (LCDs) or plasma display panels (PDPs) that contain ITO coatings. The continued popularity of larger sized monitors and televisions and their decreasing cost to consumers also contributed to the higher consumption levels.

Production

Though zinc was mined domestically, indium was apparently not recovered at U.S. zinc smelters. Production of indium in 2005 consisted of upgrading imported indium metal and powder. Lower grade (99.97%) and standard-grade (99.99%) imported indium was refined to purities of up to 99.99999%. Indium Corporation of America, Utica, NY, and Umicore Indium Products, Providence, RI (a division of n.v. Umicore, s.a., Olen, Belgium), accounted for the major share of U.S. production of indium metal and products.

Indium metal is sold in various forms (ingot, foil, powder, ribbon, wire, and others) as well as different grades. Many small companies produced high-purity indium alloys, compounds, solders, ITO coatings, and other indium products.

Small amounts of new indium scrap were recycled in 2005, as has been the case in recent years. Unlike some Asian countries, where substantial amounts of indium are recycled, there was no well developed infrastructure for collection and consumption of indium-containing scrap and waste in the United States. One of the problems with recycling is its cost; California addressed the issue with its 2003 Electronic Waste and Recycling Act (California Senate Bill 20), which banned the disposal of televisions and computer monitors in landfills, and in July 2005, began including LCD screens in a program requiring FPD purchasers to pay a fee to cover the cost of recycling (Adrian, 2005).

Consumption

The use of indium in coatings, which was mainly in the form of indium oxide and ITO, constituted almost three-quarters of total domestic indium use in 2005. The major use for these coatings was for thin-film coatings on glass and on FPDs. The use of ITO in organic light-emitting diodes (LEDs) is a relatively small segment of indium's end uses, but it is expected to have continued strong growth during the next several years.

Indium coatings are valuable for three properties—electrical conductivity, transparency, and infrared reflectance. LCDs and PDPs for portable computer screens, television screens, video monitors, and watches, which were the major commercial applications, use electrically conductive transparent coatings. These coatings are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost-free. Indium coatings on window glass take advantage of indium's infrared reflective properties and limit the transfer of radiant heat through the glass. This property of indium can be used to heat and cool buildings more efficiently. With the increased cost of indium in 2005 came a decrease in the amount used in architectural glass.

The technologies of glass coatings and semiconductors have been the largest areas of research and development for indium during the past several years. Although coatings remained the most widespread use for indium, the production of electrical components and semiconductors is expected to remain an important use for indium during the next several years. Research into uses of indium in solar cells was also ongoing.

About one-eighth of the indium used was combined with other metals to form low-melting-point alloys and solders. The alloys find various applications such as in electrical fuses and fusible links and as gripping tools for the grinding of delicate

materials. The advantages of indium-containing solders are that they have lower melting points, are more flexible over a wider temperature range, and inhibit the leaching of gold components in electronic apparatus.

Alkaline batteries used indium to prevent buildup of hydrogen gas within sealed battery casings. Indium was also used in semiconductors, including semiconductors in fiber optics. Other uses of indium included dental alloys, electrode-less lamps, mercury alloy replacements, nuclear control rods, phosphors, and white gold alloys.

Prices

After approximately tripling in 2004, the price of indium in 2005 reached peaks of more than \$1,000 per kilogram before declining at yearend. The average New York dealer price range, as reported by Platts Metals Week, for 99.97%- to 99.99%-pure indium began the year at \$850 to \$920 per kilogram. In March and September, indium sold for the highest prices of the year, before declining to yearly lows of \$830 to \$880 per kilogram in December. However, according to Platts Metals Week, the Indium Corporation of America producer price increased from \$800 to \$965 in the beginning of the year, and stayed at that level through yearend.

Stockpiling out of concern for continued rising prices in 2004 was thought to be a reason for the leveling off of prices in 2005. Japanese ITO producers in particular were thought to hold large stocks of indium bought in the 2004-05 fiscal year (Metal-Pages, 2005b§¹). This in addition to an unexpected slowing of increase in demand for LCDs led to the price dip at yearend (Roskill's Letter from Japan, 2006a). Consumers with contracts at relatively high prices did not want to buy large quantities in the spot market to prevent a price rebound (Metal-Pages, 2005d§). Factors that helped maintain the prices included speculation that China's indium export tax would be cut to 5% to 8% from 13%, which would have the effect of raising prices, and a yuan reevaluation added \$10 to \$20 per kilogram to the cost of indium (Metal Bulletin, 2005a, b).

The supply of indium-containing zinc ore remained a concern. Effects from the closure of the Metaleurop S.A., Paris, France, zinc refinery in Noyelles-Godault in 2003, which removed 60 metric tons per year (t/yr) of indium from the market, were expected to continue (Francis-Grey, 2005). However, these supply concerns, the closure of several indium smelters in China for environmental reasons, and the operation of others below capacity owing to power shortages did not cause enough concern in the market to change the relatively flat pricing in 2005.

World Review

Canada.—Falconbridge Ltd., Toronto, Ontario, continued as one of Canada's two indium refiners, through its Kidd Creek, Ontario, refinery. The other producer was Teck Cominco Ltd., at its Trail, British Columbia, smelter and refinery. Falconbridge and Teck processed indium materials that originated primarily

in their own mines. In 2005, the idled #2 slag fuming furnace at Trail was put to use recycling electronic scrap, which was expected to add to the supply of recycled indium (Moore, 2006). Both companies experienced strikes, though they had limited impact on the indium market despite slightly lower 2005 production. Teck's Trail facility experienced an 11-week strike, which was followed by a 4-week strike at Falconbridge's Kidd Creek plant (Ryan's Notes, 2005b).

China.—The year began with power shortages in China resulting in temporarily reduced indium output. Zhuzhou Smelter, a 40-t/yr indium producer in Hunan Province, shut a zinc line that was expected to result in a 50% reduction in indium production. Other zinc smelters were affected as well; Guangxi, Sichuan, and Yunnan Provinces also had small and mid-sized zinc plants operating at reduced capacity (Platts Metals Week, 2005b). The power outages were not as severe as those in 2004 because China is in the process of upgrading its electrical grid. More than \$12 billion was spent in 2005 on new powerplants and transmission lines; spending was expected to increase to almost \$20 billion per year through 2010 (American Metal Market, 2006a).

In February, environmental issues resulted in the closing of most indium smelters in Hunan Province, except the Zhouzhou Smelter, owing to pollution of the Xiang River. Resulting concern over indium availability led to increasing prices (Francis-Grey and Teo, 2005). Eight smelters were permanently closed as a result of environmental issues (Teo, 2005b). In late summer, about 20 indium smelters and refineries in Guangdong Province closed for the same reason. It was thought that some of these were smelters that had relocated from Hunan Province. These smaller operations contributed only about 3 metric tons per month (t/mo) of indium; the larger smelters with pollution controls in place contributed about 20 t/mo from this area (Teo and Lee, 2005). In December, a larger operation, the Shaoguan Smelter, and some smaller operations were closed after an environmental incident involving the Beiji River (Platts Metals Week, 2006).

For the year however, indium production increased; for example, Huludao Zinc increased indium production by 77% in 2005 compared with that in 2004 (Metal-Pages, 2006c§). Mengzi Mining and Smelting began construction of a 50-t/yr capacity indium smelter in Yunnan Province with production set to begin in summer 2006 (Teo, 2005a). Zhuzhou Smelter began trial runs of a new ITO plant that would have a 23-t/yr capacity when fully operational (Metal-Pages, 2006b§). The Hechi Jinhe Mining and Smelting Co. renovated a major zinc smelter in 2005, and in December, began trial runs of a new indium production line. The company obtained raw material from its mine in Guangxi Province; supplies of indium-rich concentrate were said to be sufficient from the area to supply the smelter (Metal-Pages, 2006a§).

Japan.—ITO production capacity was increased by all producers in Japan. Nikko Materials Co. Ltd. and Samsung Corning Co. Ltd. intended to double their capacities to 50 t/mo and 20 t/mo, respectively, by yearend; Mitsui Metal Mining planned an increase to 30 t/mo from 22 t/mo (Roskill's Letter from Japan, 2005b). The plans to increase ITO production were in response to expected increases in worldwide LCD and

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

PDP demand. Matsushita Electric Industrial Co., for example, announced plans to double output of PDPs in 2006, maintaining 2005 levels at 130,000 panels per month (Platts Metals Week, 2005c).

Japan was mostly dependent on imported indium for its ITO production. The Toyoha Mine, the last byproduct indium-producing mine in Japan, was expected to close permanently in 2006 owing to depletion of ore (Platts Metals Week, 2005d). Toho Zinc announced that as a result of high indium prices and expected increased demand it would resume 10- to 20-t/yr indium production at its Annaka zinc refinery in Gunma Prefecture (Roskill's Letter from Japan, 2005a). Indium purity would be about 90%, with production at full capacity in 2006 (Platts Metals Week, 2005a).

More emphasis was placed on recycling. The loss of production caused by the idling of Nikko Metal's Toyoha Mine in spring 2005 was offset by a 30% increase in indium recycled in 2005 (Roskill's Letter from Japan, 2006b). Dowa Mining Co. Ltd. increased its recycling capacity to 150 t/yr from 100 t/yr. This would bring the country's total recycling capacity to 350 t/yr by 2006 (Ryan's Notes, 2005c). Sharp Corporation developed a recycling system that can extract 95% of the indium in FPDs (Platts Metals Week, 2005a).

Korea, Republic of.—Korea Zinc Co. restarted an indium production line with a 34-t/yr capacity, with output used for LCDs produced by LG Phillips LCD and Samsung Electronics Corp. (Roskill's Letter from Japan, 2005b). Mitsui Mining and Smelting Co. Ltd. announced plans to build a 120-t/yr ITO processing plant in Gyeonggi Province in order to support their South Korean customer base and allow the company's Japanese and Taiwanese units to focus on the countries in which the factories are located, for increased efficiency (Metal Bulletin, 2005b).

Samsung Electronics announced that it was working on a new LCD production line at the Tangeong complex in Chuncheong Province, with production expected in 2006. The Republic of Korea was one of the main producers of LCDs, especially for FPD units for computers, mobile phones, and televisions.

Current Research and Technology

Canon Inc. said it would start making organic light-emitting diode (OLED) displays in 2006 as part of a plan to bring more production of key parts in-house and lower procurement costs. The company planned to use OLED displays in its own digital cameras, camcorders, and printers as early as the second half of 2006, replacing LCDs. Canon uses about 20 million displays each year (Appliance Magazine, 2005§).

In December, Honda Motor Co. announced plans to construct a factory that will produce 27.5-megawatt (MW)-capacity copper-indium-gallium-selenium (CIGS) solar cells in the summer of 2006 at the site of a Honda manufacturing plant for lawnmowers and motorcycles in Kumamoto on the island of Kiushu. Honda planned to start CIGS production in October 2007, ramping up to full production as soon as possible after that. Honda's modules are intended mainly for rooftop applications. The company has been testing the CIGS modules on 16 international sites since 2002 (Hirshman, 2006§).

In addition, Showa Shell Sekiyu K.K. was planning to start commercial production at a manufacturing plant producing 20-MW-capacity copper-indium-selenium thin-film in early 2007 in Miyazaki Prefecture (Tsukioka, 2005§).

The results of a 2-year joint research program by Intel Corp. and QinetiQ Ltd. into new transistor technology that substitutes indium antimonide for silicon, which could become a promising candidate for making microprocessors by the middle of the next decade, were made public. The research results obtained from the new transistor research showed a tenfold lower power consumption for the same performance, or conversely a threefold improvement in transistor performance for the same power consumption, compared with traditional transistors made from silicon (Intel Corp., 2005§).

Outlook

Indium consumption is expected to increase during the next few years. Leading the way are indium applications for ITO intended for LCDs and PDPs. In Japan, sales of LCD and plasma screens surpassed cathode-ray tube televisions for the first time, reflecting the increasing market for FPDs (American Metal Market, 2006b). The FPD market was expected to continue growing through 2008, though at slowing rates of increase. Most ITO producers announced capacity increases in 2005 although use of ITO coatings for applications such as architectural glass decreased owing to continued high prices (Compound Semiconductor, 2005§). The market for LCDs was expected to grow 40% in 2006 (Ryan's Notes, 2005a). There is some time before differences between supply and demand make themselves known. It takes 9 to 12 months to turn indium metal into powder, then into an ITO target supplied to an LCD manufacturer (Ryan's Notes, 2005b).

On the supply side, a critical element will be the ability of individual countries to recycle indium-containing electronic components. Because indium is mostly a byproduct of zinc mining and smelting, it will be hard to increase primary production unless there is an increase in zinc production. During the past decades, dwindling zinc prices forced some high cost and low-grade underground zinc mines and a few older and less efficient zinc refineries to close. Now, the price of zinc has risen, and with it zinc production could be expected to rise. With that scenario, primary indium production is expected to also increase. Higher prices for indium have resulted in increased recycling. Despite increasing demand for indium, worldwide supply is expected to be adequate with increased primary production and recycling.

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT AND WASTE AND SCRAP
OF INDIUM, BY COUNTRY^{1,2}

Country	2004		2005	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	10,300	\$5,860	8,030	\$7,170
Canada	22,800	12,100	13,200	10,700
Costa Rica	2	12	1,580	360
Denmark	30	4	--	--
China	66,100	20,200	60,400	29,300
Estonia	--	--	109	19
France	7,150	283	91	45
Germany	339	99	3,220	1,500
Hong Kong	3,230	1,780	2,360	1,660
India	1	3	--	--
Italy	230	126	--	--
Japan	22,300	12,600	31,900	26,700
Korea, Republic of	--	--	12,500	9,270
Macao	100	84	--	--
Mexico	35	3	--	--
Netherlands	546	431	462	406
Peru	2,130	1,330	3,350	3,200
Russia	3,560	2,110	825	878
Singapore	--	--	1,340	1,470
Taiwan	100	49	--	--
United Kingdom	3,510	1,750	2,260	1,750
Total	143,000	58,800	142,000	94,400

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes indium powder.

Source: U.S. Census Bureau.

TABLE 2
INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country	2001	2002	2003	2004	2005
Belgium	40	40	30	30	30
Canada	45	45	50	50	50
China	190 ^r	160 ^r	180 ^r	200	300
France	65	65	10	10	10
Germany	10	10	10	10	10
Italy	5	5	5	5	5
Japan	55	60	70	70	70
Kazakhstan	NA	NA	NA	NA	NA
Netherlands	5	5	5	5	5
Peru	4 ³	6 ³	6	6	6
Russia	15	15	15	15	15
Ukraine	NA	NA	NA	NA	NA
United Kingdom	5	5	5	5	5
Total	439 ^r	416 ^r	386 ^r	406	506

^rRevised. NA Not available.

¹World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through June 16, 2006.

³Reported figure.