



# 2009 Minerals Yearbook

## INDIUM

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By Amy C. Tolcin

The domestic table was prepared by Cheryl J. Crawford, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

All refined indium produced in the United States during 2009 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 2009. A number of smaller companies produced specialty indium alloys and other indium products.

## Production

Though zinc was mined domestically, primary indium was not known to be recovered from these zinc concentrates. Lithic Resources Ltd. (Vancouver, British Columbia, Canada), however, announced a new resource estimate for its Crypto zinc project in Utah, which revealed significant amounts of recoverable indium contained in the deposit. The property was acquired by Lithic in 2005; the company was moving the project toward the prefeasibility stage (Lithic Resources Ltd., 2009).

Indium metal was not produced as a byproduct in the United States at any zinc or lead refineries. Production of indium 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 Corp. 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 was sold in various forms (foil, ingot, powder, ribbon, wire, and others) and grades. Many smaller companies produced compounds, high-purity indium alloys, indium tin oxide (ITO) coatings, solders, and other indium products.

## Recycling

A large portion of global secondary indium was produced from ITO recycling. Sputtering, the process in which ITO is deposited as a thin-film coating onto a substrate, is highly inefficient; only about 30% of an ITO target is deposited onto the substrate. The remaining 70% resides in the spent ITO target, the grinding sludge, and the after-processing residue left on the walls of the sputtering chamber. It was estimated that 60% to 65% of the indium in a new ITO target will be recovered, and research was underway to improve this rate further. A short recycling process time for used ITO targets is critical, as a recycler may have millions of dollars worth of indium in the recycling loop at any one time, and a large increase in ITO scrap could be problematic owing to increased capital costs, environmental restrictions, and a lack of storage space. It was reported that the ITO recycling process—from collection of scrap to production of secondary materials—now takes less than 30 days. Spent ITO target recycling was concentrated in China, Japan, and the Republic of Korea—the

countries where ITO production and sputtering takes place (Phipps and others, 2007; Stevens, 2007, p. 1–16).

Indium may also be reclaimed directly from old liquid crystal display (LCD) panels. The panels are crushed to millimeter-sized particles and then soaked in an acid solution to dissolve the ITO from which the indium is recovered.

Indium recovery from tailings was thought to have been insignificant, as these wastes contain small percentages of the metal and can be difficult to process. However, improvements to the process technology have made indium recovery from tailings feasible when the price of indium is high.

## Consumption

**Indium Tin Oxide.**—Production of ITO was the leading end use of indium, accounting for the majority of global indium consumption. ITO is used for electrically conductive purposes in a variety of flat-panel display devices—most commonly, LCDs. Most ITO production was in Japan. Significant amounts of ITO were also produced in China, the Republic of Korea, and Taiwan.

Global indium consumption was strong during the first quarter of 2009 owing to flat-screen television shipments to North America increasing compared with those of the same period of 2008. In April, Nippon Mining & Metals Corp. (Japan), the leading global producer of ITO, was reported to be operating at 60% to 70% of its rated capacity, up from a 40% to 50% operating rate in December 2008. The increased operating rate was attributed to stronger ITO demand from flat-panel makers in the Republic of Korea, owing to rising flat-panel television shipments to China. During the summer, several ITO producers reportedly returned to full production. By December, most leading Japanese ITO plants were operating at nearly full capacity (Platts Metals Week, 2009e; Roskill's Letters From Japan, 2009; Watanabe, 2009b, c).

**Alloys and Solders.**—Alloys and solders were the second leading end use of indium. Indium-containing solders have lower crack propagation and improved resistance to thermal fatigue when compared to tin-lead solders. They also inhibit the leaching of gold components in electronic apparatus. Low-melting-point indium alloys are used as fuses or plugs for sprinkler systems. In the optical industry, low-melting-point alloys are applied to lenses and act as a surface for machine tools to grip during the polishing process. Certain types of indium alloys can also be used as a bonding agent between nonmetallic materials, such as glass, glazed ceramics, and quartz. Indium has also been used in dental alloys and in white gold alloys.

**Other.**—Another important use of indium was for III-V semiconductor materials for light-emitting diodes (LEDs) and laser diodes. In indium-based semiconductors, indium

antimonide, indium arsenide, or indium phosphide can be used as the substrate, and several indium-containing compounds can be used as the epitaxial layer (or substrate coating), such as indium gallium arsenide. Indium-based LEDs are used predominantly to optically transmit data and, to a lesser extent, in LED displays. Indium-based laser diodes are used in fiber-optic communications.

Other uses of indium included electrode-less lamps, mercury alloy replacements, and nuclear control rods. Alkaline batteries use indium to prevent buildup of hydrogen gas within sealed battery casings.

## Prices

The 2009 average annual Platts Metals Week New York dealer price range for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] was \$360 to \$400 per kilogram. Indium prices began the year ranging from \$350 to \$400 per kilogram and then declined through May, dipping to \$275 to \$340 per kilogram. Prices rose until mid-October, reaching \$475 to \$525 per kilogram. Subsequently, prices declined through the end of November to \$400 to \$450 per kilogram, after which prices increased during December, ending the year at \$460 to \$500 per kilogram.

According to Platts Metals Week, the Indium Corp. of America producer price for indium (99.97% purity, 1-kilogram bar in lots of 10,000 troy ounces) began the year at \$500 per kilogram and remained unchanged for the entire year.

## Foreign Trade

During 2009, U.S. imports for consumption of unwrought indium metal and indium powders totaled 105 metric tons (t), a 27% decrease from the 144 t imported in 2008. Canada surpassed China as the leading supplier in 2009, accounting for 42% of the imports. Other leading suppliers in 2009 were China (18%) and Japan (11%). Belgium, Hong Kong, and the United Kingdom also continued to be significant import sources for indium (table 1). There was no exclusive domestic export classification code for unwrought indium and indium powders.

## World Review

**Argentina.**—Minerals exploration company Argentex Mining Corp. (Vancouver) continued a drilling program to define the mineral resources at its Pinguino property in Santa Cruz. Drilling results at Pinguino revealed the presence of numerous veins containing silver-gold and indium-enriched base-metal mineralization. In September, the company announced its initial resource estimate for Pinguino; resources totaled 7.32 million metric tons (Mt) of ore grading 16.26 grams per metric ton (g/t) indium, and inferred resources totaled 35.4 Mt of ore at 8.89 g/t indium (Argentex Mining Corp., 2009).

**Australia.**—North Queensland Metals Ltd. (Fortitude Valley, Queensland) continued progress on the Baal Gammon copper, tin, silver, and indium project. North Queensland Metals originally planned to postpone construction of the mine owing to depressed economic conditions. However, the company announced at the end of the third quarter that it had reviewed Baal Gammon's mine design and decided that a smaller

high-grade pit may be feasible for mining in the current market. Estimated probable ore reserves at Baal Gammon reportedly were 3.1 Mt of ore grading 29.6 g/t indium (North Queensland Metals Ltd., 2009, p. 18).

**Belgium.**—Indium metal (foil and ingots) was produced at Umicore's precious metals refinery at Hoboken. A special metals plant at the refinery recovered indium from dusts and residues generated by the facility's lead refinery. Production capacity was 30 metric tons per year (t/yr) of indium.

**Bolivia.**—Several mines in Bolivia produced indium-bearing concentrates, which were thought to be exported and processed elsewhere.

**Canada.**—Refined indium was produced at Teck Resources Ltd.'s (Vancouver) lead-zinc metallurgical complex at Trail, British Columbia, and at Xstrata plc's (Zug, Switzerland) Kidd Creek copper-zinc metallurgical operations at Timmins, Ontario. Indium production capacity at Trail was about 75 t/yr. Actual production would be determined by the availability of indium-bearing concentrates. Xstrata produced 11.5 t of refined indium at Kidd Creek in 2009 (Xstrata Copper Canada, 2010, p. 15).

**China.**—China was a major global producer of primary indium. China Metal Market—Precious & Minor Metals Monthly (2009b) estimated that there were approximately 40 indium producers in China. Huludao Zinc, one of the leading indium refineries in China, had the capacity to produce 50 t/yr of primary indium. In June, the company reached a monthly production record of 3 t of refined indium and 1.34 t of indium sponge.

Around midyear, China's Government launched a series of environmental regulations that restricted nonferrous metals production, including byproduct metals such as bismuth and indium, after emissions from a lead smelter reportedly poisoned several hundred children in Shaanxi Province. In Hunan Province, at least five plants that produced indium were shut down during this time because of pollution problems. The plant closures reduced indium output, which possibly contributed to the higher indium prices during midyear (Ryan's Notes, 2009b).

The 2009 indium export quota was 233 t. The first batch of quotas, released in early 2009, totaled 139.8 t of indium, down 17% from the first export quota total of 2008. The first batch accounted for 60% of total exports for the calendar year and was based on production quantities from 2005 to 2007 and export quantities and values from 2006 to October 2008. The second batch of export quotas, released on June 30, totaled 93.2 t. Leading exporters in 2009 were Hunan Zhuzhou Smelting Plant Torch Metal Import & Export Co., Ltd., Liuzhou China Tin Group Co., Ltd., and Nanjing Foreign Economic & Trade Development Co., Ltd. (China Metal Market—Precious & Minor Metals Monthly, 2009c; Platts Metals Week, 2009a).

China's Government reduced the export tax on indium to 5% from 15%, effective July 1. The Government reduced the tax to increase China's competitiveness in the global market. However, it was reported that some producers wanted the tax removed if the tax reduction did not significantly improve market conditions in China. Some licensed exporters claimed that the tax encouraged the smuggling of indium out of the country. Nanjing Germanium Factory Co., Ltd., a secondary indium

producer, constructed an indium refining facility in Laos to avoid the export tax (Ryan's Notes, 2009c; Watanabe, 2009a, e).

Annual indium consumption in China in 2009 was reported to be about 40 t, of which 65% was used for the production of ITO and 6% was used for alloys and solders. However, China's indium consumption may significantly increase in the coming years as leading Japanese ITO producers consider constructing ITO plants in China alongside the increased flat-panel display manufacturing that has been taking place in China. Nippon Mining & Metals planned to build an ITO production unit at its facilities in China, which were used to process copper and other metals. The decision was made following announcements made by Japanese, South Korean, and Taiwanese flat-panel makers to increase their production capacities or build new production plants in China. Mitsui Mining & Smelting Co., Ltd. (Japan) was also considering constructing an ITO production base in China. It is uncertain how this will affect global indium consumption, as smaller Japanese ITO producers may not continue to operate if ITO production increasingly shifts to China. However, it was also reported that some Japanese ITO producers were turning down Chinese partnerships in order to protect their proprietary technology (Metal-Pages, 2009b; Watanabe, 2009d).

Suzhou GroupSat Solar Co. began constructing a copper-indium-gallium-diselenide (CIGS) solar cell manufacturing plant in Suzhou, Jiangsu Province, which was scheduled to begin producing in 2010. The plant would have the capacity to produce 25 megawatts per year of CIGS solar cells (China Metal Market—Precious & Minor Metals Monthly, 2009a).

**France.**—Nyrstar NV's Aubry zinc smelter had an indium recovery plant that produced a concentrate grading 20% indium, which was sold to third parties for further processing.

**Germany.**—Indium was produced at PPM Pure Metals GmbH (Langelsheim) and Norddeutsche Affinerie AG (Hamburg). PPM recovered indium from indium-containing materials at its special metals production facility in Langelsheim. The company produced high-purity indium ingot, semifinished products, and indium compounds. Norddeutsche Affinerie AG also produced high-purity indium, which it consumed for the development of solar cells.

**Japan.**—In addition to China, Japan was a significant producer of indium. Indium producing-companies included Asahi Pretec Corp., Dowa Metals & Mining Co., Ltd., Nikko Metals, Mitsui Mining & Smelting, Sumitomo Metal Mining Co., Ltd., and Toho Zinc Co., Ltd. Dowa Metals & Mining operated an indium recycling facility in Akita Prefecture. Production capacity at the facility was 150 t/yr of secondary indium. Dowa also had the capacity to produce 70 t/yr of primary indium. Dowa's production was sold to consumers in Japan. Asahi Pretec had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant in Fukuoka.

Japan also is a leading consumer of indium. Major Japanese indium consumers included ITO producers Mitsui Mining & Smelting, Nippon Mining & Metals, Sumitomo Metal Mining, Tosoh Corp., and Ulvac Technologies, Inc. Nippon Mining & Metals operated the world's leading ITO production plant—the 50-metric-ton-per-month (t/mo) Isohara plant near Tokyo. In July, the company confirmed plans to further increase ITO

production capacity at Isohara by the end of summer owing to increased flat-panel demand in China and the United States. However, the size of the increase was not announced. Mitsui Mining & Smelting reportedly operated the second leading ITO manufacturing plant, the Omuta plant in southern Japan, which had the capacity to produce about 20 to 30 t/mo of ITO. Dowa estimated that Japanese indium consumption in 2009 totaled 602 t, with 525 t (87%) used for the production of ITO. Primary indium consumption was 240 t, with 70 t (29%) from domestic producers, and the balance was imported. Secondary indium consumption was 362 t (Platts Metals Week, 2009d, e; Roskill's Letters From Japan, 2009).

The Japanese Government planned to include gallium and indium in its rare-metal stockpile. Japan's metal stockpile was created to support stable economic conditions for key domestic industries that consumed these metals. The Ministry of Economy, Trade, and Industry requested a \$2 million supplementary budget for stockpiling; a portion of this budget would be allotted for purchasing gallium and indium. Once the budget was approved, Japan Oil, Gas, and Metals Corporation (the government agency that manages the stockpile) would purchase the metal from domestic producers or consumers. The amount of indium held in the stockpile would be equivalent to 42 days worth of domestic consumption (Platts Metals Week, 2009b).

**Korea, Republic of.**—The Republic of Korea also held a stockpile of indium. In addition to indium, the country stockpiled other metals—such as aluminum, cobalt, copper, manganese, molybdenum, nickel, silicon, and vanadium—to prepare for national emergencies. In 2009, the Government budgeted \$200 billion for the national metal stockpile, of which 20% was allocated for the procurement of minor metals, including indium. In 2008, the Republic of Korea's Public Procurement Service was reported to have purchased 5 t of indium from Korea Zinc Co., Ltd. for the stockpile (Platts Metals Week, 2009b, c).

Korea Zinc produced primary and secondary indium at its Onsan zinc refinery. Production capacity at the plant was thought to be 200 t/yr of indium, of which 100 t/yr was primary and 100 t/yr was secondary. Secondary feedstock was sourced from Japanese ITO producers.

**Peru.**—Refined indium was produced at Doe Run Peru's La Oroya metallurgical complex (temporarily closed as of June 2009) and Votorantim Metais' Cajamarquilla zinc refinery. Votorantim began producing indium at Cajamarquilla in late December 2008. Initial production capacity was forecast to be 38 t/yr of indium. However, capacity may increase to 76 t/yr of indium after an ongoing expansion project at the refinery is complete (Votorantim Metais, 2008).

**Russia.**—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co. (UMMC) produced refined indium. In 2009, annual production in the country was between 4 and 5 t, most of which was thought to be exported. About 1 t of total production was recovered from secondary materials (Metal-Pages, 2009a).

## Outlook

Long-term demand for indium was expected to continue to rise as the flat-panel market continues to expand, assuming that

flat-panel display manufacturers continue to rely on ITO as the transparent conducting material. Although ITO substitutes have been developed, there is no evidence of a significant shift towards the use of these alternative materials in flat-panel displays. The LCD market still has significant room for growth; LCD television penetration has remained low, according to Corning Inc. The company estimated that only 8% of installed televisions worldwide were LCDs. Toshiba expected global sales of its LCD televisions during fiscal year 2011 to increase by 80% compared with sales in fiscal year 2009 owing to increased demand in emerging markets. The Japan Electronics and Information Technology Industries Association forecasted global demand for flat-screen televisions would increase to 180 million units in 2012 from 86.2 million units in 2007 (Ryan's Notes, 2008, 2009a).

The solar cell industry is experiencing growth, and the amount of indium consumed for this market may increase substantially in the future. According to Indium Corp., indium demand for thin-film CIGS solar cells potentially could increase to 300 t/yr by 2013. Indium consumption for CIGS in 2009 was nearly 30 to 35 t/yr. Strong investment in CIGS solar cell projects coupled with new or recently expanded manufacturing plants in Europe, Japan, and the United States indicated that indium consumption for solar cells was expected to increase globally (Platts Metals Week, 2008; Watanabe, 2008).

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TABLE 1  
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM METAL,  
BY COUNTRY<sup>1</sup>

Country	2008		2009	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	12,100	\$5,360	8,790	\$2,860
Canada	27,900	13,400	44,600	13,400
China	51,200	27,000	19,000	7,040
Costa Rica	87	9	--	--
Germany	848	381	57	19
Hong Kong	5,490	1,860	5,910	2,050
Israel	28	5	--	--
Japan	25,800	12,000	12,000	3,690
Korea, Republic of	2,020	1,030	3,320	973
Malaysia	23	3	322	69
Peru	2,660	1,110	2,570	737
Singapore	237	119	--	--
Sweden	169	25	--	--
Switzerland	213	26	594	26
Taiwan	876	152	1,600	563
United Kingdom	14,200	7,070	6,500	3,780
Total	144,000	69,500	105,000	35,200

-- Zero.

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

Source: U.S. Census Bureau.

TABLE 2  
INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons)

Country	2005	2006	2007	2008	2009
Belgium	30	30	30	30	30
Brazil	--	--	--	--	5
Canada	45	50	50	45	40
China	370 <sup>r</sup>	400 <sup>r</sup>	370 <sup>r</sup>	340 <sup>r</sup>	280
Germany <sup>3</sup>	10	10	10	10	10
Italy	5	5	5	5	5
Japan	70	55	60	65	67
Kazakhstan	(4) <sup>r</sup>	(4) <sup>r</sup>	(4) <sup>r</sup>	(4) <sup>r</sup>	(4)
Korea, Republic of	50	60 <sup>r</sup>	70	75	70
Netherlands	5	5	5	5	5
Peru	7 <sup>r</sup>	6	5 <sup>r</sup>	6	25
Russia	10 <sup>r</sup>	10 <sup>r</sup>	10 <sup>r</sup>	10 <sup>r</sup>	4
Ukraine <sup>5</sup>	NA	NA	NA	NA	NA
United Kingdom	5	5	5	5	5
Total	607 <sup>r</sup>	636 <sup>r</sup>	620 <sup>r</sup>	601 <sup>r</sup>	546

<sup>r</sup>Revised. NA Not available. -- Zero.

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

<sup>2</sup>Table includes data available through August 4, 2010.

<sup>3</sup>Production of indium reinstated, because both PPM Pure Metals GmbH (PPM) and Norddeutsche Affinerie AG (NA) reported that they were producing indium in 2007. NA is reportedly using its own indium in designing new solar cell technologies, but no estimates of indium production were actually available. This data represents only estimated production by PPM at the company's Langelsheim special metals plant.

<sup>4</sup>Less than ½ unit.

<sup>5</sup>Information is not adequate to estimate production.