



# 2016 Minerals Yearbook

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## INDIUM [ADVANCE RELEASE]

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# INDIUM

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Indium was not recovered from concentrates in the United States during 2016. Several facilities imported indium metal and powders for the production of high-purity indium metal, indium compounds, specialty indium alloys, and other indium products. During 2016, U.S. imports for consumption of unwrought indium metal and indium powders were 160 metric tons (t), a 14% increase from the 140 t imported in 2015 (table 1). Global primary refined indium production was estimated to have decreased for the second consecutive year; production decreased by 7% to 682 t in 2016 from 731 t in 2015 and was 23% lower than 881 t in 2014 (table 3).

## Production

Globally, zinc concentrates were the principal source of primary indium. Although the United States was a significant producer of zinc concentrates, indium was not known to be recovered from these concentrates domestically. In 2016, one indium-containing deposit in the United States continued to progress towards development—InZinc Mining Ltd.'s (Canada) West Desert zinc-copper-iron-indium deposit in Utah. InZinc Mining released a preliminary economic assessment of West Desert on April 1, 2014, which projected that an average of about 38 metric tons per year (t/yr) of indium could be produced from the zinc concentrate during a 15-year mine life (InZinc Mining Ltd., 2015).

A significant amount of indium-containing scrap was recycled domestically; however, sufficient data were not available to estimate the quantity of indium recovered or recycled back into new indium products.

## Consumption

Domestic indium consumption, based on import levels, was estimated to have ranged between 100 and 160 t/yr during the past 5 years. Imported indium metal and powders were either upgraded to higher purities and (or) consumed for the production of indium alloys, chemicals, shapes, and specialty products, which were sold to downstream users. Indium Corp. of America (Utica, NY) and Umicore Thin Film Products (Providence, RI, a division of Umicore NV, Belgium) accounted for the majority of U.S. consumption of indium. Other companies that consumed indium in the United States included 5N Plus Semiconductors LLC (St. George, UT), ACI Alloys Inc. (San Jose, CA), AIM Specialty Materials USA (Cranston, RI), AXT Inc. (Fremont, CA), ESPI Corp. Inc. (Ashland, OR), Exotech Inc. (Pompano Beach, FL), and JX Nippon Mining & Metals USA Inc. (Chandler, AZ).

**Indium-Tin Oxide.**—Production of indium-tin oxide (ITO) was the leading global use of indium (Indium Corp., 2016). ITO is principally used as a transparent, electrically conductive, thin-film coating on flat-panel displays—most commonly,

liquid crystal displays (LCDs). In 2016, global ITO production capacity (excluding China) remained stable at 1,980 t/yr. Four ITO producers, Samsung Corning Precision Materials Korea Co. Ltd. and Heesung Metal Ltd. in the Republic of Korea and JX Nippon Mining & Metals Corp. and Mitsui Metal Mining Co. Ltd. in Japan, accounted for about 90% of capacity. According to Vital Materials Co., Ltd. (China), global ITO consumption was about 1,500 t/yr and took place almost entirely in China, Japan, the Republic of Korea, and Taiwan (Roskill's Letter from Japan, 2018). Globally, a significant amount of indium was reclaimed in the ITO recycling process and reused for the production of ITO. About 1,200 t/yr of indium can be reclaimed from ITO recycling (Vareha-Walsh, 2016).

**Alloys.**—Indium-containing alloys were thought to be the second leading global end use of indium and were commonly used as solders in a wide range of applications owing to indium's high ductility and malleability, high thermal conductivity, and low melting point. Indium-lead solders were used to inhibit the leaching of gold components in electronic apparatus. Indium-silver alloys or pure indium foil were used as thermal interface materials in electronics (a substance used to seal a heat-generating surface to a heat sink, filling microscopic air voids to allow for effective heat transfer). Certain indium-tin alloys were used as bonding agents between nonmetallic materials. Indium was also used in dental alloys, in low melting temperature alloys for fuses, as a substitute for mercury, and in white gold alloys.

**III-V Semiconductor Materials.**—An important use of indium was for III-V semiconductor materials, most commonly indium phosphide (InP) in optoelectronic devices (such as laser diodes) for fiber-optic communications. InP was mostly produced in Asia, followed by Europe and the United States, in descending order of quantity (Beijing Dimen International Information Consulting Co. Ltd., 2014). Companies that produced InP polycrystalline ingot or substrates included AXT Inc. (Fremont, CA), InPact Inc. (France), JX Nippon Mining and Metals Corp. (Japan), Phostec S.R.O. (Slovakia), Sumitomo Electric Industries Ltd. (Japan), and Wafer Technology Ltd. (United Kingdom).

**Other.**—Indium was used in the manufacturing of copper-indium-gallium-selenide (CIGS) thin-film photovoltaic solar cells. CIGS thin-film cells accounted for 2% (1.5 gigawatts) of global solar cell production in 2016. Crystalline silicon continued to be the dominant solar cell-type, accounting for 93% of global production (National Renewable Energy Laboratory, 2017, p. 69). An estimated 40 t of indium was consumed globally for the production of CIGS solar cells (Roskill's Letter from Japan, 2016b). Solar Frontier K.K. (Japan) was thought to be the only mass producer of CIGS solar cells in 2016. The company operated three CIGS plants in Japan with a combined capacity to produce approximately 1 gigawatt

per year of solar cells (Solar Frontier K.K., undated). In 2015, Solar Frontier announced that it had completed the construction of a CIGS solar cell production plant [150-megawatt-per-year (MW/yr) capacity] at Ohira-mura, Miyagi Prefecture (Tohoku region), and was in the rampup phase throughout 2016 (Solar Frontier K.K., 2015).

Indium was also used for the production of the semiconducting compound, indium gallium zinc oxide (IGZO), in organic light-emitting diode (OLED) displays and LCDs. IGZO has replaced amorphous silicon as the thin-film transistor in some displays because it allows for more pixels per square inch on small displays and ultra-high definition on large displays. IGZO also requires less voltage to operate. Sharp Corp. (Japan) consumed IGZO for the production of small- and medium-sized high-performance LCD panels for smartphones and tablets at its Kameyama Plant No. 2 in Japan (Cammell, 2012). Although IGZO had yet to be used commercially in large-screen LCD displays, LG Display (Republic of Korea) has been using IGZO in its OLED televisions (Harrower, 2015). Indium consumption for the production of IGZO remained level in 2016 at 20 t (Roskill's Letter from Japan, 2016a).

### Prices

In 2016, the average monthly Metal Bulletin free market price for indium was \$240 per kilogram, 42% less than that in 2015. The free market price for indium was an average of \$255 per kilogram in January 2016, and then increased to a peak of \$262 per kilogram in April before decreasing through the rest of the year to an average of \$209 per kilogram in December. The average annual Platts Metals Week New York dealer price for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] in 2016 was \$345 per kilogram, 34% less than the 2015 price of \$523 per kilogram. The price ranged from about \$300 to \$370 per kilogram in the first half of the year and from about \$330 to \$380 per kilogram in the last half.

### Foreign Trade

During 2016, U.S. imports for consumption of unwrought indium metal and indium powders were 160 t, a 14% increase from the 140 t imported in 2015 (table 1). Leading suppliers in 2016 were China (41%), Canada (20%), and the Republic of Korea (14%). Imports of indium from China increased substantially in 2016 to 65 t from 36 t in 2015 after several years of reduced import levels (15 t imported in 2012, 8 t in 2013, and 4 t in 2014), coincident with the operation of the Fanya Metal Exchange (Fanya), which opened in 2011 and closed in 2015. Data on indium exports were not available because there was no exclusive domestic export Schedule B code for unwrought indium and indium powders.

### World Review

Global production of primary indium decreased by 7% in 2016 from that of 2015, mostly as a result of decreased production in France and China (table 3). China was the leading producer, followed by the Republic of Korea, Canada, and Japan. France produced 41,000 kg of primary indium in 2015, but no indium was produced in 2016. Primary indium

was recovered mainly from the residues generated during the smelting of zinc concentrates. Although an important factor, global changes in zinc mine production may not be an indicator of a corresponding change in the production of indium. It has been estimated that only about 35% of the indium contained in zinc concentrates reaches refineries that are capable of extracting and producing indium. Data on the amount of secondary production were not available; however, market sources estimated that up to 1,200 t/yr of indium can be reclaimed from ITO recycling. Estimated global consumption of indium was about 1,430 t in 2016, essentially unchanged from that of 2015 (Indium Corp., 2016).

**Belgium.**—Indium metal was produced at Umicore's precious metals refinery at Hoboken. A specialty metals plant at the refinery had the capacity to recover 50 t/yr of indium from dusts and residues generated by the facility's lead refinery (Umicore NV, 2015).

**Canada.**—Refined indium was produced at Teck Resources Ltd.'s metallurgical complex at Trail, British Columbia, as a byproduct of processing lead-zinc concentrates. Indium production capacity at Trail was last reported to be 75 t/yr in 2005 (Teck Cominco Ltd., 2006, p. 27).

**China.**—China was the leading producer of refined indium, accounting for 43% of global primary refined production in 2016. Production was estimated to have decreased by 8% in 2016 from that of 2015 in response to continued decreasing indium prices. China's indium consumption was reported to have increased in 2016 from that of 2015, but the actual amount was not disclosed (Minor Metals Monthly, 2017). China consumed indium mostly for the production of ITO (about 75%) and alloys (about 20%). Umicore and Vital Materials completed an ITO production plant in Qingyuan, Guangdong Province. The 200-t/yr plant produced planar and rotary targets for thin-film transistor LCDs. The joint venture was referred to as Umicore Vital Thin Film Technologies and was created with the support of China's leading LCD display producer, BOE Technology Group Co. Ltd. In recent years, China has been actively developing its domestic ITO industry in an effort to move away from being a net importer of ITO; the country has been nearly 100% import reliant on Japan, the Republic of Korea, and Taiwan for the type of ITO sputtering targets needed for the production of advanced display technologies (Metal Bulletin, 2014a; Smith, 2014; Minor Metals Monthly, 2016; Umicore NV, 2016).

Large amounts of indium metal have accumulated in the now-defunct Fanya Metal Exchange warehouses. By November 2015, when the Kunming municipal government took over Fanya, exchange warehouses reportedly held about 3,610 t of indium, equivalent to more than 4 years of primary production. The Kunming municipal government later announced that it had launched a criminal investigation into Fanya (Gu, 2015a, b; Zhao, 2015), and on February 5, 2016, the owner of the Fanya Metal Exchange was arrested on suspicion of unlawfully raising funds from the public. Fanya's indium inventory was expected to be mothballed in the short term owing to difficulties in confirming the tonnage of indium that is registered with metal processors and trading companies (Metal Pages 2016a, b, c; Roskill's Letter from Japan, 2016a).

Other exchanges in China trading indium included the Shaanxi Nonferrous Metal Exchange (which began trading indium in June 2014), the South Rare Precious Metals Exchange, the Tianfu Mercantile Exchange, and the Wuxi Stainless Steel Exchange (Burton, 2013; Metal Bulletin, 2014b).

China continued to be a net exporter of indium in 2016, exporting 162 t of unwrought indium, while importing 104 t of unwrought indium. Exports were shipped predominately to the Republic of Korea (39%), Japan (27%), the United States (23%), and Germany (6%) (Global Trade Information Services Inc., 2017).

For most of 2016, China regulated its indium production industry through the imposition of an export duty and quota system. In May, China removed the 2% export duty on indium. However, indium producers and traders in China were still required to apply for and receive an export license from the Ministry of Finance and Commerce in order to export indium. In 2016, 14 companies were approved to export indium, and the total export quota was set at 231 t. Companies with the largest export quotas included Zhuzhou Keneng New Material Co. (125 t), Debang Technology Co. Ltd. (39 t), Hunan Zhuye Torch Metals Co., Ltd (21 t), Liuzhou China Tin Group Co., Ltd. (8 t), and Shanghai Dingli Technology Development (Group) Co., Ltd (7 t). In December, China's new list of export quotas for 2017 from the Ministry of Commerce did not include indium (Shen, 2015; Ministry of Commerce, Foreign Trade Division, 2016).

**France.**—Nyrstar NV (Belgium) had previously produced 99.998% indium metal at its zinc smelter in Auby, but a fire in November 2015 halted indium production in 2016. The smelter was originally expected to restart within 6 months, but the restart date was pushed back to the first quarter of 2017. Nyrstar planned to increase the indium production capacity at Auby to 70 t/yr from 45 t/yr, and commissioning of the new equipment was originally expected to take place at the end of the third quarter of 2016 (Metal Bulletin, 2016; Nyrstar NV, 2016, p. 8–9, 16; Nyrstar NV, 2018, p. 7–8).

**Japan.**—Japan was a significant producer and recycler of indium. Dowa Metals and Mining Co. Ltd. had the capacity to produce about 70 t/yr of primary indium and to recover up to 150 t/yr of secondary indium at its zinc smelter and rare metals recycling facility in Akita. Other primary producers included Mitsui Mining and Smelter Co. Ltd. (Takehara plant) and Sumitomo Metal Mining Co. Ltd. (Harima smelter). Asahi Pretec Corp. had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant at Fukuoka (Metal-Pages, 2008). Other secondary indium producers included JX Nippon Mining and Metals, Mitsui Mining & Smelting Co. Ltd., Sumitomo Metal Mining Co. Ltd., and Toho Zinc Co. Ltd.

Japan was a leading consumer of indium, mostly for the production of ITO. ITO producers included Mitsui Mining & Smelting, which operated an ITO manufacturing plant at Omuta, and JX Nippon Mining & Metals, which operated the world's leading ITO production plant at Isohara near Tokyo (Roskill's Letter from Japan, 2016b).

Japan's imports of indium metal, powder, and scrap decreased by 15% to 193 t in 2016 from that of 2015. Leading import sources in 2016 included the Republic of Korea (44%), China (26%), Canada (16%), and Taiwan (13%) (Global Trade Information Services Inc., 2017).

**Korea, Republic of.**—Korea Zinc Co. Ltd. was a significant producer of primary and secondary indium at its Onsan zinc refinery (260-t/yr capacity, including secondary). Young Poong Corp. had the capacity to produce up to 30 t/yr of indium at its Sukpo zinc refinery (Young Poong Corp., 2016). The Republic of Korea was also a notable consumer of indium. Major consumers were the ITO producers, Heesung Metal and Corning Precision Materials Korea.

The Republic of Korea imported 95 t of indium (metal, powder, and scrap) in 2016, 45% less than that in 2015, mostly from China (69%), Taiwan (18%), and Japan (9%), and exported 145 t predominantly to Japan (60%) (Global Trade Information Services Inc., 2017).

**Russia.**—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co.'s Electrozink smelter produced refined indium. Most of Russia's refined indium output was thought to be exported.

## Outlook

World indium production is expected to decrease going into 2017 but recover through the year. Output in China is estimated to increase to about 300 t in 2017, whereas the rest of the world is expected to produce up to 340 t in the same time period, mainly driven by France (20 t) and Canada (10 t) (Roskill's Letter from Japan, 2016a). In the next 2 to 10 years, consumption of indium is projected to be driven by ITO use in LCD production. Market research firm IHS Markit Ltd. forecast 6% growth in the flat-panel display market in 2017, mostly as a result of a projected increase in demand for larger-sized television screens by consumers. Television panels account for about 70% of the display market in terms of area (Kang, 2017).

On the supply side, China is expected to continue to be the main global supplier of primary indium metal with some additional primary production capacity anticipated in France. Several indium-containing exploration or development projects, mostly in Canada, South America, and the United States, are advancing, but it is uncertain as to when or whether these projects will begin production.

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TABLE 1  
 U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM AND INDIUM  
 POWDERS, BY COUNTRY OR LOCALITY<sup>1, 2</sup>

Country or locality	2015		2016	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Argentina	600	\$300	--	--
Belgium	12,400	4,650	4,170	\$869
Canada	37,800	14,700	32,600	7,590
China	36,200	12,300	65,100	13,300
France	21,600	9,450	--	--
Germany	342	125	68	10
Hong Kong	1,680	484	3,020	552
Israel	1	5	--	--
Japan	2,540	927	12,000	3,800
Korea, Republic of	10,100	4,780	23,100	4,630
Laos	500	264	--	--
Netherlands	--	--	330	70
Peru	1,450	801	--	--
Russia	514	272	1,530	347
Taiwan	11,600	4,560	15,500	3,140
United Kingdom	2,910	1,850	2,870	771
Total	140,000	55,500	160,000	35,100

-- Zero.

<sup>1</sup>Table includes data available through May 15, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes Harmonized Tariff Schedule of the United States code 8112.92.3000.

Source: U.S. Census Bureau.

TABLE 2  
WORLD PRIMARY INDIUM PRODUCTION CAPACITY<sup>1</sup>

(Metric tons)

Country	Major operating company	Location of main facilities	Primary annual capacity <sup>c</sup>
Belgium	Umicore NV	Hoboken	50
Canada	Teck Resources Ltd.	Trail, British Columbia	75
China <sup>2</sup>	Guangxi Debang Technology Co. Ltd.	Guangxi, Liuzhou	85
Do. <sup>2</sup>	Guangxi Hechi Jinhe Mining and Smelting Co. Ltd.	Guangxi, Hechi	10
Do. <sup>2</sup>	Guangxi Tanghan Zinc & Indium Co. Ltd.	do.	30
Do. <sup>2</sup>	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Hunan, Lengshuijiang	7
Do. <sup>2</sup>	Huludao Nonferrous Metals Group Co.	Liaoning, Huludao	60
Do. <sup>2</sup>	Hunan Jingshi Group Co. Ltd.	Hunan, Zhuzhou	40
Do. <sup>2</sup>	Laibin Smelter [Liuzhou Huaxi (China Tin) Group Co.]	Guangxi, Laibin	50
Do. <sup>2</sup>	Liuzhou Zinc Products Co.	Guangxi, Liuzhou	20
Do. <sup>2</sup>	Nanjing Germanium Co. Ltd.	Jiangsu, Nanjing	150
Do. <sup>2</sup>	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do. <sup>2</sup>	Shaoguan Smelter (Shenzhen Nonfemet Co.)	Guangdong, Shaoguan	25
Do. <sup>2</sup>	Tibet Summit Industry Co. Ltd.	Qinghai, Xining	15
Do. <sup>2</sup>	Xiangtan Zhengtan Nonferrous Metal Co. Ltd.	Hunan, Xiangtan	75
Do. <sup>2</sup>	Yintai Technology Co. Ltd.	Guangxi, Liuzhou	40
Do. <sup>2</sup>	Yuguang Gold-Lead Co. Ltd.	Henan, Jiyuan	20
Do. <sup>2</sup>	Yunnan Chengfeng Nonferrous Metals Co. Ltd.	Yunnan, Gejiu	10
Do. <sup>2</sup>	Yunnan Hualian Zinc and Indium Co. Ltd.	Yunnan, Wenshan	60
Do. <sup>2</sup>	Yunnan Luoping Zinc & Electricity Co. Ltd.	Yunnan, Luoping	20
Do. <sup>2</sup>	Yunnan Mengzi Mining and Smelting Co. Ltd.	Yunnan, Honghe	60
Do. <sup>2</sup>	Zhuzhou Smelter Group Co. Ltd.	Hunan, Zhuzhou	60
France	Nyrstar NV	Auby	48
Japan	Dowa Metals and Mining Co. Ltd.	Iijima, Akita	70
Do.	Mitsui Mining and Smelting Co. Ltd.	Takehara, Hiroshima	NA
Do.	Sumitomo Metal Mining Co. Ltd.	Harima, Hyogo	NA
Korea, Republic of	Korea Zinc Co. Ltd.	Onsan	160
Do.	Young Poong Corp.	Sukpo	35
Peru	Doe Run Peru S.R. Ltda.	La Oroya	5
Do.	Votorantim Metais Ltda.	Cajamarquilla	50
Russia	Chelyabinsk Zinc Plant OJSC	Chelyabinsk	15
Do.	Ural Mining and Metals Co.	Vladikavkaz	5

<sup>c</sup>Estimated; estimated data are rounded to no more than two significant digits. Do., do. Ditto. NA Not available.

<sup>1</sup>Table includes data available through May 15, 2018.

<sup>2</sup>Includes facilities that consume mineral concentrates as well as processors that consume unrefined indium.

TABLE 3  
INDIUM: WORLD REFINERY PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Kilograms)

Country or locality <sup>2</sup>	2012	2013	2014	2015	2016 <sup>p, c</sup>
Belgium	30,000	30,000	28,000	20,000	20,000
Canada <sup>c</sup>	65,000	70,000	67,000	70,000	71,000
China	405,000	415,000	460,000	320,000 <sup>r</sup>	296,000
France	13,000	33,000	43,000	41,000	--
Germany <sup>c</sup>	10	--	--	--	--
Japan	71,000	72,000	70,000	70,000	70,000
Korea, Republic of	180,000	175,000	195,000	195,000	210,000
Peru	11,080	11,080 <sup>r</sup>	14,000 <sup>c</sup>	10,000 <sup>r, c</sup>	10,000
Russia <sup>c</sup>	9,000	9,500	4,000	5,000 <sup>r</sup>	5,000
Total	784,000	816,000 <sup>r</sup>	881,000	731,000 <sup>r</sup>	682,000

<sup>c</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through August 30, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>In addition to the countries and (or) localities listed, Kazakhstan and Ukraine may have produced primary indium.