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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 2017. Several facilities imported indium metal for the production of high-purity indium metal, indium compounds, specialty indium alloys, solders, and other indium products. During 2017, U.S. imports for consumption of unwrought indium metal and indium powders were 127 metric tons (t), a 21% decrease from the 160 t imported in 2016 (table 1). Global primary refined indium production was estimated to have increased by 5% to 714 t in 2017 from that of the 2016 quantity (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 or in other countries. In 2017, 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, that 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 was 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 Vital Thin Film Technologies Co., Ltd. (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).

On October 20, Umicore announced that it would sell its stake in Umicore Vital Thin Film Technologies Co., Ltd. to Vital Materials Co. Ltd. (China). Umicore Vital Thin Film Technologies Co., Ltd. was originally a joint venture that was 60% owned by Umicore and 40% owned by First Rare Materials Co. Ltd. (China). As part of the transaction terms, all indium-tin oxide (ITO) manufacturing at Umicore Vital Thin Film Technologies' facility in Providence, RI, was to cease by the end of 2017 (Umicore NV, 2017).

Indium-Tin Oxide.—Production of ITO was the leading global use of indium. ITO is principally used as a transparent, electrically conductive, thin-film coating on flat-panel displays—most commonly, liquid crystal displays (LCDs). In 2017, global ITO production capacity (excluding China) remained stable at 1,980 t/yr. Four ITO producers accounted for 90% of global capacity—Heesung Metal Ltd. (Republic of Korea), JX Nippon Mining & Metals Corp. (Japan), Mitsui Mining and Smelting Co. Ltd. (Japan), and Samsung Corning Precision Materials Korea Co. Ltd. (Republic of Korea). Capacity utilization at global ITO facilities was estimated to be about 66% in 2017 with production at 1,320 t and production capacity at 1,980 t. World consumption of ITO was reportedly 1,500 t, with more than 95% consumed in China, Japan, the Republic of Korea, and Taiwan. 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 (Indium Corp., 2016; Roskill's Letter from Japan, 2018).

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. Indium phosphide was mostly produced in Asia, followed by Europe and the United States, in descending order of quantity. Companies that produced InP polycrystalline ingot or substrates included AXT Inc., InPact Inc. (France), JX Nippon Mining & Metals (Japan), Phostec S.R.O. (Slovakia), Sumitomo Electric Industries Ltd. (Japan), and Wafer Technology Ltd. (United Kingdom) (Beijing Dimen International Information Consulting Co. Ltd., 2014).

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. An estimated 40 t of indium was consumed globally for the production of CIGS solar cells. Solar Frontier K.K. (Japan) was thought to be the only mass producer of CIGS solar cells in 2017. The company operated three CIGS plants in Japan with a combined capacity to produce approximately 1.2 gigawatts per year of solar cells (Roskill's Letter from Japan, 2016b; National Renewable Energy Laboratory, 2017, p. 69; Solar Frontier K.K., undated).

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. 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 (Cammell, 2012; Harrower, 2015; Roskill's Letter from Japan, 2016a).

Prices

In 2017, the average Platts Metals Week New York dealer price for indium (99.99% minimum purity in minimum lots of 50 kilograms) was about $360 per kilogram, an increase of 5% compared with that in 2016. The 2017 average Metal Bulletin free market price for indium, however, decreased by 10% from that of 2016 to $215 per kilogram. The average monthly free market price for indium was $210 per kilogram in January, decreasing to a low of $193 per kilogram in July, rising through November to a high of $274 per kilogram, and ending the year at $260 per kilogram.

Foreign Trade

During 2017, U.S. imports for consumption of unwrought indium metal and indium powders were 127 t, a 21% decrease from the 160 t imported in 2016 (table 1). Leading suppliers in 2017 were China (32%), Canada (18%), Hong Kong (15%), and the Republic of Korea (12%). Imports of indium from Hong Kong increased substantially in 2017 to about 20 t, whereas imports from China, Canada, and the Republic of Korea decreased by 25 t, 10 t, and 8 t, respectively. 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 increased by 5% in 2017 from that of 2016, mostly as a result of increased production in France and the Republic of Korea (table 3). China continued to be the leading producer, followed by the Republic of Korea, Japan, and Canada. Production resumed at Nyrstar NV's (Belgium) Auby zinc smelter in France in 2017. The smelter had not produced any indium since November 2015 owing to a fire (Metal-Pages, 2017b; Nyrstar NV, 2018).

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. Estimated global consumption of indium was about 1,450 t in 2017, essentially unchanged from that of 2016 (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 75 t/yr (Teck Cominco Ltd., 2006, p. 27).

China.—China was the leading producer of refined indium, accounting for 40% of global primary refined production in 2017. Production was estimated to have decreased slightly in 2017 from that of 2016 in response to a reduced supply of zinc concentrates. China's indium consumption for ITO was reported to have remained unchanged in 2017 from that of 2016, but the actual amount was not disclosed. China consumes indium mostly for the production of ITO (about 75%) and alloys (about 20%). 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 (Lu, 2014a; Smith, 2014; Minor Metals Monthly, 2018).

Large amounts of indium metal have accumulated in commodity exchange warehouses in China, most notably, the Fanya Metal Exchange. By November 2015, the Kunming municipal government took over Fanya, and exchange warehouses reportedly held about 3,610 t of indium, equivalent to more than 4 years of primary production. The Kunming municipal government announced that it had launched a criminal investigation into Fanya, 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 until the tonnage of indium that is registered with metal processors and trading companies was confirmed (Gu, 2015; Metal-Pages, 2016).

Other exchanges in China that traded indium included the Shaanxi Nonferrous Metal Exchange, the South Rare Precious Metals Exchange, the Tianfu Mercantile Exchange, and the Wuxi Stainless Steel Exchange (Burton, 2013; Lu, 2014b).

China continued being a net exporter of indium in 2017, exporting 160 t of unwrought indium, powders,

and waste and scrap, while importing 128 t of unwrought indium, powders, and waste and scrap. Exports were shipped predominately to Japan (39%), the Republic of Korea (25%), and the United States (22%). Imports were sourced predominately from Hong Kong (40%). In 2016, China's Ministry of Commerce removed the export quotas for indium, replacing it with an export license system (Metal-Pages, 2017a; Global Trade Information Services Inc., 2018).

France.—Nyrstar resumed producing indium at its zinc smelter in Auby in the first quarter of 2017, after a fire in November 2015 closed the plant. Nyrstar produced 29.8 t of indium in 2017, with 9.7 t produced in the first half of the year and 20.1 t produced in the second half (Nyrstar NV, 2018).

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. The other primary producer was Mitsui Mining and Smelting Co. Ltd. (Takehara plant). Asahi Pretec Corp. had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant at Fukuoka. Other secondary indium producers included JX Nippon Mining & Metals Corp., Mitsui Mining and Smelting Co. Ltd., Sumitomo Metal Mining Co. Ltd., and Toho Zinc Co. Ltd. (Metal-Pages, 2008).

Japan was a leading consumer of indium, mostly for the production of ITO. ITO producers included Mitsui Mining and Smelting, which operated the 420-t/yr ITO manufacturing plant at Omuta, and JX Nippon Mining & Metals Corp., which operated the world's leading ITO production plant (648-t/yr capacity) at Isohara near Tokyo (Roskill's Letter from Japan, 2018).

Japan's imports of indium metal, powder, and scrap increased by 88% to 363 t in 2017 from those of 2016, reportedly owing to consumers replenishing low inventory levels. Leading import sources in 2017 included the Republic of Korea (57%), China (22%), Canada (10%), and Taiwan (8%) (Global Trade Information Services Inc., 2018; Roskill's Letter from Japan, 2018).

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. The Republic of Korea was also a notable consumer of indium. Major consumers were the ITO producers, Samsung Corning Precision Materials Korea Co. Ltd. (540 t/yr) and Heesung Metal (180 t/yr) (Young Poong Corp., 2016; Roskill's Letter from Japan, 2018).

The Republic of Korea imported 96 t of indium (metal, powder, and scrap) in 2017, essentially unchanged from that in 2016, mostly from China (40%), Taiwan (23%), France (15%), and the United States (12%), and exported 245 t, predominantly to Japan (84%) (Global Trade Information Services Inc., 2018).

Russia.—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co.'s Electrozink smelters produced refined indium. Most of Russia's refined indium output was thought to be exported. Production was estimated to be 5 t in 2017, essentially unchanged from that in 2016.

Outlook

World indium production is expected to remain stable into 2018 but reactive to prices, the possible release of Fanya's inventory, and China's new export license system. Consumption of indium is projected to continue to follow demand for ITO for LCD production, which, according to IHS Markit Ltd., is due for a correction in 2018 because of a reduction in purchases from China's television manufacturers. Beijing Antaike Information Development Co., Ltd. forecast that China's consumption of indium is expected to increase by 2020 (Minor Metals Monthly, 2017, 2018; Yang, 2018).

On the supply side, China is expected to continue to be the main global supplier of primary indium metal. Additional primary production capacity is anticipated in France, up to a capacity of 70 t/yr. Several indium-containing exploration or development projects, mostly in South America, Canada, and the United States, are advancing, but it is uncertain as to when or whether these projects will begin production (Metal-Pages, 2017b).

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM AND INDIUM POWDERS, BY COUNTRY OR LOCALITY[1]

	2016		2017	
Country or locality	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	4,170	$869	4,370	$845
Canada	32,600	7,590	23,100	4,680
China	65,100	13,300	40,600	8,030
Estonia	--	--	220	40
France	--	--	3,030	551
Germany	68	10	67	9
Hong Kong	3,020	552	19,600	3,370
Japan	12,000	3,800	9,840	4,710
Kazakhstan	--	--	418	79
Korea, Republic of	23,100	4,630	15,100	2,730
Netherlands	330	70	--	--
Russia	1,530	347	2,520	505
Switzerland	--	--	520	90
Taiwan	15,500	3,140	6,420	1,040
United Kingdom	2,870	771	1,320	240
Total	160,000	35,100	127,000	26,900

-- Zero.
[1]Table includes data available through August 9, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau. Harmonized Tariff Schedule of the United States code 8112.92.3000.

TABLE 2
ESTIMATED WORLD PRIMARY INDIUM PRODUCTION CAPACITY[1]

(Metric tons)

Country	Major operating company	Location of main facilities	Primary annual capacity
Belgium	Umicore NV	Hoboken	50
Canada	Teck Resources Ltd.	Trail, British Columbia	75
China[2]	Guangxi Debang Technology Co. Ltd.	Liuzhou, Guangxi	85
Do.[2]	Guangxi Hechi Jinhe Mining and Smelting Co. Ltd.	Hechi, Guangxi	10
Do.[2]	Guangxi Tanghan Zinc & Indium Co. Ltd.	do.	30
Do.[2]	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Lengshuijiang, Hunan	7
Do.[2]	Huludao Nonferrous Metals Group Co.	Huludao, Liaoning	60
Do.[2]	Hunan Jingshi Group Co. Ltd.	Zhuzhou, Hunan	40
Do.[2]	Laibin Smelter [Liuzhou Huaxi (China Tin) Group Co.]	Laibin, Guangxi	50
Do.[2]	Liuzhou Zinc Products Co.	Liuzhou, Guangxi	20
Do.[2]	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.[2]	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do.[2]	Shaoguan Smelter (Shenzhen Nonfemet Co.)	Shaoguan, Guangdong	25
Do.[2]	Tibet Summit Industry Co. Ltd.	Xining, Qinghai	15
Do.[2]	Xiangtan Zhengtan Nonferrous Metal Co. Ltd.	Xiangtan, Hunan	75
Do.[2]	Yintai Technology Co. Ltd.	Liuzhou, Guangxi	40
Do.[2]	Yuguang Gold-Lead Co. Ltd.	Jiyuan, Henan	20
Do.[2]	Yunnan Chengfeng Nonferrous Metals Co. Ltd.	Gejiu, Yunnan	10
Do.[2]	Yunnan Hualian Zinc and Indium Co. Ltd.	Wenshan, Yunnan	60
Do.[2]	Yunnan Luoping Zinc & Electricity Co. Ltd.	Luoping, Yunnan	20
Do.[2]	Yunnan Mengzi Mining and Smelting Co. Ltd.	Honghe, Yunnan	60
Do.[2]	Zhuzhou Smelter Group Co. Ltd.	Zhuzhou, Hunan	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

Do., do. Ditto. NA Not available.
[1]Table includes data available through August 9, 2018. Data are rounded to no more than two significant digits.
[2]Includes facilities that consume mineral concentrates as well as processors that consume unrefined indium.

TABLE 3
INDIUM: WORLD REFINERY PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Kilograms)

Country or locality[2]	2013	2014	2015	2016	2017
Belgium	30,000	28,000	20,000	20,000	20,000 e
Canada	70,000 e	67,000 e	70,000 e	71,000 e	67,000
China	430,000 r	460,000	320,000	296,000 e	287,000 e
France	33,000	43,000	41,000	--	29,800
Japan	72,000	70,000	70,000	70,000	70,000 e
Korea, Republic of	175,000	195,000	195,000	210,000	225,000 e
Peru	11,080	14,000 e	10,000 e	10,000 e	10,000 e
Russia[e]	9,500	4,000	5,000	5,000	5,000
Total	831,000 r	881,000	731,000	682,000	714,000

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through May 2, 2018. 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.

[2]In addition to the countries and (or) localities listed, Kazakhstan and Ukraine may have produced primary indium, but available information was inadequate to make reliable estimates of output.