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2022 Minerals Yearbook

INDIUM [ADVANCE RELEASE]

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Indium

By Andrew A. Stewart

Domestic survey data and tables were prepared by Michael J. Rose, statistical assistant.

Indium was not recovered from concentrates in the United States during 2022. Several facilities imported indium metal to produce high-purity indium metal, indium compounds, specialty indium alloys, solders, and other indium products. During 2022, U.S. imports for consumption of unwrought indium metal and indium powders were 202 metric tons (t), 28% more than the 158 t imported in 2021 (table 1). There was no exclusive U.S. export trade code for indium. Global primary refined indium production was estimated to have increased by 5% in 2022 to 999 t from 954 t (revised) in 2021 (table 3).

Indium is a lustrous, malleable, and silvery-white metal with a relatively low melting point of 156.6 degrees Celsius (°C). Indium does not occur as the principal commodity in deposits but is instead found associated with copper, lead, tin, and zinc ores. The main associated minerals include cassiterite, chalcopyrite, galena, sphalerite, and stannite. Sphalerite generally has the highest indium content, though the content can vary widely. Indium does form several minerals, such as dzhalindite and indite, but none are mined solely for their indium content. Most indium is recovered as a byproduct from zinc concentrates (Briskey, 2005; Simandl and others, 2023).

Indium has a relatively low crustal abundance of approximately 56 parts per billion (Rudnick and Gao, 2014). The most common type of mineral deposit associated with indium is volcanic-hosted or volcanogenic massive sulfides. These deposits form in submarine volcanic environments where hydrothermal fluids are discharged from seafloor vents. Indium also is associated with epithermal, sediment-hosted stratiform copper, sediment-hosted lead-zinc, granite-related porphyry, and skarn deposits. More than 95% of reported indium resources are found in skarn, volcanogenic massive sulfide, epithermal, and sediment-hosted lead-zinc deposits. Approximately 75% of reported indium resources are located in Bolivia, Canada, China, Japan, and Russia. The largest known resource is in the Gaiskoye deposit in Russia, which contains more than 9,000 t of indium. In the United States, indium is found in porphyry and skarn deposits in Arizona, New Mexico, and Utah (Werner and others, 2017).

Production

Globally, zinc concentrates were the principal source of primary indium. Most zinc producers were not equipped with indium-processing circuits, so a significant proportion of indium contained in zinc ores was not recovered. Although the United States was a significant producer and exporter of zinc concentrates, no data were available on the content of indium in these concentrates.

Indium-containing scrap was recycled domestically from products such as indium-gallium alloys, indium-tin oxide (ITO), and indium-zinc oxide. Globally, a significant amount of indium was reclaimed from spent ITO targets and reused in the production of new ITO sputtering targets. Most recycling was done within a manufacturer's internal production process. Sufficient data were not available to estimate the quantity of indium recovered or recycled into new indium products.

In 2022, development of the West Desert zinc-copper-iron-indium deposit in Utah continued. A 2014 preliminary economic assessment estimated the indicated and inferred resources of the deposit to be about 1,600 t of indium and the grade of the deposit to be 26 grams per metric ton of indium. In 2021, American West Metals Ltd. (Australia) acquired the project from InZinc Mining Ltd. (Canada) and began exploration and infrastructure activities, including a gravity survey, mine design work, and a scoping study. A drilling campaign was conducted in 2022 to determine a maiden resource estimate, but indium was excluded owing to an absence of indium assays in historical drill holes. American West announced that they would resample the historical core and assay the samples to include indium in future updates. In 2022, the Utah Geological Survey was awarded a $300,000 grant to evaluate the West Desert deposit by the U.S. Geological Survey (USGS) Earth Mapping Resource Initiative. The research would investigate the origins of the indium contained in the deposit, in addition to studying exploration indicators to help locate similar deposits (InZinc Mining Ltd., 2021; American West Metals Ltd., 2023, p. 19, 32).

Consumption

Consumption data on indium were not collected by the USGS. Imported indium metal was upgraded to higher purities and (or) consumed to produce indium alloys, chemicals, specialty products, and shapes, which were sold to downstream users.

The main global applications of indium in 2022 were flat panel displays (61%), semiconductor materials (10%), photovoltaics (8%), solders (7%), alloys (6%), thermal interface materials (5%), and batteries (3%) (Data Bridge Market Research Inc., 2023, p. 70).

ITO accounted for most indium consumption globally (Simandl and others, 2023). Indium oxide has strong electrical conductivity, heat reflection, and transparency, and when combined with tin oxide, exhibits enhanced heat reflection and electrical conductivity, making it an ideal material for transforming electrical data into optical forms. Flat-panel displays use ITO, which is applied as a thin, transparent film on a display screen or touchscreen. Flat-panel displays include computer monitors, laptops, smartphones, tablets, televisions, vehicle displays, and wearable smart devices.

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-based substrates were used in both laser and photo diodes in transceivers and in fifth-generation (5G) fiber-optic telecommunications networks. InP also was expected to be used with gallium arsenide in the development

of facial recognition and detection. Additionally, InP was used in three-dimensional (3D) sensing technologies, such as virtual reality. Indium also was used to produce the semiconducting compound indium-gallium-zinc oxide (IGZO) in organic light-emitting diode (OLED) displays and liquid crystal displays (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.

Indium was used in the manufacturing of copper-indium-gallium-diselenide (CIGS) or copper-indium-diselenide (CIS) thin-film solar cells. In 2022, most global photovoltaic (PV) shipments were of crystalline silicon technology, with CIGS and CIS solar cells accounting for less than 1%. Annual shipments based on CIGS and CIS technology have steadily decreased since 2014 (National Renewable Energy Laboratory, 2023, p. 63).

Indium-containing alloys were used commonly 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 apparatuses. Indium-silver alloys or pure indium foil were used as thermal interface materials (a substance used to seal a heat-generating surface to a heat sink, filling microscopic air voids to allow for effective heat transfer) in electronics. Certain indium-tin alloys were used as bonding agents between nonmetallic materials. Indium also was used in dental alloys, in low melting temperature alloys for fuses, as a substitute for mercury, and in white gold alloys.

Additionally, indium was used as a replacement for mercury in alkaline batteries. The indium reduces energy loss during storage and therefore increases shelf life of the battery. In recent years, some research has investigated the potential use of a lithium-indium alloy in solid state rechargeable batteries (Umicore SA, undated).

Prices

The 2022 average free on board U.S. price for indium (minimum 99.99% indium) increased by 12% to $250 per kilogram in 2022 from $223 per kilogram in 2021. The price for indium decreased during 2022, beginning the year at $275 per kilogram and decreasing to $223 per kilogram by yearend (Argus Metals International, undated).

Foreign Trade

U.S. imports for consumption of unwrought indium metal and indium powders were 202 t in 2022, a 28% increase from the 158 t imported in 2021. Indium imports have increased steadily in recent years, increasing by 113% from 2019 to 2022. Leading suppliers in 2022 were Belgium (30%), the Republic of Korea (18%), Japan (17%), Canada (14%), and China (13%). Significant increases in imports from Belgium (by 60 t), Japan (30 t), and China (19 t) were partially offset by decreases in imports from the Republic of Korea (by 44 t) and Peru (21 t) (table 1). Data on indium exports were not available because there is no exclusive domestic export Schedule B code for unwrought indium and indium powders, and there is no exclusive international Harmonized System code at the six-digit level for analyzing world trade statistics.

World Review

Global production of primary indium was estimated to have increased by 5% in 2022 from that in 2021, mostly because of increased production in China (table 3). China continued to be the leading producer, followed by the Republic of Korea, Japan, and Canada. However, most of these production numbers are estimates because reported indium production data were limited or not available.

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.

China.—China was the leading producer of refined indium, producing an estimated 670 t of indium in 2022, accounting for 67% of global primary refined production.

China continued to develop its 5G network in 2022. In 2020, the country had 718,000 5G base stations, increasing to 1.4 million by early 2022. The Ministry of Industry and Information Technology announced that China was on target to build 2 million 5G base stations by the end of 2022 (Argus Metals International, 2022c).

In June, China released a renewable energy development plan to increase the non-fossil-fuel share of total energy consumption to 25%. Under the plan, China would increase wind and solar capacity to 1.2 terawatts by the year 2030. This could increase demand for CIGS solar panels, which use about 30 t of indium per 1-gigawatt (GW) solar cell (Argus Metals International, 2022a).

In October, the local court of Xiangyun County in Yunnan Province held an auction of indium metal owned by Yunnan Xiangyun Feilong Recycling Technology. Four companies participated in the bidding process. Yunnan Renju Mining bought 49.38 t of indium valued at $7.68 million (Argus Metals International, 2022b).

In 2022, China imported 84 t of indium, an increase of 45% from the 58 t imported in 2021. China exported 711 t of indium, 39% more than the 511 t exported in 2021. Indium was exported mainly to the Republic of Korea (48%), Hong Kong (28%), Singapore (8%), the United States (4%), and Japan (4%) (Zen Innovations AG, 2023).

India.—India planned to have 300 GW of solar capacity by the year 2030, which would increase demand for metals used in the photovoltaic industry, such as indium. In 2022, India had 10 gigawatts per year (GW/yr) of solar module manufacturing capacity and about 3 GW/yr of solar photovoltaic capacity (Argus Metals International, 2022d).

Outlook

World indium consumption is expected to continue to increase with the development of 5G technologies, where InP lasers and receivers are used to send data through fiberoptic lines, providing the "backbone" for wired communications. 5G is designed to provide faster data transfer speeds, lower latency, and more efficient data handling, which can improve performance and reduce data losses during transmission. By the end of 2021, there were an estimated 85 million 5G devices being used in the United States, an increase of 507% from 14 million in 2020 (CTIA, 2022). Additional demand may come from increased use of solar panels and continued growth from the flat-panel-display market.

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

Country or locality	2021		2022	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Austria	--	--	45	$11
Belgium	--	--	60,000	1,810
Canada	26,000	$5,750	28,000	7,180
China	7,140	1,610	26,300	6,180
France	6,990	1,350	6,890	1,410
Germany	95	49	511	120
Japan	4,890	1,150	35,200	8,560
Korea, Republic of	80,800	14,600	36,500	8,470
Peru	20,900	479	--	--
Poland	--	--	426	360
Russia	2,040	368	2,160	534
Singapore	4,180	762	--	--
Taiwan	4,520	952	5,040	695
Thailand	--	--	400	24
United Kingdom	310	18	--	--
Total	158,000	27,100	202,000	35,400

-- Zero.

[1]Table includes data available through June 22, 2023. 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, 2]

(Metric tons per year)

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	Guangxi Debang Technology Co. Ltd.	Liuzhou, Guangxi	120
Do.	Guangxi Hechi Jinhe Mining and Smelting Co. Ltd.	Hechi, Guangxi	10
Do.	Guangxi Huaxi Group Co. Ltd.	Laibin, Guangxi	60
Do.	Guangxi Tanghan Zinc & Indium Co. Ltd.	Hechi, Guangxi	30
Do.	Guangxi Yintai Technology Co. Ltd.	Liuzhou, Guangxi	40
Do.	Henan Yuguang Zinc Industry Co. Ltd. (Henan Yuguang Gold and Lead Group Co. Ltd.)	Jiyuan, Henan	38
Do.	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Lengshuijiang, Hunan	7
Do.	Huludao Nonferrous Metals Group Co.	Huludao, Liaoning	60
Do.	Hulunbuir Chihong Mining Co. Ltd. (Yunnan Chihong Zinc and Germanium Co. Ltd.)	Hulunbuir, Inner Mongolia	NA
Do.	Hunan Jingshi Group Co. Ltd.	Zhuzhou, Hunan	40
Do.	Liuzhou Zinc Products Co.	Liuzhou, Guangxi	20
Do.	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do.	Shaanxi Zinc Industry Co., Ltd.	Shangluo, Shaanxi	20
Do.	Shenzhen Nonfemet Co.	Shaoquan, Guangdong	25
Do.	Tibet Summit Industry Co. Ltd.	Xining, Qinghai	15
Do.	Wenshan Zinc and Indium Smelting Co. Ltd. (Yunnan Tin Co. Ltd.)	Wenshan, Yunnan	80
Do.	Xiangtan Zhengtan Nonferrous Metal Co. Ltd.	Xiangtan, Hunan	75
Do.	Yunnan Chengfeng Nonferrous Metals Co. Ltd.	Gejiu, Yunnan	10
Do.	Yunnan Mengzi Mining and Smelting Co. Ltd.	Honghe, Yunnan	60
Do.	Zhuzhou Hongyilong Industry Co. Ltd.	Zhuzhou, Hunan	96
Do.	Zhuzhou Smelting Group Co. Ltd.	Changning, Hunan	60
France	Nyrstar NV	Auby	48
Japan	Dowa Metals and Mining Co. Ltd.	Iijima, Akita	70
Do.	Mitsui Mining and Smelter 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 Co., Ltd.	Sukpo	100
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 Metallurgical Co.[3]	Vladikavkaz	--

Do., do. Ditto. NA Not available. -- Zero.

[1]Table includes data available through June 22, 2023. Estimated data are rounded to no more than two significant digits.

[2]Does not represent a complete list of facilities in China; includes facilities that produce crude indium and (or) high-purity indium.

[3]Ural Mining and Metallurgical Co. closed the Electrozink smelter in Vladikavkaz in 2019.

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

(Kilograms)

Country or locality[2]	2018	2019	2020	2021	2022
Belgium[e]	22,000	20,000	20,000	20,000	19,000
Canada	65,000 [e]	64,802 [r]	60,653 [r]	44,315 [r]	39,000 [e]
China	483,000	534,000 [e]	540,000 [e]	590,000 [r,e]	670,000 [e]
France	46,200	40,000 [e]	38,000 [e]	38,000 [e]	19,000 [e]
Japan[e]	70,000	70,000	66,000	66,000	66,000
Korea, Republic of[e]	235,000	225,000	210,000	190,000	180,000
Russia[e]	5,000	5,000	5,000	5,000	5,000
Uzbekistan	800	1,000	1,030	1,180 [r]	1,180 [e]
Total	927,000 [r]	960,000 [r]	941,000 [r]	954,000 [r]	999,000

[e]Estimated. [r]Revised.

[1]Table includes data available through May 30, 2023. All data are reported unless otherwise noted; totals may include estimated data. 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, Peru, and Ukraine may have produced primary indium, but available information was inadequate to make reliable estimates of output.