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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 2023. Several facilities imported indium metal to produce high-purity indium metal, indium compounds, specialty indium alloys, solders, and other indium products. During 2023, U.S. imports for consumption of unwrought indium metal and indium powders were 219 metric tons (t), 9% greater than the 202 t imported in 2022 (table 1). There was no exclusive export trade code for indium, so export data could not be determined. Global primary refined indium production was estimated to have increased in 2023 to 1,020 t from 999 t in 2022 (table 3).

Indium is a lustrous, malleable, and silvery-white metal with a relatively low melting point of 156.6 degrees Celsius. Indium does not occur as the principal mineral in deposits and is instead found associated with copper, lead, tin, and zinc ores. The minerals associated primarily with indium include cassiterite, chalcopyrite, galena, sphalerite, and stannite (Briskey, 2005). 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 (Simandl and others, 2023, p. 143).

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 a volcanic-hosted massive sulfide, also called a volcanogenic massive sulfide. This type of deposit forms in submarine volcanic environments where hydrothermal fluids are discharged from sea floor vents. Indium also is associated with epithermal, granite-related porphyry, sediment-hosted lead-zinc, sediment-hosted stratiform copper, and skarn deposits. More than 95% of reported indium resources are found in epithermal, sediment-hosted lead-zinc, skarn, and volcanogenic massive sulfide deposits. Approximately 75% of reported indium resources are located in Bolivia, Canada, China, Japan, and Russia. The largest identified resource was 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, p. 944–945).

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 in 2023, no data were available on the content of indium in these concentrates.

America West Metals Ltd. (Australia) updated its independent Joint Ore Reserve Committee-compliant inferred mineral resource estimate for the West Desert zinc-copper-iron-indium deposit in Utah to include 675 t indium. The inferred resource was estimated to be 18.7 million metric tons (Mt) at 13 grams per ton (g/t) indium from open pit resources and 15 Mt at 28.7 g/t indium from underground resources (American West Metals Ltd., 2023).

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 sputtering 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.

Consumption

Consumption data on indium were not collected by the U.S. Geological Survey. 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 2023 were flat panel displays (61%), semiconductor materials (10%), photovoltaics (8%), solders (8%), alloys (6%), thermal interface materials (5%), and batteries (2%) (Data Bridge Market Research Inc., 2023, p. 70).

ITO accounts for most indium consumption globally (Simandl and others, 2023, p. 143). Indium oxide has strong electrical conductivity, heat reflection, and transparency, and when combined with tin oxide, it experiences 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 laptops and computer monitors, 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, which allow for more devices to be supported on a cellular network, have lower latency within the network, have reduced signal loss within optical fiber, and produce faster speeds for all users. Additionally, InP was used in 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 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 2023, most global photovoltaic (PV) shipments were of crystalline silicon technology cells, with CIGS and CIS solar cells accounting for less than 1% of solar cells shipped. Annual shipments of CIGS and CIS cells have decreased since 2014 (National Renewable Energy Laboratory, 2024, p. 66).

Indium-containing alloys commonly were 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 (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 the 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 2023 average free onboard U.S. warehouse price for indium (minimum 99.99% indium) decreased to $244 per kilogram in 2023 from $250 per kilogram in 2022. The U.S. price for indium generally increased during 2023, beginning the year at $223 per kilogram and ending the year at $265 per kilogram (Argus Media group, Argus Non-Ferrous Markets, undated).

Foreign Trade

The United States has been 100% reliant on imports for unwrought indium metal and indium powders since 1993. In 2023, 219 t of indium were imported for U.S. consumption, a 9% increase from the 202 t imported in 2022. Indium imports have increased steadily in recent years, growing by 131% from 2019 to 2023. Leading suppliers in 2023 were Japan (33%), Brazil (23%), and the Republic of Korea (19%). There was a significant increase in imports from Japan (37 t) and Brazil (51 t). There was a decrease in imports from Belgium (60 t), China (16 t), and Canada (12 t) (table 1). Data on indium exports were not available because there is no exclusive domestic export Schedule B number 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 slightly in 2023 from that in 2022, mostly because of increased production in China (table 3). China remained the leading producer, followed by the Republic of Korea, Japan, and Canada. However, most of these production numbers were 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.

Bolivia.—State-owned Empresa Metalurgica Vinto S.A., with a $350 million loan backed by China's Export-Import Bank, planned to construct a refinery with the capacity to process 150,000 metric tons per year of zinc concentrate. The refinery also would process indium, gallium, and germanium contained in the zinc concentrate (Argus Media Group, Argus Non-Ferrous Markets, 2023). This new indium production facility would be the second of its kind in South America. Based on 2023 estimates, this new refinery was expected to maintain between 8% and 23% of the global indium production capacity. This new indium production could possibly affect current indium-producing countries that rely on imported zinc concentrate because there would be less concentrate exported from Bolivia.

China.—China produced an estimated 690 t of indium in 2023, accounting for 68% of global primary refined production.

In 2023, China's total imports of indium were 867 t. China imported 459 t of indium, excluding reimports, more than five times the 84 t imported in 2022. China's indium imports from Singapore increased substantially in the second half of 2023, accounting for 86% of all imports for the year. This high level of imports could have been the result of commodity buying on the Liyang Zhonglianjin e-Exchange (Minor Metals Trade Association, 2024).

In 2023, China exported 1,010 t of indium (some of which was reimported), 42% more than the 709 t exported in 2022. Indium was exported mainly to Hong Kong (37%), the Republic of Korea (34%), and Singapore (25%). Hong Kong had zero indium exports in 2023 (Zen Innovations AG, 2024).

Outlook

The United States will remain import dependent on unwrought indium metal and indium powders in the near term. 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 fiber-optic lines, providing the "backbone" for wired communications. By the end of 2023, there were an estimated 216 million active 5G devices being used in the United States, an increase of more than 1,400% from 14 million in 2020 (CTIA, 2024). Additional demand may come from increased use of solar panels and continued growth in 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	2022 Quantity (kilograms)	2022 Value (thousands)	2023 Quantity (kilograms)	2023 Value (thousands)
Austria	45	$11	--	--
Belgium	60,000	1,810	--	--
Brazil	--	--	51,000	$1,330
Canada	28,000	7,180	15,900	4,470
China	26,400 r	6,190 r	10,200	2,360
Estonia	--	--	128	57
France	6,890	1,410	5,120	1,070
Germany	511	120	102	90
Japan	35,200	8,560	72,400	14,600
Korea, Republic of	36,500	8,470	42,500	9,110
Liechtenstein	--	--	225	18
Malaysia	--	--	150	27
Poland	426	360	--	--
Russia	2,160	534	1,000	198
Switzerland	--	--	10	9
Taiwan	5,040	695	14,400	3,150
Thailand	400	24	5,550	228
United Kingdom	--	--	3	11
Total	202,000	35,400	219,000	36,700

rRevised. -- Zero.
[1]Table includes data available through June 25, 2024. 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
WORLD PRIMARY INDIUM PRODUCTION CAPACITY[1]

(Metric tons)

Country	Major operating company	Location of main facilities	Primary annual capacity[e]
Belgium	Umicore N.V-S.A.	Hoboken	50
Canada	Teck Resources Ltd.	Trail, British Columbia	70
China[2]	Guangxi Debang Technology Co. Ltd.	Liuzhou, Guangxi	120
Do.	Guangxi Tanghan Zinc & Indium Co. Ltd.	Hechi, Guangxi	7
Do.	Liuzhou Huaxi Group Co.	Laibin, Guangxi	60
Do.	Guangxi Tanghan Zinc & Indium Co. Ltd.	Hechi, Guangxi	30
Do.	Huludao Nonferrous Metals Group Co. Ltd.	Huludao, Liaoning	50
Do.	Jinshan Indium and Germanium Metallurgical Chemical Co.	Hechi, Nandan, Guangxi	NA
Do.	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Lengshuijiang, Hunan	7
Do.	Huludao Nonferrous Metals Group Co.	Huludao, Liaoning	60
Do.	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do.	Liuzhou Zinc Products Co. Ltd.	Liuzhou, Guangxi	20
Do.	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.	Yintai Technology Co. Ltd.	Liuzhou, Guangxi	40
Do.	Yuguang Gold-Lead Co. Ltd.	Jiyuan, Henan	10
Do.	Shenzhen Nonfemet Co. Ltd.	Shaoguan, Guangdong	25
Do.	Yunnan Mengzi Mining and Smelting Co. Ltd.	Honghe, Yunnan	30
Do.	Zhuzhou Smelter Group Co. Ltd.	Zhuzhou, Hunan	60
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	30
Do.	Zhuzhou Hongyilong Industry Co. Ltd.	Zhuzhou, Hunan	96
Do.	Zhuzhou Smelting Group Co. Ltd.	do.	60
France	Nyrstar NV	Auby	70
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, Ulsan	200
Do.	Young Poong Corp.	Seokpo, Gyeongbuk	110
Peru	Nexa Resources Peru S.A.A.	Lurigancho-Chosica, Lima	50
Russia	Chelyabinsk Zinc Plant OJSC	Chelyabinsk	15
Do.	OAO Urals Mining and Metallurgical Co.[3]	Vladikavkaz, North Caucası	--

[e]Estimated; estimated data are rounded to no more than two significant digits. Do., do. Ditto. NA Not available. -- Zero.
[1]Table includes data available through June 25, 2024.
[2]Does not represent a complete list of facilities. Includes plants that produce crude indium and (or) high-purity indium.
[3]The Electrozink smelter was not in operation in 2023.

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

(Kilograms)

Country or locality[2]	2019	2020	2021	2022	2023
Belgium, crude indium hydroxide[e]	20,000	20,000	20,000	19,000	19,000
Canada	64,802	60,653	44,315	39,000 [e]	40,000 [e]
China	534,000 [e]	590,000 [r]	600,000 [r]	670,000	690,000 [e]
France[e]	40,000	38,000	38,000	19,000	21,000
Japan[e]	70,000	66,000	66,000	66,000	65,000
Korea, Republic of[e]	225,000	210,000	190,000	180,000	180,000
Russia[e]	5,000	5,000	5,000	5,000	5,000
Uzbekistan	1,000	1,030	1,180	1,113 [r]	1,000 [e]
Total	960,000	991,000 [r]	964,000 [r]	999,000	1,020,000

[e]Estimated. [r]Revised.
[1]Table includes data available through August 28, 2024. 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.