INDIUM

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The year continued the optimism started in 2000 as worldwide economies, particularly in electronics, continued to do well. However, a chill wind starting in the second quarter soon cleared away the optimism, as it became apparent that all the forecasts for growth in electronics were hugely over-optimistic. Some markets fared particularly badly, but indium remained relatively healthy on the demand side, buoyed principally by the technology change to flat screens in the display industry.

Occurrence and Extraction

Indium has the same relative abundance as silver, being approximately 0.1 parts per million of the earth's crust. Unlike silver, however, it does not occur in concentrated deposits which can be mined in their own right but is principally associated with the commercial ores of zinc (sphalerite), lead (galena), copper (polymetallic ores) and tin (stannite and cassiterite). Production of the metal is therefore centred around the extraction of these ores and the refining of the major metal concerned. The majority of commercial extraction is centred around zinc and tin production. Ascertaining the exact volume of economically recoverable reserves is extremely difficult and the refining operations concerned can be situated far from the mine sources, often in different countries and on different continents. The US Geological Survey estimated that 'Reserves' were 2,500 t with a further 5,000 t in the 'Reserve Base' based on zinc ore sources only. If copper, lead and tin ores were included then total 'currently economic' reserves are probably in excess of 10,000 t.

The most significant mine sources of indium-bearing 'major' metals are in China and Canada although the refining operations are also located in other areas, the most significant being in Western Europe, Japan and Canada.

The separation of indium from flue and sinter dusts, slags, residues and drosses is technically exacting and not always completed. Indium is usually concentrated in lead bullion dross during the treatment of electrolytic zinc plant residues. The dross is treated for the recovery of matte copper and lead bullion and the resultant slag contains a few per cent indium plus high levels of copper, lead and tin. A flotation process concentrates the copper to generate tailings which are sintered and reduced electrothermally to produce a crude bullion. Electrolytic treatment of the bullion generates an anode slime containing up to 30% indium. Commercial grade indium is produced by leaching, cementation and electro-refining. Solvent extraction is often employed to recover indium from leach residues.

Production

World primary production increased again during 2001, with the Chinese plants expanding production more than the increase in consumption. The principal grade of metal most commonly produced, traded and utilised as a raw material is of 99.99% (4N) minimum purity.

World Primary Indium Production[e] (t)

	1997	1998	1999	2000	2001
European Union	75	75	75	80	70
Canada	25	30	35	35	35
Japan	35	25	30	25	55
China	30	40	58	80	170
CIS	30	15	15	5	4
Peru	2	4	4	4	4
Total	**197**	**189**	**217**	**229**	**338**

[e] *estimated*

Whereas the Japanese consumer market is the principal factor of the indium market on the demand side, the production is dominated by the Chinese producers. There are 14 main

factories producing between 5 t and 30 t each per year, making an estimated total capacity of around 170 t. These include the well known Huludao and Zhuzhou zinc smelters, along with China Tin, Luizhou Intai and others.

Metaleurop of France remains the largest single prime quality indium producer in the world and Cominco-Teck the second largest primary Western source.

There has also been a considerable amount of indium recycled, which could account for a further 270 t of material usage, although not all processes are economical at current Indium prices.

Applications

Indium is well known as a very versatile metal which is incorporated into a wide variety of applications covering a broad range of industry, although the main area of usage is ultimately in the electronics industry.

The principal application, accounting for half of world consumption, is in displays. Indium is used as a sol-gel for coating CRT screens or by sputtering on glass as a transparent electrode in TFT LCD screens. It is this latter application which is expanding and which has accounted for the large increase in consumption. The material used for both types of application is indium tin oxide (ITO), production of which is still dominated by Japanese manufacturers. The display industry in general is centred mainly in Korea, the largest producer, Japan and Taiwan.

Other major applications include semiconductors, solders, low melting point alloys, sox lamps, cryogenic seals, and alkaline-manganese batteries.

Supply and Demand

The supply side of the market has continued to grow, dominated by China which has the potential to expand production further by another 50%, thereby ensuring adequate supply for the foreseeable future.

As usual, the metal consumption is largest in Japan and hence it is always instructive to analyse that market.

Japanese Consumption by Application[e] (t)

	1997	1998	1999	2000	2001
ITO	70	60	68	80	117
Phosphors	6	6	6	5	8
Semi-conductors	6	7	7	8	14
Batteries	4	4	4	4	5
Solder/Fusible Alloys	9	11	10	11	8
Dental Alloys	2	2	2	2	3
Other	8	9	9	10	24
Total	**105**	**99**	**106**	**120**	**179**

These statistics are based on virgin indium consumption.

[e] estimated

The import data are as follows:

Japanese Imports (kg)

	1997	1998	1999	2000	2001
Belgium	3,984	2,906	3,014	3,408	3,286
Canada	3,391	-	4,004	22,730	20,110
China	23,360	23,737	42,045	50,296	85,957
CIS	11,057	7,515	1,361	919	1,295
France	46,800	41,763	36,650	49,259	41,605
US	8,903	7,008	2,404	2,581	10,913
Other	3,301	2,465	1,731	3,568	7,834
Total	**100,796**	**85,394**	**91,209**	**132,752**	**171,000**

Pricing

The year started with an average price level of US$120/kg and fell to US$100/kg by the year end with further falls in prospect. A decline of around 17% over the year and around 45% in the last two years.

The price declined because of the large increase in production which more than off-set the increase in up take for screen coating (ITO) applications. As the world economy slows into 2002 it is anticipated that prices will decline further despite the relative buoyant usage of this material.

Outlook

With expected further increases in display applications, including flat screen TVs and LCDs/OLEDs for the next generation of mobile telephone, there is an excellent future for this metal. The annual consumption will continue to increase, interspersed with some down turns, as anticipated in 2002.

The next generation of compound semiconductors is also increasing demand for indium phosphide, a material which uses the very high purity grade (6N+) of metal. Supply is not expected to disturb the growth, given the increasing availability of capacity. Excess material production is usually stockpiled at source during times of a diminution in demand.