

## INDIUM

*By Malcolm Harrower  
MCP Ltd, Northants, UK*

Indium has several particularly important and interesting applications, the main one, which assumed greater prominence during 2003, being the use of indium in indium tin oxide as a coating for use as a transparent electrode in display screens. This is a long-standing and well-known application but the further widespread use of flat-panel display screens, particularly for televisions, is once again providing a boost for indium. The increased use of lead-free solders, due to the introduction of new legislation, is also boosting the market. Indium demand, therefore, grew appreciably in 2003 and a further increase is deemed likely in 2004.

### **Occurrence and extraction**

Indium and silver have approximately the same relative abundance, each representing around one part per million of the Earth's crust. However, indium, unlike silver, does not occur in sufficient concentrations to be mined in its own right. Instead, indium is obtained as a by-product, principally associated with commercial ores of zinc, lead, copper and tin. Most of the commercial extraction of indium is associated with zinc and tin production. Precise estimates of economically recoverable reserves of indium are extremely difficult to gauge: the metal is often refined far from the mine source, sometimes in a different country and on a different continent. In addition, major metal miners do not always elect to extract indium as a by-product and the residues from these operations are often bought by third parties in order for them to extract the indium content.

The US Geological Survey has estimated that there are around 2,500 t of indium in recoverable reserves, with a total of about 6,000 t in the 'Reserve Base'. The most significant mine sources of indium-bearing major metals are in China and Canada although there are other sources in Japan and Russia.

Indium is separated from flue and sinter dusts, slags, residues and drosses. Also, it 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 electrothermically 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 used to recover Indium from leach residues.

### **Production**

During 2003, indium production became firmly centred on China, which is now the major supply driver for this market. Within the country there are many suppliers however, some being major metal producers such as China Tin, but

many others are the purchasers of the tailings or crudes from major metal production in order to extract the indium, which may be their only product. Therefore, the market in China is quite complex and there are various levels of producer of different grades. The major producers are also gradually looking at value addition in order to strengthen their market. As can be seen from the tables following, there are other countries producing indium where the situation is more clear, with generally one major producer in each country.

During the latter part of 2003, further indium recycling capacity was installed in response to higher indium prices. The move towards greater usage of indium tin oxide, makes the need for indium recycling inevitable.

Most recently, in South Korea, it has been announced that Korea Zinc will commission a plant to recover 34 t/y of indium from lead and zinc concentrates at its Onsan smelting and refining complex. The project has involved an estimated investment of US\$39 million. Indium, in the form of indium-tin oxide is used in liquid-crystal displays and plasma screens, and Korea Zinc expects to sell its indium to domestic manufacturers such as Samsung and LG Group, thereby reducing their reliance on imported indium. Korea Zinc estimates that its annual net profit will be US\$15 million.

### **Applications**

There are many applications for this interesting minor metal. However, the one that dominates by far is its use as an indium tin oxide (ITO) coating on glass or polymer film. It is then effective as a transparent electrode in the application of flat panel displays, be they liquid crystal displays (LCD), organic light emitting diodes (OLED), plasma display panels (PDP) or cathode ray tubes (CRT)

The growth in the use of display screens generally is responsible for some of the market growth seen, but the conversion to flat screens for computers (generally LCD) and now the mass market conversion of TVs from CRTs to various types of flat panel displays, means that the demand for indium has soared in the past year. The principal usage is in the Far East, particularly Japan, Taiwan and Korea, the major production centres.

Other applications for indium include ITO-coated transparent film for automotive windscreens, semiconductors for opto-electronics, low melting point alloys, solders, batteries, sox lamps and cryogenic seals. Indium usage in solders has also shown a healthy increase during 2003 as a substitute for lead.

### **Supply and demand**

Despite the massive increase in demand as a result of the burgeoning flat panel display industry, the supply of indium has kept pace and the capacity available is sufficient for further increases. However, there is little spare new indium capacity hence the rapid price increases seen over the year.

Future demand will be assisted by the increasing amount of ITO scrap that will be coming back for recovery from the newly installed display capacity.

### Pricing

The year started with the London *Metal Bulletin* average at US\$95/kg and ended with the same indicator quoting US\$317.5/kg, an increase of 334%, with further increases likely into 2004. The trigger for the pricing increases was the closure of Metaleurop in France, which removed 60 t of prime metal from the market. The driver since then has been the rapidly increasing demand for flat panel displays and the consequent increased requirement for indium.

Whilst the general increased use of various displays in modern society is of interest, it is the widespread conversion, of TVs in particular, to flat-screen technology, which is the main force. Therefore, it is likely that the price will increase considerably more before falling back to a more realistic and sustainable level. As always in these volatile markets, the activities of merchants and traders tend to exacerbate the peaks and troughs in the market, and manufacturers yearn for stability.

There will be a dampening of the market price once large volumes of scrap are returned from the new display panel manufacturers. Up to 70% of an ITO target can be recycled, which should ensure a ready supply of indium once all the new capacity is installed.

### Outlook

With continued excellent demand, the market will remain buoyant and a much needed stability will be achieved once all the new flat screen capacity is in place. But the price is unlikely to fall back to the low levels seen in recent years.

### Tables

**Estimated world primary indium production (t)**

	1998	1999	2000	2001	2002	2003
European Union	75	75	80	70	65	26
Canada	30	35	35	35	36	40
Japan	25	30	25	55	55	70
China	40	58	80	170	175	203
CIS	15	15	5	4	5	16
Peru	4	4	4	4	3	4
	189	217	229	338	339	359

**Estimated Japanese consumption by application (t)**

	1998	1999	2000	2001	2002	2003
ITO	60	68	80	117	153	216
Phosphors	6	6	5	8	8	8
Semi-conductors	7	7	8	14	5	6
Batteries	4	4	4	5	5	5
Solder/fusible alloys	11	10	11	8	8	27
Dental alloys	2	2	2	3	3	3
Other	9	9	10	24	29	20
Total	99	106	120	179	211	285

**Japanese indium imports (kg)**

	1998	1999	2000	2001	2002	2003
Belgium	2,906	3,014	3,408	3,286	1,894	2,799
Canada	-	4,004	22,730	20,110	13,830	29,578
China	23,737	42,045	50,296	85,957	75,224	156,062
CIS	7,515	1,361	919	1,295	184	12,862
France	41,763	36,650	49,259	41,605	16,188	5,103
US	7,008	2,404	2,581	10,913	29,987	47,798
Other	2,465	1,731	3,568	7,834	3,167	10,316
Total	85,394	91,209	132,752	171,000	140,474	264,518