

## Features and Interviews

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# Indium: No Screen Test Needed

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### The Nature Of The Metal

Although at number 49 in the periodic table indium lies just one notch up from cadmium, it is not a member of any Toxic Trio.

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| Li | Be |    |    |    |    |    |    |    |    |    |    | B  | C  | N  | O  | F  |  | Ne |    |
| Na | Mg |    |    |    |    |    |    |    |    |    |    | Al | Si | P  | S  | Cl |  | Ar |    |
| K  | Ca | Sc | Ti | V  | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br |  | Kr |    |
| Rb | Sr | Y  | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I  |  | Xe |    |
| Cs | Ba | La | Hf | Ta | W  | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At |  | Rn |    |
|    |    | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |    |  |    |    |
|    |    | Th | Pa | U  | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |    |  |    |    |

As with a number of the strategic metals, though, indium was not only quite a late addition to the table, it was also not used for much until the early part of this last century.

The metal was only “discovered” in 1863 by the duo of German chemists Ferdinand Reich and Hieronymus Richter. It is appropriately named after the indigo blue line that appears when the element is subjected to spectroscopic analysis.

As for its physical characteristics, the metal is a shiny silver color and very soft. Like some of the other strategic metals such as gallium, indium is solid at room temperature but has a relatively low melting point: 313.88 °F (156.6 °C). (Indeed, when indium is alloyed with gallium in the proportions indium 24 percent and gallium 76 percent, the resulting eutectic alloy is [liquid](#) at room temperature—quite useful in situations when you don’t want to use a toxic metal like mercury.)

Although it had already been used to coat mirrors (equal in quality to those made with a coating of silver), indium really only came into its element during World War II, when it was used to coat bearings in fighter aircraft. (When a bearing is coated with indium, any lubricating oil is consequently distributed evenly over its surface.)

But in the last 20-30 years, commercial use of indium has taken off, particularly with the development of flat-panel displays, semiconductors and photovoltaic cells. Production of the metal, too, has increased over this period: In 1989, the [U.S. Geological Survey](#) (USGS) estimated indium refinery production was 115 tonnes; in 2008, that figure had risen to 568 tonnes.

## Whence The Indium

With an [abundance](#) in the Earth's continental crust of 0.05 parts per million (ppm) and its oceanic crust of 0.072 ppm, indium is somewhat more abundant than its lookalike, silver. However, since it does not occur in the same concentrations as silver, indium is never mined in its own right. Instead, like many other strategic and minor metals, indium is mined as a by-product of the production of other ore.

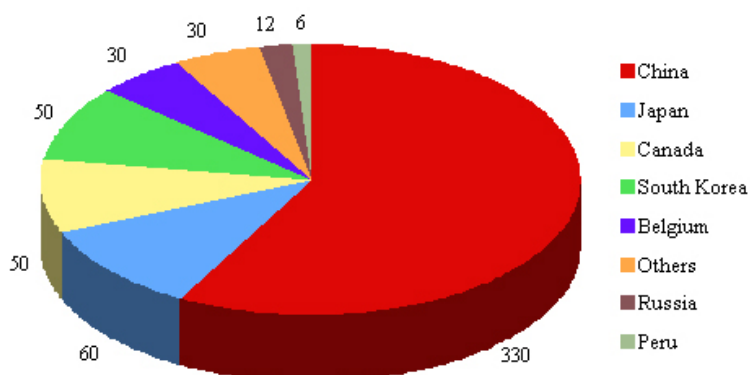
Commercially, "virgin" indium is extracted primarily as a by-product of zinc and tin mining. However, it can be extracted also as a by-product from the production of other metals, including lead, copper and, less extensively, bismuth, cadmium and silver.

Even when it occurs most liberally, indium is an impurity whose concentration can be measured only in ppm. But the technology used to extract the metal has improved so much that it can now be produced from "[concentrations as little as 100 ppm of indium per ton material.](#)"

However, extraction rates remain small: Historically, less than 20 percent of the indium content in concentrates could be extracted, and even with modern technological improvements, producers still can only extract 30 percent of the "1,500 mt of indium mined every year worldwide," says the [Indium Corporation](#) of Utica, N.Y.

As far as refining indium is concerned, according to the USGS, China is the world's largest refiner of the metal, using feedstock either produced domestically or imported from abroad.

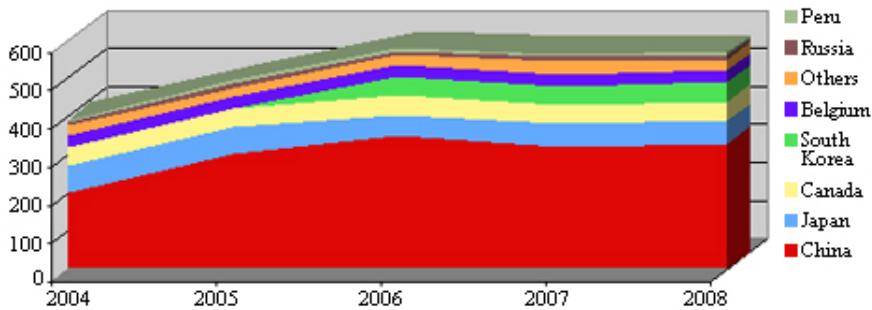
*Indium - Est. Refinery Production 2008 (Tonnes)*



Source: [USGS](#)

Indeed, China, followed by Japan, has held this position for at least the last five years.

**Indium - Refinery Production 2004-8 (Tonnes)**



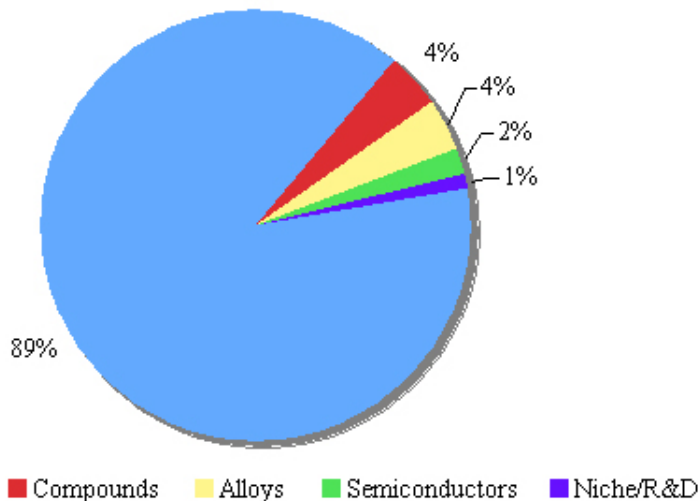
Source: [USGS](#)

Secondary indium, of which around twice as much as the virgin metal is produced each year, is sourced predominantly from recycling the indium-tin oxide (ITO) sputtering targets used to make liquid crystal display (LCD) flat-panel screens. The figure given by the Indium Corporation for such reclaimed indium is some 1,000 tonnes per year. Recycling takes place mainly in China, Japan and Korea where, according to the USGS, “ITO production and sputtering take place.”

### The Many Uses of Indium

By far the major use of indium is in flat-panel displays and, in particular, LCDs. After that, its most important uses are in various compounds, alloys and semiconductors, respectively.

**Indium - End Uses 2009**



Source: [AIM Specialty Materials](#)

Aside from its use in thin films, especially in the ITO form, indium is important in a number of other applications, including:

- **Solder:** Indium is an important ingredient in lead-free solders, as it improves the solder’s resistance to thermal fatigue and lowers its tendency to crack. Since lead-based solder has been banned in many countries, indium has been found increasingly useful for this purpose.

- *Low-Temperature Alloys:* With its low melting point, indium in alloy form can be used to hold high-value items while they are being worked on; for example, turbine blades, or glass lenses as they're being ground. The alloy can then be melted away at a low temperature with no resulting damage to the item it held.
- *Bonding:* Indium is a great “glue,” not only for glass, glazed ceramics and quartz, but also itself.
- *Lamps:* Indium can be used as a light filter in low-pressure sodium vapor lamps.
- *Nuclear Control Rods:* In nuclear reactors, there are four general methods of controlling either the power or flux of neutrons. In addition to the temporary addition or removal of fuel, and using a moderator or reflector, a neutron absorber, or “poison,” can also be used. When indium is alloyed with silver and cadmium (silver: 80 percent, indium: 15 percent, cadmium: 5 percent), the resulting material serves as an effective poison, particularly in pressurized water reactors.

Still, the primary use of indium (consuming some 50 percent of the world's virgin indium and 80 percent of reclaimed indium) is in the ITO, which, when deposited (using a sputtering target) as a thin film on either clear glass or plastic, becomes a transparent electrical conductor.

As a transparent electrical conductor, ITO thin films are found in the LCDs used in TVs, cell phones, computers and other electronic devices. They are also used to make touch screen cathode ray tubes (CRTs) found, for example, in banks' ATMs. And, since ITO works well at both de-icing and de-misting, thin films of it are also applied both to car and aircraft windshields.

In addition to being both electrically conductive and optically transparent, thin films of ITO are ideal for the job as they are also:

- Both stable and long lived;
- Efficiently, rapidly and uniformly etched; and,
- Uniform over wide areas when applied by physical vapor deposition (PVD) using, for example, a sputtering target.

## **Indium Supply And Demand**

While the market price of indium may sometimes not seem to reflect it (it rose from around \$400 per kilo in early December to some \$450-500 per kilo just before the holiday season), there should be enough indium around to supply man's need for the metal for quite some time to come.

In September, Clair Mikolajczak, director of metals and chemicals at Indium Corporation, discussed the future availability of indium, quoting the 2002 *vade mecum* on indium “Indium: Geology, Mineralogy, and Economics” by Ulrich Schwarz-Schampera and Peter M. Herzig, writing “...future increases in indium production are expected to be easily accomplished ... indium could [sic] enjoy virtually infinite growth in use without supply limitations.”

Studies by the company indicate “Western” world indium reserves (“proven and probably, measured and indicated, and inferred”) in “identified base metal mines” of some 26,000 tonnes, with combined reserves in China and the former Soviet Union amounting to some 23,000 tonnes. According to Asian Metal, “China has 13,014 tonnes of indium reserves, scattering [sic] in 15 districts, with Yunnan Prov-

ince accounting for 40%, Guangxi Province 31.4%, Inner Mongolia 8.2%, Qianhai Province 7.8% and Guangdong 7%.”

What’s more, apart from the indium waiting to be extracted when primary metals are mined, considerable quantities of the metal remain to be recovered, both through extraction from unprocessed base metal concentrates and through recycling.

In the first instance, it has been [estimated](#) that of the indium in such concentrates, 30 percent is lost because it never reaches a smelter that can (or will) extract the metal. Of the remaining 70 percent, the final average rate of extraction of the metal is only around 50 percent. Therefore, there is still a great deal of indium-bearing concentrate that could be processed.

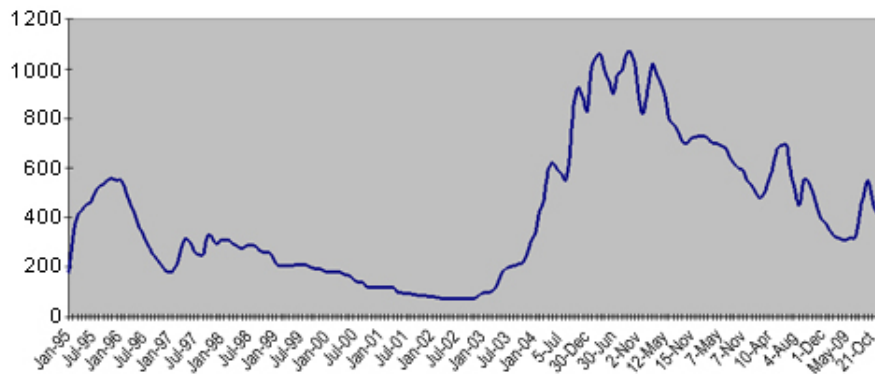
In the second instance, using sputtering to deposit ITO on panels is amazingly wasteful of the sputtering target itself. In the sputtering process, less than 30 percent of the ITO actually ends up stuck to the panel. The remaining 70 percent ends up on the walls of the sputtering chamber, in the grinding sludge and in the “used” target itself. While some of the indium therein can now be recovered (amounting to 60-65 percent of the original ITO target), the remainder still goes to waste. As recovery methods improve, more indium will also, therefore, become available through recycling.

## Prospects For Indium

For the last couple of decades, indium has experienced not only some extreme pricing volatility, but also, at times, various supply concerns. These last have in turn affected the metal’s price.

Over the last 15 years in particular, we’ve seen some significant swings in pricing.

*Raw Indium Price: 1995 - November 2009 (US\$/Kg)*



Source: [AIM Specialty Materials](#)

In particular, recent supply concerns have focused on China. In the past couple of years, various revisions in export quotas and tariffs have led certain major consumers of indium, especially Japan, to reach out to other sources of the metal to secure supply predictability.

In 2008, in addition to the effects from the global economic downturn, matters were not made any easier for Chinese producers when the government canceled “the tolling trade of indium metal.” According to Asian Metal, “the output of reclaimed indium ingot fell from 120tpy to zero,” and the major Chinese recycler of indium had to set up business in neighboring Laos to compensate for the ban. Various other

Chinese indium producers have also been affected by further government moves to protect the environment—moves which look set to continue.

One interesting side effect of the Chinese authorities' actions has been the significant smuggling of indium from China to Japan. From January to October 2008 alone, the differences between Japanese and Chinese statistics appear to indicate that some 21.2 tonnes of indium were smuggled into Japan from China. The smuggled amount accounted for some 41.2 percent of the total volume of the metal coming into the country from China.

While it is understandable that supply concerns may be leading certain major indium users to seek substitutes for ITO, it is far less likely that the price of the metal itself has that much to do with such a decision. Brian O'Neill, indium manager at AIM Specialty Materials of Cranston, RI, pointed out in a presentation in 2004 when the price of indium stood around \$600 per kilogram, "In terms of the cost structure of an LCD panel, the cost of ITO per panel is insignificant. Even at today's elevated indium prices, the cost of indium that is applied to a 32" LCD panel would be <US\$0.55."

Concerns about neither pricing nor supply appear to be affecting too greatly some of those companies that are currently looking to use indium in new and innovative ways.

In the world of solar cells, companies producing thin films using copper, indium, gallium and selenium (CIGS) (see [Gallium: A Slippery Metal](#)) are still betting that their product will win out against not only traditional crystalline solar panels, but also thin films using cadmium telluride (CdTe) (see [Tellurium and Garlic](#)) and amorphous silicon. And for those involved in photovoltaics, the stakes appear to be quite significant. According to a recent [article](#) in The Economist, "...thin film's share of the market has continued to rise: it is now almost half, compared with just 10% in 2004."

Researchers at [Purdue University](#) in Indiana are developing a new type of transistor (called a fin-type field effect transistor—finFET—after its finlike, as opposed to flat, design) using indium, which, if it works, could lead to smaller, faster computer chips. Using indium gallium arsenide instead of the more traditional silicon, the team at Purdue claims to be the first to have produced such a new transistor using atomic layer deposition.

For those involved in chips used in ultra high speed fiber-optic communications, photonic integrated circuits (PICs) appear extremely promising. While silicon does not emit light when an electric current is passed through it, indium phosphide (InP) does. PICs made of the stuff, therefore, are ideal for use in fiber-optic telecoms networks. The newest such chips have been loaded with as many as 200 devices and can transmit data at speeds of up to 1.6 terabits per second.

And when it comes to compound semiconductors, the bonding properties of indium have once more started to come to the fore. According to an [article](#) in The Financial Times in early 2009, "Intel has been actively experimenting with compound semiconductor technology at its research labs in Santa Clara,

California. It has talked about recent breakthroughs in bonding compound semiconductor-based chips onto silicon chips, using indium antimonide (InSb) and indium gallium arsenide (InGaAs)."

## **Investment Opportunities**

Except for investing in the physical metal itself (with all the myriad caveats that go with such an action), there are few opportunities out there to gain any significant exposure to indium.

Unfortunately, the likes of AIM Specialty Materials and the Indium Corporation are privately held. And Umicore Indium Products, which is part of [Umicore](#) (Bloomberg Ticker - UMI:BB) group's "Thin Film Products" division, is just a small part of a very much bigger whole.

Although [Teck Resources Ltd](#) (Bloomberg Ticker - TCK:US) is a big, if not the biggest, indium producer in Canada (it does not disclose its annual indium production), it too treats indium as just a by-product from its base metal mining operations; likewise for other international companies, such as Dowa Mining (part of [Dowa Holdings](#)) of Japan, and [Korea Zinc](#), where indium production is just a sideline, albeit at present, profitable, business.

[Unionmet \(Singapore\) Ltd](#) (Bloomberg Ticker - UMS:SP), out of Singapore, manufactures and trades indium, but only in addition to other zinc-based products. And although the company is headquartered in Singapore, its production facilities and R&D divisions are located in Liuzhou, Guangxi, in China.

Keeping a close eye on the developing technologies now starting to use, or further exploit, indium will certainly prove an interesting exercise. It may also throw up suitable opportunities for investment in companies that go on to prove their worth using the metal.

## Resources

[AIM Specialty Materials](#)

[Asian Metal Ltd](#)

[Hudson Metals Corp](#)

[Indium Corporation](#)

[U.S. Geological Survey \(USGS\)](#)

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