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GALLIUM

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GOVERNMENT OF INDIA
MINISTRY OF MINES
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7 Gallium

Gallium is a soft, silvery-white strategic metal predominantly used in electronics. There is no primary source of gallium in the country. Gallium does not occur as a free element in nature. It usually occurs as trace component in zinc & bauxite ores. It is generally recovered from sodium aluminate liquors obtained in Bayer's alumina process during aluminium production and from residues obtained during zinc processing in some countries. It can also be extracted from polymetallic ores by leaching and also from coal ash and coal. Gallium is also recycled from scrap generated from industries that manufacture Gallium arsenide (GaAs) and Gallium nitride (GaN) based devices. Though India is endowed with bauxite ores in abundance, due to limitation in the viability of economically producing gallium, no production has been reported in the recent past.

USES

Gallium is predominantly used in the Electronic Industry. It has an unusual property that it expands by 3.1% when it solidifies. Gallium based compounds, such as, Gallium arsenide (GaAs) and Gallium nitride (GaN), are used in the production of semi-conductors for use in Electronic Industry. GaAs and GaN are increasingly used in production of light-emitting diodes (LEDs), solar panels and laser diodes. It is also used in the manufacture of memory cells and other optoelectronic devices such as photo-detectors and solar cells. Use of GaAs is expected to increase, especially in Electronics & Communication Industry. Increased use of cellular communications and direct broadcast satellite applications are expected to inflate the demand for gallium.

Gallium is increasingly used in the manufacture of new gallium nitride devices used in high density data storage (compact disk players and digital video disk players), high-quality laser printing, communications and lighting purposes. Gallium nitride power transistors operate at high voltages and with higher power density than current GaAs devices. Gallium nitride is also used as a semi-conductor and in Blu-ray Technology, mobile smartphones and LEDs.

Gallium salts, such as, gallium citrate and gallium nitrate are used in medical imaging as radio contrast agents. The plutonium used in nuclear weapon pits is machined by alloying with gallium to stabilise its phase. It is used as the alloying element in the "Magnetic-shape-memory alloy" Ni-Mn-Ga". Gallium gadolinium garnet (GGG) is used as substrate for a bubble memory device. Gallium is used in some high temperature thermometers and an eutectic alloy of gallium, indium and tin is widely utilised in fever thermometers, replacing mercury. It is also used as a component in low melting alloys and in creating brilliant mirrors.

PRODUCTION

Gallium is recovered as a by-product while producing alumina. Two plants, namely, Hindalco Industries Ltd, at Renukoot, Uttar Pradesh and National Aluminium Co. Ltd at Damanjodi alumina refinery, Odisha, had recovered gallium in the past.

NALCO

NALCO was reportedly in the process of sourcing environment friendly technology for establishing a gallium extraction plant. Nalco has plans to set up 10 tpy gallium extraction plant at its Alumina Refinery in Damanjodi (Odisha). NALCO has targets to produce gallium metal with a purity of 99.99%. In December 2015, NALCO has signed R & D agreement with Chalieco, China for separation of iron concentrate from Red Mud and extraction of Gallium from Bayer Liquor. An MoU was signed with Bhabha Atomic Research Centre (BARC), Mumbai on 10.05.2016 for various R & D projects for gallium recovery from Bayers liquor.

VAL

Vedanta Aluminium Co. Ltd (VAL) reportedly has received offers from Nippon Aluminium in Japan for setting up of gallium plant with a capacity to produce 50-60 tonnes of gallium at an initial investment of 25 crores. The plant is likely to come up at its alumina refinery Lanjigarh in Odisha.

SUBSTITUTES

Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific wavelength applications. The GaAs competes with helium-neon lasers in visible laser diode applications. Silicon is the principal competitor for GaAs in solar cell applications. GaAs-based integrated circuits are used in many defence applications because of their unique properties but these are not effective substitutes for GaAs in these applications. In some bipolar transistor applications, silicon-germanium is used as substitute for GaAs. Researchers are working to develop organic-based LED that may compete with GaAs in future.

WORLD REVIEW

The average gallium content of bauxite is 50 parts per million. The world resources of gallium in bauxite are estimated to be one million tonnes. Besides, substantial quantity is available in zinc reserves. However, only small fractions of the gallium content in bauxite and zinc ores are economically recoverable. New scrap is significant source of supply for gallium principally because the process required to make wafers for a range of gallium products yields a significant amount of scrape. This secondary gallium is produced by a variety of chemical dissolution processes suitable for treatment of scraps obtained from specific sources.

World production of primary gallium in 2015 was estimated to be 400 tonnes. China is believed to be the leading producer followed by Germany, Ukraine, Rep. of Korea and Russia. Hungary & Japan too have reported gallium production. China, Japan, Slovakia, UK and USA were the principal producers of refined gallium.

Gallium was recycled from new scrap in Canada, Germany, Japan, UK and USA. Worldwide, low-grade gallium production capacity in 2015 was estimated to be 730 tonnes. In addition, 200 tonnes as secondary capacity and 230 tonnes as high priority refinery capacity was estimated.

The world demand has been strongest in opto-electronic applications, particularly, in light-emitting displays. The enhanced properties of GaAs-based integrated circuits have enabled its use as substitute for silicon in many defence applications. The cellular telephone market was principally responsible for growth in gallium consumption in the past few years.

World low-grade primary gallium (99.9% pure) production was estimated to be 315 tonnes in 2017, which was an increase of 15% from 274 tonnes in 2016. China, Japan, the Republic of Korea, Russia, and Ukraine were the leading producers of low grade primary gallium.

Primary refined high-purity gallium (99.9999% pure) production in 2017 was estimated to be about 180 tonnes. China, Japan, Slovakia, the United Kingdom and the United States were the known principal producers of high-purity refined gallium. Gallium was recovered from new scrap in Canada, China, Germany, Japan, the United Kingdom and the United States.

World primary low-grade gallium production capacity in 2017 was estimated to be 730 tonnes per year, refined high-purity gallium production capacity was 320 tonnes per year and secondary gallium production capacity was 270 tonnes per year.

USA

Some domestic zinc ores contain up to 50 parts per million gallium and could be a significant resource, although no gallium is currently recovered from domestic ores.

Germany

Germany ceased low grade primary gallium production in 2016.

China

China's primary gallium producers were Aluminium Corporation of China Ltd, Beijing Jia Semi-conductor Material Co. Ltd, China Crystal Technologies Ltd, East Hope Mianchi Gallium Industry Co. and Zhuhai Fangyuan.

China's low-grade primary gallium production capacity has expanded more than four times from 140 tonnes per year in 2010 to 600 tonnes per year in 2015 due to demand from LED - based lighting.

China's low-grade gallium production increased in 2017 to approximately 300 tonnes, 20% more than the estimated 250 tonnes in 2016. Despite the increase in production and prices in China in 2017, low-grade gallium prices were most likely below the operating costs of many producers.

Canada

Orbite Aluminae Inc. announced that construction of its high purity alumina plant (located in Cap-Chat, Quebec), experienced significant delays and that the commercial operation was to commence in 2015. A separation facility was to be built at alumina plant to recover 4 N purity (99.99%) gallium and other rare metals and rare earth elements. Production capacity was 90 tonnes per year of primary gallium.

FUTURE OUTLOOK

The demand for gallium is likely to increase with the growth of Electronic Industry in the country. Strategic importance of gallium has raised the imperative demand for development of indigenous technology and also the need for collaboration with foreign countries for refining and improving production of gallium. Zinc deposits, as an alternative source, may attract attention in the future, when the present accessible sources would deplete.

India has potential for increasing alumina production with greenfield export-oriented plants which can contribute substantially in meeting the domestic demand of gallium by establishment of gallium recovery units.

The value of worldwide GaAs device consumption increased slightly to exceed $7.5 billion in 2016 owing to a growing wireless telecommunications infrastructure in Asia; growth of feature-rich, application-intensive, third- and fourth generation (3G, 4G) "smartphones," which employ up to 10 times the amount of GaAs in standard cellular handsets; and robust use in military radar and communications applications.

Cellular telephone applications accounted for approximately 53% of total GaAs device revenue and wireless communications accounted for 27%. Various automotive, consumer, fiber-optic and military applications accounted for the remaining revenue.

Installation of 3G and 4G mobile networks in India and the Republic of Korea is expected to further increase sales of smartphones. Additional increases in GaAs demand will also result from new Wi-Fi applications, such as point-to-point communications, smart meters and tablet personal computer technologies.

Market research firm Strategy Analytics Inc. forecast that while commercial GaAs device sales would increase by less than 5% per year through 2018. Military GaAs device sales are expected to increase by approximately 13% per year through 2018 owing to increasing use of GaAs technologies in radar, electronic warfare, communications and other military applications. The largest use of military GaAs devices is expected to come from radar applications, accounting for approximately 60% of GaAs military market revenue.

Yole Developpement forecast that the Radio Frequency (RF) GaN device market would increase by 14% per year between 2016 and 2022 owing to increased adoption of GaN technology in wireless infrastructure and defence applications, as well as implementation of new fifth generation (5G) networks beginning around 2019. High-frequency RF applications over 3.5 gigahertz, including military radar and electronic warfare systems, commercial wireless telecommunications and Cable Television (CATV) applications, require the high voltage and high power capabilities of GaN devices. GaAs and silicon devices cannot operate at such high frequencies.

Owing to significant expansion of Light Emitting Diode (LED) manufacturing capacity, reduced prices and Government incentives, the global LED market is expected to increase by 17% per year between 2016 and 2020. General lighting is expected to remain the largest segment of the LED market for the rest of the decade, followed by backlighting and automotive lighting. The Asia-Pacific region is expected to remain the leading consumer of LED material owing to rapid construction in many Asian countries, Government incentives to encourage use of energy-efficient lighting, and the presence of the majority of the LED industry.