1st Stakeholder Consultation – Compilation of initial substance information for indium phosphide (CAS 22398-80-7; EC 244-959-5)

Indium phosphide industry comments to 2018 Stakeholder Consultation 1 in the frame of the Study to support the review of the list of restricted substances and to assess a new exclusion request under RoHS 2 (Pack 15)

Introduction

The Minor Metals Trade Association (MMTA) wishes to input to the 1st Stakeholder Consultation on indium phosphide (CAS 22398-80-7; EC 244-959-5), which has been included in the list of seven shortlisted substances to be initially evaluated. The information provided is based on input from a cross-section of InP industry experts, drawn together by the MMTA, acting in support of one of its constituent industry sectors.

Firstly, industry participants highly recommend coordination with other EU policies, in particular Critical Raw Materials. Indium is listed on the 2017 list of Critical Raw Materials for the EU (COM(2017) 490 final)2. Materials appearing on this list have been identified as critical for the EU because of their importance to the economy and therefore warrant consideration of any supply risks. From previous studies it has been concluded that Europe is a nett exporter of indium, so the risk of supply disruption is small. We consider that the substance would be best discussed in the context of CRM initiatives under the wider framework covering overall circular economy policy *before* commencing studies under RoHS, in view of the identified industrial and economic importance.

Additionally, we wonder why this substance is included in this study, given the lack of data justifying its nomination as "priority substance under RoHS". Examples provided refer solely to data on indium, including reference to most of global indium consumption (stated as 723 metric tonnes in 2015) being accounted for by the production of indium tin oxide (ITO) for flat screens and also in the production of lead-free solders.

The key points the industry wishes to stress in this submission are that volumes are several decades lower than estimated in the background document, that the use of indium phosphide is critical and irreplaceable in its key applications, and that any inherent risks are well managed.

1. Applications in which indium phosphide is in use

Compound semiconductors provide the core photonics technology behind the Internet of Everything and all Big Data systems. InP technology is key to the entire internet infrastructure.

Fiber optic communications are by far the most important and critical current use of InP. Indium phosphide is a III-V semiconductor with much higher electron mobility than silicon. InP is mainly used in high power and high frequency optoelectronic devices including laser diodes, LED, photo detectors, optical transceivers, which are operating in optical fiber communication systems. These devices, along with InP based transistors, are fabricated by the epitaxial growth of III-V ternary and quaternary compound semiconductors on InP substrates.

It should also be noted that InP-based tele- and data-communication systems offer unprecedented and several orders of magnitude higher energy efficiencies, and lower environmental impact, compared with legacy/incumbent systems e.g. copper. This aspect is fast-becoming paramount in

being able to support the continued explosion of growth[1] of data transmission and storage requirements to Zettabyte levels in the next few years.

Examples of other applications of InP include:

- Data centre communication systems
- RF/satellite communications
- Night vision/military applications
- Wireless devices
- Power control systems
- Gas detection
- A wide range of sensors
- LIDAR (Light detection and ranging) for autonomous and assisted vehicles is a fast-growing market

Indium phosphide is critical to enabling high value supply chains in a range of sectors including:

- Automotive
- Robotics
- Communications
- Energy Efficiency
- Internet of Things
- Security
- Healthcare
- Aerospace

It should also be noted that the application of InP in professional test and measurement equipment is critical for the continued development, qualification and manufacture of both current and next generation communications optical/photonic fibre network applications. Any potential restriction in the use of InP applicable to professional test and measurement equipment will therefore impact innovation of the next generation of such devices and limit any investigation into substitution possibilities across all EEE sectors.

Indium phosphide manufacture is a tightly controlled process and the materials used are valuable, so great care is taken to collect and recycle materials arising from the production process. The process materials which cannot be used are shipped under controlled regulations to a licensed recycling facility which recovers the metal and returns value to the indium phosphide wafer manufacturer. Records are kept of each shipment, so full traceability is ensured. The recovered metal is then refined for use in this or other applications.

2. Quantities and ranges in which indium phosphide is in use

Estimates given by Oeko Institut in the guidance document are far from accurate, including conflating of indium metal, ITO and InP.

[1] https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html

For the purpose of this submission, our focus is on the following applications and quantities placed on the EEA market annually:

Photonic applications:

- Fiber-optic networks, wireless base stations and satellite communications - annual EU/EEA consumption 9-10KG
- Other laser and sensor applications, LIDAR autonomous driving, vehicle emissions testing, spectroscopy analysis for food, chemical analysis - annual EU/EEA consumption 6KG

Electronic semiconductor applications:

- High speed (Terahertz) Hetero-junction Bipolar Transistors in measurement analysers and non-military radio frequency communications - annual EU/EEA consumption 8Kg

This gives a total annual EU/EEA consumption of approximately 24KG of InP contained. Working on the estimate that EU/EEA represents between 20-25% of the global market, this would mean a global total of between 96 and 120KG per year.

From a survey of our members, we have an estimate of roughly 25KG per annum of InP being delivered to the European market as part of fiber-optic systems and test & measurement systems. This number does not include military, aerospace or automotive applications, which are not covered by our co-signatories.

Military uses of InP in laser guidance systems including guided weapons and THz HBT transistor semiconductors in communications and decision-making applications are almost certainly far greater than uses in EEE products within the scope of RoHS.

The amount of InP used in an individual optoelectronic component is also very small, averaging between 0.23 and 1 mg.

During the manufacturing process a proportion of the InP wafer is ground away and the backgrind slurry is safely disposed of as hazardous chemical waste using a specialist chemical disposal company. Any whole, unused wafers are sent to a specialist company for re-use. Neither of these raw material process waste streams are within the scope of RoHS.

As amounts of indium phosphide in finished products are very small, compared to the amount purchased, it is considered to present a low risk to recycling workers handling the end of life electronic products.

3. Potential emissions in the waste stream

The vast majority of InP is in optical communication devices, being managed by professional users in large facilities e.g. data-centres, proficient in managing any risks and end of life waste issues. There is confidence that negligible amounts would come into contact with consumers, and that any risks are well managed. If fiber into the home becomes more widespread, domestic premises might

contain miniscule amounts (approximately 1mg) of InP, but the telecommunications box would remain the property of the provider and would, therefore, be managed by them.

As stated, the amounts of InP contained in finished products are extremely small, and InP is not a declarable substance; therefore, recyclers would be unlikely to be specifically notified of its presence. The general methods used to treat PCA (printed circuit assembly) waste are those used to process any electronic device that contains an indium phosphide based integrated circuit on the PCA.

Under the restriction of hazardous substances, WEEE requires authorised treatment processes: authorised waste recyclers must be used, with the employment of respiratory protection as standard.

To our knowledge, there are no special engineering controls in place during electronics recycling to specifically collect and treat InP waste, however shredding / mechanical-processing dust is captured by recyclers using baghouses, thus mitigating risks of inhalation during production, and is sent to smelters for recovery. In this way, a variety of materials in electronics that can cause respiratory issues are mitigated. Even the smallest particles generated during the shredding process are more than adequately contained by the use of standard PPE equipment.

Air monitoring and blood testing programs are also employed by recyclers, but are more likely to be targeted towards key/legacy-risk heavy metals (e.g: lead, beryllium, cadmium, chromium, mercury).

The industry is seeking an exclusion to RoHS for this substance.

Suppliers of InP wafers include:

AXT – China

InPACT - France

JX Nippon Mining and Metals Corporation, (ACROTEC brand)

Sumitomo – Japan

Wafer Technology – UK (subsidiary of IQE)

Vital Materials – China

For additional reference:

- https://www.relightitalia.it/en/follow-up/projects-and-cooperation/160-reclaim
- http://www.aqua-t.co.jp/english/technique/rare-metal.html
- http://pmr.umicore.com/en/recyclables/electronic-scrap

4. Substitution

Indium phosphide has unique properties and no viable substitutes are on the horizon.

The Oeko Institut background documentation suggests several substances for which InP might itself be a substitute; it is, however, incorrect to state that gallium arsenide (GaAs) is a viable substitute for InP, except potentially in some minor applications. In fact, InP was introduced as a substitute for GaAs in the past, as it was found to have better performance. It should also be noted that GaAs has a comparable risk profile to InP.

Currently, InP is the only substance viable for its existing uses in semiconductors. InP is the unique material for substrates of III-V ternary and quaternary compound semiconductors which have a direct energy bandgap of 1.344 eV and can cover the wavelength range from 0.9 µm to 2 µm. There is no alternative available, as InP is the only material to make the laser at the required wavelengths.

In the photonics/optical communications field, silicon can perform some of the functions of InP, but as silicon does not emit light, InP is still needed, so this is not a solution. Indeed, the silicon and semiconductor industries work together and complement each other, providing increasing integration.

In the data centre applications, it should be noted that silicon germanium technology has some limited functions, however, it is unsuccessful where there are greater distances between individual data centres.

There is no substitute to InP with equivalent performance and, given its economic importance, indium has been classified a Critical Raw Material (CRM) to the EU.

5. **Socio economic impact of a possible restriction**

Industry representatives are confident that quite simply put, telecommunications networks delivering the global internet, would not survive without the use of InP, and that it is essential for the current and future digital landscape.

Global communications networks operate through the use of InP lasers that connect switches and routers within and between data centres and throughout the global Internet. European companies help support a global EUR 25 billion industry in optical networking equipment and components, which supports a nearly EUR 3 trillion global industry in telecommunications services. This does not include European jobs and revenues associated with e-commerce, social media, streaming entertainment, and other online businesses. It is even realistic to say that nearly the entire European economy of EUR 15 billion, and the entire EUR 67 trillion global economy, depends in some way on InP-based optical communications, because nearly every business today is somehow connected to cloud-based and other networking services.

Any socio-economic assessment would need to consider the viability, availability and reliability of parts and/or products employing substituted materials.

6. **Further information and comments**

We would like to take this opportunity to clarify that Quantum Dots are not used in optoelectronics that are specific for fiber optics data transfer and telecommunications. Quantum Dots are used to enhance the colour gamut in flat-panel displays. This is a totally different technology.

In summary, telecommunications, including the global internet, data centres, the cloud, all data transfers, mobile 4G and 5G, all require fiber optic infrastructure, and there are no alternatives to indium phosphide. Without InP, the technological clock would need to be turned back 40 years. The

global economy is completely reliant on digital communications, and its disappearance is impossible to imagine.

Indium phosphide presents an enormous economic benefit, and with such low volumes consumed globally, any risks from its use are minimal, not forgetting the risk factors of potential alternatives, however inadequate.

As such, the aim of the users of indium phosphide is to have it removed entirely from the scope of this consultation and for it to be excluded from the scope of RoHS.

Yours faithfully,

Signed on behalf of the below listed organisations

Maria Cox

General Manager, Minor Metals Trade Association

Logo	Organisation	Contact
mmta Minor Metals trade association	The Minor Metals Trade Association (MMTA) is a not-for-profit organisation, which serves to benefit and promote the interests of its international Membership, comprising companies actively involved in all aspects of the international minor metals sector. The MMTA is the world's largest association focused exclusively on minor metals, and is comprised of over 140 companies from across the globe, engaged in all aspects of minor metals activity. The association works together with and on behalf of its members, to promote the importance of minor metals and inform on the issues affecting their trade, availability and use. Over 60% of MMTA members are European based companies. The MMTA has members in over 20 countries.	Maria Cox General Manager Minor Metals Trade Association 1st Floor, 33 Queen Street London, EC4R 1BR, UK Tel: +44 (0)207 833 0237 maria@mmta.co.uk www.mmta.co.uk
InPACT	InPACT S.A. 265 Route de la Volta 73600 Moutiers France	Didier Marsan CTO Tel: 33 4 79 24 47 80 Email: didier@inpactsemicon.com

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IQE	IQE has been at the forefront of the compound semiconductor industry for more than thirty years. The Group is clearly recognised as the leading global supplier of advanced wafer products and wafer services to the semiconductor industry, products used by major global chip companies enabling a wide range of high-tech applications. The unique properties of these materials enable a diverse range of markets including wireless communications, advanced solar power (CPV), high resolution infrared systems, high efficiency LED lighting, efficient power switching and a range of consumer and industrial applications using advanced photonic lasers and detectors.	Iwan Davies, Group Technology Director IQE plc, Pascal Close, Cardiff CF3 0LW UK idavies@iqep.com www.iqep.com
EPIC European Photonics Industry Consortium	EPIC is the industry association that promotes the sustainable development of 370 organizations working in the field of photonics in Europe. We foster a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement. EPIC publishes market and technology reports, organizes technical workshops and B2B roundtables, supports EU funding proposals, advocacy and lobbying, education and training activities, standards and roadmaps, pavilions at exhibitions.	Carlos Lee, Director General, EPIC carlos.lee@epic-assoc.com www.epic-assoc.com
PHOTONICS21	The European Technology Platform Photonics21 unites the majority of the leading photonics industries and relevant R&D stakeholders along the whole economic value chain throughout Europe. Today Photonics21 has more than 2500 members and aims to establish Europe as a leader in the development and deployment of photonics technologies within the various applications fields such as ICT, lighting, industrial manufacturing, life science, safety as well as in education and training.	Markus Wilkens, Photonics 21 Wilkens@vdi.de secretariat@photonics21.org https://www.photonics21.org
PHOTONICS LEADERSHIP GROUP	The PLG aims to work with stakeholders from across the UK Photonics industry, including major industrial manufactures and exporters, globally leading researchers, high growth SMEs and support agencies. **Photonics** encompasses all of the technologies, products and processes around the emission, manipulation and detection of light, providing the key functionality in a vast range of products e.g. fibre optics powering the internet and instrumentation essential to modern healthcare. Photonics is a global market (€300bn) and is forecast to grow by 8-10% annually to €550bn by 2020.	John Lincoln, CEO, PLG john.lincoln@photonicsuk.org https://photonicsuk.org/
OSA Industry Development Associates	OIDA (OSA Industry Development Associates) serves and represents the optics and photonics community, with over 265 corporate members. It is a division of OSA, the Optical Society. Since 1916, OSA has been the world's leading champion for optics and photonics, uniting and educating scientists, engineers, educators, technicians and business leaders worldwide to foster and promote technical and professional development.	Tom Hausken, OIDA and OSA—The Optical Society thausken@osa.org

III-V lab	III-V Lab is an industrial Research Laboratory created in 2004 by Alcatel-Lucent (now Nokia) and Thales. Nokia is one of the leaders in communication technologies (mobile, fixed, IP and Optics technologies), applications and services, while Thales is a major electronic systems company acting in areas such as defence, aerospace, information technology, and transportation. In 2010, III-V Lab was extended with the entrance of the LETI from CEA in the capital. III-V Lab conducts R&D activities in the field of micro/nano-electronics and photonics semiconductor components for different application, telecoms, space, defence, security, safety, etc.	Mohand Achouche Director III-V Lab 1, Avenue Augustin Fresnel 91767 Palaiseau France Mohand.achouche@3-5lab.fr www.3-5lab.fr
OCLARO	Oclaro is a provider and innovator of optical communication solutions for the core optical, enterprise and data center markets. Oclaro's optical components, modules and subsystems are at the heart of the fast optical networks and high-speed interconnects driving the next wave of streaming video, cloud computing, voice over IP and other bandwidth-intensive and high-speed applications. For the year ended July 1, 2017, our revenue was $601.0 million	Carol Ann Cooper Manager, Product Environmental Oclaro, Caswell, Towcester, Northamptonshire, NN12 8EQ, U.K. Telephone +44 (0)1327 356346 carolann.cooper@oclaro.com | www.oclaro.com
HUDSON Metal & Alloy LLC	Hudson Metal & Alloy LLC is a leading international supplier of minor metals, noble alloys, and rare earth elements to the the global superalloy, energy, and optoelectronic industries, and beyond.	Noah Munro Lehrman Senior Vice President hudson@hudmet.com www.HudsonMetals.com
INDIUM CORPORATION	Indium Corporation is a developer and manufacturer of Indium based products and has been at the forefront of the electronics and semiconductor industry for the last 84 years. During this time the range of products and integration with industry has steadily increased and Indium Corporation are currently a major worldwide supplier to the semiconductor industry for several process needs, including wafer manufacture (InP, InSb) and epitaxy processes. Established in 12 locations worldwide and with a skilled workforce of over 800 people, Indium Corporation is working on future development with its industry partners in a wide variety of advanced technology markets.	Malcolm Harrower Global Sales Manager Indium Corporation of America 34, Robinson Road, Clinton NY 13323 USA mharrower@indium.com www.indium.com
VITAL	Vital Materials is a global rare metals oriented materials technology group. Its products cover more than 100 rare metals and their derivatives including Se, Te, In, Ga, Ge, Bi, Cd their oxides, alloys and compounds etc , which are widely used in both general and high-tech industries. By following its unique vertical integration strategy, is dedicated to developing	Frank Boghe Business Manager tel: +32-497.918.001 Pegasuslaan 5 1830 Diegem

	advanced materials and technologies for fast growing, high tech industries in clean energy, LED, communications, infrared detection, laser, fibers, healthcare, etc. Vital Materials, by providing customized closed loop recycling solutions, is committed to being a responsible and sustainable materials technology group.	BELGIUM frank.boghe@vitalchem.com www.vitalchem.com
ESIA European Semiconductor Industry Association	The European Semiconductor Industry Association (ESIA) is the voice of the Semiconductor Industry in Europe. Its mission is to represent and promote the common interests of the Europe-based semiconductor industry towards the European Institutions and stakeholders in order to ensure a sustainable business environment and foster its global competitiveness. As a provider of key enabling technologies the industry creates innovative solutions for industrial development, contributing to economic growth and responding to major societal challenges. Being ranked as the most R&D intensive sector by the European Commission, the European Semiconductor ecosystem supports approx. 200.000 jobs directly and up to 1.000.000 induced jobs in systems, applications and services in Europe. Overall, micro- and nano-electronics enable the generation of at least 10% of GDP in Europe and the world. ESIA is an industry association under the EECA umbrella. EECA is registered in the EU Transparency Registry: 22092908193-23	Shane Harte ESH & Sustainability Manager European Semiconductor Industry Association 11/13 rue de la Duchesse, 1150 Bruxelles, Belgium. E-mail shane.harte@eusemiconductors.eu
nmi Electronics Manufacturing	NMI are a Trade Association for the Electronics & Microelectronics Industry. NMI is a membership service of TechWorks Hub Ltd	Chris Bennett Director of Manufacturing Services Mobile - +44 7739 427767
DIGITALEUROPE	DIGITALEUROPE represents the digital technology industry in Europe. Our members include some of the world's largest IT, telecoms and consumer electronics companies and national associations from every part of Europe. DIGITALEUROPE's members include in total over 35,000 ICT Companies in Europe represented by over 60 Corporate Members and 38 National Trade Associations from across Europe. http://www.digitaleurope.org	Lara Visser Senior Policy Manager DIGITALEUROPE lara.visser@digitaleurope.org http://www.digitaleurope.org
soitec	Soitec is a world leader in designing and manufacturing innovative semiconductor materials. The company uses its unique technologies and semiconductor expertise to serve the electronics market. With more than 3,000 patents worldwide, Soitec's strategy is based on disruptive innovation to answer its customers' needs for high performance, energy efficiency and cost competitiveness. Soitec has manufacturing facilities, R&D centers and offices in Europe, the U.S. and Asia.	Cécile Lacroix Partnership Program Manager Soitec Parc technologique des fontaines, 38190 Bernin, France. cecile.lacroix@soitec.com www.soitec.com