ANIE Federation contribution on Indium phosphide

Background and contact information

ANIE is the **Italian federation of electronic and electro technical industries** and represents **1.300 companies** operating in Italy. The sector employs **468.000 employees** with an aggregate turnover (at the end of 2016) of **74 billion euros**.

Firstly, we wonder why Indium Phosphide – InP has been included in this study, given the lack of data justifying its classification as "*RoHS priority substance*". 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. As industrial associations we would like to underline that volumes are far 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.

Additionally we would like 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 LCDs. 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 development would be turned back of 40 years.

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 excluded from the scope of RoHS Directive.

For specific question on the content of the document please contact ANIE Environment and Technical Legislation Department: ambiente@anie.it , **Tel. +39 023.264.317, Viale V. Lancetti, 43 – 20158, Milano.**

Applications

Fiber optic communications are by far the most important and critical 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 are fabricated by the epitaxial growth of III-V ternary and quaternary compound semiconductors on InP substrates. **Compound semiconductors** provide the core photonics technology behind the Internet of Things and all Big Data systems. InP technology is the core technology for the entire internet infrastructure.

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

As told before Indium phosphide is critical to enabling high value supply chains in a wide range of sectors such as: automotive, robotics, communications, Energy Efficiency, Internet of Things, security and 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.

Quantities and ranges

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

Substitution

The 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.

Potential emissions in the waste stream

The vast majority of InP is in optical communication devices, being managed by professional users 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

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electronic device that contains an indium phosphide based integrated circuit on the PCA. Under the restriction of hazardous substances, WEE 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).

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