



## **Arsenic and Gallium Arsenide are fundamental to Semiconductor (Microchip) Manufacturing**

Arsenic is the fundamental critical element of the periodic table of elements (As, 33) which is used in the manufacturing steps for semiconductor production. The continued usage of arsenic doping in the production process for semiconductor devices in tiny (atomic) amounts is essential. Semiconductor devices are the enabling technology for the IT revolution and form the key parts of all electronic and electrical equipment.

### **Gallium Arsenide- Arsenic Compounds**

The proposed new chapter on the prohibition of certain hazardous substances in consumer products, which lists arsenic and arsenic compounds, would essentially restrict the sales of a wide variety of current and next generation wireless communication devices in Norway. Gallium arsenide (GaAs) is a compound of the two elements, gallium and arsenic. It is a fundamental compound semiconductor material and forms the core substrate for semiconductor technology. The proliferation of consumer communication products such as digital mobile phones, personal communication systems, GPS navigation units, satellite and fiber optic communications and wireless networks have driven demand for semiconductor devices manufactured with GaAs. Semiconductor technology devices based on GaAs circuitry are a key element of many wireless and wi-fi consumer electronic products.

### **Arsenic is rigorously managed in the semiconductor manufacturing environment and there is no consumer exposure**

The use of arsenic as a component of GaAs in semiconductor manufacturing does not pose a threat to the human health or the environment due to the closed system manufacturing and the stringent manufacturing controls in place in semiconductor factories using GaAs. The use of GaAs as a semiconductor wafer material is stringently monitored and highly regulated. There is no arsenic exposure potential for the consumer during the use phase of the electronic product, e.g the mobile phone. The end of life phase of the mobile phones and other electronic products are covered by the EU WEEE directive and therefore potential environmental exposure is minimized.

### **Why are GaAs a core technology for a range of communication applications including current and next generation mobile handsets and Wi-Fi applications, opto-electronics, and control systems?**

GaAs have many technical advantages which ensure a high volume demand for advanced communication systems and wireless applications in particular. The lower knee voltage of GaAs circuitry offers higher efficiencies and output power at lower voltages. It has a higher saturated electron velocity and higher electron mobility, allowing better high frequency

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<sup>1</sup> The ESIA, part of the European Electronic Component manufacturer's Association (EECA), represents the European-based manufacturers of semiconductor devices. The semiconductor industry provides the key enabling technologies at the forefront of the development of the digital economy. In Europe, the semiconductor market was valued at around EUR31.8bn in 2006.

performance. GaAs devices generate ultra low noise when operated at high frequencies thus ensuring improved signal reception. They can also be operated at higher power levels than the equivalent silicon device because they have higher breakdown voltages. GaAs have a direct band gap, which means that it can be used to emit light. GaAs also demonstrate potential in opto-electronics for application in medical systems and especially in high brightness light emitting diodes (LED) and laser diodes. LED (light emitting diodes) producers use GaAs as a substrate. LED's are the current and future lighting sources of most display technologies and are a key alternative to less energy efficient alternatives. These electronic properties of GaAs circuitry enable its use in most mobile phones for the power amplifiers and switches. GaAs are also commonly used in satellite communications, microwave point-to-point links, and some defence and radar systems. All these specific technical aspects of GaAs ensure improved material and energy efficiency, whilst ensuring quality and high performance products for the final consumer.

### **Use of Arsenic in Silicon based semiconductor manufacturing**

Arsenic is one of the critical elements used in the manufacturing of silicon-based semiconductors. Arsenic is the fundamental physical building block for all semiconductor devices. Due to the unique characteristics of arsenic doping chemistry there are no replacement elements for arsenic. In its intrinsic state, silicon is not very useful for building an integrated circuit because it does not carry an electrical current very well (high resistivity). Its molecular and electrical properties must be changed in order to increase its conductivity. Adding elements that have “extra” electrons in their outer shell accomplishes this objective. Within the semiconductor industry, this process is commonly referred to as “doping.”

### **Alternatives do not exist for Arsenic in semiconductor manufacturing**

Arsenic, phosphorus, antimony and boron are all used for doping semiconductors. These elements each produce unique electrical conductivity properties when used as dopants. As a result, they are not interchangeable. Arsenic is critical for integrated circuits with very small features, such as microprocessors, memory devices, networking applications, and many others. No other element has both the low diffusion rate and the necessary electrical properties needed to make silicon into a highly complex integrated circuit. The amount of arsenic in a semiconductor device is typically very low, in the atomic range. Furthermore, the tiny amounts of arsenic present in the semiconductor pose no exposure risk to the consumer of the final electronic product. These trace amounts of arsenic are chemically bound in the silicon crystal and then encapsulated in SiO<sub>2</sub>. The semiconductor device is further encapsulated in a final package to both physically protect the device and to create a practical means of attaching the device to a printed circuit board.

### **Arsenic is rigorously managed in the manufacturing environment**

Arsenic can be used in either a solid and gaseous form in semiconductor manufacturing. It is typically introduced into the silicon in a vacuum chamber through a process called ion implantation. Arsenic use is strictly controlled and monitored to prevent human exposure. This is accomplished through application of a combination of technologies, including sealed tools, negative air pressure, constant monitoring, automatic shutdown capability, and containment. Arsenic has been used as a dopant in the silicon based semiconductor industry for decades now, and it is a well characterized material and the safety issues of handling this material as well as the environmental impact of this material in manufacturing and end of life have been addressed to the satisfaction of regulatory agencies. The consumer impact in use is

not a concern since the amount of Arsenic is very very low in a semiconductor chip, in addition the Arsenic is stable in the chip, and does not pose a release threat. There is no concern for inhalation, or ingestion in an encapsulated silicon based semiconductor device used by the consumer under normal operation and within the product specifications.

Arsenic is a naturally occurring element in the ores used in the manufacture of solders and is not intentionally added. Arsenic is also found as a trace element in the metal alloys used for solder in concentrations that are higher as the proposed maximum concentration.

**ESIA believes that for all these reasons it is imperative that the proposed prohibition on arsenic and arsenic compounds should not apply for all consumer products in which semiconductor devices can be found, including electrical and electronic products.**

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