Plessey Semiconductors – Permit Variation Non-Technical Summary

Prepared by: Arthian Ltd

For: Plessey Semiconductors Limited

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1. Non-Technical Summary

1.1 Introduction

Plessey Semiconductors Limited (Plessey Semiconductors), a subsidiary of Haylo Ventures Limited, is a UK-based company that specialises in research into novel semiconductor products and their pilot-scale manufacture. Plessey Semiconductors is focussed on the development of microLEDs (micro light-emitting diodes), arrays of which can be used in a wide range of modern display technologies, including: televisions, smartphones and tablets, head-up displays, and Augmented Reality (AR) and Virtual Reality (VR) devices.

Plessey Semiconductor's principal research facility, which also serves as the company's headquarters, is located at Roborough near Plymouth. The site features a range of production, assembly, development and analytical equipment operating in ultra-clean environments. Plessey Semiconductors solely undertakes research activities and pilot-scale manufacturing processes; large-scale production is undertaken by third parties at dedicated fabrication plants.

The Roborough site currently has the capacity to produce microLED arrays on Silicon substrates and at its maximum throughput can process around 17,000 substrate wafers per annum. Each wafer is subjected to an iterative series of process stages during which various materials – including metals, insulators, and semiconductors – are precisely deposited on the surface of the wafers and then selectively etched away. Repeated deposition and etching stages allow the orderly build-up of complex, layered electronic circuits, ultimately forming the desired microLED arrays.

The processing stages involved in microLED manufacturing utilise a wide range of chemical reagents. As a result, the Roborough site is regulated as a Part A(1) chemicals installation by the Environment Agency (EA) under the terms of an Environmental Permitting Regulations 2016 (EPR) permit (Ref: EPR/BX1586IH).

This report provides a brief explanation of a number of proposed changes to operations at the Roborough installation, the methods used to minimise emissions resulting from these changes and how Plessey Semiconductors will operate the site to ensure that the changes do not have an adverse environmental impact.

1.2 Proposed Variation

Devices based on the microLED technology are currently an active area of research and development as they offer a range of performance characteristics which would make them suitable for wide-scale adoption in consumer electronic display devices. Plessey Semiconductors is actively researching the use of novel substrate materials in microLED fabrication at the Roborough site and it is now intended to extend the production capabilities of the site to allow the pilot-scale manufacture of devices based on Gallium Arsenide (GaAs) substrate wafers. Semiconductors such as Aluminium Gallium Indium Phosphide (AlGaInP) when deposited on GaAs substrates may be used in the fabrication of LEDs with a broad colour emission palette, including red and orange wavelengths which have been difficult to achieve with current technologies.

The production of microLEDs based on Gallium Arsenide (GaAs) substrates will be complementary to the existing research and manufacturing processes at the Roborough site, based on Silicon substrates. There will be no change to the total number of wafers that will be processed at the site each year.

Much of the processing of the Gallium Arsenide substrate wafers will be achieved using the existing equipment already installed at the Roborough site. However, the deposition of semiconductor layers on the Gallium Arsenide wafers will necessitate the addition of a pair of new dedicated production reactors. These two reactors will utilise the Metalorganic Chemical Vapour Deposition (MOCVD) technology to deposit layers of Aluminium

Gallium Indium Phosphide on the Gallium Arsenide substrate. The new reactors will use a range of chemical reagents not currently stored or utilised in the installation, including Arsine (AsH_3), Phosphine (PH_3) and Trimethylindium ($In(Ch_3)_3$). Given this, it is considered that the new reactors will constitute a regulated activity under the Environmental Permitting Regulations, and that the addition of this activity necessitates a substantial variation to the site's environmental permit.

1.3 Process Description

The manufacture of microLEDs is a cyclical process involving:

- Deposition of semiconductor layers on the required substrate material;
- Photolithography, a photographic process used to transfer an electronic circuit pattern onto the surface of the substrate wafers;
- Etching, in which areas of the deposited semiconductor layers are selectively removed from the substrate wafers in accordance with the transferred circuit pattern created in the photolithography step.

Repeated cycles of deposition, photolithography and etching allow the controlled build-up of complex circuit designs on the substrate wafers.

Much of the installation will be unaffected by the proposed variation, but two new deposition reactors at the site (two Aixtron G10-AsP reactors) will be added to the site, which will be dedicated to microLED production on Gallium Arsenide substrates. The new reactors will be based on the Metalorganic Chemical Vapour Deposition (MOCVD) technique and will be located at the northern end of the FAB3 fabrication area of the plant.

The new reactors will make use of existing infrastructure in FAB3, including the closed loop process cooling water system and the existing exhaust extraction system for pyrophoric gases (emission point A3 in the site's Environmental Permit). New gas handling systems will be added for the management of the additional reagent gases to be used in the reactors, along with dedicated abatement systems for control of the emissions to air from the process.

1.4 Emissions

1.4.1 Point Source Emissions to Air

There are sixteen emission point to air specified in the Roborough site's environmental permit and the proposed variation will affect emissions from only one of these, the FAB3 pyrophoric extraction system, designated emission point A3.

The exhaust gases from each of the two new Aixtron reactors will be abated using a two-stage abatement system provided by CS CLEAN SOLUTIONS GmbH, a well-established technology provider to the semiconductor industry. The two stages are:

- a CS CLEAN CLEANSORB PRIMELINE absorption system, which uses absorber columns packed with a bespoke absorption medium designed to chemically react with the reactive materials in the MOCVD exhaust gases; and
- a CS CLEAN PCS EXO Plasma Conversion System, which uses a plasma technology to safely combust any residual flammable gases in the reactor exhausts.

Following abatement, the new reactors will then exhaust into the FAB3 pyrophoric extraction system. The predicted maximum abated emissions have been provided by the abatement equipment manufacturer and used to calculate the revised future emissions from the FAB3 pyrophoric extraction system. The significance of the

environmental impact of these emissions has been assessed using the Environment Agency's (EA's) H1 software tool.

No significant environmental impacts are predicted in relation to the air emissions from the new reactors.

1.4.2 Point Source Emissions to Surface Water

There will be no changes to surface water emissions as a result of this proposed variation.

1.4.3 Point Source Emissions to Land and Groundwater

There will be no changes to groundwater emissions as a result of this proposed variation.

1.4.4 Point Source Emissions to Sewer, Effluent Treatment Plant or Other Transfers Off-site

Effluent from production processes involving the aqueous treatment of Gallium Arsenide wafers, including substrate cleaning and wet etching activities, will be collected in drums and IBCs within the production building. Following the proposed variation, samples of the effluent will be taken and sent for analysis so that the suitability of the effluent for treatment in the Roborough installation's effluent treatment plant can be evaluated. Pending the completion of that evaluation, the collected effluent will be sent for off-site treatment and disposal by appropriately trained and competent third-party waste contactors.

This diversion of effluent for disposal as waste will likely result in a minor decrease in the volume of effluent treated at the Roborough site and then discharged to sewer. The process effluent discharged to sewer will otherwise be unaffected by the proposed variation

1.4.5 Fugitive Emissions to Air

Management and plant controls are currently in place for the minimisation of fugitive emissions to air, these will remain in place and be extended to include all relevant new plant. They include:

- Planned preventative and reactive maintenance programmes to minimise the risk of leaks from process operations;
- Effective raw material transfer and storage management to ensure there are minimal fugitive emissions associated with these operations; and
- Effective waste management to ensure that no residual waste is retained on site for long periods and there are minimal associated fugitive emissions.

1.4.6 Fugitive Emissions to Surface Water, Sewer and Groundwater

Fugitive emissions to water could potentially arise through spillages and leaks or significant plant failure. However, various control mechanisms, including the bunding of all storage containers and the use of high-quality hardstanding throughout the site will minimise the potential impact of these emissions should they arise. Operators are trained to clean up all chemical spills immediately should they occur.

1.4.7 Odour

Some of the raw materials used and wastes generated as a result of the proposed variation will have the potential to cause odorous releases both during process steps and in storage. However, all process steps with the potential to release odorous emissions will be undertaken indoors, within fully enclosed systems equipped with effective control measures to prevent emissions arising.

1.5 Management

The Roborough installation is currently subject to an Environmental Management System which is certified to meet ISO14001:2015 standards. This system will be extended to include all additional plant proposed in this variation.

1.6 Raw Materials

A small number of additional raw materials will be consumed at the installation following this variation, associated with the new MOCVD reactors. However, as there will be no increase in the production capacity of the site, the total quantities of raw materials consumed is not expected to increase.

The selection of raw materials will be carefully controlled by senior site management in line with process requirements and relevant legislation. Consumption of these materials will be regularly reviewed as part of ongoing environmental and cost-control and they will only be purchased from a list of approved suppliers.

The site will continue to maintain an up-to-date inventory of raw materials consumed on site and, as part of the Environmental Management System, Plessey Semiconductors will review the inventory regularly to identify if material substitutions are possible, taking into consideration best practice environmental options, the effectiveness of the materials in their intended function, cost and the COSHH (Control of Substances Hazardous to Health) Regulations.

1.6.1 Water Use

The use of water in the Roborough installation will not increase as a consequence of the proposed variation.

1.7 Waste

A small number of new waste streams will be produced following the proposed variation, as a consequence of the new materials to be used at the site. Waste handling, transfer and management procedures, along with waste storage area capacities and locations will not change following this proposed variation. Where practicable, all wastes derived from Gallium Arsenide wafers will be segregated from the wastes produced using the Silicon wafers currently employed at the site.

1.8 Energy

Although the proposed variation will see the addition of two new reactors at the site, along with their associated emissions abatement equipment, the increase in the energy consumption of the site will likely be minimal as there will be no increase in the total production output of the site. Use of the new reactors will lead to a reduced utilisation of other, existing plant at the site.

Various energy saving measures are currently installed in the installation to maximise energy efficiency such as the use of automated control systems and the integration of heat recovery where appropriate.

1.9 Accident Risk

The hazardous nature of many of the process chemicals used in the installation has necessitated the highest standards of process safety are employed across the installation. A wide range of safety measures, including gas detection systems, process interlocks, extensive gas extraction and abatement systems, have been included in the design of the new reactors and their use is not expected to significantly affect the accident risk associated with the installation.

1.10 Noise and Vibration

All of the new plant to be installed as part of the proposed variation is located within the main processing building and will not increase the noise emissions of the site as a whole. It is considered that the proposed variation will not result in a significant noise impact upon the closest noise sensitive receptors.

1.11 Monitoring

Air: The Environmental Permit for the Roborough installation does not specify any emissions monitoring requirements for the FAB3 pyrophoric exhaust system (emission point A3), which will be utilised as the sole emission point for air emissions from the new MOCVD reactors. It is proposed to undertake air emissions monitoring during the commissioning of the reactors to assess the revised emissions from this exhaust. An ongoing monitoring programme for this emission point will be defined thereafter, if required.

The proposed variation will not affect the emissions from any of the other air emission points at the site, so no further changes to air emissions monitoring are considered necessary.

Water: No changes are proposed for the monitoring of water emissions from the site, which are not expected to be affected by the proposed variation.

1.12 Environmental Impact

1.12.1 Air Quality

An assessment of the environmental impact of the emissions to air from the new MOCVD reactors has been undertaken using the Environment Agency's H1 spreadsheet tool. No significant impact is predicted for the new reactors and detailed assessment of their emissions to air is not considered necessary.

1.12.2 Water Quality

The proposed variation is not expected to result in any change to the installation's impact of the water environment.