18 December 2018

BLUGLASS BUSINESS UPDATE

Key Points:

- Negotiations with Lumileds continue and BluGlass is no longer bound by exclusivity
- BluGlass has successfully demonstrated functioning tunnel junctions using its unique as-grown and activated p-GaN (AAG) technology by remote plasma chemical vapour deposition (RPCVD)
- Facilities upgrade is nearing completion

Lumileds Collaboration Update

Australian technology innovator, BluGlass Limited (ASX: BLG), advises further to its recent disclosure at its Annual General Meeting, that the Company remains in negotiations with Lumileds to extend the collaboration between the parties and potentially enter into a commercialisation agreement.

BluGlass is no longer bound by exclusivity arrangements with Lumileds in relation to the RPCVD field of use being developed by the parties.

The Board notes there is no certainty that these negotiations will result in a new set of agreements with Lumileds.

Technology Update

BluGlass is commercialising a breakthrough semiconductor manufacturing process called RPCVD - for the manufacture of high-performance LEDs and other devices.

The Company has successfully demonstrated functioning tunnel junctions to enable cascaded LEDs using its unique low temperature RPCVD manufacturing technique.

A cascaded LED is a device where two or more LEDs are grown in a continuous vertical stack using a tunnel junction to interconnect the multiple LEDs in a single chip. A cascaded LED addresses the fundamental challenge of ‘efficiency droop’ in GaN-based LEDs by decreasing the required electric current while increasing the emitted light power density.

This is a significant breakthrough for BluGlass, as a successful cascaded LED is not commercially available to date and is not easily achieved by the incumbent manufacturing technology, metal-organic chemical vapour deposition (MOCVD).

RPCVD grown tunnel junctions could be commercially compelling for applications such as high-performance LEDs for automotive lighting, UV LEDs for water purification, high power laser diodes for industrial machining applications and in high efficiency multi-junction solar cells.

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BluGlass has been designing and developing its tunnel junction capability for several years, initially for triple-junction InGaN solar cells. BluGlass is actively optimising the RPCVD tunnel junctions for realising cascaded LEDs with unprecedented performance to address the stringent requirements of both brightness and small form factor for existing and emerging LED markets.

BluGlass' Chief Operations and Technology Officer, Dr. Ian Mann will present a talk on RPCVD grown tunnel junctions for cascaded LEDs at the upcoming Photonics West conference in the US in February 2019.

Further information about the competitive advantages of cascaded LEDs and RPCVD grown tunnel junctions is provided in an Appendix in this announcement along with a Glossary of technical terms.

New Facilities Update

The BluGlass Facility upgrade is approaching completion. BluGlass has taken delivery of the AIX 2800 G4, an Aixtron commercial scale MOCVD platform to be retrofitted with RPCVD, and the first of two new systems to be installed in the new cleanrooms. The second system will arrive on-site at BluGlass in January 2019.

The facility upgrade will provide BluGlass additional capacity for industry collaborations to demonstrate the key benefits of RPCVD platform technology for tunnel junction enabled cascaded LEDs, microLEDs and power electronics amongst other applications.

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Technical Appendix and Glossary follow over page.

About BluGlass

BluGlass Limited (ASX: BLG) is a global leader commercialising a breakthrough technology using Remote Plasma Chemical Vapour Deposition (RPCVD) for the manufacture of high-performance LEDs and other devices. BluGlass has invented a new process using RPCVD to grow advanced materials such as gallium nitride (GaN) and indium gallium nitride (InGaN). These materials are crucial to the production of high-efficiency devices such as power electronics and high-brightness light emitting diodes (LEDs) used in next-generation vehicle lighting, virtual reality systems and device backlighting.

The RPCVD technology, because of its low temperature and flexible nature, offers many potential benefits over existing technologies including higher efficiency, lower cost, substrate flexibility (including GaN on silicon) and scalability. BluGlass was spun off from Macquarie University in 2005 and listed in 2006.

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Appendix:

Tunnel junctions using as-grown and activated p-GaN (AAG) technology by remote plasma chemical vapour deposition (RPCVD)

Efficiency droop is a well-known problem associated with GaN-based LEDs. It is a fundamental property of LEDs where the efficiency of the light output drops as the driving current increases. For many applications, particularly in the lighting market where high brightness is critical, LEDs are typically driven at high current to generate the maximum brightness. These high currents are significantly higher than the point where the efficiency begins to drop, which means the devices are operating outside of their peak efficiency range.

A simple solution to combat efficiency droop is to replace a single LED with two or more LED chips, in which case the desired amount of light can be generated by driving each LED at a lower current that is matched to the individual LED chip's peak efficiency. However, the use of multiple LED chips increases cost and the required real-estate. In today's markets the demand for increasingly smaller devices is growing, including in the automotive industry, where there are strict limits on physical device dimensions.

A better solution is to use a single chip that has two LEDs stacked vertically, called a cascaded LED. A vertically arranged multi-junction LED benefits from the reduced efficiency droop as power is increased by stacking voltage, and not current, without increasing the required device real-estate. The vertical solution also increases the number of devices than can be made from a single wafer – reducing manufacturing costs.

Amongst other applications, cascaded LEDs can be used in the automotive headlight industry where there are strict limitations on the lateral size of the devices to achieve optimal performance. These vertically stacked devices require a critical interface, a tunnel junction, to be grown connecting the two devices to enable them to function.

Figure 1: Illustrates the different structure and physical arrangement between two laterally-spaced and interconnected LEDs versus a single cascaded LED using a tunnel junction.

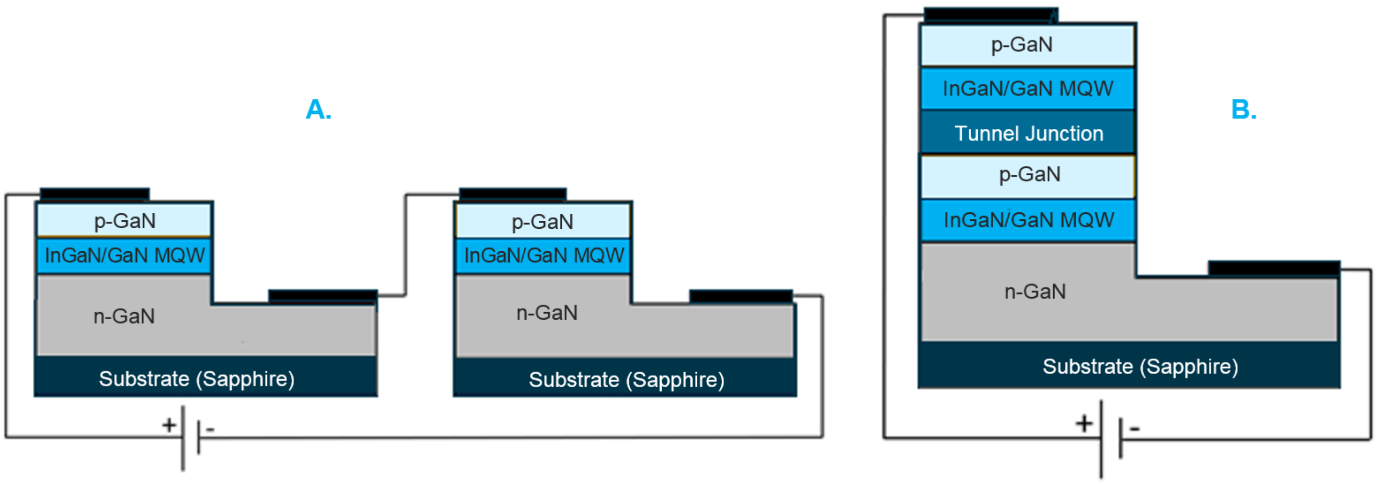


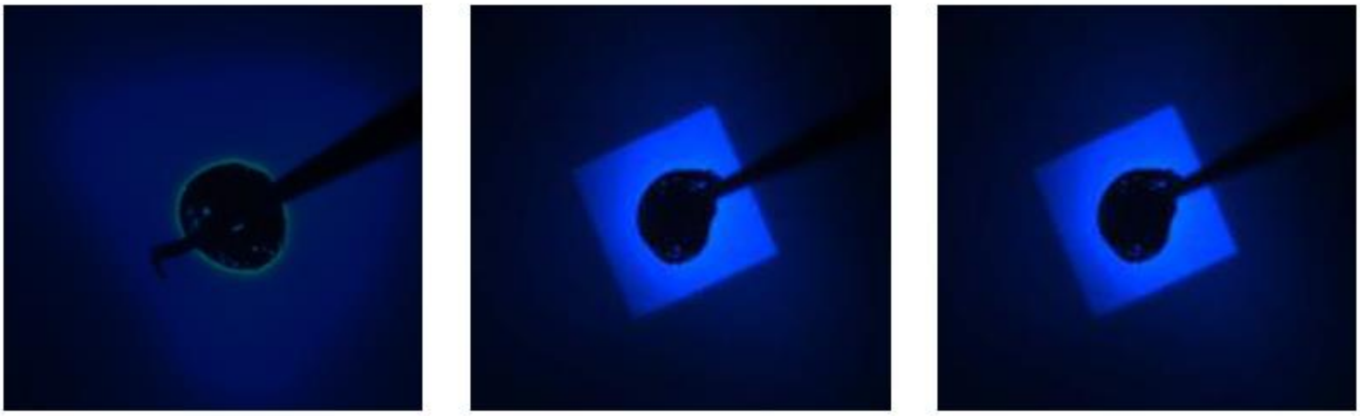
Figure 1. *A. Two laterally-spaced and interconnected LEDs and B. Vertical cascaded LED using a tunnel junction.*

Tunnel junctions are utilised in other semiconductor applications such as solar cells, but there are currently no GaN-based commercial products on the market that utilises them. This is because achieving working tunnel junctions in the GaN-based material system has proven very difficult for MOCVD with its ammonia nitrogen source, which requires high growth temperatures and results in significant quantities of hydrogen incorporated in the epitaxial layers when deposited with this method.

The advantages of BluGlass' RPCVD technology, which include low temperature deposition coupled with the ability to grow with little incorporated hydrogen, have enabled practical GaN-based tunnel junction devices.

A key feature of RPCVD is the ability to achieve the required buried activated p-GaN – critical for the function of the tunnel junction – without the need for the complicated and time-consuming ex-situ lateral activation methods currently employed by MOCVD. This unique 'as-grown and activated p-GaN' (or AAG) technology is a fundamental key advantage of using RPCVD.

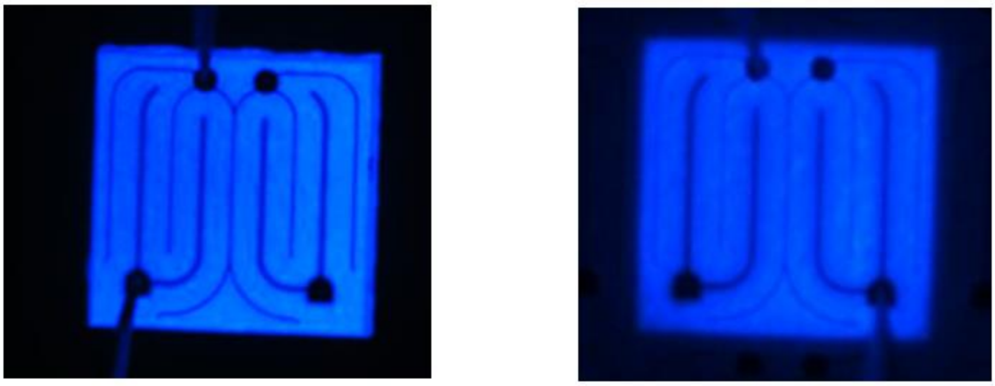
Figure 2: Bare Wafer Comparison



A. B. C.

Figure 2: *Optical micrographs of the light distribution of non-processed LED wafers* (a) commercial MOCVD full blue LED without indium tin oxide (ITO), (b) commercial MOCVD full blue LED with ITO and (c) RPCVD tunnel junction overgrowth on commercial MOCVD partial blue LED without ITO.*
** These are characterised on wafer using BLG electroluminescence quick test (using indium dot contacts)*

Figure 3: Fully Processed Wafer Comparison



A. B.

Figure 3: *Optical micrographs of the fully processed LED light distribution of (a) commercial MOCVD full blue LED with ITO and (b) RPCVD tunnel junction overgrown on a commercial MOCVD partial blue LED without ITO.*

Technical Terms Glossary:

As-grown and Activated p-GaN (AAG): BluGlass RPCVD technology to enable a buried p-GaN layer to remain activated in various devices

Cascaded LED: A cascaded LED is where two or more LEDs are grown in a continuous vertical stack using a tunnel junction to integrate the multiple LEDs in a single device tower. A cascaded LED can address the significant industry challenge of 'efficiency droop' and enable smaller, cheaper and higher performing LEDs.

Efficiency: Efficiency is a measure of how effectively LED device converts electricity into light. It is calculated as the ratio of output power to input power and is quoted as a percentage.

Efficiency Droop: Efficiency droop is the decrease in luminous efficiency of LEDs as the electric current increases beyond the peak efficiency threshold.

GaN: Gallium nitride (GaN) is a group III nitride semiconductor material with a direct bandgap. It is commonly used in optoelectronic and power electronic devices including light emitting diodes, lasers, transistors, Blu-ray disks and memory devices. GaN is a very hard material that has a Wurtzite crystal structure. Its wide band gap of 3.4 eV affords it special properties for applications in optoelectronic, high-power and high-frequency devices. It is also a suitable material for solar cell arrays for satellites and utility scale concentrated photovoltaics.

ITO: Indium tin oxide is a transparent thin film conductor.

MOCVD: MOCVD is a method used to deposit (grow) semiconductor films onto a substrate (wafer). When producing gallium nitride (GaN) organometallic compounds are reacted with ammonia inside a deposition chamber. This gas mixture is precisely delivered to a heated substrate (up to approximately 1,200°C).

The precursor molecules undergo pyrolysis (thermal decomposition) leaving the desired atoms, e.g., Ga and N. These atoms bond at the surface and crystalline layers of GaN are formed in neatly stacked layers.

For the growth of GaN, MOCVD uses ammonia (NH3) as the nitrogen source. MOCVD relies on very high temperature to effectively break the nitrogen-hydrogen bonds to result in a quality deposition.

p-GaN: p-GaN (or p-type GaN) refers to a GaN film that has been doped with certain types of atoms (typically magnesium), to increase the number of free charge carriers (in this case positive holes). Low temperature grown p-GaN is one area that BluGlass is presently focusing on.

RPCVD: Remote Plasma Chemical Vapour Deposition is a lower temperature manufacturing solution for GaN based devices. It replaces toxic and expensive ammonia as it's active nitrogen source with a nitrogen plasma, offering device manufacturers several competitive advantages

Tunnel Junction: Vertically stacked LEDs - known as cascaded LEDs – require a critical tunnel junction to be grown connecting the two devices to enable them to function. A tunnel junction is a barrier, between two electrically conducting materials. Electrons pass through the barrier by the process of quantum tunnelling. In multijunction LEDs or photovoltaic cells, tunnel junctions form the connections between consecutive p-n junctions. They function as an ohmic electrical contact in the middle of a semiconductor device (See Figure 1).