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Technology Review

Good morning, my name is Ian Mann and I am the Chief Operations and Technology Officer at BluGlass. Today I will be presenting: 1) a brief update on our current collaborative projects, 2) a technical update of our LED work that we are currently marketing, 3) a high-level overview of our equipment scaling plans, and 4) an update on our facility upgrade activities and expected outcomes.

Lumileds and Other Collaborations Highlights

We have made strong technical progress over the year working on the Phase II milestones of our collaboration with Lumileds. With the faster turnaround cycles on fabrication of LEDs and the subsequent device characterisation both parties have accelerated the project. While there remain technical specifications to be achieved, the results have been substantial to where we have now commenced commercial discussions for the next phase of the program. BluGlass remains confident in the RPCVD technology and will be starting the scaling activities needed for commercialisation in parallel with advancing the LED technical milestones with Lumileds.

A major next step for commercialisation of RPCVD involves a high-volume production scale platform. The design of this RPCVD chamber is underway and will be implemented in 2019. This new platform will represent RPCVD equipment that would be suitable for use in a production environment once completed. I will highlight some of the technical nuances of our scaling project shortly.

To achieve the results to date on the Lumileds collaboration, BluGlass has used both RPCVD systems extensively and as such, several of the other industry projects were slowed considerably. Despite the limited resource allocation, we continued to progress the technical specifications of BluGlass based LEDs, primarily for microLED applications.

We also continue to work closely with Griffith University (as part of the Innovative Manufacturing Cooperative Research Centre Grant Program) in a collaboration for the demonstration of power electronics devices employing RPCVD. The initial efforts are encouraging and BluGlass aims to share device results with various power electronics manufacturers as device performance improves.

Our collaborations with IQE, HC Semitek, and Veeco remain active and we expect to continue with these albeit at reduced levels until the new facility upgrade is completed and additional RPCVD capacity becomes available.

RPCVD p-GaN and MOCVD for Green LEDs

We continue to make performance improvements in our RPCVD p-GaN when compared to MOCVD p-GaN for green LEDs. The main application area of interest continues to be microLEDs where LED efficiency improvements for green LEDs are sought. This year we are reporting longer wavelength green LEDs with strong performance and have recently demonstrated very long wavelength LEDs in the green-yellow region.

The images shown here, combined with similar planned experiments and results, will form part of an upcoming presentation that BluGlass has been invited to give at a conference in early February in the USA – targeting customers in the opto-electronics industry.

These LED wafers were measured in our lab using an LED quick test technique at the wafer level (using indium contacts). However, over the last several months we have also had full LEDs fabricated with an overseas supplier.

RPCVD p-GaN + MOCVD for LEDs

The images on this slide show these recent efforts in fully packaged blue and green LEDs – both incorporating low temperature RPCVD p-GaN. These are complete functioning LED products that compare well with their MOCVD counterparts – further product testing is ongoing and BluGlass continues to push toward longer wavelengths of green (and yellow) in the pursuit of the highest efficiency green (and yellow) LEDs.

RPCVD p-GaN + RPCVD MQWs for RGB LEDs

In addition to simply using RPCVD p-GaN, another value proposition for low temperature RPCVD is to also grow the multi-quantum well (MQW), which are the active light emitting layers of an LED. The MQW active region is made of alternating layers of gallium nitride and indium gallium nitride (InGaN) and it is this active region that is critical for the light generation and performance in an LED.

The key advantages of RPCVD are the lower temperature and low hydrogen environment that enables more indium to incorporate into the MQWs that is necessary for long wavelength LEDs (such as red) in a nitride material system.

This figure shows two simplified LED structures comparing a full MOCVD grown LED structure and a hybrid MOCVD/RPCVD grown structure, where RPCVD is used to grow both the MQW layers and the p-GaN layers at low temperature.

RPCVD p-GaN + RPCVD MQWs for RGB LEDs

A key challenge to be overcome for low cost supply of Red-Green-Blue (RGB) microLEDs is the fabrication of these three colours in the same material system. Today red LEDs are made using a different compound semiconductor material system making it challenging to integrate with today's blue and green LEDs that are based on nitrides.

Shown here is BluGlass' brightest blue LED to date (RPCVD p-GaN and RPCVD MQW) – a key stepping stone towards showing improved LEDs at longer wavelengths. We continue to try to push the performance towards the industry elusive high performance red LEDs based on nitrides.

RPCVD Scaling in 2019

On the back of the recent technical achievements BluGlass is building its largest RPCVD platform to date – compatible with modern LED manufacturing and capable of multiple 6” wafers. The images on this slide provide some perspective on the deposition area for the new RPCVD system planned, to that of our existing BLG-300™ RPCVD system, which is capable of 19x2” wafers or equivalent deposition area configurations such as 5x4” or 2x6” wafers.

The newest RPCVD chamber design will be capable of 6x6” wafers (or 42x2”) based on the MOCVD equipment we have selected to retrofit in our upgraded facility. A key technical challenge with scaling RPCVD to this size will be ensuring uniformity of the deposited GaN thin films across all of the wafers.

Uniformity Improvement Plan for Large Scale RPCVD

To overcome the challenge of non-uniformity, it is worth highlighting some of the various differences in the production MOCVD systems that are used in LED manufacturing today and how RPCVD might best integrate with these on a large scale.

BluGlass has multiple chamber designs, each with different features, and dependent on the target market and device manufacturer. One common feature to all of the deposition systems of interest is that of a rotating wafer carrier. A wafer carrier holds the wafers during the deposition of the thin films and the rotation assists with the uniformity of the thin films. This is the case with all of the deposition systems at BluGlass, including, both our BLG-180™ and BLG-300™.

To achieve even further improvements in uniformity on large scale, BluGlass is designing its latest RPCVD on an Aixtron MOCVD planetary style deposition system. The’ planetary’ simply means that the wafers are rotated on two different axes – the analogy is that planets revolve around the sun, but the individual planets also rotate – in this case the planets represent an individual wafer carrier that can hold either a single 6” wafer or a multiple of wafers (7x2”). This style of deposition tends to average out the thin film properties across the revolving and rotating wafers.

Facility Upgrade and RPCVD Plans

BluGlass recently commenced construction of two new cleanrooms at our Silverwater facility in Sydney that will house two new RPCVD systems in 2019. BluGlass has purchased two MOCVD systems (directly from various LED manufacturers) and will commence the retrofit of these immediately upon completion of the construction of the cleanrooms.

One of these systems, is the Aixtron planetary type – known as a G4, and the other is a Thomas Swan 19x2” (identical to that already used by BluGlass in our current RPCVD implementation of the BLG-300™).

Facility Upgrade – Two New RPCVD Platforms

The initial use of the systems will be for a) the RPCVD scaling demonstration on the G4, targeting multi wafer uniformity and performance and b) a second BLG-300™ system suitable for working on current industry projects and further RPCVD development projects.

The construction of the cleanrooms has been designed so that the lab spaces within each cleanroom can be worked in independently and are each equipped with the various specialty gases. These cleanrooms, we refer to as production bays, are capable of housing and supporting a wide variety and size of deposition equipment with a key goal of maintaining flexibility in the deposition processes (and RPCVD projects) that can occur.

It is the intention that we can for example, retrofit a MOCVD system with RPCVD then ship it to a customer, and subsequently work on other equipment platforms suited to the individual customer requirements. For the initial commercial adoption of RPCVD, we view this as a key step in supporting customers requiring RPCVD integrated into their production lines in their respective geographies – BluGlass can test the system in house prior to shipping to a customer.

In addition, we can maintain a dedicated RPCVD foundry service for customers to purchase RPCVD wafers for low volume wafer production runs or for evaluation prior to committing to purchasing RPCVD equipment.

Both of these avenues support our RPCVD IP licensing model.

BluGlass Capability and Capacity Summary

This slide summarises all of the deposition capability and how we intend to employ these resources in both the short and long term. We will maintain our applied development capability with the existing infrastructure, but the new production bays will add the capability to ship RPCVD equipment retrofits and deliver RPCVD wafer services.

In conclusion, with the Lumileds commercial discussions underway, the RPCVD scaling activities, and the growing demand for RPCVD applications we look forward to the year ahead in approaching our RPCVD commercialisation goals and reporting the progress.

Thank-you

I would also like to thank all our shareholders and stakeholders for their support and to also thank all of the BluGlass technology team and support staff for their dedicated efforts over the past year. Thank you for your attention.