The Manager

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TECHNOLOGY REVIEW

Good morning, my name is Ian Mann and I am the Chief Operations and Technology Officer at BluGlass and I will be presenting a technical update on the progress over the last year and will be looking at some of the current projects that are ongoing with key players in more detail; where I am able to do so within the bounds of the confidentiality agreements in place.

KEY TECHNICAL HIGHLIGHTS (1)

The main outcome from our efforts since the last AGM update has been transitioning from our internal materials properties and device demonstrations of RPCVD grown materials, to working directly with industry players in either testing the RPCVD technology in their products, or in collaborating with them for potential commercialisation of RPCVD. I would like to take a few minutes to summarise the key projects that are underway.

To provide some context for the projects, you may recall at last year's AGM we provided a list of applications for RPCVD all of which we have received customer interest for. Despite these applications having distinctly different RPCVD value propositions – several of these have required low temperature p-GaN which is where our current development expertise is centered and where BluGlass has devoted the most of its development effort. All but one of these industry projects are based on our p-GaN development. To recap, the RPCVD opportunities tabled last year (and remain the same this year) include high-brightness (HB) White LEDs, Green and Yellow LEDs, UV LEDs, Green and Yellow Laser Diodes, and Power Electronics.

The most recent new project announced is working with a global LED manufacturer, a top brand. This company approached BluGlass following the review of some of our published work. They have a novel implementation in mind for

RPCVD that requires integrating with their existing LED process (and hardware) to reap the potential benefits. The nature of the project will initially be a development one; and will require new RPCVD approaches to be used.

One of our key activities over the last several months has been working with Veeco Instruments in their evaluation of RPCVD p-GaN for both green LEDs and Power Electronics applications. I will review some of our internal LED results in the upcoming slides.

With respect to green LEDs we also have an ongoing foundry customer to whom we supply MOCVD grown LEDs that have also trialed RPCVD p-GaN for green LEDs with initial working devices in their product development. They continue to express interest in the ability of RPCVD to enhance the green LED performance.

In addition to RPCVD p-GaN, we have also been developing RPCVD grown aluminum nitride (AlN) on sapphire. The customer driven project that is currently under evaluation involves a Chinese LED manufacturer making their LED structures on BluGlass supplied AlN coated sapphire wafers aiming to reduce the total LED growth time that customers require using their MOCVD reactors. Our internal results have shown this approach to work and we await the customer feedback on this first iteration of trials.

KEY TECHNICAL HIGHLIGHTS (2)

Taking a step back to help understand the recent commercial interest; we have been actively promoting the RPCVD p-GaN results, for example, BluGlass was invited to speak at SemiCon China earlier this year and data was shown from our larger RPCVD system, the BLG-300 (only commissioned in Aug 2014). The quick transfer of RPCVD process from our smaller reactor to this system was received well by the industry in showing the portability of the technology from the different hardware platforms (one a Veeco system and the other, an Aixtron system). At this conference we also presented some of our best electrical properties of p-GaN and tabled our working p-GaN based LEDs indicating the promise of the technology. With the base p-GaN process well established on both of the BluGlass RPCVD platforms we were able to generate results for the Veeco and other company evaluations.

GREEN LED APPLICATION

A green LED can be combined with a red and a blue LED to generate white light. This is in contrast with most commercial white LEDs available today that use a blue LED combined with a yellow phosphor – while this works, it does not always produce a satisfying white light. White LEDs are limited in performance in part due to light loss when using a phosphor, which can be up to a 30% performance loss. Using a direct red, green and blue (RGB) LED solution (note that a yellow LED can be included too) is theoretically capable of the highest lumen/Watt. There are two key markets interested in RGB LEDs; the first is the rapidly growing general lighting market. RGB LEDs can also be used to generate any colour combination so have the additional attraction for display applications, for example portable projectors. There are also a number of niche applications for both green (stand-alone) LEDs and RGB LEDs.

Cost effective RGB LED solutions are presently limited by the relative poor efficiency of green LEDs compared to red or blue and this is where RPCVD can play a key role in addressing the efficiency issue.

RPCVD p-GaN FOR LED APPLICATIONS

One of the key aspects of the RPCVD p-GaN value proposition for LEDs including green, is the low temperature. This figure shows a simplified LED structure of which the p-GaN layer is of immediate interest when successfully grown at low temperature. The p-GaN layer is grown on top of the multi-quantum-well (MQW) region which is made of alternating layers of gallium nitride and indium gallium nitride (InGaN) and it is the MQW that is the active region of the LED critical for light generation.

InGaN must be grown at low enough temperatures to incorporate sufficient indium to get, for example, blue, green or yellow light emission. Once the MQW region has been grown, the next layer to be grown is one of several p-GaN layers (including p-AlGaN) on-top of this temperature sensitive active region. The high temperature growth of p-GaN negatively affects the active region and can degrade the optical performance of InGaN layers, reducing the efficiency of the quantum-wells and therefore the light output of the LED. This effect is more prominent the larger the temperature difference between the p-GaN and MQW growth temperatures. Green LEDs require much more indium in the MQW and this layer suffers even more than blue MQWs if overgrown with p-GaN at conventional temperatures. The low temperature RPCVD p-GaN helps prevent the green region degradation and can allow for a more optimised green structure to be grown in the first place. This alone does not solve all the issues with green LED efficiency but goes a long way to improving the quality of the MQWs that can be implemented, which is a key to better efficiency.

We grow LED wafers on our MOCVD system and measure the performance to compare it with a similar LED wafers that are grown under the exact same MOCVD growth conditions with the exception of the p-GaN layer which we grow using RPCVD. Essentially we make a partial LED structure with MOCVD that stops above the MQW and then complete the LED by growing p-GaN with RPCVD. With this LED structure I will show our latest results for green and blue LEDs compared to our best MOCVD efforts.

RPCVD p-GaN FOR LEDs UPDATE

The table shown represents our best results grown in the BluGlass facility comparing RPCVD p-GaN grown on MOCVD partial LEDs (per the last slide) and comparing it to growing a complete MOCVD LED. Please note that we use our MOCVD deposition system for this work and this was done on 2” sapphire wafers. The data chosen is comparing our best results for each method to date and uses the best points on each respective wafer. The key measurements are how bright the LEDs are and what electrical input was required. A high light output and a low forward voltage are desired.

We currently are able to make a better performing green LED when incorporating RPCVD p-GaN and our blue LED is essentially on par with our MOCVD results.

For green LEDs we are now working with Veeco to establish a process on their partial green LED wafers but on 4" sapphire – a size that potential customers would fabricate LEDs for testing. This is part of the ongoing evaluation with Veeco. With our current BLG-300 setup we can readily grow on 2 and 4" wafers but larger wafers currently suffer from thickness and film quality non-uniformity.

This is an area that will need to be addressed but at present we are working with Veeco and other players on demonstrating the device performance in the specific applications first before addressing the uniformity challenge. This is the next step in working with Veeco and may involve hardware modification. The uniformity on larger wafers is important for GaN on Silicon applications such as power electronics due to the market interest being for 6" and 8' silicon wafer sizes to achieve a lower cost solution.

FOUNDRY UPDATE

While we are clearly pursuing the major players for consideration of RPCVD we also recognise that many opportunities can come from start-up companies currently developing new products and readily willing to adopt new technology to advance their own commercialisation paths. The establishment of a fee for service foundry business to accommodate potential customers to try RPCVD is seen as an important path to get market exposure to existing problems with GaN based products today and with our MOCVD reactor on site to do initial work we are well positioned to work on current issues and best implement RPCVD where it can help the most.

In addition to the customer that we recently announced committing to approximately $300k of LED work and who has trialled RPCVD for green LEDs; we also have a growing pipeline of interested prospects. All of these opportunities are covered under NDAs where these companies have shared their specific requirements and we are looking at ways to meet those specifications with either MOCVD or a combination of MOCVD and RPCVD. For the majority of these opportunities we have done some initial experiments to help demonstrate our capability to help secure the business in 2016.

THANK-YOU

In summary, the last 12 months has seen a shift in efforts within the labs at BluGlass from developing the hardware and process for initial materials properties and device demonstrations to active experimental collaboration with key players in the Nitrides industry. We are now working on vendor specific application areas that show the most promise for initial RPCVD commercialisation. As in previous years I would like to personally acknowledge and thank the BluGlass technology team and support staff for their continuous dedicated effort.

Thank you for your attention today.

About BluGlass: BluGlass Limited is an Australian green technology company formed to commercialise a breakthrough in the Semiconductor Industry. BluGlass has invented a new process using Remote Plasma Chemical Vapour Deposition (RPCVD) to grow semiconductor materials such as gallium nitride (GaN) and indium gallium nitride (InGaN), crucial to the production of high efficiency devices such as next generation lighting technology Light Emitting Diodes (LEDs) with advanced low cost potential.

The RPCVD technology, because of its low temperature and highly flexible nature, offers many potential benefits over existing technologies including higher efficiency and lower cost.

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