25 November 2013

The Manager

Company Announcements Platform

ASX Limited

BLUGLASS 2013 AGM

CTO Address

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 achieved during the year and what we are doing to reach our next milestones.

Slide 15 - POTENTIAL BENEFITS OF RPCVD FOR LED

First I would like to start with a little bit of background information on the key programme that we have undertaken over the period – namely, our target of improving LED efficiency through the use of our low temperature RPCVD technology. I would like to recap the basic value proposition of low temperature p-GaN, as the bulk of this presentation will relate to the progress made and the challenges ahead in order for BluGlass to achieve our ***Brighter LEDs*** milestone.

This figure shows a simplified LED structure divided into the key regions of an LED. I'd like to draw your attention to the top layer called the p-GaN layer. This is a GaN layer that has been doped with magnesium to provide an excess of holes. The reason that this layer is so interesting for the RPCVD technology is that this p-GaN layer is grown on top of a lower temperature layer that is needed in every LED. This lower temperature layer is called the multi-quantum-well (MQW) and is the active region of the LED critical for light generation and responsible for the 'brightness', or light output of the LED. This active region is a key component of the LED and is made of alternating layers of gallium nitride and indium gallium nitride (InGaN).

InGaN must be grown at low enough temperatures to incorporate sufficient indium to get, for example, the widely used blue light emission. Even more indium is required to achieve green light emission. Once the MQW has been deposited the next layer to be grown is one of several p-GaN layers (including p-AlGaN) on-top of this temperature sensitive active region.

This high temperature growth of p-GaN negatively affects the active region and causes damage to these critical InGaN layers reducing the efficiency of the quantum-well 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.

Slide 16 - DEMONSTRATION PLANNED FOR LOW TEMPERATURE p-GaN

We intend to take a known LED structure grown by MOCVD (MOCVD being today's incumbent deposition technology for the LED industry at large), to use as a control sample and measure the base performance and to compare it with a similar LED structure that is grown under the exact same MOCVD growth conditions with the exception of the p-GaN layer which would instead be grown using RPCVD. In other words we will grow a partial LED structure with MOCVD that stops above the MQW and will then be completed with BluGlass' RPCVD growth for the deposition of low temperature p-GaN. The device performance results of the combined MOCVD/RPCVD grown LED can then be compared to the baseline MOCVD grown LED. We expect to see an improvement with an optimised set of RPCVD conditions.

Slide 17 - 2012 PROGRESS – Low impurities and n-GaN

Two years ago we highlighted the critical challenges facing RPCVD was the then high level of impurities found in the GaN films that we grew. In 2012, through hardware and process improvements, both of which have been encompassed in patent applications, we were able to lower the impurity levels to within industry standards and this quickly lead to the achievement of good quality films with industry matching defect density as shown in this Transmission Electron Microscopy image.

Following on from our demonstration of reduced impurities we demonstrated electrical properties on par with those of films grown by MOCVD for our RPCVD n-GaN layers when grown on top of MOCVD GaN templates. This was a critical demonstration to show that the RPCVD technology could successfully dope GaN and influence the electrical properties necessary to use in an LED. Demonstrating the doping of GaN with silicon was the precursor to commencing the task of doping with magnesium necessary for p-type.

At this point we undertook a plan to:

1) Demonstrate working p-GaN
2) Demonstrate p-GaN meeting an MOCVD material demonstration specification
3) Demonstrate improved LED efficiency

I realise that all of you are anxious to hear about the last item so I will only quickly recap the first two.

Slide 18 - 2012 PROGRESS – Demonstration of p-GaN

In December 2012 we demonstrated a working RPCVD p-GaN layer as evidenced by light emission. The RPCVD p-GaN layer was grown on top of an MOCVD MQW template. In February 2013 we announced that BluGlass had successfully produced p-GaN with industry matching electrical properties. This work was carried out using the same hardware setup as our earlier published impurity reduction and n-GaN work.

First we sought to improve p-GaN further. This was successful based on electrical measurements. The data on this slide contains a summary of the performance improvement we have made since earlier this year. In this case we have improved the p-GaN carrier concentration. This table provides a summary of the electrical performance, comparing our earlier and most recent data to that of a typical minimum specification of MOCVD. In this case we have improved the p-GaN carrier concentration considerably over the course of 2013.

To help understand this data it is important to recognise the role that the individual layers play in producing light. The n-GaN layer acts to transport electrons from one side of the device into the MQW (active region), while the p-GaN layer allows the transport of holes from the other side into the MQW. In an efficient and functional LED, these electrons and holes will meet in the active region, recombine and produce light. The efficiency of an LED is affected by the ease with which these layers can transport their respective carriers to the active region.

Quantitatively speaking, the ease with which a material transports carriers can be defined by three parameters: the carrier concentration, the mobility and the resistivity:

Carrier concentration: This is the number of carriers (electrons and/or holes) generated by the active dopant in the n-type or p-type GaN layers that are available to conduct the electrical current.

Mobility: Refers to how mobile the carriers are in the n-type or p-type GaN layer. In other words how freely a charge carrier (electron or hole) can be transported throughout the material.

Resistivity: How strongly a given material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electric charge. A low resistivity also allows for easy electrical contact.

The carrier concentration, mobility and resistivity are all interrelated. For example, a low value of resistivity can be achieved by either increasing the carrier concentration or by increasing the mobility. However it is typical that the higher the carrier concentration, the more difficult it is to maintain material quality. The significance of this result (increased p-GaN carrier concentration) is that we have been able to increase the carrier concentration of our p-GaN layer without compromising the material quality. This provides us with more freedom for optimising the electrical properties of our p-GaN in order to improve LED light emission. Put simply, for a given resistivity (all other things being equal) the higher the carrier concentration the better, as more light emission can be achieved.

These results were measured by the same method we demonstrated our low impurities and good quality n-GaN layers – by growing the RPCVD material on top of an MOCVD grown GaN template.

Slide 19 - 2013 PROGRESS - Challenges and Opportunities

Giles and I have met with various LED manufacturers and key players within the LED value chain and it was made clear that two key requisites be shown: 1) an improved LED performance demonstration and; 2) evidence that our RPCVD technology is scalable. I would like to take some time to address each of these in turn.

Improved LED performance requirement

Firstly we are still working on translating the improved electrical properties of our p-GaN mentioned earlier into a demonstration of an LED exhibiting an increase in efficiency compared to MOCVD. We have spent considerable effort in working on demonstrating the advantages of p-GaN in the laboratory by conducting research and experiments in combining partially grown MOCVD devices with RPCVD overgrown p-GaN. However, to date all our MOCVD MQWs have been purchased from overseas in various batches.

We believe the key technical challenge to demonstrate an improvement in LED performance using RPCVD is overcoming the growth initiation issues or the 'interface issues' that are limiting the performance potential at present. While we have formed the view the p-GaN quality is very good when grown on an MOCVD GaN template, we have not yet achieved a high performance LED device when growing an RPCVD p-GaN layer on top of the MOCVD MQW template.

We remain confident that we can overcome these interface issues and the means to address these challenges include integrating MOCVD growth with RPCVD growth by using the newly commissioned MOCVD on site at BluGlass to provide us with complete control over the LED process, i.e. we can modify both the MOCVD and RPCVD process to maximize the performance. It is of particular importance how the MOCVD growth of the multi quantum wells is terminated before growing p-GaN with RPCVD. We have also just implemented a new hardware change to our RPCVD system that incorporates an enhanced plasma source, which should also assist in mitigating the challenges.

Demonstrating RPCVD scalability

BluGlass has already commenced development to address the second critical customer requirement and demonstrate that RPCVD is scalable. The plasma enhancement installed recently will serve to supply more active nitrogen which is also necessary as one goes to larger and larger deposition areas. The challenge is to achieve uniform deposition over these large areas. To help meet this challenge, we have acquired a second 19x2" Thomas Swan MOCVD system which will undergo a conversion into RPCVD in the New Year.

Slides 20 & 21 - FACILITIES UPGRADE – BluGlass deposition systems

Our facility has now matured to the point where we now have three deposition systems. One is our current 7x2" RPCVD system but with a recent (just this month) chamber design with enhanced plasma capability to target the p-GaN LED milestone.

The second system shown in the image is our recently commissioned MOCVD 19x2" system which will be used primarily to produce the MQW LED partial structures to target the p-GaN LED milestone. Establishing MOCVD capability on site at Silverwater was a major undertaking requiring approximately 10 months to acquire, install and commission the necessary facility support and hardware required for a fully functioning MOCVD system. The third system is an additional 19x2" MOCVD system that will be converted into an RPCVD system that will initially be used to assist with both the p-GaN LED milestone and the scaling of the technology.

Slide 22 – BLUGLASS ROADMAP

This slide is simply a recap of what we achieved this year and what is in the works. I hope some of my earlier discussion has helped clarify why we think the use of MOCVD in-house will help BluGlass reach our ***Brighter LEDs*** milestone. I would also like to reiterate that potential customers whilst expressing interest in the p-GaN opportunity are also interested in our low temperature technology to explore the opportunities enabled by two key underlying technologies – in particular GaN on silicon and indium rich InGaN, both of which can be exploited with a low temperature process.

Slide 23 - RPCVD GaN on silicon

LED manufacturers continue to look for ways to reduce cost – one option is to replace the commonly used sapphire wafer with silicon, for example Samsung and Toshiba are both actively pursuing LED manufacturing on silicon. However GaN on silicon is prone to cracking during manufacturing due to a large lattice and thermal mismatch. Notably the thermal mismatch can lead to severe bowing during cooling from the high temperatures used in MOCVD growth.

RPCVD has the potential to address this issue for larger silicon substrates simply by growing the LED at lower temperatures leading to reduced bowing and avoiding cracking. BluGlass aims to convert one of two recently acquired MOCVD systems into an RPCVD system that will enable us to work on larger substrates – up to 200mm.

Customers of nitride deposition systems are increasingly looking to additional markets outside of LEDs.
One of these includes the emerging market of power electronics using GaN on silicon – applications include the power conversion for consumer devices such as PCs, mobile phones and power supplies. The electrical properties of GaN on silicon should enable higher switching frequencies, higher blocking voltages, lower switching losses, better thermal conductivity and higher operating temperatures.

RPCVD GaN on silicon, grown at lower temperatures, has the potential to reduce the complexity of growth of the nitride layers for similar reasons stated above for LEDs.

Slide 24 - BLUGLASS ROADMAP

Again, this slide summarises the key steps going forward to enable the commercialisation for GaN on silicon. I should also point out that our recently awarded Clean Tech Innovation Program Grant from the Federal Government is supporting the LED aspects of this and the previous p-GaN roadmap.

The technology team will also continue our research into nitride solar cells and look to translate the benefits of low temperature deposition to our solar research. The roadmap underpins one key advantage of the low temperature RPCVD in that we believe that our technology can lead to indium rich InGaN, something that is very difficult to achieve with MOCVD.

Slide 25 – THANK YOU

I would like to thank you for your attention today.

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