The Manager

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CHIEF OPERATIONS AND TECHNOLOGY OFFICER'S ADDRESS

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 brief technical update on the progress over the last year and where I am able to discuss, the planned activities ahead.

LUMILEDS HIGHLIGHTS (Phase I)

Last year Lumileds approached BluGlass to investigate the use of RPCVD in a novel approach targeting improving LED performance and cost. Lumileds is a leading player in the LED industry, and this collaboration agreement is a potential opportunity to accelerate the commercialisation of RPCVD. As such BluGlass focused considerable technical resources to this development effort with the aim of achieving the technical milestones set out in our collaboration agreement as quickly as possible.

Both parties agreed to stage the development program into two phases; an initial phase to test the individual building blocks of RPCVD, effectively the materials properties. While we have published material properties such as p-type GaN for use in Green LEDs and Power Electronics applications, BluGlass was required in this project to pursue other material properties of different types of GaN, involving, in part, completely new work to BluGlass. I would like to reiterate from our announcements over the year, that the agreement with Lumileds does not preclude BluGlass from exploiting any of these new technology developments outside of the LED applications defined in our agreement. We are confident in stating that the processes used in these activities can be used in other applications and while not on our immediate agenda to pursue; are under review as to how best extract the most value from the efforts to date.

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LUMILEDS HIGHLIGHTS (Phase II)

The second phase of the development program with Lumileds involves LED device testing. These devices will require the integration of both Lumileds processes and BluGlass' RPCVD for the purpose of fabricating and testing LED devices and therefore significant effort and investment by both parties. There is a higher level of complexity in these experiments including a strong interdependence on the technologies of both companies. This was known before hand and was the main reason for the plan having a first phase of testing the materials or building blocks before embarking on the device integration and testing. We are very pleased with the successful completion of Phase I and are confident that Phase II efforts can progress on a similar timeframe to that of the first phase. This is a BluGlass view and estimate on timing.

Lumileds and BluGlass are taking a typical phase gate approach to the project and expect that detailed commercial negotiations would only commence upon the successful demonstration of the Phase II LED device (incorporating RPCVD) performance milestones.

Achieving the Phase II technical milestones would represent our most significant technical accomplishment and is expected to crystalise a very clear path to market.

HC SEMITEK HIGHLIGHTS

BluGlass has developed RPCVD grown aluminum nitride (AlN) on sapphire that is currently under evaluation with HC Semitek, a major Chinese LED manufacturer. BluGlass has supplied AlN coated sapphire wafers aiming to reduce the total LED growth time that customers require using their MOCVD reactors whilst achieving high LED performance.

BluGlass has worked closely with HC Semitek, and HC Semitek has made fully packaged LEDs containing the RPCVD AlN layers – these performance measurements have shown strong promise for RPCVD and development iterations are ongoing. All of this work was performed using BluGlass' larger RPCVD system, the BLG-300, and were grown on 4" patterned sapphire substrates (PSS). HC Semitek has been very encouraged by the results to date and we are working closely in order to optimise the RPCVD AlN based on their LED performance data feedback. It should be noted that the RPCVD AlN efforts are quite rapid as the layers are very thin so a high number of experiments can be performed in several days at BluGlass.

I would like to take a few minutes to explain why RPCVD has a potential advantage for the AlN layers for LEDs and why companies like HC Semitek and others are so interested. Most modern LEDs are fabricated on sapphire substrates. Several years ago, most LED manufacturers transitioned from using standard sapphire wafers to patterned sapphire wafers primarily as the shapes on the surface of the sapphire help reduce defects when growing GaN and the geometry of the patterns help with light extraction – both factors lead to improved LED performance. A more recent idea in the industry has been to coat these PSS wafers with AlN as a separate process to MOCVD. This allows for important time savings when using the MOCVD by not having to do any annealing of the sapphire and less GaN is required, resulting in

an increased throughput of the MOCVD and subsequently a lower cost LED. The performance of the AlN containing LED must be as good as or better than the case without it. To date a number of LED manufacturers have been using or are trialing a deposition technique called 'sputtering' for the AlN. RPCVD must demonstrate an advantage over this technique. Sputtering is a technique that is very directional in nature, whereas CVD approaches are more multi-directional – given the requirement of depositing the AlN on patterned (i.e. curved) surfaces there is a good opportunity for RPCVD to show improvement in the coating uniformity on various patterned substrates. In addition, the crystal quality of nitrides grown by CVD approaches is typically better than sputtering approaches. These aspects are been investigated internally within BluGlass and with HC SemiTek.

The p-GaN work for green LEDs is also ongoing, initial results were promising but further work is required to integrate our RPCVD with their MOCVD grown partial LED structures to show a commercially meaningful demonstration. We have had to invest internal efforts in modifying our MOCVD process to more closely match the work of HC Semitek to accelerate the development. In contrast to the AlN work, the p-GaN overgrowth development work is quite time consuming.

VEECO HIGLIGHTS

On the back of our internal p-GaN for green LED efforts where we currently are able to make a better performing green LED when incorporating RPCVD p-GaN we have been working with Veeco on p-GaN evaluations. We were successful in showing our working p-GaN in both green LED trials and in power electronics wafer level (materials properties) evaluations. Both parties have agreed that the next step is for BluGlass to demonstrate the results already achieved on smaller wafers but now over larger deposition areas before engaging end customers of Veeco. Specifically, what we are working on, as one key demonstration, is to grow RPCVD p-GaN on 8" silicon wafer devices as this is the anticipated commercial size required for power electronics players.

In order to complete this demonstration, BluGlass will require upgrading its BLG-300 chamber. We expect this to be implemented in early 2017.

RPCVD SCALING HIGHLIGHTS

Whilst I just mentioned the specific requirement for the Veeco engagement to demonstrate RPCVD on an 8" wafer it is also a requirement that the scalability of RPCVD needs to be demonstrated for all eventual commercial opportunities. This presents a challenge given we are still routinely demonstrating performance improvements of RPCVD without making modifications for scaling purposes. Fortunately we have two RPCVD systems on site with our smaller system the BLG-180 and the larger system the BLG-300. To ensure we could progress the various industry projects we chose to start improving the thickness uniformity (a scaling attribute) on the BLG-180 essentially keeping the BLG-300 available for all other projects.

In this slide I am showing the thickness uniformity improvement made with our new design. Over the last several months we have implemented a number of scaling activities on the BLG-180; we are now at a point of reintroducing the BLG-180 back into the industry partner project development program as there are further collaboration opportunities we wish to pursue with this new and improved chamber design.

It is our plan to implement the larger chamber improvement for scaling in the new-year where we expect similar improvements. The timetable is difficult to forecast however as we need to integrate into the project plans with the existing industry collaborations such as Lumileds and HC Semitek, without significantly impacting their progress. We feel the learnings from the BLG-180 chamber changes were well worth the effort to ensure a smooth chamber install on our main RPCVD work horse, the BLG-300.

FOUNDRY HIGLIGHTS

While we remain primarily focused on the development and industry evaluations of RPCVD, we continue to offer MOCVD services using our on-site MOCVD deposition system, primarily helping early stage companies in developing new products but that are also readily willing to adopt new technologies such as RPCVD to advance their own commercialisation paths. Our foundry business can accommodate potential customers using a combination of RPCVD + MOCVD hybrid devices - this is seen as an important path to get market exposure to existing problems to better target RPCVD. To this end, BluGlass has published several important demonstrators, most recently at an International Nitrides conference in August (IWN 2016), primarily to showcase to the nitrides community some of the key possibilities of RPCVD. I am not able to share any of the detailed work with collaborators or customers but the demonstrators depicted here in these slides are results generated solely by BluGlass and in part relate to the various areas that we already have existing engagements or are pursuing. These include RPCVD p-GaN for LEDs and power electronics, AlN for LEDs and other applications, and our very own full RPCVD LED structures getting attention for micro LED and solar applications.

These services continue to gain interest, and we are excited to have a significant new customer announced last week join the growing list of companies seeking our specialist services.

THANK-YOU

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.