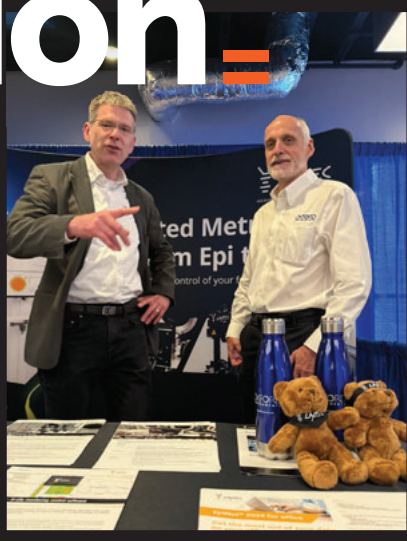
Ian Wright speaks with **Dr. Kolja Haberland**
LayTec co-founder and CTO

Enhancements in endpoint detection



__Ian Wright (IW)__, VP of Production Sales for Oxford Instruments Plasma Technology sat down with LayTec's Chief Technology Officer, __Dr Kolja Haberland (KH),__ during this year's CS Mantech to discuss LayTec's extensive experience in the GaN power electronics (PE) and radio frequency (RF) markets. Dr Haberland highlights their innovative Etchpoint™ technology, developed in collaboration with Oxford Instruments, to enable precise endpoint control during plasma etching of GaN-based structures, as well as the benefits of their 'Connected Metrology' approach, which integrates deposition and etching data for enhanced process accuracy.

IW: What is LayTec's experience with the GaN PE and RF markets?

KH: LayTec has been active in the power electronics market for more than two decades. We have been working with customers on in-situ metrology for growth of wide bandgap (WGB) structures, mainly in metal organic chemical vapour deposition (MOCVD) when it was still a research topic. Our integrated optical in-situ metrology tools were used by leading universities and research institutes to control wafer and pocket temperature, growth rate and layer thickness, surface roughness and ternary composition, and most importantly, the wafer curvature or wafer bow. When the application transitioned from R&D to high volume manufacturing (HVM), we have grown with the market. Today, we have a huge installed base of close to 4,000 systems and are providing our products to all major industrial production and HVM customers around

Ian Wright is the VP of Global Production Sales for Oxford Instruments Plasma Technology. Ian has more than 35 years' experience and has been especially involved in the sales and business development of plasma solutions for the MEMS, Optics, Optoelectronics, CS Power, AR/VR and Packaging markets segments. He was also on one of the original teams to bring the 'Bosch' Silicon DRIE to market in the mid 90's, whilst at STS. Ian is now based in the UK having recently returned from 20 years based in Singapore, where he led sales and business developments teams across Asia.

Dr Kolja Haberland is CTO at LayTec AG, a leading manufacturer of integrated metrology for the compound semiconductor industry. He studied physics at the Technical University of Berlin and obtained his PhD for his work on 'optical in-situ monitoring during epitaxial growth'. As co-founder he has been with LayTec since 1999. Over the years he has contributed significantly to LayTec's rapid growth providing both industry and academia with integrated metrology solutions for epitaxy and plasma etching of LEDs, lasers, transistors and solar cells.

the world. For instance, nowadays, the vast majority of shipped MOCVD tools are equipped with at least one LayTec in-situ monitoring system – which is fully integrated and used for feedback control in a closed-loop approach. This market has been a strong motor of growth for LayTec in recent years, which enabled LayTec to become the market leader for in-situ metrology in MOCVD. We have seen wafer sizes increasing from 50 mm to 200 mm – accompanied by a whole range of new challenges and the world is now preparing for 300 mm. Today, power electronics customers are using LayTec metrology in epi, for wafer mapping and to control the plasma etch process.

IW: What were the challenges with moving from monitoring and control of deposition to end point control in etch?

KH: At first glance, it seemed a big step for us to develop in-situ metrology for an etching process, but it turned out that our metrology solution was ideally suited to this purpose. Our expertise in thin film analysis during deposition processes and material growth helped a lot. We had the physical background, we had the material knowledge, and we had the right metrology techniques. From our 25 years of experience in in-situ metrology for epitaxy, we realised that the questions and requirements of customers were basically the same: understanding the residual thickness, etch rate and surface morphology. Etching is, in principle, time-inverted growth – the physics are the same. When Oxford Instruments approached us with an unsolved problem about etching GaN-based metal insulator semiconductor high electron mobility transistor (MISHEMT) structures, requiring in-situ metrology, we could relatively quickly offer a solution. In a very fruitful collaboration with Oxford Instruments, first announced in 2021, we developed an exclusive product for their low damage, accurate etch solutions. The system is designed to allow a blind etch stop within the AlGaN layer, for the formation of a partial recess on GaN MISHEMT device architectures. The goal was to stop the atomic layer etch (ALE) process with the precise amount of required material remaining, typically in the 2-5 nm range depending on the device design. Accurately stopping the process before the interface is reached enables the device to function in enhanced mode (E-mode or normally

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off), which is the key characteristic of the GaN MISHEMT. We were able to develop a novel algorithm that calculates the residual thickness above the interface during the etching run in real time without any need to know the total layer thickness. It turned out to be a very robust solution. The residual thickness can even be varied... 2 nm, 5 nm or even 10 nm. The resulting sub-nm accuracy was later confirmed by cross-section transmission electron microscopy (TEM). As mentioned, this is an exclusive product for Oxford Instruments, called Etchpoint™, that is fully integrated into the Oxford Instruments' PTIQ control software and is custom designed for ALE and conventional plasma etch of GaN HEMTs and MISHEMTs. So, we are happy to see customers gaining benefits from this solution. Oxford Instruments' customer Rohm uses it in its HVM process of p-GaN HEMTs, as do other GaN PE and RF companies. Optical emission spectroscopy (OES) is a widely used technique to enable endpointing when etching down to a stop layer. Etchpoint™ however, differs significantly by demonstrating that in-situ reflectance measurements enable endpoint detection within, or just above, the under-layer, which is critical for GaN, due to the very sensitive characteristics of the underlying 2DEG layer.

Leading GaN device manufacturer Rohm Semiconductor partners with Oxford Instruments Plasma Technology for greener and more reliable GaN power electronics using ALE technology – scan the QR code or visit www.oxinst.com/news/rohm-semiconductor-selects-our-ale-solutions

IW: What benefits come from having products in both etch and dep solutions?

KH: While you actively control the creation of the layer stack in MOCVD, with ALE, you are etching into the layer stack as it is, without any possibility to change it. However, endpointing must be accurate, otherwise the valuable wafer might be lost, or the yield reduced. It is even more important, as specs get tighter and device structures become more complex, to have information about the layer stack, such as thickness and ternary composition of each layer. I mean the actual layer stack of the very wafer you are etching, not just the nominal thickness of the batch, which is where in-situ metrology during deposition comes into play. If optical in-situ metrology is used during the growth of the layer structure, it is possible to determine layer thicknesses and composition during the epitaxy by using advanced fitting routines. This information is then linked to the wafer ID and stored in a database. When the same wafer (again identified by its ID) is loaded in the plasma etch chamber, all the 'upstream' information can be retrieved from the database. We call it 'Connected Metrology'. In a first approximation, the reflectance trace that is expected during the plasma etching is the time-inverted reflectance measurement of the deposition process. More precisely, we can use the thickness and composition determined during deposition to model and simulate the expected reflectance measurement during etching. Then, we can also accommodate changes in wafer temperature, measurement wavelength,

differences in etch rate versus growth rate and remove growth interruptions, providing a more realistic target dataset that the real measurement follows during the etch process. The bottom line is: you are etching into a known structure, instead of an unknown one, which would be the case without Connected Metrology. Obviously, this makes setting up and tweaking endpointing algorithms much easier and allows for a much more precise control and the algorithms can automatically compensate for and adapt to variations of the layer stack, even for complex layer structures, such as vertical cavity surface emitting lasers (VCSELs).

Of course, the in-situ data during the etch process can also be analysed and fitted using our database of optical constants. It is then also possible to track changes in etch rate over time, from run-to-run, or to compare system-to-system reproducibility. This offers a lot of additional benefits beyond endpointing such as applications in fault detection or statistical process control.

Also note, the vast majority of MOCVD systems are equipped with LayTec metrology, so the Connected Metrology approach would be readily available and compatible with Oxford Instruments' plasma etch systems fitted with LayTec technology.

IW: Are you looking at any technology solutions for SiC?

KH: The SiC market is different to conventional III-V compound semiconductor markets, because unlike GaN or GaAs/InP containing layer stacks, the growth of SiC is homoepitaxial. This means that no interfaces between different materials give rise to growth oscillations, which are typically used to determine layer thicknesses and material properties. However, changes in doping levels can also give rise to growth oscillations. Also, for SiC, the questions of wafer bow and surface quality are dominating. LayTec's metrology solutions allow wafer bow and morphology measurements in real-time. With our wafer mapping tool, we can also measure the wafer thickness of a SiC wafer, before and after growth, to provide nm-precise thickness and uniformity information. Again, it's important to control endpoints during plasma etching, thereby maximising yield across a non-uniform wafer.

IW: What about solutions for other compound semi materials e.g. InP?

KH: As the physics for all compound semiconductor structures is the same, LayTec's measurement techniques and products also work for InP or GaAs based structures. As we have more than 25 years of experience with thin film metrology, we know that it is crucial for precision and accuracy to perform the optical measurements at wavelengths that are optimised for the material system in question. LayTec's TRIton is a versatile optical in-situ tool for plasma etching and comprises a three-wavelength reflectance measurement, a CCD camera to control the measurement position, automated x, y scanning capabilities for positioning, and with SimulyzR and EtchNet, we have two software suites that allow the user to control the measurement and define endpointing algorithms. It provides the precision of Etchpoint™ to a wider range of applications and TRIton is successfully used by customers on laser structures, VCSELs, LEDs, quantum cascade lasers and detectors, and many other device structures.

Connected Metrology approach would be readily available and compatible with Oxford Instruments' plasma etch systems fitted with LayTec technology.

To learn more about LayTec's endpointing abilities scan the QR code or visit www.laytec.de/home