ISSLED 2017: Conference Report

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The 11th International Symposium on Semiconductor Light Emitting Devices (ISSLED) was held at the Banff Centre for Arts and Creativity in Banff, Alberta, CA from the 8-12th of October. The conference consisted of four plenary talks and 24 sessions on various topics featuring both invited and contributed talks. There were also two interactive poster session which was useful for discussion and networking. I was given the opportunity to present my research in the form of a contributed talk titled 'Semi-polar InGaN Quantum Well structures for long wavelength emission' in the Semipolar and Nonpolar GaN session. Below are the outlines of some talks I found interesting.

Perspectives of Solid State Lighting

Berthold Hahn, OSRAM

This plenary talk gave an excellent overview of the current state of LEDs and lasers within industry. Berthold Hahn spoke of how blue InGaN LEDs had progressed reaching internal quantum efficiencies (IQEs) of over 80% at room temperature, and the lifetimes of these devices had increased from 10000 hours to over 50000. It was also encouraging to hear that these devices have low self-absorption and high extraction efficiency. However, efficiency droop remains the main problem, with saturation of defects at low current densities, and Auger recombination limiting efficiency at higher current densities. Following on from that, he explained how these InGaN LEDS can be combined with a phosphor to produce white light. OSRAM hope to reach a target of 220-240lm/W within the next 2-4 years, but thereafter they do not expect a lot of further improvement, rather white LED development will be reaching saturation. UV LEDs was another topic he covered, explaining the challenges in achieving high quality AlGaN, the large number of threading dislocations (TDs) being the main issue. Growth on AlN instead of sapphire was one way of reducing the TD density. Other challenges were the control of point defect incorporation, and achieving efficient p and n-doping. Hahn went on to explain some applications coming into use now, or in the near future. Car headlights are currently using their Adaptive Driving Beam technology, which senses other cars approaching and switches off the LEDs which would blind them, allowing drivers to leave their full beam headlights running at all times in the dark. He also spoke of blue laser diodes, which have increased from 10%-45% efficiency in the last 10 years, and their use in Light Detection and Ranging (LIDAR) systems having potential applications in self-driving cars. Another application covered was the use of LEDs in Horticultural lighting, including supplemental lighting, i.e. in addition to sunlight, and plant cultivation without daylight. He said different combinations of colours were necessary for different plants and that they needed to be temporally controlled. Overall it was a very interesting and informative talk which expanded my knowledge in the field of solid-state lighting.

Nonpolar and Semipolar GaN for solid-state lighting: will this ever become real?

Jung Han, Yale University

This talk gave an excellent introduction into the world of non-polar and semi-polar III-nitrides. Jung Han explained that there has been much attention given to non-polar and semi-polar orientations of GaN-based systems due to the reduction of the quantum confined Stark effect (QCSE) which limits device performance. He gave examples of high-power green and blue emitting devices, but explained that these were grown on bulk-GaN substrates, which is very expensive and impractical for mass production. Han went through various growth and fabrication techniques which can be implemented larger scale, e.g. planar epitaxy, epitaxial lateral overgrowth, and patterned sapphire substrates. He discussed how stacking faults (SFs) are a big problem associated with semi-polar and non-polar growth, and referenced the work of Tao Wang and his group, overgrowth on the micro-rod templates, as one method for reducing the number of SFs. Furthermore, he presented some of his own research and showed some high quality GaN-on-sapphire templates grown using orientation controlled epitaxy, which can selectively grow semi-polar GaN on standard sapphire substrates. So his answer to the question in the title of the talk, was with these high-quality templates, high performance semi-polar GaN LEDs will penetrate industry.

Understanding and mitigating Auger recombination in nitride LEDs

Emmanouil Kioupakis, University of Michigan

This theoretical talk shed some light on Auger recombination in III-nitride LEDs. Kioupakis began by explaining the big problem of Auger recombination, and how it resulted in low efficiency of devices emitting at longer wavelengths, and those operating at high current densities, namely high power devices. He explained that his group had been working on calculations to understand Auger recombination better, and from that work out ways to mitigate its effects. They inferred that localisation of carriers due to random alloy fluctuations in InGaN devices causes a disproportionate rise in Auger recombination as opposed to radiative recombination. Kioupakis finished by suggesting Boron Indium Gallium Nitride (BInGaN) as an alternative to InGaN as they claimed it could be better lattice matched to GaN, reducing the piezoelectric polarisation, and offer high-power high-efficiency LEDS.

Semipolar InGaN optical devices on patterned Si substrates

Maki Kushimoto, Nagoya University

Maki Kushimoto gave a very informative talk on semi-polar InGaN grown on silicon rather than the conventional sapphire substrates. She explained that the main advantage of using silicon substrates for optoelectronic devices, was their compatibility with integrated circuits (ICs). However it is not a simple transition, as reported laser diodes are grown on Si (111) whereas ICs are grown on Si (001). To overcome this, the group at Nagoya University, use selective area MOVPE in combination with micromachining to achieve semipolar (1-101) GaN grown on Si (001). Using this method it is possible to increase the growth temperature, while achieving high InN content InGaN, due to higher indium

incorporation in some semi-polar orientations. Using this method, Kushimoto presented lasing from (1-101) GaN on (001) Si, indicating potential for introduction into ICs.

Prospects and challenges for AlGaN based deep UV LED technologies

Michael Kneissl, TU Berlin

UV LEDs and were very prominent at ISSLED 2017. The plenary given by Michael Kneissl was an excellent introduction to this topic. He explained the many potential benefits UV emitters could contribute to society, such as water purification, phototherapy, gas sensing and UV curing. UV LEDs have very low efficiencies when compared to their visible counterparts, however UVA LEDs are reaching efficiencies and lifetimes suitable for commercial use. UVB and UVC LEDs on the other hand are lagging behind in efficiency. He stated that most UV devices are grown on the readily available, inexpensive and more importantly UV transparent substrate, sapphire. He showed MOVPE of AlN layers with a low defect density grown using ELOG methods. He finished his talk by presenting AlGaN MQW LEDs emitting in the UVC region and their current use in NO gas sensing.

High efficacy direct InGaN LEDs

Adam Bauer, OSRAM

Bauer gave a thought-provoking talk on green LEDs although wasn't able to go into too much detail, due to company confidentiality. He explained that green LED efficiencies peak at very low current densities making them irrelevant to most applications. He stated that the greatest problem with green LEDs is carrier transport, and that solving transport issues without lowering brightness, could gain 20% in efficacy. By optimizing carrier transport OSRAM achieved efficacies of 140 lm/W for a device emitting at 530nm.

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