



5th International workshop on Gallium Oxide and related materials (IWGO2024)

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IWGO2024 hosted by the GraFOx group in Berlin, took place from the 26th to the 31st of May consisting of a welcome session; five days of oral presentations, the first three days featured a poster session at the end of a bloc of presentations; the subsequent featured a rump session where industry representatives gave their perspective on the current state of the Ga₂O₃ landscape; and the final featured an awards ceremony and closing remarks. The conference featured three keynote lectures, 19 invited speakers, 65 oral presentations, 153 posters, and an industry focused rump session. The conference focused on a number of topics including: Material growth and characteristics, doping and alloying, devices, and other materials such as Germanium Oxide.

I was offered the opportunity to present a poster on the optical characteristics of different polymorphs of Ga₂O₃. The study consisted of using different optical methods such as UV-Vis and photoluminescence. On the poster I demonstrated that each individual phase had distinct optical properties such as refractive index curves, and luminescence characteristics.

I will be discussing a small selection of talks and a poster that I took a particular interest in during my time in Berlin.

MOVPE growth and properties of orthorhombic κ-Ga₂O₃

Speaker: Roberto Fornari

Type: Invited Talk

Prof. Fornari discussed the nature of growth and material's properties of κ-phase Ga₂O₃. He laid out the distinction between ε-phase, precursors and growth conditions required to create κ-phase and brought attention to the structure of κ-phase being that it consists of three orientations rotated 120° related to each other forming a hexagonal pattern, he went on to talk about how he aims to eliminate this phenomena and produce a crystal with singular orientation which he stated would improve crystal properties.

I found this talk somewhat interesting as κ-phase Ga₂O₃ is a material I have previously studied, I was aware that it possessed the 120° rotation and that was what made κ-phase, but I was not aware that it was considered an imperfection and I will look closely at the developments of removing this phenomena, even hoping to get a sample for study.

Heteroepitaxial growth of β -Ga₂O₃(-201)/AlN(0001) and ϵ/κ -Ga₂O₃(001)/AlN(0001) structures by molecular-beam epitaxy

Speaker: Sushma Raghuvansy (Student)

Type: Oral Presentation

This presentation mainly discussed crystal growth techniques that focused on both producing Ga₂O₃ on AlN substrates, with reference to MBE, suboxide-MBE and, MOXITACY/MEXCAT growth techniques. Greater focus was given to the latter two which utilises Ga suboxide (Ga₂O) in suboxide-MBE and liquid Ga in MOXITACY/MEXCAT, these techniques were stated to produce samples with a faster growth rate and higher quality crystals. It also focused on how initial growth conditions such as the environment was rich in Ga or O would impact the resulting material such as what phase the resultant material would be.

While growth is outside the scope of my PhD it is important that I work to build connections in order to secure samples for analysis, this attending presentations on fabrication to ascertain what would be worth pursuing then talking to the speakers afterwards it is imperative in my PhD journey.

Optical library of α -, β -, γ - and κ -Ga₂O₃ polymorphs: comparative study of emission and absorption properties

Speaker: Augustinas Galeckas

Type: Oral Presentation

This talk covered primarily the luminescence and transmittance/reflectance of the polymorphs of Ga₂O₃, with additional discussing on XRD and Raman spectra of said polymorphs. Their aim is to create a reference library that categorises the optical properties of each phase that can be used by future work to compare the data against. Their results showcase distinct differences in each polymorph in their spectra, and deconvolution which shows their distinct bandgaps and luminescence spectra, additionally deconvolution was performed to ascertain the components of each spectrum. They have also demonstrated that light polarisation has an effect on the emission of the samples.

This talk was the one that I was most anticipating to attend as its work is close to my own, it was helpful as I could compare their results to mine. Additionally, after the talk I partook in a conversation with the speaker and another student discussing their results in greater depth.

Comparative Study of Temperature-Dependent Bandgap Transitions in Ga₂O₃ Polymorphs

Speaker: Benjamin M. Janzen (Student)

Type: Oral Presentation

This talk - which was one of the award winning talks of the conference – showcased a study into the temperature dependence of the bandgap of a variety of polymorphs of Ga₂O₃ using photoluminescence excitation spectroscopy (PLE). They also investigated the effect of light polarisation and the resultant emission spectrum. To obtain the bandgap, the PLE of the incident and emitted light was graphed against each other to create a 'heat map' – I interpret this as a form of matrix multiplication – with the most intense point being the bandgap. They compared their own experimental data to model they produced and found a good agreement, while also doing comparisons to DFTs, ellipsometry, and reflectance from literature and also found good agreement.

This technique did raise questions as taking just the peaks of the spectra may not yield accurate results, only near accurate ones. Personally I would have liked to see some deconvolution done on the spectra, particularly the emitted spectra. I would also doubt this technique's accuracy as since Ga₂O₃ is an indirect bandgap semiconductor (and it was not stated in the presentation that it was pure α -phase Ga₂O₃) the photon emission would not be that of the bandgap (yet still proportional to it)

Photoluminescence Mapping of Defects in β -Ga₂O₃

Speaker: Matthew D. McCluskey

Type: Invited Talk

This invited talk focused on using an advanced characterisation technique of photoluminescence mapping to produce a Hyperspectral image that can aid in described sample characterisation, it also focused on the effects of Cr and Ir impurities in β -Ga₂O₃. The PL was carried out with a lases ranging from 266 nm – 405 nm using a new commercially available setup that is purpose built for PL hyperspectral imaging, in addition to also being able conduct Raman spectroscopy and having the option of being a conventional optical microscope. It was found that defects on the surface such as pits caused an increase in emission attributed to Cr and beam damage from the laser removed the Cr from the surface.

I feel that I expected more from this talk scientifically as it turns out to be designed to demonstrate the capabilities of this new system (the speaker is the CTO and co-founder of the Klar Scientific company that produces the setup). However is has given me motivation to consider creating a 'home grown' equivalent.

Rutile GeO₂ and GeSnO₂ Alloys: A New Family of UWBG Semiconductors

Speaker: Sieun Chae

Type: Invited Talk

This invited speaker demonstrated a potential future in the Oxide community with Germanium Oxide (GeO₂), specifically its rutile polymorph as there are two types: wurtzite and rutile. Though it poses inferior properties to Ga₂O₃ such as a lesser bandgap (thus a lower breakdown voltage), it does feature a much more favourable band structure as DFT calculations indicate that it is a direct bandgap semiconductor featuring a high carrier mobility and thermal conductivity, in addition it also has a high Baliga figure of merit which is desirable for high powered applications. The talk also looked into its properties to be allowed with SnO₂.

This talk proved to be of interest as I must expand my analysis of UV-C semiconductors beyond Ga₂O₃ and GeO₂ may prove a suitable candidate for analysis. It may serve as an interesting field to explore in my PhD as I am expected to explore other wide bandgap semiconductors

Resolving a new excitation channel in β -Ga₂O₃

Author: Moritz Meißner (Student)

Type: Poster

Meißner's poster demonstrates his recently published work¹ where PLE is used to showcase two different optical transitions in β -phase Ga₂O₃ and identify a third phenomenon named 'M-peak', and then goes on to analyse the PL emission of the transitions which produce similar spectra that can be deconvoluted with Gaussians with identical peak locations.

I took an interest in this poster as it contains work that is very similar to my own; and the results would prove useful to compare my data against.

¹<https://doi.org/10.1063/5.0189751>

Conclusion

I'd like to take this opportunity to thank the UKNC for their financial support to attend this conference. This gave me a great opportunity to network with other groups in the Ga₂O₃ community, assess the current landscape of the field, and build relationships with fellow PhD students and the wider Ga₂O₃ community.