## European Materials Research Society 2023 Fall Meeting


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The 2023 EMRS fall meeting was held at the University of Technology in Warsaw, Poland. The 4-day event was made up of 24 different symposia across five main sections. The symposia I was involved in was on Ultra wide bandgap semiconductors for energy and electronics. The symposia offered a great selection of talks covering Growth, Theory and Characterisation.

I was honoured to have the opportunity to deliver three presentations (one oral, two poster) at the conference. My first poster presentation detailed my recent work on how we can measure the absorption coefficient in semiconductors at below bandgap energies using a technique known as the constant photocurrent method (CPM). CPM was widely used for the measurement of the sub bandgap absorption coefficient in Silicon but hasn't been transferred to wide bandgap materials until our work. The 2$^{nd}$ poster was focussed on a novel technique we developed to monitor fresh water quality, and was well received at the conference. My oral presentation was a discussion on the impact of Hydrogen on the optical properties of α-Ga2O3. Here we showed that H incorporation in Ga2O3 films leads to the emergence of a deep UV luminescence line centred at 3.8 eV that we ascribed to a recombination model involving Hydrogen decorated Gallium Vacancies. This conference was a great opportunity to network with people in the field, and has already led to a new collaboration to understand more about Hydrogen decorated vacancies in Gallium Oxide

**Pulsed Laser Deposition for the fabrication of Wide Bandgap Semiconductors**
*Dr David Rodgers, Nanovation*

In this talk, Dr David Rodgers discussed a growth method that I was not too familiar with regarding growth of $Ga_2O_3$. During my PhD I have looked at samples grown by Halide Phase Vapor Epitaxy and Pulsed Layer Deposition, and started to become interested in how different growth methods will impact defect/ impurity concentrations. Pulsed Laser Deposition (PLD) is a vacuum-based method that uses a high-power laser to ionise a target material, creating a plasma that deposits onto a substrate, forming thin films. Initially developed in the late 1980s, PLD excels in producing complex oxide thin films and has more recently found application in growing wide bandgap oxide semiconductors with superior quality and versatile properties. Despite being recognized in research, PLD has yet to gain widespread adoption in the semiconductor industry, despite its advantages, including lower energy consumption, shorter growth cycles, and cost-effectiveness compared to other methods like chemical vapor deposition and molecular beam epitaxy.

**Growth and Ambient-driven Crystalline Phase Transition in $Ga_2O_3$ Thin Films**

*Amit Khare, Trinity college Dublin*

The study examines crystalline Ga2O3 thin films, focusing on phase control, stability, and growth mechanisms. β- and γ-Ga2O3 thin films were deposited on c-plane sapphire and MgO (100) substrates using pulsed laser deposition under varying ambient conditions, from a vacuum (2e-7 Torr) to controlled oxygen pressures (0.5-5 mTorr). Both β- and γ-phases exhibited high crystallinity at the same deposition temperature, determined solely by the ambient environment during growth. Reflection high-energy electron diffraction and high-resolution x-ray diffraction confirmed single-phase films with excellent crystalline quality. β-Ga2O3 formed with (-201) orientation in oxygen-rich environments, while γ-Ga2O3 with (111) orientation developed in vacuum conditions. Subtle lattice spacing differences between the phases challenged phase identification using HRXRD. Electrical conductivity measurements at room temperature revealed insulating behaviour across all films, indicating minimal oxygen vacancy-related defects in β-Ga2O3. Raman spectroscopy effectively distinguished phases, with Raman active modes exclusive to β-Ga2O3.

**Modeling Properties of Ga2O3 based quantum structures to achieve hole conductivity**

*T. Tchelidze, Ivane Javakhisvili Tblisi State University*

In this paper, the authors investigate the electronic properties of Ga2O3-based quantum structures with triangular confinement potentials. This geometry resembles potential profiles observed in quantum heterojunctions, making it relevant for enhancing hole-concentration and mobility in Ga2O3-based materials. They employ the Wentzel-Kramers-Brillouin (WKB) approximation to solve the Schrödinger equation for the triangular potential, a method used in quantum mechanics. Additionally, they develop a finite-element approach to address the more complex case of a triangular barrier with finite walls. The study also considers the influence of impurities, particularly Zn atoms substituting Ga, on the electronic properties.

Their calculations account for heavy-light hole mixing, relevant in nanoscale materials, and suggest the potential for p-conductivity in quantum wells with thicknesses less than 8nm. These findings provide valuable insights for designing high-performance electronic and optoelectronic devices based on Ga2O3 and offers a great insight to future studies.

**Implantation for polymorphic transformation in $Ga_2O_3$: Thermal evolution and luminescence**

*S.B. Kjeldby, Univesity of Oslo*

In this talk, the presenter investigated the impact of high-energy irradiance on the phase transformation process in $Ga_2O_3$.  Understanding the impact of high-energy radiation on the structural properties of Ga2O3 is particularly important for the development of UV- photodetectors in space applications. Thus far it is well understood that under high implantation fluence, monoclinic β-Ga2O3 (which is the most stable of the polymorphs) transforms to the cubic spinel γ-Ga2O3 phase. The group used cross sectional cathodoluminescence to study the optical properties of the two polymorphs on the same sample and they observed a strong decrease in relative intensity of the luminescence line attributed to the recombination of electrons and self trapped holes, which is a characteristic luminescence line of Ga2O3. This relative intensity variation was observed in the layer, which has undergone a phase transformation. A lot of the work so far in this field has focussed on the effect of high irradiation impact on the electrically active defects in the material through DLTS measurements, so it was great to see a study focusing on the optically active recombination centres

**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 semiconductor characterisation community and build relationships with fellow PhD students. Keeping up to date with the most recent research in the field always provides a great source of motivation, and at the finishing stages of my PhD this has given me so much to think about for my career moving forward.