4th International workshop on Gallium Oxide and related materials
Nagano, Japan

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The 4th international workshop on Gallium Oxide and related materials 2022 was held in Nagano, Japan. The conference consisted of four days of oral presentations and two days of poster presentations covering growth, device processing, and characterisation of Gallium Oxide materials. This conference offered me the first opportunity socialise and build relationships with my fellow researchers from the Gallium Oxide community.

I was selected for poster a poster presentation were I presented my research showing H –related UV luminescence in $\alpha - Ga_2O_3$. The study consisted of temperature dependent photoluminescence measurements of samples containing measureable variations in Hydrogen concentration. It was shown that a luminescence line centred at 3.8 eV strongly correlated with Hydrogen concentration and exhibited a strong temperature dependence.

Split Vacancies in β-Ga_2O_3 crystals
Oral presentation by Filip Tuomisto
Department of Physics, University of Helsinki, Finland

This talk was material characterisation based with the invited speaker and co authors used positron annihilation spectroscopy to study acceptor type vacancy defects in Ga_2O_3. In this work, previously discovered strong Doppler broadening of β-Ga_2O_3, and temperature-dependent positron lifetime measurements complements by first principal calculations to find that split Ga vacancies are dominant in positron trapping. It has previously been shown that Gallium vacancies exhibit strong relaxation to split configurations.

Gallium vacancy in β-Ga2O3 : An electron paramagnetic resonance and theoretical study
Oral presentation by Ken Goto
Department of Applied Chemistry, Tokyo University of Agriculture and Technology, Japan

In this talk, the speaker discussed Electron paramagnetic resonance and theoretical studies of Gallium Vacancy's in Ga_2O_3. Specifically, electron paramagnetic resonance was used to identify specific defects, which were responsible for compensation of shallow donors in the beta phase of Gallium Oxide. This is a hugely impactful study as it shines light on how defects can interact with shallow donors in Gallium Oxide, from which theoretical studies predict acts as sources of n-type conductivity.

Here the samples were annealed in N_2 at 1450 °C to activate the shallow donors in the material and electron paramagnetic resonance measurements carried out at 15 K identified Si as the dominant shallow donor. After then annealing in O_2 at 1450 °C for 3 hours, the shallow donor signal in the EPR measurement was completely removed. The speaker stated that the most plausible explanation for the removal of the shallow donor was the resulting increase in the concentration of Gallium vacancies and these defects were identified via electron paramagnetic resonance.

Understanding point defects and impurities in Ga_2O_3 and $(Al,Ga)_2O_3$ through atomistic simulations

Joel Basile Varley
Lawrence Livermore National Laboratory, United States of America

This presentation discussed a theoretical approach to understanding dopants and impurities in Ga_2O_3 through first principle calculations. This talk discussed the current state of the art in the understanding of point defects in Ga_2O_3 and their impact on the optical and electrical properties. This was of particular interest to me as my PhD has been focussed on characterising Ga_2O_3 through optical and electrical techniques.

During the talk, it was established that the origin of unintentional conductivity in Gallium Oxide is heavily linked to shallow donor impurities such as Si and H. It was shown that H can have multiple effects in Ga_2O_3 were it can act as a shallow donor dopant, or increase the compensation of acceptors. H can interact with Gallium Vacancies by forming complexes, which are favourable in oxygen rich conditions. In terms of additional impurities, it was shown that Fe, Ti, and Ir can substitute on Gallium sites and are electrically and optically active.

The anisotropy of Ohmic contacts to Gallium Oxide

Rebecca L. Peterson
Department of Electrical Engineering and Computer Science, University of Michigan, United States of America

Understanding contact deposition on Gallium Oxide is essential for developing efficient devices in the future. This talk utilized the anisotropy of $\beta - Ga_2O_3$ to improve ohmic contact behaviour. Ti/Au Contact deposition was conducted on (100) and (010) Ga_2O_3 and contact resistivity of 5.1×10^{-5} Ω.cm^2 and 3.29×10^{-3} Ω.cm^2 was measured, respectively. Temperature dependent measurements were measurements were carried out to determine the dominant charge transport mechanism in across the contact-(100) Gallium oxide junction was field emission or thermionic field emission.

High-resolution microscopy on the cross section of the Ga_2O_3 film showed that a Ti-TiO_x layer formed on the (100) Ga_2O_3 film with a thickness of around 2-2.5 nm, whereas on the (010) substrate had an increased thickness of 3-5 nm.

The low contact resistance on the (100) surface resulted from the thinner layer of Ti-TiO_x. It was seen that rapid thermal annealing of 520 °C degrades the contact performance.

Conduction processes, modelling and deep levels in nitrogen-implanted β-Gallium oxide Schottky diodes

Carlo de Santi
Department of Information Engineering, University of Padova, Italy

The group led by Dr de Santi characterised the electrical behaviour of deep level traps in Nitrogen implanted Gallium Oxide Schottky barrier diodes at a range of increasing temperatures from 800 °C to 1200 °C with idea of increasing temperature populating/depopulating different trap states in the material. In the study, I- V measurements were carried out at each annealing temperature indicated the presence of deep traps with further capacitance measurements used to investigate the trapping level in the material. Finally deep level transient spectroscopy was used to give an in depth analysis of the concentration of the electrically active defects in the material.