The 15th International Conference on Nitride Semiconductors (ICNS-15)

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The 15th International Conference on Nitride Semiconductors (ICNS-15) was successfully held in Malmö, Sweden from 6 to 11 July 2025. ICNS is one of the most important international conferences about group-III nitride semiconductors, which presents high-impact scientific and technological advances in materials and devices based on group-III nitride semiconductors.

My recently work focuses on the relationship between polarised light emission of zincblende InGaN single quantum well and stacking fault-related quantum wires. We prepared samples with different stacking fault density to vary the density of quantum wires and used polarisation-resolved cathodoluminescence technique to determine the influence. The measurements show that the polarisation is approximately independent to the quantum wires and is dominantly from the SQW emission. I made a poster presentation on this work at ICNS-15 titled "Polarisation-resolved cathodoluminescence study of zincblende InGaN/GaN single quantum well samples" and had discussions with the colleagues working in the similar fields, on their inquiries and insights. I am grateful to the members in our group for this work, especially my supervisor Prof. Rachel Oliver and my postdoc Dr. Martin Frentrup and Dr. Menno Kappers. I would also thank the Cambridge Centre for Gallium Nitride, the UK Nitrides Consortium (UKNC) for funding my attendance at ICNS-15.

The Cambridge Centre for Gallium Nitride also contributed two excellent talks on porous GaN. Prof. Rachel Oliver made an invited talk titled "The role of dislocations in etching porous GaN" and Ben Thornley had a talk on "Characterisation of porous gallium nitride via volumetric focussed ion beam scanning electron microscope tomography". Additionally, we had poster presentations on a broader field, including the mechanism for porous GaN etching, Bragg reflector and growth of zb GaN.

During the conference, I also engaged in many insightful presentations from other institutions. The following are some notes on selected talks.

Nitride materials with unconventional structures and semiconducting properties

Invited talk by Andriy Zakutayev, National Renewable Energy Laboratory, Golden CO USA.

Recent innovations show that alloying of nitride semiconductors with transition metal nitrides tend to crystallise in rock-salt structure. This presentation explores novel nitride semiconductors with unconventional structures, such as ZnTiN having a wurtzite-derived structure and $MgMoN_2$ in layered hexagonal structure, and proposed that the structure for this ABN ternary nitride depends on the electronegativity of A and B. These materials can have some useful properties such as low optical absorption onset and narrow bandgap that are promising for applications, such as photoelectrochemical CO2 reduction or thermoelectric applications.

It suggests more possibilities of crystal structures for nitride semiconductors, especially some interesting derived structure which can alter some specific property of material. Moreover, high-quality growth has been demonstrated for the materials discussed, paving the way for exploration of their potential applications.

Magnesium Intercalation in Gallium Nitride with Different Polarities

Jia Wang, Institute for Advanced Research, Nagoya University, Japan and Institute of Materials and Systems for Sustainability, Nagoya University, Japan.

This work focuses on Mg intercalation in wurtzite GaN, highlighting a hierarchical relationship among Mg interstitials, segregation and intercalation. Intercalation will induce periodic polarity inversion and strong uniaxial compression. Furthermore, experiments show that the intercalation can be induced by thermal annealing of Mg on metal- and non-polar surfaces, instead of N-polar, which has been attributed to different diffusion kinetics. Mg intercalation can improve p-type conductivity, supported by a higher acceptor concentration and hole concentration in the pGaN.

It improves p-type doping and may reduce Mg segregation, which is a good breakthrough. I would also expect some spectroscopic data, such as TEM-CL or STEM-CL for further investigation. Additionally, it will also be interesting trying to induce such intercalations in cubic GaN and explore the relationship to SFs, for example the strain relaxation.

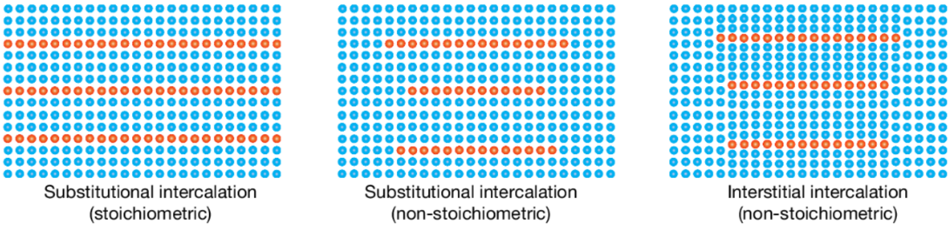

Figure 1: A schematic of the three cases of intercalation of atomic sheets into non-van der Waals solids

Determination of the band splitting and hole effective mass of GaN from valence-band structure observed by angle-resolved photoemission spectroscopy

The talk was given by Akihira Munakata, Department of Electrical Engineering and Information Systems, The University of Tokyo, Japan.

This study precisely determines band split and effective mass of valence band using high-resolution angle-resolved photoemission spectroscopy (ARPES). Measurements were conducted at 30 K using various light polarizations to probe the electronic states along the Γ-A direction. Heavy hole (HH), light hole (LH) and crystal-field split-off (CH) bands were identified clearly according to binding energy. Then the energy separation between HH and LH, HH and CH were extracted by fitting.

It is an interesting technique that provides a direct insight into the band structure for the first time. However, the experimental results are much larger than the theory and much greater than previous measurements. This overestimation can be caused for many reasons, for example, the signals captured at slightly different momentum points, the limit in momentum or energy resolution (21 meV in this study), or an oversimplified parabolic model for fitting. And they didn't provide error bar extracted from experiments for the results (split off and effective mass), instead they used error bar from fits, which makes it less reliable.

Ultra-high-pressure annealing with a carbon capping layer for activation of Mg ion-implanted GaN

Invited talk by Kensuke Sumida, Nagoya University, Nagoya, Aichi, Japan.

Ultra-high-pressure annealing (UHPA) can realize high Mg activation with suppressing thermal decomposition in Mg ion-implanted GaN. And carbon powder is industrially more suitable and low-cost than GaN power to reach thermal equilibrium during UHPA. They demonstrated UHPA (1300°C, 500 MPa of N_2 pressure for 120 min) with this carbon cap and the easy removal of the cap. Results show a homogeneous and smooth surface afterwards, and a higher activation ratio of Mg (over 70%) and lower concentration of compensating donor (Nd/Na ≈ 9% or higher).

It provides a method for high efficiency Mg doping and carbon is easy to obtain and has lower a cost. But I am not sure whether the quality of carbon power will affect and if it is still suitable for more complex devices, such as LED.

Study of Beryllium Acceptor States in Aluminum Nitride via Cathodoluminescence Analysis

Invited talk by Yingying Lin, Deep Tech Serial Innovation Center, Nagoya University, Nagoya, Japan

Beryllium is a potential acceptor for AlN doping but is less studied. This report shows a comprehensive study of Be-doped AlN by cathodoluminescence (CL). Be-doped AlN was prepared by ion implantation into MOVPE-grown AlN, followed by rapid thermal annealing at 1300 °C for 20 min. SIMS confirmed a Be concentration of ~1019 cm-3. Temperature-dependent CL revealed a –0.2% from thermal expansion mismatch with sapphire, consistent with a ~30 meV strain-induced bandgap shift. In Be-doped AlN, additional peaks at 6.08 eV and 5.96 eV appeared. The 6.08 eV peak corresponds to a neutral Be acceptor bound exciton with a 44.1 meV binding energy. This emission quenched above 60 K and disappeared at about 100 K. Arrhenius analysis indicated two activation energies: 7.3 ± 1.1 meV (20-60 K) exciton delocalization and 66.4 ± 3.3 meV (70-100 K) for bound exciton ionization.

This work presents the first CL-based determination of Be acceptor binding energy in AlN, and shows typical procedures for studying dopants by CL or PL. It might be better to have a series of samples with different Be doping concentration to confirm that these peaks are Be-related, and this can also be correlated to some theoretical calculations.

Phonon structure in Nitride semiconductor

Tao Wang, Electron Microscopy Laboratory, School of Physics, Peking University, Beijing 100871, China

In this work, atomic-scale STEM-EELS was used to study phonons in GaN defects: 8-atom ring dislocations, prismatic stacking faults (PSF) and buckled 2D GaN. Dislocations show localized modes and strain-induced phonon shifts. PSF exhibits defect modes (58–62, 99–105 meV) and a reduced phonon gap, enhancing scattering. Buckled 2D GaN shows optical phonon blue-shift and a larger acoustic-optical gap. The observations reveal the influences of defects and strain on phonon dispersion and thermal transport in GaN.

Direct observations of defect-induced phonon modes, dispersion modifications and energy shifts, providing insights into thermal transport in III-nitrides. These findings highlight the role of atomic-scale structural distortions in tailoring phonon behavior for device applications. In the future, researchers can try to quantify the impact of different defect types and densities on phonon transport and improve thermal management in devices by defect engineering.

Conclusion:

I am grateful to UK Nitrides Consortium for this financial support, which helped me present my research work in the ICNS-15. The topics such as new characterisation techniques, novel structures of nitrides (novel materials) and techniques that can improve p-type doping may deserve attention in the future.