8th International Workshop on Nitride Semiconductor (IWN)
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Conference Report

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Introduction

The 8th International Workshop on Nitride Semiconductor (IWN) was held in Wroclaw, Poland from 24 to 29 August 2014. The conference consisted of 7 plenary lectures; about 250 invited and contributed oral presentations in four parallel topical workshop: Growth, Basic physic and characterisations, Optical devices and Electronic devices and about 500 posters across a wide range of topics. Two rump sessions on optoelectronic devices and electronic devices and a satellite event, AGATE project, were also held during the conference. Exhibitions of products related to the areas of research of nitride were also presented. A gala dinner with a jazz performance on the first day of the conference and a farewell cocktail at the end of the conference were provided by the organiser. Several social programmes for sightseeing and culture experiencing in Poland were also available for conference attendees.

Summaries of selected oral presentations

40 years of nitride optoelectronics (plenary)

A brief history of nitride semiconductors was given by Shuji Nakamura, who is one of the pioneers of nitride materials. Researches into nitride semiconductors can be traced back to 1965, however, due to the invention of ZnSe blue/green emitters, nitrides have been thought of no future. Although the first blue emitter and laser were made by II-VI semiconductors, these materials have some disadvantages, such as short lifetime and easily affected by water.
First blue/green/yellow LEDs were realised by Nakamura in 1995 and the number of papers regarding the nitrides rose significantly since then. The 1st generation of nitride-based emitting devices are grown on sapphire, SiC and Si, in which dislocations are induced due to the lattice mismatch. The 2nd generation nitride devices are grown on GaN substrate in order to reduce the dislocations. Research into semipolar nitrides, growth by HVPE and ammonthermal techniques are also on going.

16 years GaN-on-Si (plenary)

GaN on Si substrate progress was introduced by Armin Dadgar. First AlN on Si was demonstrated in 1971 and more research regarding this topic has increased since mid-1990 and Macon became the first company to commercialise this technology. The major issue of using Si substrate is the thermal mismatch between Si and nitrides. Several solutions have been proposed, including selective area growth, using AlN/GaN superlattice and AlGaN as buffer layers and growing an AlN interlayers. Plastic deformation is another problem for growing GaN on Si. N-doped GaN has also been grown on Si with no crack and tensile stress recently.

Growth and optical properties of III-Nitride Nanowire Quantum Dots for single photon emission at room temperature (invited)

Single photon emission is interested for quantum information processing. The talks expressed the challenges of III-N quantum dots and their approaches to solve them. Catalyst-free and template-free grown of nanowire by MOCVD was tried. However, the density of nanowire was found low and the nanowires grew randomly. Therefore, selected area growth was used. Desirable quantum dots were obtained in the top part of the nanowire and the photo emission was found to be temperature dependence.

Behaviour of carbon impurities in the nitride semiconductors (invited)

DFT study showed that carbon impurities in nitrides act as acceptors and have an atomic-like orbit. Acceptor C is found more stable than interstitial C and donor C in both GaN and AlN, on the contrary, donor C is more stable in InN. The hole behaviours have also be discussed.

Hydride Vapor Phase Epiaxy and characterisation of High-quality ScN epilayers (contributed)

HVPE-grown ScN films were demonstrated. The impurities that usually found in ScN are C, O, Cl, H and Si. The problems that researchers are facing are the oxygen and chlorine contamination. The in-plane relationship between the substrates and the films are also revealed. It was shown that the crystal quality is improved as the film thickness increases.

Band gaps and internal electric fields in semipolar short period InN/GaN superlattices (contributed)

Two aspects of GaN/InN superlattices: relaxed atomic positions and energy band structure were studied using DFT. It was found that polar InN/GaN has large lattice relaxation, high internal electric field and small band gap. The band gap of the superlattice decreases with the thickness of the quantum well as well as the In content. In the cases of semi-polar and non-polar InN/GaN, only small and no electric field was found respectively. The simulation results suggested that the internal electric field affects the valence and conduction band profiles and the results matched the experimental results.

Composition and ordering in nominal InN/GaN superlattices – towards understanding their optical properties (invited)

Quantitative TEM/STEM were presented for the understanding of InN/GaN superlattices. Due to the polarisation field, the band potential is deformed in the superlattice, which enable band gap engineering while can avoid composition fluctuation and obtain better crystal quality. Since the contrast in STEM images depends on the sample thickness, it is difficult to do quantitative analysis. In order to reduce the noise, 30 TEM images were taken and averaged. The images were then coloured and lattice parameters were measured. The luminescence results agreed with the measurement from the images that there are 33% In in a monolayer.

TEM studies of defects in Mg-doped GaN High Nitrogen Pressure Solution Grown Crystals (contributed)

Pyramids, which are possibly due to the Mg sequestration on c-plane, were seen on the surface. Dislocation loops were also found in the crystal. MgO was found as defect in the crystal, and the orientation relationship between MgO and GaN were determined. Using EELS, a compound of Mg3GaN3 or Mg3N2 may be formed within the crystal but further analysis is required.

Comparison of Pressure-Induced Piezoelectric Effects in Near-Lattice-Matched GaN/AlInN and ZnO/ZnMgO Quantum Wells (contributed)

The effects on pressure and quantum well thickness on the piezoelectric polarisation were studied. As strain induced piezoelectric polarisation only occurs in heterostructure, GaN/AlInN was grown on c-sapphire by MOVPE while ZnO/ZnMgO was grown on a-sapphire by MBE. It was found that the build in energy decreases as the quantum well thickness increases while the energy increases as the pressure increases. The trends were found in both GaN/AlInN and ZnO/MgO, however, the effect of thickness and pressure were more significant in the GaN/AlInN case than the ZnO/MgO.

Enhanced Ferromagnetic coupling in (Ga,Mn)N superlattices (contributed)

A high magnetisation with a curie temperature of 13 K was measured in MnGaN film and the effect was attributed to super exchange coupling. It was also found that the curie temperature decreases as the Mn content decreases. In order to increase the curie temperature, codoping (Mn, Ga)N with Mg was tried, however, the curie temperature was not improved. The curie temperature was successfully improved using the superlattice approach while keeping the high magnetisation.

The influences of defects on the band gaps of $Sc_xGa_{1-x}N$ films (contributed)

My talk was scheduled on Thursday in the growth session. The title of my submitted abstract was “Growth of stacking-fault-free $Sc_xGa_{1-x}N$ films”, however, as recent results revealed defects in the films, I changed the presentation title.

I presented the microstructures of MBE-grown $Sc_xGa_{1-x}N$ films on different buffer layers (MBE-GaN, MOVPE-GaN and MOVPE-AlN), in which stacking faults were found in all samples while cubic inclusion was only found in MBE-GaN. The band gaps of $Sc_xGa_{1-x}N$ films on MBE-GaN has a decreasing trend while the $Sc_xGa_{1-x}N$ films on MOVPE GaN or AlN have an increasing trend as the Sc content increases. The absorption of MBE-GaN sample was attributed to the cubic stacking in the films.

Conclusions

It was a great experience of attending an international conference and giving a presentation in front of the community. I received helpful discussion on my research during the talk and I am definitely benefited from it. Research into UV-LEDs/Lasers and power electronics will still be the major directions for nitrides materials. New growth methods and advanced characterisation techniques will also help developing high performance devices with high crystal quality. Though majority of research is still on the conventional nitrides and their alloys, new materials, for example, BGaN, SbGaN, MnGaN, ScGaN, YGaN and $MgSiN_2$ are also gaining attention.

Acknowledgement

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