European Materials Research Society (E-MRS) Fall Meeting 2022

Conference Report

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Introduction

The European Materials Research Society (E-MRS) Fall meeting was held at Warsaw University of Technology, Poland from September 19th to 22nd, 2022.

The conference consisted of 16 parallel symposiums, which were broken up under the four main headings of Functional materials, Wide-band-gap semiconductors, Nanomaterials and Materials for a sustainable transitions. The main symposiums which I attended were Symposium F: Ultra wide-band-gap semiconductors for energy and electronics (UWBG2E), Symposium G: New frontiers in wide-band-gap semiconductors and heterostructures for electronics, optoelectronics and sensing and Symposium H: Innovative and advanced epitaxy.

These symposiums consisted of various oral presentations; 45 minutes for plenary talks, 30 minutes for invited talks and 15 minutes for contributed talks. Two Posters sessions were also run on the 19th and 20th of September. I was given the opportunity to present my research in the form of an oral presentation in Symposium H: Innovative and Advanced Epitaxy on the 19th of September. The title of my talk was "Growth and characterization of MQWs of BGaN with AlGaN barrier".

I am grateful to the UKNC for providing me with the financial support which made it possible for me to present my work. EMRS was an invaluable experience as I am currently the only student in my group working on the research of this novel material. The ability to network was crucial to understand and develop this area which in turn improved my networking skills which are vital in my professional life.

A short summary of some of the main talks and posters that interested me can be seen below.

Title: *Structural and optical properties of BGaN epitaxial layers*

Type: *Poster*

Speaker: *Ewelina B. Możdżyńska*

Affiliation: *Łukasiewicz Research Network-Institute of Microelectronics and Photonics, Al. Lotników 32/46, 02-668 Warsaw, Poland*

In this poster, BGaN thin layers were grown by metalorganic chemical vapour deposition with temperatures ranging from 840°C to 1090°C with H_2 as the main carrier gas. X-ray diffraction was used to determine a maximum BN incorporation of 2.5% at 840°C and at higher temperatures, a reduction in BN incorporation. However, it was interesting to see that the SIMS results indicated that a constant BN incorporation was obtained for all the grown samples indicating that temperature had no effect on BN incorporation. This is because an increase in growth temperature leads to a transfer of BGa from the Ga sites to the interstitial sites. The photoluminescence results at room temperature showed bright emission peaks for the near band edge. The growth temperature for the samples resulted in an increase in the luminescence defect peak from the BGaN sample. The BGaN bandgap activation energy was also analysed, six gallium deep traps were observed using high-resolution photoinduced transient spectroscopy (HRPITS) with energies ranging from 500 meV to 1350 meV.

Title: *III-Nitrides hetero-epitaxy and applications*

Type: *Talk*

Speaker: *Yvon Cordier*

Affiliation: *Université Côte d'Azur, CNRS, CRHEA, rue B.Grégory, 06560 Valbonne, France*

This talk gave a nice overview of the III-Nitride field today. It highlighted the advancements made in the community, in particular the growth of GaN on Si resulting in the rapid integration of materials in low-cost CMOS applications. The new emerging industries for III-Nitrides were also discussed. Silicon or SiC devices in power switching systems are being replaced by GaN HEMT. The high demand for micro LEDs which are being developed for displays. The advantages of using III-N materials was also highlighted. The reduction in thermoelastic strain by the introduction of the AlN. This prevents the severe wafer bowing and reduces the cracks in the films which are caused by the 2.4% lattice mismatch with GaN, by introducing compressive strain in the material. The introduction of an AlN nucleation layer protects the Si substrate from the chemical reactions that occur with the introduction of metals such as Gallium. Some of the challenges were also focused on. The preferred substrate orientation for III-N materials on Si(111) or Si(110) are not mainstream for monolithic co-integration with Si CMOS Si(111). This has been improved by the growth on substrates with a miscut angle or hybrid SOI substrates Si(111)/ Si(100).

Title: *Altering the optical and electrical properties of BN-based layers grown via MOCVD by changing the ammonia flow rate*

Type: *Poster*

Speaker: *Arkadiusz Ciesielski*

Affiliation: *University of Warsaw, Faculty of Physics, Pasteura 5, 02-093 Warsaw, Poland*

Standard BN requires a high growth temperature to reach the transported limited regime otherwise the growth will be kinetically limited. This talk focused on the growth of BN layers by MOCVD at a temperature below 1200°C. By varying the ammonia flow, they showed that the growth of the different layered materials contained drastically different optical and electrical properties. From the literature, one of the key parameters for BN growth is the ammonia flow rate. For an ammonia flow that is close to the TEB flow, low amounts of carbon are incorporated into the layer. The BN layer was porous, transparent and highly resistive High amounts of carbon were incorporated for high ammonia flows, about fifty times that of the TEB flow rate. The BN layers were non-transparent, contained high absorption and low resistance.

Title: *Two-Stage Epitaxy of Boron Nitride and the Influence of the Initial Conditions*

Type: *Talk*

Speaker*: Aleksandra Dabrowska*

Affiliation: *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*

In this talk, BN was grown by MOVPE on a sapphire substrate with triethylboron as the metalorganic and ammonia as the main nitrogen source. Thin layers were grown (few nm) in continuous flow growth mode and then flow rate modulated epitaxy (FME) was used to grow BN on top. By using this FME technique they were able to avoid the chaotic nucleation that occurs with traditional growth modes used in MOVPE which limits the high quality of the layer. This method leads to the growth of high crystalline quality with a lattice constant close to that of bulk hexagonal BN crystals.

Title: *Distributed Bragg Reflectors based on porous BN layers fabricated via MOCVD*

Type: *Talk*

Speaker: *Arkadiusz Ciesielski*

Affiliation: *University of Warsaw, Faculty of Physics, Pasteura 5, 02-093 Warsaw, Poland*

Optoelectronics often use distributed Bragg reflectors (DBRs)) as an optical cavity. DBRs consist of a high and low refractive index material stacked on top of one another. In this work, the fabrication and optical performance of a DBR with both layers consisting of BN were analysed. The standard growth procedure of a DBR consists of two different materials or different concentrations. The difference in refractive index in this work was achieved by varying the levels of porosity in the different layers. A value of ~90% was obtained for peak reflectance. This material could be tuned for the visible and infrared spectrum.

Title: *Growth, fabrication and applications of far-UVC LEDs with emission below 240 nm*

Type: *Talk*

Speaker: *Tim Wernicke*

Affiliation: *Technische Universitat Berlin, Institute of Solid State Physics*

The many challenges and applications with the growth of a deep UV LED, were highlighted in this talk. Short emission wavelength LEDs require a large Al concentration in the active region to achieve large bandgap energies. However, LEDs emitting at short wavelengths lead to an exponential decrease in the output power. A high incorporation of defects propagate into the active region which increases the amount of non-radiative recombination. The starting substrate is an important starting factor for improving the efficiency of the device. The growth on native AlN or AlN on sapphire provides different dislocation densities and transparencies. In this work, they showed by altering the temperature and V/III ratio an improvement can be obtained in the radiative recombination efficiency. From their simulation work, the design of the electron blocking layer and quantum wells can also lead to an improvement in the overall performance of the device.