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Conference Report

GaN Marathon

6-10th June 2026: Florence, Italy

Introduction

GaN Marathon is a biennial workshop on GaN technologies, including invited speakers and poster presentations. It began in 2016, and takes place in Italy, with the city varying each time. Akin to a marathon, several talks are presented in sequence, with frequent breaks to encourage interaction and networking, stimulating discussion and potential collaboration opportunities. This conference highlights the rapid evolution of III-nitride and ultra-wide bandgap semiconductor technologies across fields such as power electronics, RF devices, photonics, and advanced materials engineering. Together, these provide a comprehensive view of the scientific advances and industrial directions shaping the next generation of GaN and III-nitride devices. This conference brought together leading experts from academia and industry to talk about the aforementioned fields, including keynote talks by Hiroshi Amano and Umesh Mishra.

The workshop commenced on June 6th with a series of optional short courses delivered by three of the invited speakers: Patrick Fay, Stefano Leone, and Debdeep Jena (all experts in the GaN field). These sessions were designed to provide participants with background knowledge relevant to the topics that would be explored in greater depth during the main workshop.

Patrick Fay presented on impact ionisation in nitride semiconductors, Stefano Leone discussed carbon-free growth, functional doping, and novel alloys, and Debdeep Jena spoke on polarisation doping in nitride semiconductors. All three speakers delivered talks later in the workshop. I found the short courses extremely valuable, as they offered meaningful context for their research and enhanced my overall understanding of the field.

I was given the opportunity to present a poster on my work relating to the effect of the NH_3 pre-dose time on wafer bowing and threading dislocation density in GaN-on-Si structures. I presented and discussed the work with guests and peers during a poster session on June 9th.

I will discuss some of the talks and posters that interested me the most.

Highlighted Works

Fundamental Challenges in Realising Ultra-wide Bandgap AlGaN Heterostructures

Hiroshi Amano, Nagoya University

Diamond, $(Al_xGa_{1-x})_2O_3$, and high Al-content $Al_xGa_{1-x}N$ are the so-called ultra-wide bandgap (UWBG) semiconductors for next-generation optoelectronics, power electronics, and high-frequency electronics capable of operating in unexplored wavelength, voltage, and frequency ranges. Among these three materials, only $Al_xGa_{1-x}N$ can realise both conductive n-type and p-type layers. Therefore, devices based on this material system are the closest to practical implementation. The distributed polarisation doping (DPD) of p-type AlGaN without impurity

doping has already been demonstrated for UV-C and UV-B laser diodes (LDs). Additionally, pr-n junction diodes without impurity doping exhibiting breakdown fields more than twice those of GaN or SiC have also been demonstrated. For high-frequency applications, realising high-quality AlN/GaN heterostructures with steep interfaces is essential. Amano discussed fundamental challenges and anticipated applications for next-generation electronics. This talk was delivered in addition to his keynote talk, both of which I found very interesting and insightful.

The Many Faces of GaN

Umesh Mishra, University of California, Santa Barbara

As the second of the two keynote presentations, Umesh delivered a comprehensive overview of the development of GaN research, tracing its progression from the early stages of fundamental investigation to the advanced technologies being explored today. The talk provided valuable insight into both the contributions of his research group and the broader evolution of the field. I found the historical perspective particularly informative, as it highlighted the key scientific and technological milestones that have enabled current advances in GaN-based devices (as well as UWBG devices). The presentation was engaging, with doses of humour sprinkled throughout. Overall, it served as an excellent introduction to the conference and effectively set the scene for the technical discussions that followed.

Polar Heterostructures on bulk AlN Substrates and Their Use in Electronic and Photonic Devices

Debdeep Jena, Cornell University

Semiconductor heterostructures on GaN such as AlGaN/GaN and InGaN/GaN have now been widely studied. The availability of single-crystal, bulk substrates of aluminium nitride (AlN) offers a new material platform to examine the effect of polarisation on heterostructures and applications in electronic and photonic devices. Debdeep discussed the growth of various heterostructures on bulk AlN, resulting in a rich range of 2D and 3D electron and hole gas systems. He also discussed the application of each of these polarisation-induced carrier populations for electronic and photonic devices that benefit from going from wide to ultrawide bandgap active layers.

Introducing AlN XHEMT- A New Kid on The Block

Huili Grace Xing, Cornell University

AlN XHEMT is a new family of high electron mobility transistors (HEMTs) based on pseudomorphically strained channels on AlN. AlN has been ardently pursued as one of the most promising ultrawide bandgap semiconductors after GaN and SiC, as the industry has been expanding rapidly in high-volume manufacturing of GaN and SiC-based technologies, including

12-inch GaN-on-Si, 12-inch SiC substrates, and processing foundries. In this talk, Grace presented the findings from her group's journey in developing new RF devices on AlN over the past decades.

Conventional MOCVD: Precursor Chemistry Unlocks Next-Generation Nitride HEMTs

Stefano Leone, Fraunhofer IAF

Advancements in nitrides technology seem to be no longer limited solely by device layout. There is a need to go beyond conventional metalorganic chemical vapour deposition (MOCVD). The epitaxial growth of nitrides, e.g. for high power and frequency applications, suffers from limitations due to unintentional impurities like carbon, which partially originates from the alkyl-metal precursors used in MOCVD, as well as in the challenges of incorporating transition metal nitrides due to the lack of suitable precursors. In this context, precursor chemistry and precursor delivery are critical parameters. Over the past few years, at Fraunhofer IAF, a novel patented precursor delivery system has been developed, which enables the growth of low vapour pressure precursors, such as carbon-free brominated precursors ($GaBr_3$ and $AlBr_3$), and precursors for transition metal nitrides (Sc and Y). In the first case, carbon-free precursors can reduce carbon impurities in GaN and AlN layers, which should enhance the performance of vertical and lateral devices. In the second case, AlScN and AlYN for advanced HEMTs could be used to deposited to boost the performance of nitride HEMTs thanks to higher charge densities in the barrier layer.

Effect of Growth Temperature on Device Performance of AlGaN-based UV-B Laser Diodes

Takumu Saito, Meijo University and Mie University

AlGaN is conventionally grown at high temperatures of 1000-1300°C, based on the assumption that higher growth temperatures universally improve crystal quality. Here, device-level evidence is presented, showing that this paradigm does not necessarily hold for AlGaN-based UV-B laser diodes. By varying only the metalorganic vapour phase epitaxy growth temperature while keeping all structural parameters fixed, they showed that lowering the growth temperature to 775-800°C resulted in a threefold enhancement in carrier injection efficiency and a fourfold reduction in threshold current density, without increasing the internal optical loss. Furthermore, consistent with previous reports, high temperature growth is known to induce heterointerface broadening, indicating that AlGaN-based UV-B laser diodes are intrinsically limited by heterointerface quality.

Dissociation of Mixed Threading Dislocations in GaN

Roman Gröger, Czech Academy of Sciences, IPM

Atomistic modelling of threading dislocations in GaN has been hindered by the inability of traditional empirical potentials to capture its mixed ionic-covalent bonding. Here, a study using

a newly developed variable-charge interatomic potential based on the Streitz-Mintmire formalism is presented, which enables self-consistent determination of atomic charges and atomic positions, thereby facilitating large-scale simulations of extended defects. The model is used to calculate energies of all stacking faults on the *a* and *m* planes of the wurtzite lattice, which are important for the stability of threading dislocations. The results predict a climb dissociation of *a* + *c* mixed threading dislocations and validate the dissociation reaction of Hirsch as well as their direct observations using transmission electron microscopy.

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I would like to express my sincere gratitude to the team at UKNC for providing financial support that enabled me to attend this conference. It was a fantastic opportunity to connect with members of the international GaN community, learn about the latest developments in the field, and I returned with renewed enthusiasm and confidence in my own research.