Engineering and Physical Sciences Research Council

CS HUB NEWSLETTER

CS Hub

Welcome to the January 2023 edition of our CS Hub newsletter.
This edition contains a reminder about abstracts for SIOE 2023, which are due early February and also some of the work we are doing in helping to inspire the next generation, by working with local school children.
Our focus work package summarises the recent excellent work done improving the efficiency and functionality of GaN based micro-LEDs, which are of use for displays in Augmented Reality (AR) systems and Visible Light Communications (VLC). Led by Professor Tao Wang this internationally leading work is now moving to the next stage with the transfer of technology to a major corporation and new inward investor to the UK. We are proud of the role we and the University of Sheffield have taken in making this happen. Such activity again, illustrates the value of the Compound Semiconductor industry to the UK economy.
Academics and industrial partners of the Hub have been contributing to the UK policy on semiconductors via a number of government departments. We eagerly await the strategy on semiconductors, being organised from the Department of Media Culture and Sport (DCMS) and other studies on semiconductors from, for example, the Government Office for Science.

SIOE Conference 2023 – April 22

Cardiff University / Prifysgol Caerdydd — SIOE 2023

We are very pleased to announce that SIOE 2023 will take place at Cardiff University from 4th – 6th April.

SIOE aims to provide an informal atmosphere for the discussion of research in semiconductor opto-electronics.

Submissions are sought in the form of oral (15 minutes including discussion) and poster presentation papers.

Contributions are invited on the following topics:

- Growth and fabrication, including materials and devices
- Solar cells / photovoltaics
- Mid Infra-red semiconductor opto-electronics
- Micro-cavity and photonic band-gap effects
- GaN based materials and devices
- Theory and numerical simulation of semiconductor optoelectronics
- Optical detectors, modulations, amplifiers and switches
- All optical and opto-electronic integrated circuits
- Integration of optical and electrical functions
- Hybrid, heterogeneous and epitaxial integration

Abstracts should be a single sheet of A4, sent in PDF or word document format. Please ensure you include a list of authors, affiliations and a corresponding author email.

Please email your abstract to Kate James:

future-CSHub@Cardiff.ac.uk

Deadline for submission: Monday 6th Feb 2023

The University Of Sheffield. · MANCHESTER 1824 The University of Manchester · UCL · Cardiff University / Prifysgol Caerdydd

Inspiring a Generation

CS Hub is thrilled to report the ongoing success of the Generation Tech workshop and the part it has played in ensuring as many young people as possible are inspired by its message.

Generation Tech is an interactive, interdisciplinary workshop, inviting local students to explore hands-on activities, group problem-solving and career connections – engaging them with the microchip technology being developed and produced in South Wales and used in everyday life.

Generation Tech has been co-developed by scientists at Cardiff University School of Physics and Astronomy, School of Engineering and Science Made Simple.

Aimed at 9-12 year olds, and delivered by researchers and student ambassadors within the compound semiconductor industry, the 'free' workshop (funded by Cardiff University's 'Innovation for All' Scheme) has to date inspired over 250 young minds.

Funding from CS Hub has specifically been used to fund Student Ambassador involvement.

The project is now embarking on its second phase with aims to expand its reach.

Stay in Touch

All our latest news is available on our website: compoundsemiconductorhub.org

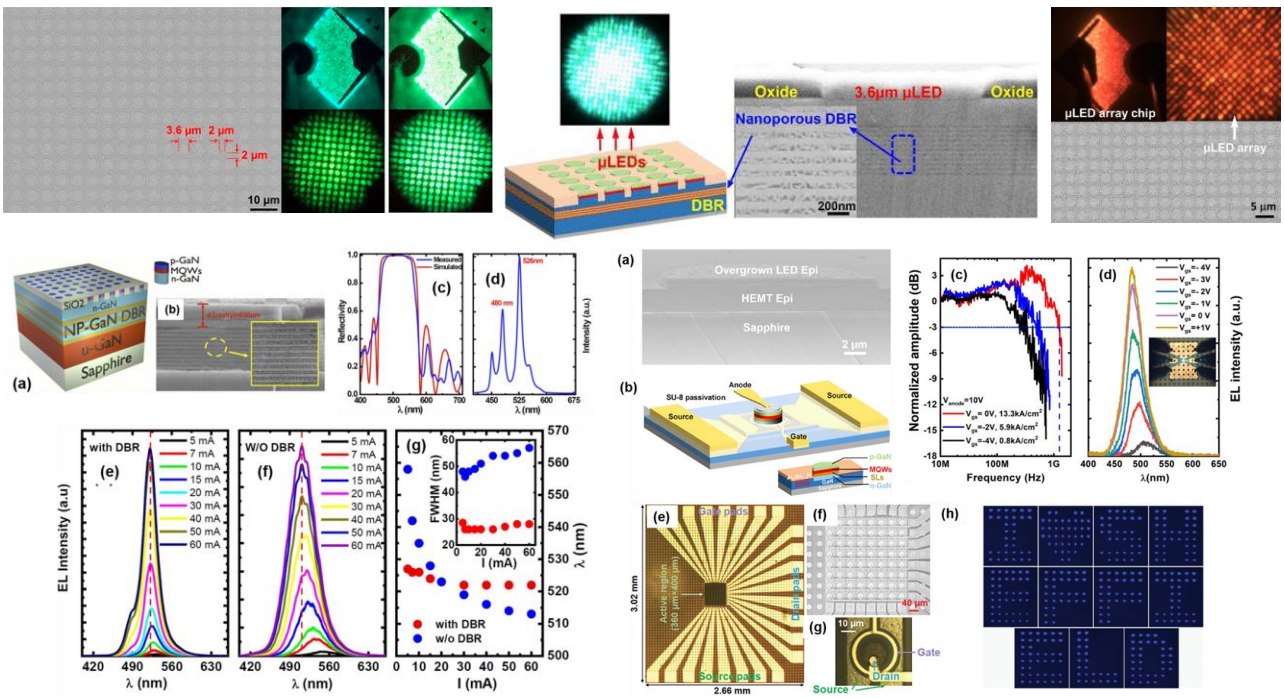
Follow us on Twitter: @FutureCSHub

In Focus: Work Package 6

"We have developed a unique epitaxial integration technology aiming to monolithically integrate either optoelectronic components or optoelectronic and electronic components on a single chip on a microscale by a direct epitaxial approach, meaning that conventional dry-etching processes for device fabrication, which unavoidably lead to degradation in device performance, are not required. Our approach based on the "confined selective epitaxy" (CSE) technique which we developed is fundamentally different from either homoepitaxy or heteroepitaxy approaches. Our approach is also different from conventional selective epitaxy approaches. Consequently, a number of globally leading results on Monolithic Integration of Micro-LEDs and HEMTs for micro-display and Li-Fi applications have been achieved, evidenced by wide attention drawn by many global companies and a number of high-profile publications. The major technological breakthrough has been successfully transferred to a global company in the US, which is the largest project in the history of the University of Sheffield."

Research Summary

There is a significantly increasing demand of developing III-nitride microLEDs (μLEDs) and monolithic on-chip integration of μLEDs and electronics for microdisplay for AR/VR and visible light communication. We have pioneered the development of a direct epitaxy approach to achieving III-nitride μLEDs without involving the utilisation of dry-etching technique, the conventional method leading to severe degradation in the performance of μLEDs. Our unique technologies have been developed based on the so-called "confined selective epitaxy" (CSE) approach, which is different from any standard epitaxial approaches or selective epitaxy approaches. Our approach has been protected via three major IPs and led to internationally leading achievements: (1) green μLEDs (with a diameter of 3.6 μm) with a then record external quantum efficiency (EQE) of 6%; (2) epitaxially integrated green μLEDs and DBRs leading to a new record EQE of 9%; (3) epitaxially integrated microcavity and μLEDs, leading to the coupling of the microcavity and the emission wavelength and thus a stable emission wavelength with increasing injection current (the long-standing issue due to the nature of III-nitrides); (4) monolithic integration of μLEDs with high electron mobility transistors (HEMTs), leading to the then recorded modulation bandwidth of 1.2 GHz; (5) the 1st monolithically integrated μLEDs and HEMTs microdisplay on a single chip.



Continued

In Focus: Work Package 6

Progress and challenges to date

For the 1st time, we have demonstrated a direct epitaxial approach to achieving µLEDs without using conventional dry-etching techniques, leading to the demonstration of ultrasmall and ultrabright green µLEDs.

For the 1st time, we have demonstrated epitaxially integrated µLEDs and lattice-matched distributed Bragg reflectors (DBRs), leading to a record EQE of 9% and the narrowest spectral linewidth.

For the 1st time, we have demonstrated epitaxially integrated µLED and a microcavity, allowing the emission to be coupled with the microcavity and thus leading to a negligible emission wavelength shift. This approach provides a simple solution to resolving the 30-year issue in the field of III-nitride optoelectronics.

We have demonstrated an epitaxial integration of monolithic on-chip µLED-HEMT with a record modulation bandwidth of 1.2 GHz.

We developed a new epitaxial integration concept, aiming to monolithically integrate µLEDs and HEMTs on a single chip. By this approach, an 8 × 8 µLED microdisplay has been demonstrated, where each µLED is electrically driven by an individual HEMT.

It is expected that the unique technologies developed via WP-6 will have a major impact in the AR/VR and VLC industry. High standard device packaging is necessary.

Lead: Prof Tao Wang

Publication Spotlight

1) J. Bai, Y. Cai, P. Feng, P. Fletcher, X. Zhao, C. Zhu and T. Wang,
"A direct epitaxial approach to achieving ultra-small and ultra-bright InGaN-based micro light emitting diodes (µLEDs)"
ACS Photonics **7**, 411-415 (2020);

2) J. Bai, Y. Cai, P. Feng, P. Fletcher, C. Zhu, Y. Tian and T. Wang,
"Ultra-small, ultra-compact and ultra-high efficient InGaN micro light emitting diodes (µLEDs) with narrow spectra linewidth"
ACS Nano **14**, 6906–6911 (2020);

3. G Martinez de Arriba, P Feng, C Xu, C Zhu, J Bai and T Wang,
"Simple approach to mitigate the emission wavelength instability of III-nitride µLED arrays"
ACS Photonics **9**, 2073–2078 (2022).

4) Y. Cai, J. IH. Haggar, C. Zhu, P. Feng, J. Bai and T. Wang,
"A direct epitaxial approach to achieve a monolithic on-chip integration of a HEMT and a single micro-LED with a high modulation bandwidth"
ACS Appl. Electron. Mater. **3**, 445-450 (2021).

5) Y. Cai, C. Zhu, W. Zhong, P. Feng, S. Jiang and T. Wang,
"Monolithically integrated µLEDs/HEMTs microdisplay on a single chip by a direct epitaxial approach"
Adv. Mater. Technol. **9**, 2100214 (2021)

Congratulations

Huge congratulations go to Fwoziah Albeladi and co-authors at Cardiff University for their achievement at the 28th International Semiconductor Laser Conference (ISLC2022), held in Matsue, Japan in October 2022. The Paper Title - 'Multi-Mode Interference Reflector Based InAs-QD Laser was awarded 'Best Student Poster Award'.