# Future Compound Semiconductor Manufacturing Hub

# Newsletter

Sept, 2018

**For more information**: http://compoundsemiconductorhub.org/ @FutureCSHub

**This newsletter introduces our new Feasibility Studies, we welcome 8 new partners to the Hub. Details of these important investments are outlined in an extended "Research Focus".**

## Wales Festival of Innovation Compound Semiconductor day at the CS Cluster in South Wales:

CS Hub partner and CS Cluster member, Newport Wafer Fab, hosted a fantastic daytime event for the cluster partners. Our 80 visitors were given an overview of what the CS Cluster can offer them, as well as tours of the wafer fab, in person and via some nifty VR headsets!

Some visitors also joined us in the evening to celebrate the official launch of the Institute for Compound Semiconductors (ICS) cleanroom at the University.

## See inside The Centre for GaN Materials & Devices:

Our colleagues at the Centre for GaN Materials and Devices have released a new film. Find out more about their research interests, facilities and collaboration below:

Video: https://youtu.be/4Wvnntq_Gt4

Website: http://gancentre.group.shef.ac.uk/

Twitter: @GaNCentre

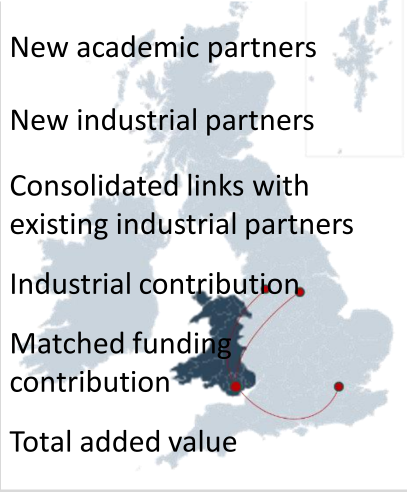
## UK Semiconductors Conference:

The CS Hub held an information stand and CS Hub Director Peter Smowton gave a presentation on ICS, with several Hub researchers giving talks and posters. A selection is shown below:

- ***Modelling and Characterization of Zero-Bias Asymmetrical Spacer Layer Tunnel (ASPAT) Diode Detectors.*** *Abdulwahid OS, Muttlak SG, Sexton J, Kelly MJ, Missous M.*
- ***1.3 µm InAs Quantum Dot Lasers Monolithically Grown on On-axis (001) Si Substrates***. *Liu Z, Tang M, Chen S, Liao M, Wu J, Martin M, Baron T, Seeds A, Liu H.*
- ***Barrier Width Effects in InAsP/AlGaInP Quantum Dot Lasers.*** *Allford CP, Gillgrass SJ, Al-Ghamdi MS, Krysa AB, Shutts S, Smowton PM.*

## *Extended* Research Focus: Introducing six new CS Hub-funded feasibility studies

**The CS Hub is investing £229,992 in 6x 6-month high-risk, novel studies. The research is aligned with CS Hub mission and vision, and will contribute to the achievement of our Key Performance Indicators.**



| | |
|---|---|
| **5** | New academic partners |
| **3** | New industrial partners |
| **5** | Consolidated links with existing industrial partners |
| **£74,700** | Industrial contribution |
| **£57,498** | Matched funding contribution |
| **£132,198** | Total added value |

**FEASIBILITY SYUDY: Three-dimensional mapping of active compound semiconductor structures** Prof Oleg Kolosov, Lancaster University

Compound semiconductors (CS) are true workhorses of modern technology – from GaN street lights to GaAs based materials in telecommunication and solar cells. Majority of CS devices use ultra-thin layers, nanowires, or both. By varying their composition and dimensions, researchers in the Hub can drastically improve device performance, create new functionalities, and advance manufacturing processes. Unfortunately, three-dimensional (3D) geometry of devices means that their layers and interfaces are hidden, making their properties, a key to the device performance, difficult or impossible to analyse. To overcome this, our project develops a new platform that combines Lancaster invention of oblique Ar ion 3D nano-cross-sectioning with material sensitive scanning probe microscopy probing local mechanical, thermal and electrical properties of buried layers from few nanometres to few micrometres deep, over wide half a millimetre area, with nanometre scale resolution. This provides fast, efficient and comprehensive study of heteroepitaxial layers, quantum wells, nanowires and nanopillars of CS materials, mapping their 3D morphology, composition, defects, and electrical and thermal transport.

Further studies are described overleaf…

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CS Hub

## Research Focus: Six new CS Hub-funded feasibility studies

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**FEASIBILITY STUDY: Angled-Cage Etching of Semiconductors (ACES)** Prof Robert Taylor, Oxford University
Gallium nitride is a wide bandgap semiconductor of huge economic importance, and the subject of the Nobel Prize for Physics in 2014. It is the base material for lasers in Blue-Ray drives, light emitting diodes in solid state lighting and can also offer improvements in performance of field effect transistors at high speed and high power. GaN is hard, inert and biocompatible. It can be alloyed with indium and aluminium to tune emission from 200 to 2000nm, an unprecedented range for any semiconductor, making it a flexible platform for future device manufacturing. In addition, the material stiffness of GaN leads to high frequency and high-mechanical quality-factor oscillators that can be used as inertial sensors of superior performance to the silicon MEMS devices currently used in airbags, motion detectors and aerospace. Applications will benefit from the ability to create 3D structures of high quality. We propose to etch GaN at a steep angle using a novel single-step angled etch process with a Faraday cage. We will create suspended GaN cavities that confine light using the refractive index difference between GaN and air, for applications in photonics, nanoscale lasers and sensors.

**FEASIBILITY STUDY: Solo - GaN 600V - 1.2kV Power Trench MOSFET** Prof Petar Igic, Swansea University
Gallium Nitride (GaN) vertical devices have the potential to enable new and highly efficient high voltage applications for a low carbon society such as electric vehicles. To date, a few research groups have reported on the successful fabrication of GaN vertical devices due to the considerable challenges associated with crystal growth, reliability and fabrication process. Exploiting a consortium made up of experts from the area of GaN material, simulation and fabrication, the goal of this team is to be amongst the first groups in Europe and the world to develop and push boundaries of what has been achieved in the field of GaN devices to date. Once quality benchmarked >600V critical processes are investigated and developed, i.e. p-epi on n-epi GaN growth and gate trench etch and dielectric deposition, they will form a solid platform for follow on project investigating the process modification to enhance the device's blocking capabilities and explore the areas not-to-date investigated in great details such as floating and biased p-bodies in GaN trenched devices and their effect on threshold and output instabilities.

**FEASIBILITY STUDY: Feasibility of Compound Semiconductor Non-volatile RAM Manufacture on Si Substrates** Prof Manus Hayne, Lancaster University
The technology behind the silicon-based processor and memory chips at the heart of all computers and electronic devices emerged in the 1970s. The memory chips, dynamic random access memory (DRAM), are fast, but volatile, meaning that information is lost unless it is refreshed 10's of times per second. Furthermore, when data is read from DRAM it is destroyed (destructive read), and needs to be reprogrammed, which is inconvenient. In this project we will investigate the manufacturability of an innovative and completely new type of memory, one which fully exploits the opportunities for quantum design and engineering of materials and devices that are available in the compound semiconductor family. These memories are expected to be as fast as DRAM, but are non-volatile and with non-destructive read (NVRAM). Furthermore, despite this intrinsic robustness the energy needed to write or erase the data is substantially lower than for DRAM. Computers and electronic gadgets of the future using such memories would be fast, boot-free (instantly on or off) and consume significantly less power.

**FEASIBILITY STUDY: Spin Injection Into Dilute Magnetic Gallium Nitride Transistors** Prof Karol Kalna, Swansea University
Spin semiconductor transistors are well recognised as potential future solutions for a digital high-performance computation and memory. With Intel's announcement of corporate interests in silicon spin qubits for quantum computing, and Google, IBM and other companies making major investments in research and development to build quantum computers, semiconductor spintronic transistors have become object of a strategic economic importance. In this feasibility study, we will develop a doping methodology for gallium nitride using manganese to create contacts for wide-bandgap semiconductor transistors. We will use gallium manganese nitride, a dilute magnetic material with a low, 5% content of manganese to build a prototype of a spin injection contact. Gallium manganese nitride shows a Curie temperature (the temperature at which material loses its permanent magnetic properties) well above a room temperature, can be fabricated using high-quality epitaxial growth, and shows also a large concentration of holes. All these hold great promise for a spin injection and spin control and in a field-effect transistor.

**FEASIBILITY STUDY: Novel characterization techniques for GaN RF electronic epitaxy** Prof Martin Kuball, University of Bristol
Compound Semiconductor GaN electronic devices used for MMIC or discrete power applications require semi-insulating GaN buffers which dramatically impact their performance in terms of important parameters such as short-channel effect, and current-collapse, as well as breakdown and leakage. The Centre for Device Thermography and Reliability (CDTR) pioneered a new backbiasing technique to characterize and optimize these GaN buffer, and a "leaky dielectric" model, in collaboration with industry. Working with IQE and the Hub, the study will concentrate on GaN-on-Si based epitaxy and scope the feasibility of establishing new approaches which can be straightforwardly implemented in a manufacturing context. The study will also aim to determine whether "leaky dielectric" models can be used to understand and optimize breakdown, which is critically important for the establishment of an internationally competitive RF and power electronics manufacturing process within the CSC.

**Feasibility Studies in CS Manufacturing Challenges:**
After closing our initial call for proposals in March, we expect to release a further call before the end of the year. Our website will be updated when plans have been finalised.