Plan Overview

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Title: Diamond+X: A New Platform For Ga_2O_3 Power Devices

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Funder: Engineering and Physical Sciences Research Council (EPSRC)

Template: University of Bristol General Template

Project abstract:

Power electronics is central to the UK's progress toward net zero. As the country modernises its energy infrastructure, an increasing share of electricity—from rail transport and electric vehicles to renewable generation and high-voltage transmission—will pass through power converters. Improving the efficiency and reliability of these systems is essential for reducing energy losses, strengthening energy security and lowering the overall cost of the energy transition.

Gallium oxide (Ga_2O_3) is a new semiconductor with the potential to transform high-voltage electronics. It can withstand extremely high electric fields, enabling smaller, lighter and more efficient devices compared with current technologies. However, Ga_2O_3 has a major limitation: it struggles to remove heat. Without better thermal management, devices can overheat, reducing their performance and reliability in practical applications.

This project introduces a new materials concept called "diamond plus X" to overcome this challenge. The concept combines patterned polycrystalline diamond—which spreads heat very effectively and is far cheaper than single-crystal diamond—with a single-crystal semiconductor layer such as Ga_2O_3, silicon carbide or sapphire. The single-crystal "X" layer provides the ordered structure needed for high-quality Ga_2O_3 growth, while the patterned diamond acts as an internal heat-spreading network. This hybrid structure aims to deliver strong thermal performance while remaining practical and affordable for large-scale manufacturing.

The project will investigate how Ga_2O_3 can be grown across the diamond patterns, how the patterns should be designed to remove heat efficiently and how different material combinations influence performance. Rather than producing just one demonstration device, the goal is to develop a platform technology that can support a range of next-generation high-voltage applications across energy, transport and industrial systems.

The programme benefits from strong academic collaboration. Swansea University will provide

guidance on device modelling and thermal transport, helping inform the design of the new structures. The University of Cambridge will support microstructural and materials analysis of the diamond-based substrates. The University of Strathclyde will advise on epitaxial growth behaviour, drawing on its experience with lateral overgrowth techniques. These collaborations complement the UK’s wider effort on ultra-wide-bandgap materials, including the REWIRE Innovation and Knowledge Centre, enhancing national capability in this strategically important area.

Industry engagement ensures that the research remains aligned with real-world requirements. Oxford Instruments will provide insight into how the patterned diamond and dielectric layers interact with advanced semiconductor processing. Hitachi Energy and Vishay will offer feedback on manufacturability and high-voltage performance requirements, helping ensure that the work can be translated toward future applications and product development across the UK’s energy and semiconductor sectors.

This project directly supports national goals by enabling more efficient and reliable power-conversion technologies essential for achieving net zero. It also strengthens the semiconductor ecosystem in the South West and South Wales, a region that combines world-leading academic capability with important manufacturing assets such as the Newport Wafer Fab and a growing network of semiconductor and power-electronics companies. By overcoming the thermal limitations of Ga_2O_3, the diamond plus X platform has the potential to support cleaner transport, lower-loss power networks and more efficient renewable-energy integration.

The project will be delivered within an open and inclusive research culture that values equality, diversity and fairness, ensuring that participation and contributions are recognised across the team and shared with the wider community.

ID: 194347

Start date: 01-03-2027

End date: 28-02-2030

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Diamond+X: A New Platform For Ga_2O_3 Power Devices

Project Summary

Provide a brief description of the project and the research being carried out. State if the research is part of a larger project, if there are any funders involved, and how data fits in.

This project, *Diamond+X: A New Platform for Ga_2O_3 Power Devices*, investigates the development of a hybrid substrate that combines patterned polycrystalline diamond with single-crystal semiconductor materials to enable thermally robust Ga_2O_3 power devices. The research involves experimental materials growth, micro- and nano-fabrication, device processing, electrical and thermal characterisation, and supporting numerical simulations.

The project is an individual EPSRC New Investigator Award led by the University of Bristol and is not part of a larger funded programme, although it aligns strategically with the EPSRC REWIRE initiative on ultrawide bandgap semiconductor technologies. No other external funders are involved.

Data generated will include experimental measurement data, microscopy images, device characterisation results, and simulation outputs. These data will be used to support analysis, publications, and dissemination of research findings, and will be managed in accordance with EPSRC research data policies.

Data Types

What types of data will be involved?

The project will generate experimental, characterisation, and modelling data. This includes materials growth and fabrication process data from diamond CVD, Ga_2O_3 MOCVD and cleanroom processing; characterisation data such as SEM, AFM, Raman, PFIB/TEM, electrical and thermal measurements; and numerical data from electro-thermal and device simulations, including model inputs and outputs.

What file formats will be used?

Data will be stored in standard, widely used formats. Experimental and characterisation data will be stored as CSV, TXT, and instrument-native formats, with processed data exported to CSV or PDF. Microscopy and imaging data will be stored as TIFF or PNG. Simulation inputs and outputs will be stored as TXT, CSV, and software-native formats, with figures exported as PDF or PNG.

What will be the approximate size of the files?

- 0 - 50 GB

Data Capture

How will the data be generated and/or gathered?

Data will be generated through experimental fabrication, materials characterisation, electrical and thermal measurements, and supporting numerical simulations. Data quality will be ensured through calibrated equipment and repeat measurements. No third-party data will be used.

Data Storage and Preservation

How will the data be backed up?

All data will be stored in The University of Bristol Research Data Storage Facility (RDSF), which provides secure, long-term storage for research data. This major investment provides nightly backup of all data, with further resilience provided by three geographically distinct storage locations. A tape library is used for backup purposes and also for long-term, offline data storage. Only authorised users can access data stored within the RDSF. The RDSF is managed by Bristol’s Advanced Computing Research Centre (ACRC) which has a dedicated steering group and a rigorous data storage policy (https://www.acrc.bris.ac.uk/acrc/RDSF_policy.pdf). The RDSF upholds and reinforces Bristol’s wider Information Security Policy(www.bris.ac.uk/infosec/policies/docs/isp-01.pdf).

Do you have security procedures in place for sensitive data?

This project will not generate or use sensitive, personal, or confidential data. All research data will consist of experimental measurements and simulation outputs. Data will be stored and managed in accordance with the University of Bristol’s standard data security and IT policies, with access restricted to the project team.

What are your plans for long-term storage of the data?

Data will be stored on secure University of Bristol systems and retained for at least 10 years in accordance with institutional and EPSRC policies. Data supporting publications will be archived and made available through appropriate repositories where feasible.

Data Organisation

How will data be organised?

Data will be organised in a structured folder hierarchy by work package, experiment, and date, with standardised file naming and version control to ensure traceability and long-term usability.

Data Documentation and Description

What documentation will you keep?

Documentation will include experimental logs, growth and processing parameters, simulation settings, calibration records, and readme files describing data structure, variables, and units.

Will you be using any metadata standards?

No formal metadata standard will be used.

Data Sharing and Publication

What data do you plan to share?

Processed datasets underpinning published results will be shared, including representative material characterisation data, device measurements, and simulation outputs, subject to IP and commercial sensitivity.

Are there any ethical, commercial, legal or IPR issues which might apply when publishing your data?

No

How will your data be shared?

Data will be published through the University of Bristol Research Data Repository (data.bris). The data.bris Repository offers a means for Bristol’s researchers to openly share non-confidential research data, without the need for external data users to undergo any form of authentication. Each deposit is accompanied by appropriate metadata and is assigned a unique Digital Object Identifier (DOI) via the DataCite scheme. All data published by the Repository is available under a permissive re-use license.

Will there need to be controlled access procedures in place for your data?

No need.