Defects and their effect of reliability for Silicon Carbide power devices

Funding available for PhD studentship for Oct 2022 or Jan 2023 start - funding for international students now available. Students must have a minimum Bachelors degree of 2.1 (UK) or international equivalent qualifications and a degree in experimental engineering/chemistry/physics, with experience in semiconductors. Supervisor: [Dr Vishal Shah](), this project is jointly funded by the Diamond Light Source and Bruker UK Ltd.

Wide bandgap (WBG) semiconductor materials, such as Silicon Carbide (SiC) and Gallium Nitride (GaN), have recently been introduced into the power electronics market, with early adoption of SiC devices in hybrid and fully electric cars being the main driver of industrial uptake. Predictions state that the market will be worth $2bn by 2024 and of direct relevance to achieving the UK's net zero commitment. A major issue for SiC power electronic devices is long-term reliability due to intrinsic extended defects, e.g. the presence of basal plane dislocations in the starting substrate. In a critical area, these defects drastically reduce device long-term reliability. An in-depth study of extended defects in WBG materials is key to mitigating their effects.

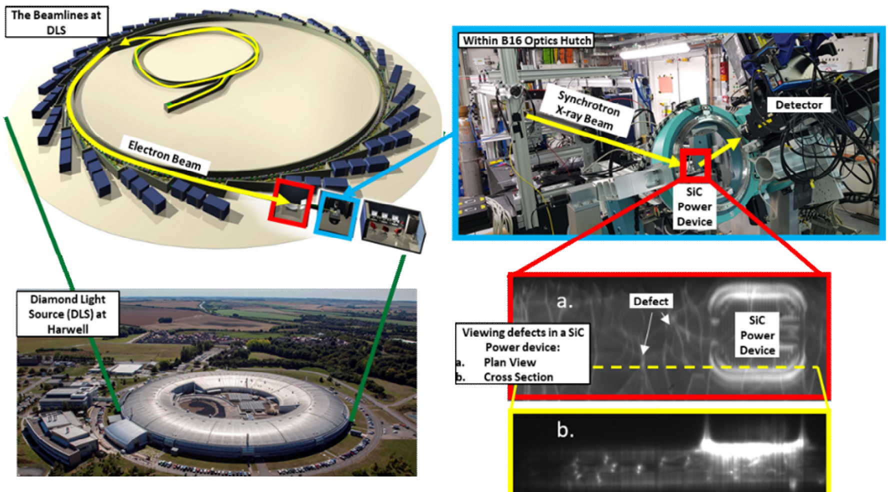

Figure 1: From synchrotron to active device imaging

Recent collaborative work between the University of Warwick, Bruker UK Ltd. and Diamond Light Source has begun to develop techniques for transmission, surface and cross-sectional imaging of defects in research and commercial off the shelf material and devices. The studentship will involve the study of SiC materials from device and materials fabrication facilities in the power electronics group (PEATER) at the University of Warwick, lab based non-destructive X-ray diffraction imaging (XRDI) at Bruker Ltd. and synchrotron white beam XRDI (SWB-XRDI) at the B16 Beamline at DLS. In this PhD, the student will develop the existing SWB-XRDI capability at B16 and will 1) optimise XRDI techniques for defect detection and classification, 2) investigate WBG defect correlation and classification compared to other techniques, 3) develop in-situ high electrical current density, UV light and thermal stressing on-chip to investigate the real-time defect dynamics within research and commercial devices, and 4) study the correlation of defect with electrical results and develop defect mitigation strategies.

Applications are open, contact Dr Shah for an informal chat (vishal.shah@warwick.ac.uk).

The School of Engineering (SoE) at Warwick University (UoW) is the ideal place to carry out power electronics research, especially a project such as this, concerned with novel material and device development. The University hosts the UK's only industrial epitaxial SiC CVD reactor, a £2.6m facility, in an ISO class 4 cleanroom. Funded by EPSRC as part of the Centre for Power Electronics, the CVD reactor is used to grow the semiconductor layers of the device on the surface of the original SiC substrate (wafer). The facility can produce defect free, precisely controlled p- and n-doped SiC layers for use in 10 kV blocking voltage devices, developed within Dr Shah's fellowship. These materials can be characterised using UoW's £24m materials and analytical sciences Research Technology Platform (RTP) with state-of-the-art electron microscopy, AFM and X-ray diffraction facilities. Its nationally unique facilities make the university one of very few institutions in Europe to house a dedicated SiC cleanroom, as well as an exhaustive list of simulation, packaging and characterisation facilities. The £3m state-of-the-art cleanroom is home annealing and oxidation furnaces, photolithography, TEOS SiO_2 deposition, RIE/ICP etching, metal deposition and atomic layer deposition tools. Alongside this, Dr Shah has established more materials-specific techniques such as DLTS, uPCD, KOH etching and Hall measurement equipment.