The development, characterisation, and application of perfect, pure, and functionalised diamond

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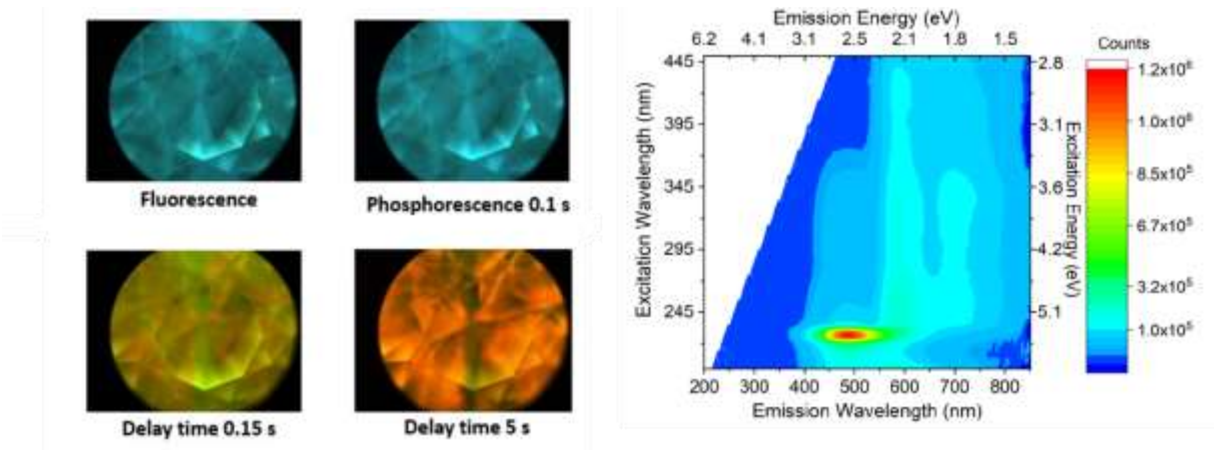
Funding: Fully funded PhD studentship (48 months).

Start date: September/October 2023.

Application deadline: Ongoing

Diamond is the epitome of a multi-functional advanced material and its extreme properties have already enabled technology and performance advances in many fields, including increased laser and microwave power densities in industrial cutting and fusion applications, in fundamental quantum information processing and communication, magnetic and electric field sensing, and radiation-hard particle detectors. Improved diamond material is at the core of all these applications.



Photoluminescence and phosphorescence are useful techniques for studying trace impurities in diamond. In this example the blue-green emission from donor acceptor pairs in a lab-grown diamond decays relatively quickly after excitation is removed. The orange emission from another impurity then dominates and persists for hours. The excitation dependence of the emission (right) shows that above bandgap photons are required to strongly excite donor-acceptor pairs but not the other luminescence centres.

Despite diamond's success, there are significant synthesis, processing and integration challenges which currently prohibit the full exploitation of diamond's superlative properties. The project will involve but is not limited to:

- Working in a team of experienced academic and industrial researchers focussed on the development of single crystal (SC) diamond grown by Chemical Vapour Deposition

(CVD) which has exceptionally high purity and very low numbers of extended defects (dislocations).

- Characterising the nature and properties of point defects and dislocations in SC CVD diamond. Dislocations generate local strain degrading the exploitable properties of the negatively charged nitrogen vacancy defect and other functional point defects, introduce optical birefringence, parasitic current leakage paths, and unwanted background luminescence. This will involve using a variety of optical spectroscopic techniques, specialised sample preparation and high-resolution Transmission Electron Microscopy (TEM).

- Characterisation of the new intrinsic diamond material and samples functionalised with point defects useful for quantum computing, communication, and sensing applications. This will involve using a variety "single defect" optical and magnetic resonance spectroscopic techniques to interrogate the quantum properties of individual point defects.

The research will be carried out in the Physics Department at Warwick in close collaboration with our industrial partner Element Six. This project is supported by the recently funded UKRI/EPSRC Engineered Diamond Technologies Prosperity Partnership grant – which aims to advance and solidify the UK's world-leading role in diamond technologies to develop solutions where no other material is capable – and the Warwick Centre for Doctoral Training in Diamond Science and Technology. The project will exploit the world-leading diamond synthesis capabilities of Element Six and Warwick's expertise in defect and material characterisation using a range of advanced spectroscopic and microscopic techniques (see image showing luminescence from lab-grown diamond), and micro/nanofabrication of diamond membranes and devices. The student will join the Prosperity Partnership team (which consists of 5 academic research groups spread across Warwick Chemistry, Physics and Engineering) and benefit from interactions with over 40 researchers in the wider diamond community at Warwick.

Applicants must have (or expect to obtain) at least the equivalent of a UK first or upper second-class degree in Physics (or related subjects). The studentship will commence in October 2023 (although an earlier start is possible based on your availability) and for UK students will provide funding for tuition fees and a maintenance grant at the standard UKRI rate, currently £18,200 for the 2023/24 academic year.

Funding may be available on a competitive basis to exceptional students of any citizenship. Applications are welcome to those able to support themselves or with funding already arranged. Such applications will go through the same level of academic assessment.

For further details please contact Prof Mark Newton (m.e.newton@warwick.ac.uk) and DST.Admin@warwick.ac.uk, and provide a CV.