Diamond Science & Technology
Professional Training Programmes

University of Warwick
2015/2016
Recent funding from the government has enabled us to establish the Centre for Diamond Science and Technology (DST). This collaboration brings together leading academics from eight partner universities and industrialists from more than 30 companies, to deliver research excellence and a unique, comprehensive training package in DST.

The training programme, based at the University of Warwick, has been devised to equip research scientists with the skill sets necessary to drive forward technological innovations in DST, and will develop and enhance the capabilities of employees working within related industrial sectors. The programme is designed to be fully flexible to meet the needs of industry, consisting of ten stand-alone modules, taught by leaders in the field. These modules can be taken in isolation, or in bundles, the latter leading to postgraduate qualifications from the University of Warwick, one of the UK’s most innovative and highly ranked universities. There is also the opportunity to undertake two ten week research projects or one twenty week research project, to suit you and your company’s needs. The projects can be carried out either at one of the partner universities or the sponsoring company.

We look forward to welcoming you onto our programme.

Prof. Mark Newton (University of Warwick)
Diamond Science & Technology Director
Introduction

Investment
Following a significant investment from EPSRC, the Diamond Science and Technology Centre for Doctoral Training is the world’s first postgraduate training centre in Diamond Science and Technology (DST). The centre brings together world leading academics drawn from eight universities across the UK, including Aberystwyth, Bristol, Cardiff, Imperial, Oxford, Newcastle, Strathclyde and Warwick. Associated with the centre is a standalone one year Masters of Science (MSc) course in DST which benefits directly from this investment and the pooling of expertise and facilities available for training.

Internationally Leading
The course takes place at the University of Warwick and is delivered by experts in DST drawn from eight leading universities, and a number of industrial partners. A seminar series, which enhances and builds on the course content, will consist of visiting speakers from industry and internationally leading academics engaged in DST. Students will gain hands-on experience of a range of techniques and technologies available in research and commercial facilities, providing them with the transferable skills required to succeed in a rapidly changing field.

Relevant
This comprehensive training package provides students with a skill set to exploit the unrivalled multi-functional properties of diamond, equipping them with expertise in materials synthesis, electronics, optics, photonics, quantum technologies, mechanics, modelling, defects and device engineering. Such skill sets are fundamental to many key industries both national and international.
MSc in Diamond Science & Technology

Diamond is the epitome of an extreme material, exhibiting unrivalled multi-functional properties ranging from the thermal and mechanical, through the electrical to the optical. Its amazing range of extreme properties lead to tremendous opportunities for commercial exploitation.

New diamond technologies, which exploit this amazing combination of extreme properties, have the potential to revolutionise society through transformative breakthroughs in electronics, optics, quantum sensing, photonics, composite materials, energy efficiency and sensing.

The course will provide...

A detailed understanding of the fundamentals of materials science, from the classical to the quantum, but with an emphasis on diamond and related materials and application-driven themes. The MSc will give students the theory, experience and problem solving skills needed to research, drive, manage and evaluate the advances in technology that underpin this field.

“Diamond is an exciting technology opportunity and we are confident further developments will emerge that will provide value not only to the defence sector but also to healthcare, environmental assessment, computing and information processing”

www.dst-dtc.ac.uk
Taught Modules

The MSc comprises ten taught modules, covering a wide range of themes, and one twenty week or two ten-week research projects. Each module is typically taught over a two-week period.

MSc Research Projects

Research projects in DST are proposed by members of staff from across the consortium of universities and industrial partners associated with the centre. Projects cover a range of topics, from material characterisation and processing to applications. Industrial students sponsored by an employer can elect to undertake two ten-week research projects or one twenty-week research project, to suit their own and their company’s needs. The projects are carried out either at one of the partner universities or at the sponsoring company, after completion of the taught modules.

Core Modules

- Novel and Efficient Methods of Material Synthesis
- Properties and Characterization of Materials
- Defects and Dopants
- Theory and Modelling of Materials
- Manufacturing the Future: Industrial Diamond
- Surfaces, Interfaces and Coatings
- Devices and Fabrication
- Diamond Photonics and Quantum Devices
- Applications of High Performance Materials

Elective Modules

- Electrochemistry and Sensors
- Biomedical Optics and Applications

MSc Research Projects

- One 20-week or two 10-week research projects

“We are very confident that this programme will deliver the right kind of highly trained, multi-disciplinary scientist, who not only has a keen understanding of materials science but can understand how materials, such as diamond, can be employed in innovative ways in the industrial sector”
Teaching

DST taught sessions take place primarily in the state of the art Materials and Analytical Sciences Building within the Departments of Physics and Chemistry at the University of Warwick. Purpose designed work rooms are available for use by students undertaking this course or selected modules.

Learning at Warwick is supported by an excellent Library as well as the Learning Grid, which offers wireless access points, networked PCs, and many other resources.

Facilities

Under the umbrella of the Global Research Programme, Warwick is home to an extraordinary array of facilities to carry out world-class research and to provide training at the highest level in the area of materials science.

It houses outstanding instrumentation in the area of microscopy, including scanning and transmission electron microscopes, atomic force microscopes, and confocal microscopes. A high-end X-ray diffraction suite dedicated to materials characterisation is shared between chemistry and physics, along with X-Ray photoelectron spectroscopy facilities, Raman spectroscopy and clean room suites for materials processing.

Our DST students will benefit from hands-on training on state-of-the-art research instruments.

www.dst-dtc.ac.uk
Module Descriptions

Core Modules

1. Novel and Efficient Methods of Material Synthesis
Students will gain a working knowledge of a range of advanced materials in use by UK science and technology industries, with an emphasis on diamond. The properties, fabrication processes and applications of these materials will be discussed. A visit to Element Six's Global Innovation Centre at Harwell, is included.

2. Properties and Characterization of Materials
This module provides an overview of important material properties, with a focus on three-dimensional crystals. Students will develop (i) an awareness of quantum mechanical theory of electronic structure and its role in determining material properties and (ii) an understanding of the electronic, mechanical, thermal, optical and magnetic measurements that can be used to investigate the properties of a material.

3. Defects and Dopants
This module covers the identification of intrinsic defects, dopants and impurities in semiconductors and insulators with a specific focus on diamond. Once the different types of defects have been introduced, characterisation techniques and the information they reveal on defect properties, will be discussed.

4. Theory and Modelling of Materials
In this module, students will be taken from the basic principles of bonding at the atomic scale, through molecular and crystalline systems, arriving at the macroscopic system in terms of elastic properties, implantation damage and electronic devices. Through a combination of theory presented in a lecture context and practical applications of computational simulation, the students will review the most commonly used theoretical approaches to modelling materials, and develop an understanding of the advantages and disadvantages of each method.

5. Manufacturing the Future: Industrial Diamond
This module introduces the students to polycrystalline diamond (PCD) composites and related materials, high pressure-high temperature synthesis and the importance of defects. The machining characteristics of PCD will be discussed along with tool fabrication, machining trials, wear and failure mechanisms.

Lecturers

Aberystwyth
Prof. Andy Evans
Dr. Martin Wilding

Bristol
Prof. Mike Ashfold FRS
Dr. Simon Kohn
Prof. Martin Kuball
Prof. Paul May

Cardiff
Prof. Paola Borri
Dr. Stephen Lynch
Dr. Oliver Williams

Imperial
Dr. Daniele Dini
Dr. Chris Dunsby

Oxford
Prof. John Foord
Dr. Joshua Nunn
Dr. Brian Patton
Dr. Jason Smith
Prof. Richard Todd

Newcastle
Dr. Jon Goss

Strathclyde
Dr. Erdan Gu
Dr. Jennifer Hastie
Prof. Alan Kemp

Warwick
Dr. Claire Dancer
Prof. Julie Macpherson
Prof. Phil Mawby
Dr. Gavin Morley
Prof. Mark Newton

Industry (De Beers/E6)
Dr. Geoff Davies
Dr. David Fisher
Dr. Philip Martineau
6. Surfaces, Interfaces and Coatings
The focus of this module is surface-specific characterisation methods widely applied in research and industrial laboratories. The emphasis is on diamond surfaces, but the techniques discussed are relevant to other structurally related materials such as Si, Ge, III-V, II-VI semiconductors and the surfaces of other semiconductors, insulators and metals. A visit to the Diamond Light Source at Harwell, is included.

7. Devices and Fabrication
This module aims to cover the basics of clean room technologies and device fabrication. The specifics of diamond processing will be addressed in context with silicon technologies. Operation of basic semiconductor devices will be explained.

8. Diamond Photonics and Quantum Devices
Students will achieve a basic grounding in the physics and application of diamond to photonics and quantum devices. They will learn about principles of operation; advantages and challenges of diamond; device design and manufacture. They will gain practical experience in optics and spintronics experiments, and in finite element modelling of relevant optical systems.

9. Applications of High Performance Materials
This module aims to promote an appreciation for the wider context of DST: the applications, the alternative materials, and the competitor technologies. Students will be encouraged to collate and critically analyse a body of scientific work and practice presenting this information to a variety of audiences. During the course of the module, students will be exposed to seminars from world-leaders in both academic and industrial DST and related fields.
10a. Electrochemistry and Sensors
This module provides a grounding in the fundamentals of electrochemistry, electroanalytical techniques and sensor technology. The module encompasses potentiometry, voltammetric and amperometric techniques, microfluidic devices, lab-on-a-chip methods, and electronic noses and tongues. The course draws on Warwick’s major strengths in this area and covers developments in ion selective electrodes, electrode kinetics, mass transport and key techniques, such as linear sweep and cyclic voltammetry, hydrodynamic electrodes, stripping voltammetry, ultra-microelectrodes and array devices.

10b. Biomedical Optics and Advanced Microscopy Techniques
This module aims to provide students with a basic understanding of biomedical optical imaging and spectroscopy and an understanding of the potential biomedical applications of diamond. Students are introduced to a variety of optical microscopy techniques including wide-field, confocal, fluorescence and advanced optical microscopy. Tissue optics (absorption, scattering, spectroscopy), imaging in biological tissue (OCT, multi-photon) and an overview of labels and probes for optical imaging will also be discussed.
Programme Pathways

We offer qualifications in three streams, allowing students to tailor their studies to match their needs and the needs of their company.

All of the taught modules within the masters programme can either be taken individually to boost skills and knowledge or in bundles, leading to a postgraduate qualifications. If you wish to obtain a qualification, you can follow one of three streams: (i) the Postgraduate Award; (ii) the Postgraduate Certificate; or (iii) the Master’s degree programme.

Flexible routes to a qualification that suits you and your employer...

Successful completion of each of our postgraduate qualifications means that you can transfer credits and fees and join the next award level if you wish to continue your studies. For example, if you successfully complete three modules to achieve a Postgraduate Award, you can then join the Postgraduate Certificate programme at the halfway point, completing three further modules to achieve this qualification.
Should I enrol?

The course and individual modules are targeted at students or industrialists who will benefit from a comprehensive training in modern aspects of materials science and processing with an emphasis on diamond science and technology. We invite applications from industrialists and students with backgrounds in chemistry, physics, materials science, engineering and maths. The MSc qualification or Postgraduate Certificates provide an excellent foundation for careers in industry and further research at PhD level.

Those who already work in industry, or any measurement, materials or application driven environment, will find the course a valuable means of updating their expertise.

Fees

You can progress between any of the postgraduate award levels. Fees already paid will be credited towards the fees for the higher award. Only a small Admin fee is charged.

For participants taking individual modules we can help in arranging on campus accommodation (subject to availability, charges will apply). Contact DST.admin@warwick.ac.uk for information.

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<tr>
<th>Postgraduate Level</th>
<th>Cost</th>
<th>Completion within</th>
<th>Modules</th>
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<tbody>
<tr>
<td>Single DST Module*.*</td>
<td>£1,300</td>
<td>10 days</td>
<td>10 credit module. Usually delivered as 5 days lectures, workshops and problem classes plus 5 days for practical and assignments.</td>
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<tr>
<td>Postgraduate Award in DST*</td>
<td>£3,665</td>
<td>24 months Part Time</td>
<td>Three 10 credit modules (30 days)</td>
</tr>
<tr>
<td>Postgraduate Certificate DST*</td>
<td>£7,212</td>
<td>24 months Part Time</td>
<td>Six 10 credit modules (60 days)</td>
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<tr>
<td>DST Master’s Degree</td>
<td>Home/EU students £7,400 Overseas (countries outside EU) £21,280</td>
<td>12 months Full Time</td>
<td>Ten 10 credit modules plus two 40 credit projects or one 80 credit project.</td>
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*For participants from a DST CDT Project Partner a 50 % fee scholarship is available. Matched-funding may be available towards fees for participants from an SME. Contact DST.admin@warwick.ac.uk to check eligibility or for further information.

*Short courses carry credits towards other programmes for a period of up to 24 months.

Information correct as of August 2015. Fees are subject to change by the University without notice.
Life at Warwick

The University of Warwick is a leading UK institution which is internationally acclaimed for research in science and engineering, and as an innovator in knowledge transfer to industry and the community. Students and researchers on campus are from over 150 countries, making for a thriving multicultural environment.

The University of Warwick boasts the largest arts centre on any campus outside of London. The Arts Centre houses two theatres, a concert hall, a cinema and an art gallery. The venue showcases some of the best in UK and international drama, comedy, dance, art, film and live music – from contemporary to classical.

Warwick’s Students’ Union is one of the biggest in the UK. With great food, amazing entertainment and over 300 sports clubs and societies, getting involved with the union is a great way to meet new people at Warwick. The postgraduate community is represented by both a dedicated Postgraduate Officer and the Postgraduate Association.

Sporting life is great at Warwick whatever your interest. Warwick Sport supports 73 sports clubs as well as organising a wide range of exercise classes and sports courses. There are excellent facilities including a swimming pool, gym, climbing wall, squash courts and playing fields.

Warwick University has a great location in the heart of England and is easy to reach via train, car or air. Coventry is about 15 minutes away, Birmingham, and the historic towns of Kenilworth, Warwick, Stratford upon Avon and Leamington Spa, are in easy reach. London is only 1 hour by train from Coventry Station.
The Centre for Doctoral Training in Diamond Science and Technology in collaboration with