Institution: University of Bath

Unit of Assessment: 9: Physics

a. Context

Impact lies at the heart of University of Bath's mission statement and the Department of Physics has always pursued research in areas that are both scientifically exciting and naturally lead to impact. As a fairly small UOA we achieve this by positioning ourselves in cutting edge fields with great potential for commercial applications, achieving critical mass either locally or as part of wider collaborations. Indeed each of our three research groups: Photonics and Photonic Materials, Nanoscience, and Condensed Matter Theory are engaged in world leading research that is generating substantial impact.

Our principal user group is high-tech businesses such as manufacturers of laser systems and medical devices. Close relationships with these businesses are fostered and maintained via consultancies, spinouts, knowledge-exchange activities and through our successful and longstanding undergraduate industrial placement scheme. Since 2008 this engagement, underpinned by our world leading research has directly resulted in product sales that are conservatively estimated to total well over £150M across a number of companies. Many of these sales also generate further major impact, for instance in improved healthcare outcomes for cancer patients.

b. Approach to impact

Our approach to impact is two-fold. On the one hand, we take an agile approach to research opportunities, moving rapidly and flexibly into exciting new areas with high impact potential, as exemplified by our recently established Centre for Graphene Science. On the other hand we recognize that for impact to emerge subsequently, one must foster successful professional relationships between academics and key external users. The Physics department at Bath is committed to supporting and developing these relationships and does so via a number of routes.

Consultancies and industrial collaborations are strongly encouraged at Bath. A large proportion of the profits from consultancy are made available to the academics to use in their research or as pump priming for further impact-oriented activities. Consultancy is also encouraged via the criteria for academic promotions. The Department of Physics has a long history of such activity. Within the REF period this has included

- Prof. Nigel Cronin's role as Chief Scientist to **Microsulis Medical Ltd**. Tens of thousands of patients suffering from Menorrhagia and Cancer have directly benefited from the medical application of our microwave ablation technology, developed and commercialised in close collaboration with industry.
- **Fianium Ltd**. has employed several members of the Centre for Photonics and Photonic Materials (CPPM) as consultants and advises CPPM on current interests of community of supercontinuum users, on problems with current supercontinuum sources, and of developments in state-of-the-art fibre-based pump laser sources. Our longstanding collaboration with Fianium is described in an impact case study.
- Prof Alison Walker of the Condensed Matter Theory group coordinates a Marie Curie Initial Training Network on "Dye sensitized solar cells wIth enhanced stability". This includes several industrial collaborators: **Oxford Photovoltaics Ltd**, **SAES Getters S.p.A., 3GSolar Photovoltaics Ltd, Greatcell Solar S.A., Tiberlab S.r.l**. They are taking a highly integrated approach to finding solutions to degradation issues that will facilitate the commercialization of dye-sensitised solar cells for applications in building integrated photovoltaics and consumer electronics.
- Walker also coordinated an EU FP6 project "Modecom" (2006-201) with industrial collaborators **Cambridge Display Technology** and **Quantumwise** (Copenhagen), aiming to bring organic light emitting diodes to mass market.
- **Mauna Kea Technologies** (Paris) informs CPPM members of the current state of

endoscope fibres and products, and the direction the industry is moving.

- The Nanofabrication Facility of the Physics department offers (via Bending) consultancy services to industrial companies and academics: e.g.
    - Fabrication of prototype electro-optic modulators for **Gooch & Housego**, Illminster
    - Fabrication of Pb humidity sensors for Marianne Odlyha, Birkbeck College, London. These are being used in a range of conservation projects for historical organs and artwork around Europe.
    - Development of hardware for mK imaging in collaboration with, and fabrication of Bi Hall effect sensors to be used in the products of **Attocube GmbH**, Germany.
    - Support for the R&D work of **Nanogan** (and the parent company **IQE PLC**).

Income from consultancy in the REF period amounts to £167k, while industrial research grants total £710k (Eg. Los Gatos Research, Seiche Measurement Ltd). Case awards amount to £76k. Industrial partners appear on £2.8M of grants.

Institutional framework. We take full advantage of a range of institutional services designed to facilitate impact. Impact seminars, workshops and guidance for academics and PGs are provided by the Research Development and Support Office (RDSO). These help academics appreciate how their research might lead to impact, and how the university can help both in achieving this impact and dealing with matters of intellectual property. They have been attended by 20 staff and postdocs from the department. The Enterprise and Knowledge Exploitation (EKE) team within RDSO coordinate the commercialisation of university research and market University research infrastructure with a view to increasing the value of consultancy work. They have helped members of the department file 10 patents since 2008. The Knowledge Transfer Account (KTA), Knowledge Transfer Partnership (KTP) and Consultancy Services support the development of collaborative projects and consultancies and have been heavily used by the Physics Department, for example in the collaboration with Fianium Ltd. This support ranges from bringing parties together to helping to write bids and to organise collaboration agreements.

Knowledge Transfer Activities. The KT champion (Wadsworth) supports departmental members in accessing KT funding. For example, Knight was helped to apply for funding to build links with Fianium Ltd. Similarly Bending was helped in an application to EKE to support the development of Hall sensors which are now marketed by Attocube. Nogaret received £17K from the Higher Education Innovation Fund to develop a heart pacemaker device, leading to preclinical trials and a market study commissioned by Ithaka Life Sciences. Overall, the department has won £272K of KT funding in the REF period including two postdoctoral KT fellows. One of these (supporting Stone) was graded “outstanding” by the KTP panel. The department has also won over £1M of TSB funding for collaborative projects with Fianium Ltd.

Continuing professional development. The CPPM ran a CPD course in 2011 and 2012 and is scheduled to repeat in 2014. This provides training in Photonic Crystal Fibre fabrication techniques for R&D staff from many of the important speciality optical fibre firms, as well as staff in research institutes around the world. The course also provides a forum via which we can better appreciate the needs of industrial end-users. It has directly resulted in one Bath PhD graduate finding employment in a global optical fibre company. The course has attracted 13 participants to date, paying £8k each.

Spinout activities. EKE is actively progressing the business case for commercialising GLOphotonics (currently under incubation in France) a spin-out company from CPPM.

c. Strategy and plans

Our long history of engagement with impact activities has taught us a number of lessons that are informing our continuously developing strategy.

Firstly we have learned that long term business consultancies, secondments and spin-outs, fully supported by the university, are essential for realizing the levels of engagement necessary for exceptional impact and mutual benefits. The department and university will remain proactive in establishing and supporting these activities. At the same time, experience shows the importance of ensuring a corresponding level of commitment from industrial partners. Accordingly, activities

supported by the EPSRC funded Impact Acceleration Account will require substantial contributions (financial or in kind) from all stakeholders.

Secondly it is vital to foster and embed an academic culture that recognises the importance of participation in impact-oriented activities. To this end, part of our strategy for academic recruitment process will continue to consider the potential for impact of candidates' research, and all new academics and ECRs will attend University impact workshops as part of their probationary process. The promotions criteria will continue to include reference to impactful activities as a factor in career progression, and these will remain a strong lever for sabbaticals and secondments.

Thirdly, we have learned the importance of positioning ourselves so as to respond rapidly and flexibly to new and exciting research opportunities that have great potential for impact. Two examples here are the recently established Centre for Graphene Science, joint between Bath and Exeter, and our Centre for Photonics and Photonic Materials. We expect that these centres will form the foci of our future impact generation as we now describe.

The Centre for Graphene Science. 15 Physics academics are members of this centre which is joint with Exeter and which totals 34 members. One of its principal aims, as expressed in its mission statement, is to exploit applications of Graphene that could lead to economic or health impacts. Applications currently under active investigation by the Bath group focus on bio-sensing and electromechanical structures. In the former category we are working with industrial and NHS partners (Oxford Nanopore Technologies, Frenchay Hospital and Nemaura Pharma) on biocompatible graphene-based biosensors for detecting glucose and sepsis. On the structures front we are developing (together with Airbus and Alchemie), electrically-active graphene-silicone composite skins for drag reduction and flow sensing on aircraft wings. Knowledge exchange and awareness of the needs of industry is facilitated via events such as the successful Graphene Industry Day (28/3/2012, attended by 12 industrialists) and via the Centre's advisory board, which includes three industrial members in each meeting, selected on a rotating basis from a broad portfolio of associate members. The centre has recently been awarded a £1M grant on Graphene Engineering, together with industrial partners (SAFC-Hitech, Oxford Instruments, Johnson-Matthey and Thomas-Swan) which will underpin fabrication and exploitation of Graphene devices.

The Centre for Photonics and Photonic Materials. This already has a track record of major impact (see case studies). Future impact is likely to arise from our recent spinout of GloPhotonics, which markets a new sub-assembly optical component called the Photonic Microcell. Current funded projects aimed at generating impact are development of novel fibres for endoscopy (with industrial partners Carestream Health Inc, ST Microelectronics Ltd and Edinburgh Biosciences Ltd), as well as fabrication of fibre arrays for inclusion in needles to sense how injected liquids dissipate under the skin. A joint grant with Mechanical Engineering in Bath on "light driven factories" plans to investigate the use of specialist optical fibers for precision metrology.

ONYX Postgraduate Training Alliance. Looking ahead to the next generation of researchers and business people, we are instilling in our future doctoral students appreciation of the needs of industry and the benefits of academia-industry collaborations. To this end we have included industrially focussed training in the ONYX postgraduate training alliance with Bristol and Exeter universities (focussed on Photonics, Spintronics, Plasmonics, Magnonics and Electronics)**.** This content has been designed together with industrial stakeholders (eg. Oxford Instruments, Siemens Magnet Technology, ST-Ericsson, Begbrook Science Park). The first ONYX Industry Day was held in May 2012 as part of a three day student conference that included a wide-range of transferable skills training. It was attended by 36 PhD students, 9 academics and 5 industrialists.

d. Relationship to case studies

The strong support for consultancy work coupled with TSB and KTP support from the university were key to the knowledge exchange that allowed the growth of Fianium. Secondments and establishment of spin out companies (Blaze Photonics) helped the transition of photonic crystal fiber from a research topic to a marketed product. Similarly, secondments to Microsulis Medical Ltd, consultancy work, and university support for its principal research staff were critical in allowing the product development that underpinned the successful growth of the company. These experiences have taught us that strong relationships with companies (aided by external and university support) can deliver exceptional long-term mutual benefit.