

UoA environment template (REF5b)

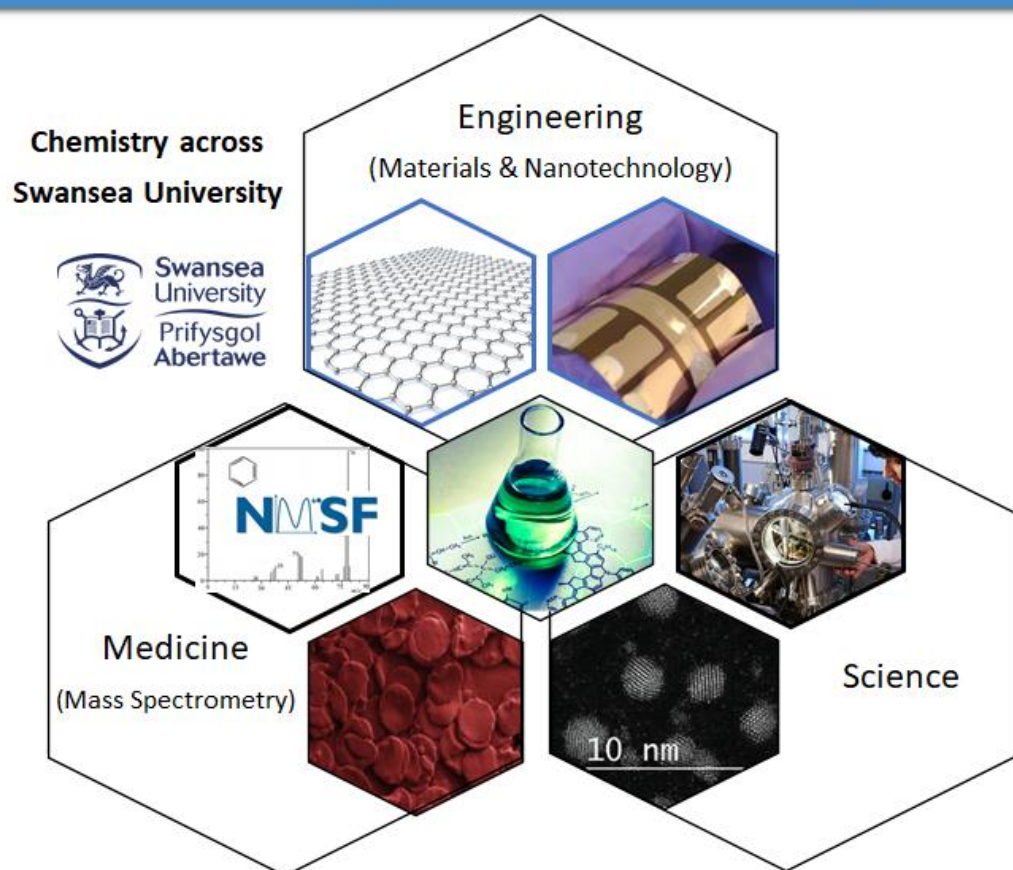
Institution: Swansea University

Unit of Assessment: 8 (Chemistry)

Section 1: Unit Context

The Chemistry department was re-established in 2016 as part of the University's strategic ambition to expand physical sciences and engineering at Swansea. Although, the original Department closed in 2004, due to sustainability issues, Chemistry continued to thrive and was invested in across the University, notably in Materials Engineering, Nanotechnology and Medicine (figure 1).

Figure 1: Up until 2016, pockets of Chemistry expertise were spread out across the University. These were strengthened and invested in over the last 10 years



The University realised this strength could be further enhanced by re-developing the department (figure 2) to act as a hub to formally bring together the chemistry community across the University, enhance training, research, grant capture, industry engagement, impact and grow the researcher base. The existing interdisciplinary chemistry community drove the re-establishment of the Department, adding new appointments and thus ensuring interdisciplinarity is within the DNA of the Unit. The last 4 years re-establishing the Unit has been strategic, exciting and very successful culminating in our first Chemistry REF submission in 20 years evidencing our ambition within the discipline.

Figure 2: Establishment of Chemistry Department 2016 - 2021



The Unit is versatile, ambitious and impact-driven, and combines established, mid-career and promising early career staff recruited since 2016, with chemists from other departments. The Unit has an inherent focus on **collaborative, interdisciplinary research**, exceptional **links with industry**, and an agenda for the generation of **long-term socio-economic impacts** arising from fundamental and applied research. Outputs represent research diversity of our staff, providing an overview of the breadth, quality and impact (figure 3).

FIGURE 3: UoA8 CHEMISTRY KEY PERFORMANCE OVER REF2021 PERIOD

20 (19.2 FTE)
STAFF SUBMITTED

£3.1M TOTAL
RESEARCH AWARDS

461
OUTPUTS PUBLISHED*

67% OF OUTPUTS IN
TOP 10% MOST CITED JOURNALS*

>9,000
CITATIONS*

AVERAGE CITATION
PER PAPER 19.4*

FIELD WEIGHTED CITATION IMPACT
1.74 – 74% ABOVE THE GLOBAL AVERAGE*

*Scopus/Scival including those not submitted to REF

Our research transcends disciplinary boundaries, integrating core areas of inorganic, organic, physical and analytical chemistries with (e.g.) Engineering, Bio-medicine and Physics. Our research in energy and the environment, nanotechnologies and advanced materials is linked to our College of Engineering (ranked 12th in UoA15, REF2014 by the Times Higher Education), and our research on health, advanced biomaterials and polymers, and molecular, imaging and computational tools and devices is linked to our Medical School (ranked 2nd in UoA3, REF2014).

Highlights include:

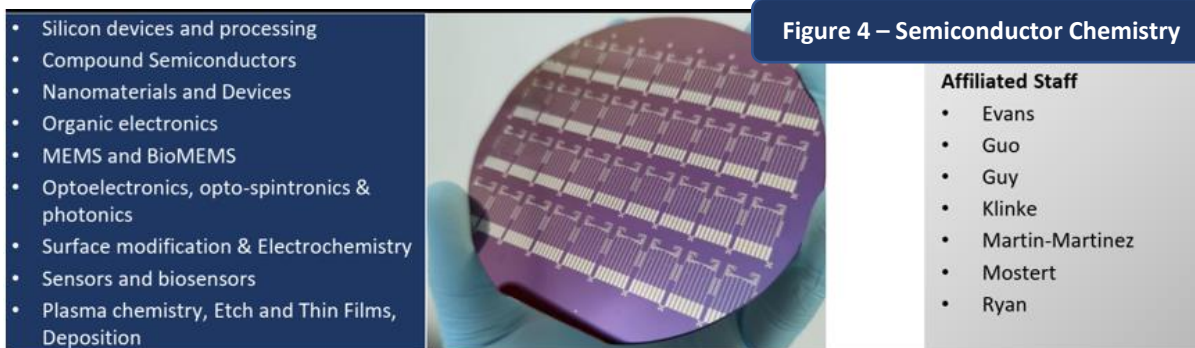
- Department re-established in 2016, with recruitment of six staff;
- Phase two recruitment of an additional seven research-active staff in 2017/2018;
- Phase three recruitment of four additional early-career research (ECR) staff (Bassetto, Martin-Martinez, Gill, Ryan) – aligned with strategic priority themes in health and materials – and the integration of seven promising ECR staff members from Engineering (Sharma, Aldous, Guo, Pitchaimuthu, Reddy, Tehrani, Devadoss);
- Establishment of core research themes to promote collaboration between researchers and external partners;
- £2.8M in research income;
- Industry in-kind support totalling over £3.1M;
- £1M investment in core instrumentation, supported by Perkin Elmer, Jeol;
- Award of a £30M **Centre for Integrative Semiconductor Materials** (CISM) to Physics, Chemistry and Engineering (part of a £90M initiative);
- Award of six competitively won Fellowships; and
- Established community of 30 postgraduate and post-doctoral researchers.

Unit Structure

Our Department is a vibrant community of 19.2 (FTE) category A research-active colleagues, including 16 recruited from leading global research institutions since 2016. We also collaborate with chemists from the original Department who are now in other UoAs (Engineering and Medicine).

The Department is purposefully structured around **five research themes aligned with areas of national importance** (e.g. health, energy, AI, enabling technologies, advanced materials):

1) Semiconductor Chemistry

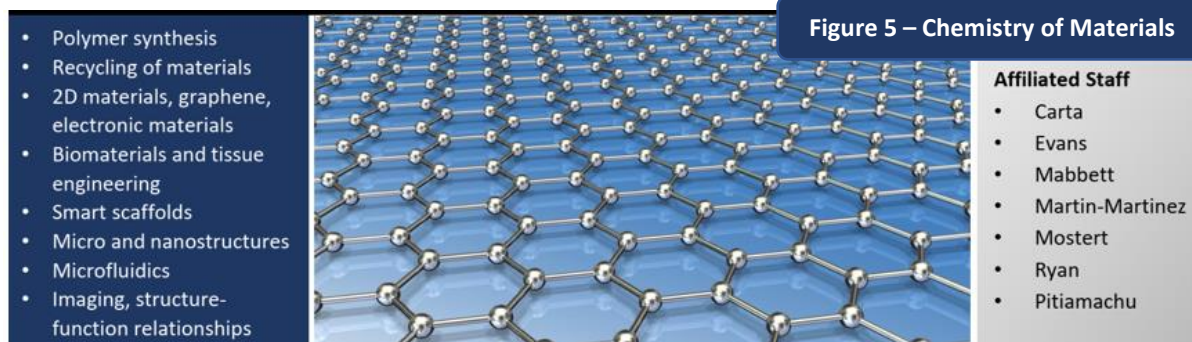


Encompasses:

- novel solid-state nano materials and their electrical and optoelectronic properties, for applications in FETs, quantum sensors, neuromorphic computing, telecoms and PV;
- the application of computational chemistry, multiscale modelling, and machine learning to design new semiconductor materials for organic PV and understand semiconductor band structures in 2D materials and transition metal oxides;
- development of experimental techniques to study new photophysical and spin properties of emergent organic semiconductors with unpaired electrons;

- development of materials, electronic and photonic devices for resistive RAM, neuromorphic devices, OPV, OLED, VCSELs, opto-spintronics, SiC power devices, sensors and MEMS;
- study of next-generation semiconductor materials (graphene, other 2D materials, organic semiconductors, metal oxide and wide bandgap semiconductors) complementing our work with industry.

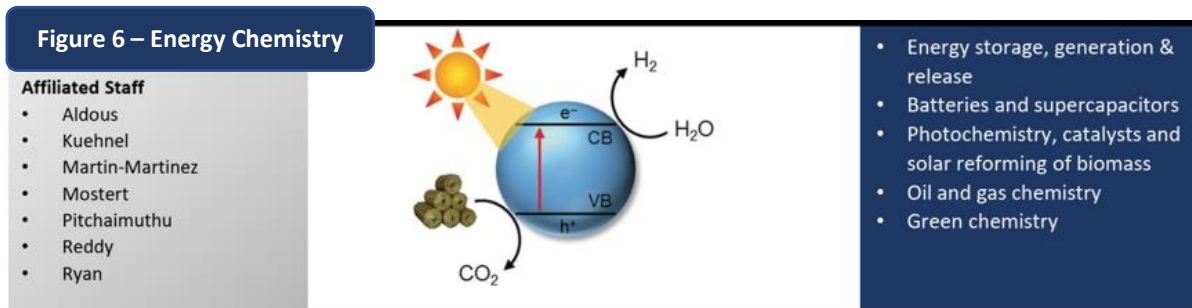
2) Chemistry of Materials



Encompasses:

- synthesis and characterisation of novel micro-porous polymers for applications in gas separation, heterogeneous catalysis, electrochemistry and CO₂ capture/storage;
- development of functional coatings for the built environment and their scale-up in global infrastructure projects (including bioderived paints, green solutions to water, sanitation, PV and electrochemical storage);
- development of nanomaterials with enzyme-like activity; nanoparticle synthesis and self-assembly;
- application of computational theory (DFT) for calculating reactivity indexes, identifying functional groups susceptible to nucleophilic or electrophilic attacks;
- prediction of oxidation, aging and corrosion;
- utilisation of big data analytics and deep learning on large molecular datasets for predicting reactivity.
- Synthesis, fabrication and characterisation of bioelectronics devices based on bio-inspired materials, for sensing applications.
- Application of neutron and muon scattering techniques to characterise structural and dynamic behaviour.

3) Energy Chemistry

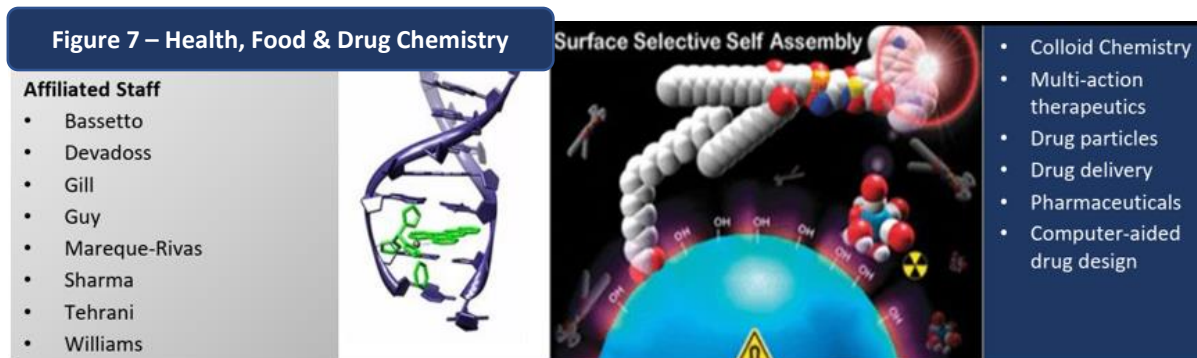


Encompasses:

- sustainable generation of fuels (hydrogen) and feedstock chemicals from abundant resources e.g. water, CO₂, biomass, used plastics and waste;
- computational chemistry, multiscale modelling, and machine learning applied to hydrothermal processing of biomass, producing nano-porous, carbon materials for energy-storage;

- development of novel materials (including thin films) and non-destructive testing tools electrode materials in lithium-ion and lithium-sulphur batteries in collaboration with industry (OXIS Energy, SPTS Technologies).

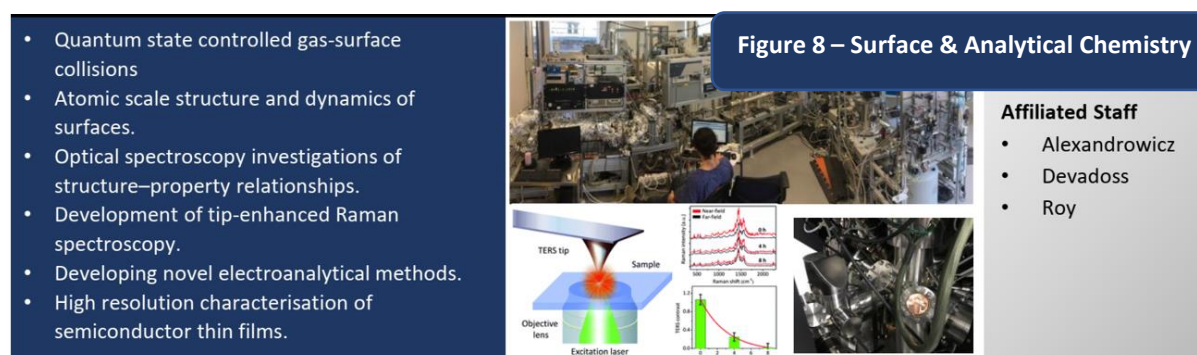
4) Health, Food and Drug Chemistry



Encompasses:

- microneedle-based theranostic devices (including drug delivery and vaccine smart patches);
- synthetic inorganic chemistry and cell biology application in bio-active molecules to combat drug resistance in cancer;
- using ruthenium complex hypersensitisation of cancer cells for synergistic cancer therapies with reduced side-effects;
- optimisation of combination therapies including multifunctional nanoparticle therapies;
- nanotechnology-enabled immunotherapy;
- multimodal imaging agent development for drug discovery;
- chemical and computer-aided drug discovery strategies to optimise immunity, design better vaccines and therapies; and synthesise novel small molecule APIs (for antiviral research);
- design and synthesis of novel antibacterial compounds and microbial volatiles for use in crop protection;
- development of innovative nanobiosensors for early point-of-application disease diagnosis and food & beverage production/storage and environmental sensing;
- vibrational spectroscopy and machine learning tools for application in clinical diagnosis.

5) Surface and Analytical Chemistry



Encompasses:

- developing / implementation of advanced experimental techniques to study fundamental molecule–surface interactions beyond the reach of conventional surface science techniques;
- controlling the rotational orientation of ground state molecules and studying stereodynamics in gas-surface collisions;
- studying the structure and atomic-scale dynamics of thin surface layers;
- separation of molecular spin isomers using magnetic lenses;

- optical spectroscopy techniques to investigate structure–property relationships and molecular reactions at the nanoscale (ambient / aqueous high resolution tip-enhanced Raman spectroscopy (TERS);
- developing novel electroanalytical methods;
- high-resolution TEM, XPS and Raman spectroscopy of semiconductor devices.

The themes, in “funding growth” sectors provide a flexible environment, in which staff can adapt according to their interests, leveraged by available university resources (major University facilities, previous investments and joint projects, see REF5a). The structure facilitates collaboration between groups, joint grant applications, infrastructure and equipment sharing, the hosting of academic guests, and co-organised symposia.

Chemistry is also a significant contributor to two major multidisciplinary research centres:

Our **Centre for Integrative Semiconductor Materials**

(CISM) is a £90M initiative supporting the globally renowned silicon and compound semiconductor sector in South Wales. CISM brings together researchers in Chemistry, Physics and Engineering to drive technology development in compound-semi-on-silicon, power devices, sensors and photonics. CISM will open at the University’s Bay Campus in 2022 and involves industrial partners across the supply chain. **Chemistry is already**

contributing to CISM’s projects (SOCRATES, Application-Specific Semiconductor Etch Technology (ASSET), Smart Partnerships, KTPs, and EngDs) and more than £20M of matched funding committed by our industry partners (SPTS Technologies, OXIS Energy and Zimmer & Peacock).



The **Centre for Nanohealth** (CNH) is a £22M open-access facility with a community of more than 40 chemists, physicists, engineers, and biomedical researchers, applying interdisciplinary research to healthcare problems, in collaboration with industry and clinicians. The CNH has worked with over 400 companies since 2012. **Chemistry contributions to the CNH include** surface science using molecular beams, electron microscopy and spectroscopic techniques; graphene biosensors; novel nanoparticle drug delivery systems; innovative plastic recycling techniques; polymer membranes; energy storage; semiconductor based sensors and bio-MEMS; and novel inorganic materials for optoelectronics.

Chemistry also contributes to **CAPTURE** (Circular Applications to Utilise and Retain Energy), a £1M partnership with ENSERV POWER focussed on the manufacture and management of energy-storage solutions, and to the £6.5M Global Challenges Research Fund (GCRF) **SUNRISE** project, which has impacted deprived communities in rural India through building installation demonstrators for next-generation PV and electrochemical energy storage platforms.

Research Strategy

The Unit’s success has relied on its recruitment of talented academics and senior staff joining from other areas of the university, who together, benefit from an active and positive environment enabling them to maximise their potential (Section 2), with access to superb facilities (Section 3) and a commitment to collaborative, impactful research (Section 4). Our aim is to be recognised as **a modern department that brings chemical science to life** through globally excellent R&D, collaborating with other disciplines to address current and future challenges, particularly in Semiconductors, Nanomaterials, Energy, Healthcare, and the Environment. We aspire to produce research of the highest calibre in an intellectually challenging, inspiring, and supportive

environment that nurtures research and fosters talent. Our ambition is to become consistently rated amongst the UK's best small Chemistry departments, with a reputation for outstanding fundamental science and industrially relevant collaborative research. Our strategy in the REF period has focussed on the following:

1. Engaging in strategic and interdisciplinary collaboration

Chemistry has established itself as a trusted partner for other University disciplines and with strategic industry and academic partners (Section 4), enabling interdisciplinary science to thrive within the Unit, for example in the translation of semiconductor technologies to healthcare applications, e.g. using graphene device technology in diagnostic sensors; microneedles (using silicon processing techniques to develop microneedles for cell/ drug/vaccine delivery); synthesised nanoparticles and implantable biomaterials and devices for medical applications.

The Unit has benefitted from funding support from UKRI, the EU, Welsh Government, the University's EPSRC Impact Acceleration Account, GCRF, and the Royal Society of Chemistry, which have helped to stimulate interdisciplinary collaborations. Our multi-disciplinary and open approach to collaboration is also evident in our **international and industry partnerships** with major collaborative programmes such as:

- CIC biomaGUNE and CiQUS in Spain in Health and Materials: biomaterials, molecular imaging, biological chemistry and molecular materials;
- Texas, Chongqing, National Physical Laboratory (NPL) in Health;
- Grenoble, Brazil (UNESP) in Materials;
- MIT, Google Cloud, US in modelling;
- the South Wales Compound Semiconductor Cluster in Semiconductors);
- Moscow (IPT), Australia, Israel in Technion;
- Netherlands (Leiden), Australia (ANS&T, Queensland, U.NSW,) all in Surface Science;
- Grenoble, U.T.Tampere, Finland in Energy.

2. Growing our research base and outputs

We are committed to maintaining research quality and excellence. Our success is evidenced by several prestigious grant awards. **More than 95% of our colleagues** have been named investigators on funding applications since 2016, with 20 grants valued at £6M awarded to our 19.2 FTE staff members. Our success is also evident from our ~460 peer-reviewed papers, 6 chapters, and 8 books, with 9023 citations (2014-2020). Of our 48 submitted impacts, 13 papers appear in Nature journals (Nature Chemistry, Nature Materials, Nature Energy, Nature Catalysis and Nature Comms); 13 in ACS Journals including JACS (2); ACS Nano (5), ACS Energy Letters; 2 in Angewandte; 3 in Functional Materials; 2 in Advanced Materials; and 1 in RSC Energy & Environmental Science.

The Unit promotes an **open research** culture to ensure accessibility of its research methods, data, and outputs (see also REF5a 2.4). Staff have ORCID accounts and go beyond the minimum open-access requirements (supported by a College REF Officer). Working within the Institution's research integrity framework the Department also follows the 'Concordat to Support Research Integrity: A Policy Framework on Research Ethics & Governance'. An Academic Dean for Research Integrity and Ethics chairs a University wide committee. All our research active staff are required to complete discipline-relevant research integrity training (via Epigeum) making staff aware of their obligations to the reproducibility of research and the benefits of open science.

3. Providing a stimulating and supportive environment

Swansea benefits from a **diverse and international community of researchers**. In re-establishing the Department, a core aim has been to foster an environment supporting researchers at every career stage. Section 2 details our progress in building our research community. Additional initiatives include an "open to all" seminar series attracting international

speakers from academia and industry; the organisation of major industrial and conference events; and joint seminars with Engineering and Medicine.

4. Growing our postgraduate community

We recognise the importance of a thriving postgraduate community to the vibrancy and sustainability of the discipline. We will return 19.2 FTE staff members in this Unit's first REF submission and in just 4 years have grown the number of our postdoctoral research assistants (PDRAs) and postgraduate research (PGR) students to **10 (0.5 per staff FTE) and 23 (>1 per staff FTE)**, respectively, and established a MSc by research programme.

5. Delivering impact

At the core of the Unit's activities is the **development of industrially relevant, innovative technologies, processes and products** that benefit society, the economy and the environment, coupled with high-quality blue skies research. The Unit utilises a range of mechanisms to enable the translation of its research into impact (Section 3). Section 4 highlights the key collaborative partners who support our approach to impact. Other mechanisms to enable impact include collaborative PhD projects that evolve from user need, and institutional funding to support researchers' engagement, outreach and dissemination activities (Section 2).

The UoA has assisted over 100 organisations from technology conception to commercialisation. We have partnered with SMEs, utilising Innovate UK and Welsh Government funding, and our research has impacted the commercialisation of graphene sensor technology through SMEs Biovici and Zimmer & Peacock. It has enabled recycling strategies in local government and underpinned the development and implementation of new transdermal drug delivery technologies in "smart patch" products. We have incorporated nanomaterials into catalysis products; developed new semiconductor and energy storage processes with SPTS Technologies (part of a submitted Impact Case Study) and OXIS Energy, and fabricated battery materials from biomass waste.

Our **impact case studies** demonstrate our commitment to working with industry. The first details the manufacturing and regulatory processes co-developed with a Welsh SME (Innoture Ltd.), which allowed them to launch their cosmetic product Radara® a year earlier than planned (pictured right). The second demonstrates how our expertise was incorporated into multinational company, SPTS's, supply chain, allowing them to increase sales of their products in previously untapped markets (picture below).



Staff are supported by a **departmental Impact Coordinator**, and utilised departmental impact funds for international **knowledge-exchange visits** and for the **feasibility** of impact-related projects. Three of our staff have formed **spin-out companies** to license IP, generate investments, and take products and processes to market (e.g., ProGnomics, Semitechnologies, BioMEMS), while several colleagues have benefitted from the University's AgorIP (Open IP) scheme, which provides **funding for IP protection**, spin-out support and investment generation.

6. Promoting the value of our research

We are committed to disseminating our research to inspire future generations of chemists. We have delivered **outreach events** in the REF period to more than 4,200 school children, who visited our laboratories for Royal Society of Chemistry activities such as "Top of the Bench". We contribute to the annual Swansea Science Festival and Research as Art competitions and engage with the Compound Semiconductor Cluster in delivering research talks to schools and hosting a permanent exhibition at Techniquet, Wales's technology showcase centre. We are also involved in a major outreach programme with the Dragons regional rugby team, to engage people in STEM, to reach **over 40,000 children per annum**.

We organised the 2020 "SEMI Talent Forum" global student recruitment event for the semiconductor industry (postponed due to COVID-19) and build our research into teaching programmes through lectures, research-focussed modules, and industry training programmes.

7. Establishing leadership for our long-term sustainability

We have purposefully established a strong Chemistry Leadership Team. In consultation with our staff, PGR students and industry advisory board this team is able to make swift and agile decisions; able to **respond rapidly to changing environments** and exploit emerging opportunities. This leads to sustainable success, (£3.1M grant capture and involvement in over £31M collaborative projects) – building on achievements with EPSRC, the ERC, Innovate UK, and the Welsh Government.

Future ambitions

Our ambition for the next REF period is to **build on our success** in rapidly establishing the Department, capitalising on our world-class infrastructure and facilities, and transitioning our rising research stars to world-leading academics. This will be achieved by University investment in facilities, PhD studentships, and support for industrial collaborative projects.

Our strategy for 2021–26 is focussed on growing existing areas of excellence, targeting investment towards challenges in the areas of semiconductors, energy, recycling, surface science, spectroscopy, and health/life science. The recent merger of the Colleges of Science and Engineering into a single Faculty provides opportunities to further strengthen interdisciplinary collaborations and to **broaden the reach of Chemistry** into other disciplines. We will:

1. Further **enhance our research portfolio**, increasing diversity and recruiting outstanding early-career academics, whilst retaining our best faculty, students, and research staff to perform world-leading fundamental and applied research. We will develop our community through mentoring Early Career Researchers; actively seeking applicants for prestigious research fellowships; converting fellowships into permanent posts; and promoting professional development programmes, e.g., Welsh Crucible and Florence Mockeridge schemes.
2. **Grow our strategic research groups**, with particular focus on materials chemistry, energy chemistry, surface science and chemistry for healthcare, aligning with University initiatives on the Shared Prosperity Fund, as part of a new school of Engineering and Applied Sciences within the new Faculty of Science & Engineering (FSE).

3. **Amplify interdisciplinary research** via investment and appointments at the interface between departments within the new FSE, with the School of Medicine and with industrial partners.
4. Continue to **develop strategic impact generating collaborations** with industry and other partners (e.g., Newport Wafer Fab, UtterBerry, CSconnected, Tata, Diamond Light Source, and NPL) and establish new collaborations through open seminars, networking events, collaborative R&D projects and the Strength In Places Fund. We will nurture new spin-outs and enhance our patent portfolio to maximise the impact of our research.
5. Optimise our impact by **strengthening knowledge-exchange partnerships**, increasing the number of industry-related projects at higher technology readiness levels, and actively pursuing secondment opportunities with external organisations.
6. **Maintain and enhance our world-class shared research facilities** and equipment, investing in strategic areas (identified above) to establish world-leading research and innovation centres.
7. **Grow our PGR and PDRA community**, increasing our international contingent and ensuring high-quality training within an inspiring environment. This builds upon our allocation of an EPSRC DTP PhD student to every new permanent academic staff member, our (ESF-funded) Knowledge Economy Skills Scholarships (KESS), collaborative funding with industry partners and interdisciplinary PhD projects.

Section 2: People

Staffing Strategy

Chemistry was re-established as a research-enabling science department supporting the University's key strategic themes of Health, Advanced Materials and Energy, with the vision of growing a small, internationally excellent research-led department. Delivery was planned in three phases using the University's Academic Career Pathway (see REF5a 3.1) and to ensure a sustainable succession plan of talent:

- **Phase 1 (2015-2017): Initial teaching/ Engagement & Innovation track appointments** to shape the degree programme (Prof. Bott, Assoc. Prof. McKinley and SL Loveridge) and to establish the new Department (Senior Lecturers Mabbett and Stanford).
- **Phase 2 (2017-2018): Establishment of active research**, led by a professorial appointment (Mareque-Rivas), focussed on designing and driving initial research strategies around health, materials and energy, followed by the appointment of three lecturers (Carta, Kuehnel, and Roy), two Associate Professors (Klinke and Alexandrowicz – both awardees of prestigious ERC starting grants) and five early-career fellows [Williams, Tehrani (both Sêr Cymru); Mostert, Devadoss (both COFUND); and Pitchaimuthu (Rising Star)].
- **Phase 3 (2018-2020): Appointment of Prof. Guy as Head of Department to oversee the scale-up in research activity**; manage the recruitment of four early-career research staff members (Bassetto, Martin-Martinez, Gill and Ryan) aligned with strategic priority themes in health and materials; and integrate seven promising early-career staff members from Engineering into the Chemistry department.

As of the Census date we now have:

- 4 professors
- 2 associate professors
- 5 senior lectures, 4 lecturers Of and 5 senior research fellows all of whom are ECRs

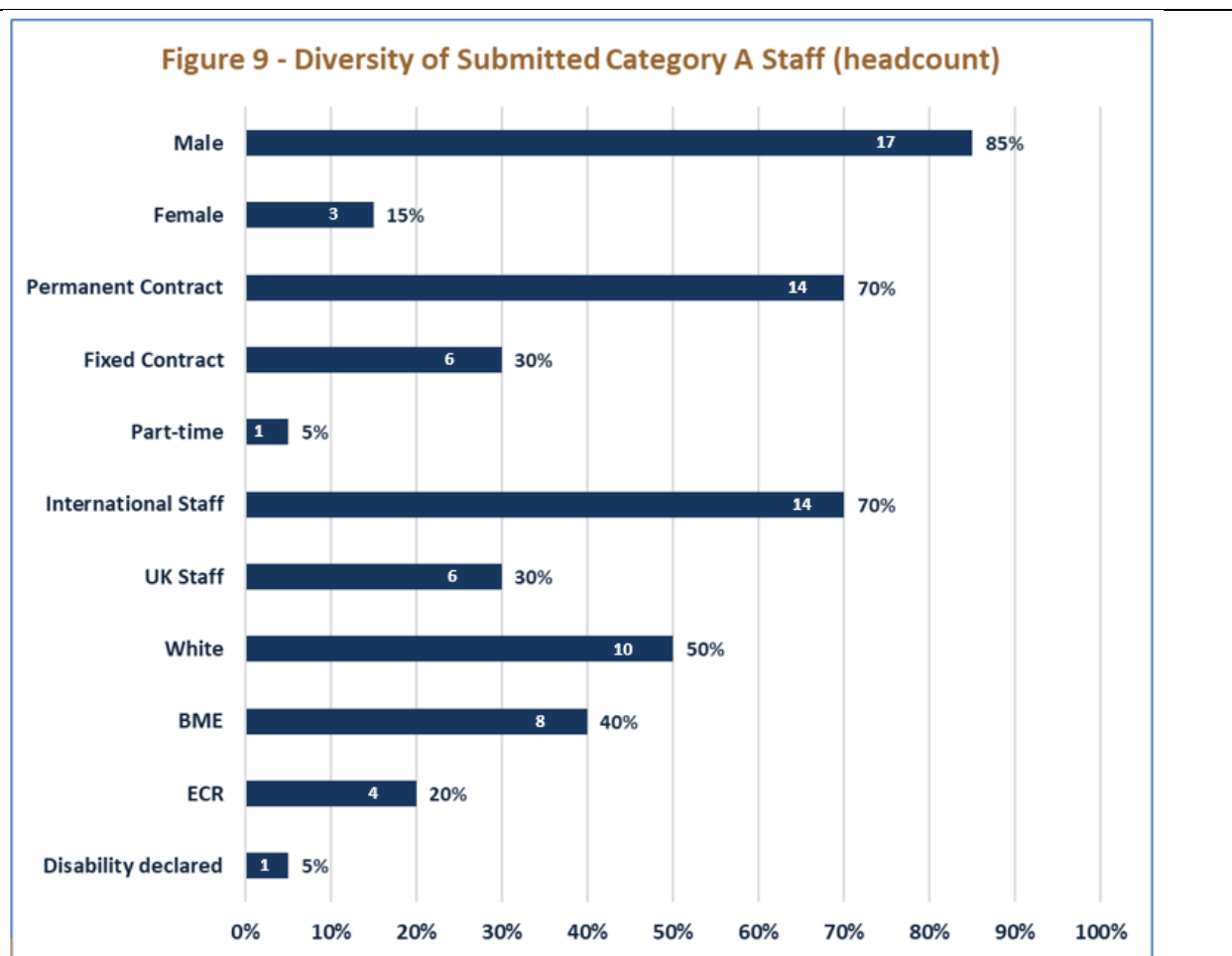
All appointments have been made to grow existing areas of excellence at the interface of the research themes and to support funded initiatives. Our early high-quality appointments (Alexandrowicz, Mareque-Rivas, and Klinke) have in turn attracted some of the best young talent globally to come to Swansea. Our recruitment rounds have been extremely competitive, with an international field of outstanding candidates, attracted by outstanding leveraged facilities, expertise already in place and the incentive of delivering a unique teaching programme.

We have deliberately enhanced our staff clusters **in key research areas through interdisciplinary appointments**, for example, Aldous and Reddy have been brought in to complement the battery activity of Guy and Margadonna (Engineering), while Sharma, Bassetto and Gill have added to our chemical biology and drug discovery/delivery core strengths, linking with Swansea's New Pharmacy Department and the School of Medicine. The overlap with medicine and pharmacy, specifically in the field of Nanomedicine, is a strategic focus, where Mareque-Rivas, Williams, Bassetto, Sharma and Gill have strengthened Swansea's CNH research capabilities, bringing a chemical- and materials-science-centric approach to create new therapies based on controlled modulation of the immune system, theranostic nanomedicine platforms, compartmentalization strategies in polymer-based drug delivery vehicles and synthetic cell research, inorganic synthesis and computer-aided drug design.

Our Chemistry research concentrates heavily on semiconductor materials and devices, sensors, nanomaterials and energy. Key recruitments include Klinke (nanomaterials for electronics), Mostert and Ryan (organic semiconductors), Sharma, Tehrani, and Devadoss (sensing) and Kuehnelt (photocatalytic energy generation) and Aldous, Reddy (both energy storage) into the Energy Chemistry group.

Our research groups represent vital hubs for our collective research endeavours and form the basis of a vibrant research culture. We pride ourselves on a **highly collegiate, inclusive, mutually supportive and intellectually stimulating** research environment. Staff retention is high, with only 1 research-active staff member reducing FTE commitment – to take up a part-time Professorial appointment in Europe.

Our Category A staff cohort is quite diverse for a developing department with a very high proportion of international (70%) and BME (40%) staff (figure 9, next page) – something we want to build on further for the future (see Equality and Diversity section):



In 2020, we also recruited a Royal Society University Research Fellow (Evans) from Cambridge and initiated our honorary chair programme, welcoming Prof. Sir Richard Friend (Cambridge), Prof. Rositza Yakimova (Linköping, Sweden) and Prof. Yufei Lui (Chongqing) to assist our strategic research programmes in next-generation semiconductor chemistry. We have appointed honorary academics from industry (e.g., Martin Peacock, Zimmer & Peacock) and plan to extend this scheme as part of our industry engagement strategy.

Future staffing and staff retention

In line with our strategic aim to further improve our research portfolio (as described in Section 1), a core focus is to continue to recruit rising stars and **support their transition to successful academics**, providing our Early-career Researchers with the support and infrastructure to become world-leaders in their fields. Integrating chemists currently affiliated with Engineering as part of the future evolution of the Faculty of Science and Engineering will be complemented by the strategic recruitment of high-profile research groups.

We also plan to increase the number of secondments with external collaborators through industry fellowships and to grow our Visiting Researcher invitation programme (which has already hosted 12 visiting international researchers during the REF period from University strategic partnerships with Grenoble and Texas as well as Japan, Israel, Portugal and China) by expanding links with our international partners.

Staff development and support

We are committed to **supporting and facilitating the growth and development of our research community**, particularly our Early-career Researchers. Measures taken to promote staff development include:

- Phased introduction of teaching activities after appointment;
- Mentorship programme – new staff are mentored in grant writing, grant application strategy and project management, with workshops and seminars run by senior staff dedicated to enhancing grant proposals through internal peer review, mock panels and bid-writing support;
- Leadership skills and network / consortium building workshops run by the Head of Department; Departmental support for Early-career researcher access to Welsh Crucible;
- Pump-priming funds, including provision of a PhD student to all newly recruited permanent academic staff and start-up funding;
- Faculty International Visitor scheme;
- Tailored training and support packages for the pursuit of key projects, e.g., EPSRC New Investigator Award group, Future Leadership Fellowships, Royal Society University Fellowships and ERC grant development.

We balance excellent research, innovation, impact and teaching through well-defined **Academic Career Pathways** (Research; Teaching & Scholarship; Innovation and Engagement), which provide indicative performance measures (e.g., relating to publications, funding bids, and research-student supervision) to support **meaningful and supportive Professional Development Reviews** (PDRs) (see also REF5a). For senior and early-career academic staff, PDRs are conducted by the Head of Chemistry, with a coaching style adopted to establish mutually agreed upon research goals and training needs. Early-career staff are supported by both a probationary supervisor and a mentor, with the probation system merging seamlessly with our Performance Enabling Programme.

For all other staff, PDRs are conducted by senior professorial staff, who are devoted to shaping research endeavours and nurturing the talent of our early-career staff and fellows. This is facilitated by our Programme Director co-ordinating all teaching and scholarship activities so research-active staff have reduced administrative load. In line with the University policy on this we also plan to introduce a new sabbatical scheme.

Our commitment to sustaining and fostering our community of researchers is **demonstrated by their career progression**. Three of our ECRs were promoted to Senior Lectureships during the REF period (Roy, 2018; Kuehnelt and Carta, 2019), Mabbett was promoted to Assoc. Prof., (2018) and Alexandrowicz was appointed to chair (2019).

Staff have access to a **comprehensive skills-development programme** coordinated by our Development and Training Services and mapped to the Vitae Research Development Framework. The University is committed to the implementation of **the 2008 Concordat to Support the Career Development of Researchers** and holds an HR Excellence in Research Award from the European Commission.

The Unit encourages staff to undertake public engagement activities and supports STEM ambassadors (e.g., Mabbett and Bassetto), who regularly speak at events, including the Cheltenham Science Festival, British Science Festival, Pint of Science, and our University-led Swansea Science Festival.

Postgraduate research students

Research students play a vital role in our research culture and are integral members of our research groups.

The Department has grown rapidly since 2016:

- 2 PhD students to 20 (plus a further 24 Engineering / Bioscience / Geography designated students supervised by Guy (13), Mabbett (9) and Loveridge (2)),
- The addition of 4 MRes students
- 19 to 114 undergraduate students

Given the Unit was only re-established in late 2016, no PhD completions occurred in the census period. These figures demonstrate a growing postgraduate community, who are part of the wider Faculty and benefit from the University's support for PGR students.

Many of our PhD students are supported via **collaborative partnerships** with industry (e.g., SPTS Technologies, Tata Steel, Biovici, Zimmer & Peacock, Tenovus, BioMEMS, Newport Wafer Fab, and Natural Resources Wales), 7 PhDs via **Knowledge Economy Skills Scholarships KESS 2** – a pan-Wales, European-Social-Fund-supported operation, 3 directly industry funded PhDs, and 7 accessed via EPSRC-funded Centres for Doctoral Training (M2A Materials Academy and Enhancing Human Interactions and Collaborations with Data and Intelligence Driven Systems). Other studentships are funded by University and College scholarships prioritising interdisciplinary projects; EPSRC Doctoral Programme Awards (10 students since 2017); Coleg Cymraeg Cenedlaethol (the national institution overseeing the promotion and development of scholarship, research and publishing through the medium of Welsh) and ERC. Chemistry will serve as a partner in future Swansea CDT applications on “Health Technologies for an Ageing Society” and “Compound Semiconductor Processing and Applications”.

PhD students are able to access extensive facilities within the new Chemistry laboratories (a £9M investment from the University), the £22M CNH and the £30M CISM facility (from 2022), as well as open-access facilities in Physics, Engineering and Medicine.

Our PhD topics and supervision team increasingly reflect interdisciplinary approaches, and the co-development of projects by academics from different institutional units is a priority. **59% (26/44) of doctoral students supervised by Chemistry staff are interdisciplinary** and co-supervised by non-chemists. **Of our doctoral students 36% are female** whilst 23% are International or EU.

The **support and supervision of our research students** is undertaken within a framework ensuring an effective induction into the University and Department and incorporating **comprehensive training tailored to individual needs** (see REF5a). Our robust progression-monitoring procedures are facilitated by a new online system (eVision) and are cited by the QAA as best practice. PhD students meet frequently with supervisors and have access to discipline-specific and generic professional modules. Chemistry PGR students are also able to select modules from Swansea MSc programmes in Nanomedicine, Nanotechnology and Semiconductor Technology.

Skills-development workshops, organised by the University and CDTs, include topics on presentation and public engagement, academic writing, research methods, safety, integrity & ethics, interdisciplinary thinking, achieving impact, research networking, and enterprise and entrepreneurship. Training is also provided to staff who supervise research students (mandatory for new staff).

Our international postgraduate community currently has students from China, Egypt, Europe, Iran, Israel, Saudi Arabia, Malaysia, Libya, and Nigeria, is valued as a major asset to our research environment. Postgraduates are ambassadors for Swansea, presenting their research at international conferences and publishing in international journals, and also contribute enormously to our collegial research culture through a range of activities, including research seminar series, competitions such as the Three Minute Thesis, Fame Lab, and the University's Research as Art initiative.

Equality and Diversity

Our commitment to equality and diversity is framed by the **University's Strategic Equality Plan**, which underpins a **culture of inclusivity** and values diversity in all areas of activity, in addition to characteristics covered by UK legislation (including Welsh-language compliance).



The University successfully secured an Athena SWAN Silver Award in 2017, is a **Race Equality Charter** member, and subscribes to **Stonewall's Diversity Champions Programme**, creating an inclusive workplace for LGBTQ+ and non-binary staff and students. Swansea ranks 6th among educational bodies in **Stonewall's Workplace Equality Index**, placing us in the top 50 of all UK employ and recognised for its commitment to the **European Charter for Researchers** and **Code of Conduct for Recruitment of Researchers** (see REF5a). We also operate a number of policies designed to support colleagues, including:

- parental leave policy;
- equal opportunities code of practice;
- sexual orientation policy;
- dignity at work policy;
- age policy and retirement;
- REF code of practice.

Our practice includes mandatory equality training for all staff, a family-friendly flexible-working policy and unconscious bias training (this was mandatory for all those involved in the selection of outputs for REF). The Department has also adopted a balanced use of email outside normal working hours via an email charter.

A range of institutional workshops related to wellbeing is also available as well as access to Occupational Health and our Health and Wellbeing Academy. Any staff with **disabilities and/or long-term illnesses** (5%) are offered support by the University's Wellbeing and Occupational Health units, and we make reasonable adjustments to their work where necessary.

The current College of Science EDI lead is from Chemistry, and the **Unit has its own Athena SWAN champion**. Women comprise 15% of our Category A staff and we are striving to increase gender equality, with encouraging steps toward gender balance demonstrated through the appointment of 1 female Lecturer and 2 additional female Senior Research Fellows and will apply for our Athena SWAN Bronze award in the next REF period.

The Faculty also runs a series of BAME and LGBTQ+ events, in which staff and students are encouraged to engage.

Abiding by the University's Code of Practice, and our UoA Statement of Intent, the **distribution of outputs across staff** reflects our unwavering commitment to equality and diversity. The submission comprises the best-quality output from each Category A submitted staff member with the balance made up of the remaining best-quality outputs from the available pool of outputs, which includes outputs of former eligible colleagues. All outputs were assessed in line with our Statement of Intent.

Section 3: Income, infrastructure and facilities

3.1: Income generated, and funding awarded

FIGURE 10: INCOME, INFRASTRUCTURE AND FACILITIES



INCOME

£3.1M WORTH OF RESEARCH GRANTS WON

£1.9M ACHIEVED IN 17-18

£2.5M MATCH FUNDING SECURED

>£3M OF IN-KIND SUPPORT FROM INDUSTRY

CONTRIBUTED TO THE CAPTURE OF £31M OVER THE REF PERIOD



INFRASTRUCTURE

>£9M CHEMISTRY FACILITY OPENED IN 2017

KEY PARTNER IN DEVELOPMENT OF £30M CISM BUILDING FOR 2022

Since 2016, we have generated grant awards of £3.1M (with a £2.8M research expenditure in the period, with a high of £1.9M in 2017/8). Expenditure is less than total awards due to several awards being received since 2019. An additional £2.5M match funding has also been secured.

Chemistry staff have contributed as PI / Co-I to awards worth more than £31M over the REF period, with notable successes range from prestigious individual awards, e.g., Alexandrowicz's €1.9M ERC Consolidator Grant (2018-2023) and £0.2M UKRI New-Horizons grant (2020); Klinke's €1.5M ERC Starting Grant (2013-2019); Guy's £1.3M EPSRC funding (2013-2018); Martinez's £0.6M Accelerating AI Research Sêr Cymru grant (2020-2023); a £0.4M Newton Fund award (2017-2020); £1.3M in Welsh Government/Industry projects (ASSET – and SOCRATES; 2019-2021); and Mostert's £0.391M STFC facilities allocation (2017-2020).

We have a **diverse research funding structure**, with major grants from research councils (EPSRC, Innovate UK), Royal Society of Chemistry, Royal Society, European Commission, EU Convergence Fund, Newton Fund, Welsh and UK Governments. We have also been successful in securing research fellowships for ECRs and established academics, including the Royal Society University Research Fellowship (Evans £760k), three COFUND fellowships (Mostert £204k; Williams £180k; and Devadoss £201k) and Sêr Cymru Fellowships (Tehrani £180k, Pitchaimuthu £559k).

A range of invaluable in-kind support (REF4c - £391K) complements our income, including access to UKRI facilities (STFC), data, and equipment and **over £3M in in-kind support from industry**. The Department has also attracted funding through Swansea University Strategic Institutional Awards, e.g., EPSRC "Small equipment items" (£100k) to Chemistry (Guy was Co-I), the £468k EPSRC Impact Acceleration Award; £450k in Regional Impact Funds, and a significant industry commitment of £21M towards CISM. The Department has benefitted from

partnership building, interdisciplinary seedcorn funding and intellectual property development funding (£100k), helping our early and mid-career researchers (Kuehnel, Roy, Williams, and Mabbett) pump-prime larger research initiatives. Several of our staff have benefitted from the college international visitor and international student schemes, as well as the Newton Bhabha fund.

Grant capture is supported by a robust institutional framework (see REF5a) coordinated by the Department of Research, Engagement, and Innovation Services and our **College Research Hub**, which provides pre- and post-award support. Dedicated Research Development Officers advise on research funding, internal peer review, bid-writing support, mock interviews and horizon scanning of thematic opportunities. Support for interdisciplinary research is provided through University-led calls, including the GCRF, Impact Acceleration Account, Materials Academy (M2A), KESS, NRN and AgorIP.

Seedcorn and PhD funding has directly led to much larger EPSRC, Innovate UK, Welsh Government and Research England projects. Chemistry has also initiated sandpits around Energy, Recycling of Plastics, Semiconductors and Drug Delivery, as well as leading the University's initiative to promote industrial collaborative research via Innovate UK and KTP projects.

3.2 Infrastructure and facilities

We have invested heavily in equipment, facilities, and staff, ensuring sustainability by partnering in multidisciplinary, University Major Research Facilities, CNH and CISM (see also REF5a). The Unit has research facilities in two buildings:

- a new >£9M Chemistry facility (opened in 2017), and
- the £22M CNH (opened in 2010).

In addition, Chemistry researchers have open access to the £100M Institute of Life Science, the National Mass Spectrometry Facility (NMSF), and a range of facilities in Engineering, including the Advanced Imaging of Materials, the Systems and Process Engineering Centre, the Energy Safety Research Institute, and the SPECIFIC solar power and active buildings centre.



We support research activities centrally through two technical teams in Chemistry and CNH. Chemistry technicians provide general chemistry support, analytical testing, chemical waste

disposal and inventory coordination. CNH-based research-support scientists run our core instrumentation (SEM, TEM, AFM, ellipsometry, XPS), while mass spectrometry is provided by two **NMSF** scientists. Our facilities are open access within the University and accessible to external and industry users through online booking systems.

The Department invested £0.6M in equipment in 2018/19, installing new Electron Microscope, spectrophotometry, glove box and molecular vapour deposition (MVD) systems, while in 2020, we installed two new semiconductor plasma etch systems, donated by SPTS Technology, worth over £1M. Current instrumentation facilities in Chemistry include:

- 500 MHz Bruker AVANCE III NMR spectrometer (with BBFO probe and SampleCase60 autochanger);
- PerkinElmer Spectrum FTIR with UATR x 3, (one with Spotlight150i FTIR microscope); PerkinElmer Altus A-10 HPLC; Four Perkin Elmer Lambda 265/365 UV/Vis; PerkinElmer Avio 200 ICP-OES with s10 autosampler; PerkinElmer CLARUS SQ8S MS / 580 GC (with Turbomatrix headspace); PerkinElmer Clarus 680 GC FID; PerkinElmer STA 6000 simultaneous thermal analyser; PerkinElmer LS55 Fluorescence;
- Solvent purification systems, nanoparticle tracking analyser, FPLC, DLS, GPC, flow chemistry reactor, and ultracentrifuges;
- Parr 4575 HP/HT Pressure reactor for hydrothermal processing;
- Microfabrication, wafer and surface characterisation/analysis (see CNH facilities)
- DEK screen and Dolomite 3D microfluidic printers;
- Surface dynamics laboratory, housing unique multi-million (£) molecular beam system - developed and built by the Alexandrowicz group and funded by the ERC. Currently the only instrument (world-wide) that can control the rotational orientation of ground-state molecules before and after surface collisions.

As noted, Chemistry is a key partner in the £22M **CNH**, which provides enabling technologies in drug delivery; drug synthesis; sensors and devices; tissue engineering; and microscopy/spectroscopy. Facilities include a full semiconductor cleanroom with tools provided by SPTS technologies: ICP etch, deep silicon etch (DSi-v, Pegaus), APS oxide etch, and molecular and chemical vapour deposition; as well as a KJ Lesker PVD; a Suss Microtec resist spray coater; an MA8 Mask Aligner and SCIL Nanoimprint Lithography; Raith E-beam lithography; and a wet bench.

CNH also houses a bio-cleanroom with extensive electrochemistry, electro-spraying and surface functionalisation facilities. In addition to tissue culture, NMR, rheology, microbiology and tissue engineering laboratories, CNH has surface science and spectroscopy facilities including microscopy (Keyence, Brucker); AFM (JBK); SNOM; Raman (Renishaw); TEM (Jeol); SEM (Hitach S4800); XPS (Thermo Fisher); and STM (Omicron). We continue to build on this strength with new vibrational spectroscopy facilities.

The most recent facilities development is the £30M investment from Research England towards **CISM**, a new semiconductor foundry opening in 2022. CISM, led by Physics, Chemistry and Engineering, is supported by £60M in industry funding from the UK semiconductor industry, with £21M in match funding for the project committed by Chemistry's strategic industry partners. CISM will develop next-generation semiconductor, sensor and energy-storage technologies. Both CNH and CISM are open-access facilities used by Chemistry, with a pipeline of undergraduate, MSc and PhD students being developed for the UK semiconductor industry.

Chemistry also benefits from access to the excellent mass spectrometry facilities in Swansea's **NMSF** (formerly part of the original Chemistry department, now part of the Medical School). The Unit is looking to expand this relationship by offering analytical services from Chemistry through the mass spectrometry portal.

Chemistry aligns closely with the **SPECIFIC Innovation and Knowledge Centre**, with a focus on coatings and solar PV. Accessible facilities range from advanced characterisation techniques (STA-FTIR-GCMS, UV-Vis-NIR, FTIR microscopy, XRD, XPS, SVET, SKP, SKP-FM, SEM, EIS, and IPCE), as well as cleanroom facilities, coating and resin laboratories, solar simulation and durability laboratories, and pilot production facilities for roll-to-roll coating, deposition and curing.

Other notable infrastructure and facilities Chemistry academic staff and PGR students are able to access include **Sunbird** at **Supercomputing Wales (SCW)**, a state-of-the-art £40M supercomputing facility (used for computational chemistry – with two HPC nodes dedicated exclusively to the Chemistry department), and the expansion of Sunbird to Graphic Processing Units (GPUs), through a Sêr Cymru Grant on Accelerating AI research; the **Google Cloud Platform** for supercomputing, through Martinez's collaborations with the Google Cloud engineering team; and Engineering's £9M **Advanced Imaging of Materials (AIM)** facility. We also benefit from a new cross-disciplinary analytical facility for stable isotope analysis by laser-induced breakdown spectroscopy and laser ablation molecular isotopic spectrometry co-established with Physics and funded by an ESRI-King Saud University collaboration award.

Chemistry academics also have access to national facilities, including STFC's Daresbury ISIS facility, where Mostert was awarded **£391k in beam time allocation**. In addition, Guy has long-standing collaborations through Innovate UK projects with the NPL.

Researchers applying nanostructures to biomolecular systems have access to CIC biomaGUNE's cutting-edge infrastructure, which includes a Molecular Imaging Facility, one of the largest pre-clinical imaging research infrastructures in Europe and a reference platform in the field of molecular and functional pre-clinical imaging.

Chemistry is also a partner of the AI3SD Network+ (Artificial Intelligence and Augmented Intelligence for Automated Investigations for Scientific Discovery), funded by EPSRC and hosted by the University of Southampton to develop AI technologies for chemistry. Future Chemistry expansion will be integrated across the University (in line with REF5a 4.3), housed in CNH and a neighbouring building on the Singleton Campus in open access facilities, while joint developments in the chemistry of materials, energy, circular economy and AI will be expanded at our Bay Campus.

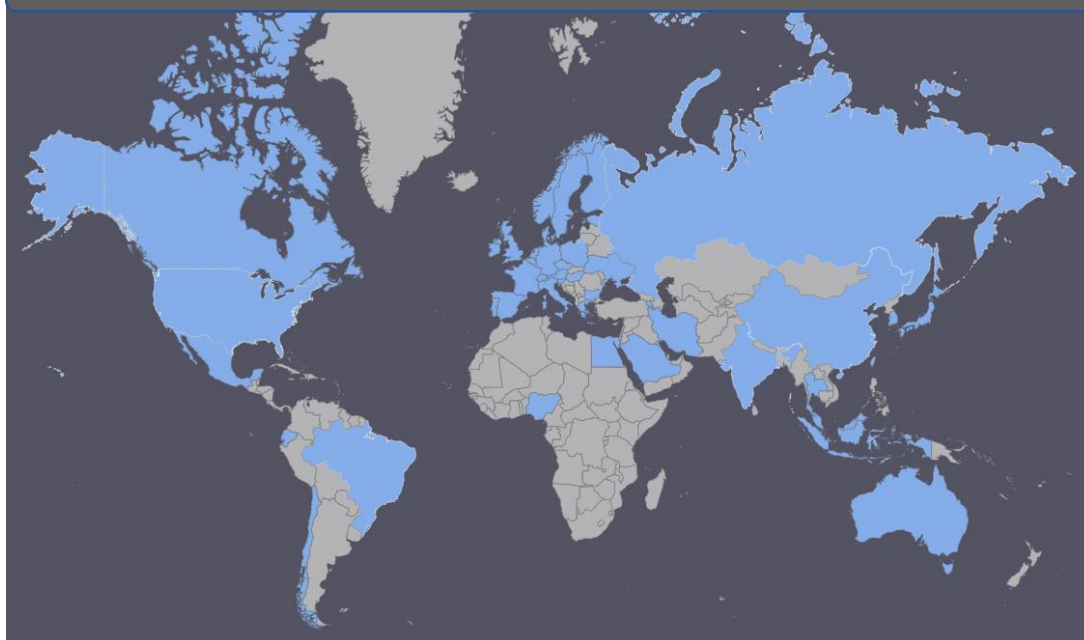
Section 4: Collaboration and contribution to the research base, economy and society

The Unit was re-established based on pre-existing collaborations between science, engineering, medicine and industry, and collaboration with academic and non-academic partners continues to underpin our work. These **collaborations are strategically developed to drive our agenda** to address global challenges in health, energy and the environment, and the digital revolution, building on core strengths from within the Department. Our collaborative research is impact driven and, in the tradition of Swansea University, has a strong industry focus.

Academic networks

As detailed in Section 1, College support for collaborative and interdisciplinary research is supplemented by University structures such as the Academic Partnerships Directorate, sandpits to develop interdisciplinary networks across campus, and funding sources including a Research-Enabling Fund (via Grenoble) and an EPSRC Impact Acceleration Account. The Unit has made full use of the support available; as a result, it has **developed significant international collaborations** (figure 11) and makes a sustained contribution to the wider discipline.

Figure 11 - UoA8 staff international co-authorship across the REF period in blue shade



Two thirds of all our outputs are co-authored with international partners (Scopus) and across the REF period, Unit staff have collaborated with academics in 48 countries as indicated in blue shade in the map above.

Strategic partnerships initiated with **international institutions** during the REF period with China (**Chongqing**) have **developed graphene sensors for the real-time detection of hepatitis** via a £1M China-UK Newton Fund project, which also resulted in the formation of **the Centre for Intelligent Sensing Technology** (CIST), a Joint International Centre with the NPL and Chongqing. CIST activities include Sensor Development for Graphene Sensors, Gas Sensors, and Optical Sensors, with a growing exchange programme, prioritising knowledge transfer between the UK and China.

In the field of materials chemistry, our activity in semiconductor research is supplemented by honorary chairs Rositsa Yakimova (Linkopings, **Sweden**), a world's leading authority in silicon carbide growth, and Prof. Yufei Liu (**Chongqing**, China).

Collaborative partners in **Spain** include the Center for Research in Biological Chemistry and Molecular Materials - CiQUS; CIC biomaGUNE; the Spanish National Research Council/Consejo Superior de Investigaciones Científicas/Instituto de Ciencia de Materiales de Madrid; Instituto Madrileño de Estudios Avanzados en Nanociencia - IMDEA Nanoscience; and University Autonoma of Madrid.

Partners in **France** include the Université Pierre-et-Marie-Curie Sorbonne and Ecole Supérieure de Physique et de Chimie Industrielle de la Ville de Paris (ESPCI), with visiting researchers hosted at Swansea. Similar relationships exist with **Ghent, Lausanne, Padua, Göttingen, Lille and Freiburg**.

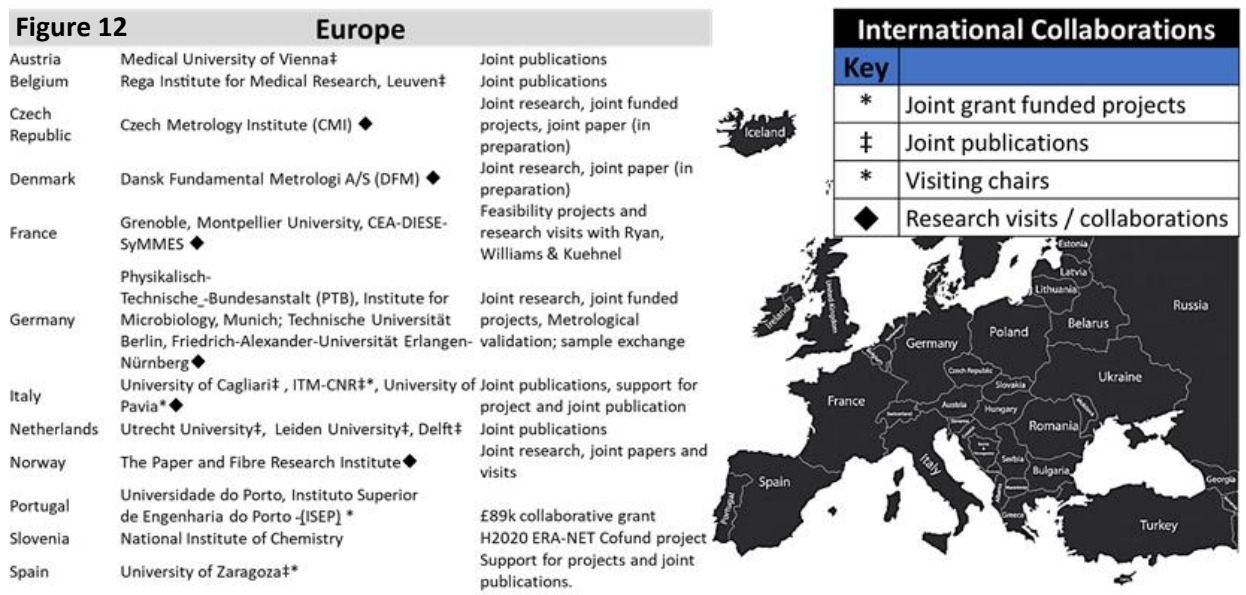
Chemistry's engagement in solar PV research and the **£6.5M GCRF SUNRISE project**, supports collaborations in the Global South, particularly India, implementing low-cost PV. The Swansea-led project brings together a consortium of five **UK** Universities (Oxford, Imperial, Cambridge, LSBU and Brunel) with universities in **India** (IIT-Bombay, IIT-Kanpur, IIT-Delhi, IISC Bangalore, IISER Pune, JNSCAR Bangalore, TISS), **Mexico** (CINVESTAV), **Kazakhstan** (IPT) and **South Africa** (UKZN, Durban), plus Five UK industrial partners (Tata Steel, NSG Pilkington glass, BIPVco Ltd, Oxford PV and Scientific Vacuum Systems Ltd) and five Indian industrial partners (Tata Cleantech Capital Ltd, Ecofirst, Nest-In, KPIT, and Gram Oorja). SUNRISE won the 2020 THE award for 'best international collaboration'.

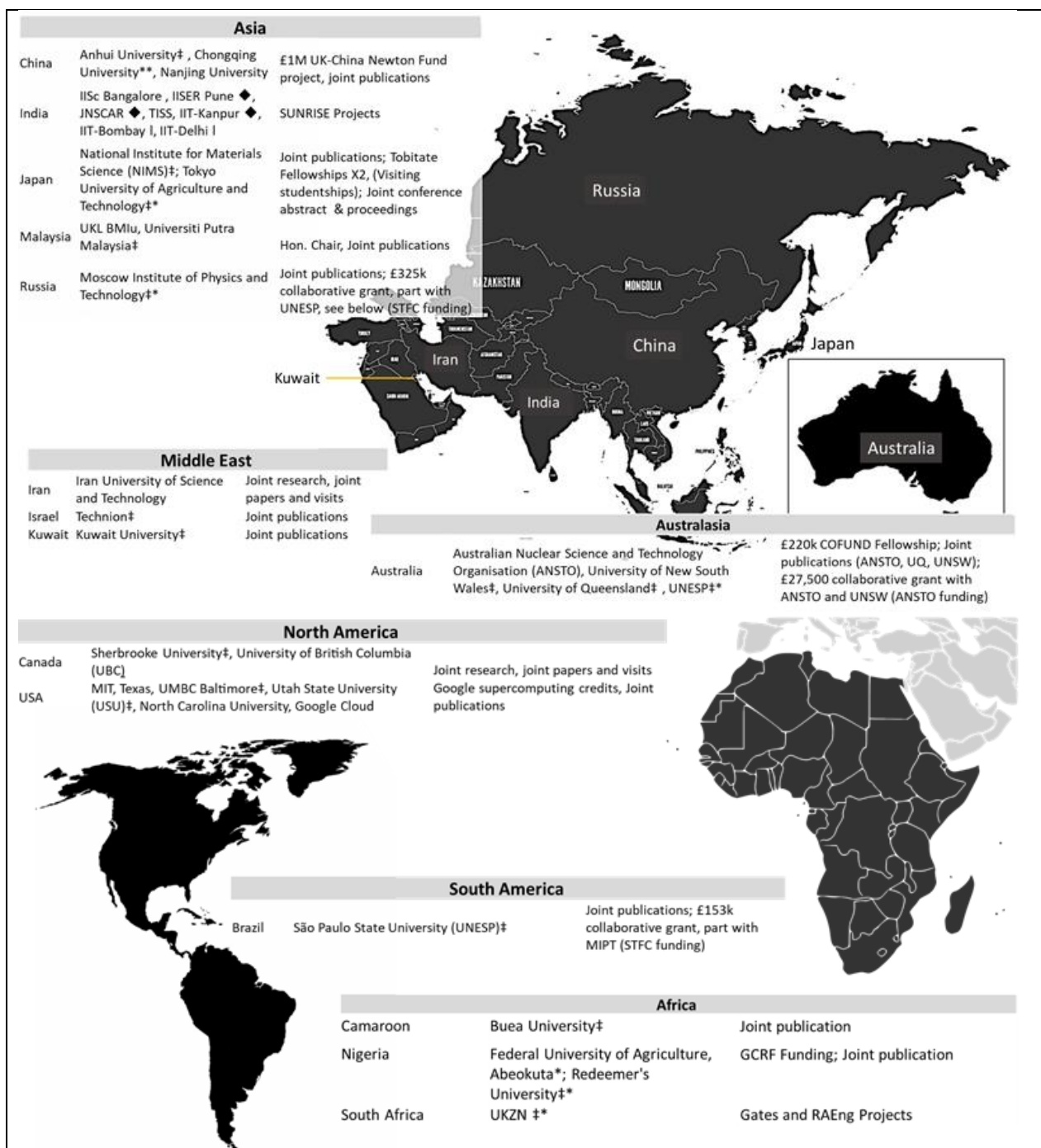


Chemistry (Roy) is a collaborator in the €3.5M EURAMET "Light-Matter Interplay for Optical Metrology beyond the Classical Spatial Resolution Limits" project, which is developing new optical measurement techniques for investigation of nanoscale structures.

Chemistry is also a partner in the Plymouth-led €4M international Marie Skłodowska-Curie ITN BBDiag project - developing diagnostic technology for dementia. Other MSCA-ITN projects involving PhD supervision from our staff are i PET 3D – a translational project developing PET imaging probes to facilitate sustainable drug discovery / development and accelerate pre-clinical to clinical transition of new drugs, coordinated by the Institute of Medical Sciences at Aberdeen; and TOLLerant, – a chemical immunology project focussed on molecular mechanisms of innate immunity, coordinated by the University of Milan.

Other international collaborations include (figure 12):





Collectively, since 2016, staff have examined PhDs at UK universities (Aberdeen, Birmingham, Bristol, Warwick, Newcastle, and Manchester) and internationally, including Universities in Spain (Santiago de Compostela, Coruña, Granada, and Basque Country), **Portugal** (Aviero), **South Africa** (UKZN Durban; Johannesburg), The **Netherlands** (TU Delft), India (India Institute of Science), and **Italy** (University of Parma, Sassari University).

Collaborations with non-academic partners

Through CISM, the Unit is part of CSconnected – the compound semiconductor community in Wales. Our close relationship with CSconnected partners (SPTS, Newport Wafer Fab, IQE, and CSC) is **building major initiatives around research and training for industry**. We are also linked to SEMI – the representative organisation for the global semiconductor industry. The Unit also provides research services for organisations in sectors including semiconductor technology

(UtterBerry), materials and chemicals (Tata and Renault), instruments (Bruker, Suss Microtec, and PerkinElmer), energy and the environment (Welsh Water) and healthcare (NHS Wales). These collaborations have yielded ~35 industry collaborative Grants.

Table 1: Key collaborative research/industry partners

Abertawe Bro Morgannwg (Swansea) University Health Board	PerkinElmer
Biovici	Purolite
Compound Semiconductor Centre	Rondra Cynon Taf Local Authority
European Plastics Forum	SEMI
Innoture	SPTS Technologies (a KLA Company)
IQE	Suss Microtec
Kurt J Lesker	Sygnature Discovery
Littelfuse	Tata
Microchip	Tenovus
National Physical Laboratory	UtterBerry
National Resources Wales	Welsh Government
Newport Gwent Dragons Rugby	Zimmer and Peacock
OXIS Energy	Google Cloud
Newport Wafer Fab	

Wider contributions to the research base

The vibrancy of the Unit's research environment is evidenced through its **leadership and engagement within the discipline**. Notable examples of our contributions include:

- two Fellows of the Royal Society of Chemistry,
- a Fellow of the International Association of Advanced Materials,
- 17 staff members serving as panel members for UKRI (EPSRC), the Irish SFI, Horizon 2020, the German Research Foundation DFG, the Alexander-von-Humboldt Foundation, the ERC, the US Department of Energy, the Israel Science Foundation, Research Foundation Flanders, Agencia I+D+i-Mincyt (Argentina), AEI-MINECO (Spain), Fondation pour la Recherche Médicale (France), the Carnegie Trust for the Universities of Scotland, and Wellcome Trust.
- Mareque-Rivas Carta and Guy are members of the EPSRC Associate Peer Review College.
- Carta is also a member of MIUR-CINECA (Italy).
- Klinke was a MATISSE Visiting Professor at the ESPCI Paris and Sorbonne Université Paris/France in 2018.
- Evans is on the Natural Sciences committee for the Coleg Cymraeg Cenedlaethol.
- Guy sits on industry boards for the CSconnected Compound Semiconductor Cluster Education Committee.

Leadership roles also include:

- Guy acting as advisor to Chongqing University, representing Welsh Universities on the Standing Committee of the RSC's Heads of Chemistry UK (HCUK) and chairing the University's Innovation Strategy group;
- Kuehnelt is an advisory board member of the UK Solar Fuels Network;
- Martin-Martinez sits on the Science Policy committee of Association of Spanish Researchers in the UK (SRUK);
- Bott sits on committees for the ACS, and
- Mabbett is a member of RSC Professional Standards Board, the IOM3 membership committee and a trustee for EESW/STEM Cymru.

The Unit has members on the **editorial boards of journals** including Zeitschrift für Physikalische Chemie, Diagnostics, Polymers (MDPI), Antiviral Chemistry and Chemotherapy, STEM Education (STEME), and Frontiers in Chemistry.

Chemistry academics serve as reviewers for numerous high-impact journals, including Science, Nature, Nature Materials, Nature Communications, Advanced Materials, Advanced Functional Materials, Nano Letters, ACS Nano, JACS, Angewandte Chemie, JPC Letters, Small, Physical Review Letters, Physical Review B, Advanced Optical Materials and many more.

Chemistry academics have already organised 8 **conference programmes**, highlights including founding the biannual International Conference on Tip-Enhanced Raman Spectroscopy as well as Co-Chairing sessions for RAEng Frontiers of Engineering for International Development, and IAAM Advanced Materials lectures (both 2020). The SUNRISE project also organises two conferences annually, with world-leading guest speakers such as Snaith, Friend, Nelson and Durant.

UoA staff have given a total of 149 invited conference lectures (including 22 keynote and 8 plenary talks delivered).

The Unit will continue to develop its national and international collaborations with academic and non-academic partners in the next REF period, with a view to furthering its contribution to the research base and discipline and delivering real societal and economic impacts.