**Institution:** University of Manchester

**Unit of Assessment:** UoA13a – Metallurgy and Materials

## a. Context

Materials Science impacts widely on society in many areas including: energy, transport, materials protection, personal hygiene and health care, food and drink, and consumer products. The UoA has activities that produce impact across this spectrum. A highlight is the contribution of members of the UoA to the award of the 2010 Nobel Prize for the discovery and isolation of graphene.

Impact is produced through collaborations with commercial organisations involving the translation of fundamental research leading to the development of new products and/or the improvement of existing ones. Impact is also occurring through the extension of the life of existing nuclear power stations and the development of new light alloys that will allow the achievement of emission targets in transport. Members of the UoA are also producing impact though their public engagement activities and research expertise developed in the UoA in X-ray imaging and composites has facilitated the establishment of commercial research services used extensively by industry.

## b. Approach to impact

Our approach to impact is on five fronts, each of which presents different challenges:

- Major Strategic Alliances
- Sector-Based Research Programmes
- Individuals Developing Impact
- Research Services
- Outreach and Public Engagement

### Major Strategic Alliances

Over the assessment period, a number of strategic alliances with multi-national companies have been established, to both set the research agenda and to exploit this research, in which members of the UoA play a leading role. These relationships are key in providing pathways to impact.

- *BP.* A major alliance was established with BP in 2012. The *International Centre for Advanced Materials (BP-ICAM)* leads research aimed at advancing the fundamental understanding and use of materials in the oil and gas industry. Withers is the Director and the 10-year investment programme is funding research into advanced materials supporting 25 new academic posts, along with 100 PhD researchers and 80 postdoctoral fellows, many in the School of Materials. The BP-ICAM is modelled on a “hub and spoke” structure, with the ‘hub’ located within the University of Manchester, with its strengths in materials, engineering, characterisation, and the School of Materials having the bulk of the funding.
- *EDF*. The University has a global framework agreement with EDF, the leading electricity producer in Europe, worth over £2m during the assessment period. It provides a framework for strengthening and extending the existing research collaborations between EDF R&D, EDF Energy and the Dalton Nuclear Institute (Director: Sherry). The research is managed through the Dalton Nuclear Institute, with R&D carried out within the Schools of Materials and elsewhere in the University. Research is focused on nuclear energy, concentrating on the extension of the life of existing nuclear power stations and the building of new.
- *Akzo Nobel.* The Akzo Nobel Laboratory of Corrosion Protection was established in 2012 as the result of a five-year strategic partnership between the largest global paints and coatings company and School of Materials with support of £0.5m/year. This has allowed the opening of a new corrosion laboratory with Lyon as the Akzo Nobel Professor of Corrosion Control. Several post-doctoral researchers and PhD students are being directly employed to work on projects ensuring impact through active Akzo Nobel technical involvement. Progress in understanding these challenges is allowing Akzo Nobel to develop improved design rules for coating systems for different substrates in challenging environments.
- *Rolls-Royce.* The RR University Technology Centre (UTC) in nuclear technology was established in the University in 2010 (Deputy Director: Preuss). This is a high-technology partnership between industry and academia and activities in the UoA are focussed upon the properties of fissile and engineering materials with support of ~£0.4m/year.

### Sector-Based Research Programmes

Interaction with business and external organisations plays a vital role in ensuring impact of

research in the UoA. This extends to research, knowledge transfer and enterprise creation. There are a number of examples of programmes aligned with the needs of industry.

- *Light Alloys Towards Environmentally Sustainable Transport 2 (LATEST2).* LATEST2 is overcoming the challenges to achieve reductions in the environmental impact of transport. The investment in the LATEST2 Programme Grant will exceed £9m over the period 2010-15, including £5.6m from the EPSRC supplemented by a £1.0m investment from the University and funding from industrial partners that include Jaguar Land Rover, Constellium and Airbus. The programme is facilitating a step change in high-performance light alloy design that is having direct impact upon the achievement of UK emissions targets.
- *The Advanced Metallic Systems Centre for Doctoral Training.* The Centre was established in 2009 with a £6.3m investment from the EPSRC. It is hosted jointly by the Universities of Sheffield and Manchester and builds on their international reputation in metallic materials science and engineering research. It provides stimulating multidisciplinary training to develop PhD graduates with professional transferable skills in leadership, business and research management working in partnership with industry. Impact is ensured by all 30 PhD projects being undertaken collaboration with UK industrial organisations that include Rolls-Royce, Magnesium Elektron, Westinghouse, TWI, DSTL, Alcoa, Airbus and BP.
- *Materials Performance Centre (MPC).* The MPC is a Centre of Excellence in nuclear materials research and training and forms a major part of the Dalton Nuclear Institute. It is the largest nuclear materials research centre in UK academia, with over 70 researchers and research income that includes a £4.1m EPSRC programme grant in New Nuclear Manufacturing. The MPC sustains strategic research partnerships with EDF, EDF Energy (formerly British Energy), National Nuclear Laboratory, Rolls-Royce, Westinghouse and Serco. The impact of the MPC is through collaborative work internationally and within the UK, enhanced through links with, amongst others, Areva, Corus, HSE, NDA and TWI.

**Individuals Developing Impact**

Academics within the School also work directly with individual companies or in an entrepreneurial way to develop impact. The University of Manchester Intellectual Property (UMIP) is the University's agent for IP commercialization with which staff in the UoA are encouraged to work closely to:

1. record and evaluate of research for potential commercialization;
2. promote strategic opportunities from UMIP and its partners;
3. recommend and develop commercialization and facilitate negotiations.

UMIP is active in helping to deliver such Impact through Proof of Principle (PoP) awards. This has led individual academics to develop and licence new materials technology with examples in: graphene nanocomposites, graphene production and new biomedical implants. Added incentivisation is through 85% of net income from commercialisation going to the investigator. Over the assessment period staff have received 12 such awards with a value of £1.2m. TSB funding has led to the establishment of Gelexir Healthcare Ltd (Saunders), a spin-out company developing a new non-surgical procedure, based upon polymer microgels, for the treatment of chronic lower back pain. Downes is also producing impact though the translation of her biomaterials research into regenerative medicine especially in nerve regeneration (with both BBSRC and MRC funding).

In 2009 the University of Manchester was awarded £8.4m from EPSRC to deliver a Knowledge Transfer Account (KTA), aimed at overcoming identified barriers to adoption, uptake and exploitation of EPSRC funded research. This has funded 18 projects in the UoA with a value of £950k (plus £375k in direct and £550k in in-kind company contributions).

In summary impact from the UoA upon industry has been maximised through:

- Knowledge Transfer Partnerships (KTPs) – with PZ Cussons (UK) Ltd, Amber Composites Ltd, Ambler Ltd, Sigmatex Ltd, PPA Ltd, BEP Surface Technologies, M. Wright and Sons and PPA Ltd. (Total contribution of £650k towards projects with a value of over £2M )
- Technology Strategy Board (TSB) Projects – HITEA (with Rolls-Royce, BAE Systems, Bombardier), SAMULET (with Rolls Royce, TWI), PANACEA (with Rolls Royce), PROMOTE (with Rolls Royce)

Impact of the research is monitored through professional development reviews and rewarded

through lighter administrative and teaching loads. Success in knowledge transfer is also used by the university in consideration of cases for academic promotion with knowledge transfer playing an important role in recent Readership and Chair promotions in the assessment period.

**Research Services**

Staff in the UoA are encouraged to undertake industrial consultancies when they have the appropriate skills. The UoA also hosts two centres that have developed from the research activities in the UoA that now produce impact through direct industrial collaboration and the provision of services. In both cases this has led to the development of new research projects in the UoA.

- *The Manchester X-Ray Imaging Facility (MXIF).* (Henry Moseley Centre) This is a unique facility that provides both academic and industrial researchers with access to a unique suite of world-class equipment for non-destructive 3D imaging. The facility provides openly available access to the widest range of differently configured laboratory CT systems in the UK. This capability is further augmented by access to Manchester-Diamond nano-tomography synchrotron X-ray beam line at the Diamond light Source that has industrial income of £0.5m/year. A Materials Testing & Analysis Unit (MTA) has been established to undertake work such as by using X-ray methods to evaluate residual stresses in Rolls-Royce aeroengine fan blades.
- *National Composites Certification and Evaluation Facility (NCCEF).* The NCCEF supports the supply chain across all sectors in the transition from metallic to advanced composite manufacturing. The centre, established with £4.9m of funding from the NWDA, operates to the procedures which are compliant with UKAS (to ISO 17025). The current turnover for services to industry is >£0.5m/year and rising.

**Outreach and Public Engagement**

Outreach based upon research undertaken in the UoA is managed by a full-time dedicated administrator. Significant impact with non-academic user groups has been delivered over the assessment period, as evidenced by the following activities, some in collaboration with the Manchester Museum of Science & Industry (MOSI):

- *So You Think You Can Design A Jet Engine?!* This project, supported by a £225k EPSRC Public Engagement grant, exploited the capability of the UoA in 3D X-ray imaging research to showcase to young people our world-class research upon aero-engine materials. The permanent interactive display “How to Design a Jet Engine” is seen by 80% of MOSI visitors. It has also featured in 8 Science Fairs and Festivals during the assessment period.
- *So You Think You Know About Nuclear Energy?!* This project, supported by another £215k EPSRC grant, is building upon the success of the jet engine project though the revamping of the MOSI Nuclear Energy Exhibition. Building upon research undertaken in the Dalton Nuclear Institute it now educates young audiences and families about nuclear energy.
- *Royal Society Summer Exhibition 2011. “Carbon Flatland”* Led by Hill, this showcased the work in the University and UoA on graphene and involved 4 staff from the UoA.
- *Awards of Public Engagement*. Staff in the UoA have won a number of awards:
  - 2013 Joshua Phillips Award - Innovation in Science Engagement (Vijayaraghavan) (Science Communicator in residence at the MOSI Manchester Science Festival)
  - Sir Colin Humphreys Education Award of IOM$^3$ (2012 **-** Laferrere & Smith (PDRAs))
- *BBC Television 2013.* Haigh appeared in *Horizon* and Vijayaraghavan on the *One Show,* both featuring their research on graphene.
- Sherry has been heavily engaged with the international media in the wake of the 2011 Fukushima nuclear incident, based upon research in the Dalton Institute.
  *Television*: BBC News programmes (x10); Sky News (x10); ITN News, Al Jazeera, CNN.
  *Radio*: BBC Radio 4 news, Materials World, Five Live and Drive Time (x5), World Service (x2), Manchester (x3); Key 103; Range of international local radio stations worldwide.

*Other outreach activities.* Members of the UoA have been active in other outreach activities over the assessment period and have given over 200 lectures based upon their research to a wide range of schools, FE colleges, Rotary clubs, alumni groups etc. The UoA hosts the annual week-long Smallpeice courses for 6$^{th}$ Formers and Horners’ Company study tours for School Teachers.

**c. Strategy and plans**

The UoA has developed robust mechanisms for delivering impact that were exemplified in the previous section (b). Much of our future strategy will rely on building upon and fostering this strong foundation as detailed below:

**Major Strategic Alliances** - The BP-ICAM and Akzo Nobel alliances established in 2012 will be developed into full-fledged research joint programmes with gearing though winning matching funds from the EPSRC and other funding bodies. Research activities in nuclear materials will be developed further through the Rolls-Royce UTC in Nuclear Technology.

**The National Graphene Institute** – 7 members of the UoA play a leading role in the Graphene Institute which aims to "take graphene out of the laboratory on to the factory floor". The new £60m building will be opened early in 2015 but interactions with companies are already being developed.

**Major Research Programmes** –The recently-established £20m Dalton Cumbrian Facility, a new state-of-art complex for the Dalton Nuclear Institute, will enable staff in the UoA and industry to jointly carry out world-leading research and deliver dedicated skills development programmes. The recently-announced £18m Multidisciplinary Characterisation Facility will be developed with additional inward 10-year investment of more than £100m from industrial partners. The LATEST2 EPSRC programme grant will continue until 2015 but plans are already being made for a "LATEST3" programme which may expand beyond light alloys into composites, with close involvement with industry. The newly-funded Graphene NOWNANO, Advanced Metallic Systems and Regenerative Medicine EPSRC Centres for Doctoral Training will deliver impact though PhD projects in collaboration with both industry and clinicians (in the case of Regenerative Medicine).

**Research Services** – It is intended to continue and develop services based on expertise developed in research to industry. NCCEF will be developed and considerable expansion of the MXIF facility is already taking place both in Manchester and at the dedicated beam-line at the Diamond Synchrotron. The extensive electron microscopy facilities used for research in the UoA were reorganised in 2013 and will now be marketed as a service to industry.

**Outreach** - This is an important mechanism to promote the impact of our research and we will co-ordinate and expand outreach activities in the next 5 years. An outreach committee to oversee developments was established in the School in 2013. In particular we intend to develop further outreach programmes based upon the highly-successful "*So You Think You…?!"* banner.

In addition a number of specific measures will be implemented:

- It will be ensured that staff are fully educated in the process of generating impact, much of which is supported by existing University mechanisms.
- Personal impact programmes will be reviewed as a part of the annual Personal Development Review in order to identify impact and further spin-out opportunities, and to ensure that the necessary support mechanisms are in place.
- There will be improved participation in training in the areas of IP and copyright that could sometimes be better understood by staff.
- The establishment of a new industrial advisory committee in 2013 will enable us to understand the environment better and target activities even more effectively.

**d. Relationship to case studies**

*High Performance Magnesium Alloys*

- Resulting from Sector-based Research Programmes in Light Alloys and Advanced Metallic Systems and PhD projects supported through the Centre for Doctoral Training.

*Friction Welding for Aeroengine Applications*

- The result of Individuals Developing Impact from fundamental research with Technology Strategy Board projects providing a pathway to impact.

*Polymers for Drinks Vending Applications*

- The result of an Individual Developing Impact based upon fundamental research.

*So You Think You Can Design A Jet Engine?! - A Toolkit For Communicating Materials Research*

- Exemplifying our approach to Outreach and Public Engagement.

*Analysis of Residual Stress in Aeroengine Fan Blades*

- Resulting from fundamental research with Research Services providing a pathway to impact.