Reports from the Materials Research Exchange 2014

24-25 February 2014

EPSRC
Pioneering research and skills

Innovate UK
Technology Strategy Board

Contents

Please note: Innovate UK is the new name for the Technology Strategy Board, the UK's innovation agency sponsored by the Department for Business, Innovation and Skills.

The Materials Research Exchange 2014 brought together the leading materials research groups in the UK on the 24th and 25th February 2014 in Coventry, UK. Their presence at a single location presented a unique opportunity to explore matters of concern to the community and to the Engineering and Physical Sciences Research Council (EPSRC) and the Innovate UK as two of the government agencies responsible for funding research and its exploitation in the UK.

The event also provide a chance to explore the opportunities in EPSRC's emerging Advanced Materials strategy. The three seminars explored the strategy's themes of Reducing Lead Times, Materials Sustainability and, Materials Discovery.

The event also included a Technology Pitch session where companies, universities and other organisations could promote their activities.

These three events are summarised in this report.

1. THE EXPERT PANEL

The bringing together of the key research groups in materials provided a prime opportunity to seek the views of the research community about the current landscape of research within the UK and the opportunities that this presents to the UK community. More specifically, it provided an opportunity to gain the community's views on where they see the prospects for the UK in materials research and development, on how to improve the ways in which research results can be disseminated to those who might be in a position to exploit them and how links between academia and industry could be improved for mutual benefit.

An Expert Panel was convened to conduct interviews with a specific focus on the areas outlined and to feedback the key findings and recommendations in order to provide a review of the advanced materials research landscape in the UK.

The key findings of the Panel's observations and perceptions were:

- There is a great breadth of innovative materials research in the UK, the UK is 'world class' in some areas of materials research (eg titanium alloys, solid oxide fuel cells, polymer science), the UK is well positioned internationally and there is a strong focus on research that is of high quality and of industrial relevance.

- Generally, university-based researchers have a good awareness of the issues facing industry. Collaborations help improve the academic understanding of what research is of real interest and what is achievable commercially. The Panel stressed the importance of collaboration as a mechanism to increase innovation and were clear that without collaboration, it is impossible to truly understand some industrial issues.

- Threats to materials research include: the lack of recruitment of skilled people into the materials research base; the advancement of competitor nations in advanced materials research, such as the USA and Germany, and the focus of the emerging economies on engineering and scientific research and the stability and methods of funding in the UK.

- There is a large opportunity for advanced materials research in a number of industrial sectors such as aerospace, oil and gas, nuclear, automotive and healthcare to be used to help overcome some of the industrial challenges; and, the drive towards sustainability due to environmental concerns provides a large opportunity to the advanced materials research base in the UK. The Panel identified that the UK has strength in many of these areas and we should build on our world leading position to generate wealth such as through our expertise metals and composites for the aerospace industry.

- There was a perception that a gap exists between the EPSRC and the Innovate UK. It was highlighted that there should be a stronger interface between the agencies and that funding mechanisms between them should be clear and span the Technology Readiness Levels (TRLs) to aid innovative developments and scale-up processes. In addition it was suggested that it would be advantageous to plan themed programmes together to gain maximum impact from investments.

- Agility in funding mechanisms is needed to allow a response to new opportunities.

- There is a need to overcome the negative connotation of "incremental" research as this is an integral part of advanced materials research and is essential to the advancement of the field.
- There is a need for continuity of funding, especially for people running characterisation facilities to maintain the knowledge and skills in order to fully utilise the equipment.
- Central Facilities (for example ISIS) need to be properly funded so they can run at full capacity.
- A follow-on fund is needed to aid the commercialisation of research outcomes.
- Scale-up and routes to manufacture are integral to the development of materials research. In order to improve this process it is essential to have closer industrial involvement in the research and a simplified process for development such as a simplification of agreements between organisations.
- There is a big opportunity to use capital funding within advanced materials research focusing on the reduction of lead times and technology translation through both equipment for processing and analysis by rejuvenating and upgrading old capital equipment.
- There is a need for clarity and coordination across the community and consistency in the vehicles and mechanisms of funding. The complexity of funding mechanism can seem too complicated to SMEs.
- Improve the liaison between EPSRC and Innovate UK so that basic science can smoothly transition to development without loss of momentum, staff and commercial interest.

2. ADVANCED MATERIALS SEMINARS

REDUCING LEAD TIMES

- Companies need to understand the capabilities of universities and on what they are working.
- With new materials comes a need to understand how they can be used. Academic/industry collaboration is key.
- Exploitation requires support being provided to enable research to progress through to prototypes and beyond.
- Automated processes for synthesis and characterisation will help reduce lead times.
- Access to data is important if groups are to avoid reinventing the wheel.
- We need both new materials and new opportunities.

MATERIALS SUSTAINABILITY

- We need to be resource efficient.
- Use of recycled materials is important, but there are issues around performance guarantees.
- The regulatory framework can affect the degree to which recycled materials are used.
- Data are needed on life cycles, including the environmental impacts.

MATERIALS DISCOVERY

- Synthesis, characterisation and analysis are key to discovery.
- There is a long lead time from discovery to deployment.
- Data are needed on the long-term performance of any new material.
- The UK has limited industrial capacity to exploit new materials: this is a weakness.

3. TECHNOLOGY PITCHES

The Technology pitch session included presentations from more than 30 representatives from industry and academia. These focused on a range of disciplines relating to materials.

Comment	Response
Training	
There is a need to increase the number of young people in materials research UK students in particular are needed. Currently a large proportion of PhD and Masters students in the UK are from overseas. To help the balance, why not write off 50% of the UK student's debt? There is also a need for a diverse and flexible student research base – Centres for Doctoral Training (CDTs) are potential threat because of their focus. It is important to also maintain flexible studentship funding to maintain the breadth of the research base and to accommodate for blue sky projects.	The materials community (academia and industry) need to discuss with relevant agencies, including EPSRC, how any skills shortage can best be met. That said, using government-allocated funding to offset the perceived effect of another government policy would be inappropriate. In addition, in a time of declining budgets such a course would only have the effect of reducing the number of studentships available.
CASE is a valuable scheme as it encourages the development of new collaborations. More Industrial CASE awards aimed at SMEs with more flexible terms would be useful and help enhance the amount of academia/industry collaborations.	CASE awards come through two routes. Industrial CASE studentships are allocated directly to businesses based on their financial contribution to EPSRC-funded research. Flexibility is, however, provided through the second route: Universities have been set a target of converting 10% of their Doctoral Training Partnership (DTP) to CASE. However, within the flexibility of the (DTP) Universities can form collaborations with partners and have considerable flexibility about the level of industrial contributions which may or may not meet the threshold for CASE.
EPSRC should consider providing a "Second Grant" to young academics to fund their first industrial collaboration.	Industrial collaborations are welcomed on any research grant application to EPSRC. We are not convinced that a separate scheme, analogous to First Grants would be a sensible addition particularly at a time when funding is declining in real terms.
There is a perception that EPSRC only funds large grants. There is a need for small flexible grants that can be accessed quickly for proof of concept and feasibility studies.	Large grants, such as Programme Grants because of their nature receive more attention than the bulk of support provided by EPSRC. Our grants mechanism is flexible and can already provide routes to funding proof of concept and feasibility studies.

Funding	Response
EPSRC should provide stable funding for the staffing and maintenance of equipment needed to support materials research.	When applying for capital funding for equipment, applicants are also able to seek funds for the staffing and maintenance costs. However, these need to be strongly justified; in particular, EPSRC looks to HEIs to contribute some of these costs as appropriate. Applicants are also encouraged to consider longer term sustainability once the funding has come to an end.
EPSRC should maintain longer, stable funding for centres of excellence but it would be useful to include mechanisms that allow additional industry and academic partner involvement as the research evolves. Alongside this it is essential to include a formal mid-term review that can cut funding in order to keep the larger centres motivated and striving at the top level.	EPSRC believes it is important to maintain flexibility in funding so as to be able to respond to new opportunities. Thus Programme Grants which, in essence, are recognition by their peers of centres of excellence, are established with a set period. Within those grants, however, there already exists the flexibility to respond to new ideas and to bring in new partners if necessary. Formal mid-term reviews are now a part of the process.
EPSRC should encourage smaller, more responsive, follow-on grants. This should include restarting the follow on and collaboration grant schemes.	This aspect of our funding is now included in the Impact Acceleration Accounts provided to universities.
EPSRC funding should build upon successes ie fund topics that already contribute to the UK economy by creating wealth.	There is certainly a place for this kind of research, however, it is equally important that support is provided for new ideas that will lay the foundation for future business and economic prosperity.
There was a general consensus that there is a perception that a gap exists between the EPSRC and the Innovate UK. It was highlighted that there should be a stronger interface between the agencies and that funding mechanisms between them should be clear and span the TRLs to aid innovative developments and scale-up processes. In addition it was suggested that it would be advantageous to plan themed programmes together to gain maximum impact from investments.	Innovate UK are constantly looking at various way to aid the effective and efficient transition of knowledge between the science base and industry. Innovate UK supports collaboration across the innovation landscape so that business, government and research work together to give innovators the right help at the right time. Innovate UK brings together partners to maximise funding for innovation and get groups of organisations working together.

Funding	**Response**
Agility in funding mechanisms between EPSRC and Innovate UK is needed to allow a response to new opportunities.	Innovate UK runs competitions for R&D funding in priority areas, as well as non-themed continuing competitions such as Smart. The Innovate UK funding tool set has mechanisms that do enable programmes of a wide range of sizes, durations and structures. An example is the Technology Inspired Innovation programme – this makes provision for shorter duration collaborative feasibility studies, typically grants of £25k over 6months through to larger CR&DT programmes of up to several million pounds over 2-3 years.
EPSRC and Innovate UK should establish a follow-on fund to aid the commercialisation of research outcomes.	
EPSRC and Innovate UK need to ensure that there is clarity and coordination across the community and consistency in the vehicles and mechanisms of funding. The complexity of funding mechanism can seem too complicated to SMEs.	
EPSRC and Innovate UK should consider providing more opportunities to bridge the "Valley of death" and help with the exploitation of technology. This could be implemented by having competitive funding available on a responsive-mode basis to proposals that have had previous RCUK funding and now need to develop the outcomes.	
Innovate UK should consider establishing programmes of a range of sizes e.g. small SMART awards to multi million pound programmes.	
Collaboration	
Outreach – each grant should have an outreach element to facilitate greater engagement with industry.	Applicants are already able to request funding for this as part of a research grant.
Create a stronger bridge with Innovate UK and Catapult Centres to allow more functional or smoother translational research process.	There is already a solid bridge between EPSRC and Innovate UK in areas where there is a strong need. This can be observed in many areas where we co-fund projects/ programmes.
There should be a mechanism to offer incentives to academic staff to encourage them to participate in more industrial engagement.	EPSRC supports the Royal Society Industry Fellowships scheme which supports secondments in both directions. Innovate UK has the Knowledge Transfer Partnerships scheme which also supports bidirectional engagements.

Strategy	
Materials research needs to be considered in the context of all the other research fields as it is an underpinning technology for many applications and sectors.	This fact is recognised by EPSRC and Innovate UK. For example, EPSRC is actively making the case that materials underpins all of the Government's "Eight Great Technologies" and much of the Industrial Strategy.
Don't take perceived 'incremental advances' as being negative – they are integral to the advancement of materials research.	There is a balance to be struck between so-called "incremental research" and the support for innovative ideas. EPSRC funding for an area is determined by the applications that it receives and the judgement on quality provided by the community through peer review. The community itself needs to decide how it responds as reviewers to research proposals.
Alignment of funding in general and especially CDTs to areas of national importance and wealth creation is central. There should also be emphasis on the importance of broader measures of success, not just academic metrics.	The Priority Areas against which institutions bid for the new CDTs were determined on the basis of national need. In awarding the new Centres, whilst quality was the primary criterion, the balance between research areas was considered.
There should be more Innovate UK led brokering events between SMEs and universities and more targeted calls at SMEs to increase SME engagement with the academic research base.	The KTN already has an important role in leading brokering events between industry and academia and has helped many SMEs engage with the relevant academic base. Innovate UK has a range of developing SME tools that look to increase the engagement of industry with the research base- an example of this is the technology inspired competitions.
Develop a better ear for smaller groups, centres and SMEs especially when technology is very novel but can be applied.	One of Innovate UK's key commitments has been to provide new support for high-potential SMEs. Innovate UK has a coordinated package of support helping early-stage businesses to bring their ideas more rapidly to market, and, for more mature small businesses, to deliver strong growth.

Strategy	Response
The Innovate UK should engage earlier with low TRL work via EPSRC and RCUK and take their advice on winners.	Innovate UK helps 'join up' the innovation landscape so that business, government and research work together to give innovators the right help at the right time. It brings together partners to maximise funding for innovation and get groups of organisations working together.
Improve the liaison between EPSRC and Innovate UK so that basic science can smoothly transition to development without loss of momentum, staff, commercial interest, etc.	Innovate UK is constantly looking at various way to aid the effective and efficient transition of knowledge between the science base and industry. Innovate UK actively engages with the EPSRC in areas where there is a strong need. A recent example of this is the collaboration on graphene and 2D materials.
Exploitation	
There should be a continuity of funding beyond ideas stage into validation and exploitation. This is the barrier to economic exploitation.	Innovate UK is looking at ways to accelerate the journey between concept and commercialisation. There are several examples of how its "toolset" allows for and facilitates continuity of funding opportunities: Smart awards provide a range of support from shorter duration feasibility studies to larger development projects. There are also the Catalysts. Catalysts are run jointly by the Innovate UK and the Research Councils. A Catalyst is a form of research and development funding which focuses on a specific priority area and aims to help take projects from research to as close to commercial viability as possible.
The Innovate UK should actively encourage 'open innovation' to overcome IP bottle-necks.	Innovate UK is a champion of the 'open innovation' approach – collaboration is at the heart of its activities. Through programmes, connections and networks, it enables people and companies to work together and share ideas to make innovation happen.

Exploitation	Response
With regards to graphene research it is important to integrate with the Catapults to deliver sector by sector opportunities that can be exploited.	In the March 2014 budget, the Chancellor announced £14m for a Graphene Applications Innovation Centre, to be housed at The Centre or Process Innovation (CPI) which is part of the HVM Catapult. The Graphene Applications Innovation Centre will provide facilities and expertise for companies that want to develop graphene-based products and will work alongside academic institutions, manufacturers and end users. For more information, see http://www.itpro.co.uk/strategy/21879/government-graphene-development-funding-details-announced#ixzz3AuuNmymB
Facilities	
There is a need for continuity of funding, especially for people running characterisation facilities to maintain the knowledge and skills in order to fully utilise the equipment.	A new process has been put in place for the renewal of existing mid-range facilities and the identification of new ones. This process allows existing facilities to make the case for their continued support, based on the quality of the science supported, the quality of the service provided by the facility, and continuing user need.
Central Facilities (for example ISIS) need to be properly funded so they can run at full capacity.	The funding for central facilities is top-sliced from the science budget. The amount of funding has to be balanced against all of the other demands on the budget. The Science and Technology Facilities Council is responsible for managing the central facilities as efficiently as possible. EPSRC and other funding agencies provide support for groups to carry out projects which use the facilities.

Exploitation	Response
Scale-up and routes to manufacture are integral to the development of materials research. In order to improve this process it is essential to have closer industrial involvement in the research and a simplified process for development such as a simplification of agreements between organisations.	Innovate UK and EPSRC agree with this statement. As an example, EPSRC's Manufacturing for the Future theme actively encourages research aimed at demonstrating scale up and routes to manufacture. The matter of the collaboration agreements between participating organisations is one for those organisations. Neither EPSRC or Innovate UK are partners to collaborative agreements.
There is a big opportunity to use capital funding within advanced materials research focussing on the reduction of lead times and technology translation through both equipment for processing and analysis by rejuvenating and upgrading old capital equipment.	We understand that many of the responses to the recent Department for Business Innovation and Skills (BIS) consultation on capital expenditure made this point. The extent to which government will take this into account in making future allocations will become clear later in the year.

The Expert Panel

INTRODUCTION AND BACKGROUND

The Materials Research Exchange 2014 brought together the leading materials research groups in the UK. Their presence at a single location presented a unique opportunity to explore matters of concern to the community and to the Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK as two of the government agencies responsible for funding research and its exploitation in the UK.

This event provided a prime opportunity to seek the views of the research community about the current landscape of research within the UK and the opportunities that this presents to the UK community. More specifically, it provided an opportunity to gain the community's views on where they see the prospects for the UK in materials research and development, on how to improve the ways in which research results can be disseminated to those who might be in a position to exploit them and how links between academia and industry could be improved for mutual benefit.

An Expert Panel was convened to conduct interviews with a specific focus on the areas outlined and to feedback the key findings and recommendations in order to provide a review of the advanced materials research landscape in the UK. Such a review is timely as both Innovate UK and EPSRC are looking at their support for advanced materials. This report provides a summary of the key findings and recommendations from the Panel.

For Innovate UK, the themes for support in advanced materials are: sustainability and materials security; materials for energy; and, high value markets. There will be a strategy review for support beyond 2015 and while changes to the themes are not envisaged, there might be opportunities for adjusting the priorities within them. The view of the community will thus inform that debate.

EPSRC senses an opportunity in the government's interest in materials to look at its priorities for the support of the area. A discussion paper for its Council focused on the research opportunities provided by the need to reduce lead times from discovery to exploitation; developing routes to improved materials sustainability; and, materials discovery. The views of participants at the Materials Research Exchange will form part of the input to the Council's continuing discussions.

TERMS OF REFERENCE

The Expert Panel's terms of reference were:

1. To visit the exhibitors' stands and interview researchers.

2. On the basis of the evidence of the interviews to advise EPSRC and Innovate UK on the,

    - health of UK materials research.
    - areas of greatest opportunity for the UK materials research.
    - major threats.
    - extent to which the academic community is aware of the UK industry needs.
    - opportunities created by academic/industry collaboration.
    - barriers to improved collaboration with industry.

In addition, the Panel members were also requested to provide general comments on their own experience. In particular, to comment on their views on leadership within the UK and translation from the research base outwards with a focus on:

- What is the role of the community and the stakeholders in this?
- How do we persuade companies to invest in and adopt advanced materials?

The Panel's membership is at Appendix 1 and a list of the exhibitors interviewed at Appendix 2.

RESEARCH QUALITY

The Panel were asked to report on the research quality that was demonstrated and discussed during the individual interviews. The main points that were highlighted by the Panel were that there is a great breadth of innovative materials research

in the UK, the UK is 'world class' in some areas of materials research (e.g. titanium alloys, solid oxide fuel cells, polymer science), the UK is well positioned internationally and there is a strong focus on research that is of high quality and of industrial relevance.

Some of the key high quality research that was demonstrated at the Materials Research Exchange included: metals and alloys; composites, including sustainable/bio-derived materials; materials chemistry, especially relating to energy applications such as batteries and fuel cells; GaN for lighting and semiconductor applications; sustainable materials and their manufacture, including working across the supply chains; technical ceramics, both structural and functional; materials for biomedical applications; carbon micro and nanomaterials; and materials modelling – especially electronic structure and atomistic calculations.

The Panel observed that the community demonstrates a clear focus on industrially important research and is very much aware of its role in the scientific ecosystem and is heavily focussed on the areas where quality and innovation were the drivers. The Panel emphasised that UK advanced materials research is internationally competitive but needs more support in funding especially in the proof of concept stage.

The Panel stressed that the community produces good quality publications; however, the publications are not necessarily transferred to applications and that it is important to concentrate on the translation of the technology into commercial applications. There were also good examples of research outputs and the successful protection of IP from the exhibitors.

However, the Panel did highlight that, as an opportunity to assess the research quality within the UK, the Materials Research Exchange did perhaps not provide this as the most industrially relevant and, hence, commercially sensitive research would not be displayed in a public environment. It was also pointed out that it was difficult to assess the research quality from interviews alone.

ACADEMIC/INDUSTRIAL COLLABORATIONS

The Panel were asked to comment on the academic/industrial collaborations with a particular focus on what works and what could be done to improve links.

The key messages that were identified were that the most successful collaborations are strategic partnerships, which involve a long-term relationship between a university and a company operating as a true shared partnership, not simply a customer-supplier relationship. Generally, university-based researchers have a good awareness of the issues facing industry. The Panel stated that collaborations help improve the academic understanding of what research is of real interest and what is achievable commercially. The Panel stressed the importance of collaboration as a mechanism to increase innovation and were clear that without collaboration, it is impossible to truly understand some industrial issues. However, it was noted that it must be a realistic collaboration, not artificially developed and with a clear goal and purpose. The Panel gave emphasis to the financial benefit of good academic/industry collaborations as they can help to obtain funding and to leverage additional funds.

A further point to note is that the Panel observed that EPSRC Industrial CASE awards were very successful at encouraging strong collaborations between academics and industry and were a good tool for establishing new collaborations. They highlighted that an increase in the number of Industrial CASE awards would lead to increased collaboration and would help to complement the CDT studentships by providing a more flexible method to meet industrial interests and opportunities quickly.

The Panel identified that the main barriers to academic/industry collaborations were the different and sometimes conflicting drivers and motivations of the different parties as well as the demands of both. Examples include the fact that academic timescales can be too long for industry and it can take too long to access funding, industry is much more focused on secrecy and intellectual property, which can be conflicting to the academic objective of publishing findings and sharing with the research community. Another barrier that was established by the Panel is that of the pricing of research. There needs to be more flexibility in pricing of research to industry

and pricing needs to be more competitive. This can be achieved through using government support for research costing to industry, especially for SMEs who are being priced out of any meaningful university research relationships.

There was a strong focus by the Panel around technology transfer as many of the exhibitors showed a strong demonstration of patents and Intellectual Property (IP) protection in collaborations. The Panel suggested that university Technology Transfer Offices (TTO) are essential in helping researchers to translate their research. An example given was of a strong involvement from the School of Chemistry Business Partnership Unit at the University of Nottingham that has led to significant progress towards the commercialisation of their metal organic framework research. Technology transfer pathways are useful tools to help researchers exploit the true potential from research and the Panel highlighted that more focus should be put on this. The Panel recommended that it is important to put a significant focus on the protection of IP when collaborating with industry and it is important to be realistic, to share and be flexible during the process with a company. Although arranging IP and licensing can take time it is necessary to have appropriate arrangements in place.

The Panel emphasised that trust is a vital part of successful collaborations and it is important that this is established not only between individuals but also between organisations. This requires time and effort from both parties and an openness and realisation of the mutual goals to be achieved but it also highly dependent on personal connections and mutual respect. It is important to dedicate time and effort to establish trust for successful collaborations as developing relationships at the engineering and scientific level is very important.

The Panel stressed that events and networking opportunities are the main opportunities for establishing collaborations and that more events to bring the materials community together would encourage and lead to increased collaboration. It was highlighted that networking opportunities are particularly beneficial to SMEs as they are a time efficient means of connecting with other organisations. A suggestion was made for more events like the Materials Research Exchange and that it would be beneficial to hold the event biannually. Collaborations are also a mechanism for large companies to help SMEs and organisations through sharing best practice.

The Panel emphasised that the visibility of university expertise and equipment/capacity is vital to allow industry to see them as potential collaborators. This is particularly important to SMEs. They also noted that it would be beneficial to have a national initiative for universities to access and understand industrial needs and opportunities, and vice versa, to establish how UK companies (especially SMEs) can see and access the research activity and capability of UK universities. Another suggestion was that there should be increased funding for networking events for universities that may not have strength in all areas, but where they have some outstanding centres of excellence that are less visible to industry. The Panel also emphasised that more flexible scale-up funding independent of the Catapults, would be beneficial as some universities are well placed to undertake this scale up in terms of knowledge and supporting equipment and facilities. Another opportunity would be to provide funded schemes that allow university staff teams to co-locate either at the university, company or a "neutral" space eg company incubator.

Finally, there was a strong focus from the Panel around SME engagement in collaborations. The Panel identified that currently mainly large industry seems to benefit from academic/industrial relationships. SMEs are not well involved in those relationships yet even though they would greatly benefit. The Panel recommended that more KTN type events should be considered to encourage SME uptake. Collaborations can successfully include big and small industries with a range of other research partners, provided they all commit. SMEs are challenged by the time and cost required to partner successfully, and the gap between academic research and SME needs can be a major issue, where there is not the time available to surmount the issues. The SME eco system does need significant support if it is going to operate in a long (3 year) style collaboration. The Panel suggested that this is an area that may require focus from Innovate UK. There could also be an opportunity for the mentorship of SMEs by big companies to also be included in this area.

OPPORTUNITIES FOR RESEARCH

The Panel was asked to highlight opportunities for materials research within the UK. The key points identified by the Panel were that: there is a large opportunity for advanced materials research in a number of industrial sectors such as aerospace, oil and gas, nuclear, automotive and healthcare to be used to help overcome some of the industrial challenges; and, the drive towards sustainability due to environmental concerns provides a large opportunity to the advanced materials research base in the UK. The Panel identified that the UK has strength in many of these areas and we should build on our world leading position to generate wealth such as through our expertise in metals and composites for the aerospace industry. National funding policy needs to address the requirement for research and training in these areas.

The Panel also emphasised that there is a large opportunity for materials science to work with other disciplines to enhance the scope of research that is undertaken. An example where this could be successful is in working to bring product and materials design together to use both the creative arts through links to the public and marketing and similarly with economics for sustainability with materials research to address challenges such as new versus re-use. Work on new materials and products needs to include elements of design and manufacturing (including scale up) so bringing product designers, materials researchers and manufacturers together could help meet this challenge. This could be implemented by joining EPSRC, Catapults, smaller research centres and SMEs together. Another example where multi-disciplinary research is essential is functional materials with research developments geared to integrate chemistry, physics and engineering as the complexity of current research developments is too high for a single field.

The Panel identified that the UK is particularly good at fundamental, underpinning science and it is a matter of identifying those which are of relevance to society and industry. Implementing materials modelling (microstructure and materials performance) and linking this with experimental work could be used to support manufacturing. There is also an opportunity in increasing the uptake of materials modelling by industry and improve the access to modelling expertise through academic/industry collaborations. The Panel identified that there could be an increase in the uptake of research results by having done more of the de-risking and incremental improvements during the initial phase of research. Using a combination of modelling, certification and testing can significantly reduce the time to exploitation and can lead to rapid development of technologies.

Energy is an area of increasing concern and there is a growing need for systems and materials to provide efficient ways of generating and storing energy and it was highlighted by the Panel as an area of research that provides significant opportunities for the UK. Energy related materials - storage (such as batteries and capacitors) and conversion are a research area where the UK has significant strength. Coupled with this is the need for materials with reduced environmental impact (lower energy required to process the materials into artefacts, more sustainable materials, reduced use of organic solvents). The environment remains an important aspect of our daily lives and anything that provides an opportunity to use less energy, or materials, or is less polluting to the environment is seen as being beneficial. The Panel outlined that this is an area of substantial potential for the UK advanced materials research base.

Some additional areas of opportunity identified by the Panel include the materials discoveries that will help overcome some of the underpinning challenges for 'Big Data', the opportunities for biomaterials for applications such as wound dressings and opportunities created through the need to scale-up technology such as moving from single sensors to large scales systems.

The Panel proposed that to help maximise some of the research opportunities that have been outlined there is a need to share roadmaps and critical needs with a consortia of non-competing businesses to look for generic materials opportunities, eg high temperature applications. They also suggested that it could be worthwhile to identify 'sub-grand' challenges for industry-academic partnerships to enable the technologies to be developed that meet the needs of multiple sectors, eg additive manufacturing to fill real component needs.

Much of the preceding paragraphs have been concerned with linking the excellent research in UK universities to industry to ensure exploitation. However, it needs to be remembered that it is important in the long-term to ensure the health of the research base by supporting a sufficient number of adventurous projects within the UK. There is a need to ensure a balanced portfolio of research covering both the incremental and the groundbreaking.

OPPORTUNITIES FOR EXPLOITATION

The Panel was asked to identify opportunities for the exploitation of materials research within the UK. The key points recognised by the Panel were that:

- There needs to be funding to support the co-location of industry and academic groups to increase collaboration opportunities and to aid technology translation.
- Universities need to be flexible in their pricing structure – many SMEs cannot afford the prices currently charged.
- There needs to be encouragement for open exploitation.
- Exploitation is more effective when the university has a strong technology transfer office as this provides a better chance for commercialisation. The EPSRC Impact Acceleration Accounts have been useful to help universities to implement this.
- There need to be realistic expectations of IP.
- Universities and Catapults need to be better connected to bridge the gaps in TRLs.
- Encourage early industrial engagement to aid subsequent exploitation as this will help make the research base aware of the relevant industrial challenges and make the outputs fit for purpose from the outset.
- Any strategy should include those topics that are already contributing to the UK economy. These have a better chance of being exploited in the UK.
- Graphene – a mandatory push to all EPSRC Centres and Catapults on the grounds that this is a unique UK leadership position with potential to achieve critical mass and should be further built upon in the sectors represented by the Catapults.
- With the demise of corporate laboratories there is an opportunity for universities to be smarter in their interaction with companies and to take the lead on some areas of materials research.
- There is a large opportunity for exploitation in the scale-up of materials from grams to kilograms. The UK is leading in science but this provides a good opportunity for the UK to exploit this.
- There is a requirement for more opportunities to help companies identify potential academic partners and vice versa. Innovate UK and EPSRC could work together to create environments where this can happen such as organising events that are attractive to both types of organisation.
- Key publications in high impact journals leads to large numbers of industrial enquiries.
- The UK is still strong in the area of technology translation and should continue to pursue this further.
- Academic collaboration allows UK SMEs to keep up.
- The current focus appears to be on materials research that has a high value and quick return. The Panel suggested that the government should place an additional emphasis to assist high value projects which may offer a long-term financial return.

THREATS

A large threat identified by many of the Panel members was focussed around people within the materials research landscape. Firstly, the main focus was around skills development and retaining people within both the academic and industrial materials research base with the appropriate skill sets to carry out materials research and make informed decisions on the direction of the research. This is particularly important to ensure the availability of appropriate skillsets to translate technology through the TRLs.

The Panel emphasised that there is a lack of ability to recruit high quality UK students at PhD and PDRA level and that it is essential to the future of materials research that more young people are attracted into science and engineering generally, but particularly in materials research. It was described that in some materials research fields there is a poor age distribution with a large proportion of the community heading towards retirement and it is important to retain the UK's strength in the field by encouraging younger researchers to come through. It was noted that this is a factor in some critical areas such as nuclear materials.

Some potential causes of this low recruitment suggested by the Panel include: poor portrayal of science and engineering in popular media; losing foreign postgraduates to international competitors after graduation; and, undergraduate student debt inhibiting PhD applications from UK graduates. The Panel suggested that incentive schemes should be used to help overcome some of the issues by attracting UK students in to careers in materials research such as financial incentives. A further point to note is that the Panel were concerned about the flow of PhD graduates internationally and that this may expose IP developed in the UK to growing economies through the movement of the researchers and knowledge.

The second focus around people was focussed on the change in the research and design landscape in UK industries and the impact that the decline of corporate laboratories has had on the research base. The Panel identified that there are no longer enough decision-makers with a materials background in the UK and this means our absorptive capacity is reduced. Also, although universities are strong, UK companies are, as a consequence, unwilling or unable to take advantage of our research strengths as the decision-makers within business do not understand the science well enough to make informed decisions. The number of people in industry capable of interacting with universities is reducing and there is a perception that the business environment in the UK is less focussed around long term scientific research and more focused on short term impacts and successes.

Another major threat identified by the Panel was that of competitor nations and the impact that they have on UK materials research. There is a major threat that other countries have a more coordinated, more strategic and more agile network of funding and many developing countries have engineering as a priority. The high speed of engineering progress in developing countries and emerging economies where engineering research is valued and growing fast can pose a significant risk to both UK academia and industry.

A suggested route to mitigate this risk is to align funding and studentships to areas of national priorities in terms of employment and economic value in order to have a more coordinated UK approach.

The Panel also noted that it is important for the UK to think European wide as we are in danger of falling behind European partners and to focus on the exploitation of research where the UK currently has less strength than competitors such as Germany.

The Panel also identified that Full Economic Costs could be making UK university research unaffordable and uncompetitive on an international basis; UK costs are unlikely to be significantly higher therefore the strong suspicion is that our competitors benefit from underpinning funding or subsidies, often in a direct attempt by competitor nations to cause our collaborators to relocate their research. The Panel identified that UK universities are not as active in seeking out industry partners as those from overseas and it is also difficult for companies to understand the opportunities within the UK academic base.

The Panel also emphasised that it is important that the UK is realistic about what we are good at (Europe wide) and avoid areas we will lose in.

The third area of threat that the Panel identified was focussed on the threats around funding. There was a strong focus on the importance of funding for facilities and particularly for the maintenance, staffing and refresh of equipment. The Panel suggested that there should be a stronger focus on this through stable funding mechanisms as it is core to many parts of materials research. The Panel identified that there is a good opportunity for the use of capital funding in materials research to be used to replace and upgrade essential equipment such as SEM and XRD equipment to increase throughput and

therefore reduce the lead times required to develop and process new materials technologies.

The Panel also suggested that there is insufficient support of large scale facilities, such as ISIS, and suggested that large facilities should be supported more for technology pathways and developments.

The Panel also noted that there is a perception that there is lack of variety of funding streams particularly for incremental development which is essential for materials research. The Panel also stressed the point that consistency of funding over multiple cycles for world class research groups is also essential to help the research base maintain momentum and support fundamental research.

Another key point was the importance that defence research has had in generating more fundamental knowledge and encouraging blue sky research that is still being exploited. It is important to support this research even though there has been a decline in funding through these means.

The Panel also pointed out that Horizon 2020 could be a problem in driving the research base to focus on higher TRLs, which may cause a gap to grow within materials research. An additional threat that was identified by the Panel was that there has been significant emphasis on over focusing of the research in the UK and there is a fear that opportunities will be missed.

NOTES FROM THE EPSRC SEMINARS HELD AT THE MATERIALS RESEARCH EXCHANGE 2014, THE RICOH ARENA, COVENTRY, 25 FEBRUARY 2014

SUMMARY

The seminars explored improving the research and exploitation of advanced materials. The discussions focused on the emerging priorities of:

- Reducing lead times
- Materials sustainability
- Materials discovery

The main points emerging included:

- The importance of partnerships between academic researchers and industry. There are a variety of models to support this, but underpinning any successful relationship is mutual trust.
- Access to data is also important. The exploitation of materials requires potential users to be aware of the existence of new materials and to be able to understand materials properties both of new and recycled materials. Users also need to have data on the environmental impact through life-cycle analyses.
- To achieve increased sustainability will require regulation to effect change in the industry.

INTRODUCTION

Governments worldwide are recognising that Advanced Materials will be instrumental in the generation of long-term economic growth. The UK has a history of pre-eminence in materials research and exploitation. As a major funder of research in this area the EPSRC's governing Council is looking at its strategy for the support of the area.

Three themes have been identified:

- Reducing lead times
- Materials sustainability
- Materials discovery

These three seminars were organised at the Materials Research Exchange exhibition to explore some of the challenges presented by the need to exploit the results of research in these areas.

For each there was a brief introduction followed by a discussion.

1. REDUCING LEAD TIMES

In speeding up the impact of research what are the barriers faced by industry in the commercialisation of new materials? What is the role of academic research in meeting these challenges?

INTRODUCERS

Mike Murray (CTO, Morgan Advanced Materials) who argued for the development of relationships between industry and academia and finding better ways to bridge the "Valley of death"

Andy Cooper (University of Liverpool) who agreed with the need for collaboration and demonstrated the value of combining modelling with high throughput methods.

MIKE MURRAY

A key challenge for industry is understanding the barriers to speeding up the lead times of the impact of research and bringing new materials to market. An important component of this is how industry learns what is being worked on in universities and research centres. The Materials Research Exchange and similar events are one way of showcasing this. They expose innovative science that would otherwise be hidden to potential users.

Industry also needs to understand the art of the possible. It needs to understand the capabilities in universities. If an industry does not know this it will miss opportunities for the research base to help companies in the marketplace and in the development of future technologies.

Being aware of the availability of new materials is one thing, but companies also need to know how these can be used and exploited. This depends on developing trust-based collaboration with appropriate research groups, leading into long-

term relationships. Morgan Advanced Materials for example uses a model of placing its own researchers into university labs to work alongside academic groups. This helps speed up development.

However the real impact only comes if a company can successfully navigate the the process between discovery and incorporation into a marketable product.

Generating ideas is relatively cheap, but as you move through concepts and prototypes the costs increase significantly. Alongside this the risk of these not turning into a commercial product is significant. It is only when a product is close to commercialisation that the risk begins to fall: it is at this point that companies are prepared to invest. So the challenge is thus how to support development through the concept of prototyping phases.

Companies and the funding agencies need to work together to facilitate the process. EPSRC Impact Acceleration Accounts are one route to do this. Catapults also provide a way to bring products into the marketplace, but there are still gaps in the process that need to be filled.

ANDY COOPER

There is much common ground between academic research and industry. Collaboration is key to exploiting this. The University of Liverpool's Centre for Materials Discovery, which opened in 2007, provides one model for doing this. Its aim is to reduce lead times by using automated processes for synthesis and characterisation. It can deal with hundreds of materials. The result is a good mix of fundamental science as well as products on the shelves. The approach is attractive to industry, for example, Unilever have a group co-located within the Centre.

However, high throughput methods are not the only answer, especially for complex materials. Jansen (Angew. Chem., Int. Ed. 2002, 41, 3746) estimated that such brute force methods would have taken 27,000 years to come up with the yttrium barium copper oxide high-temperature superconductor.

A possible answer to this problem is to integrate high throughput methods closely with computation. Andy Cooper has used this approach to develop a new gas separation membrane material and his colleague Matt Rosseinsky has used an analogous approach to develop a novel fuel cell cathode.

The need is to bring together property measurements and structure prediction in an integrated team of specialists working together. This collaboration amplifies individual expertise.

DISCUSSION

The discussion covered collaboration: what it enabled and how to establish it; issues around IP; access to data; and new materials.

COLLABORATION

Setting up good collaborative and integrated research teams takes time. This is particularly true of multidisciplinary teams were the language used by different specialists can be a barrier. If done well, however, the outcome is not dilution, but a strong enhancement of the skills of all team members.

It also takes time to build links with industry and there are a variety of models for such collaboration. These range from location of staff for research groups in universities through to the involvement of the company in a joint research project either as a sponsor or collaborator. Often these would be in funding partnership with another agency such as EPSRC.

It is also possible to have multiple companies involved as a consortium. For these to be successful, however, requires a trusting environment and common goals. The industries also need to have complementary interests or a common fundamental purpose so that there is no competition within the collaborating teams.

INTELLECTUAL PROPERTY

IP is naturally important in collaborative ventures. Licensing, joint ventures and investment partnerships all play a role. The importance of each and their interaction will, however, depend on specific cases. Often universities will dictate the terms of any agreement, but it helps if all parties can be flexible. However, it is important for the company

to be assured that the appropriate arrangements are in place, for example, agreement on delays to publication where patents need to be put in place. Perhaps more important than a licence is a close collaboration between the researchers and the potential exploiters. This is an example of where Partnerships built on trust will pay dividends.

ACCESS TO DATA

If an emphasis is placed on materials discovery there is a risk of "reinventing the wheel". Publicly accessible databases are needed where information can be archived. This includes providing data on approaches that did not work.

The Research Councils Gateway to Research is a useful first step in this process.

Information and data are not only held by universities, and companies. Again this is an area where a true partnership can unlock the unrealised potential of knowledge.

NEW MATERIALS

We need new materials that enable and lead to new opportunities and technologies as well as ways to incorporate materials innovation into existing technology.

New materials are not products in themselves but leads to the design of new products. There is a challenge integrating new and existing materials. As new materials have new properties, there can be issues with processability. This is especially true when they are combined with an existing material. It is important to bring together design and systems integration. It would be useful if generic routes could be found to enable this.

2. MATERIALS SUSTAINABILITY

What research opportunities exist in meeting the challenge of being more resource efficient in our use of materials and becoming less reliant on scarce materials?

INTRODUCER

PAUL MATIVENGA (UNIVERSITY OF MANCHESTER)

A major driver for business and society today is the need to be more resource efficient and to have less reliance on scarce materials. This sustainability is important to incorporate into businesses which operate to address the needs of society by providing goods and services that people need or want. The question is how can new materials be beneficial and contribute to the economy, society and the environment? The key is being innovative, not only in the materials, but also the products. Innovative products are those with significant reach and impact and have a wider benefit.

A life cycle analysis is required to make the products sustainable: looking at all stages from raw materials sourcing, through manufacture, use and then the recycling of the product. This enables the identification of opportunities to conserve energy, water and materials at each stage.

Different materials also produce different challenges. For example, the production of carbon steel produces 3 kg of carbon dioxide for each 1 kg of steel. In the case of some strategic materials, however production can produce more than 1000 kg of carbon dioxide per kilogram of material. Such materials are thus not only scarce and expensive, but also have a significant environmental impact. Finding ways to use less, recycle or replace these becomes important.

The opportunities for savings vary depending on the sector. For example, in construction it is the materials production phase that has the most environmental cost, whereas in aerospace the cost lies in the use, rather than the production.

To achieve sustainability requires understanding the industry drivers: what is it that will encourage investment long-term in sustainable production and products.

DISCUSSION

The discussion covered the use of recycled materials, the role the regulation, the need for data and, environmental impacts.

USE OF RECYCLED MATERIALS

There is a serious barrier to the increased use of recycled materials. Recycled materials, for example polymers, have different properties to the first-generation material. Moreover, the performance data for those is robust, so designers have confidence in their use. The data for recycled materials are deficient or not so robust. This leads to a reluctance to use them because manufacturers have less confidence in their properties.

For sustainable manufacturing generally this reliability is important. We need to ensure that the properties of recycled materials are reliable and predictable and thus capable of delivering the design specification. The robust characterisation of second, third, fourth, etc generation materials is important.

There is thus a need for more robust characterisation data for recycled materials.

Futher environmental advantages would accrue if the use of recycled materials increased. For example, the process energy can be lower for recycled materials compared to the original.

REGULATION

A key issue for industry is regulation. There are moves in Europe to address some aspects of this. At the moment such analyses that are carried out are focused on carbon emission in production, not the whole life-cycle. We need to find ways to encourage regulators to take a broader approach if industry is to change. Life-cycle analysis is needed in order to identify the key points where intervention and innovation will make the most impact.

There is also the issue of competition. Raw materials suppliers do not want to see recycling because it will affect their businesses. Regulation and legislation could be a possible answer here.

THE NEED FOR DATA

The accurate use of life-cycle analyses requires the collection of more data and providing access. There are efforts to make life-cycle analysis more accessible to companies, for example through EU projects looking at how to make analyses easier for SMEs.

Where a product or process is new, the data are incomplete because the products have not come to the end of their lives and thus the data for the latter part of the cycle are not available. However it is possible to look at things like energy and water use and to consider ways of reducing usage.

There are databases, for example the Cambridge Engineering Selector (http://www.grantadesign.com/products/ces/), which contain environmental data for materials (the manufacturing and recycling data continue to be added).

ENVIRONMENTAL IMPACTS

It is worth looking at the quantities of a given material. If the environmental impact of a material is high, but the material is only used in small amounts, perhaps finding alternatives will not make a significant impact.

Water is another significant challenge, not just in usage, but also ensuring that the waste water is clean before it is discharged.

We owe it the next generation to ensure that processes are viable in the long term.

3. MATERIALS DISCOVERY

What research opportunities exist in the creation of new materials that will open up new markets? How can such materials be readied for commercialisation? What does industry need in order to understand the opportunities offered by a new material and what is needed to aid its take-up?

INTRODUCERS

Neil Alford (Imperial College) who spoke about the role of universities and the long lead times needed for exploitation.

Kwang-Leong Choy (UCL) who spoke about the skills needed.

NEIL ALFORD

We need to be clear that new uses of existing materials - which can be novel and patentable - is not materials discovery. Materials discovery is, simply, looking for new materials.

Andy Cooper spoke about high throughput methods. This is certainly a means for materials discovery, but it is of limited use if you cannot process the data obtained. The rate-limiting step is thus how quickly you can characterise the materials that you have made.

Materials discovery is, generally, very straightforward – you just need smart people to do it, good analytical kit and, for high throughput, the ability to do characterisation quickly.

It is worth remembering that 20 or so years ago the UK had large corporate laboratories whose purpose was to look for new materials. They needed these to make new products. Now we no longer have the likes of GEC and ICI, and even AT&T Bell Labs and IBM have scaled back their activity. This means that the universities need to fill this gap of materials discovery.

Often discovery comes about as a way to meet a specific objective. Yttrium barium copper oxide was discovered as the result of a specific aim: in this case the need for a high-temperature superconductor.

There is a long lead time from discovery to deployment. For example, Kevlar, discovered by DuPont, took 30 years and linear polyethylene also took a long time to come to market. We need patience and we need to be targeted about where we look for new materials.

KWANG-LEONG CHOY

Speeding up the process of discovery needs a combination of simulation, design, modelling and characterisation. You also need to link theory to practice and to integrate expertise in chemistry, physics, biology, engineering, nanotechnology and biomedicine. You also need to ensure that the routes to production are sustainable.

The new UCL venture in Materials Discovery is attempting to do this and is actively seeking partners.

DISCUSSION

The discussion covered the need for synthesis facilities, the need for data and the difficulties of exploitation, with an opening comment that the importance of serendipity should not be overlooked. There were many examples of materials produced by accident.

SYNTHESIS FACILITIES

The introduction covered the need for characterisation. However the ability to synthesise new materials was also important. Many synthesis facilities exist in universities, many funded by EPSRC. The challenge is how to open these up to the community. Payment for access can be a legitimate charge on a user's research grant but the difficulty is making the community aware of what is available. Facilities for characterisation are generally well known, but facilities for synthesis are not and these are important in the discovery area.

DATA

One problem with speeding up exploitation of new materials is the lack of data on long-term performance. There are ways of accelerating the tests to look at degradation.

EXPLOITATION

Another issue for the UK is that we have the ability to develop new materials, but we no longer have the industrial capability to exploit these. There needs to be careful thought about the strategy. There seems to be no point in encouraging the establishment of SMEs to exploit new materials if there is no source of long-term investment to allow them to grow. One issue here is a disconnect between universities and companies. With no large corporate laboratories this link is an important one that needs to be addressed.

The European Union also has a role here as the UK cannot be globally successful if it is insular in its approach.

If discoveries are to be exploited then we need to find a way to continue funding beyond a traditional 3 to 5 year research grant.

The Technology Pitch session was aimed to allow companies, universities and other organisations to broadly promote their activities to a large audience of delegates. Each pitch was limited to one minute and most referred to a stand in the main exhibition hall where interested people could find out more.

There were presentations from over 30 representatives from industry and academia, with a focus on a range of disciplines relating to materials as well as specific areas of EPSRC interest. A sample of the diversity of expertise is listed below:

INDUSTRY

Mike Murray (Morgan Advanced Materials): Additive manufacturing;

Laura Cohen (Ceramics Trade Association): Developing technologies across a range of applications including resource efficiency;

John Gearing (Gearing Scientific): Nanoplasmonic sensing;

Martin Cowshill (Goldmine BD): Superhydrophobic coatings for built environment;

Mark Hadley (Smartlife): Design and engineering of wearable technology;

Nitin Rai (OxPly): Marine biomaterials;

Rob Hardeman (Seagate): Optical components for data storage solutions; new plasmonic materials.

ACADEMIA:

Andrew Bell (Leeds): Piezoelectric ceramics (energy ceramics) ;

Richard Bonza (Brunel): Smart engineering into materials from lessons learnt in Nature;

Senina Corr (Glasgow) : Functional nanomaterials;

Nick Bennet (Nottingham) : Metal organic frameworks;

Peter Duckworth (Bristol): Novel nanoparticles (for antiseptic purposes);

Martin Turner (Harwell): Promoting the connection to national (imaging) facilities;

Philip Smith (Warwick): Corporate relations with respect to advanced materials;

Alison MCMillan (Glyndwr University): Advanced materials for demanding applications;

Chris Holland (Sheffield): Materials solutions from nature;

Rafaella Cassisello (Loughborough): Material applications for food packaging/ tissue engineering;

Anna Speher-Deleze (University Rovira): Biosensors for sports/healthcare.

APPENDIX 1 – PANEL MEMBERS

Neil Alford	Imperial College London (Chair)
Steve Beeby	University of Southampton
Alan Bickley	James Walker
Jon Binner	University of Birmingham
Martin Brunnock	Tata Steel
Bill Clegg	University of Cambridge
Robert Dorey	University of Surrey
Neil Glover	Rolls-Royce
Patrick Grant	University of Oxford
Nick Green	Doncasters
Stuart Green	Victrex
Rob Hardeman	Seagate
Steve Harris	BAE Systems
Paul Hodgkinson	Durham University
Alma Hodzic	University of Sheffield
Mike Murray	Morgan Advanced Materials
Mike Osborne	Optek
Michael Preuss	The University of Manchester
Robert Sorrell	BP
Keith Strickland	Plessey
Sally Price	University College London
Su Varma	NSG Pilkington
Nick Warrior	University of Nottingham

APPENDIX 2 – EXHIBITORS

ACCIS, University of Bristol
Advanced Materials @ UCL
ARTIS
ATG Scientific
Baltex Ltd
Brunel University
Cavendish Laboratory, Cambridge
Cranfield University
dstl
Durham University
EPSRC CDT in Metal Processing
Gearing Scientific
Goodfellow
HIP & CCPi
Imperial College London
IOM3
Knowledge Centre for Materials
Loughborough University
Lucideon
Maney Publishing
Materials Centre Leicester University
Meritics Ltd
Morgan Advanced Materials
National Graphene Institute
National Physical Laboratory
Oxford University
Pera Technology
Queen Mary University of London
SCFED Project
Sheffield Hallam University
Shimadzu UK Ltd
Shipbuilders and Shiprepairers Association
Simpleware
Specific IKC
Tun Abdul Rezak Research Centre
UCL Materials Discovery Centre
University of Bath
University of Birmingham
University of Brighton
University of Cambridge - DMSM
University of Glasgow
University of Hertfordshire
University of Huddersfield
University of Leeds
University of Liverpool
University of Manchester
University of Nottingham - MOFs
University of Reading
University of Sheffield
University of Southampton
University of St Andrews
University of Strathclyde
University of Surrey
University of Warwick

Produced by JRS, RCUK's internal service provider.