EPSRC International Review of Materials Science Evidence Framework

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A. To what extent is the UK materials community addressing key technological/societal challenges through engaging in new research opportunities

i) What are the key technological/societal challenges and research directions in materials research? To what extent is the UK materials research community focused on these? Are there fields where UK activity does not match the potential significance of the area? Are there areas where the UK has particular strengths?

The forthcoming key technological directions in materials research can be seen to lie in energy, biomaterials, and nanotechnology.

With regards to energy, this includes generation, storage and efficiency. There are signs of encouragement in this area, with the forthcoming Energy Research Institute and the ongoing EPSRC SUPERGEN consortium. There is a danger that research funds will be diverted to some areas more than others, *i.e.* are we second guessing where the breakthroughs will be? In the UK there appears to be a shortfall in research in photovoltaics, a key energy technology.

In terms of energy there needs to be a strategic consideration of large scale, centralised energy generation versus local, microgeneration. This will have an effect on research priorities. For example, in centralised systems energy loss through transmission is a problem, but less so for microgeneration. Major decisions need to be made at a high-level, and this brings the danger that some aspects of materials science will be neglected. There needs to be supported, significant investment in bridging technologies in the energy sector.

Nanotechnology is still a relative newcomer and there are significant opportunities for development. The well understood focus on applications must be viewed in a supportive context, embracing fundamental research at one end of the scale and societal impact (both benefits and risks.) at the other.

Societal needs and communication will also be key. Any future changes in research direction need to be presented in such a way as to gain backing from the wider community. This needs to be implemented carefully so as to avoid similar problems encountered during, for example, the development of GM and nanotechnology.

ii) In terms of the defined remit of the EPSRC Materials programme, are there any areas which are under-supported in relation to the situation overseas? If so, what are the reasons underlying this situation and how can the situation be remedied?

As stated in section A (i) photovoltaics remain under supported especially when considering the level of current and potential future economic growth and future importance of this technology.

In the case of functional materials, it is perceived to be the case that there is an imbalance in support, with more funding available for device fabrication than for chemical research to develop new molecular components.

The interface between Materials Science and Chemistry is frequently construed in terms of synthesis and analysis only. There is a need for greater emphasis to be placed on the development of novel techniques for nanofabrication and the characterisation of new materials.

iii) Is the research community structured to deliver solutions to current and emerging technological/societal challenges? If not, what improvements could be implemented?

The lack of research institutes can be limiting, however, this could be a problem of scale. Have institutions in the UK got critical mass and do we have the resources? There is concern that the UK funding community remains too inward looking with respect to Europe.

It is necessary to achieve an appropriate balance between consortium (targeted) programmes against smaller scale responsive mode funding.

A highly successful multidisciplinary, multi-site consortium was the Polymer IRC, which incorporated research centres from Leeds, Durham and Bradford with expertise in polymer chemistry, processing and engineering, respectively.

B. To what extent is the materials research base contributing to other disciplines and multidisciplinary research?

i) What evidence is there that there is sufficient research involving investigators from a broad range of traditional disciplines including chemistry, physics and engineering as well as materials scientists.

There is significant evidence that research collaborations between scientists from a wide range of disciplines, such as chemists, physicists and engineers, is taking place. The extent of this collaboration should be apparent from EPSRC grant portfolio data. However, many research projects may not be labelled as ‘materials’; it has influenced and catalysed research in other disciplines.

Many chemistry departments now have a strong materials theme, especially in the physical and inorganic aspects.

There has also been a significant emergence of research consortia, but not an increase in the number of Materials Departments.

The materials department at the University of Oxford is very strong in computational research and materials modelling, and many of the techniques developed are generic and can be applied across many other disciplines.

Regionally, the White Rose Universities have considerable strength in materials, with expertise in liquid crystals at York, polymers at Sheffield, and soft matter physics at Leeds.

ii) Are there appropriate levels of knowledge exchange between the materials community and other disciplines? What are the main barriers to effective knowledge and information flow and how can they be overcome?

There are good levels of knowledge exchange between the materials community and other disciplines when there is an established community and where funding is available. The culture in the UK may be a barrier to this and the RAE in particular may damage it further.

The approach to materials research in the UK is very multidisciplinary, possibly as a result of the low numbers of materials departments. There is considerable collaboration between, for example, chemistry and physics departments in UK Universities in this area, but there is perceived to be a lack of large scale grants.

There is an opportunity for the EPSRC and the major scientific societies in the subject area to work together to run and fund broad interest symposia.

iii) What evidence is there to demonstrate the influence that the EPSRC programme has had in encouraging multidisciplinary research?

Data from the EPSRC grant portfolio should provide a strong indication as to the success of their efforts to encourage multidisciplinary research. There is a perception that the culture is moving in the right direction, and schemes such as Supergen encourage this process.

Chemistry will be vital to research breakthroughs in the area of materials in the future. The bulk properties of materials depend on interfaces or domains, and those scientists with the knowledge to understand and skills to manipulate these interfaces are chemists.

C. What is the level of knowledge exchange between the research base and industry that is of benefit to both sides?

i) What is the flow of trained people between industry and the research base and vice versa? Is this sufficient and how does it compare with international norms?

The UK is perceived to be doing well in this regard and, encouragingly, things are getting even better. Schemes such as CASE and Knowledge Transfer Partnerships (KTPs) are crucial to this success.

It is as yet unknown as to what extent the introduction of full economic costing could have on these collaborative schemes, and this needs to be monitored.

ii) How robust are the relationships between UK academia and industry both nationally and internationally and how can these be improved?

In some areas of the materials community the relationship between academia and industry is very robust. An example of this would be the influence of Rolls Royce on the development of the EPSRC. However, on the whole it does remain patchy.

In some cases there is a very strong academic research base that is not matched by a strong industrial sector. This includes superconductivity, microporous solids and photovoltaics. In the latter, the main interest comes from Japanese companies with bases in Europe (e.g. EDF).

Academics working in areas key to large companies, such as IBM or Rolls Royce, will thrive. However, the focusing of new technologies in small businesses combined with the government's emphasis on large companies means that other scientific areas can suffer from a lack of representation. Contrastingly, in Germany the presence of large companies working in the materials sector, such as BASF, Bayer and Degussa, means that Government has to listen to them and so the sector flourishes. In the UK, mergers and the rising number of SMEs creates an inhomogeneous sector and, as a result, organisations such as the RSC, Society of Chemical Industry (SCI) and the Chemical Industries Association (CIA) become increasingly important. The success of bioscience SMEs in the UK has been helped by the presence of large pharmaceutical companies providing representation of the sector.

iii) To what extent does the materials community take advantage of EPSRC schemes to enable this knowledge exchange? Is there more that could be done to encourage knowledge transfer?

See answer to C (i)

iv) What is the scale of industrial R&D in materials nationally and internationally and what is the trend? What are the implications for the UK materials research community and to what extent is it well-positioned to respond? Is there any way that its position could be improved?

With regards to fundamental materials research in the UK the scale of industrial efforts is declining. Internationally, it is growing well in some areas. Globalisation appears to be very 'one way' for the UK chemistry and materials industry. The takeover of Rover, for example, is likely to lead to R&D being based overseas, not in the UK. The movement of research efforts to countries of ownership is having an increasingly negative impact on industry in the UK as a result of foreign takeovers and mergers.

D. To what extent is the UK Materials research activity focussed to benefit the UK economy and global competitiveness?

i) *What are the major innovations in the materials area, current and emerging, which are benefiting the UK? Which of these include a significant contribution from UK research?*

ii) *How successful has the UK materials community (academic and industrial) been at innovation? What are the barriers to successful innovation in materials in the UK and how can these be overcome?*

The UK still carries out cutting edge fundamental research. It is not focused to benefit the UK economy, but is more often exploited by multinational companies to the benefit of the global economy. An example of this is the development of liquid crystals at Hull University, which has since been exploited overseas.

A recent, high profile example is the recent acquisition of CDT Ltd by Shimimoto Chemicals, Japan. CDT's technology was developed in the UK at the University of Cambridge and is based on organic light emitting diodes (OLEDs). This market is growing rapidly and will have a large influence on lighting and energy consumption.

An exception to this is in the pharmaceutical sector where there is an acceptance of a 20 year pay back period; more commonly, investors are looking for 5 years.

There has been a increase in the number of successful spin out companies from University departments compared to Europe, indicating that innovative technology can be taken from the laboratory to the commercial stage.

E. ***To what extent is the UK able to attract talented young scientists and engineers into materials research? Is there evidence that they are being nurtured and supported at every stage of their career?***

i) *Are the numbers of graduates (at first and higher degree level) sufficient to maintain the UK research base in this area? Is there sufficient demand from undergraduates to become engaged in materials research? How does this compare with the experience in other countries?*

The numbers of undergraduates entering materials courses is small, however there is a good supply of graduates from related disciplines, such as chemistry and physics. On the whole the numbers entering materials research is healthy, although one concern is the lack of employment opportunities resulting from a weak industrial base.

ii) *How effective are public engagement activities aimed at attracting school age students into materials?*

Public engagement activities should be aimed at getting school age students interested in science in general, and not necessarily at such a specific level as materials. One example of a materials based public engagement event was the high profile Royal Institution Christmas lectures from Professor Tony Ryan of the University of Sheffield.

F. ***To what extent are UK researchers engaged in "best with best" science-driven international interactions?***

i) What is the nature and extent of engagement between the UK and Europe, USA, China and India respectively.

ii) How effective is the engagement between the UK and the rest of the world? Are there particular issues for the materials research area? What could be done to improve international interactions?

UK researchers do engage well with both Europe, although concerns over bureaucracy and poor administration within these programmes still persevere.

Outside of Europe there are good interactions with the USA and Japan, although funding can often be more difficult to obtain than within Europe. With regards to the US, collaborations can be one-sided simply as a result of scale and funding.

Collaborations with other parts of the world, such as China, are growing, but there can be difficulties. The RSC and the Royal Society, amongst others, have initiatives in place to enhance collaboration between UK and overseas (non-EU) scientists.

The EPSRC has been very supportive towards international collaboration both within and outside of the EU.

G. What is the impact on a global scale of the UK Materials research community both in terms of research quality and the profile of researchers?

i) Is the UK the international leader in materials research? In which areas? What contributes to the UK strength and what are the recommendations for continued strength?

The UK materials research community is still highly influential, although not an international leader. There are pockets of research in which the UK is internationally recognised, including, for example, lithium ion batteries, materials modelling and polymer technology.

iii) What are the opportunities/threats for the future?

A significant threat to materials research in the UK is the continual acquisition of UK industry by overseas companies, leading to a decline in the UK industrial research base.

There is an opportunity to develop materials to ensure energy security, supplies and efficiency, although the number of targeted programmes must be balanced with sufficient funding for fundamental, basic research.

H. What evidence is there to support the existence of a creative and adventurous research base and portfolio?

i) Is the current balance between high-risk/high-return research and "safe research" appropriate?

The term ‘safe research’ is both unclear in meaning and inappropriate. A clearer boundary could be drawn between incremental research and high risk research.

The EPSRC does support adventurous research in materials science in the UK, but these are often small initiatives centred on selected research groups. There is a need to have both incremental research and high risk research, and the correct balance needs to be attained.

Fundamental research needs protection, but by supporting too much high risk research then there is a risk of having a succession of short term projects.

ii) What are the barriers to more "adventurous research" and how can they be overcome?

The barriers to high quality materials research are not specific to this field, but generic to the physical sciences. There needs to be a decrease in the complexity of obtaining funding for adventurous research and a reduction in the time taken for funds to be obtained. A perception of the research councils remaining risk adverse, in some areas more than other, still remains. More adventurous research could be carried out under the Platform grants scheme, whereby successful research groups could obtain longer term funding.