EPSRC Engineering and Physical Sciences Research Council

ICT Programme Theme Day
Electronic Materials and Devices

Wednesday 24th May 2009
Met Hotel, Leeds

Executive Summary

This workshop, the third in a series of five being organised by the ICT programme for EPSRC was attended by 26 members of the UK Electronic Materials and Devices Community. Delegates were invited as being leading researchers in the EPSRC portfolio with additional invitations made to industry. This series of workshops are aimed at providing baseline knowledge for the programme on the community's view of the research portfolio in the UK and will feed directly into programme strategy in the coming years. Key messages and observations taken from this particular workshop are:

Perceptions:

- The international profile of the research was felt to be strong with 86% of respondents either agreeing or strongly agreeing with this statement
- The contribution of the research portfolio to socio-economic issues was also felt to be strong with 67% of respondent agreeing or strongly agreeing with this statement
- Looking forwards, respondents were less enthusiastic with around 61% agreeing or strongly agreeing that area has a bright future and only 33% agreeing or strongly agreeing that the future research leadership is in a strong position
- Only 11% of respondents agree or strongly agree that the area's researchers are sufficiently resourced

It is acknowledged that this portfolio covers distinct research communities, a more complete description and breakdown by area can be found in the report.

SWOT Analysis

- Key strengths of this portfolio were captured as being a very strong academic community with good international links and representation. The links between the design and devices communities are strong and are continuing to develop while the common vision/grand challenges within each community are also having a positive impact on the respective communities.
- Weaknesses identified include the lack of a national strategy for Electronics, perhaps contributing to a low public and political profile. The loss of major UK industry was also highlighted as having an impact of the academic research landscape, with high levels of SMEs resulting in a fragmented industrial community and lower levels of R&D spend.
- Opportunities identified by the separate groups as their most important were raising the profile of Electronics at all levels (public, schools, undergraduate, postgraduate and government); community building – bringing the design and devices communities closer together, while also looking outwards to higher level global challenges (energy, healthcare, digital economy); the creation of a nano-processing facility for technology

Matthew Ball
Senior Sector Manager, Electronics

demonstration and whether more can be done to improve the exploitation of Electronics research outputs.

- The primary threats to the health of the discipline in the UK that were identified included long term funding for the area – what effect the current economic crisis would have on funding for UK science in general and whether this would further impact on the UK's ability to remain competitive with, for example, the Far East, where large scale investments are being made. Related to this was a concern that reliance on overseas students who often return home soon after completion of their PhD, meant that the UK was exporting expertise, often to direct competitors. The low profile of Electronics as an entity in its own right was also a key threat identified.

Conclusions and Next Steps

The outputs from all of the theme days across the ICT portfolio will be collated and common issues identified. Potential future actions to address these issues will, where appropriate, be considered by the ICT programme. The reports from all workshops will be published alongside an overall response to the issues raised.

For this particular workshop, shortly after the event, the design and device communities began working together on a Network proposal to EPSRC that will bring the communities closer together. EPSRC will seek to engage with this activity and seek opportunities to work with the community in developing and supporting activities that have been identified from this workshop.

Electronic Materials and Devices Theme Day

The ICT programme organised a series of theme days for each of the sub programme areas across its portfolio. The theme days are part of an on going community engagement strategy and aimed to provide baseline information and achieve a consistent view of the research landscape in order to inform future strategy for the programme. Three of the four exercises were common to all theme days with the final afternoon session being individual to a particular community. The exercises consisted of the completion of a Perceptions Chart, answers to general questions pertaining to research funding, a SWOT analysis of the area and an examination of the ways in which Electronics research can provide impact in the different sub categories of the research council definition of economic impact. The outputs from each session are presented below:

Perceptions of UK Electronics Research

In this exercise, the delegates of the workshop were invited to provide their perception of how their area of research measures up to different criteria. The topics represent the different areas of research covered by the Electronics portfolio and delegates were asked to provide votes against criteria that match those used in the wider EPSRC landscape documents published on the website.

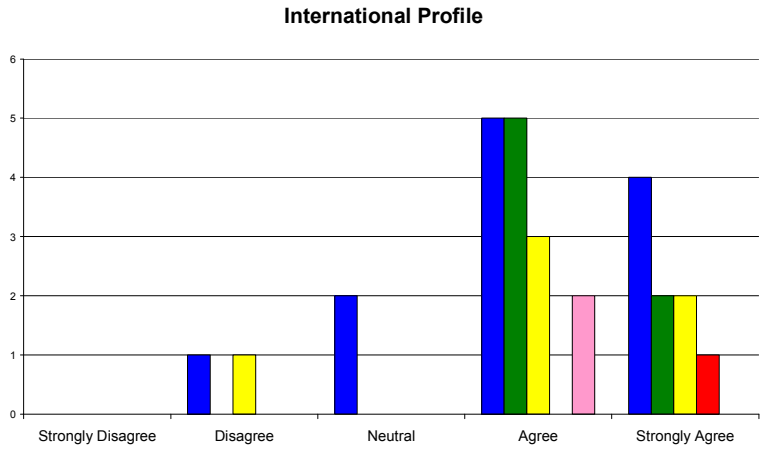
Electronic Devices and Subsystems

Parallel Computing

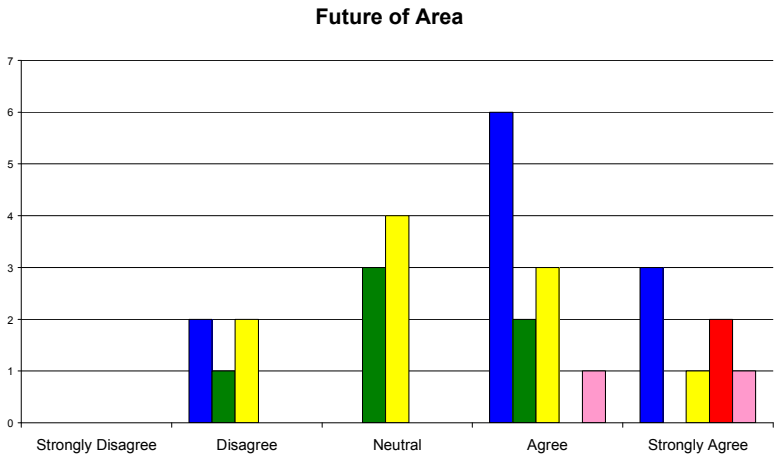
Systems on a Chip

VLSI Design

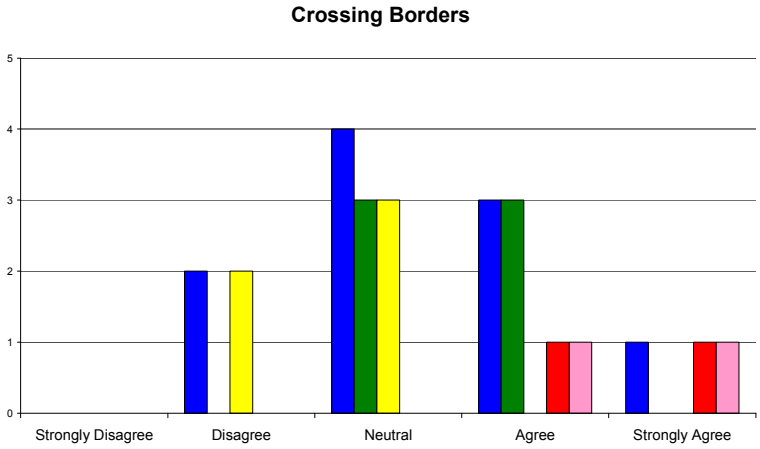
Bioelectronic Devices



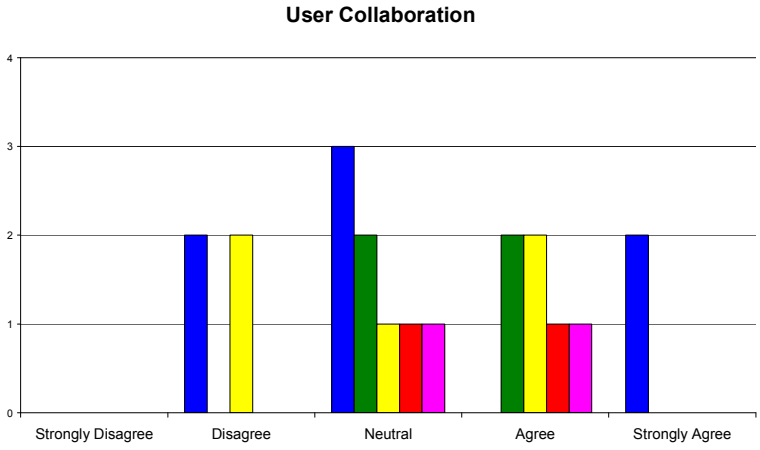
The research area is of high international standard, with researchers collaborating extensively internationally and the researchers are recognised as world leaders.



Research area has a bright future, with plenty of novel and adventurous research and without areas of stagnation.

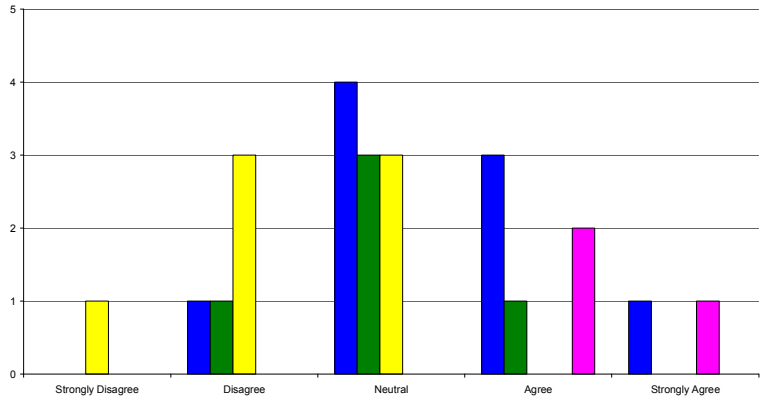


Research area crosses borders between disciplines where necessary, as evidenced by many multi-disciplinary projects and good engagement with other research councils.



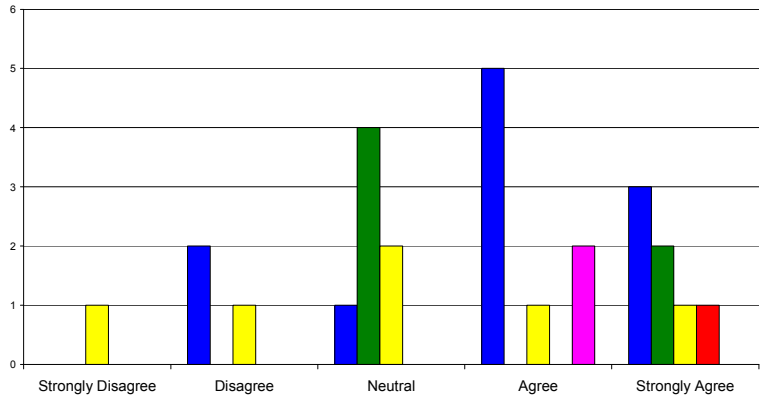
The level of collaboration and two-way knowledge flow with users, both in terms of quantity and quality is sufficient to assure that the knowledge generated makes a difference.

Future Research Leadership



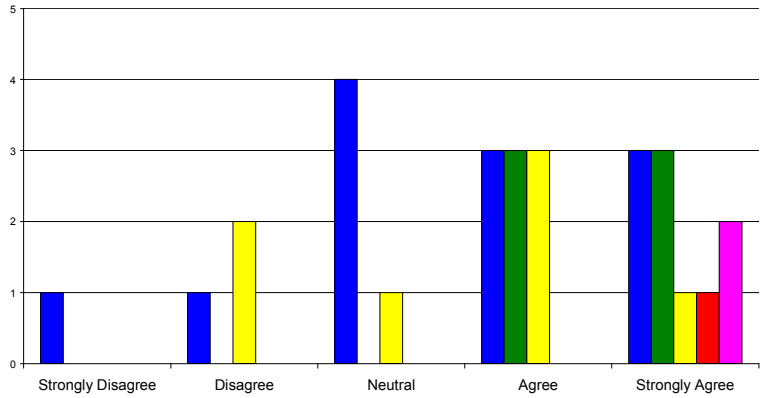
There is a rising generation of future research leaders in this area, suitable to ensure its future development, evidenced by numbers of Career Acceleration/ Postdoctoral Fellows, First Grants, etc.

Creativity and Adventure

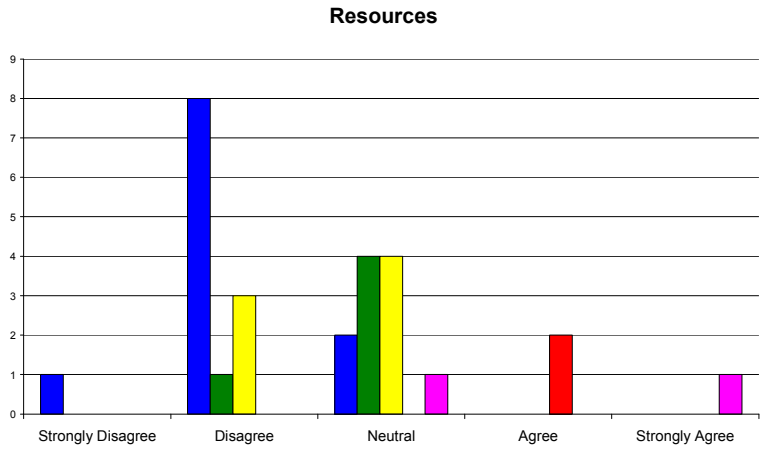


Research area is highly creative and adventurous with potential to lead to a step change, resulting in new areas of research.

Socio-Economic Benefits



Research area is addressing topics of potential value to both UK society and the UK economy and will increase the global competitiveness of the UK.



Researchers in this area are sufficiently resourced in terms of facilities, equipment and availability of non-EPSRC funding, ensuring maximum leverage of EPSRC funds.

SWOT Analysis of UK Electronics Research

The objective of this exercise was to seek the views of the community on the key Strengths, Weaknesses, Opportunities and Threats of particular relevance to the Electronics community. EPSRC will then look across the ICT portfolio to identify common issues from the different Theme Days where there is a need for intervention or to work with communities to build on strengths, exploit opportunities and seek to address weaknesses and threats.

STRENGTHS

There was a consistent view that the UK academic community was strong in Electronics. There were various "pockets of excellence" identified which contain world class groups in both the design and technology areas with excellent links into a strong physics community which underpins a lot of the device activity. The international links were thought to be strong with good representation in Europe with the some members of the community playing a leading role in representing the UK's interests. The high levels of peer reviewed funding currently being held by this community is thought to be evidence of the high levels of innovation and standing both in Europe and beyond. The industrial Electronics design community is very strong globally and is a key strength for the UK. There is a vibrant SME base in the Electronics sector with the UK being especially strong in niche areas. A notable strength of this portfolio is the level of interaction and sharing of vision between the design and technology communities.

WEAKNESSES

A strong theme across the groups during this process was the lack of a clear national strategy for Electronics, with no professional institute to represent it at a policy level. This perhaps contributes to the sense that Electronics has a low profile, both politically and publicly, illustrated by a lack of top-down government intervention and low numbers of people feeding the skills supply chain. A feature of the industrial landscape is that major Electronics manufacturing has been lost from the UK and, although Electronics design is strong, the high levels of SMEs in both the technology and design sectors results in a fragmented community, weak supply chain, low levels of exploitation and overall, low levels of research spend by industry. It was observed that the overall levels of funding for UK Electronics was not sufficient to maintain the volume of research necessary to make significant impacts with the lack of national labs perceived as contributing to this.

OPPORTUNITIES

There was a strong message from the opportunities session that there are potentially large gains to be made from this community reaching out to other disciplines within and without the traditional ICT subjects. Specifically mentioned was the potential to improve links with theoretical computer science and communications disciplines (while also building on good links with the biological communities) with the recommendation that funding be directed towards activities that promote this. In this way, Electronics can contribute strongly to the ICT research agenda and ICT research can then contribute strongly to global issues for example, in the energy domain. In a similar way, the More than Moore agenda (i.e. diversifying technologies to improve performance) was seen as a particularly good opportunity for making impact. More generally, there was an opportunity highlighted to maintain and further links into Europe and to build links with China. There was a view that more could be done to capitalise on the vibrant SME base in the UK with opportunities for better methods of engaging with this potential route to exploitation, while the presence of world leading design houses (e.g. ARM, Wolfson, CSR) is also seen as an opportunity that should not be missed.

Of these opportunities, those chosen by each group as being the most important for the community to consider were:

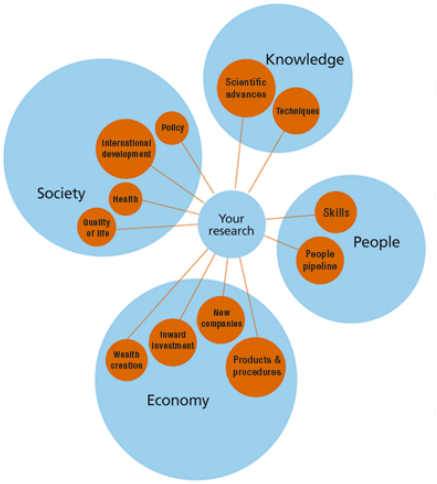
- Better Exploitation – there is a need to engage better with SMEs in this space and to somehow unify the domestic Electronics industry
- Nano-processing Facilities – this is a key enabling step between physics and semiconductor research and is essential for technology demonstration
- Green Agenda – how can Electronics contribute to this? This could help to attract a new generation of young scientists for whom sustainability is an issue. Other societal challenges should also be considered, for example Energy, Digital Economy and Healthcare.
- Raising the profile of Electronics – there needs to be some strong public engagement to achieve this. It needs to be done at all levels – public, school, undergraduate, postgraduate and government
- Community Building – bring the design and technology communities closer together and look wider to other communities. Look for true vertical integration.
- Network – build and network to incorporate the Electronics areas, build leadership roles, coordinate research and speak with a common voice into the EU. This would also help build critical mass and have make a contribution to raising the profile of Electronics.

THREATS

A key threat identified to the portfolio was funding. The economic downturn was thought to have potential implications for the overall levels of government funding across the UK and could potentially result in reductions in industrial funding for research and development which will result in lower levels of collaboration. Competition from overseas was the other main threat identified. With large scale investments in Electronics, especially in the Far East, being made, there is thought to be a threat that the UK will fall behind. For skills, a principle threat identified was the potential loss of the cap for student fees as this may well impact strongly on engineering disciplines as the perceived career benefits are lower than for other areas (e.g. Law, Finance). Additionally, a reliance on overseas students for PhD places contributes to a perceived loss of expertise; most likely directly supporting our main competitors. A lower level of funding for Industrial Doctoral Training Centres of direct impact in Electronics was also seen as a long term threat to the area. Finally the poor public perception of Electronics research was a threat as it has direct impact of the take up of the related disciplines and also diminishes the political profile.

Electronics and Impact

With the introduction of the impact statement for all submissions to EPSRC and the ongoing need for research councils to be able to demonstrate the impact of the research they fund, this session was intended to provide the community the opportunity to discuss the wider research council definition of impact (see schematic below) and how Electronics can contribute to each of the sub-categories.



IMPACT ON SOCIETY

Public engagement/education:
- who is the best person to do this?
- schools
- general interest publications
- engaging with professional bodies, e.g. IET and BCS

Social inclusion:
- who is the best person to do this?
- what level is appropriate?
- well educated people
- regeneration

Electronics is pervasive but unnoticed and undervalued

Low power contribution to sustainability – potential for huge impact

Healthcare:
- sensors
- monitoring

Agri-electronics

Counter-terrorism and security

Culture change
- scientific/mathematical literacy & transferable skills

Information provision

Policy – difficult to influence individually, better at community level

Efficiency/green issues
- environment
- health
- lead to better computer architecture

IMPACT ON KNOWLEDGE

New computer architectures and paradigms
Design characterisation
Enabling technologies for fabrication
Novel device concepts
Impact into other industries (material – chemical)
Design tools
Bioelectronics – health/neuro (bio-inspired)
Communications
Finance and High Performance Computing
Education of overseas students (knowledge creation and reputation of UK)
Design – benefitting from UK knowledge
Increasing UK representation (being first to know something)
Timescales depend on competition
Techniques – how to do things
Developing new disciplines via electronics
Linking to new disciplines (complexity)
Providing combination of disciplines
Electronics and Sustainability
Producing a new device
Understanding how the brain works
Value of establishing a 'knowledge base' geographic ecosystem to support research
Sustained knowledge through research (more than what you just publish)
World competitiveness
Design tools techniques (methods) – IP value
Fundamental understanding of how things behave
Knowing with a purpose – applying that knowledge
Need people to understand
Combining knowledge with expertise
Commodity in its own right
Spreading knowledge through people

IMPACT ON PEOPLE

Ability to think for themselves
Planning and delivery
More opportunities for training and development
Self motivation from an education point of view
Role models
People pipeline – STEM skills
Creativity and problem solving
Bringing research into teaching
Transferable skills
Entrepreneurial skills
Exposure to multidisciplinary activities resulting in networking between groups
International students become ambassadors for UK
Density of skills – creates inward investment
Specific skill base
Improved quality of life
Reduced cost of living
Training and up-skilling
Electronics impacts directly in everything – peoples lives improve hopefully directly

IMPACT ON THE ECONOMY

Address a market need – who would be end user
Point out drawbacks of existing technology where research may replace
State of art or competition – who benchmarking against when making claims
Quantification of estimates
Access to facilities
S-curve – is your proposed technology on upwards trajectory while current is flattening out?
Density for skills/capabilities
Are you feeding into an established chain at multiple points?
Need a credible path between science and application that can be visualised
Need to choose the correct place where it can have impact (which may not be the obvious one)
If you claim something then this has to be credible, but not a problem if you can't make a claim
Can create wealth
More efficient electronics – has a cost associated
Enabling something else to happen
Creates new industry (or could do)
Spin-outs
Free IP
Spin-ins
Exploitation route – who to talk to or who to take it to
As reviewers, looking for more than "motherhood and apple pie"
Inward investment
Create jobs
Capabilities – ability to do something
Educate society on technology
Licensing IP
Understand where you are in technology pipe
Capability magnet – attracts companies etc
Standards

Wider Issues
The purpose of this first session was to pose general questions that are common issues across the ICT portfolio and where a broad view from the communities within ICT would be useful. The set of questions was identical for all five of the sub-programme theme days.

1. ***What would you expect to see in a CV for an internationally leading group?***
   Good publications
   International industrial collaboration
   Funding – well resourced
   Awards & esteem (e.g. Medals, Fellowships, FRS)
   Good references
   Critical mass
   International links (especially EU)
   Highly qualified graduates
   High profile young researchers
   Unique capability/strength
   Commercialisation links
   Excellent infrastructure (e.g. equipment/facilities)

2. ***What is the exploitation by industry like in your area? Is this an issue?***
   Yes, but it has been like this for decades
   Critical that IP protection is in place – but it can kill the research too
   Consider spin outs – cannot do this and still be active academic
   No UK volume manufacture
   Good exploitation in some areas but not always in the UK
   Research is approximately 10% of bringing product to marketplace – need better funding for the pipeline post research
   In Electronics we need a mid range facility for nano-processing
   Lack of government support for industry means many lack R&D culture
   Time lag – difficult to get continuity between research and exploitation

3. ***What metrics should be used to measure research quality***
   Delay assessment – need time to assess impact
   Keynotes/invited talks
   Peer reviewed papers – quantitative impact factor, Bibliometrics
   Patents
   Spin-outs
   Economic impact assessment – review by industry, should contribute to inward investment
   Destinations of researchers
   Contribution to RAE
   Flow of good people
   Researcher esteem
   Citations
   Review of exploitation potential (annual) with the objective of identification of trends and establishment of appropriate research/industrial relationships

4. ***How can we identify and sustain young/new talent in ICT?***
   Reduce impact of RAE on younger staff
   Fellowships
   Improve perception of ICT
   Comparative bibliometrics (c.f. physics/chemistry) – important when assessed together, e.g. fellowships

A package for new faculty
First grants don't work
A sense of opportunity
Support – Funding and belief, culture, enthusiasm & knowledge
Brilliant/charismatic leaders
Pipeline all the way back to school
We need more undergrads in ICT
Successful projects deliver successful RAs
Track RAs

5. Where do you think the competition is globally in your research area?

EPFL
Taiwan for Moore's Law research – System on Chip – 200 new lecturers
UK
US: Berkeley, Stanford, Virginia Tech
Spain: Barcelona, Torino
Canada: University of Technology, UBC
China
Korea
IMEC
LETI
Ireland

6. What would you expect to see in a good first grant?

Realistic but imaginative
Build on a track record
Naivety
Good planning
Strong institutional support and mentoring
High potential – either on person or idea
New ideas
Strong mentor input

7. What would you expect to see in a CV for an internationally-leading researcher?

High quality publications - citations of papers
Invited talks
FREng/FRS
International collaborators on projects
External impact beyond personal boundary of individual
Participation
Established a large research group – PostDocs and PhD
Capacity to attract research funding
Paradigm shifts in a field, i.e. set directions
Cross disciplinary research
Participation in an internationally pre-eminent research team

8. What is the next quantum leap for research in your area?

Bioelectronic interface
Convergence of technology simulation and design
Understanding the brain
Strong AI
Beyond Moore's law
For Electronics to emerge from consumer and defence technologies
Are all new technologies beyond CMOS a quantum leap?
Determining the most appropriate level of abstraction to represent design and understand complex systems, e.g. biological inspired systems

General purpose adaptive parallel machines
Cognitive and adaptive hardware
Functional systems on imperfect components

9. What is your perception of multidisciplinary working?

Can be fun to learn about another discipline
Can lead to poor work on both/all sides
Hard to do state of the art work in your own discipline
Can lead to new insights and inspiration – pay-offs can be big
Increased prospects for genuine creativity and novelty
Cannot be forced
Needs solid expert from each discipline
Not one person trying to straddle disciplines
The future of Electronics is multidisciplinary projects/applications
How does one find the right people?
Too many meetings when partners are in other institutions
Long lead time and risk
Funding problems – referees from <u>each</u> area must sign up
Needs massive underpinning of infrastructure
Takes time to understand each others language
Difficult for early to mid career researchers
Managing the process is key; tools for managing context are not context vital
Must be made to work
Petty administration issues must be overcome

10. Of all our funding mechanisms (fellowships, first grants, platform grants, networks) which do you think are most effective and which needs to be encouraged more?

First grants:
- don't work very well
- often not good enough
- PIs who are strong can get responsive mode anyway
- need mentoring – experienced CoI should be obligatory
- doesn't lead automatically to successful academic career

Fellowships are good (if you can get one…)
Networks very effective for informing strategy
How cost effective are fellowships?
They are different – with different strengths and drawbacks
Should be more International collaboration schemes
Platform Grants:
- more
- bigger value

Baseline funding for world-leading research essential
EngDs are a great loss in this area
Studentships – most RFs are a waste of money
Need to be able to use DTA funding for international students. We want the <u>best</u> students

11. What should the balance be between fundamental/applied, hardware, software research in the ICT programme?

Fundamental populated by smaller grants?
2 year grants for new ideas
Foremost, quality must be the over-riding criteria
Should be demand and quality driven – find excellence where it may be found
Less materials/device work unless clear exploitation route

Universities should focus on basic research and be dragged into applied research by enthusiastic researchers
EPSRC is in a unique position to fund fundamental research but applied research should be funded when alternative mechanisms are demonstrably unavailable

12. What are the barriers to international collaboration?

UK companies – too few
No UK way to prove concept e.g. nano fab
Perceptions about external/overseas exploitation
Time – balancing research and teaching
Few effective funding mechanisms – except EU
Few mechanisms for identifying partners (networking)
Too big a carbon footprint (and travel inconvenience)
Double jeopardy (on joint funding)
National funding policies and regional concerns
National and regional issues will have an international solution so it is impossible to find these by looking only at local opportunities

Appendix 1 – Objectives and Agenda

Objectives

- Bring together the research community covering Electronic Materials, Devices and Design in order promote dialogue and a constructive relationship with EPSRC
- Gather and exchange views on the health of the discipline in the UK and explore upcoming opportunities and threats for the area
- Stimulate discussion about innovative approaches to further raise the profile of Electronics research in the UK
- Feed into a future strategy for the ICT programme

10:00 Registration & Coffee
Delegates are encouraged to complete the "Perceptions of UK Electronics Research" poster over coffee.
10:30 Welcome
10:40 Introduction to the ICT Programme
11:00 Plenary Session 1: Wider Issues
Delegates will be asked to consider a number of general questions relating to ICT/EPSRC funding and policy in small groups.
11:45 Plenary Session 2: Open Q&A
Your chance to ask the ICT team any questions that you have.
12:30 Lunch
13:15 Breakout Session 1: Analysis of UK Electronics Research
Delegates will break out into small groups to provide a Strengths, Weaknesses, Opportunities & Threats analysis of the UK Electronics research.
14:20 Plenary Session 2: Feedback and Discussion of Opportunities
Groups will feedback their key opportunities for the community with time for discussion.
14:50 Coffee Break
15:05 Breakout Session 2: Impact and Electronics
Delegates will breakout into small groups to explore how Electronics research contributes to the broad impact agenda (Economy, People, Society & Knowledge) and identify opportunities.
16:20 Wrap Up and Finish

Appendix 2 – Delegate List

Bashir	Al-Ashimi	University of Southampton
Mervyn	Armstrong	Queens University Belfast
Asen	Asenov	University of Glasgow
Andrew	Brown	University of Southampton
George	Constantinides	Imperial College London
David	Cumming	University of Glasgow
Zahid	Durrani	Imperial College
Kristel	Fobelets	Imperial College London
Steve	Furber	University of Manchester
Steve	Hall	University of Liverpool
Bruce	Hamilton	University of Manchester
Paul	Harrison	University of Leeds
Peter	Ivey	Innotec
Michael	Lancaster	University of Birmingham
Steve	McLaughlin	University of Edinburgh
David	McNeill	Queens University Belfast
Anthony	O'Neil	Newcastle University
Evan	Parker	University of Warwick
Ian	Phillips	ARM Ltd
Ian	Robertson	University of Leeds
Luke	Seed	University of Sheffield
Iain	Thayne	University of Glasgow
Ian	Underwood	University of Edinburgh
Roger	Webb	University of Surrey
Roger	Woods	Queens University Belfast
Fei	Xia	University of Newcastle