

Creating an Innovation Pipeline for Compound Semiconductors in the UK

9th February 2022

Round-Table Discussion

A meeting of the compound semiconductor research and development community in the UK was held on 9th February 2022, to map out the significant resources available to the community and to raise visibility of the infrastructure, mechanisms and support available to create a world-class innovation pipeline, developing research from the laboratory to manufacturing and commercialisation.

Following a comprehensive programme of presentations, the meeting concluded with a round-table discussion with contributors from industry, academia, funding and professional bodies to identify needs and opportunities to facilitate successful innovation. Issues addressed were as follows:

Gaps in the innovation landscape

Do we have the things we need to help innovation happen?

What is out there that is under-used, and what do we need that is missing?

Do we need more infrastructure and facilities?

- A gap exists between materials discovery and reproducibility during the scale-up process: there is access to instruments for small-scale characterisation but the facilities for examining multiple samples or uniformity of samples on a large wafer scale is less common. As well as access to equipment, having researchers and manufacturing/engineering together is important to stimulate innovation culture. This requires interfacing existing facilities into industry and building a culture where research is carried out with a mind towards exploitation of that research. Leadership is key to building that culture, and we need more mechanisms of coordination and the establishment of a network of academic excellence, coordination in both industry and government so that BEIS, DCMS and UKRI have a common understanding of UK capabilities, strategic priorities and industry position. Role models and examples of best practice will also promote further innovation. Also, there is a need to consider leadership and entrepreneurship and how to promote and provide resources for this.
- Pump-priming schemes are also important to improve the growth of innovation, and support is required for the filing and maintaining of IP and exploitation of IP from universities.
- It was also noted that innovation is international, involving public-private partnerships. For example, the first IPCEI (Important Project of Common European Interest) on microelectronics includes 10 companies with 4 based in the UK in the compound semiconductor chapter. Companies in France, Germany and Italy have national funding for first industrial deployment.

- There is a gap in the UK at the top TRL levels to de-risk the last steps into commercialisation, for funding research at pilot-line level (TRL 6-8) and for investigating issues of reproducibility, reliability and uniformity. The UK is no longer supporting IPCEI with national funding, so UK companies are not involved in related projects addressing these issues.
- During the meeting, good examples of the capabilities which already exist in the community and can be built upon were identified. However, the government needs to be able to recognise and support significant opportunities or challenges when they arise. A recent example is the policy alignment and government investment in the Quantum Technologies Strategy. Exploiting opportunities of scale in the UK (or for them to move/grow in the UK) may require investment of >£100m and these opportunities need to be identified from high-TRL, 'customer' focussed input as well as building capability.
- The expectations concerning the timescale for return on investment, both in terms of government expectations for economic impact and from industry to academic partners, were also raised. Mechanisms for strong community engagement to increase clarity on this issue is needed.
- Another area to be addressed is the relationship between the demand from larger industry for investment in fabrication at scale (going up to for example 8" wafer size) and what is required by SMEs for sustainable business growth. How will large-scale fabrication capabilities are also utilised for the demands of small business and their development?
- Although many compound semiconductors are relatively mature materials, research involves new device configurations and heterogeneous integration – the focus on reliability and reproducibility becomes even more important in these cases. Compound semiconductors do not typically have a high volume manufacturing application comparable to silicon transistors, so the focus on specialised areas is important and this impacts on considerations of required wafer sizes, scale of plant, etc. It is also the source of opportunities with seeding of investments in a portfolio of areas leading to a diversified market share. More value can be extracted from the supply chains enabled by semiconductor technologies; especially as integration and miniaturisation becomes more important. There is a place for high-value, diversified manufacturing to exploit IP in compound semiconductors.
- Co-ordination between the related areas of compound semiconductors, photonics and quantum technologies was also discussed. Each of these have their separate themes and focuses, so how do we step-up the networks between these areas? Possibilities could include government intervention to create semiconductor innovation zones focussing on subject areas including photonics, rf, power, quantum etc., with incentives for start-ups to feed into the levelling-up agenda.
- Concern was also raised for support for existing facilities and infrastructure (including those outlined today), and how to refresh and update these. Currently this is done by a piecemeal approach, but needs to be done in a more a strategically coordinated fashion.
- Training, particularly for PhD students, can be difficult to fund: current compound semiconductors research often uses large, expensive equipment and use of this equipment for training purposes cannot be directly funded by a typical PhD project training budget. This risks the pipeline of future leaders. TRAC funding restricts cross-subsidising, adding further difficulties for funding process for PhD projects. A coordinated response to this including beyond CDT mechanisms should be examined.

Government intervention: what is needed?

If the government were to make a new investment in compound semiconductors, what would be asked for? Are we hearing a great enough range of viewpoints in this discussion?

- It was recognised that the ambitions of the community need alignment with government priorities and national needs, including the importance of addressing government narratives of security and prosperity in a strategic case. It was noted that while an innovation system may be built around multi-technology platform challenges (e.g. net zero, transforming construction, Industrial Strategy Challenge Funding), the UKRI funding structure at research council level is usually looking at a single application/single material system. A change of perspective is needed to look at semiconductors as a platform rather than a collection of isolated materials and technologies.
- The market opportunity for compound semiconductors is huge and well-established for 40+ years, with a market value of 50-100 billion (over materials, devices and systems), large market segmentation, and growing with CAGR of ~11% p.a. As well as the established markets, we need to consider areas of growth not yet predicted, as compound semiconductors can be a disruptive technology. The business case for compound semiconductors exists and there is a well-established, globally-respected UK research base and a level of coordination to make linkages between that research base and accelerated commercialisation.
- The UK compound semiconductors community does not need the massive £multi-billion price-tag investment that would be required for e.g. silicon microprocessors, and we need to challenge the perception outside the community that massive investment is needed. Rather, it needs additions to existing manufacturing and innovation landscape with a sector-level intervention, addressing leadership, research, scale-up, skills and international marketing.
- There is an appetite and recognition of the opportunity at government level and with MPs, and there will be competition between nations to grab these opportunities. UK market opportunities including helping supply chain to other sectors (e.g. automotive), and national security considerations. The sector could be aided by government procurement policy, to ensure procurement from UK companies, and also leveraging procurement policy to ensure training and diversity standards.
- It was suggested to define funding missions with a definite objective within a set timescale (e.g. X% share of a global market by Y date), requiring the requested investment to achieve it. With the head of the Advanced Research and Intervention Agency (ARIA) now appointed, it is also useful to look to aims of that agency as a possible avenue for funding. We already have good funding from government (e.g. via EPSRC) for low TRL research and the starting point for transfer to manufacturing, we need to add to this not change it.
- It was also discussed how to increase involvement from end-user representatives (e.g. from healthcare, smart cities, MOD), who are not necessarily conversant with the technology but would give more pull from the end of the supply chain. Opportunities are needed to open this dialogue and this could be a role for the Compound Semiconductors Applications Catapult and other higher TRL organisations with clear mechanisms for feeding back to the community, including those working at lower TRLs.
- Concern was raised as to whether we are we hearing from the full range of views in the community, including a full geographical spread, diverse viewpoints, and from all career

stages. Further actions to address this issue, including follow-up meetings, are being formulated.

The role of international co-operation

What should be the role of international collaboration in the UK's compound semiconductor activities? How can international co-operation bolster the UK's strengths in this area?

- The EU has announced the first detail of CHIPS act: a 15 billion uplift on existing programmes (total 43 billion) investment over 5-10 years take EU from 9% domestic manufacturing to 20%. There is an EU objective to cement European partnerships to achieve this across the supply chain: this emphasises the need to maintain good relationships in Europe.
- We need mechanisms post-Brexit to continue the quality and level of interaction, especially with European counterparts. The South Wales semiconductor cluster has also seen recent US and Asian acquisitions, giving opportunities to connect to global semiconductor players. Other examples include new emerging markets in India, and their declared intention to create their own sovereign supply chain and indigenous semiconductor industry. We need to collaborate internationally to meet the investment required to develop compound semiconductor technologies. Countries are considering trading partnerships for security of supply and for sovereign technologies or those with security implications. UK science base is highly tradeable; the government will have to decide on its partnerships and compound semiconductors are part of UK assets as a strategic capability.
- Continued dialogue with government is needed, particularly to clarify their position and seek guidance from government about their expectations of the community and industry to respond to the (sometimes conflicting) challenges to maximise market opportunities and address security concerns.

Ensuring cohesion in the community to increase the pace of innovation

Do the available facilities and support working together effectively and what can we do to improve the interactions?

What can individual organisations and the wider research community do?

What are the barriers to UK researchers using UK facilities?

- There was not time to fully address these issues during the round-table discussion but comments will continue to be collated from the delegates and follow up sessions will be organised, including during a dedicated session at the UK Semiconductors 2022 conference, to be held at Sheffield University in July 2022.