INQUIRY: the semiconductor industry in the UK

Evidence submitted to the BEIS Select Committee on Semiconductors by the Compound Semiconductor Applications Catapult, 14 June 2022

About the Compound Semiconductor Applications (CSA) Catapult

The CSA Catapult is a non-profit research and technology organisation established by Innovate UK to grow the UK economy by helping companies develop advanced electronic systems using compound semiconductors, developing sovereign supply chains where possible. Since 2018, the Catapult has initiated over £160m projects, helping companies develop electronic systems for electric vehicles, telecom networks, defence and quantum applications.

As a neutral, non-profit organisation, the CSA Catapult is ideally placed to represent the collective views of industry and academia relating to semiconductors.

Introduction

Modern products are becoming increasingly 'smart' due to the addition of intelligence and connectivity provided by semiconductors. Semiconductor devices, otherwise known as chips, are essential to the production of electric vehicles, household objects such as fridges and more complex products such as smart phones and defence systems.

These products use three types of semiconductors: silicon semiconductors, compound semiconductors and emerging technology semiconductors.

Silicon semiconductors are the most common, typically representing 70-80% of the semiconductor value of a product.

Compound semiconductors provide specialist functions such as facial recognition, 5G connectivity and power control in electric vehicles. They typically represent 10-20% of the semiconductor value of a product, depending on the product.

The third category provides display functions, representing typically 10% of the semiconductor value of a product. This category includes emerging technologies such as graphene and printed electronics.

Recent shortages have highlighted the need to consider the strategic importance of semiconductors to support UK resilience and security. This paper addresses the eight questions posed by the BEIS Select Committee on Semiconductors.

What is the current and future anticipated demand for common products built with semiconductor materials (e.g., computer chips) both in the UK and globally?

1. Global megatrends are driving demand for semiconductors to create smart products with increasing levels of intelligence and connectivity. Total semiconductor revenues in the 1980s were around $50bn, driven mostly by the PC industry. Revenues in the early 2000s rose to $140bn driven by smart phones. Revenues in 2020s are expected to reach $470bn driven by smart machines. By 2030, semiconductor revenues are expected to reach $1tr driven by artificial intelligence (AI).
2. In 2020, the global compound semiconductor market was estimated to be worth $91bn and forecast to reach $136bn by 2024. We estimate that the UK compound semiconductor

market was worth around $8bn in 2020 rising to $11bn in 2024, which is around 8% of the global market.

What is the UK's semiconductor supply chain and is this secure? If not, how can this be improved?

3. Semiconductor supply chains consist of six stages that convert raw materials into end products:

Stage 1: Raw materials are used to produce a base wafer, which is a circular crystalline disc, typically 4" (100mm) to 12" (300mm) in diameter. The UK has no companies that operate in this part of the supply chain.

Stage 2: Atomic layers of semiconductor material are deposited on the base wafer in a process known as 'epitaxial growth'. The UK has two companies that operate in this part of the supply chain.

Stage 3: The epitaxial wafer is processed under vacuum to implant hundreds or thousands of individual chips into the wafer. This stage is referred to as 'fabrication', the UK has around 25 fabrication facilities, known as 'fabs', capable of handling 6" (150mm) to 8" (200mm) diameter wafers.

Stage 4: Individual chips are removed from the wafer, and electrical contacts are added in a process known as 'microelectronic packaging'. The UK has around 20 packaging companies.

Stage 5: Chips are combined with other electronic components to form an electronic system. The UK has around 5,000 companies that design and manufacture electronic systems.

Stage 6: Electronic systems are integrated to form an end product such as an electric vehicle, a mobile phone or RADAR for defence.

4. Electronic products use three types of semiconductors: silicon semiconductors, compound semiconductors and emerging technology semiconductors.
5. Silicon semiconductors are the most common, typically representing 70-80% of the semiconductor value of a product. The UK has good design strengths, but UK fabrication is limited to older (legacy) designs pre-dating 2000. The UK has a supply chain for legacy silicon semiconductors.
6. Compound semiconductors provide specialist functions such as facial recognition, 5G connectivity and power control in electric vehicles. They typically represent 10-20% of the semiconductor value of a product. The UK has representation across the supply chain, from a robust design capability to medium scale fabrication.
7. The third category represents emerging technologies such as graphene and printed electronics. The UK has a good research base, with the potential to realise full commercialisation.
8. There are gaps in the UK's semiconductor supply chains, although no one country has a full supply chain in all three types of semiconductor material.
9. The UK's semiconductor supply chains could be improved by:

- Widening access and incentivising the UK's silicon fabrication facilities (fabs) to upgrade from older legacy processes to newer mainstream processes, to improve resilience.
- Supporting scale-up of compound semiconductor chips through an open-access foundry model across the UK.
- Pilot lines to integrate silicon and compound semiconductors to create highly functional chips that exploit UK intellectual property, supported by industrial test capability to scale-up production.
- Supporting an ecosystem for emerging semiconductor technologies.

10. In addition, there's an opportunity to identify synergies that exploit economies of scale between supply chains in different sectors, building resilience and security. For example, there are many synergies between the requirements for telecoms and defence, which often use similar semiconductor materials for different applications. There is also an opportunity to build closer links between the UK design community and UK semiconductor manufacturers, to scale-up production for global markets.

2b What specific strengths does the UK have to contribute to regional or global semiconductor supply chains?

11. Referring to the three types of semiconductors:

- Silicon: the UK has world-leading design capabilities in silicon semiconductors with companies such as ARM, Imagination and XMOS.
- Compound: the UK has world-leading research in compound semiconductors, which have received around £1bn of funding from the Engineering and Physical Research Council (EPSRC) since 2006. In addition, the UK has good design and small-scale manufacturing in compound semiconductors.
- Emerging technologies: the UK has world-leading research in emerging semiconductors, which are starting to attract private investment for production.

2c How competitive is the UK within the global context of the semiconductor industry?

12. Referring to the three types of semiconductors:

- Silicon: the UK's design is world leading. The UK's fabrication of older (pre-2000) silicon chips is highly competitive, but they are not leading-edge silicon chips.
- Compound: the UK's research is world leading. Most parts of the fabrication supply chain are competitive, although some parts are off shored to lower cost economies. The UK has a strong capability in power electronics, mainly through inward investments, and there is potential to be globally competitive in photonics integration.
- Emerging technologies: the UK has a head-start in emerging technologies (graphene, printed electronics), but full commercialisation may be some way off, and there may be uncertainties.

3. Are there opportunities for strengthening different parts of the current UK semiconductor industry? What are the potential weaknesses and strengths of the UK semiconductor industry to meet future requirements of electronic device manufacturing?

13. The UK's semiconductor industry could be strengthened through the following initiatives:

- Widening access and incentivising the UK's silicon fabs to upgrade from older legacy processes to newer mainstream processes.
- Supporting scale-up of compound semiconductor chips through a UK-wide open-access foundry model. Ideally, this would involve investments in existing UK facilities, potentially attracting inward investments.
- There is a significant opportunity to integrate silicon and compound semiconductors to create highly functional chips that deliver exceptional performance, exploiting UK strengths in design and intellectual property. This is an emerging technology that would benefit from pilot line investments, supported by industrial test capability to scale-up production, propelling the UK into leading position.
- Supporting an ecosystem of emerging semiconductor technologies.

4. In which industries does the UK not have an end-to-end semiconductor supply chain? Are there any opportunities for these supply chain gaps to be filled within the UK?

14. The UK does not have a full semiconductor supply chain in any industry, although no one country has a full semiconductor supply chain, so we are not unique in this respect.
15. To address this question, it is important to identify where value is captured in supply chains, which parts of the supply chain are addressable by UK companies, and which countries we should prioritise for collaboration.
16. For example, the UK has no base wafer manufacturing capability, as it is all imported. While this part of the supply chain is highly commoditised for silicon semiconductors, it represents one of the highest value-add stages in compound semiconductor production, particularly for gallium nitride (GaN) and silicon carbide (SiC).
17. The resilience of UK semiconductor supply chains could be strengthened through the following initiatives:

- Widening access and incentivising the UK's legacy silicon fabs to upgrade from older legacy processes to newer mainstream processes.
- Supporting scale-up of compound semiconductor chips through a UK-wide open-access foundry model.
- Investing in pilot lines to integrate silicon and compound semiconductors to create highly functional chips that deliver exceptional performance, supported by industrial test capability to scale-up production.
- Supporting an ecosystem of emerging semiconductor technologies.

5. How can the Government strengthen semiconductor research and innovation? Are there any current areas of weakness in the present Government strategy to semiconductor innovation? Is there effective communication between the various stakeholders within the UK's semiconductor ecosystem?

18. The UK Government has invested around £1bn in semiconductor research since 2006 through the Engineering and Physical Research Council (EPSRC), which has mostly funded university research. There is an opportunity to translate this academic research into commercial applications through facilities such as the Compound Semiconductor Applications Catapult. Since our inception in 2018, the CSA Catapult has initiated over £160m of industry-led commercial projects, with potential to go further.
19. In addition, we recommend further industry-led research programmes, similar to existing programmes such as Driving the Electric Revolution and Commercialising Quantum, which were run by Innovate UK and UKRI. We also recommend continued support for the Advanced Propulsion Centre (APC), supported by BEIS, which has been instrumental in helping to create UK semiconductor supply chains for automotive applications.
20. The Catapult is recognised for its central role in connecting the innovation ecosystem, linking academic excellence with industrial applications. For example, we have convened consortia involving companies and academics from every part of the compound semiconductor supply chain to create UK sourced power modules for electric vehicles. However, we recognise an opportunity to increase coordination with other stakeholders such as trade associations, bringing design and manufacturing closer together.

6. Does the UK have the required skills, talent and diversity to be able to boost its current semiconductor industry and to respond to future disruption?

21. While the UK has world leading universities specialising in semiconductors and electronic engineering, there is a severe lack of STEM (science, technology, engineering and mathematics) graduates to address an aging skills base. There is a need to attract and retain STEM students at a much earlier age. According to the Gatsby Foundation, around 12% of UK graduates are STEM compared with around 60% from the EU.
22. There is an opportunity to increase diversity in the skills base, tapping into a wider talent pool.
23. The UK Electronics Skills Foundation (UKESF) is doing an excellent job and would benefit from expansion.

7. What are the potential national security concerns or vulnerabilities in our semiconductor industry? How should the UK collaborate with the United States and European Union? What are the ramifications on other industries and the wider economy within the UK?

24. Around 85% of the most advanced silicon semiconductors are produced by one or two fabs in south-east Asia. These semiconductors are used in consumer electronic products and are critical for artificial intelligence. This limited supply base represents a single point of failure, which has been recognised by the EU, the USA, and other emerging economies. Without access to advanced silicon semiconductors, the global electronics industry will be affected.
25. The UK cannot act alone due to the significant investments required, as the cost of an advanced silicon semiconductor fab is typically $5-20bn. It is therefore essential that we form partnerships with like-minded countries, such as the EU, India, Taiwan, and the USA. The CSA Catapult has entered preliminary discussions with India and Taiwan.

8. Is the Government currently providing the clarity and direction required to enable growth and security in the semiconductor industry? Are the right governmental organisations involved with ensuring effective development of our current semiconductor industry to thrive in the future?

26. Semiconductors are used in widespread applications from automotive to defence and telecoms, so it is natural that there is interest in semiconductors across several Government departments.
27. The Government has made a good start, supporting Innovate UK's request to invest in the CSA Catapult in 2018.
28. To improve clarity and co-ordination, industry would benefit from a central point of contact within Government.

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