Written submission from the Bessemer Semiconductor Manufacturing Group (SEM0074)

Response to questions raised by BEIS Parliamentary Committee on the current state of the UK semiconductor industry

The responses to the questions below are submitted on behalf of the Bessemer Semiconductor Manufacturing Group which comprises the leaders (CEOs and / or founders) of over 40 mainly smaller, startup companies in the sectors covered.

1. 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?
    a. Key global mega trends are enabled by semiconductor devices and semiconductor content in these devices is expected to increase x4.
    b. The global market for semiconductor materials is a ~$1Trn market. There are any number of sources for specific market data, but a good recent global overview is provided by a report from Boston Consulting Group for the US Semiconductor Industry Assoc (SIA https://www.semiconductors.org) (Apr 21).
    c. This creates a critical need for any world scale economy such as the UK to have a strategy that can address the most essential needs for an advanced economy. However, the "common products" used in the myriad of everyday electrical and electronic products require huge investment, now almost entirely concentrated in Asia, and could only be replicated in an extreme scenario where the world breaks into two internal trading blocs.
    a. The key question however to ask is "what is the impact on the UK economy of "common products" that depend on semiconductors. Electric vehicles are one key product for example significantly affected by the semiconductor supply chain. It applies to multiple sectors example. Thus, a UK Strategy needs to identify where support is most needed.
2. What is the UK's semiconductor supply chain and is this secure? If not, how can this be improved? What specific strengths does the UK have to contribute to regional or global semiconductor supply chains? How competitive is the UK within the global context of the semiconductor industry?
    a. The UK has progressively trailed other major world economies in its strength in this critical sector and that gap is increasing. The BCG report highlights the gap between Europe (inc the UK) generally and economies such as China, S. Korea and Taiwan. In addition, recent announcements from economies such as China, US, South Korea and even Europe for investments of many 100s £bn in fab manufacturing mean that the UK will fall back further. The bad news is that for the UK, 'that ship has sailed' However, it is important to recognise that this statement applies to high volume silicon CMOS manufacturing which is the type of technology used for computer processors and memory devices. The good news is that all this spend on volume CMOS semiconductor capacity means there could be world-wide over-capacity in say 1.5 to 3 years' time. The UK can, in principle, benefit from this by aiming its investments in more advanced, less cyclical areas of the semiconductor marketplace, for example on the specialised semiconductor technologies and higher added value manufacturing areas where it still has strengths.
    b. In compound semiconductor markets, the UK has tended to focus on speciality applications in Opto, Sensors and Discretes (OSD) and data storage. When the UK focuses and coordinates effort, as it does in OSD, it can be highly successful. Underlying strengths are particularly in chip design IP (e.g. ARM) and in newer materials, like compound III-V materials and graphene.

c. In terms of chip design such as Graphic Processor Units, AI and other silicon IP, the UK has built several world-class companies, notably Arm, Graphcore , Imagination Technologies, Element 14 (acquired by Broadcom) , Icera (acquired by Nvidia). It has also been strong in analogue and mixed signal processors, e.g. Dialog Semiconductor (acquired by Renesas), Cambridge Silicon Radio (acquired by Qualcom), Wolfson (acquired by Cirrus), EnSilica
d. A serious weakness is that many young semiconductor-focussed UK tech start-ups, whether compound semi based or silicon need access to small / medium volume manufacture in order to develop small quantities of prototypes for development purposes in addition to a clear and secure sovereign scale up pathway. The lack of suitable facilities that can help them scale to partial or full commercial volume means that many UK-originated chip developments are delayed or lost because they cannot produce design test quantities.
e. The South Wales cluster of semiconductor-related technology companies includes two world leaders, IQE (compound semi epitaxy wafer manufacturer) and SPTS, now owned by KLA Inc, a leading semiconductor tool maker. In addition, the US company, Microchip Inc., has a large packaging activity close by. And when Newport Wafer Fab was an independent fab (before its acquisition by Nexperia) it was central to an end-to-end supply chain cluster unique in Europe.
f. There are smaller fabs in the UK, which can offer prototyping services but not for scale up to commercial volume. Plessey Semiconductor is one of the larger fabs which could offer scaling facilities, except not now as it is dedicated to a single customer. There are three larger fabs, two in Manchester and one near Durham, which are larger fabs but foreign owned. They are therefore geared to supplying their global supply chain customers, not the UK supply chain.
g. So, while the UK is doing very well in the design of semiconductor chips requiring leading node (sub 22nm) silicon technologies, the availability of suitable fab facilities with the packaging and test capabilities to realise their best operational performance holds back the extent to which the UK could make a much greater contribution to global supply chains.
h. Often overlooked as well is that tight coupling between device design, development, manufacture, packaging linked to the application requirements within a closely controlled supply chain is best able to secure unique product advantages. The semiconductor supply chain in South Wales was moving strongly in this direction but the sale of Newport Wafer Fab to Nexperia is at risk of removing this opportunity for the UK industry.
i. There was a tremendous dislocation in the late 1990s and early 2000s as larger companies were acquired and production offshored. A case in point is STC acquired by Nortel of Canada which employed 6000 people in the Torbay area. Much of the key knowledge remained locally however and led to the establishment of several start-ups, including Bay Photonics, SIFAM Fibre Optics, Effect Photonics, Davies & Bell and Rydon Technology. There are also companies that have survived from that period such as Lumentum, Spirent, Nanusens, Plessey, and Gooch & Housego so that together they form an important cluster, supported by the Torbay Hi-Tech Cluster and the Torbay Development Agency. The same is found in places in Scotland, the North East, South Wales and to some extent around Manchester. These clusters can develop end-to-end supply chain capability in strategic, high-value areas with further support.
j. Due to the lack of indigenous scale up infrastructure and supply chain, foreign companies' licence or buy the technologies and continue funding the development overseas. Very often UK companies are also acquired by overseas companies, and

despite initial assurances, eventually the jobs and expertise are lost. There are countless examples of this in the history of the UK semiconductor industry where £100's of millions of taxpayers' money has been spent on subsidising overseas companies to set up operations in the UK, only to see them leave when more economically attractive alternatives become available in their home countries.

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?
    a. There are areas where the UK has real strength on a global basis, e.g. chip / application circuit design (IP), compound semiconductors, new materials for chip manufacture – beyond silicon. These strengths are in areas of newly emerging, specialised, higher added value products and in turn support other important elements of the UK's wider technology landscape, e.g. EV and fast charging infrastructure technology, medical devices, robotics, 5G/6G, space technology etc.
    b. To capitalise on this the UK needs its semiconductor base strengthening in ensuring:
        i. Sufficient open access semiconductor fab capacity (such as Newport Wafer Fab) to ensure development of an indigenous advanced electronics and semiconductor development capability
        ii. Sufficient capacity for design and manufacture of advanced chip packaging technologies in specialised areas like compound semiconductors and related advanced electronics applications.
    c. There remains critical know-how in packaging & volume manufacture (processes & materials) of semiconductor devices in the UK, the fact that today's volume manufacture utilizes automated workstations means that the "labour cost" element of manufacture is no longer the disadvantage to the UK (vs Asia) that led to the "off-shoring" of device manufacture in the early 2000s.
    d. Today, the UK can compete globally, provided there is sufficient investment in capital equipment. What is important is that both chip and packaging expertise is driven by the "device" users, in the case of power semiconductor this would most likely be the Tier 1 supplier to the OEM. So, any encouragement to higher Tier businesses to locate to, or be established in, the UK would stimulate the development and sustain the operations of the semiconductor supplier. Without the Tier 1s, such as those in Germany, and Japan for example, the supply chain is not sustainable.
    e. This should not be a debate about IP / design vs manufacturing. A vibrant sector needs both, and with both it can sustain and support UK demand for these vital products and command an important and competitive position in world markets.
    f. The UK has 'islands' of expertise in semiconductor prototyping, both governmental- and private sector-owned, for example, the Manchester Graphene Centre, Southampton University's Advanced Photonics Institute, the Sheffield III-V Materials Centre, CSC in Cardiff, the Centre for Process Innovation in the North East, etc. However, many of these world-class fundamental technology development and prototyping facilities are under-utilised by young innovative companies due to lack of awareness of what is available. Scarce investment resource is often used instead by these companies to build facilities which often duplicate better facilities already in existence. To avoid this, it should be a pre requisite for any young innovative company receiving Govt related support that they should include in their business plan a section showing how they propose to make use of organisations that are already in place before committing their own resource to such equipment / facilities.

g. The current status of the UK semi industry is an outcome of 20 years of under investment. Going forward, investment needs to be part of a 20-30 year horizon because it isn't possible to fast track such technology and market developments.
h. Support for the domestic supply chain could helped be by offering tax incentives for multinational fab and packaging-related companies to invest in UK facilities which provide domestic capability. Also, there could be incentives or requirements for UK pension funds to invest a small portion of their funds in domestic semiconductor supply chain companies.
i. Through the activities of the Bessemer Society a company has been formed to establish a semiconductor and advanced electronics investment fund which will support the scale up of fabs and packaging facilities, as well for manufacturing scale up at companies making semi-related products. This is in response to the absence of private equity capital in the UK due to the time-scales for returns which are too long for traditional VC. The fund will be established on an evergreen basis, offering an annual dividend yield suitable for long-term institutional investors. To deliver this, the fund will be organised and led by an Industry Task Force, using industry 'smarts' to make safer, long-term investment decisions.
j. Newport Wafer Fab – use of facilities for manufacturing of the most strategic applications of semiconductors, notably for example quantum photonics. If the Government intends to support strategic industries it can provide cornerstone funding of an independent NWF in order to establish a sovereign supply chain capability that may be vital to UK defence and other strategic interests. Currently a start up like Quantum Dice Ltd has to go to a company in Holland for the supply of the specialised chips which are then sent to a facility in Germany for packaging before returning to Quantum Dice in the UK.

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?
    a. The UK has most of the supply chain in place for certain compound semiconductor based advanced applications and for some sectors of capital equipment needed to produce compound semiconductors.
    b. These supply chains are most developed in sectors which are highly niche, such as ones related to national defence. On the other hand, those that operate in more open markets, characterised by global supply chains, like telecoms or automotive, tend to have fragmented and very fractured local supply chains. Within the Transportation sector however there are sub-sets, such as shipping, marine, off-road, or undersea, and in Telecoms, there are private networks; here there are often niche opportunities for joined up supply chains drawing on novel technologies which can be packaged into highly customised solutions. In the case of the health diagnostic market, in principle the NHS is large enough to serve as an internal market that could support and encourage innovation and scale up, but in practice rarely if ever does. Instead, it happens earlier in the USA or China.
    c. The automotive sector is critical to the UK economy and here the Government has provided significant R&D funding support, including the Automotive Transformation Fund together with generous funding for the Advanced Propulsion Centre and the Drive the Electric Revolution Challenge Fund. Supporting this is additional funding for the Compound Semiconductor Applications Catapult which seeks to ensure a role for packaged semiconductor solutions from the start of the manufacturing supply chain through to the end product. These funding agencies have encouraged several end-to-end R&D supply chain collaborations to form, which could offer valuable templates for more such programmes, not only in automotive but other

sectors. This topic is the focus of a Bessemer Society semi-related dinner in London on June 9th.

d. In areas where a "sovereign" capability is important, such as defence, but also to some extent in aerospace and space, there is an end-to-end supply chain capability in the UK, but as these industries are mostly owned by foreign multinationals it is harder to promote localised supply chain solutions. Nonetheless, they exist, and the benefits of localised supply chains are recognised.

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?
    a. Generally, semiconductor innovation is well supported in the UK both through Government support systems and by UK based early-stage technology investors. The complaint heard rather is that not enough support is given to the higher TRLs, that is technology development closer to the point of manufacture where much more of the value-added lies. Some would say the universities have ambushed the budget here and others respond that EU State Aid Rules prevent support for development nearer to market (although it does not seem to stop governments in France or Germany supporting their industries).
    b. In Germany, the Fraunhofer Institutes offer a more effective way of bridging university research and industry needs. There is no equivalent in the UK either to the commercialisation-focused approach of semiconductor institutes like the Tyndall National Institute in Ireland, or VTT Micronova in Finland. The UK instead tends to let a thousand flowers bloom with no over-arching plan. For example, both Cambridge and Manchester operate national centres for graphene research.
    c. We can always do better of course so more Government support in compound semiconductors and new semiconductor materials would be welcome. However, as stated there should be more urgency to restore some level of manufacturing capacity in the UK, and this means availability of significant later stage investment in companies and facilities that provide that manufacturing support. Whilst such investment would benefit from Government support, this should be done as well to catalyse the inflow of funding from the private / institutional sector.
    d. Government tax incentives could also be used to get multinational corporations who are active in the sector to onshore in the UK, for example packaging companies, like Amkor or Unisem, who could invest in development / low-to-medium volume packaging facilities. This could be an alternative to the costly route of building sovereign capacity.
    e. Subsidies/co-fund IP and corporate R&D expenses – not just R&D tax credits.
    f. Grants to cover the cost of tape-out of prototype chips.
    g. There could also be incentives or requirements for UK pension funds to invest a small portion of their funds in strategic enabling technologies, like domestic semiconductor supply chain companies.
    h. If the Government discontinues participation in the EU Horizon budget it will release a large amount of money looking for a new home to invest. One place could be to invest in the most technically sensitive, and long-term areas of scale up such as Quantum Photonics.

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?
    a. Home grown talent with skills below university degree level are required to support manufacturing. Operator and technician level positions are often overlooked. However, this weakness can be addressed, as has been demonstrated in South

Devon, where the local semiconductor photonics cluster has teamed with South Devon College to create a tailored set of educational modules largely created and delivered by experienced employees from local manufacturing companies. These same local companies have donated state-of-the-art equipment, critical for semiconductor device manufacture to facilitate a manufacturing training suite. This model can be repeated nationally.

b. The biggest gap in the skills area is for materials and process engineers in the age bracket 35-50 years old who would now be key repositories of experience. Instead, this knowledge is now concentrated mainly in people aged over 50 years of age who obtained their training in the 1980s and early 1990s when semi fabs employed large numbers of people in places like Silicon Glen in Scotland in particular, but also at companies like Plessey or GEC-Plessey in Swindon, Lincoln, Torbay, Bristol, Manchester and elsewhere.
c. In spite of this the UK still manages to generate innovations both from home grown and imported talent. In the short to medium term the key is to maintain support funding for innovation (which will draw in skilled talent) but then to have follow on funding that keeps growing innovative companies in the UK and ensures that rewards for innovation are sustained and celebrated.
d. An important phenomenon to recognise is that in the last five to ten years the opportunities have started to multiply again for start ups designing and making semiconductors for sensor, photonic, wireless or novel power applications. In quite a few cases their founders are foreign nationals, either lured here by the generous tax incentives for EIS type private investment, or who graduated from UK universities. The English language similarly makes it easier to recruit foreign talent. They will come to international hot spots like Cambridge or Oxford, but they are also willing to take jobs in South of Wales, or the South of England.
e. There is not enough home-grown talent being trained up at the universities where more often a majority of post-graduates in particular will be foreign nationals. There are now (slightly late-in-the day) greater efforts to address this in South Wales and the North East around Durham where the semi industry is growing fastest, but much more will be needed.
f. It should be noted that engineering skills are to an extent transferable. Thus, in the 1980s and 1990s engineers who had worked in declining manufacturing sectors in South Wales could transfer across to work in the many electronics factories which Japanese companies established or at the semiconductor fab in Newport.

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?
    a. The biggest concern is the massive dependence on Asia for the supply of most parts for the electronics and semiconductor industry. COVID lockdowns in Shanghai and Shenzhen have huge knock-on effects. If Taiwan should be invaded and ultimately controlled by a Chinese Government determined to use its near total grip on the supply chain to blackmail the West, the difficulties for western security planners are almost incalculable. The willingness by governments in Europe, the USA, and Japan to invest in new fabs aims to reduce this risk. They have taken the decision to invest in high volume fabs which are too expensive for the UK with no indigenous global semiconductor companies still operating (e.g. Plessey GEC, Ferranti, STC, etc.,). The UK therefore will be last in line under the likely rationing system that will allocate supplies to those who have made the investment.
    b. The shift from 3G to 5G increases the importance and strategic value of an advanced telecoms capability

c. To strengthen its position, the UK could help coordinate a Five Eyes equivalent for the semiconductor and advanced electronics industry which extends the traditional definition of national security beyond military defence into protection of the most sensitive parts of the economy. There are areas here where the UK has tradable strengths, such as AI, Cyber Security, and Quantum Computing and Communications.
d. Entities that might form the basis for building such a framework of cooperation include In-Q-Tel in the USA and its UK counterpart the National Security Strategic Investment Fund (NSSIF) as the function of both is to protect and support sensitive technologies based on a high degree of sharing between their respective security agencies.
e. It should be born in mind though that International Traffic in Arms Regulations (ITAR) which controls exports and imports of technologies deemed sensitive to US security frequently come up as an issue for UK high-tech companies.
f. The UK needs to remain part of the Horizon Europe funding programme. Some of their research programmes might be designed to improve sovereign supply chain capability under frameworks like the "Important Projects of Common European Interest (IPCEI)".
g. The best protection is to develop a vibrant domestic industry which is globally competitive in specialised semiconductor technologies. This will enable the UK to enter into trade agreements with other nations which need access to this specialised technology.
h. The ramifications of failing to do this are that important sectors of the UK's advanced manufacturing economy will be undermined. In particular the transition of the car industry to an electric future will be compromised as high-performance car makers must seek ways to differentiate by using novel or proprietary technologies that are unique to their supply chain. The same argument will apply to companies involved in the electrification of flight; in fields like advanced diagnostics (sensors); or advanced communications and data processing using photonics.

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?
    a. A clear strategy and roadmap is required which needs to define which areas of "semicon" the UK is looking to lead / dominate. This isn't possible for every application area but in selected areas e.g. Power discretes.
    b. An industry complaint is that there is no over-arching vision, direction or joined-up (whole system) thinking in Government. This is not easy to achieve either because there are many sub-sets within semiconductors (silicon, hybrid, photonic, MEMS, graphene, diamond, and so on) and many different end applications. This is reflected in the overlap between BEIS and DCMS, the latter responsible for digital technologies and given responsibility for proposing a Semiconductor Strategy which many felt to be the natural preserve of BEIS. The Semiconductor industry would benefit from a unified centre of responsibility, located within BEIS. Having clear ownership of semiconductors under one department would enable clarity of strategy and direction.
    c. There is the all-too-present risk of silo thinking. There are also arguably too many bodies which have a hand in proposing policies for the sector. Contrast this with the top-down planning system long used in Japan. This falls under the control of the Ministry, METI, which relies for input on industry to reach agreement on medium to

long-term planning goals which then determine funding for research updated and refined at regular reviews.

d. Unlike in the UK, METI's function is not affected by changes in government (the same party has more or less ruled anyway continuously). A supra-industry planning body, modelled on the Bank of England, that is independent of the government but serving the national economic interest, could be a consideration.

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