ENABLING THE NEXT WAVE OF INNOVATION

Soon to launch, the Compound Semiconductor Applications Catapult will be in a strong position to assist UK industry in fully exploiting this technology.

The advances made possible by silicon have seen electronic systems pervade almost every part of life. The advanced control that electronic design enables is helping to transform the way products are designed. The automotive sector is an example, beginning the move from petrol and diesel engines to electric traction – taking advantage of novel power-conversion architectures and semiconductors to maximise battery capacity and motor efficiency.

For the UK, which manufactures 2.5 million engines every year, such a transition provides a huge opportunity. Electric traction requires the ability to convert power at high efficiency and in as small a space as possible. But silicon power converter technology is reaching the limits of its capabilities.

Low switching speeds translate into heat losses that force manufacturers to use bulky heatsinks. Compound semiconductor materials such as gallium nitride (GaN) and silicon carbide (SiC) let manufacturers attack the problem at multiple levels. Not only can they switch faster – delivering greater efficiency and cooler operation – they are far better at handling heat. This makes it possible to integrate many power devices in one compact package, cutting size and weight.

Because they enable high-speed switching, compound semiconductors already support key markets such as optical and RF communications, with devices used in mobile handsets, basestations and high-speed telecom switches. And the UK already has a strong position, with more than 100 companies operating across the compound-semiconductor supply chain.

Some UK companies and operations have achieved leadership positions at multiple levels of the supply chain. They include start-ups, SMEs and multinationals. IQE, based in South Wales, is the leading manufacturer of wafers for compound semiconductors. CST Global operates one of the very few foundries set up to handle the complexity of outsourced production using these novel materials. Plessey Semiconductors is integrating GaN on low-cost, high-volume silicon wafers to create LED lighting and power components. With manufacturing bases in the UK, Oclaro and Kaim have pioneered the use of semiconductor manufacturing to build highly integrated photonics devices.

The market for compound semiconductors is worth $66 billion, with a UK share of 9%, according to analysts, and seeing double-digit percentage growth. Thanks to the need for advanced power, photonics and RF devices, the global market is forecast to grow to around $140 billion by 2023. Future growth will be enhanced by compound semiconductors expanding into a host of new markets.

Not only will devices based on compound semiconductors find their way into the infrastructure for 5G cellular networks, they will also support novel applications. The UK has a rich base of research on which to build those applications, with around £750 million invested over the past decade by EPSRC and Innovate UK in compound semiconductor technologies and the application of semiconductors.

Vertical cavity surface emitting lasers (VCSELs) have already found application in the medical field, where they are used for the treatment of skin and eye conditions. A £400,000 project being conducted by a consortium of...
UK-based R&D groups and startups is investigating ways in which to use similar lasers based on compound semiconductors to develop new types of wearable analysis for health. They will support non-invasive ways of measuring glucose levels in diabetics and monitor dehydration: a particularly acute problem in older people.

The same core technology of VCSELs is being pursued in another £1m project to shrink atomic clocks to the point where they can be integrated into portable navigation devices. The market for such quantum timing devices alone is expected to be worth £100m within the next decade. In national security, quantum cascade lasers and other devices based on compound semiconductors are helping to support the development of scanners that use terahertz frequencies and highly sensitive gas analysers.

A strong background in compound semiconductor R&D and the potential of the applications persuaded the UK Government to announce a £50m investment in the Compound Semiconductor Applications (CSA) Catapult in order to help turn ideas and research into profitable, volume applications.

To be located in South Wales, the Compound Semiconductor Applications Catapult is one of a network of centres set up by Innovate UK in which the very best of the UK’s businesses, scientists and engineers work side by side on late-stage R&D – transforming high potential ideas into new products and services to generate economic growth. The Catapults recognise that many companies have brilliant ideas but often lack cost-effective access to resources, expertise, equipment or contacts to translate their ideas into new products and services.

As part of its strategy, the CSA Catapult will develop core skills and capabilities that can be exploited by companies who need the performance of compound semiconductors, providing support through advanced SPICE models to support the design-in process and to develop links to supply-chain partners. The Catapult will also invest in dedicated laboratories to support technology advances in hybridised packaging, and facilities to help companies develop and test new systems using compound semiconductors.

Among the possibilities for the Catapult are development kits to support the adoption of compound semiconductors in various applications. For example, imagine the applications – from automotive to industrial robots – if we can shrink a 3kW converter to the size of a matchbox. Such a level of performance requires innovation in cooling, possibly using diamond-like materials, as well as automated placement and packaging and novel circuit topologies that can take advantage of GaN or SiC devices.

Advanced cooling materials, hybrid packaging and circuit architecture are all areas where UK companies have made significant progress. Such a project is expensive for an SME, but the commonality of challenges makes it possible for the Catapult, working with the UK supply chain, to service the needs of many and provide them with the R&D support of a multinational.

The Catapult forms part of an overall investment made by the UK Government working in partnership with industry. The Compound Semiconductor Centre – a £40m joint venture between Cardiff University and IQE – is working closely with the Future Compound Semiconductor Manufacturing Hub, set up with £10m from EPSRC. The Institute for Compound Semiconductors will provide a link between original research and industry with the aid of an £80m investment from the Welsh Government and IQE. With its location in South Wales, the CSA Catapult will be able to take advantage of the benefits of being within a technology cluster, demonstrated previously by Silicon Valley and Boston’s Life Sciences Corridor. But the Catapult will serve industry across the UK.

The investment in the Catapult, together with other R&D activities around compound semiconductors, aligns with the Industrial Strategy Challenge Fund. This includes the ‘Faraday Challenge’ to support battery technology for vehicle electrification, funding for AI and robotic systems for extreme environments, a satellite test facility, and AI for autonomous vehicles. All provide scope for the high-speed, power-delivery and sensory capabilities of compound semiconductors. When the Compound Semiconductor Applications Catapult launches next year, it will be in a strong position to assist UK industry in fully exploiting this technology.

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