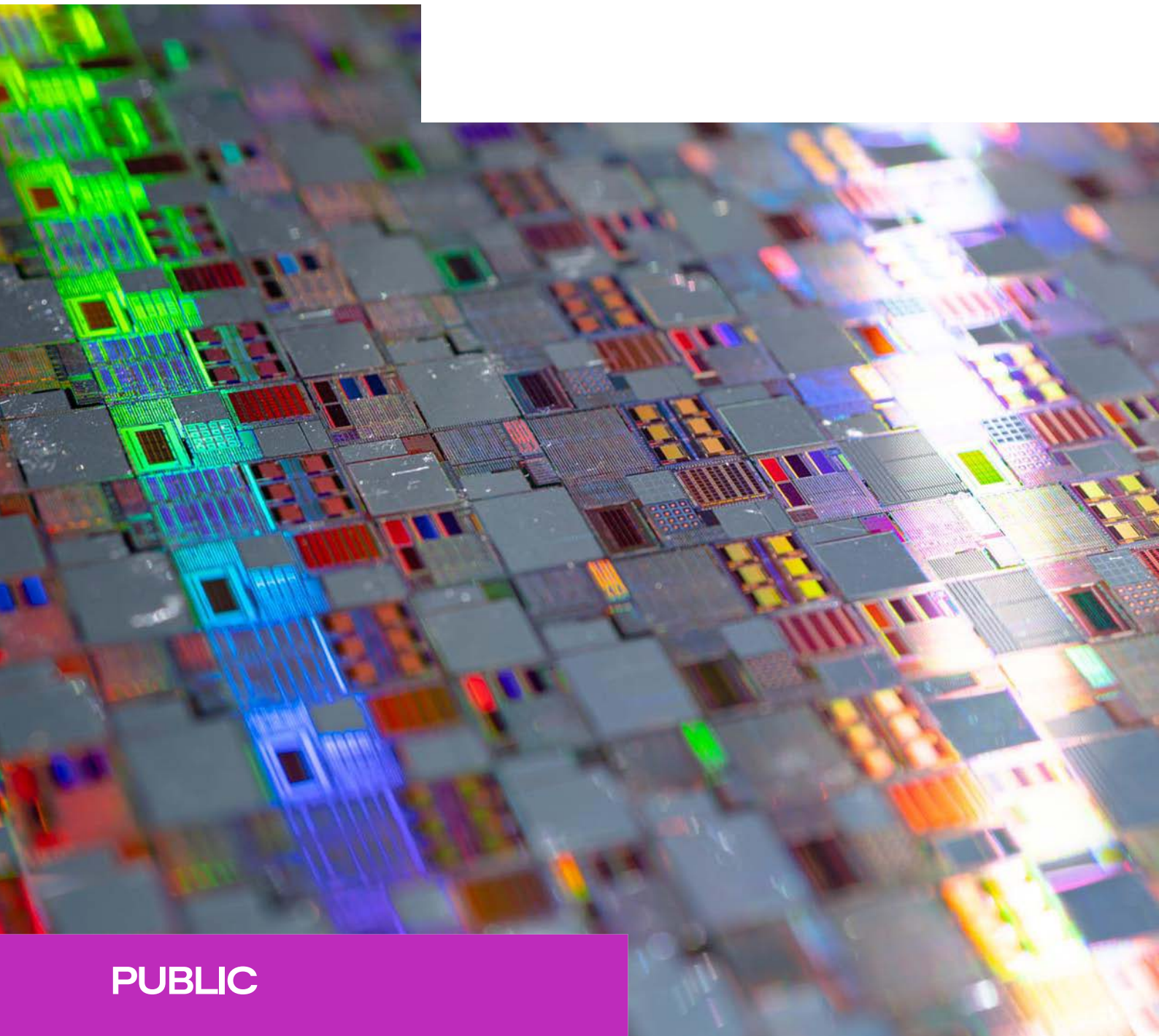
Innovate UK

Innovate UK Global Expert Mission Report

Semiconductors in Republic of Korea

February 2024



PUBLIC

Contents

01. Executive Summary

The Semiconductor Global Expert Mission (GEM) visited Seoul, Republic of Korea (RoK) in February 2024, with the purpose of identifying areas of potential collaboration between UK innovators and RoK partners on semiconductor research and development (R&D). The objectives included:

- finding out how Innovate UK can support UK businesses in establishing innovation partnerships with the RoK;
- exploring the semiconductor landscape in the RoK with a view to building relationships;
- identifying synergies between the semiconductor activities of the two countries; and
- creating an understanding of the RoK semiconductor market and key stakeholders, to develop long-term engagement strategies to support collaboration between the two countries.

The scope included semiconductor manufacture and design, compound and wide bandgap semiconductors and advanced packaging. Challenges and opportunities related to potential collaborations were also identified.

During the five-day mission, the GEM delegates attended the SEMICON Korea conference and trade show, and had meetings with both Samsung Semiconductor and SK Hynix, the two largest semiconductor manufacturers in the RoK – these companies are also the two leading memory manufacturers globally.

The GEM also visited:

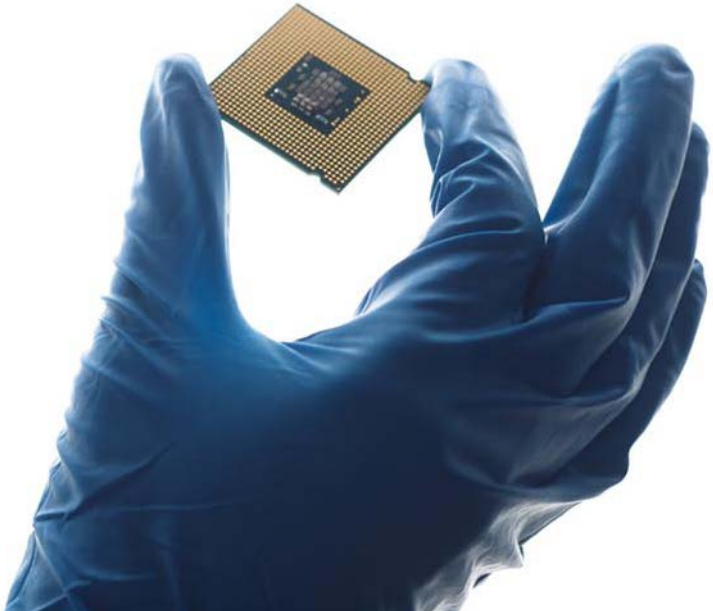
- the Inter-University Semiconductor Research Centre at Seoul National University and
- the Korea Institute for Advancement of Technology (KIAT), which is a quasi-governmental organisation that promotes the development of industrial technology in the RoK.

Finally, a roundtable discussion was held with key industry and academic stakeholders to discuss the potential for future collaboration in semiconductor innovation between the UK and the RoK. These stakeholders included:

- the Korea Semiconductor Industry Association (KSIA);
- the Korea Electronics Technology Institute (KETI);
- the National NanoFab Center (NNFC), which is part of the Korea Advanced Institute of Science and Technology (KAIST);
- the Wide Bandgap Semiconductor Research Center of Kwangwoon University;
- the Electronics and Telecommunication Research Institute, (ETRI);
- the Korea Research Institute of Standards and Science (KRISS); and
- the Next-Generation Intelligence Semiconductor Foundation.

The meetings and roundtable discussion identified several **collaboration opportunities**, that are detailed in **Section 7**, and included:

- Custom and fabless semiconductor design
- Compound semiconductor technology
- Heterogenous integration and advanced packaging
- Next-generation memory
- Photonics and wireless
- Testing and metrology
- Telecom R&D
- Skills and education



02. Acronyms

AI	Artificial Intelligence
ASIC	Application Specific Integrated Circuit
AQNMOL	Advanced Quantum-Nano Materials and Optoelectronics Laboratory
B2B	Business to Business
B2C	Business to Consumer
CS	Compound Semiconductor
CSA	Compound Semiconductor Applications
CPU	Central Processing Unit
CMOS	Complementary Metal-Oxide-Semiconductor.
DBT	Department for Business and Trade
DSIT	Department for Science, Innovation and Technology
DRAM	Dynamic Random-Access Memory
EDA	Electronic Design Automation
EIS	Enterprise Investment Scheme
ETRI	Electronics and Telecommunications Research Institute
EU	European Union
FET	Field Effect Transistor
FCDO	Foreign, Commonwealth and Development Office
GAA	Gate-All-Around
GaAs	Gallium Arsenide
GaN	Gallium Nitride
GEM	Global Expert Mission
GDP	Gross Domestic Product
HBM	High Bandwidth Memory
HBT	Heterojunction Bipolar Transistor
IC	Integrated Circuit
ICT	Information and Communications Technology
IIoT	Industrial Internet of Things

InP	Indium Phosphide
IMEC	Interuniversity Micro-Electronics Center
IoT	Internet of Things
IP	Intellectual Property
KAIST	Korea Advanced Institute of Science and Technology
KETI	Korea Electronics Technology Institute
KIAT	Korea Institute for Advancement of Technology
KOPS	Korea Optics and Photonics Society
KSIA	Korea Semiconductor Industry Association
LDMO	Laterally-Diffused Metal-Oxide Semiconductor
LiDAR	Light Detection And Ranging
LLM	Large Language Models
MMIC	Monolithic Microwave Integrated Circuit
MOU	Memorandum Of Understanding
MOTIE	Ministry of Trade, Industry and Energy
MSIT	Ministry of Science and ICT
MTI	Ministry of Trade and Industry
NAND	Not And
NIS	Next-generation Intelligence Semiconductor Foundation
NNFC	National NanoFab Center
OECD	Organisation for Economic Co-operation and Development
OSK	Optical Society of Korea
PDK	Design & Process Design

PLG	Photonics Leadership Group
POSTECH	Pohang University of Science and Technology
PPA	Performance, Power Consumption, And Area
RAN	Radio Access Network
R&D	Research and development
RF	Radio Frequency
RFIC	Radio Frequency Integrated Circuit
RISC-V	Reduced Instruction Set Computer - 5th Generation
RoK	Republic of Korea
SEIS	Seed Enterprise Investment Scheme
SIN	Science and Innovation Network
SiC	Silicon Carbide
SiGe	Silicon Germanium
SiP	System-in-Package
SoC	System-on-Chip
STEM	Science, Technology, Engineering and Mathematics
TPU	Tensor Processing Units
TSMC	Taiwan Semiconductor Manufacturing Company Limited
TSV	Through-Silicon Via
UCIe	Universal Chiplet Interconnect Express
UKRI	UK Research and Innovation
WBG	Wide Bandgap

03. Introduction

Innovate UK and the Global Expert Missions

Innovate UK supports business-led innovation and is part of UK Research and Innovation (UKRI).[1] UKRI convenes, catalyses and invests in close collaboration with others to build a thriving, inclusive research and innovation system. To this end, Innovate UK helps businesses to identify the commercial potential in new technologies and turn them into new products and services that will generate economic growth and increase productivity. With a strong business focus, Innovate UK drives growth by working with companies to de-risk, enable and support innovation. Innovate UK Business Connect exists to connect innovators with new partners and new opportunities beyond their existing thinking – accelerating ambitious ideas into real-world solutions.

As innovation is increasingly a global endeavour and the ambition of UK businesses to become truly international enterprises is at its highest, Innovate UK established its Global Expert Mission (GEM)[2] programme in 2017. Delivered by Innovate UK Business Connect, in partnership with the FCDO Science and Innovation Network (SIN),[3] GEMs help further Innovate UK's global strategy by providing the evidence base for where it should invest and by providing the opportunities for UK businesses to build partnerships and collaborations with key economies.

1 https://www.ukri.org/
2 https://iuk.ktn-uk.org/programme/global-expert-missions/
3 https://www.gov.uk/world/organisations/uk-science-and-innovation-network

Mission Overview and Objectives

With the significant increase in the global demand for semiconductors, there is an urgency to explore bi- and multilateral research opportunities to ensure a stable supply chain for the UK and RoK manufacturing industries. The purpose of the GEM was to identify areas and programmes that will enable UK innovators to collaborate more effectively with RoK partners to deepen research and development and innovation collaboration on semiconductors. This mission presented an excellent opportunity to exchange knowledge and expertise about the semiconductor industry in both countries.

The objectives of this mission were:

- Help determine how Innovate UK can best support UK businesses more effectively and efficiently when considering semiconductor innovation partnerships with the RoK.
- Develop a deeper understanding of the research and innovation landscape in the RoK and build relationships with key individuals and organisations.
- Identify synergies between the semiconductor activities of both countries and relative strengths and weaknesses across the sector.
- To understand the RoK market and key semiconductor stakeholders and develop long-term engagement strategies to support business collaboration for new products and services.

The Semiconductor GEM took place in Seoul, RoK, coinciding with the SEMICON Korea[4] conference, attended by over 70,000 people as 500 companies showcased the latest semiconductor manufacturing technologies.[5]

Seven UK delegates, active in the semiconductor industry, along with representatives from Innovate UK, DSIT and DBT, met with fifteen key research and industry private and public sector organisations in RoK focused on different aspects of the semiconductor supply chain. With the significant increase in the global demand for semiconductors, there is an urgency to explore bi- and multilateral research opportunities to ensure a stable supply chain for the UK and RoK manufacturing industries.

4 https://www.semiconkorea.org/en/about/overview

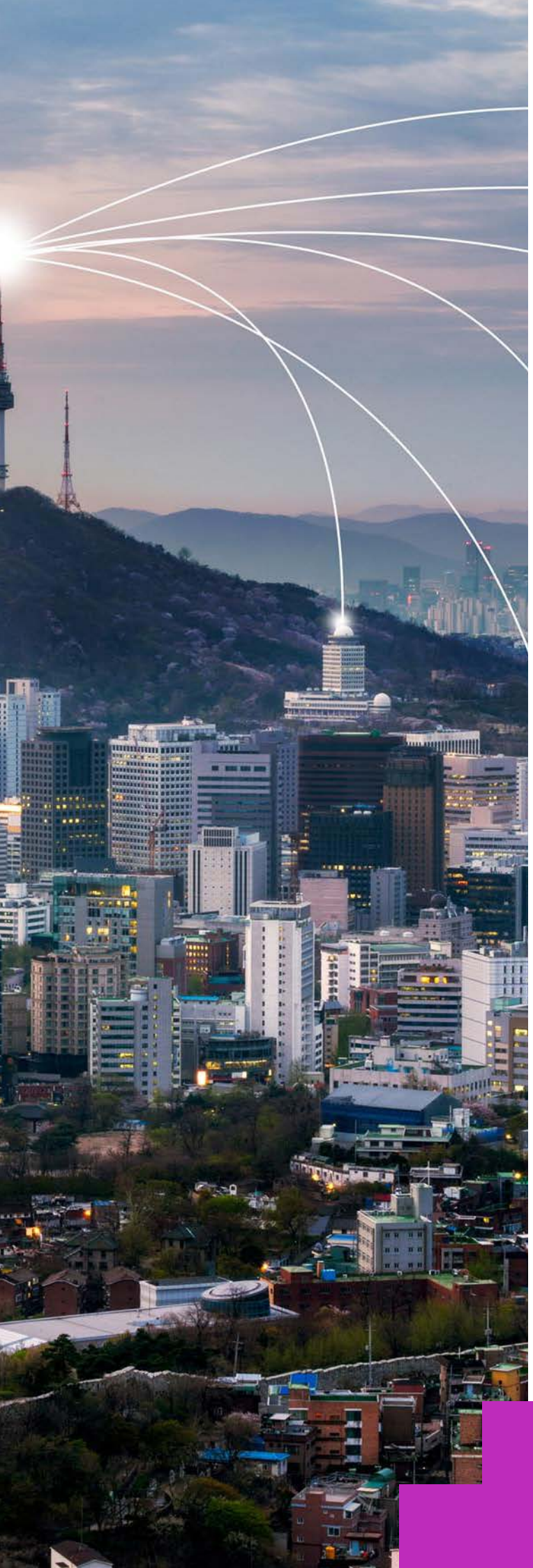
5 https://semi.org/en/news-media-press-releases/semi-press-releases/semicon-korea-2024-opens-tomorrow-to-spotlight-chip-industry-innovation-and-growth-opportunities

Mission Scope

The aim of the mission was to identify focus areas in terms of technology, sector, location, and the type of programs required to enhance collaboration between the RoK and the UK.

To achieve this, we reviewed key enabling technologies for the UK's semiconductor industries, focusing on improving supply-chain robustness and identifying the synergies in policy and strategy between the two countries to determine whether there is appetite for further collaboration in semiconductors, mainly related to semiconductor manufacture, design, materials and packaging.

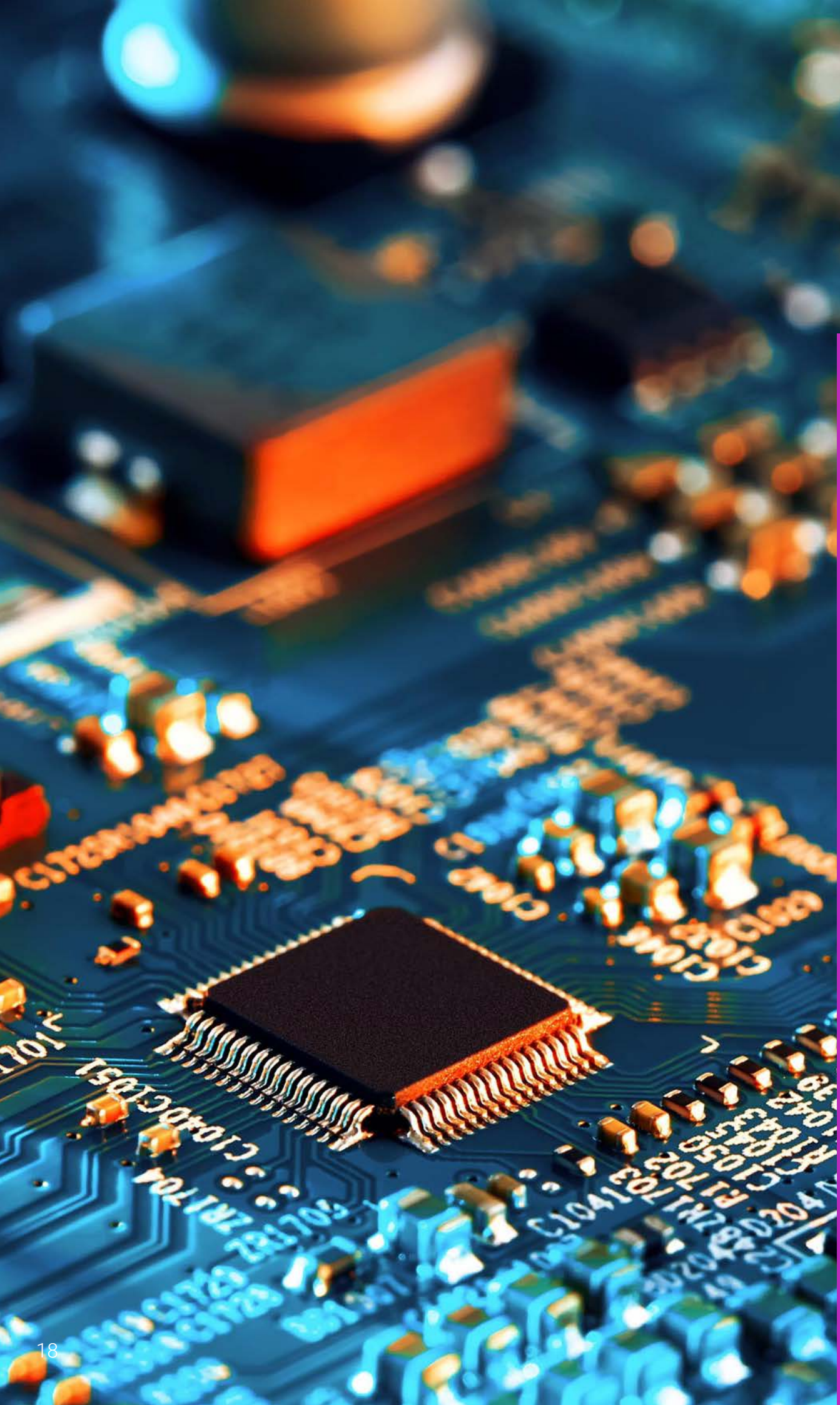
Finally, we identified challenges and opportunities for developing innovative technologies, products, and services when considering collaboration.



Principal Themes

The mission was focused on specific technical areas within the defined scope:

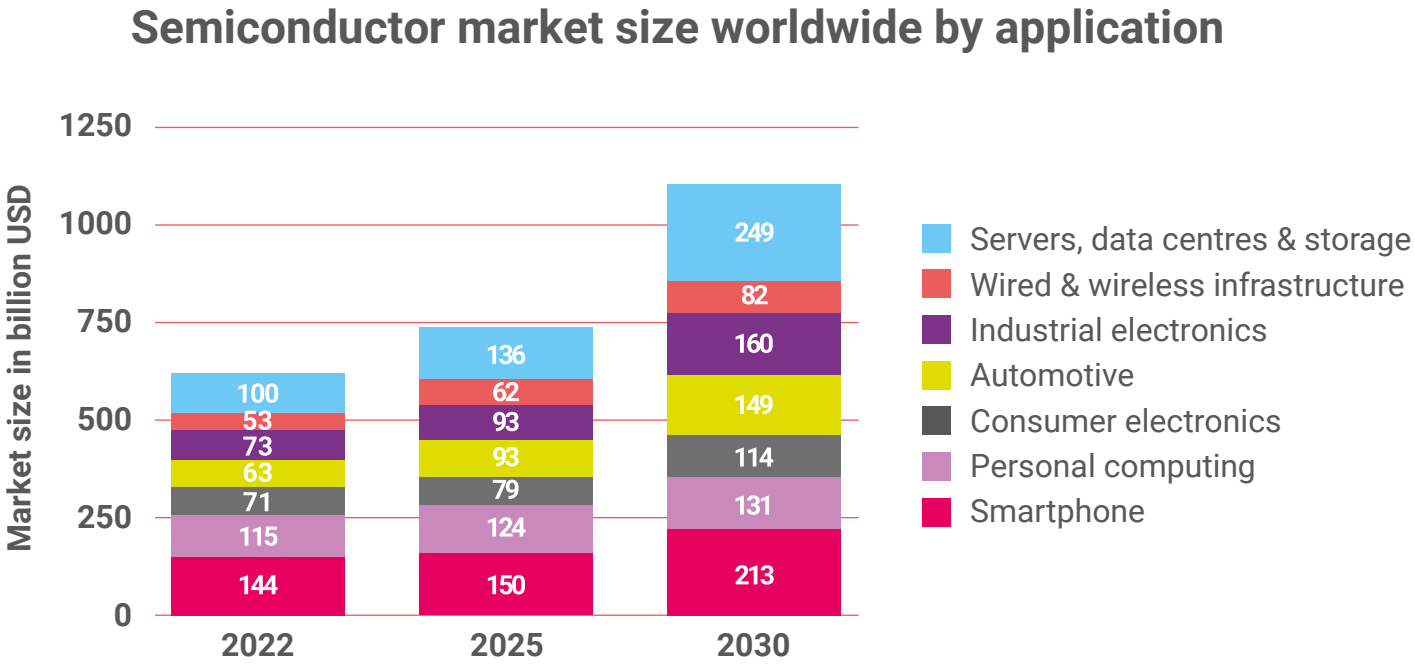
- Semiconductor manufacturing
- Design & Process Design Kit (PDK) development
- Compound (including Wide Bandgap (WBG)) Semiconductors (i.e. power, photonics, radio frequency (RF), quantum)
- Advanced packaging – System-on-Chip (SoC), System-in-Package (SiP), heterogeneous/hybrid integrations, silicon photonics



04. Sector Overview

Semiconductors are the key components in all electronic circuits and systems, and therefore are crucial to the UK and global economies, and to UK national security. Semiconductor devices represent the enabler of all the technology that underpins modern life: IT and the Internet, mobile telecommunications, defence, automotive electronics, consumer technology, and the Industrial Internet of Things (IIoT). The digital economy, industry, and much of the national infrastructure would be unable to function without them.

Global semiconductor revenue in 2024 is estimated to be US$624 billion, according to Gartner,[6] growing at 16.8% from the 2023 figure. Although the market is cyclical, it is forecast by McKinsey to grow at an average of between 6% and 8% until 2030 to become a trillion-dollar industry by the end of the decade.[7]



[Data source: ASML, Megatrends, wafer demand and capacity plans to support future growth]

Figure 1: **Semiconductor market size worldwide by application**

6 https://www.gartner.com/en/newsroom/press-releases/2023-12-04-gartner-forecasts-worldwide-semiconductor-revenue-to-grow-17-percent-in-2024

7 https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry

UK semiconductor landscape

Despite a contraction in the UK's semiconductor manufacturing sector over the past 30 years, the country retains a very strong technical skills base in semiconductor design and research. The UK is home to several world-class universities and research centres, which offer well-respected courses and research programmes in semiconductor physics, electronics and supporting technologies like materials science and chemistry.

The UK is also home to several technology clusters and hubs that support tech start-ups and semiconductor innovation. These include 'Silicon Fen' in Cambridge, 'Silicon Gorge' in the Bristol area and 'Silicon Glen' in Scotland, as well as the compound semiconductor cluster in South Wales. Together these are home to a total of over 20 semiconductor fabs, including silicon, compound semiconductor including WBG, photonics and novel substrate materials (graphene and flexible polymer).

The UK government has several features and initiatives that support the tech and innovation sectors, including tax incentives, like the Enterprise Investment Scheme and Seed Enterprise Investment Scheme (SEIS), R&D tax credits, and Patent Box[8] (reduced Corporation Tax for profits from patented products and services). A wide range of grants and subsidies are also available to support innovation, from Innovate UK, Horizon Europe and EUREKA/Eurostars.[9] In addition there is a relatively strong venture capital ecosystem, providing capital to support start-ups and spin-outs.

The UK has particular strengths in fabless semiconductor design, including in silicon processors (ARM, Imagination Technologies, Graphcore). It has a number of semiconductor design centres – both corporate and small independent consultancies – including for RF ICs and for Reduced Instruction Set Computer - 5th Generation (RISC-V) processors. Compound semiconductors are particularly well represented, with a number of start-ups and universities specialising in the technology, as well as the cluster in South Wales with the Compound Semiconductor Applications (CSA) Catapult at its heart.

8 https://www.gov.uk/guidance/corporation-tax-the-patent-box

9 https://eurekanetwork.org/countries/united-kingdom/eurostars/

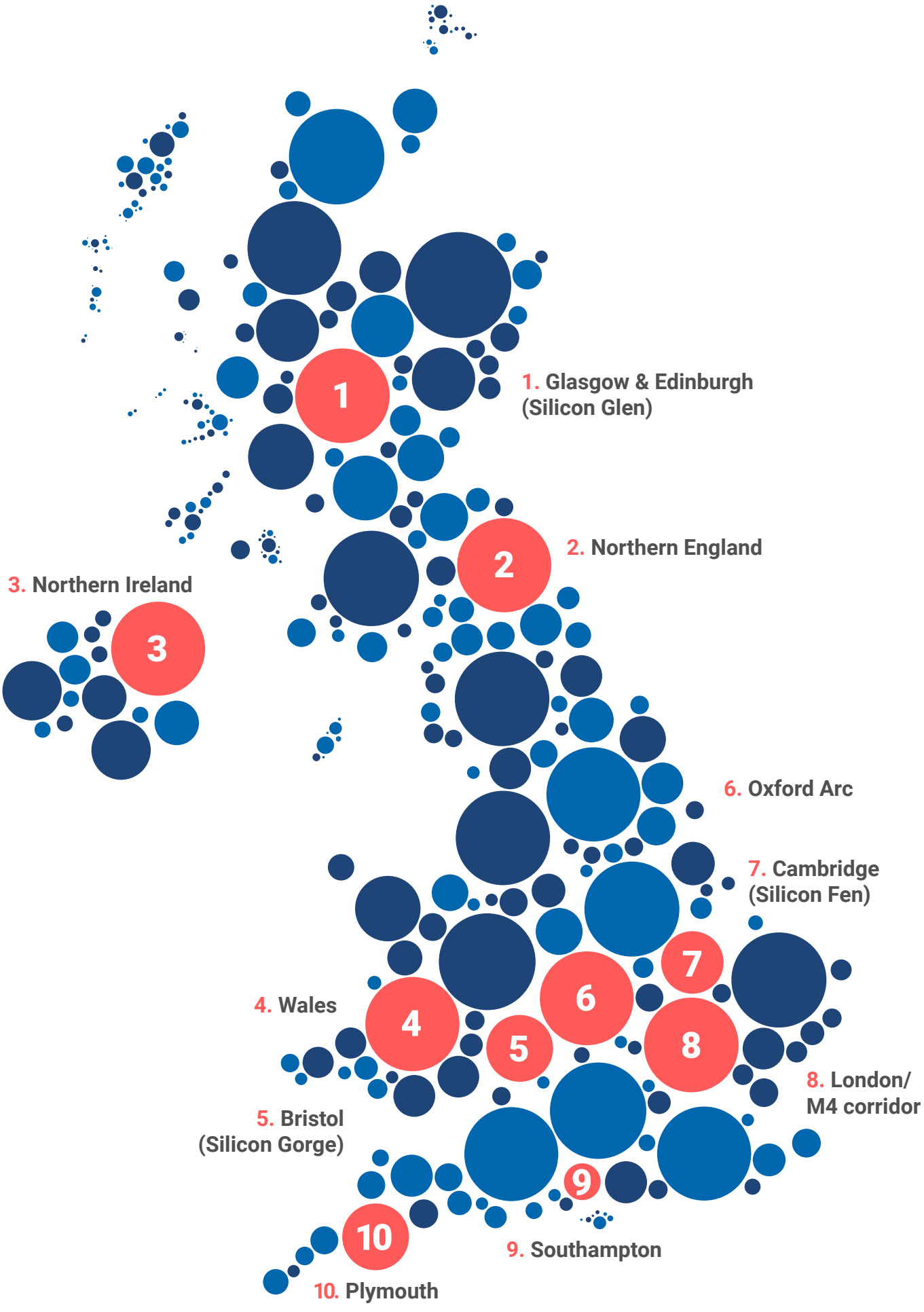


Figure 2: Technology Clusters and Hubs on Semiconductor Innovation in the UK

UK strategy

The UK is playing a significant role in advancing innovation in the field of semiconductors by these several key activities:

National Semiconductor Strategy: The UK government has unveiled a new twenty-year plan to secure the world-leading strengths of the UK's semiconductor industry.[10] The National Semiconductor Strategy defines semiconductors as one of the 'five technologies of tomorrow', along with quantum, AI, engineering biology and future telecoms. Semiconductors also underpin three of these other technology categories, meaning that they are critical to the UK's economic and national security, and to the strategic advantage the UK plans to secure on the global stage.

UK and EU Investment: The UK government has committed to investing up to £1 billion over the next decade to improve infrastructure accessibility, facilitate greater international cooperation, and power more research and development. This investment is expected to boost the sector's research, innovation, and commercialisation efforts, ultimately helping to bring products from the lab to the market.

In March 2024 it was announced[11] that the UK has joined the EU's 'Chips Joint Undertaking'. This means that the UK semiconductor sector will be able to gain access to the €1.3 billion Horizon Europe funding that has been earmarked for collaborative semiconductor research projects. This EU funding is being backed up by an initial £5 million this year from the Department for Science, Innovation and Technology (DSIT), with a further £30 million available to support UK participation in further research between 2025 and 2027. This includes the opportunity for the UK to be a part of a new funding opportunity with RoK to research advanced packaging for semiconductors.

10 https://assets.publishing.service.gov.uk/media/646626780b72d3001334476d/national_semiconductor_strategy.pdf

11 https://www.gov.uk/government/news/35-million-boost-for-british-semiconductor-scientists-and-businesses-on-international-chip-research

Focus on Strengths: The UK's strategy[12] emphasises its unique strengths in the field of semiconductors. These include semiconductor design and IP, advanced compound semiconductors,[13] and an outstanding R&D ecosystem. The physical properties of compound semiconductors mean that they can operate at higher frequencies and higher power levels than silicon, making them ideal for emerging technologies including electric vehicles and autonomous driving, and for future telecoms.

Global Leadership: The UK is a world leader in semiconductor design (both silicon and compound semiconductors, for analogue, digital and photonics), intellectual property and advanced packaging, positioning the country to play a critical role in shaping the future of semiconductors.[14] The UK is ranked 4th in the world (by field citation ratio) for semiconductor research impact. It is also the 5th nation globally for semiconductor research publications, and the second in Europe.

Research Capabilities: The UK has strengths across the semiconductor value chain, with three significant areas of strategic advantage: semiconductor design and IP, compound semiconductors, and world-leading semiconductor research capabilities, supported by a robust academic network.[15]

12 https://www.gov.uk/government/news/new-1-billion-strategy-for-uks-semiconductor-sector

13 https://csa.catapult.org.uk/blog/2023/05/19/seizing-the-opportunity-of-a-thriving-uk-semiconductor-industry/

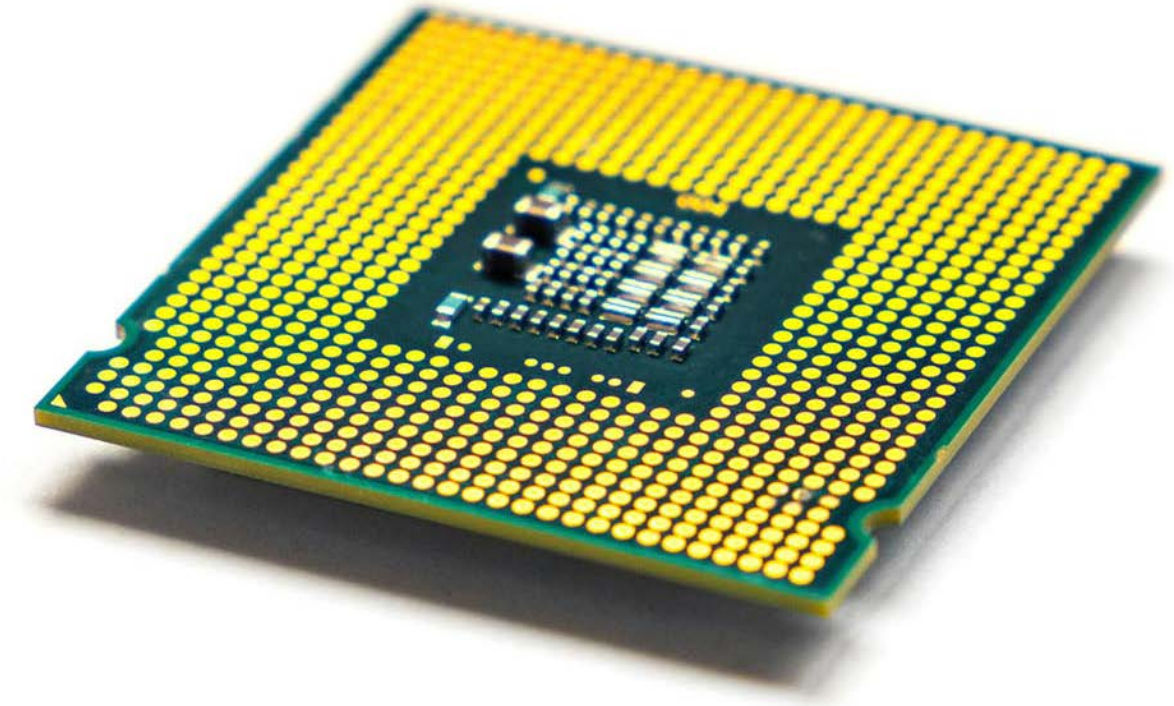
14 https://csa.catapult.org.uk/blog/2023/05/19/seizing-the-opportunity-of-a-thriving-uk-semiconductor-industry/

15 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1181611/GBIP_Semiconductors_Taiwan_Brochure_Sept_2023__Final_.pdf

UK – RoK collaboration

The RoK holds a crucial position for Innovate UK, owing to its substantial semiconductor industry and aspirations of becoming a major global 'chip powerhouse'. With the existing semiconductor market scenario, the UK has been collaborating with the RoK to establish a robust and strategic partnership between the two nations. Here are some noteworthy highlights of their recent cooperation:

1. **UK-RoK Agreement on Supply Chain Resilience:** In February 2022, the UK and RoK signed an agreement to strengthen supply chain resilience.[16] This agreement includes discussions on semiconductors. The inaugural UK-RoK Senior Economic Dialogue held in Seoul saw UK Minister of State for the Indo-Pacific Anne-Marie Trevelyan and the RoK's Vice Minister of Foreign Affairs, Lee Dohoon, agreeing to closer coordination on critical and emerging technology policies.[17]



16 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1181611/GBIP_Semiconductors_Taiwan_Brochure_Sept_2023__Final_.pdf

17 https://www.bloomberg.com/news/articles/2023-05-13/south-korea-uk-commit-to-cooperate-on-reinforcing-supply-chains?leadSource=uverify%20wall

2. **UK-RoK Free Trade Agreement:** The UK and the RoK have a Free Trade Agreement in place.[18] This agreement supports the strong economic ties between the two countries.[19] Both countries have acknowledged a shared commitment to start work to upgrade their bilateral Free Trade Agreement. Trade between the UK and the RoK totalled £13.3 billion in the year to September 2021.[20]
3. **UK-RoK Digital Partnership:** The UK and the RoK are currently discussing a Digital Partnership.[21] This partnership is intended to deepen bilateral engagement across digital infrastructure, economic security, digital technical standards, and online safety, and to steer closer cooperation on critical and emerging technologies.[22]
4. **MOU (MOTIE & BEIS) in Place "Industry and Energy Dialogue" (2021):** The UK and the RoK have a Memorandum of Understanding (MoU) in place to enhance industrial and energy cooperation.[23] This MoU establishes a dialogue between the UK government and the RoK. The dialogue supports cooperation in a range of areas, including energy, science, research, innovation, business, trade, investment, and emerging technology.

During the upcoming UK-RoK strategic dialogue on technology and innovation,[24] Semiconductors has been agreed as a priority area of future technology collaboration between the UK and the RoK.

18 https://www.gov.uk/government/collections/uk-south-korea-trade-agreement
19 https://www.gov.uk/government/publications/uk-republic-of-korea-strategic-dialogue-2022/uk-republic-of-korea-foreign-ministerial-strategic-dialogue-2022-joint-statement
20 https://www.gov.uk/government/news/uk-and-south-korea-eye-bigger-deal-following-bumper-year-of-trade#:~:text=Trade%20between%20the%20UK%20and,cent%20in%20the%20same%20year
21 https://www.gov.uk/government/publications/uk-republic-of-korea-digital-partnership/uk-republic-of-korea-digital-partnership
22 https://www.gov.uk/government/news/uk-and-south-korea-eye-bigger-deal-following-bumper-year-of-trade
23 https://www.gov.uk/government/publications/uk-and-south-korea-memorandum-of-understanding-mou-to-enhance-industrial-and-energy-cooperation
24 https://www.gov.uk/government/publications/uk-republic-of-korea-strategic-dialogue-2022/uk-republic-of-korea-foreign-ministerial-strategic-dialogue-2022-joint-statement

Insight...

RoK Government Incentives to foster talent in the semiconductor industry

The RoK government has implemented several incentives to foster talent in the semiconductor industry:

- **Education and Training**: A 350 billion won fund raised by public-private cooperation will be used to offer masters and doctorate courses to students.[25] The government has also allocated 54 billion won (US$40.7 million) to help several universities across the nation foster semiconductor talent.[26]
- **Research Centres:** Each region will have its own research centre for semiconductor studies, establishing a national network of centres.[27]
- **Student Quotas:** The ministry will lift current student quotas at Seoul metropolitan universities in semiconductor-related departments.[28]
- **Tax Credits and Subsidies:** The government provides tax credits of up to 50% for investment in R&D, and up to 20% for facility investment. It also grants low-rate loans to chipmakers for facility investment.[29]

These measures are part of the government's efforts to train an additional 150,000 people with semiconductor expertise over the next 10 years.[30]

25 https://www.koreatimes.co.kr/www/tech/2022/07/419_333156.html
26 https://koreajoongangdaily.joins.com/2023/02/28/national/kcampus/korea-semiconductor/20230228173156846.html
27 https://www.timeshighereducation.com/news/koreas-semiconductor-talent-boost-too-little-too-late
28 https://www.timeshighereducation.com/news/koreas-semiconductor-talent-boost-too-little-too-late
29 http://www.xinhuanet.com/english/asiapacific/2021-05/13/c_139943361.htm
30 https://www.timeshighereducation.com/news/koreas-semiconductor-talent-boost-too-little-too-late

05. Innovation Landscape

RoK position

Demographics

The RoK population was 51.6 million in 2022,[31] and is currently shrinking at a rate of 0.2% per annum, mainly due to its low fertility rate of 0.7 – the lowest among Organisation for Economic Co-operation and Development (OECD) countries. Life expectancy at birth is 84 years. The population is highly educated and computer-literate, with 50% of 19- to 20-year-olds enrolled on a bachelor's degree course,[32] compared with an OECD average of 30%. Of these, 34% are studying science, technology, engineering and mathematics (STEM) subjects, which is the second highest proportion after Germany.

The RoK GDP was US$1.67 trillion in 2022 (US$32,423 per capita), growing at 2.6% per annum. Unemployment is low, at 2.9% of the total labour force, and the country has the second longest working hours among OECD countries.

Semiconductor industry and market

Semiconductor manufacturing accounts for 9.7% of the country's GDP and 11.3% of its total manufacturing output.

The RoK has ranked second to the USA in the global semiconductor market for the past decade, with a 17.7% share in 2022.[33] It holds the top position, with 60.5% share, in the global memory market and accounts for 70.5% of the Dynamic random-access memory (DRAM) market and 52.6% of the NAND market globally.

31 https://data.worldbank.org/country/korea-rep
32 https://www.oecd.org/education/education-at-a-glance/EAG2019_CN_KOR.pdf
33 https://www.investkorea.org/ik-en/cntnts/i-312/web.do

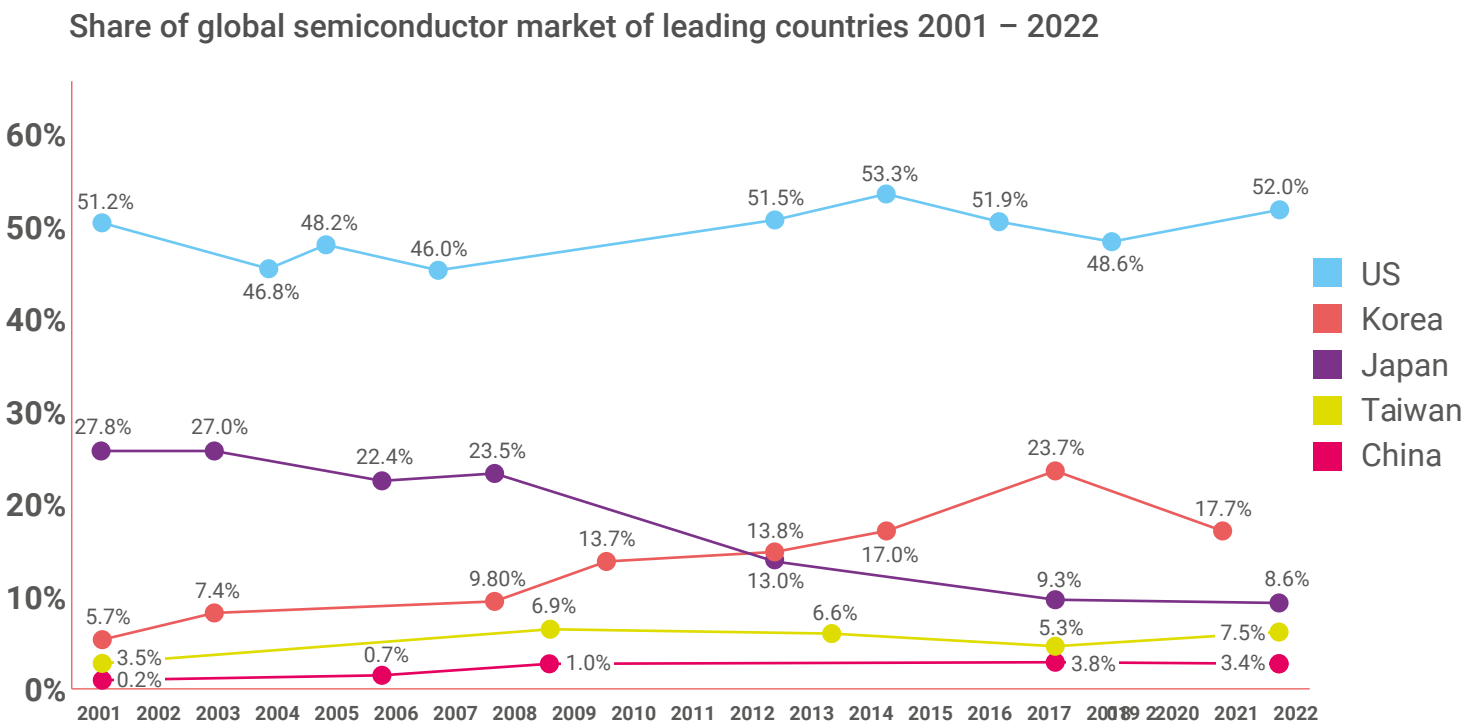
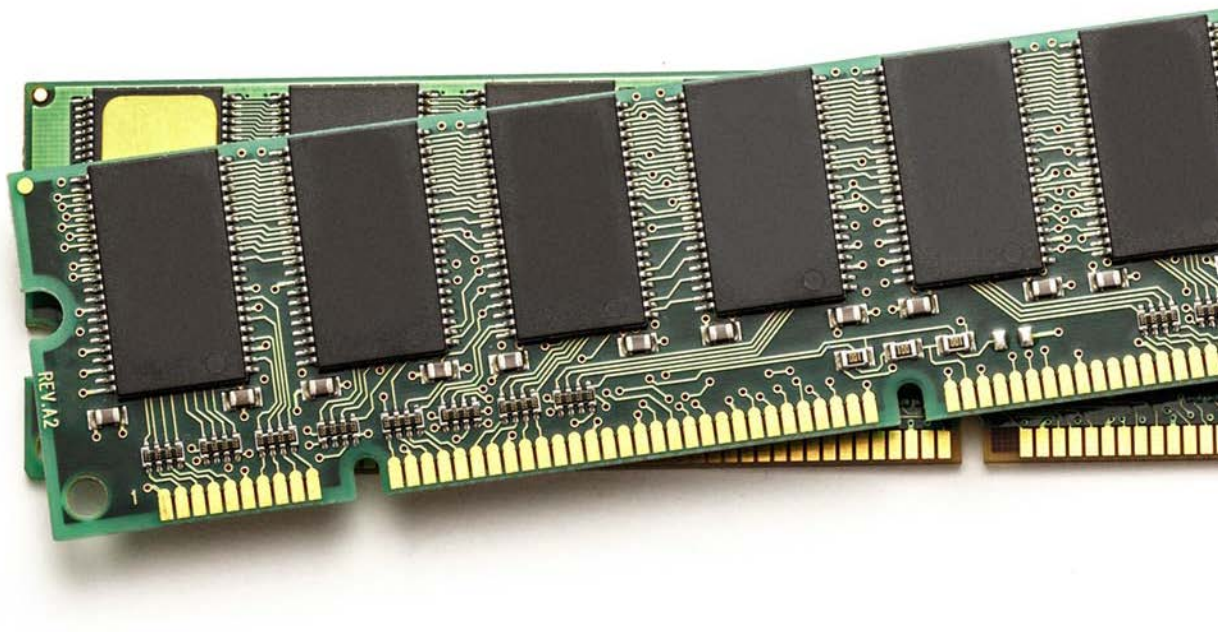


Figure 3: Share of global semiconductor market of leading countries 2001 - 2022
Source: OMDIA 2023

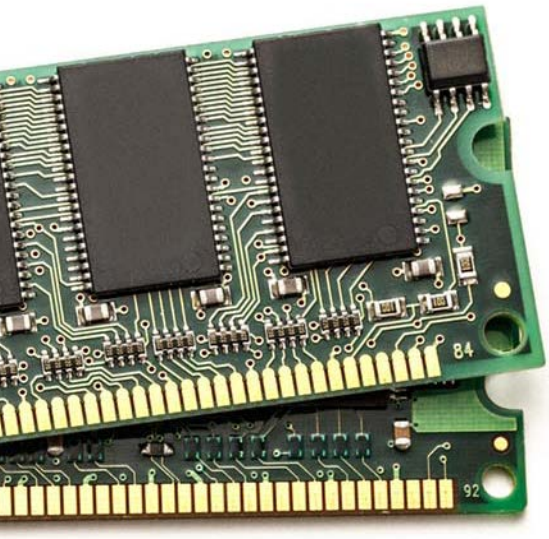


Company	Estimated sales ($m)	Global market share
Samsung	31,880	40.70%
SK Hynix	22,559	28.80%
Micron Technology	20,679	26.40%
Nanya Technology Corp	1,567	2.00%
Winbond Electronics Corp	627	0.80%
Powerchip Semiconductor Manufacturing Corp. (PSMC)	157	0.20%
Others*	862	1.10%
Total	**78,330**	**100.00%**

*Transcend Information, Inc., Infineon Technologies AG, Kingston Technology Corporation, Etron Technology, Inc and Others

Source: Trendforce

In foundry services, Samsung ranks second to TSMC of Korea, with global sales of US$22.9 billion in 2022, which represents 16% of the market (**Source: IC Insights**).



The RoK is the second largest market globally for both semiconductor materials and semiconductor manufacturing equipment. The market for materials in 2022 was US$12.2 billion, equivalent to 18.3% of the worldwide market, and for equipment was US$25.0 billion, representing a 24.4% share globally.

RoK semiconductor strategy

The **K-Chips Act**, passed by the National Assembly in March 2024, aims to safeguard economic priorities and foster a vibrant semiconductor industry in the RoK through tax incentives and promote technological innovation.

Beyond chips, this law positions Seoul to navigate the complex landscape of international trade, strategic priorities, and foreign relations. By emphasising indigenous technological innovation, the RoK seeks to secure future success in the global semiconductor market and influence industry rules and dynamics.[34]

The plan for a '**Semiconductor Mega Cluster**' in southern Seoul was announced by RoK on 15 January 2024, to be completed by 2047. This is backed by a 622 trillion KRW (£471 bn) investment involving Samsung Electronics and SK Hynix. When complete, the cluster will cover 21 km^2 in southern Gyeonggi Province (south of Seoul) and aims for a monthly production capacity of 7.7 million wafers by 2030. The cluster will comprise 19 production fabs and two research fabs.

The newly named '**K-semiconductor belt**' expected to become the hub of the country's semiconductor industry. The government is planning to train 36,000 semiconductor experts, provide funds for chip research and development, and introduce favourable legislation in this regard. (For more information, see **Insight: K-semiconductor belt: Strategic Semiconductor Clusters**)

Private Sector Investments: Private companies in RoK mirror the government's commitment. They invest in research, development, and production facilities to stay at the forefront of semiconductor technology.

34 **https://koreapro.org/2023/04/how-south-koreas-k-chips-act-balances-strategic-priorities-and-foreign-affairs/**

Insight...

K-semiconductor belt: Strategic Semiconductor Clusters

The RoK has unveiled a plan to establish a "semiconductor mega cluster" in southern Seoul by 2047.[35] This project involves a total investment of 622 trillion won (US$472 billion) with Samsung Electronics Co. and SK Hynix Inc. The envisioned cluster, which includes various industrial zones throughout southern Gyeonggi Province, will boast a total area of 21 million square meters and post a monthly production capacity of 7.7 million wafers by 2030.[36] The government plans to establish exclusive zones for the fabless industry in Pangyo, along with foundry and memory chip production facilities in Hwaseong, Yongin, Icheon, and Pyeongtaek.

The RoK will also build an industrial zone for material, part, and equipment businesses in Anseong, with research and development facilities in Giheung and Suwon. Under the plan, the area, which currently houses 21 fabrication facilities, will host 16 additional fabs by 2047, including three for research. Samsung Electronics plans to invest a total of 500 trillion won for the project, including the 360 trillion-won budget for six new fabs in Yongin, 33 kilometres south of Seoul. The country's top chipmaker will also invest 120 trillion won to build three new fabs in Pyeongtaek, 54 kilometres south of Seoul, along with three research fabs in Giheung with 20 trillion won. No. 2 chipmaker SK Hynix will allocate 122 trillion won to build four new fabs in Yongin.[37]

The government plans to have the complex boast world-class production capacity focusing on cutting-edge products, including chips with a 2nm process and high bandwidth memory.[38] The ministry added the 622 trillion-won project will eventually create 3.46 million jobs during the process. The RoK will take up ten percent of the global market for non-memory chips by 2030 as well, rising sharply from the current estimate of 3 percent. Along with the construction of the mega cluster, the government vowed to support the ecosystem by advancing the country's self-sufficiency in the supply chain of key materials, parts, and equipment to 50 percent by 2030 from the current estimate of 30 percent. Other policy support includes launching a testbed for suppliers of chip-related materials, parts, and equipment at the Yongin complex by 2027, where companies can test-run their products.

35 https://en.yna.co.kr/view/AEN20240115001800320
36 https://www.koreatimes.co.kr/www/tech/2024/01/133_366917.html
37 https://en.yna.co.kr/view/AEN20240115001800320?section=economy-finance/economy
38 https://www.koreatimes.co.kr/www/tech/2024/01/129_366948.html

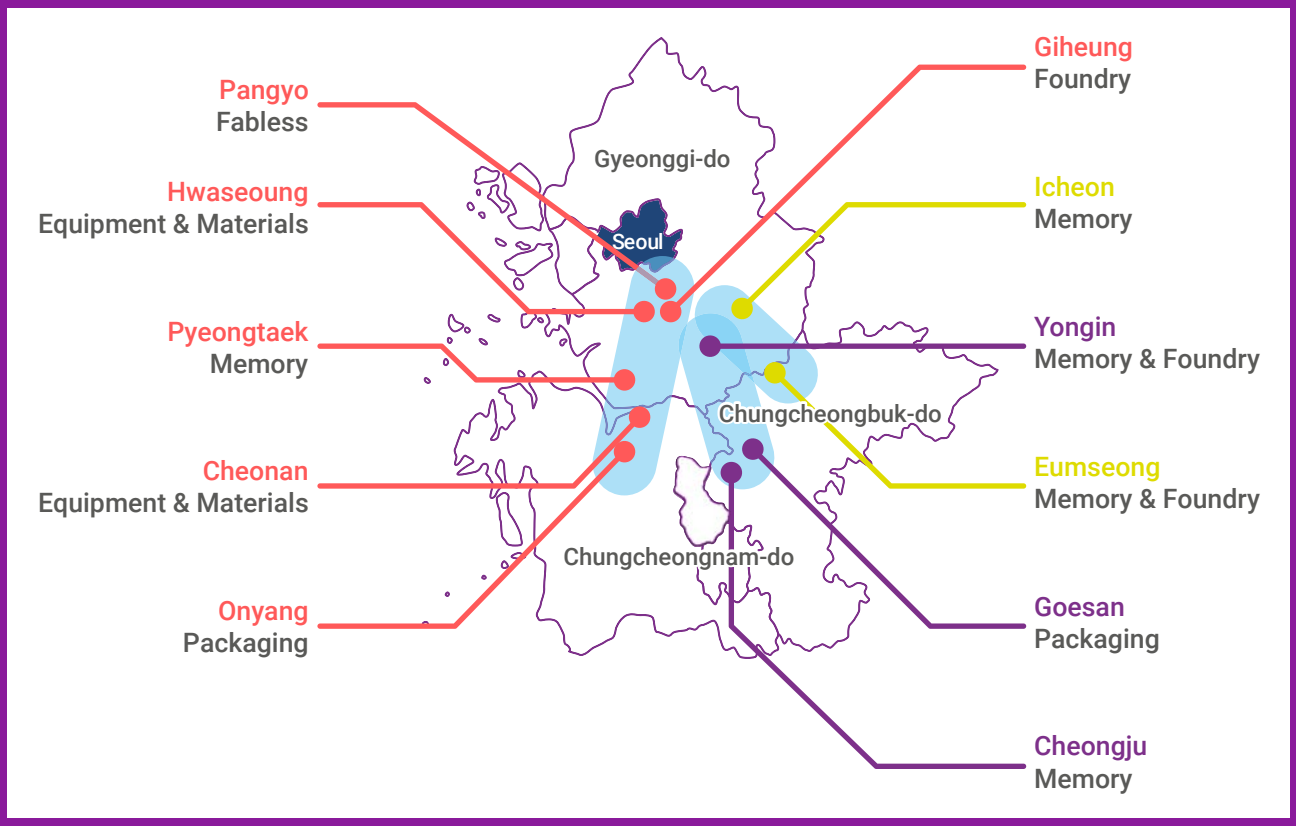


Figure 4: The K-Semiconductor Belt

Source: Invest Korea https://www.investkorea.org/ik-en/cntnts/i-312/web.do

Insight...

Challenges with memory

Memory chips represent a significant sector in the global semiconductor market, typically accounting for around 25% of overall semiconductor shipments by value.

The rapid growth in AI is placing ever-growing demands on both processors and memory. As the volume of data grows ever larger, advances in memory performance have failed to keep pace with that in processors, resulting in what is known as the Memory Wall (or Von Neumann bottleneck). This means that computer system throughput is limited in its ability to achieve top rates of data transfer due to the relative ability of memory compared with that of processors. The problem becomes even more pronounced when multicore central processing units (CPUs) are used, as processors can remain idle while waiting for data.

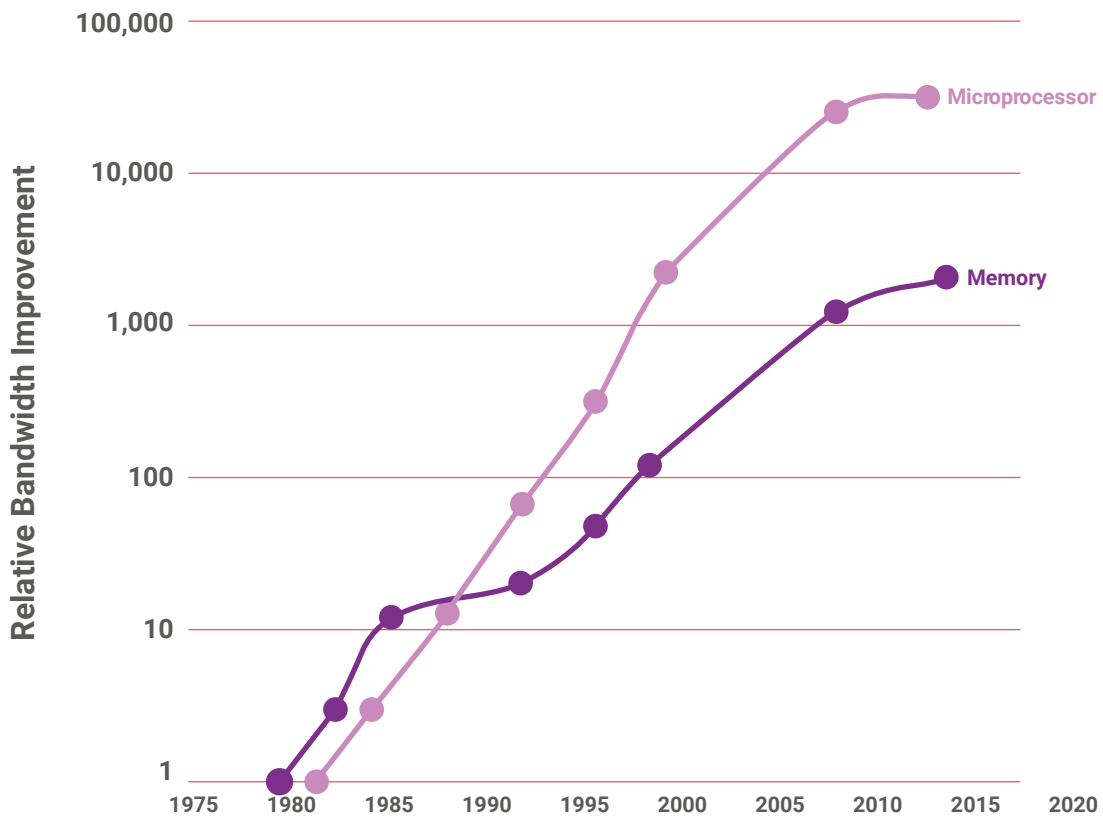


Figure 5: Growth of the Memory Wall
Source: Hennessy and Patterson[39]

39 Computer Architecture: A Quantitative Approach, Hennessy, J.L. and Patterson, D.A., 6th Edition 2019

Memory technologies, such as DRAM and NAND Flash, are becoming increasingly complex to manufacture as they approach the physical limits of Moore's Law, and continuous innovation – in terms of novel materials, architectures and 3D integration techniques – is necessary to continue improving capacity, speed, and energy efficiency.

Additionally, due to the demand for devices to become smaller and more powerful, scaling memory to fit within these form factors while improving performance is a challenge. This includes issues like leakage current and crosstalk between cells. Finally, current memory technologies are reaching the limits of what traditional materials can achieve.

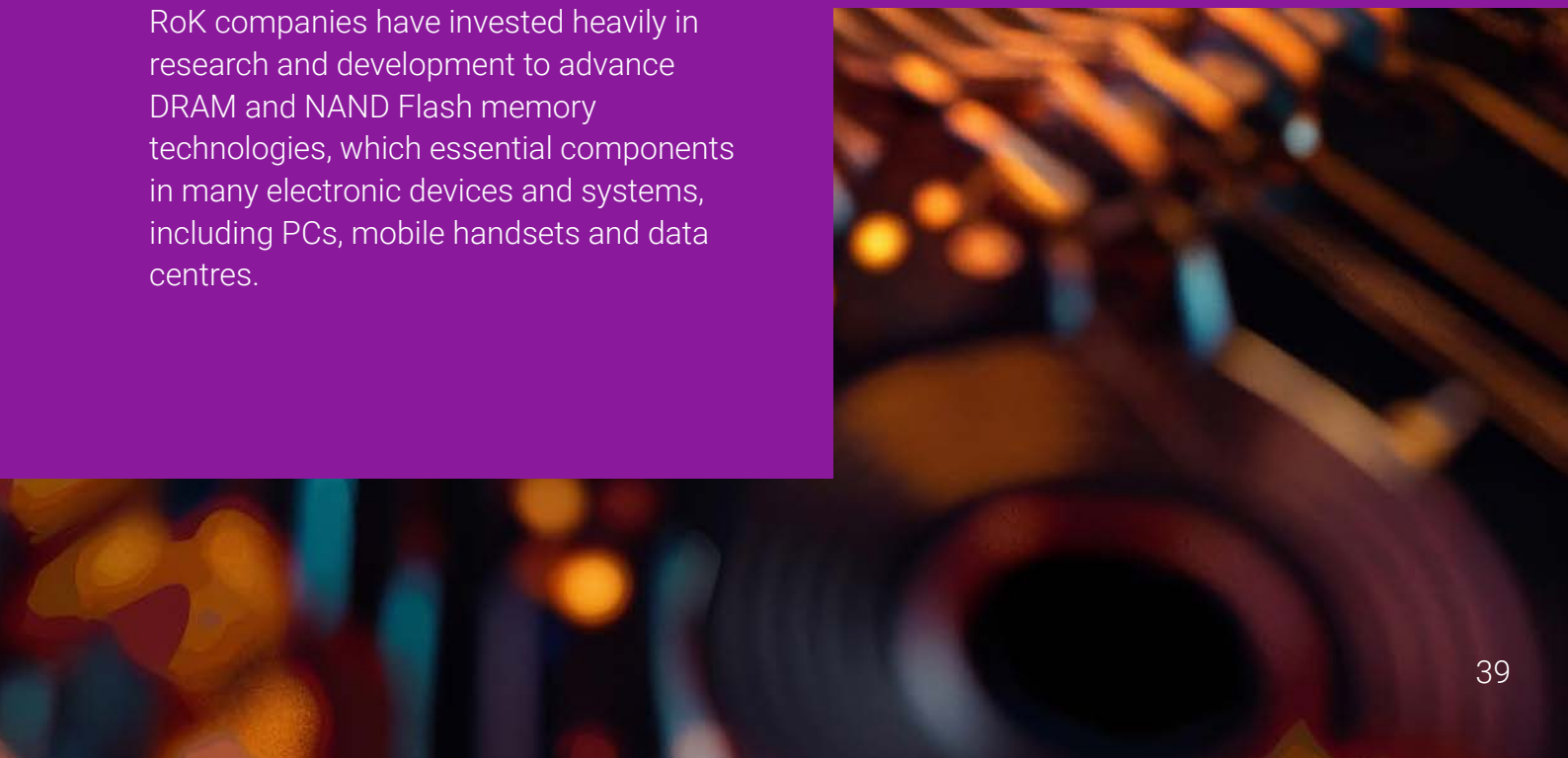
RoK is one of the leading players in the global semiconductor industry, with companies like Samsung and SK Hynix being major players in memory manufacturing.

RoK companies have invested heavily in research and development to advance DRAM and NAND Flash memory technologies, which essential components in many electronic devices and systems, including PCs, mobile handsets and data centres.

Korea accounted for 60.5% of the global memory semiconductor market, with DRAM market share of 70.5% and NAND market share of 52.6%, and it is pioneering the growth in HBM. Korean-made memory semiconductors are widely acknowledged as leading the world in capability and innovation.

Additionally, RoK has been exploring emerging technologies such as MRAM and 3D XPoint memory to maintain its competitive edge in the global semiconductor market.

The UK and the RoK recognise the importance of memory innovation for the semiconductor sector. They are actively investing in research, development, and collaboration to address the challenges and drive technological advancements in this field.



International Cooperation

RoK's semiconductor prowess is fuelled by a blend of government support, private sector initiatives, and strategic international partnerships. These efforts not only drive technological advancements but also contribute to global economic growth.

International Partnerships and Alliances:

United States – RoK Semiconductor Partnership: These two tech-savvy nations have forged a strong alliance in the semiconductor domain. They jointly seek to protect leading-edge technology through export controls and promote advanced chip production. The recent U.S. CHIPS and Science Act, signed into law by President Joe Biden, allocates US$39 billion in domestic manufacturing incentives for chipmakers, including RoK firms.

UK - RoK Accord: The UK and the RoK, both innovation powerhouses, have committed to collaborating on critical technologies such as AI, quantum computing, and semiconductors. This landmark accord aims to boost research links, create jobs, and unlock economic growth. A new fund of £4.5 million will foster joint research and innovation partnerships.[40]

40 https://www.gov.uk/government/news/landmark-sci-tech-deal-with-the-republic-of-korea-to-boost-cooperation-in-critical-technologies-such-as-ai-and-semiconductors

EU and the RoK Forward-looking Digital Partnership: This partnership launched on 28 November 2022 with an aim to strengthen cooperation between trusted and technologically advanced partners in the digital domain where semiconductors R&D is one of the key areas of joint work. Additionally, the EU and the RoK, both possessing leading capabilities in semiconductors, have established a RoK-EU Forum for Semiconductor Researchers.[41]

Global Collaboration and Safe AI Development

The RoK actively collaborates with other nations, including Japan and the United States, to formalise semiconductor cooperation. The "Chip 4" alliance framework aims to strengthen ties and ensure a stable supply chain for critical components.[42]

The upcoming AI Safety Summit, co-hosted by the RoK and the UK, focuses on safe and responsible AI development. It's a platform for international progress and knowledge sharing in the field of artificial intelligence (AI).

41 https://digital-strategy.ec.europa.eu/en/news/eu-and-republic-korea-digital-partnership-strengthening-our-economic-resilience

42 https://www.cfr.org/blog/strengthening-strategic-technology-cooperation-between-south-korea-and-united-states

Insight...

What is a chiplet?

A chiplet refers to a small, individual semiconductor die that is manufactured separately to perform a specific function, such as computing, memory, or input/output (I/O). These discrete chiplets can then be integrated with other chiplets into a single package, or onto a larger substrate using advanced packaging and interconnect techniques such as through-silicon vias (TSVs) and interposers, to create a larger and more complex integrated circuit (IC) or system-in-package (SiP).

The main advantage of chiplets is that they allow devices produced on different process nodes, and even using different semiconductor material technologies, to be combined into a single package. The optimum process for each function can therefore be used without compromising performance for the sake of cost reduction or using a more expensive process for basic functions where a lower-cost process is adequate. The integration techniques for combining chiplets can be 2D, 2.5D or 3D, although to date there have been no commercial 3D-ICs announced.[43]

43 **https://semiengineering.com/why-there-are-still-no-commercial-3d-ics/**

The use of chiplets also offers several other advantages:

- **Design flexibility:** Chiplets allow designers to mix and match different functional blocks or intellectual property (IP) cores to create customised SoCs tailored to specific applications or market needs.
- **Performance optimisation:** By using specialised chiplets for different functions, designers can optimise the performance, power consumption, and area (PPA) of the overall system.
- **Time-to-Market:** Chiplets can potentially accelerate time-to-market by enabling parallel development and testing of individual components. However there have been concerns that benefit this is being partially offset by the greater complexity of designing the overall SiP using EDA tools, which are still evolving to handle chiplets.
- **Cost reduction:** Chiplets can be manufactured using different process nodes, allowing designers to utilise the most cost-effective manufacturing processes for each functional block. Additionally, chiplets can be reused across multiple products, allowing development costs to be amortised.
- **Improved yield:** Since chiplets are less complex than monolithic chips, they typically have higher yields, resulting in lower overall manufacturing costs.

Chiplet-based architectures are increasingly being adopted for applications including data centres, AI, automotive, and consumer electronics, to address the need for solutions with the optimum balance of performance, power efficiency, and flexibility.

Semiconductor taxonomy, identifying the device types used in telecoms

('Semiconductors for Telecoms', UKTIN Semiconductor Expert Working Group (to be published))

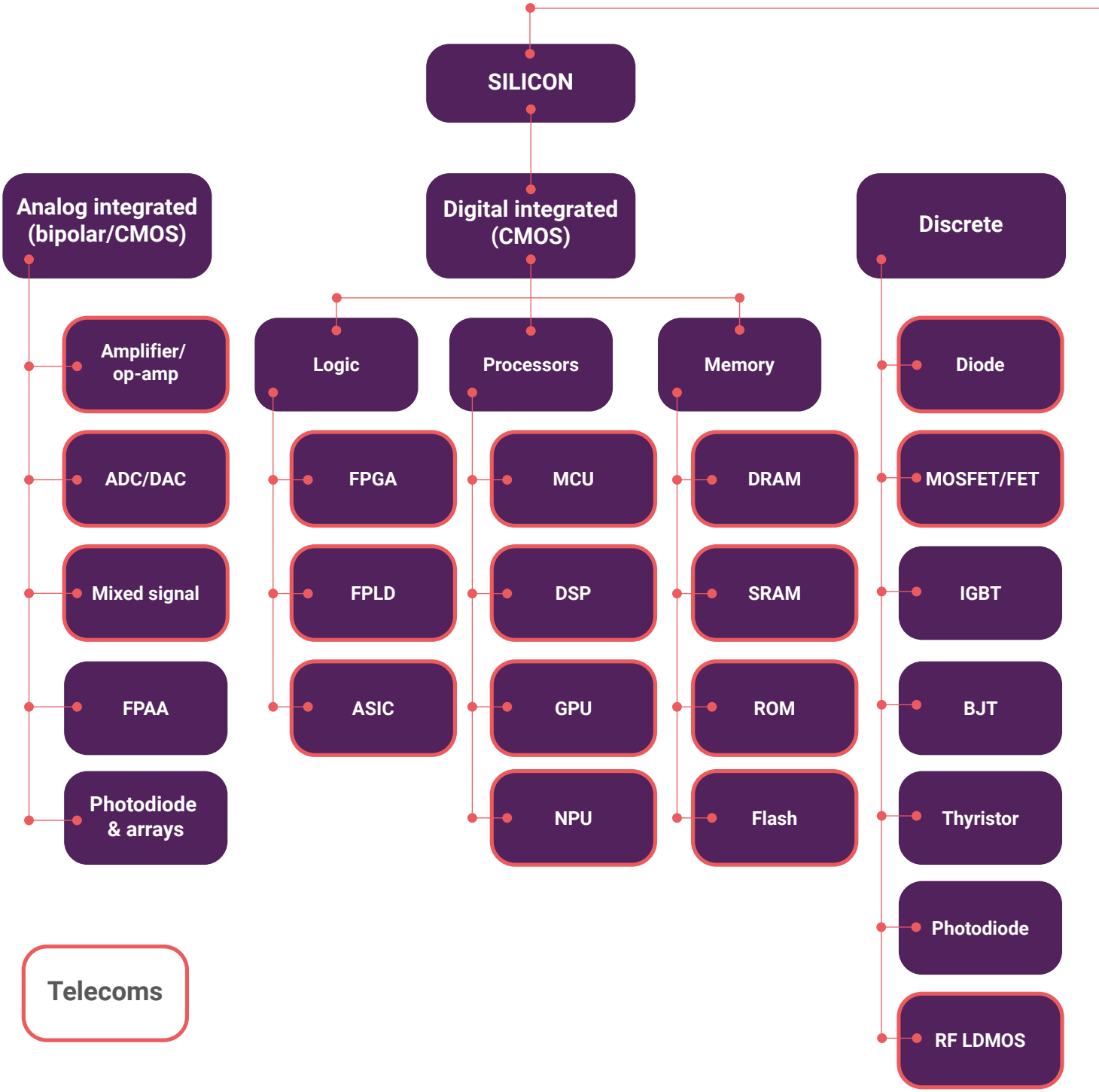
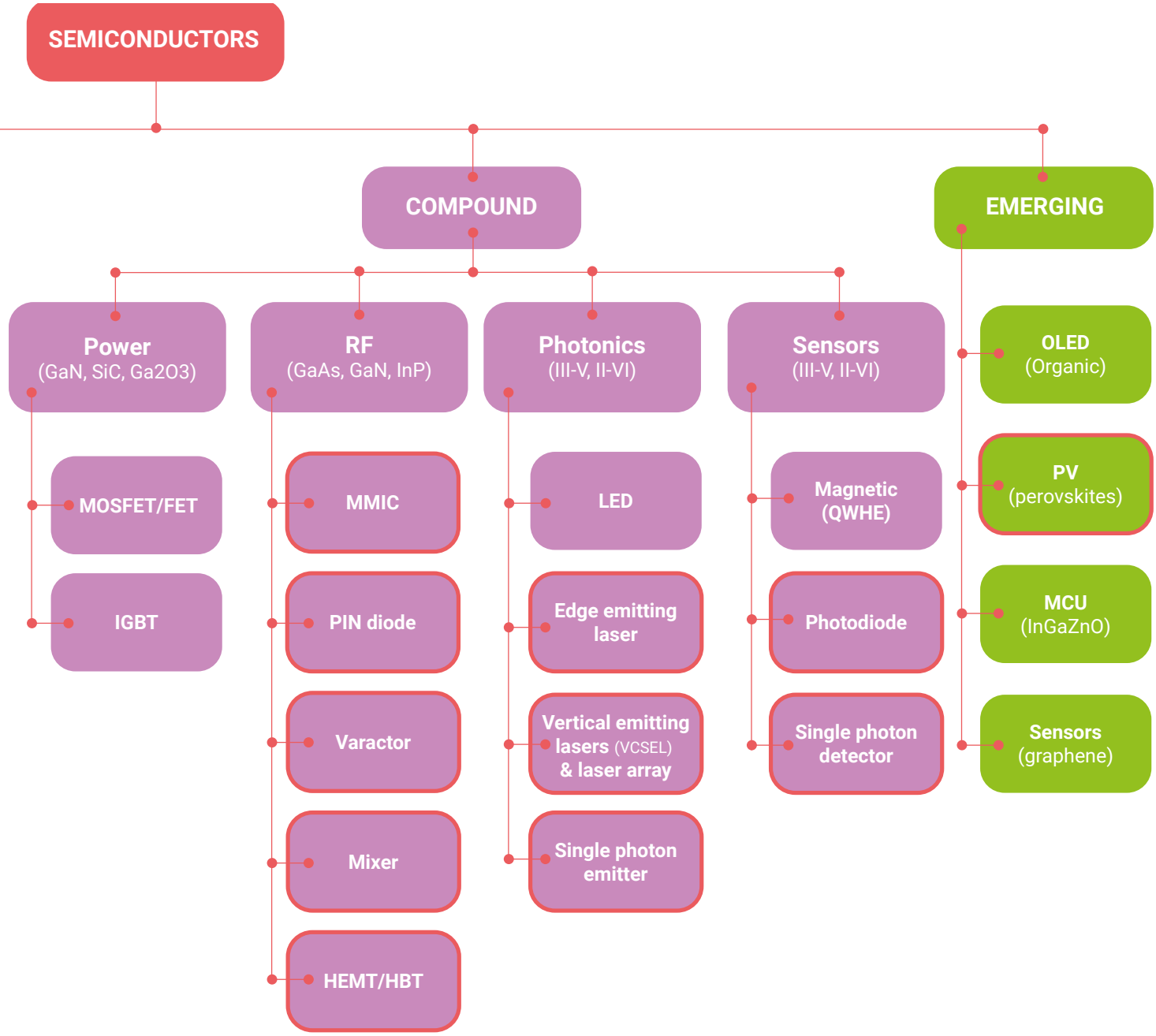


Figure 6: Semiconductor taxonomy, identifying the device types used in telecoms ('Semiconductors for Telecoms', UKTIN S



Semiconductor Expert Working Group (to be published))

06. Stakeholder Engagement

During the GEM week, the delegation had the opportunity to meet with some of the leading innovators in the field of semiconductor manufacturing and research.

Based on their extensive involvement in international collaboration, these stakeholders were carefully selected as future-looking innovative organisations in semiconductors, with a focus on manufacturing, design and PDK, compound and WBG semiconductors and advanced packaging.

The delegation engaged in detailed discussions with the innovators, exploring the latest trends and cutting-edge technologies being developed in the industry. They also had the chance to witness some of these technologies first-hand, gaining valuable insights into their potential applications and impact.

The overview of the key RoK organisations engaged during the GEM are as follows:

Samsung Electronics

Samsung Electronics is a RoK multinational company that specialises in the production of consumer electronics, semiconductors, and home appliances. The company is headquartered in Suwon, RoK, and is the world's largest manufacturer of smartphones and memory chips. Samsung Electronics offers a wide range of products and solutions for various applications such as mobile, PC, consumer, and automotive. The company has a strong focus on research and development and has been awarded numerous patents for its innovations. Samsung Electronics is also committed to sustainability and has implemented various initiatives to reduce its environmental impact.

Samsung Semiconductor[44] – a subsidiary of Samsung Electronics – consistently ranks as one of the top two semiconductor companies worldwide, and in 2023 had 7.5% of the global market (Source: Statista), despite seeing a US$40 billion drop in revenue that year in line with the reduction in worldwide memory sales. The company has a particularly strong focus on memory products: it is the global market leader in DRAM worldwide, with over 40% of the market in 2022. It now plans to pivot towards high bandwidth memory (HBM).

Samsung is also strong in foundry services, holding second place in the world after TSMC. They are planning the second generation of their 3nm node process using Gate-All-Around (GAA) by the end of 2024, and are also developing 2nm and 2.4nm nodes.

Power electronics is also a key focus for Samsung, and it has announced plans to open an 8inch (200mm) GaN foundry line in 2025, targeted at automotive power applications.

44 https://semiconductor.samsung.com/

SK Hynix

SK Hynix[45] is a RoK supplier of DRAM chips and flash memory chips. It is the world's second-largest memory manufacturer after Samsung, with around 30% of the market in 2022, and the world's third-largest semiconductor company. SK Hynix offers a wide range of memory and storage products and solutions for applications such as server, networking, mobile, PC, consumer, and automotive.

The growth in AI presents both opportunities and challenges for SK Hynix, particularly due to the closer interaction this requires between memory and CPU functions. In the longer term, they have expressed an interest in both photonic interconnects and quantum.

In March 2024[46] SK Hynix announced that it has begun volume production of its latest HBM for AI, HBM3E. HBM is a high-performance memory product that vertically interconnects multiple DRAM chips, dramatically increasing data processing speed compared with conventional DRAM products.

45 https://www.skhynix.com/
46 https://www.digitimes.com/news/a20240319PR200.html?chid=9

Korea Semiconductor Industry Association

The Korea Semiconductor Industry Association (KSIA)[47] is a private, member-based organisation established to promote the growth and development of the semiconductor industry in the RoK. KSIA plays a crucial role in this context by providing a platform for collaboration, networking, and promotion of the semiconductor industry.

Internationally, KSIA helps RoK semiconductor companies to expand their global footprint. This is achieved through international exhibitions and marketing activities, which allow member companies to showcase their products and technologies to a global audience. Furthermore, KSIA's activities support the global semiconductor supply chain, contributing to the overall growth and development of the global semiconductor industry.

47 http://www.industrykorea.net/web/ksia/landscape03.htm

Korea Institute for Advancement of Technology (KIAT)

The KIAT[48] is a quasi-governmental organisation under the Ministry of Trade, Industry and Energy in Korea. KIAT was established in May 2009 to promote the development of industrial technology in the RoK. The organisation provides various services to its members, including policy advocacy, research and development support, talent cultivation, and international technological cooperation. KIAT also acts as an industrial technology innovation funding agency to help create RoK's industrial and technological ecosystem.

Towards this aim, KIAT works to strengthen global cooperation by means of international R&D collaborations with overseas enterprises, universities, and research institutions.

KIAT runs an international joint R&D programme to cooperate and co-fund strategic development of core technologies, working with 14 countries including Germany, France, China & the UK. This currently includes a RoK-UK Bilateral Joint R&D programme to be administered on a 1:1 joint funding basis with Innovate UK. The areas of cooperation are: advanced materials; AI; and future mobility, with semiconductors newly added.

KIAT also participates in the European Technological Cooperative Platform, supporting multilateral joint R&D with 44 European member countries via EUREKA and Horizon Europe, having committed £11.4 million (19.2 bn KRW) to this programme between 2009 and 2020.

48 https://www.kiat.or.kr/eng/user/main.do

Korea Electronics Technology Institute (KETI)

KETI[49] is a research and development institute specialising in electronics and information technology under the Ministry of Trade, Industry and Energy (MOTIE) of the RoK. KETI has been a strong partner of small and medium-sized companies in the RoK since its establishment in 1991.

The SOC Centre at KETI is likely a part of the institute's research divisions. While specific information about the SOC Centre is not readily available, KETI's research divisions include IT Materials & Components Research Division, Semiconductor and Display Research Division, Smart Energy & Machine Research Division, Communications & Media Research Division, Convergence System Research Division, and Intelligent Information Research Division.

KETI is involved in various areas of technology, including Metaverse, AI, Lifecare, Full Automation, Industry 5.0, and Net-Zero. It has been leading the growth of the domestic electronics industry for the past 30 years.

SNU - Inter-university Semiconductor Research Centre Seoul National University

The Inter-University Semiconductor Research Center[50] is a research institution at Seoul National University[51] that specialises in semiconductor technology research. The centre was established in 1985 and has been a dominant incubator for semiconductor experts and leaders ever since. The researchers at the centre are continuously working on semiconductor processing technology, nano-device technology, and multimedia SoC design technology, to name a few. The centre provides various services to its members, including research and development support, policy advocacy, and international technological cooperation.

49 https://www.keti.re.kr/eng/main/main.php

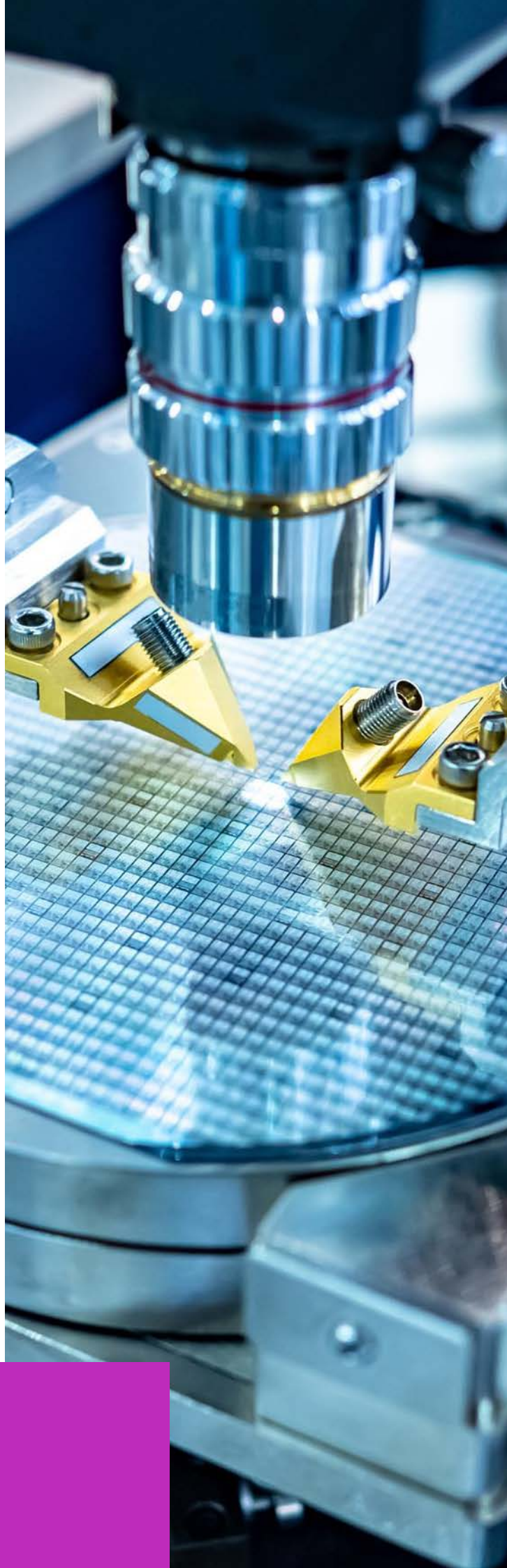
50 https://koreajoongangdaily.joins.com/2016/03/20/industry/Korea-fights-for-semiconductor-supremacy/3016443.html

51 https://en.snu.ac.kr/

National NanoFab Center (NNFC)

NNFC[52] is a state-run research institution in Korea that was established to promote and support nanotechnology research and development activities in the academic, research institutes, and industry. It is an affiliated institution of KAIST. The centre provides nanofabrication services and equipment to its users (industry, academia and R&D institutes), and acts as an industrial technology innovation funding agency. The 26,400m^2 facility includes 5,000m^2 of cleanroom and employs 238 personnel.

In 2021 the NNFC invested 45 billion won (US$38.7 million) in establishing a 300mm (12inch) semiconductor testbed to help speed up the localisation of semiconductor materials, parts, and equipment. The testbed is expected to help raise self-sufficiency in the country's semiconductor industry. The NNFC also organises events such as the annual "Semiconductor's Day" to celebrate the achievements of the semiconductor industry and to promote its status to the public.



52 https://www.nnfc.re.kr/eng/

Wide Bandgap Semiconductor Research Center, Kwangwoon University

Kwangwoon University[53] is a private university in Seoul, RoK that offers various courses in electronics and information engineering. The university's Department of Electronic Materials Engineering conducts research in silicon semiconductor, compound semiconductor, semiconductor devices, dielectric materials and devices, memory and electronics, integrated circuit design and experiments. The department aims to produce skilled engineers equipped with creativity and extensive knowledge in electronics devices and materials including semiconductors.

The university also has a number of research centres and laboratories that conduct research in various fields of electronics engineering, including the AQNMOL[54] (Advanced Quantum-Nano Materials and Optoelectronics Laboratory) and the RFIC/MMIC[55] Lab (Radio Frequency/Monolithic Microwave Integrated Circuits). The AQNMOL is dedicated to the development of green energy-based devices and technologies that consume less energy and produce less waste.

The RFIC/MMIC Lab carries out active research on RF integrated circuit design, microwave integrated circuit design, high-linearity analog circuit design in III-V Heterojunction Bipolar Transistors (HBT), III-V Field Effect Transistor (FET) and Complementary metal–oxide–semiconductor (CMOS), SiGe HBT technologies for various wireless applications. The university also has a number of research centres and laboratories that conduct research in various fields of electronics engineering, including the AQNMOL (Advanced Quantum-Nano Materials and Optoelectronics Laboratory) and the RFIC/MMIC Lab (Radio Frequency/Monolithic Microwave Integrated Circuits) applications.

53 https://www.kw.ac.kr/en/index.jsp
54 http://aqnmol.or.kr/
55 https://ee.kw.ac.kr/ENG/research_center/laboratory_rfic.html

Electronics and Telecommunication Research Institute, (ETRI)

ETRI[56] is a research institute in Korea that specialises in wireless communication technology. ETRI has over 2,500 patents filed and has developed technologies such as ship-area network technology, portable automatic language interpretation, and automated valet parking technology. The institute has about 2,000 employees, of which about 1,800 are researchers. ETRI provides various services to its members, including research and development support, policy advocacy, and international technological cooperation. The organisation also acts as an industrial technology innovation funding agency and creates Korea's industrial and technological ecosystem.

Korea Research Institute of Standards and Science (KRISS)

KRISS[57] is the national measurement standards laboratory for the RoK. It is a government-funded institute responsible for providing national measurement standards and advancing measurement technologies, with an operating budget of US$153 million and employing 507 personnel.

KRISS was established in 1975 as the Korea Standards Research Institute, and initiated calibration services in 1979. The institute became known as the Korea Research Institute of Standards and Science in 1991. In 1999, KRISS was officially designated to serve as the national metrology institute by the Framework Act on National Standards (Article 13). It maintains the RoK's primary measurement standards.

KRISS already has a strong working partnership with NPL, established under a MoU signed in 2002 and regularly renewed since then.

56 https://www.etri.re.kr/eng/main/main.etri
57 https://www.kriss.re.kr/eng/

Ministry of Trade, Industry and Energy (MOTIE)

MOTIE[58] is a ministry under the Government of the RoK that regulates economic policy, especially with regard to the industrial and energy sectors. The ministry also works to encourage foreign investment in Korea. MOTIE was established in 1948 as the Ministry of Trade and Industry (MTI) with the mission to coordinate the nation's industries. In 1993, MTI was merged with the Ministry of Energy and Resources to create MOTIE. The ministry provides various services to its members, including policy advocacy, research and development support, talent cultivation, and international technological cooperation. MOTIE also acts as an industrial technology innovation funding agency and creates Korea's industrial and technological ecosystem.

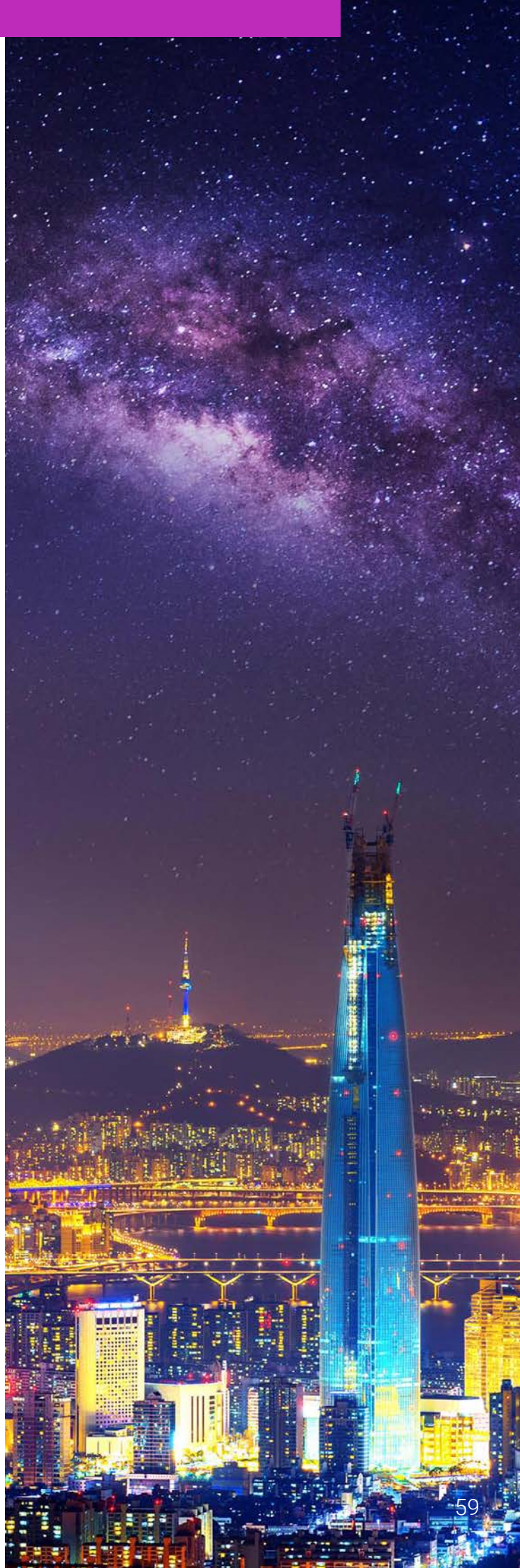
Ministry of Science and ICT (MSIT)

MSIT[59] is a government agency in the RoK responsible for setting, managing, and evaluating science and technology policy, supporting scientific research and development, and overseeing the information and communications technology (ICT) industry. MSIT is also involved in planning national computerisation[60] and information protection strategies. In the semiconductor field, MSIT has shown significant interest, as evidenced by their announcement of the "Semiconductor Future Technology Roadmap" and the establishment of the "Semiconductor Future Technology Public-Private Collaborative Group" to share the technological trends of major semiconductor companies and their R&D achievements. They aim to secure future core technologies, maintain a leading edge in semiconductor technology, and secure a new edge in system semiconductors.

58 https://english.motie.go.kr/eng/contents/3
59 https://www.msit.go.kr/eng/contents/cont.do?sCode=eng&mPid=19&mId=20
60 https://jps.scholasticahq.com/article/21502

Korea Advanced Institute of Science and Technology (KAIST)

KAIST[61] was established by the Korean government in 1971 as the country's first public research-oriented science and engineering institution. KAIST is considered to be the top science and technology university in the RoK, and it has two campuses in Daejeon (one of which houses the NNFC) and one campus in Seoul.



61 https://www.kaist.ac.kr/en/

Korea Evaluation Institute of Industrial Technology (KEIT)

KEIT[62] is specialised institution in the RoK that focuses on the planning, evaluation, and management of industrial technology R&D. KEIT aims to lead the tide of technological innovation and recreate Korea into a technology-led giant. They enhance their R&D planning capabilities with a focus on the marketability, creativeness, and ambitiousness of technologies.

In the semiconductor field, while specific programmes or initiatives by KEIT are not explicitly mentioned in the search results, the overall goal of KEIT to enhance Korea's technological competitiveness would naturally extend to the semiconductor industry, given its importance to Korea's economy and global technology infrastructure.

62 https://www.keit.re.kr/index.es?sid=a2

Next-generation Intelligence Semiconductor Foundation

The Next Generation Intelligence Semiconductor Foundation[63] in Korea is part of a nationwide effort to advance the AI semiconductor industry. The foundation is involved in research and development of advanced AI semiconductor technology.

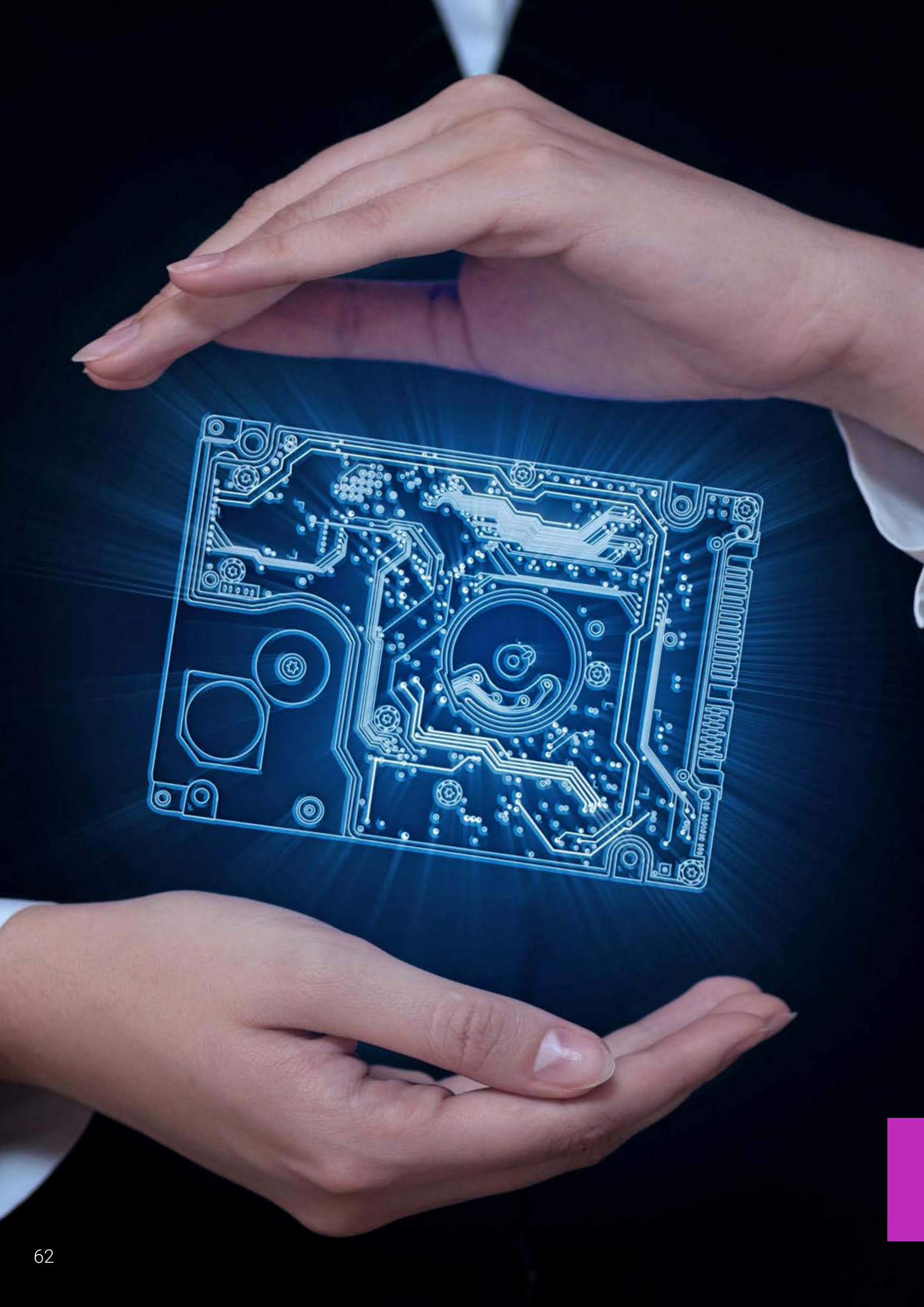
The RoK's government has launched the K-semiconductor strategy, aiming to build the world's best semiconductor supply chain by 2030 with a US$450B investment plan. The strategy includes stabilising and internalising the semiconductor supply chain by gathering fabless, foundry, and packaging companies in a clustered area called the K-Semiconductor Belt.

The foundation is also involved in fostering more than 7,000 artificial intelligence semiconductor experts. They are investing KRW 5 trillion over the next five years in AI semiconductor advanced technology research.

The foundation's work is part of the RoK's broader efforts to become a comprehensive semiconductor powerhouse by pre-empting the emerging AI semiconductor market. This includes efforts from the government, major companies, fabless start-ups, and academia.

The foundation is chaired by Sungwook Park, who is also an advisor for SK Hynix. The foundation's work is crucial in the rapidly evolving semiconductor industry, where AI technology can potentially increase productivity up to 10 times.

63 https://nis2030.org/



07. Collaboration Opportunities

A partnership in semiconductors between the UK and the RoK is crucial for achieving the UK's ambitions and ensuring that both countries remain at the forefront of research and innovation, and the stakeholder meetings during the mission found that the UK and the RoK have a shared interest in identifying areas of potential collaboration between UK innovators and RoK partners. The following details captured areas of mutual interest for future collaboration.

Opportunity 1

Custom Design and Fabless for Integrated Device Manufacturer (IDM) and Foundry technologies

UK companies have the potential to assist the manufacturing process of key companies in the RoK, such as Samsung and SK Hynix. The RoK has a rich background in silicon and memory design, but it could benefit from the UK's design capabilities in newer semiconductor materials like compound semiconductors, including WBG. The UK is well-known for its strong IP and innovative design, along with fabless SMEs and start-ups in semiconductor device technology. The UK has the potential to complement the RoK companies in IDM and foundry technologies.

Opportunity 2

Compound Semiconductor Technology Consultancy

The UK has a strong history in materials design, specifically with GaAs and InP, and is also developing capabilities with GaN and Silicon Carbide (SiC) for advanced product design and prototyping.

These materials can be applied in photonics, RF and power devices for various applications such as telecommunications, automotive and the power. The UK has an opportunity to share its knowledge and innovative IP, particularly in compound semiconductor materials (including WBG materials) and packaging techniques, for example to improve thermal efficiency in power electronics devices. UK capabilities would be synergistic in supporting the creation of the RoK semiconductor mega-cluster project, which will include the commissioning of an 8-inch GaN foundry by Samsung Electronics in 2025.

RF, wireless and photonics devices using compound semiconductor technology are also key components in future telecoms and smart networks – see **Insight: Hardware for Artificial Intelligence.**

Opportunity 3

Heterogeneous Integration and Advanced Packaging

The UK and the RoK have a shared interest in heterogeneous integration, which involves integrating components manufactured using different technologies. The UK's custom design fabless capabilities and the RoK's fabs create an opportunity for both countries to address new markets. For instance, by creating combinations of photonic, compound semiconductors, analogue ICs, ASICs, and memory on the same substrate or in the same package, they could create the next generation of semiconductor devices for telecommunications.

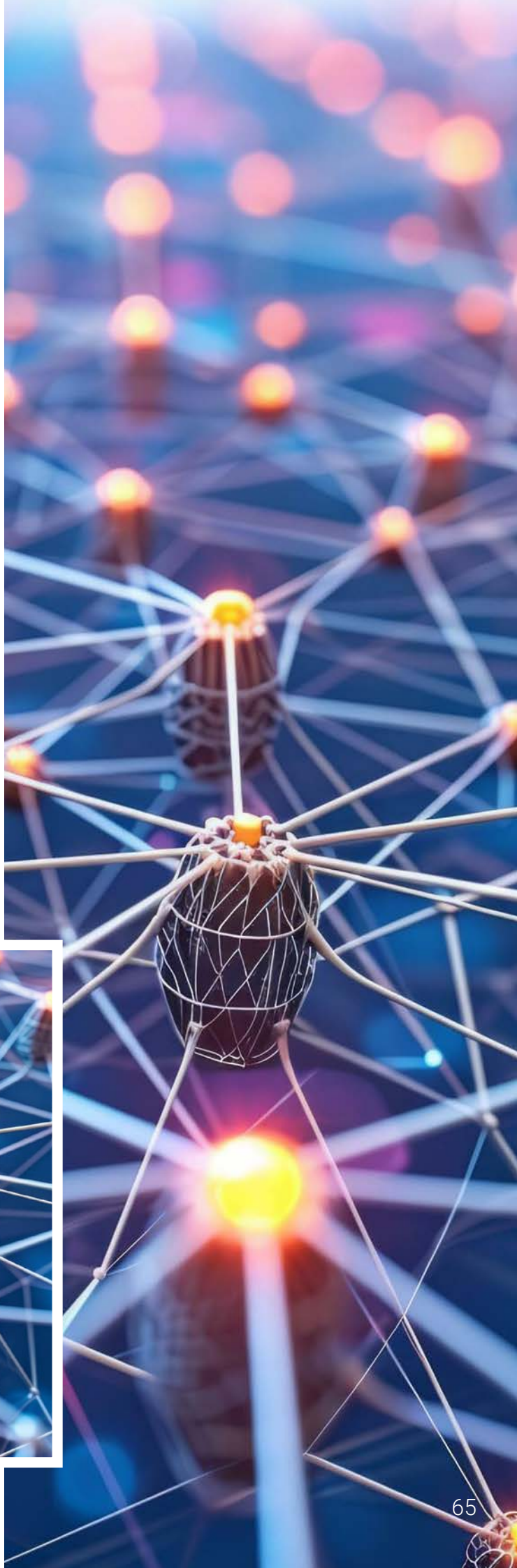
There has been a significant shift in semiconductor architectures, which presents a UK design opportunity for evolving hardware and developing further advanced packaging techniques. UK design consultancies could collaborate with research institutes such as ETRI, which is working on GaN MMICs and heterogeneous 3D photonic/electronic integration.

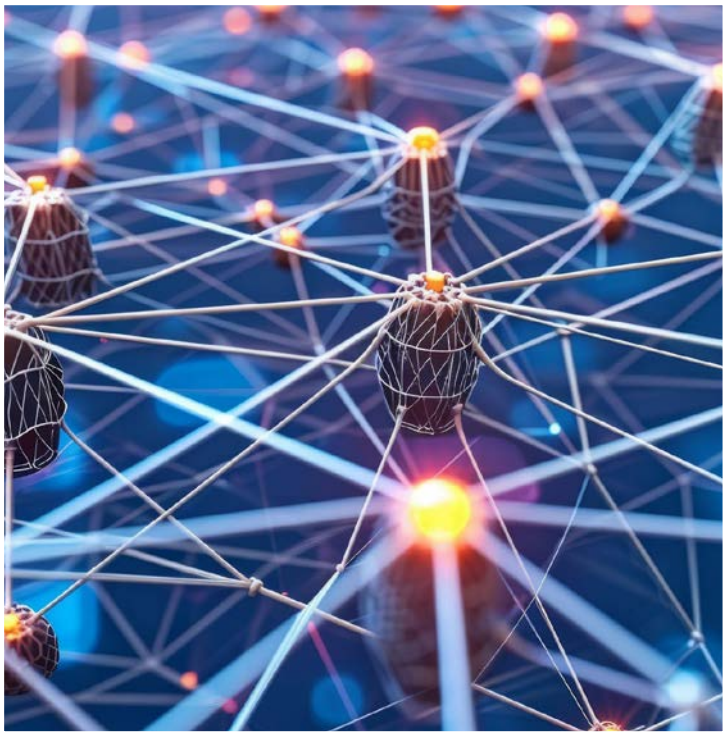
The RoK is interested in hybrid bonding and using chiplets to maximise the capabilities of current semiconductors, and these are areas where the UK could bring expertise and capability through its proposal. Samsung, SK Hynix and LG are all active in the Universal Chiplet Interconnect Express (UCIe) ecosystem, which is working to set the third standard for connecting chiplets.

Opportunity 4

Development of the next-generation memory

AI is currently a major application focus in the UK, and could potentially provide support to the RoK. The RoK is currently working on optimising memory for AI training and inference. The UK has start-ups that are developing third-generation technologies, including processors in memory, which could be of great interest to the RoK companies such as SK Hynix. SK Hynix is currently focusing on third-generation technology, but still relies on second-generation architecture in production.





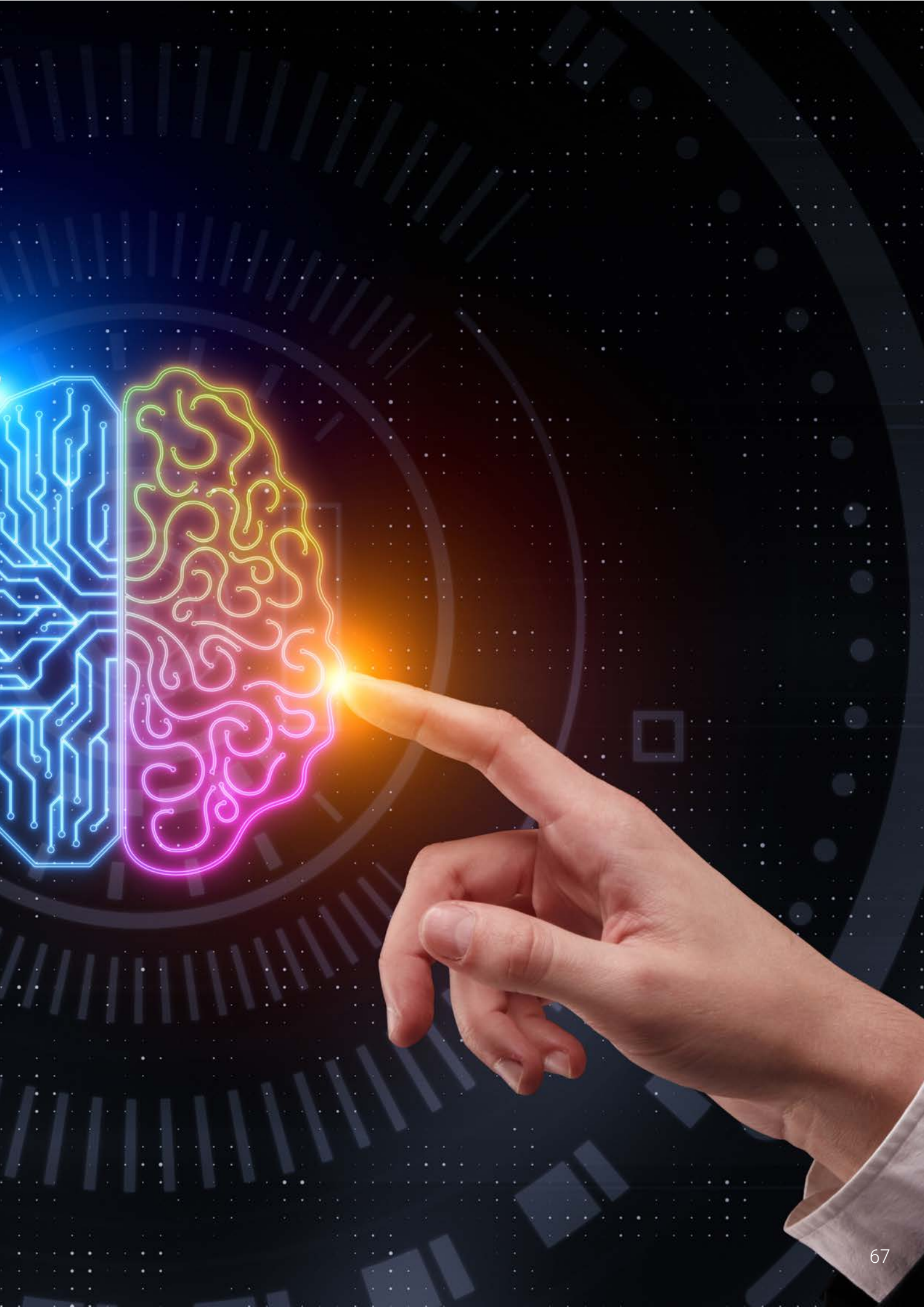
Insight...

Hardware for AI

There are two fundamental processes in the development and deployment of AI systems: AI inference and AI training.

Training is the process of teaching an AI model to perform a specific task or make predictions based on input data. During training, the AI model learns to recognise patterns and relationships in the data through the use of algorithms and mathematical optimisation techniques. This involves collecting a large amount of relevant data, which may include images, text, sensor readings, or other types of information relevant to the task the AI model will perform. This is then pre-processed to make it suitable for input to the AI model. Different types of AI models may be used, but Large Language Models (LLM) are becoming increasingly important, and these reference a huge amount of data, making it a task that demands huge computational resources to run the optimisation algorithms used to train the model.

Once the AI model has been trained, it can be deployed and used in real-world scenarios to make predictions or decisions based on new, unseen data, without further modification. This process is known as AI inference. These systems need to be scalable in order to process large volumes of data in real-time or near-real-time. Because of the size of the data being processed, inference systems require semiconductor devices that make the most efficient use of computational resources. These devices include Graphical Processing Units (GPU), Tensor Processing Units (TPU) and specialised hardware accelerators.



Opportunity 5

Photonics and radio frequency

One of the laboratories that make up the RoK Research Institute, ETRI, conducts extensive research in telecommunications and related semiconductor technology for photonic and wireless devices, such as optical components for telecoms networks, infrared and light detection and ranging (LiDAR) sensors for automotive, GaN RF and power devices for radar and 5G/6G, and thin GaN optoelectronic devices for microLEDs and EV.

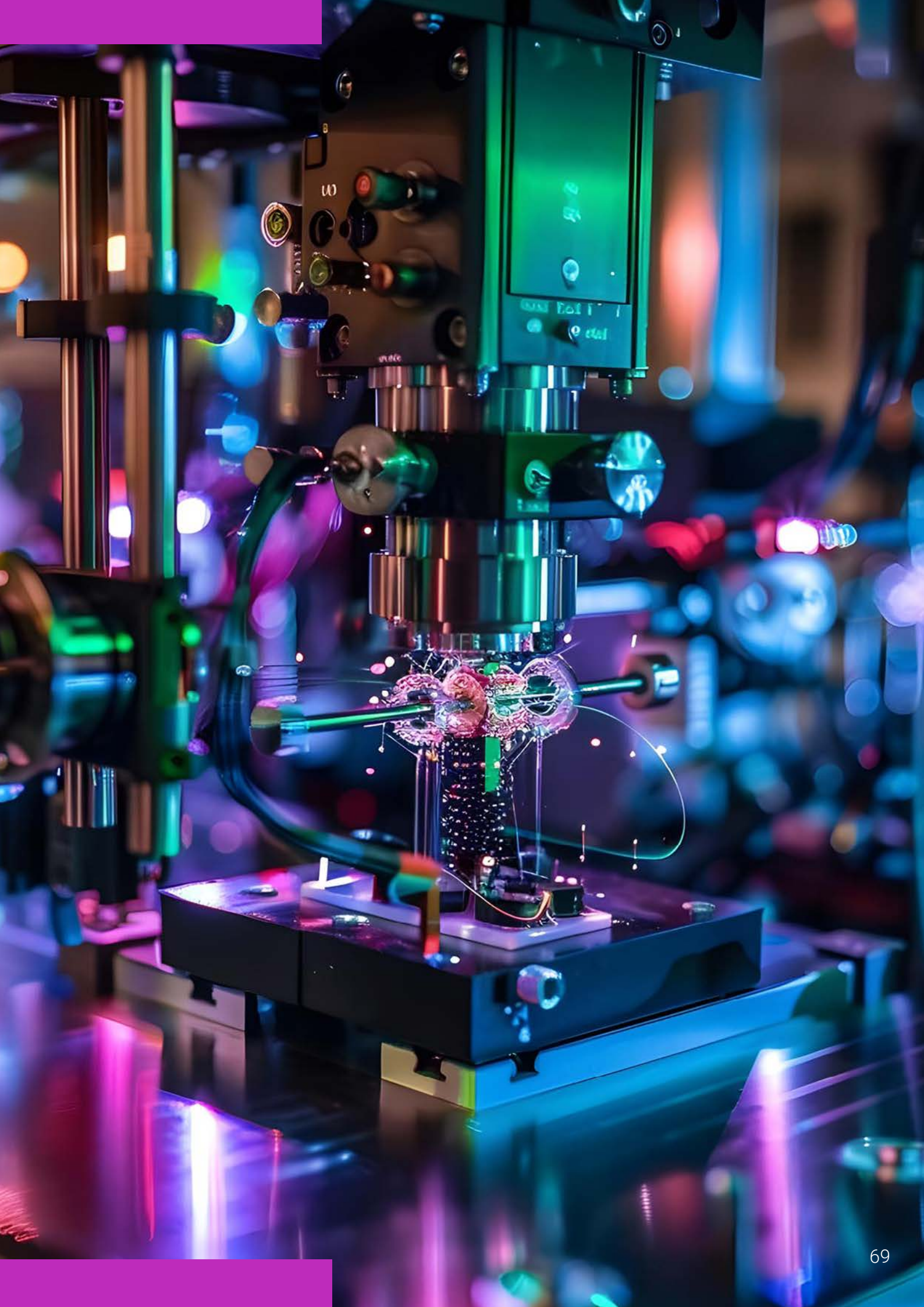
Recently, an MoU has been established between Photonic Leadership Group (PLG) and the Optical Society of Korea (OSK) to support collaboration between the RoK and the UK, facilitating the development of new products and solutions for the market. This collaboration presents a strategic opportunity for both countries. For instance, in 2022, a joint call was made to establish global leadership in the priority area of open radio access network (OpenRAN) power efficiency, where the UK already has significant expertise.

Opportunity 6

Testing and Metrology

Collaboration is necessary to update or create reference samples for calibration, as the current ones were developed several decades ago and are not representative of present semiconductor metrology needs.

There is a clear opportunity to strengthen the relationship with RoK research centres and the International Organization for Standardization Technical Committee 201 (Surface Chemical Analysis) (ISO/TC201) by developing and publishing a roadmap for the standardisation of nanoscale techniques for semiconductors. This would involve pre-standards research in nanoscale metrology to identify key measurement challenges in the semiconductor industry. The goal is to characterise and validate semiconductor devices, from device physics to electrical measurement.



Opportunity 7

Skills and Education

Despite the RoK higher education system being well geared towards fulfilling workforce needs, a 100,000 workforce shortfall is expected over the next few years. There is an opportuntiy to work with the UK, particularly in areas such as compound semiconductors, advanced materials, and design, where native expertise in the RoK is limited. Academic research in the UK could lead to significant innovation in the semiconductor industry, which could benefit the RoK.

Both the RoK and UK academics are interested in promoting international exchanges to improve education via UK lecturers and postgraduate exchange programmes for short course delivery at the university.

Opportunity 8

Entry to the Ecosystem

Large companies have already established fully localised R&D departments in various regions. However, there is still room for collaboration between smaller and Tier 2 companies in the UK and the RoK or via local representation in areas such as new memory architectures, materials, and photonics. This collaboration can help these companies gain entry into the future ecosystem in the RoK, with a focus on research and design rather than production. Additionally, the Mega-Cluster plan presents new opportunities for interested parties to join in.

Opportunity 9

Telecom R&D

There is a strong R&D presence in the UK telecom industry. Collaborations between the two countries can be created to address applications beyond 5G and 6G. Including energy-efficient modules, next-generation cellular networks, free-space telecommunications, wireless back-haul, co-packaged optics for space telecommunications (one of UK's strengths with regional clusters like Spacewest), creating significant new opportunities and new challenges requiring compound semiconductors (UK's strengths).

Future AI approaches will require technologies beyond CMOS, leading to spiking neuromorphics, analogue-optical-quantum compute – areas for fertile collaboration between the UK and the RoK. Finally, working with the RoK and other nations can strengthen the coordination efforts on telecoms security, resilience and innovation.

Insight...

Semiconductor devices for telecoms

The UK introduced its 5G Supply Chain Diversification Strategy in 2020,[64] which lays out a plan to expand the telecoms supply chain while ensuring it is resilient to future trends and threats. Three core strands are identified: supporting incumbent suppliers; attracting new suppliers into the UK market; and accelerating the development and deployment of open-interface solutions – specifically Open radio access network (RAN), for which the government set up a series of initiatives aimed at boosting investment in the wireless R&D ecosystem. Semiconductor devices clearly form a pivotal element of the telecoms supply chain.

Future telecoms has also been identified in the UK Semiconductor Strategy[65] – along with semiconductors itself – as one of the five 'technologies of tomorrow' that are critical to the UK's economic and national security and to securing strategic advantage on the global stage. **Figure 6** (see over) identifies the types of semiconductor devices that are widely used in telecoms applications.[66]

Of these, the ones coloured purple are compound semiconductor (CS) devices (RF, photonics and sensors), while those in blue are silicon devices, including processors, memory, logic and analogue/mixed signal. The UK has significant IP and design capability in most of these categories, and also some CS manufacturing capability.

64 https://assets.publishing.service.gov.uk/media/646626780b72d3001334476d/national_semiconductor_strategy.pdf

65 https://assets.publishing.service.gov.uk/media/646626780b72d3001334476d/national_semiconductor_strategy.pdf

66 'Semiconductors for Telecoms', UKTIN Semiconductor Expert Working Group (to be published)

Unlike silicon, which is an element in group IV of the Periodic Table, compound semiconductors are made up of two or more elements from adjacent groups, typically III-V compounds like gallium arsenide (GaAs), gallium nitride (GaN) and indium phosphide (InP), and less commonly II-V compounds.

Heterogeneous materials integration, advanced process technology and chip-level integration are the major challenging domains for the next generation of semiconductor technology for future telecoms. Since the late 1970s, III-V CS materials have been recognised as offering superior performance for high frequency and optoelectronics applications – and more recently also for high power electronics. III-V devices are now being used for advanced 5G communication systems, and for microwave and millimetre-wave satellite (satcoms). Photonics CS devices are also used in fixed telecommunications (fibre optics) and in the backbone of mobile networks.

Advanced RF Complementary Metal-Oxide-Semiconductor (CMOS) and CS programmes are required to focus on critical parts of the 5G infrastructure: the analogue electronics that provide the interface between the digital hardware and the antennas. The CS devices used in the infrastructure are mainly GaN devices, but Si RF laterally-diffused metal-oxide semiconductor (LDMOS) are also still used in the transmitter chain of base stations. In addition CS devices are used in the terrestrial and non-terrestrial networks for wireless mobile backhaul – connecting the radio access network (RAN) back to the core network. RF, millimetre-wave and microwave devices also find uses in mobile handsets, where both GaAs and low-power CMOS devices are deployed.

Challenges identified at the system level guide decisions on the semiconductor and packaging technology side, and vice versa. Compound semiconductors can be combined with silicon in cost-effective ways. A global heterogeneous integration approach is needed comprising the active electronics – analogue, digital, and even photonics – as well as components like antennas and heat sinks.

08. Barriers to Collaboration

The top four challenges identified during the GEM were:

Challenge 1

The self-sufficiency of the RoK semiconductor sector

The large business conglomerates and universities in the RoK seem to be self-sustaining. They prefer to develop their technology and innovation without seeking help from external sources. IP is closely guarded, making it difficult to form business partnerships with top-tier companies. The process of building relationships and forming social capital is crucial in this context. This self-sufficiency is evident even in the field of GaN (gallium nitride), where little information is shared despite the UK's expertise in this area.

For semiconductor manufacturing equipment and raw materials, the RoK is seeking to increase its autonomy and reduce imports.

Challenge 2

Perception and lack of clarity about the UK offering and capabilities

The RoK has established partnerships with the USA and India, along with IMEC in Belgium. However, some in the RoK perceive UK semiconductor industry stakeholders as being relatively small and find their offerings unclear. The RoK collaborates more extensively with European countries that possess foundry capabilities, as well as countries that can help them access new markets.

Challenge 3

Export Control and the National Security Bill

Collaboration between the UK and the RoK on semiconductor R&D for innovation and academic purposes may face challenges due to export controls from both countries. Researchers and institutions involved in joint projects may encounter restrictions when sharing certain semiconductor-related knowledge, technologies, or materials. Export controls could limit the exchange of research findings, collaborative experiments, and access to cutting-edge semiconductor technologies.

Challenge 4

Building relationships can be a lengthy endeavour

The semiconductor industry in the RoK is thriving, and it is built on strong relationships. However, building and maintaining new relationships requires patience, cultural awareness, and a long-term commitment. In the RoK business culture, personal relationships are highly valued. Trust is established through face-to-face interactions, shared meals, and social events. These cultural norms demand patience and persistence, and it is important to remember that RoK companies often have hierarchical structures. Decision-making processes involve multiple layers of management, and building relationships in this environment requires understanding and adaptability.


EMT9-3310-007
Characteristics:
Rated Output 370
Rated Torque 1.337
Input 120-230
Current 5.3
Speed 4300
Weight 0.97

09. Conclusion

Semiconductor manufacturing accounts for 9.7% of the RoK's GDP, and the country is consistently ranked second in the global semiconductor market, with a 17.7% share in 2022. It is also the world's largest manufacturer of memory chips, with a 60.5% share of the global market.

The Semiconductor GEM visited Seoul, RoK in February 2024, with the dual purpose of identifying areas of potential collaboration between UK innovators and RoK partners on semiconductor R&D and to also determine how Innovate UK can support UK businesses in establishing innovation partnerships there.

The team of experts from industry and academia, along with representatives of Innovate UK engaged RoK's key stakeholders, including the country's leading semiconductor manufacturers, academic bodies and research institutions, to explore the semiconductor landscape and to discuss the potential for future collaboration in semiconductor innovation between the UK and the RoK.

In summary, the GEM found that the UK and the RoK have a shared interest in heterogeneous integration; the UK's custom design fabless capabilities and the RoK's fabs create an opportunity for both countries to address new markets, and the significant shift in semiconductor architectures presents the UK with an opportunity for evolving hardware and developing further advanced packaging techniques.

The GEM extends its gratitude to the RoK and all the organisations, companies, and individuals who kindly welcomed the team of UK experts from industry and academia.


System
Measure Setting
Work Data

10. Annex 1 – List of UK Participants

Alter Technology TUV Nord / iMAPS
Blueshift Memory
Compound Semiconductor Applications Catapult
Dalrada Technology / National Microelectronics Institute
Innovate UK Business Connect
National Physical Laboratory
Singular Photonics / Photonics Leadership Group
University of Sheffield / EPSRC National Epitaxy Facility

Technical writer: Helen Duncan, MWE Media Ltd

CONTACT

Dr. Géraldine Durand
Knowledge Transfer Manager
Global Expert Mission- Mission Lead
geraldine.durand@iuk.ktn-uk.org

Dr. Sven Knowles
Knowledge Transfer Manager
Industrial Technologies
sven.knowles@iuk.ktn-uk.org

Innovate UK, part of UK Research and Innovation (UKRI), is the UK's innovation agency.

It works to create a better future by inspiring, involving and investing in businesses developing life-changing innovations. Its mission is to help companies to grow through their development and commercialisation of new products, processes and services, supported by an outstanding innovation ecosystem that is agile, inclusive and easy to navigate.

For more information visit ukri.org/councils/innovate-uk/

Follow us

Telephone: 01793 361000
Email: support@iuk.ukri.org
ukri.org/councils/innovate-uk/