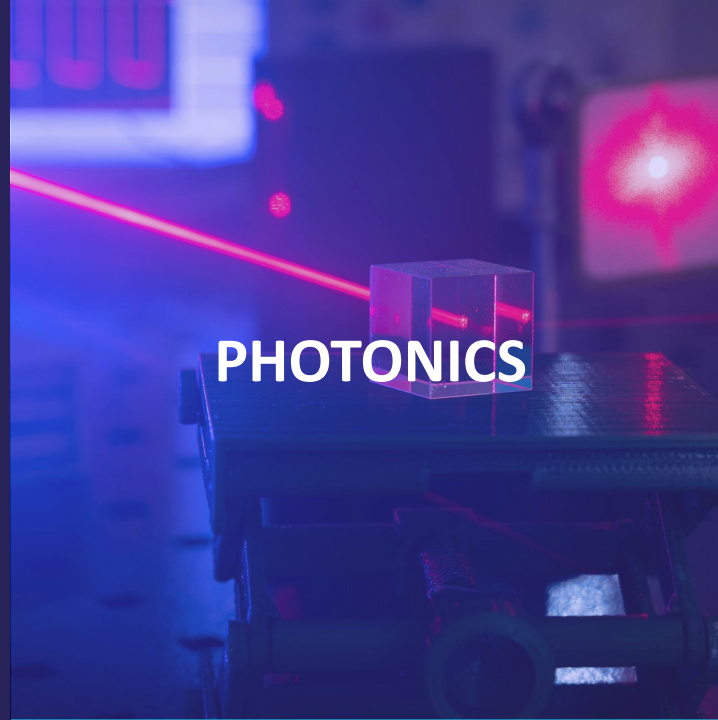




Scotland's
Critical Technologies
Supercluster

The four critical technologies



What makes these technologies critical?

Produce high levels
of export income

Vital for our
security, defence
and economic
independence

Generate secure,
well-paid
employment for the
future

Secures the supply
chain for our
advanced industries

Enables smarter
cities, transport and
energy networks

Essential for
drive to net-zero
e.g., environmental
monitoring and efficient
low-carbon
infrastructure

Critical technologies for...healthcare

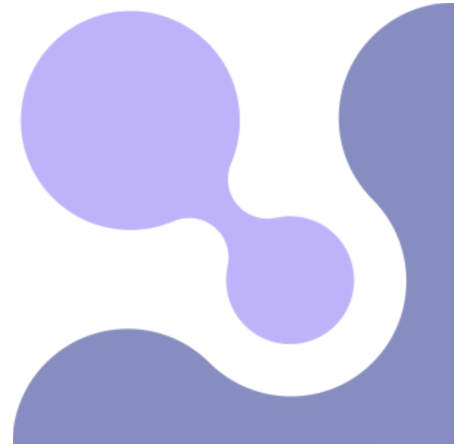
- **Medical imaging** - quantum enabled techniques allow imaging through human tissue, providing an opportunity for cheaper, more portable non-invasive diagnostics.
- **Wearable devices** – critical technologies underpin functionality in fitness trackers and medical sensors that enable early detection of issues before they become emergencies.
- **Laser and robotic surgery** - advances in laser surgery and robotics techniques are improving outcomes of complicated surgical procedures.
- **Diagnostics** – photonics sensors are used to identify key markers in biological samples, allowing early detection of serious illness including cancer.
- **Remote monitoring** – advancements in connectivity and sensing are allowing continuous real-time monitoring of patient data, reducing the need for frequent healthcare visits.



Critical technologies for... communications

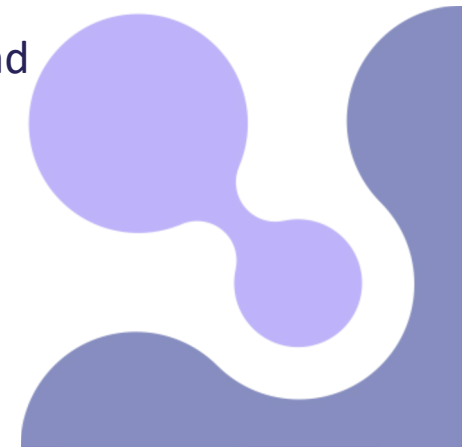


- **Mobile phones** – from displays and camera systems to facial recognition and wireless charging, our smart phones are littered with devices underpinned by critical technologies.
- **High speed internet** – optical fibres use light to transfer data over long distances at high speed, offering significant speed and bandwidth advantages over traditional copper cables.
- **Data centres** – the backbone of our data economy could not exist without critical technologies and advances in these technologies will improve their efficiency in future.
- **Wireless communications** – our demand for ubiquitous connectivity will be met by a range of communications services, including WiFi, LiFi, 5G/6G and satellite.
- **Security** – quantum cryptography, including Quantum Key Distribution (QKD), will secure our communications, ensuring our sensitive data is protected from malicious interference.



Critical technologies for...space

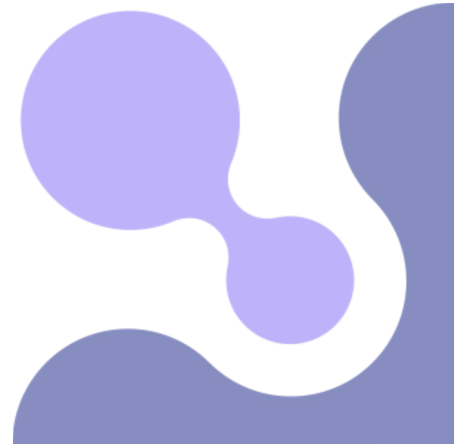
- **Earth observation** – imaging technologies are improving the way we observe our planet, supporting climate monitoring, disaster response and transport management.
- **Satellite communications** – semiconductors are essential for transmitting and receiving weak signals over the vast distances between satellites and ground stations.
- **Weather forecasting** – advanced optical systems allow multi-wavelength imaging of the earth's atmosphere, oceans and land masses to support highly accurate weather forecasting.
- **Security** – quantum encryption will secure vital communication lines between satellites and ground stations, ensuring sensitive military and civilian data is protected from interception.
- **Navigation** – atomic clocks provide extremely precise time signals for Global Positioning Systems (GPS) that support navigation through your smart phone and other devices.



Critical technologies for... sustainability and climate change

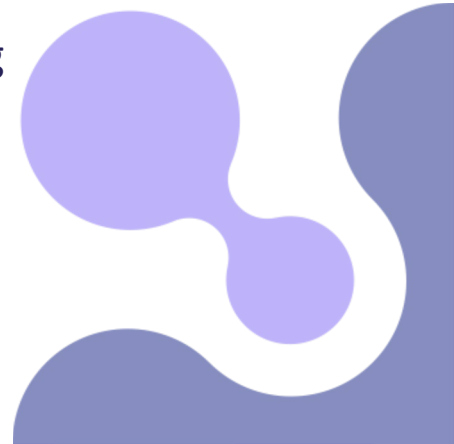


- **Electric vehicles** – semiconductors are driving our electric revolution by facilitating the conversion of battery energy to power electric vehicle motors.
- **Environmental monitoring** – photonics technologies enable accurate monitoring of air and water quality by identifying trace levels of pollutants and greenhouse gases.
- **Agriculture** - vertical farming is securing our future food supply by creating regulated, indoor environments that allow optimised food production in any location.
- **Renewable energy** – advanced semiconductor materials manage the flow of electricity from renewable sources to the grid, allowing seamless integration of multiple energy sources.
- **Recycling** – optical sorting uses lasers and camera systems to identify the structural and chemical properties of materials to allow more efficient recycling of plastics.



Critical technologies for...robotics

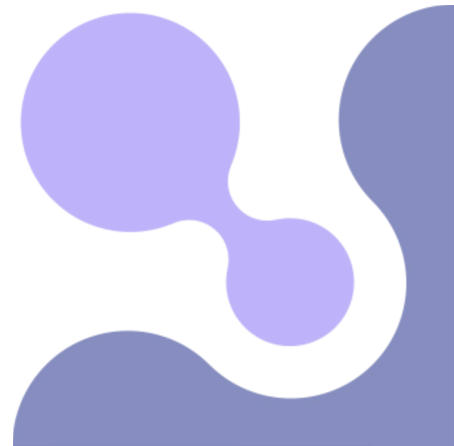
- **Perception** – imaging and sensing systems allow robots to interpret the world around them, providing the ‘eyes’ of our future automated systems.
- **Robotic networks** – advances in high-speed communication technologies are allowing robots to communicate more effectively, creating ‘automated teams’ that can work on shared tasks.
- **Movement/speed** – semiconductors underpin rapid data processing and real-time feedback that allows precise movement control for advanced manufacturing applications.
- **Safety** – critical technologies are vital to the safe implementation of robotic systems, underpinning sensing systems that allow robots to work safely alongside human partners.
- **Security** – quantum encryption will secure robotic networks, ensuring that potentially dangerous systems are protected from malicious interference.



Critical technologies for... quantum applications



- **Medical imaging** – quantum enabled techniques allow imaging through human tissue, providing an opportunity for cheaper, more portable non-invasive diagnostics.
- **Object detection** – quantum sensors offer an opportunity to ‘see’ where we are currently unable, including underground surveying and poor weather navigation.
- **Cyber security** – quantum encryption will underpin our future cyber resilience, securing communication networks vital to our national security and critical infrastructure.
- **Drug discovery** – quantum computers will allow rapid modelling of biological systems and molecular interactions, greatly accelerating the development times of lifesaving medicines.
- **Timing** – quantum clocks will vastly improve timing accuracy, a vital consideration in applications such as financial transactions and navigation systems for autonomous vehicles.



Technical synergies

Photonics is essential to implementing most quantum systems

Semiconductor lasers and control chips are used in most photonic systems

Connectivity technologies, quantum key distribution and photonics are all necessary for next generation secure communications

Quantum computer qubits are often fabricated using semiconductor processing technology

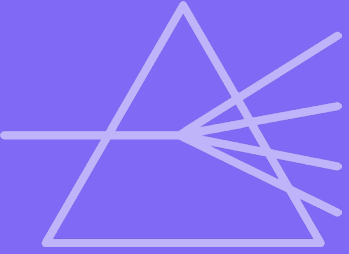
All sensing systems use semiconductors for signal processing and protocol management

Ecosystem synergies

Similar expertise across a highly skilled workforce allowing a common skills pipeline and giving companies a wide talent pool

Scottish based companies address the same demanding global markets and customers which drives collaboration and allows Government support to be cohesive and targeted

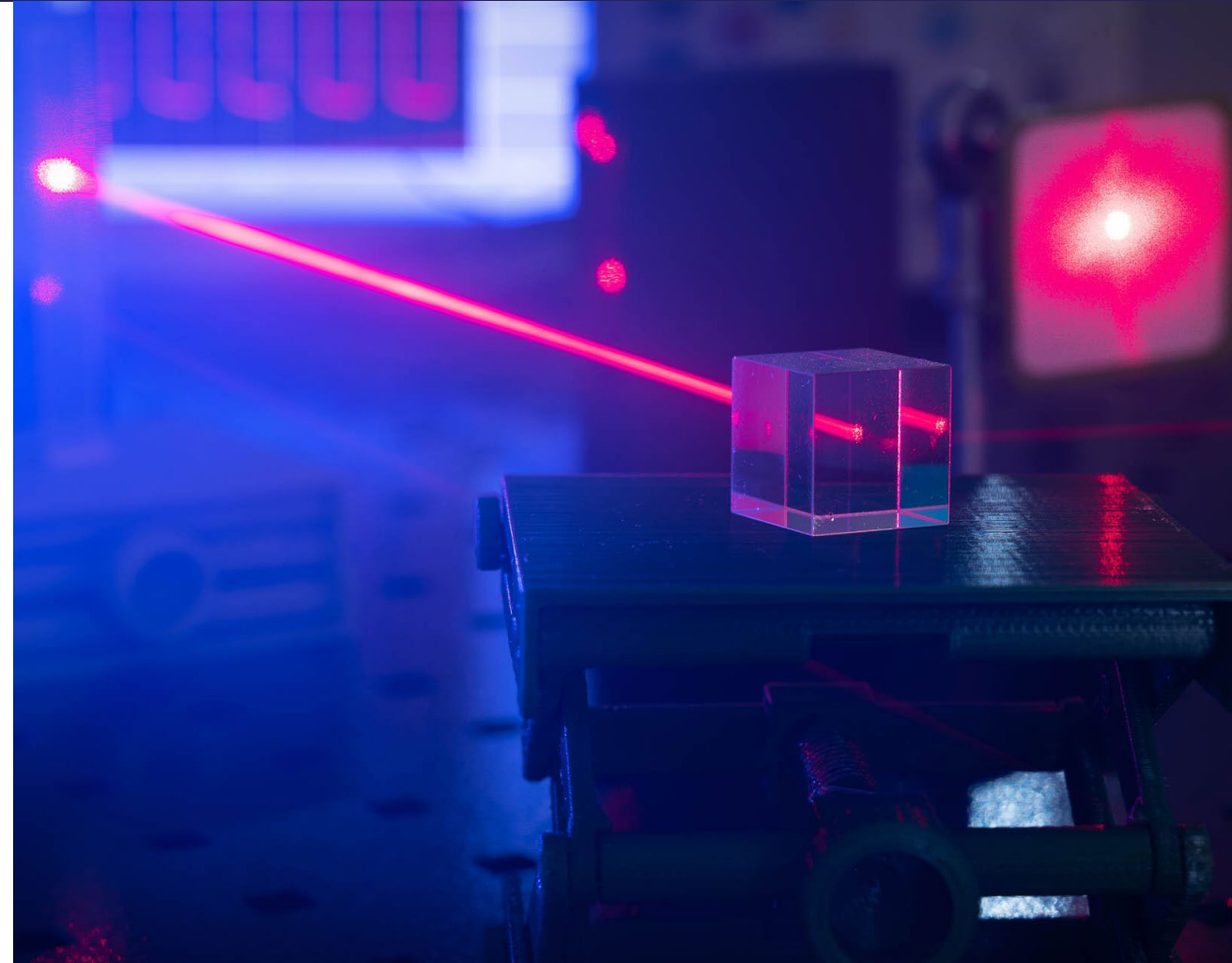
Companies progress through frequent investment cycles driven by rapid technology development both individually and as consortia



Photonics

Photonics is the technology of harnessing light, including lasers, optics and sensing.

The inherent properties of light – it is fast, it is clean, it is precise – provide the basis for recent advancements in communications, healthcare, manufacturing and space technologies.

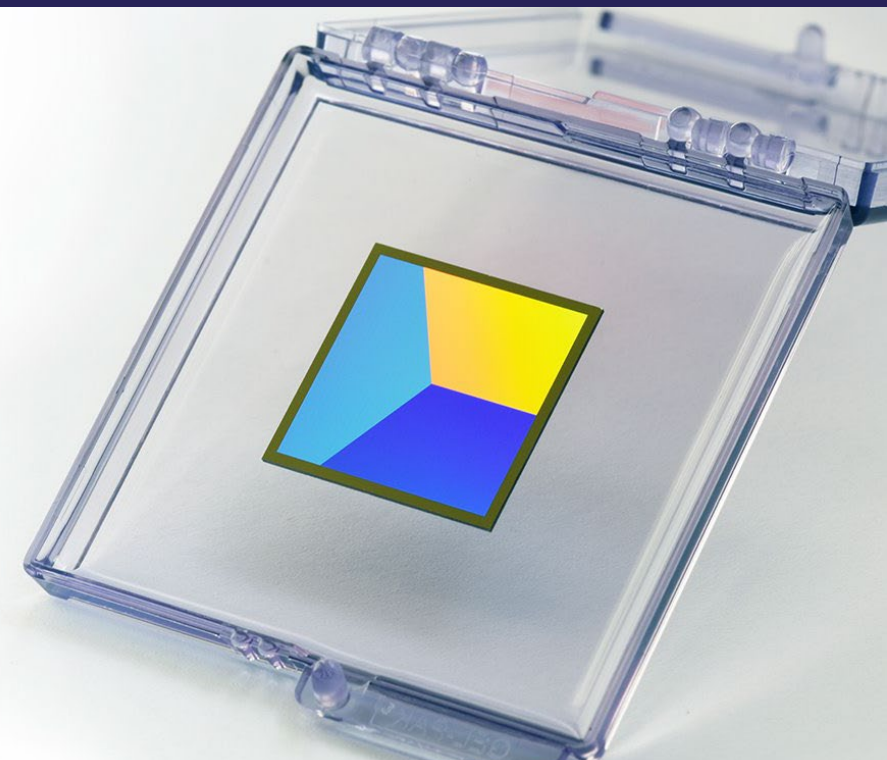




Photonics

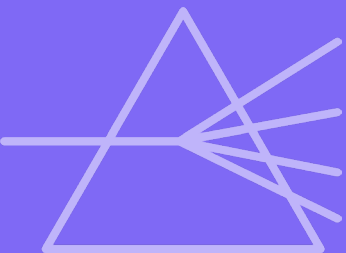
Scotland is home to a world class cluster in photonics:

- Vibrant industry cluster generating over \$1.7bn in revenues.
- World leading concentration of academic institutions, rated top 3 globally for publications per head.
- Internationally recognised skills base in manufacturing photonics products.
- Powerful network of translational assets and RTOs, including Fraunhofer Centre for Applied Photonics.



**Magneto Optical Trap Grating
Manufactured by KNT**

Developed by KNT, NPL, University of Strathclyde,
University of Glasgow and Imperial College



Photonics companies in Scotland



RENISHAW
THALES
sivers PHOTONICS
Metahelios
CRUCIBLE MEDTECH
VECTOR PHOTONICS
SST
PRECISION Photometrics
Alba Sense
HORIBA Jobin Yvon IBH Ltd
Tannin
Machines With Vision
Lidars
SOLUS TECHNOLOGY SOLUTIONS
Greengage Enlightened Farming
nctech
OPTOSCI
PowerPhotonic Enhancing Beam Performance
optos
HELIA PHOTONICS
FC Laboratories Co., Ltd.
LEVITON
4D FORTH DIMENSION DISPLAYS
DIGIFLEC DIGITAL REFLECTIONS
PHOTONIC SOLUTIONS EST. 1999
LUMACRON Instrumenting Optical Networks
WATT LASER
DXCOVER
CALCIVIS
Adept Optical
ALBAN LASER SYSTEMS
Brinell Vision Protecting and Enhancing Vision
OPTOSCRIBE
CLYDE HSI
epipole
CALEDONIAN PHOTONICS
CERES HOLOGRAPHICS
EDINBURGH INSTRUMENTS
CYTOMOS. SEE THE UNSEEN
COHERENT
designLED

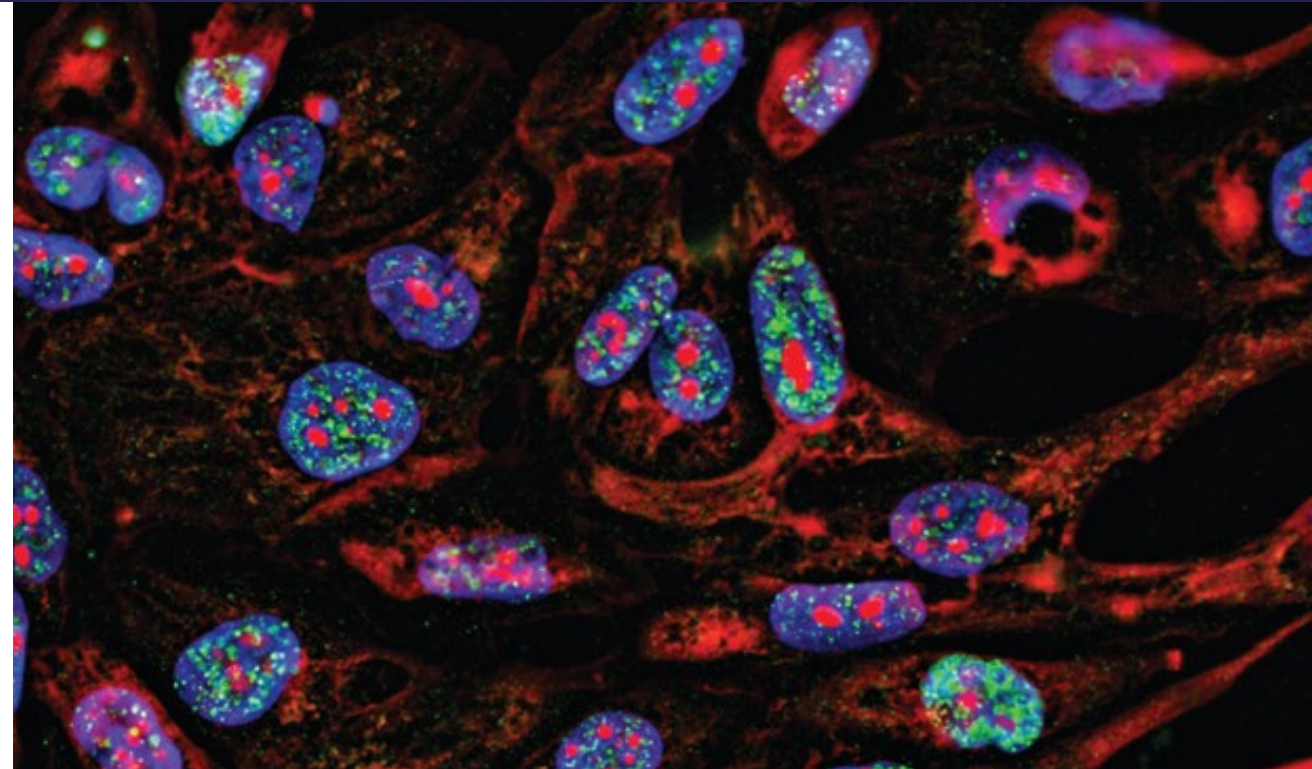


Quantum technologies

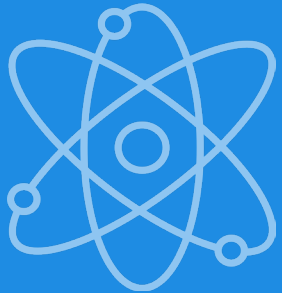
Quantum technologies encompass a range of emerging technologies at the atomic scale, based around the principles of quantum mechanics.

These technologies are set to revolutionise communications, security, computing, sensing and imaging.

Over the last 10 years, Scottish institutions have been successful in securing over 30% of UK collaborative funding in commercialising quantum technologies.



Fluorescent Imaging immunofluorescence of cancer cells growing in 2D



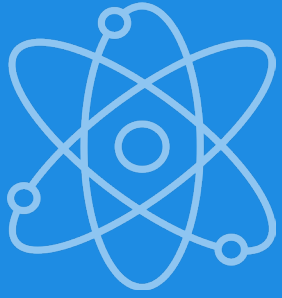
Quantum technologies

Built on existing strengths across the critical technologies, Scotland has an ambition to create a billion-dollar quantum industry:

- 30 companies active in the development and application of quantum technologies.
- 2 of the 5 UK National Quantum Hubs are led from Scotland (Scottish institutions active in all 5).
- World leading capabilities in quantum component/device development and manufacture.
- Strengths in key commercial markets for quantum technologies e.g. space & defence, life sciences, financial services.



AAC ClydeSpace – active in use of payloads with quantum technologies e.g. cold atom gravimeter, QKD



Quantum companies in Scotland



TopbaN Lasers



III-V Epi



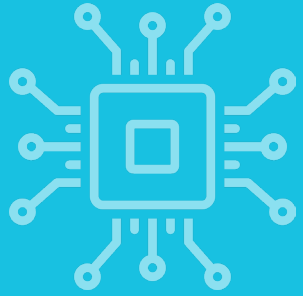
Skylark

wideblue



Chromacity



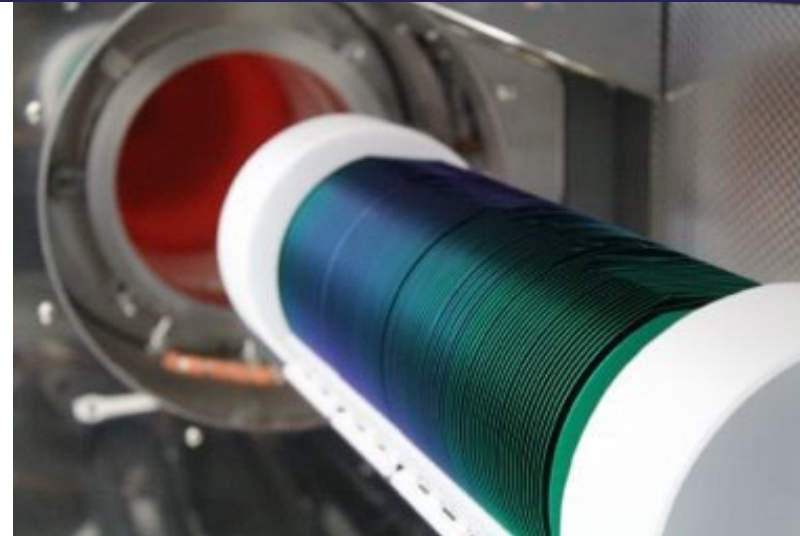


Semiconductors

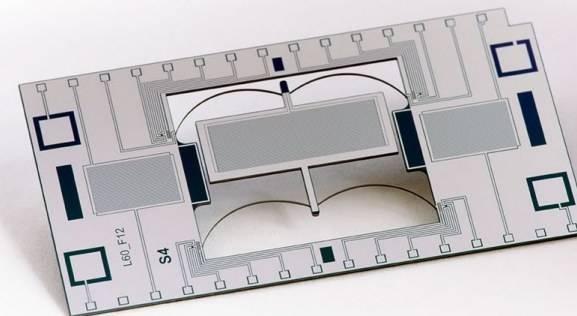
Semiconductors' electrical properties are used to process information, manage electrical power, as laser sources and in a myriad of other applications.

We all own thousands of semiconductors embedded in equipment we use daily.

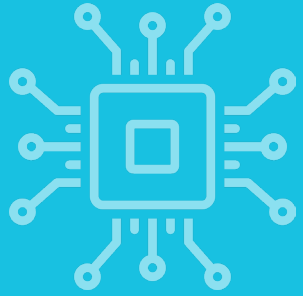
If you paid for something today with your phone or watch then it went through an NXP security chip - with crypto IP designed in Scotland.



Silicon Carbide power transistor wafers being processed at Clas-SiC wafer Fab in Fife



Wee-g Silicon Gravimeter chip from JWNC providing earthquake warnings on Mount Etna



Semiconductors



Scotland's
Critical Technologies
Supercluster

Scotland has the most diverse semiconductor cluster in the UK

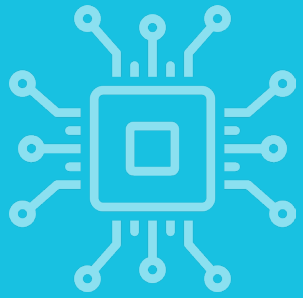
- Semiconductors have been manufactured in Scotland for over 50 years. Today, compound & analog semiconductors are fabricated in Scotland for global markets.
- Varied supply chain in Scotland (wafers, equipment, design software) serving Europe.
- Strong analogue and mixed signal design community in Edinburgh.
- Groundbreaking academic research producing innovative spin-outs.



Diodes 200mm silicon digital, analogue and mixed signal wafer fab in Greenock, employing 300 staff



Billions of smartphones use components developed in Scotland for auto-focus, music and cryptography.



Semiconductor companies in Scotland





Sensing & connectivity



The air today is full of radio signals emanating from everything from RADAR systems to mobile phones. Often, radio signals are used to connect networks of sensors, keeping our environment safe.

In 2023, at the King's Coronation, a Strathclyde University spin-out Neutral Wireless provided the world's largest pop-up 5G standalone non-public network for media contribution.





Sensing & connectivity

Scottish companies are active in many areas, for example:

- Advanced RADAR systems
- Novel satellite tracking antennas
- Use of the Inter of Things (IoT) for remote environmental monitoring and asset management



Censis IoT centre



Sensing & connectivity companies in Scotland

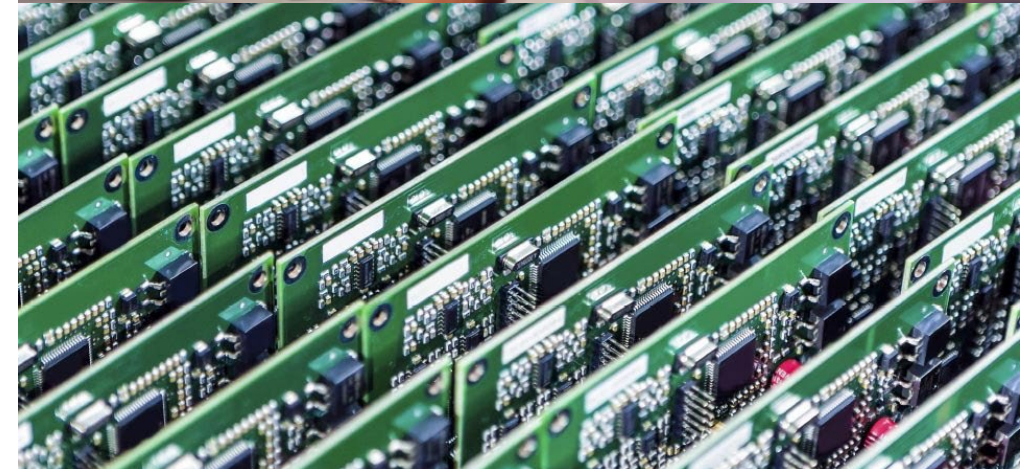
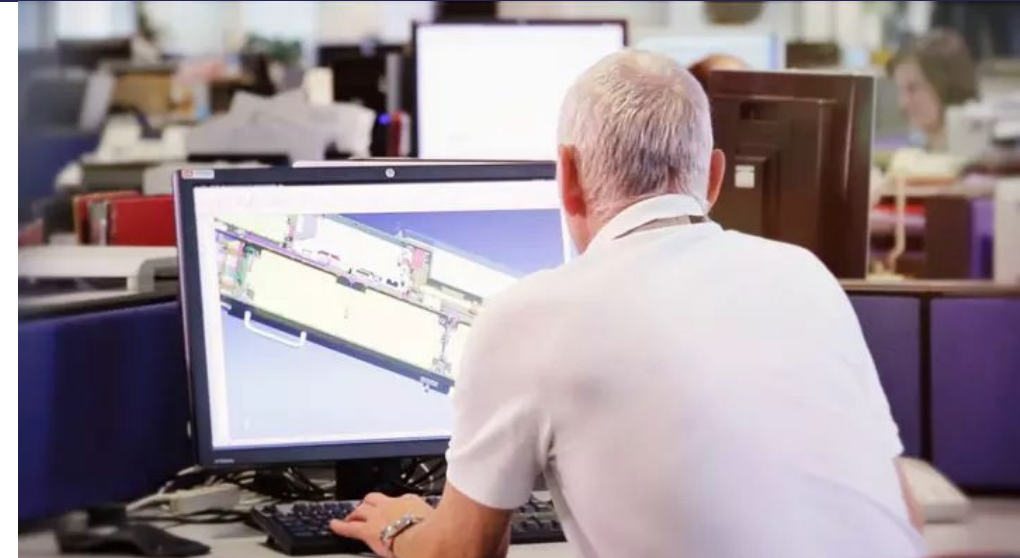


BROADDEX TECHNOLOGIES



Industrial ecosystem

- Scotland has a comprehensive ecosystem of professional services supporting its Critical technologies cluster
- Contract manufacturers for small-medium volumes able to work to the highest standards for space, defence and offshore applications
- Engineering and design consultancies able to turn product concepts into manufacturable designs
- Various test and verification services
- Specialist legal, IP and recruitment firms



Manufacturing service companies in Scotland



Invent Design Build Ltd



Workforce



Central belt
produces

20,000

graduates per year
from HNC to PhD in
engineering and
the physical
sciences



Average salary
is well above
national
average

**£52.3k in
2022**



High geographic
concentration of
companies in the
central belt
provides good
opportunities
for career
development and
job security



Skilled workforce
attracts ongoing
investment from
leading companies



Scotland is an
attractive
destination for
international talent

Research infrastructure

Five high-ranking research universities working across the Critical Technologies

Several Research and Technology Organisations *e.g.*, Fraunhofer Centre for Applied Photonics

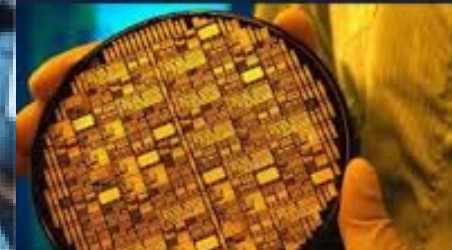
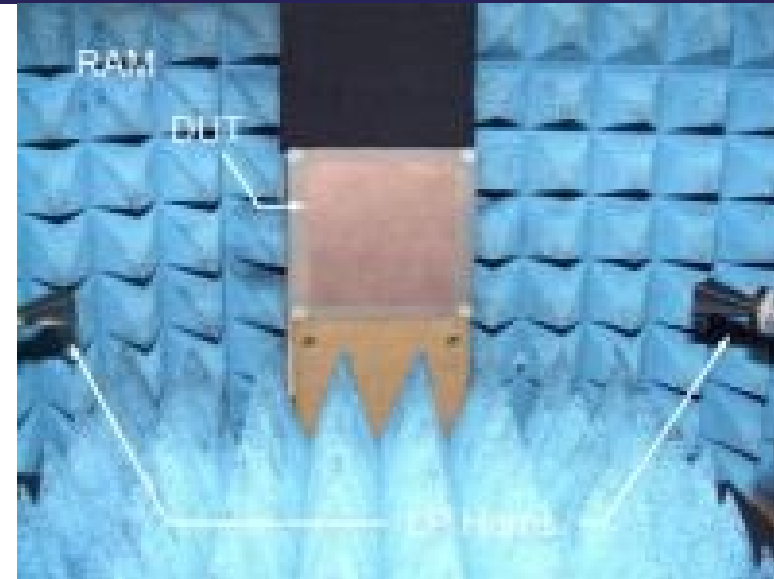
Five nanotech / semiconductor research fabs

R&D grants available from UK and Scottish governments

Research excellence

- Approximately £160M of current awards from the UK's Engineering and Physical Sciences Research Council in projects relevant to the Critical Technologies at Scottish Universities
- A similar quantum of investment into research projects is won from a wide variety of other funders

Overall, Scottish Engineering Schools win research funding at double the per-capita rate of the rest of the UK – the tradition of James Watt is still very alive!



International outlook

80% of Scotland's output is exported

Scotland welcomes ambitious companies
– the majority of our workforce is employed by
multinationals

Our universities and companies attract technical talent
from all over the world who appreciate Scotland's culture
and lifestyle

Scotland is too small to do everything, but we're world
class in our particular niches – so we're always looking for
new connections, partners and opportunities to grow
together.

Economic growth indicators

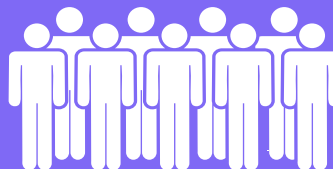
WORKFORCE > 150 COMPANIES

10,900



2022

17,500



2035

BUSINESS R&D INVESTMENT

£339m



2022

£1bn



2035

TURNOVER

£4.2bn



2022

£10bn



2035

EXPORTS

£3.4bn



2022

£8bn



2035

Our mission

Exploit Scotland's existing strengths and synergies across critical technologies to achieve **£10 billion** turnover by 2035, creating **7,200** additional high-quality jobs

Action plan

Continue to grow
our skills base and
attract foreign
talent

Attract new Foreign
Direct Investment

Assist the growth of
existing base of
international
companies

Encourage more
start-ups and
support SMEs
to scale

Raise the
profile of the
supercluster in the
UK and world

Drive increased
collaboration across the
ecosystem

Policy approach

The Scottish Government is committed to supporting industry to develop **world leading clusters of excellence**, with long-term tailored packages of support, and a Strategic Industry Clusters Group representing priority areas.

Scotland has the capability, talent and ecosystem to deliver UK ambitions across critical technologies.

The supercluster supports UK National Quantum and Semiconductor strategies (2023) and overlaps with the UK's 5 critical technologies (quantum, semiconductors, AI, engineering biology and future telecoms).

Critical technologies have an important role to play in delivering Scotland's;

- **Green Industrial Strategy (2024)**
- **Innovation Strategy (2023)**
- **National Strategy for Economic Transformation (2022)**



Management organisations



Integrated with industry, academia and government



How can we help?

- Sector specific advice
- Talent attraction
- Site visits
- Introduction to local partners
- Referrals to IP specialists, visa specialists, tax specialists etc.