

Driving tomorrow's technologies



Driving Technology with Compound Semiconductors

16 November 2022

Semiconductors in the news



"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run"

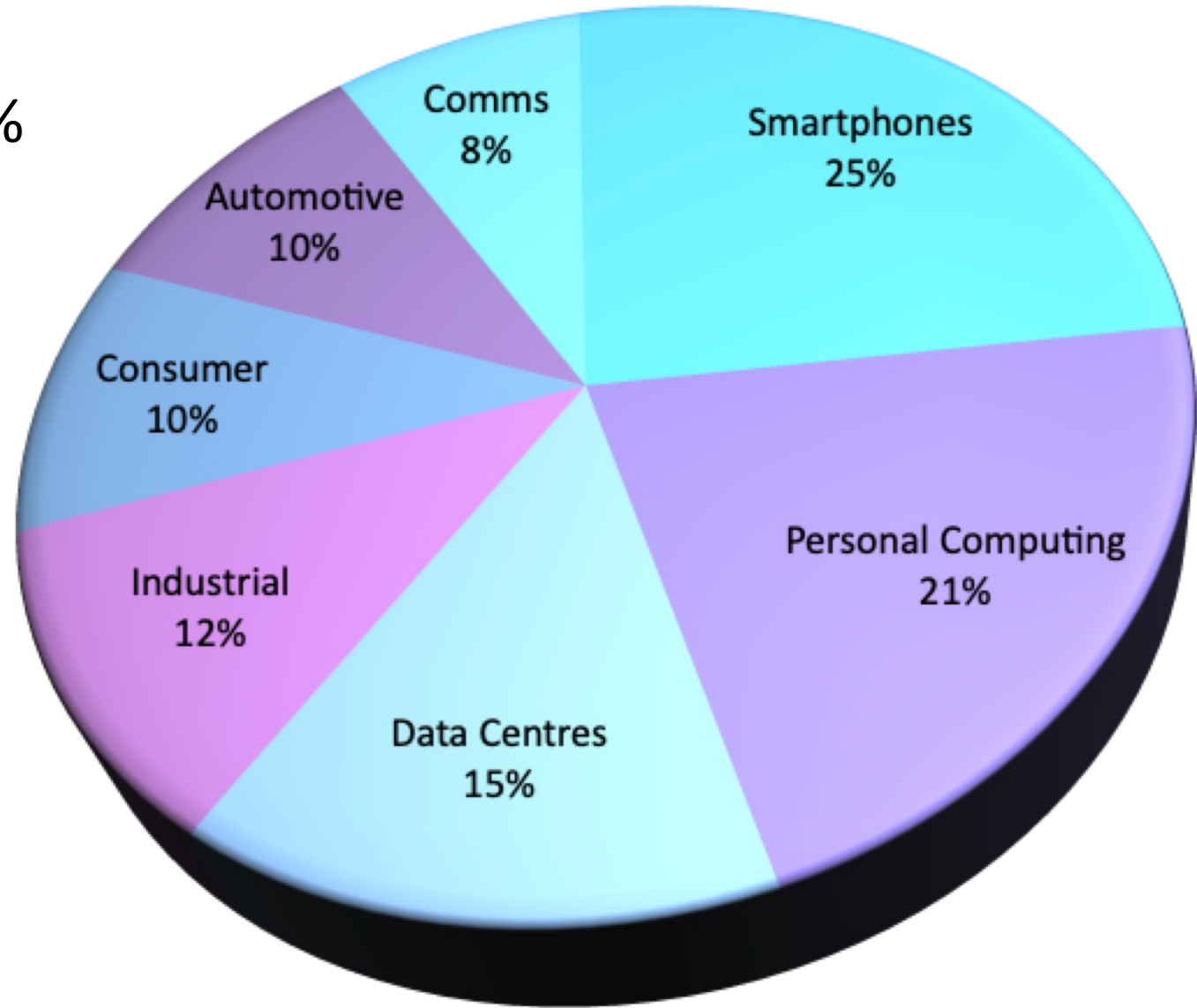
Amara's Law (American Futurist Roy Amara)





Primary Semiconductor Markets

- Digital economy accounts for 22.5% of global GDP
- 4th largest sector (~ \$460B)
- Estimated ~ \$1T by 2035
- Compound Semiconductors account for ~ 12% of total
- Chip shortage impacting auto & consumer (estimated >\$200b hit)
- Shortage expected to extend into 2023



Overview

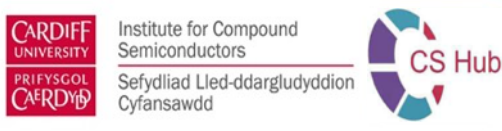
- Compound semiconductors are “next generation” materials that offer enhanced properties over silicon technologies in terms of:
 - Power (power control, inverters, energy efficiency net-zero)
 - Speed (connectivity – 5G and beyond)
 - Photonics (sensors, optical communications, data storage)
- South Wales is home to the World’s largest Compound Semiconductor Cluster
 - World class research (Cardiff & Swansea Universities, Institute for Compound Semiconductors, Centre for Integrative Semiconductor Manufacturing)
 - Prototyping – routes to commercialization
 - Volume manufacturing

South Wales Semiconductor Cluster: Deal flow: RD & Innovation



THE COMPOUND SEMICONDUCTOR CENTRE

>£42M Investment in a JV between IQE and Cardiff University
Focus on materials and device innovation translation
Secured >£80M research funds since 2016



>£100M investment by Cardiff University in 8" fab
Focus on research to pilot production: RF and Photonics
New facility opens in September 2022



>£50M investment by UK Government: 2018-2023
RTO: Focus on CS chip design, packaging and test
100 staff co-located in IQE MegaFoundry, Newport



>£90M investment £40M capex/ £50M revenue
Focus on process development and integration
New facility opens in Swansea in Q2 2023



South Wales Semiconductor Cluster: Deal flow: Manufacturing



>£39M Investment from public sector to establish Mega-Foundry
Space for up to 100 epitaxy materials manufacturing tools
Estimate >£100M executed since 2018: >£375M to full capacity



UKs largest Silicon Power Wafer Fab
Divested from Infineon in 2018 to form Newport Wafer Fab
Acquired by Nexperia in 2021 for £63M



Primary manufacturer of fab capital equipment
SPTS acquired by KLA in 2019 for \$3.4B (Orbotech)
2-3x expansion with new HQ announced in 2021 >£100M?



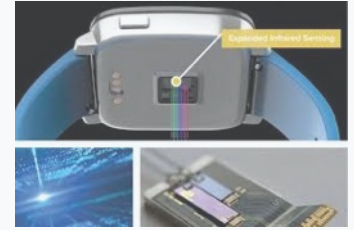
Focus on chip packaging
Microsemi acquired by Microchip for \$10B in 2018
<£5M capex expansion to create power package line



South Wales Semiconductor Cluster: Deal flow: Bridgeheads



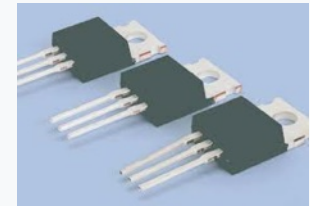
Rockley Photonics: \$1.2B SPAC in 2021
35 staff in South Wales expanding to ~65
Focus on Photonic Integration Centre of Excellence



US manufacturer of flexible Photovoltaics
UK bridgehead to service UK and EU aerospace market
Integrated into the RD&I ecosystem



Specialist MOSFET design house HQ in San Jose
UK bridgehead to take advantage of infrastructure + talent
(Maxpower acquired by Vishay for \$55M Oct 2022)



Established Power Electronics Innovation Hub in July 2022
Co-located with CS Applications Catapult
Access to Infrastructure, Innovation and Talent



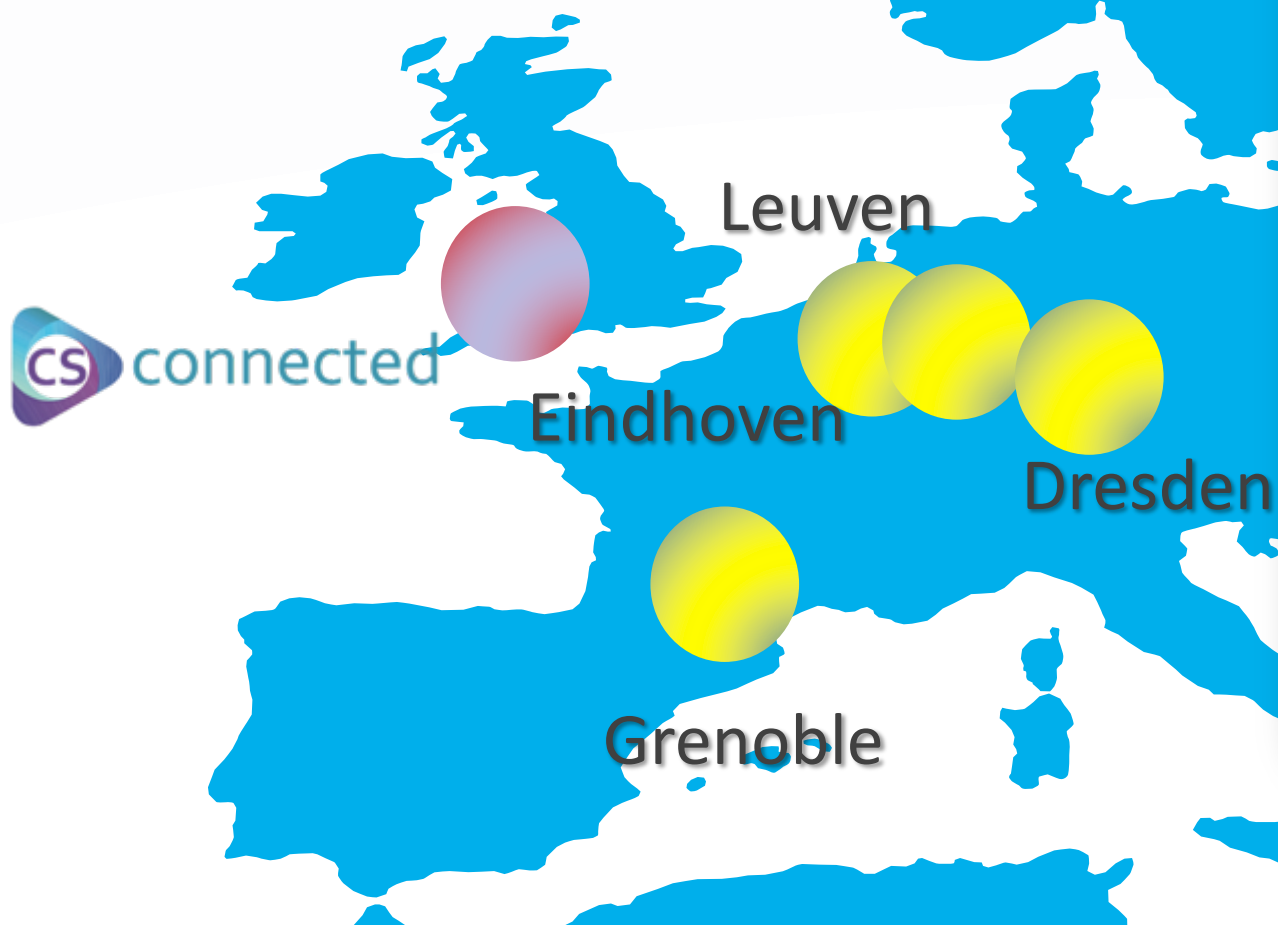


2) Clusters, eco-systems and collaboration

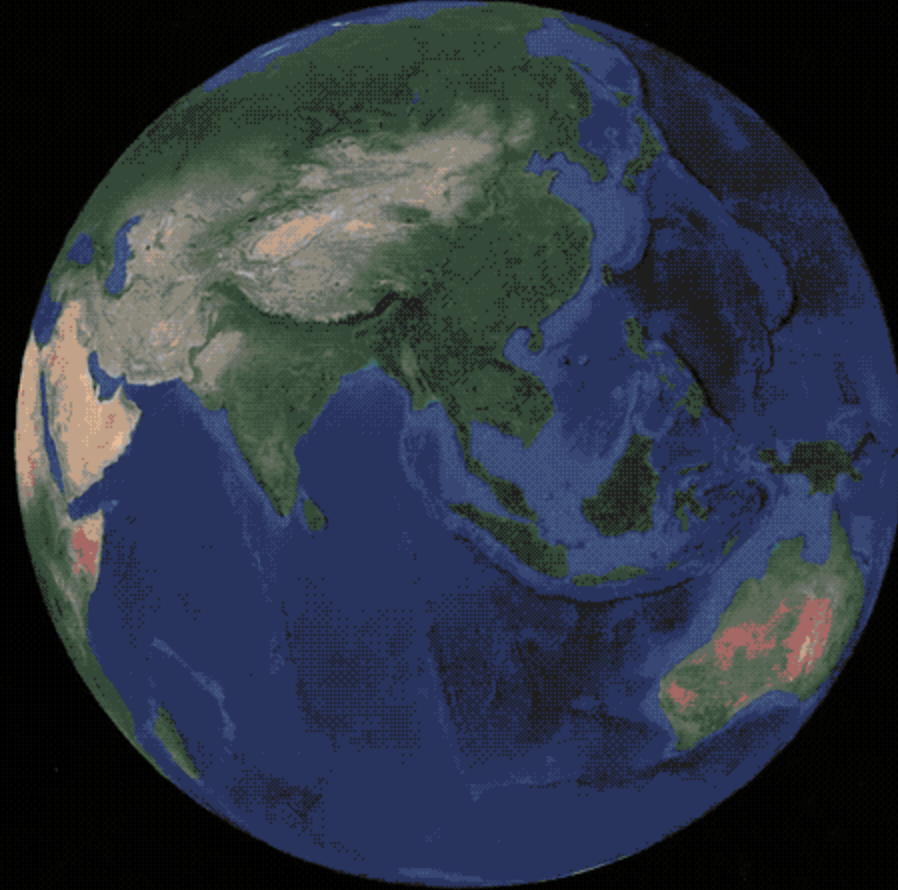
Global semiconductor clusters - silicon



European semiconductor clusters

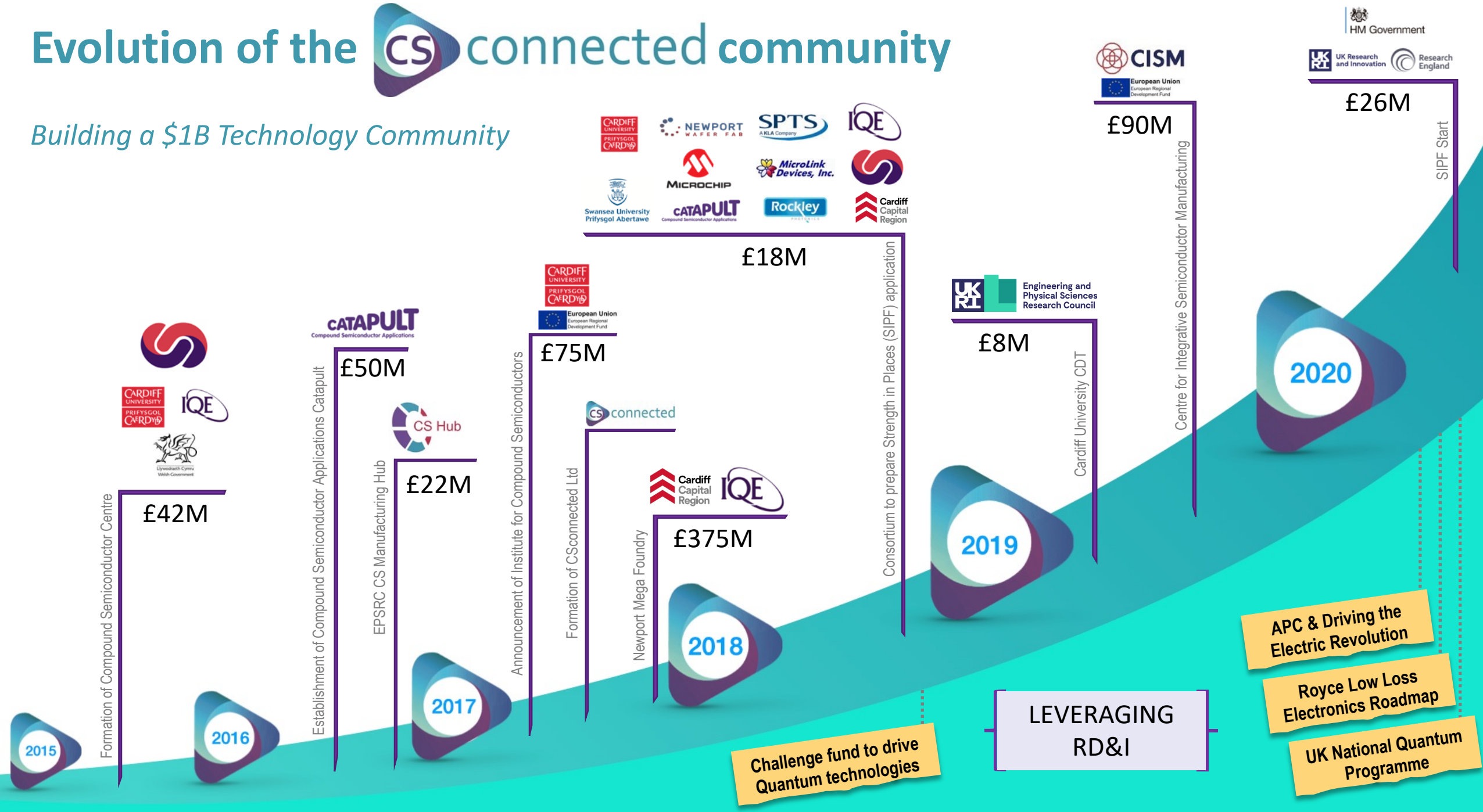


CSconnected cluster



Evolution of the connected community

Building a \$1B Technology Community





3) Live projects: Wide-bandgap (WBG) applications

Collaborative Research & Development Packages

3.1: Next generation optical comms and sensing

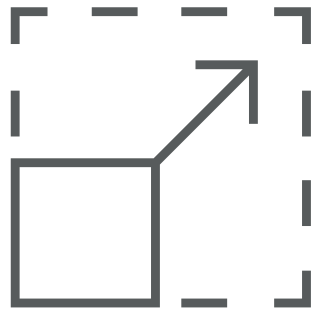
Package includes high capacity data-centres and LIDAR sensing for autonomous vehicles.



NWF, Cardiff Uni, Swansea Uni, CSC, IQE, SPTS, CSA Catapult, Microsemi, Rockley Photonics

3.2: Large Scale GaAs-based wafer manufacturing

Development scalable compound semiconductor solutions for photonic, wireless and flexible photovoltaic applications.



IQE, NWF, Microsemi, Swansea, Microlink devices

3.3: Novel and efficient CS Wafer Fabrication Tools

This activity will address the development of next generation processing equipment and associated processes required to scale up CS wafer and device fabrication.



SPTS, Cardiff Uni, CSC, IQE, NWF, CSA Catapult.

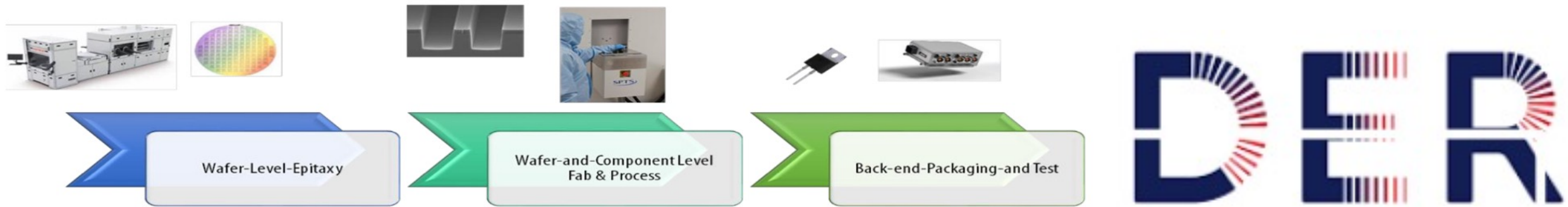
3.4: Advanced processes for 5G and EAV systems

Demonstration of an advanced volume assembly capability for high value CS based electronic modules for 5G components and miniaturised electric vehicle motor drives.



MicroChip, CSA Catapult, Cardiff Uni, Swansea Uni, SPTS, NWF, IQE, CSC

PowerWales

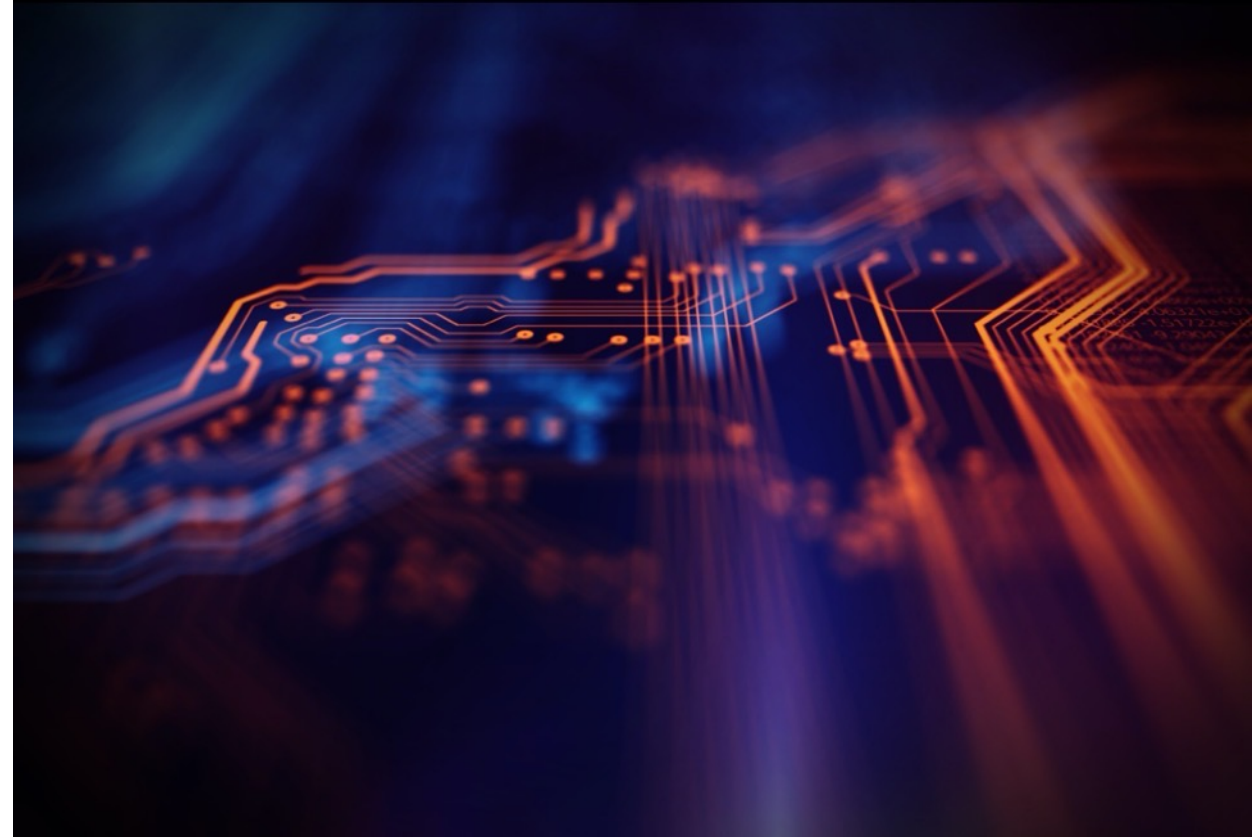


- Co-ordinated manufacturing supply chain in power semiconductor technology
- Seed a model of inward investment for manufacturing of semiconductor enabled products
- Pilot line established in 2022 at Swansea University Centre for Integrated Semiconductor Materials
- Complimentary activity across the CS Cluster in WBG epitaxy, fabrication and chip packaging



SOCRATES – Silicon Carbide Transistor Etch Process

- SOCRATES - SilicOn Carbide tRAnsistor Trench process
- Driving the Electric Revolution (DER) Industrial Centre
- Centre for Integrative Semiconductor Materials (CISM), Swansea University



SOCRATES – Silicon Carbide Transistor Etch Process

Project Partners

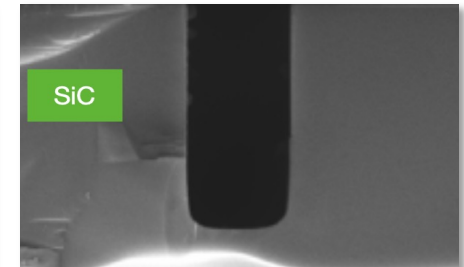
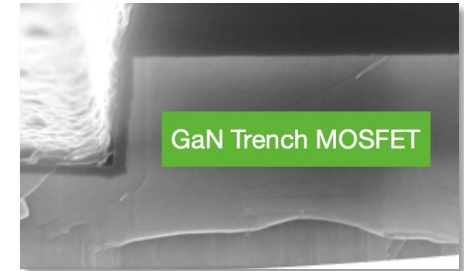
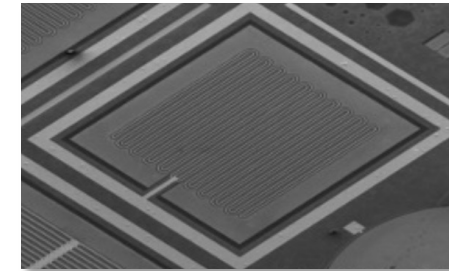


Mission

- To define a market ready trench etch process for SiC and GaN
- SiC trench MOSFET and vertical GaN on SiC transistor architectures

Main Objectives/outcomes

- To establish an industry scaled-up trench etch process for SiC and GaN power devices
- SENSIBILITY feasibility project for SiC scale-up
- PEMD outreach programme



Centre for Integrative Semiconductor Materials (CISM), *Swansea University*

Project Partners



- £90M Project; including £30M RPIF
- Manufacturing grade R&I Fab supporting the regional industry
- Themes:
 - Power Electronics
 - Photonics & Data Comms
 - Opto & Energy Systems
 - Bio (Nano) & Sensors



GaN HEMT Lateral

- 200mm 650V HEMT – fab process development plus GaN epi optimization
- Regional partners CSC, NWF, Bristol University
- Full 200mm GaN HEMT process and PDK development
- Industrial/Academic collaboration
- Real-time in-fab test of epi performance
- Rapid feedback to epi design
- Interdependencies of Epi and Fab processing identified
- Development of robust processes for volume manufacture
- Solid platform to accelerate a full 200mm 650V GaN HEMT scale-up

GaN Trench FET (Vertical)

Novel GaN trench FET device architectures and processes

- Improved power density and cost
- Scale voltage without increasing chip area
- Supply chain development project
- Regional Partners CSC, NWF, Swansea University, Coventry University, SPTS, CSA Catapult and TPS
- Voltage-scalable, vertical GaN process platform targeting electric vehicle applications
- Development of thick epitaxial GaN layers with complex in-situ doping
- Development of GaN trench etch with vertical sidewall and rounded corners
- Swansea University has produced first working devices (April 2021)

GaN on SiC (Connectivity/Security)

- Follow on from Innovate UK Project
- **UK Supply Chain Build**
- **X-band and Ka-band** power bar and MMIC development
- Cardiff University, CSAC, CSC, IQE, NWF, SPTS, TT Electronics, MBDA, Leonardo, Arralis, Iconic RF, Filtronic, Mesuro.
- Process Development at Cardiff University
- Industrialisation at NWF
 - 5G base station
 - Wireless backhaul
 - Military radar, EW and comms
 - V2V and V2X for CAV



Semiconductors are the new oil?

- Our Ambition:
 - **Grow to support >5000 jobs** in South Wales by >2025
 - Established as **World's First Compound Semiconductor cluster**
 - Catalyse a **renaissance in UK electronic system manufacturing**
- CSconnected **is looking for:**
 - Inward investment to locate RD&I + manufacturing in the region
 - Opportunities to engage globally
- CSconnected **offers:**
 - Unrivalled RD&I infrastructure and capacity
 - IP development in emerging technologies
 - A rapidly expanding talent pool in semiconductor skills
 - A proactive business environment for semiconductor tech



Thank you

www.csconnected.com