

Compound Semiconductors for Electronics & Photonics – Two Sides of One Coin

Munich, 14th November 2023

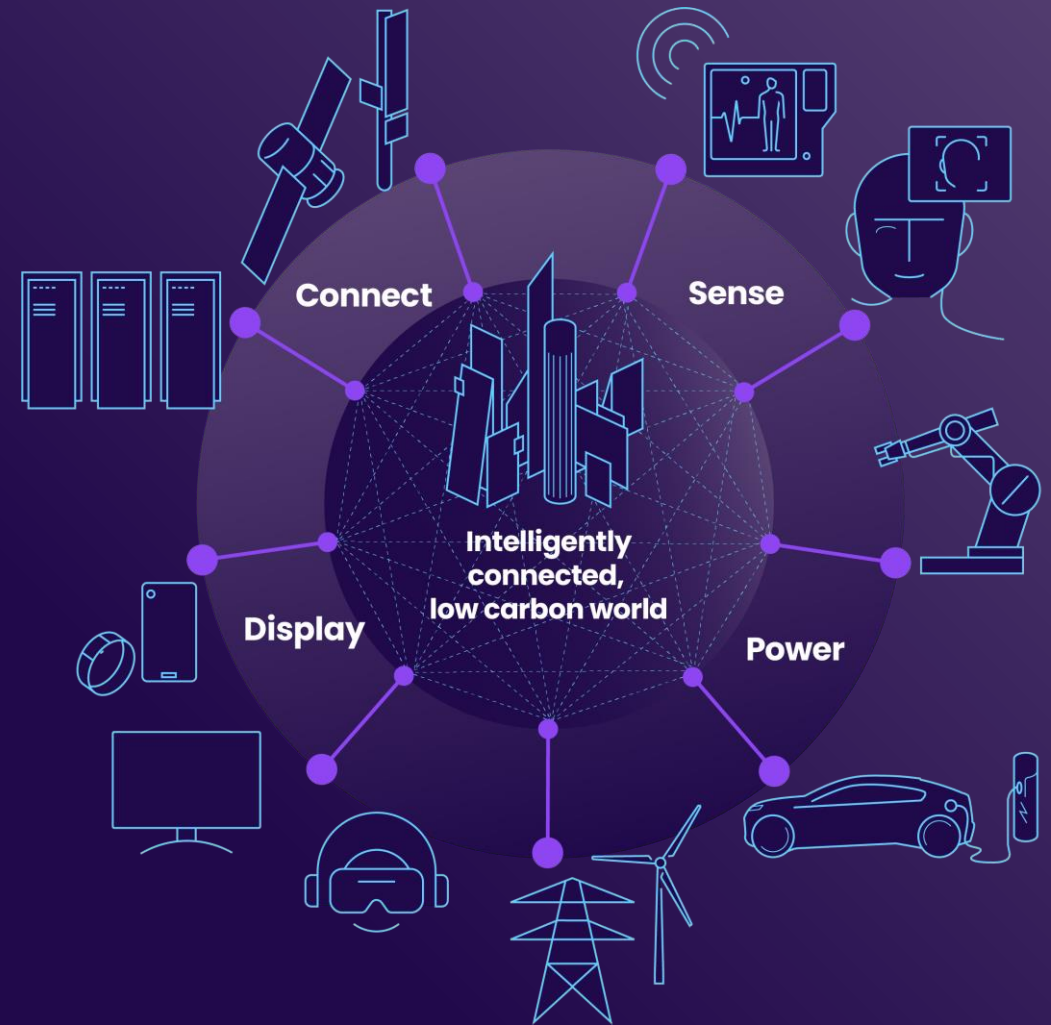


**Architects
of tomorrow**

Compound semiconductors are everywhere

They underpin a vast range of today's technology applications

At the core of our daily lives

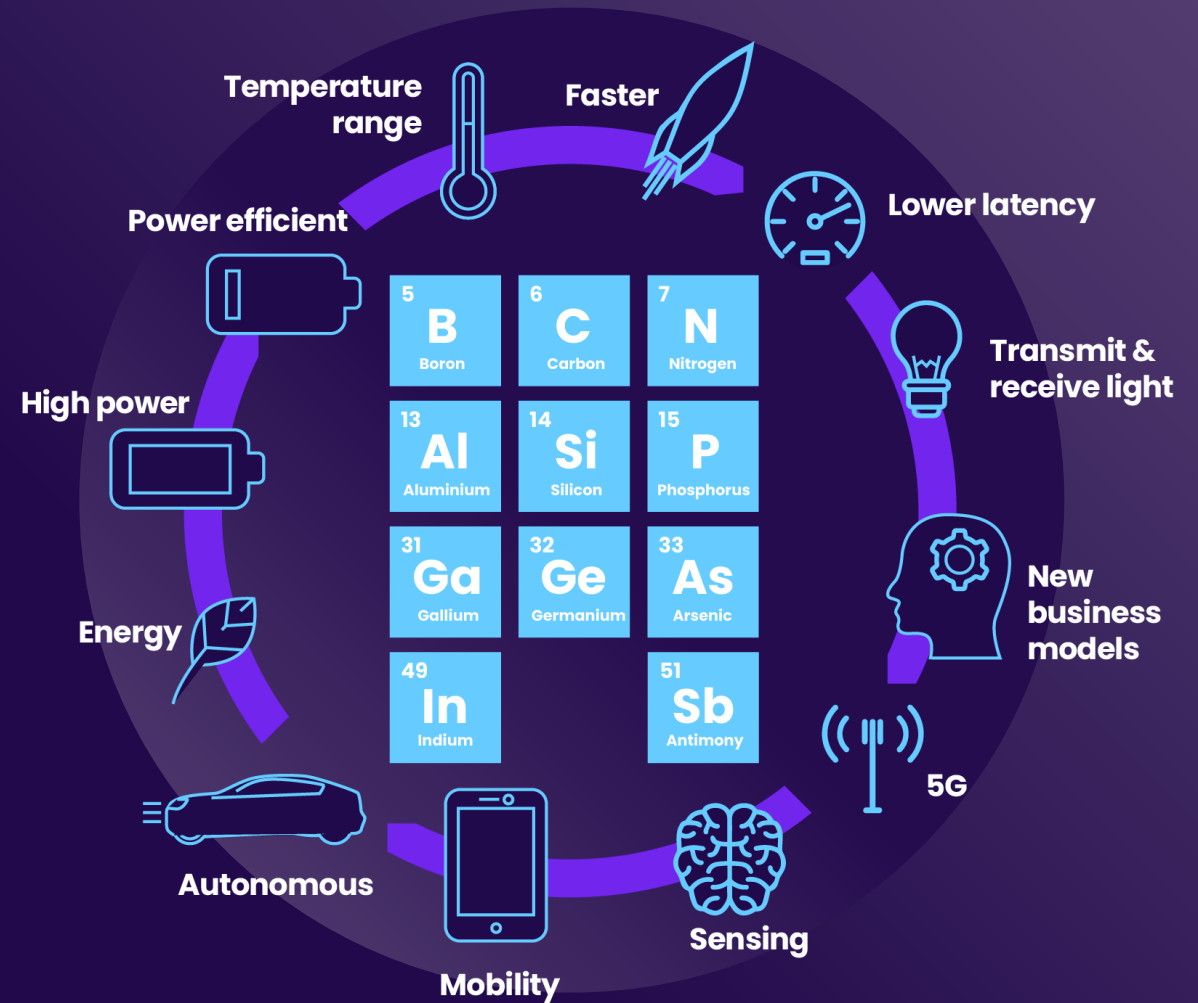


The future is compound semiconductors

Devices required for modern life require compound semiconductors

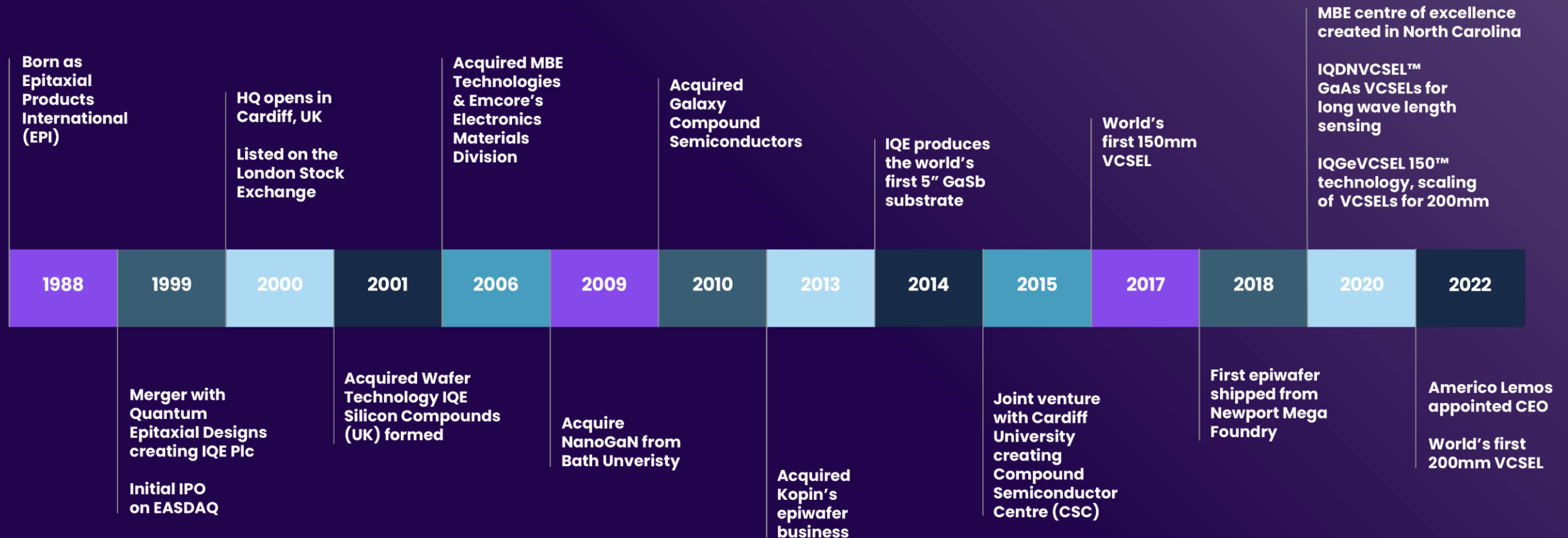
Advantages:

- Excellent high frequency performance
- Emission and detection of light from UV to IR
- Superb high temperature performance



The making of a global epitaxy leader

35 years of epitaxy expertise underpinned by a vast IP portfolio



Strategic sites for high volume manufacturing

Europe

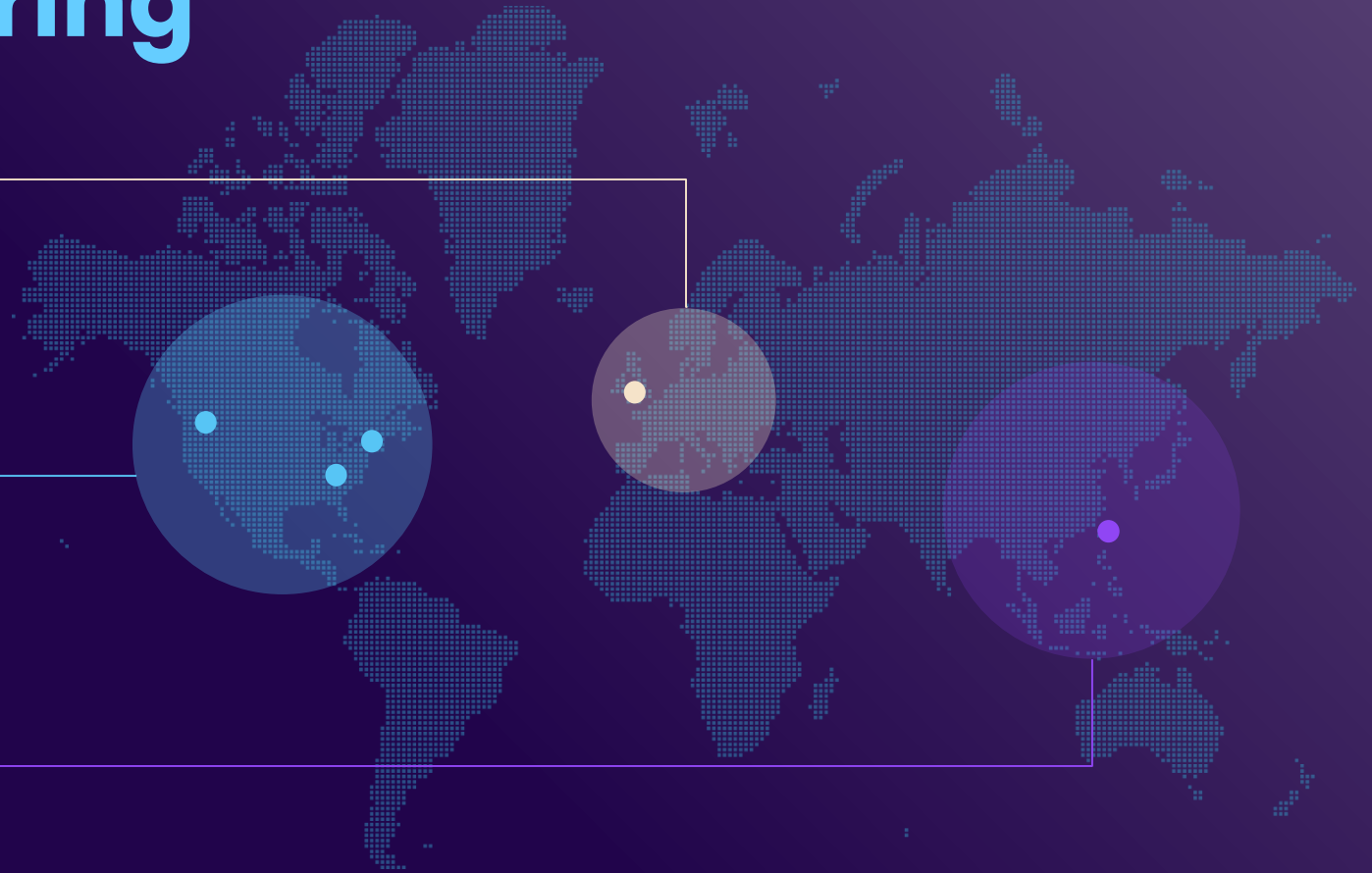
Cardiff (Innovation Centre)
Newport
Milton Keynes (substrates)

North America

Massachusetts
North Carolina
Spokane (substrates)

Asia

Taiwan

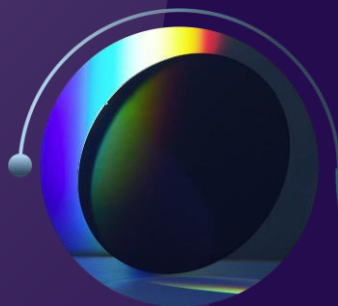


Resilience, flexibility and ability to rapidly scale

Strategically positioned in the global value chain



Epiwafer production



Substrates
Base materials



Foundries
Device fabrication



Fabless
Design



Device makers
Device manufacture

Growth Markets

Smart Connected Devices

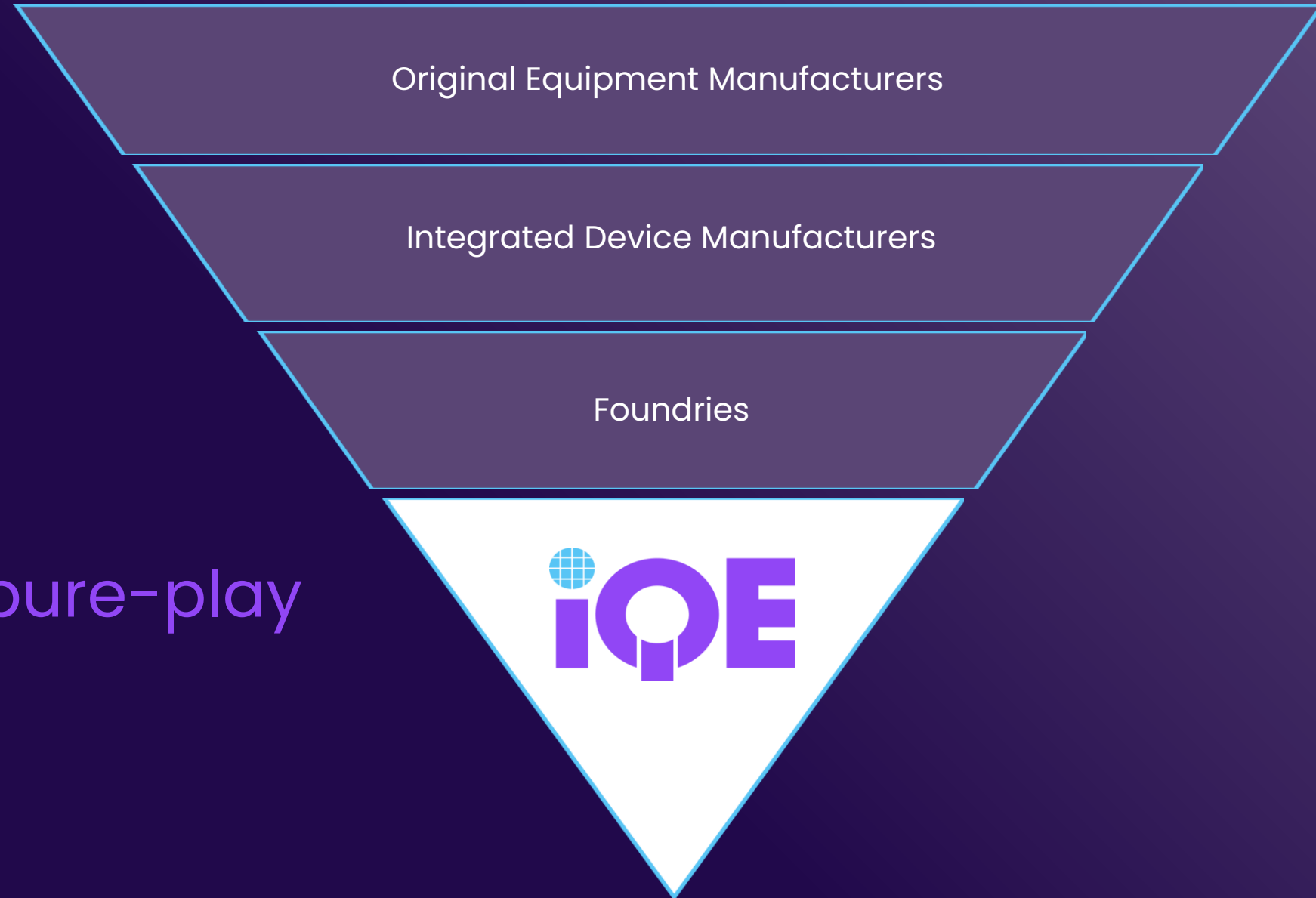
Communications Infrastructure and Security

Automotive and Industrial

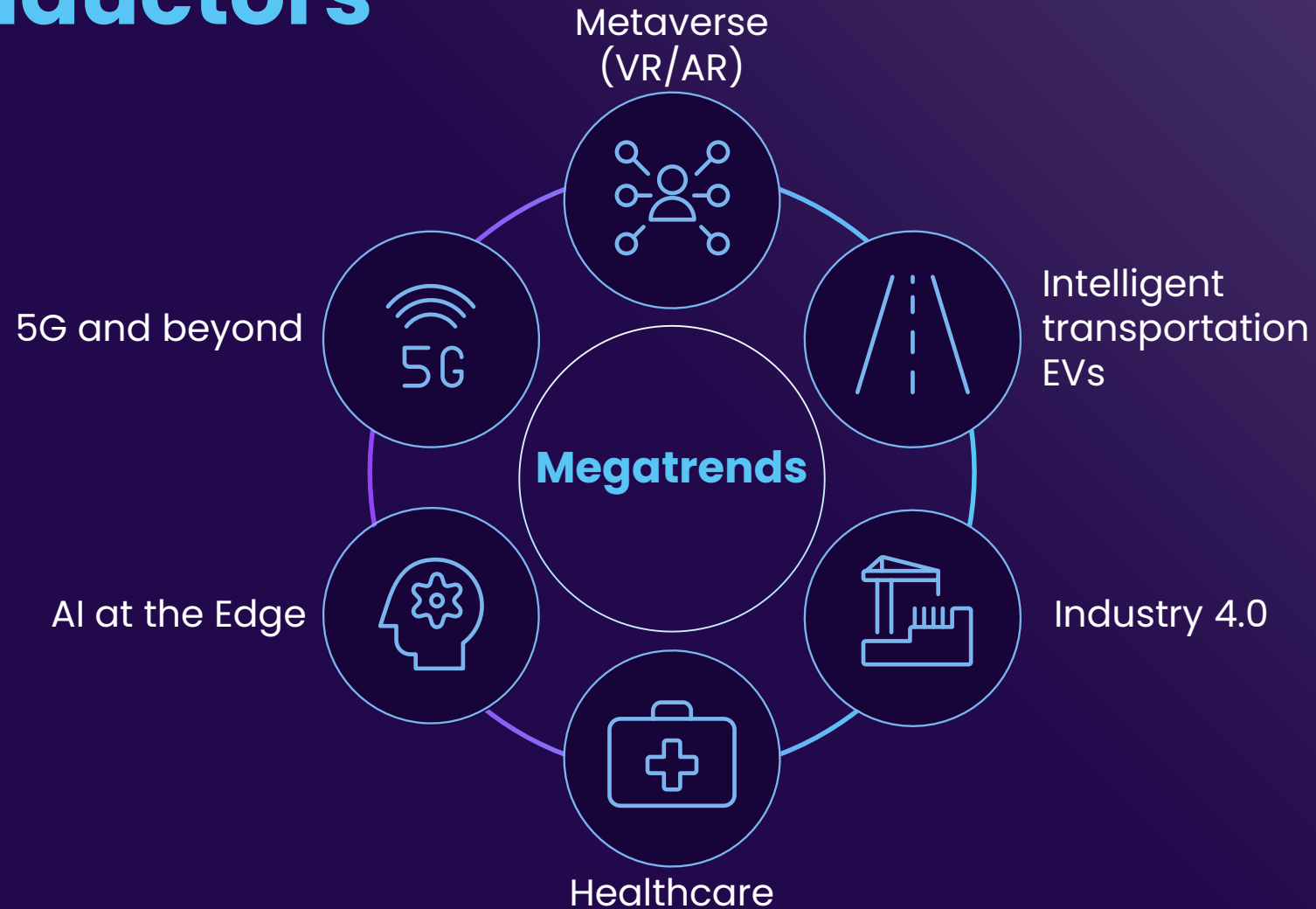


Strategically positioned in the global ecosystem

The only **global** pure-play epitaxy provider



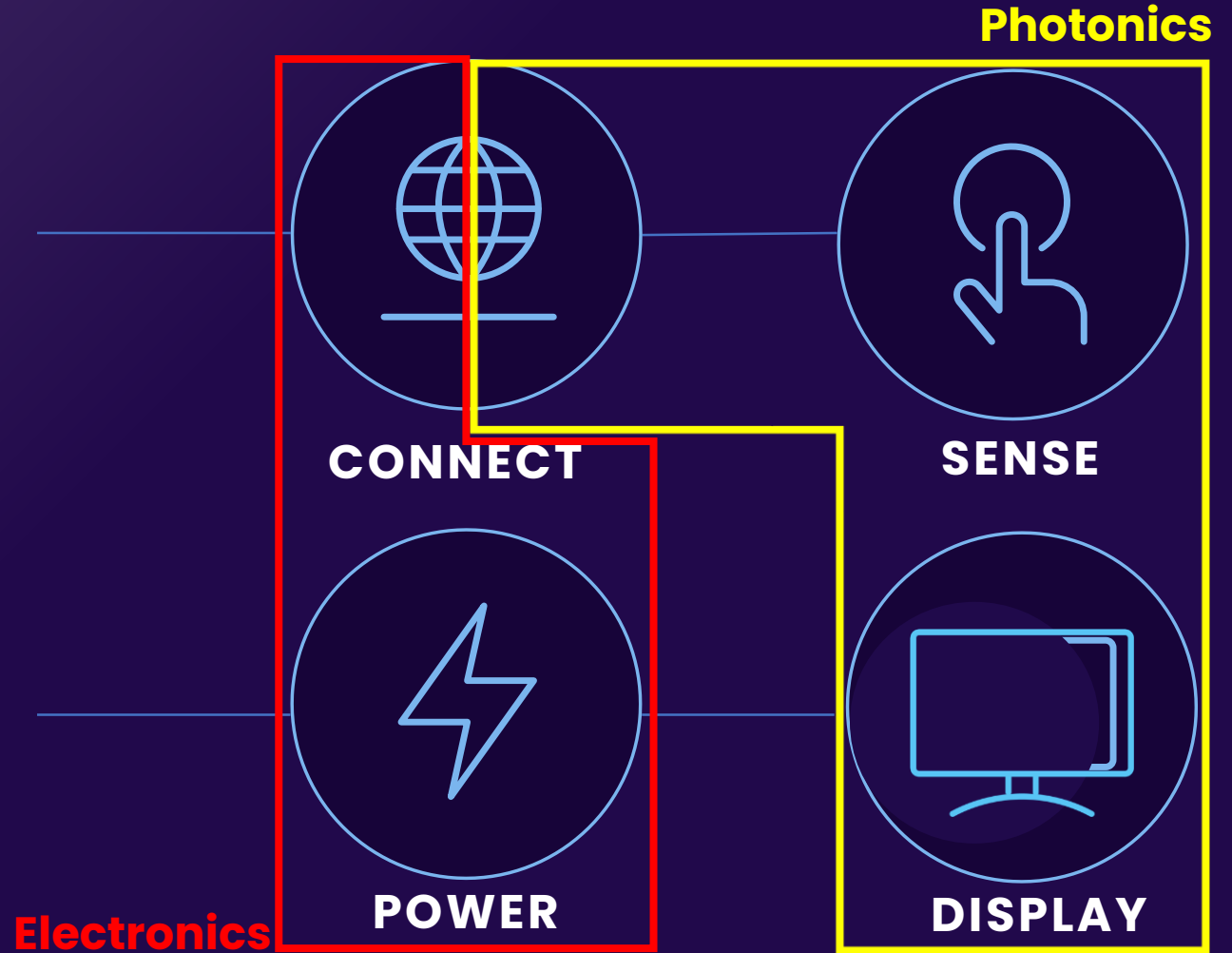
Megatrends driving demand for semiconductors



IQE strategy

Maintain and grow our position in connect and sense markets

Diversify into power and display markets

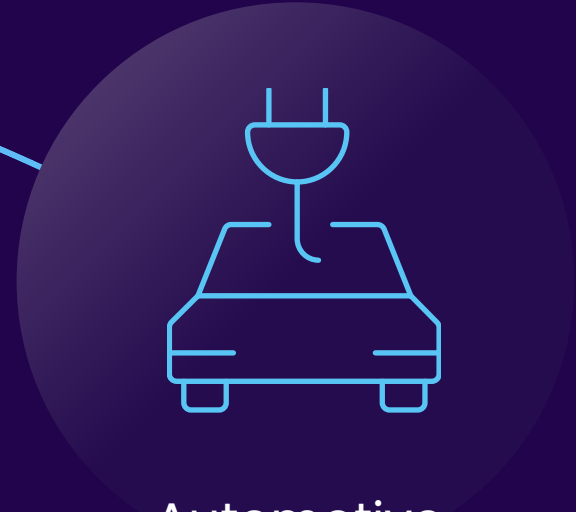




Smart connected devices



Communications infrastructure & Security



Automotive and Industrial

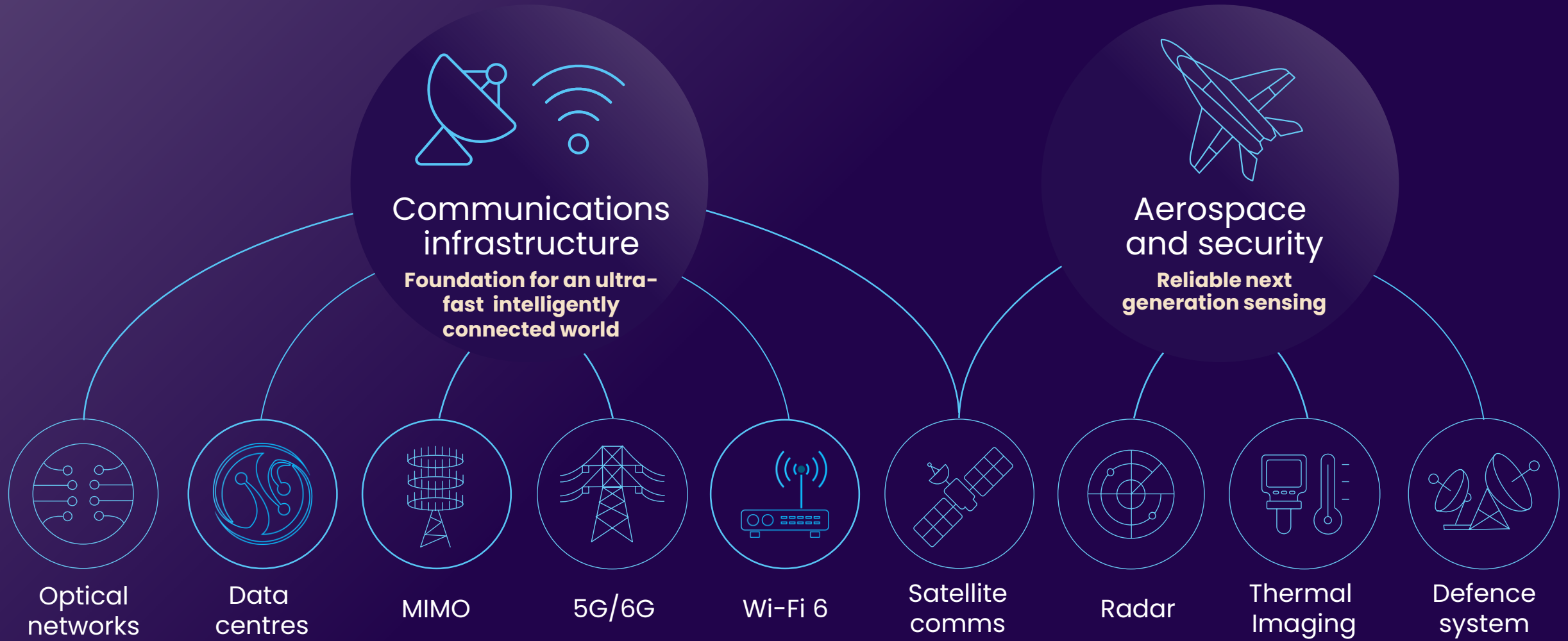
Our growth markets

Smart connected devices

Enabling intelligently connected devices

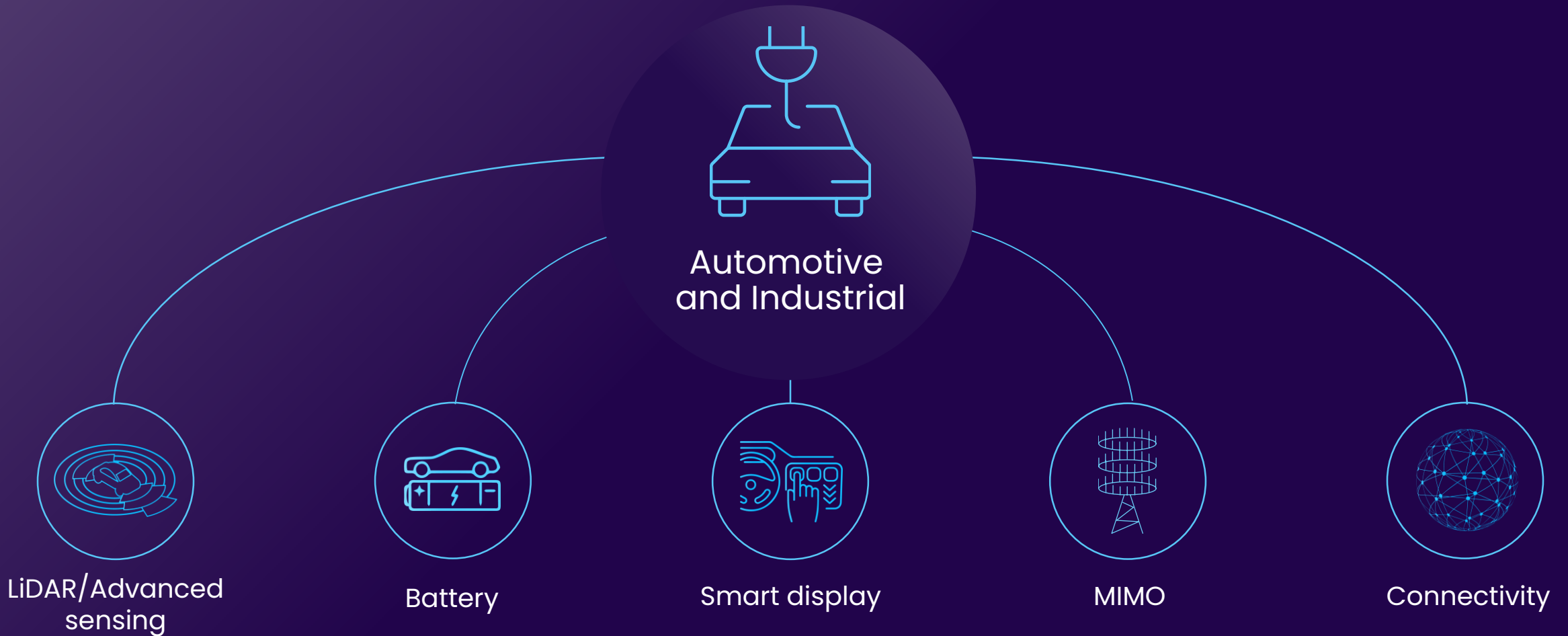


Communications infrastructure & security



Automotive and Industrial

Compound semiconductors are transforming our every move





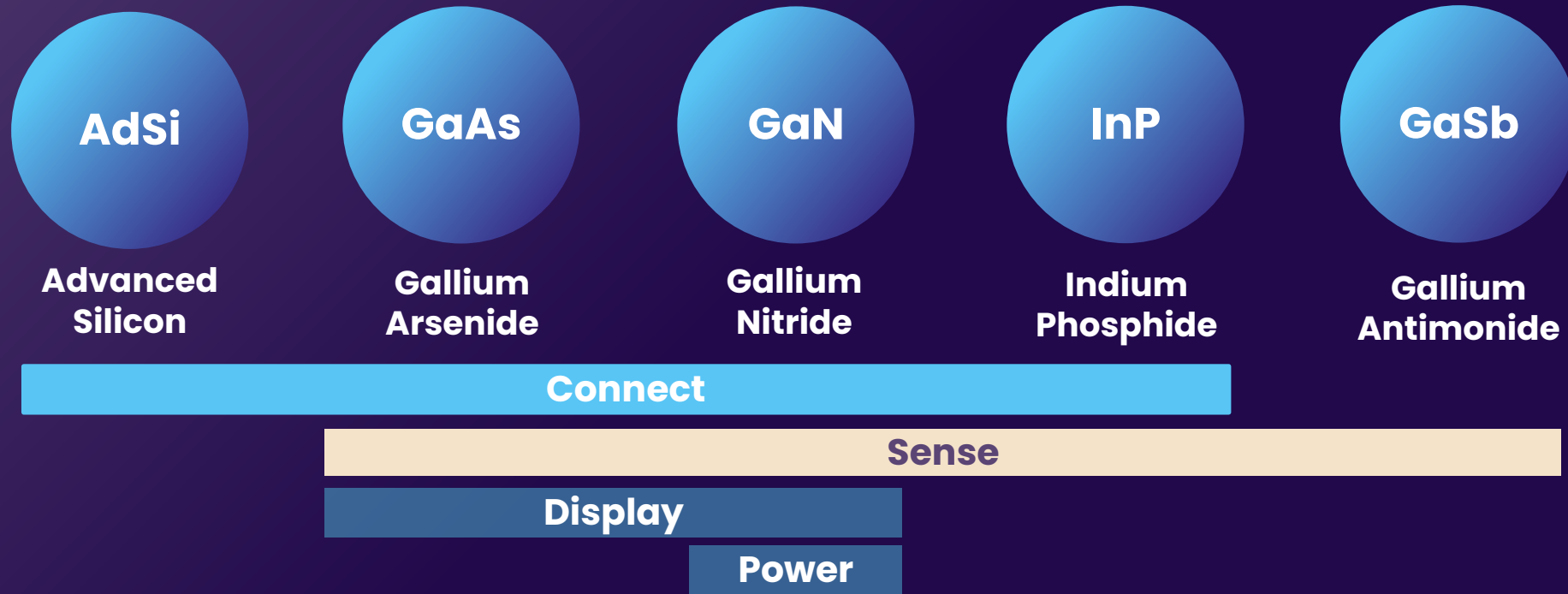
Materials for Photonic and Electronic devices

November 2023



Industry leading technology portfolio

Scaled material platforms



Scale across all epitaxy manufacturing technologies: MOCVD, MBE, CVD

30+ years of trade secrets and patents covering all technology development areas

Leveraging the versatility of GaN

Underpins today's business and creates waves of innovation for growth

Electronics

Connect

Power

Photonics

Display

Communications
Infrastructure

Smart Connected
Devices

Smart Connected
Devices

Automotive
& Industrial

Smart Connected
Devices

Automotive
& Industrial



GaN device
CAGR
= 14%

\$724m

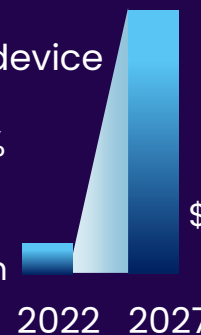


\$1.4b

2022 2027

GaN device
CAGR
= 50%

\$182m



\$1.4b

2022 2027

GaN device
CAGR
= 158%

\$7.3m

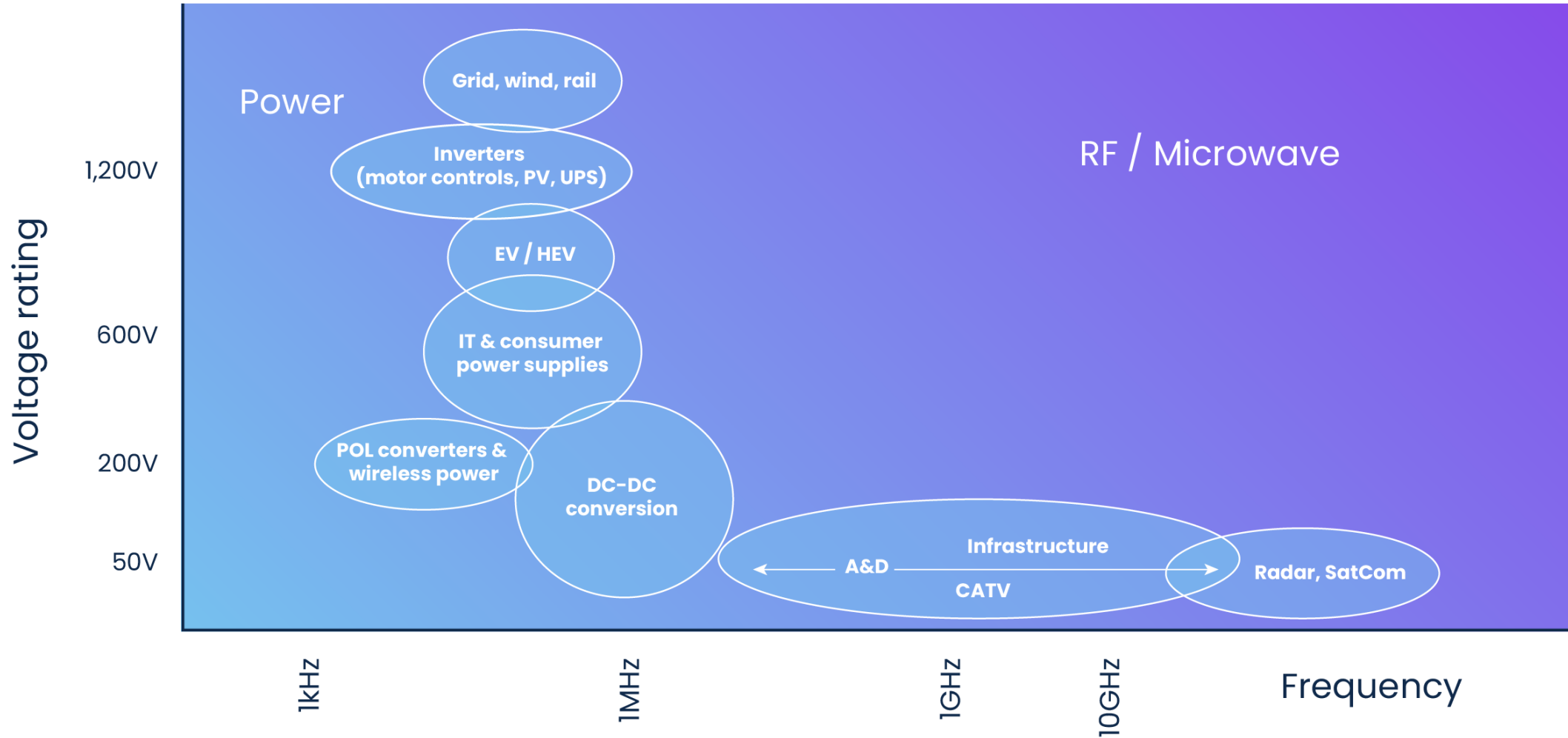


\$834m

2022 2027

Source: Yole Intelligence Q4 2022

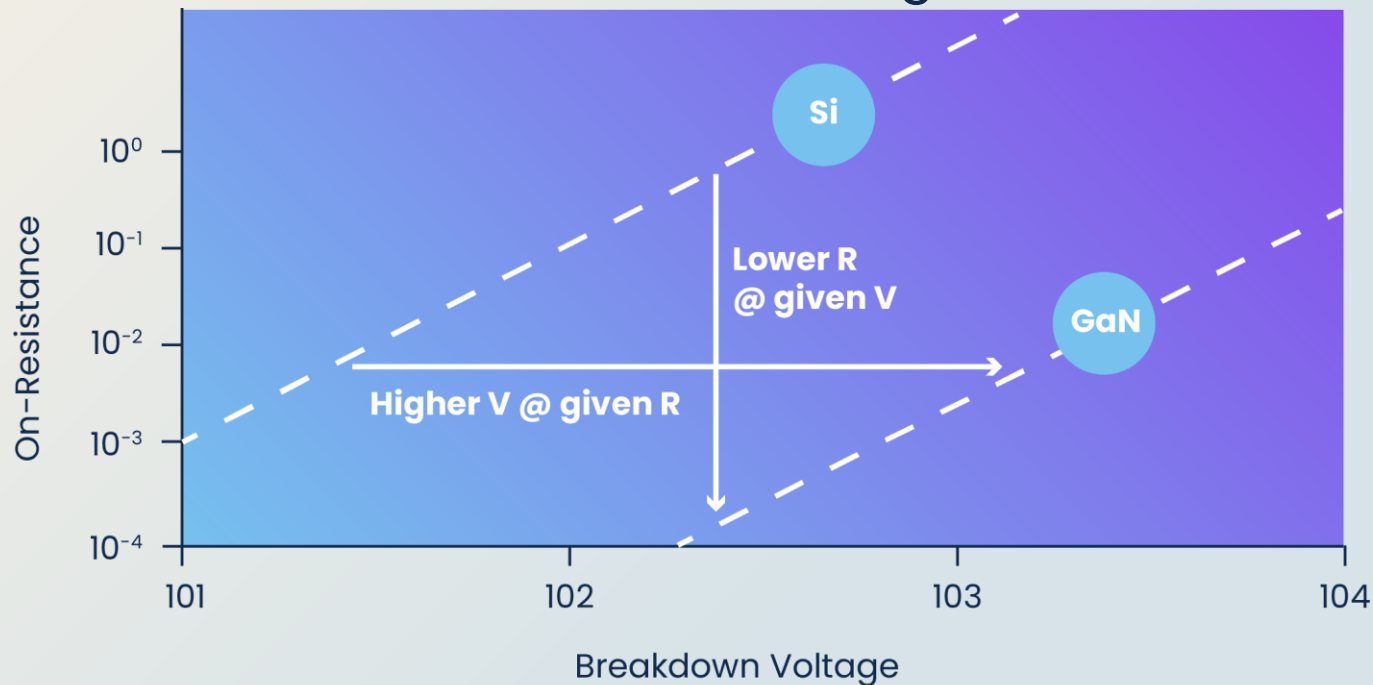
GaN for RF and PE markets



GaN for PE

More efficient power electronics

Low on-resistance leads to reduced switching loss



High breakdown voltage leads to smaller device size



μLED display technology

Leveraging epi expertise and unique technology portfolio

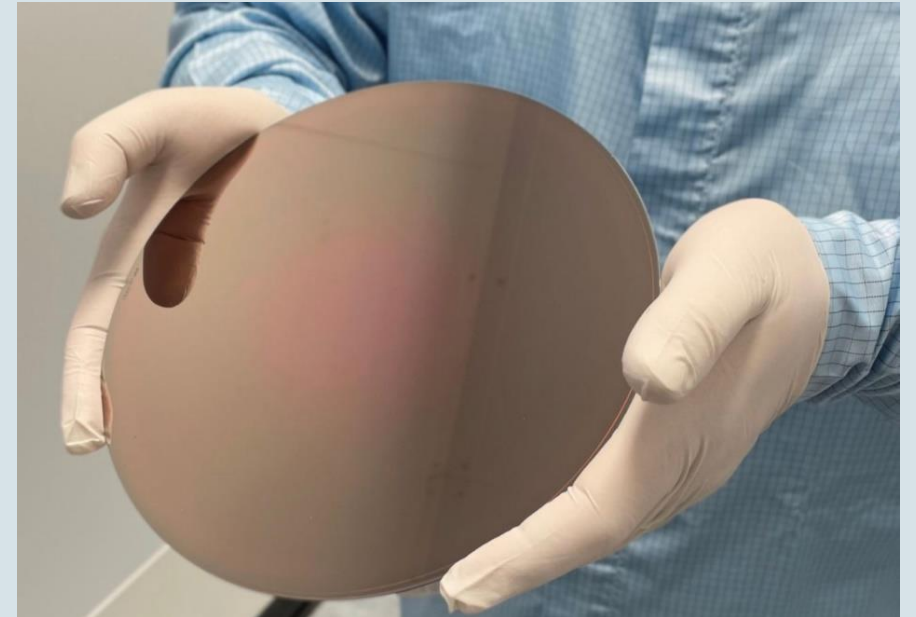
- Experience with all substrate types (Si, Sapphire, GaN)

Demonstrated RGB capability, all being scaled to 200 mm

- Blue/Green: 100 mm sapphire, scaling to 200mm
- Red: AlInGaP on 150 mm GaAs, scaling to 200 mm
- GaN-based red: under development

Multiple sites with room to scale

- USA: Massachusetts
- UK: South Wales





Scaling

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Leader in scaling to larger diameters

30+ years experience in transferring complex technology to larger wafer diameters

- Early 2000s: Scaled HBTs and PHEMTs to 150 mm
- First to scale GaN / SiC to 150mm (2014)
- First to release 150 mm VCSELs (2017)
- First to release 200 mm VCSELs (2022)
- Scaled quantum dot technology to 300 mm (2022)
- Supplier of 200 mm GaN/Si for RF, Power and μ LED
- Capability for 200 mm GaAs for RFFE products
- Capability for 150mm InP photonic wafers
- Line of sight to 300 mm for GaN/Si ??



Newport manufacturing facility

Poised to expand rapidly for growth markets



Typical MOCVD Reactor



Newport facility: **10%** occupied



Collaboration and Clusters

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Strategic Commercial Partnering across the value chain

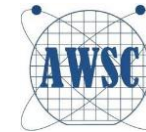
Substrate suppliers



Tool vendors



Foundries



IDM / Fabless



RD&I and Industry Association Engagement

Academic Engagement

- Many EPSRC proposals/grants supported or funded
- 9 PhD students (I-CASE, CDT) funded in strategically aligned areas
- Support several CDTs, 2 EPSRC manufacturing hubs, KTPs

Innovation Landscape Engagement

- Currently 17 collaborative R&D projects in progress
- Funded by I-UK, Horizon, ESA, Welsh Gov
 - Strength in Places, Quantum Techs, SMART, RIA, IA → various TRLs PoC through to Pilot Line and beyond....

Industry Body Engagement

- Photonics21 Board of Stakeholders – framing EU Horizon R&D topics
- European Photonic Industry Consortium (EPIC)
- UK Photonics Leadership Group
- APPG (Photonics & Quantum)



Strategic Research Agendas (UK & EU) / Lobbying / Advocacy

A Global Compound Semiconductor Cluster

The Entities




Institute for Compound Semiconductors
£75m



Centre for Integrative Semiconductor Materials
£90m



Compound Semiconductor Centre (CSC)
£42M

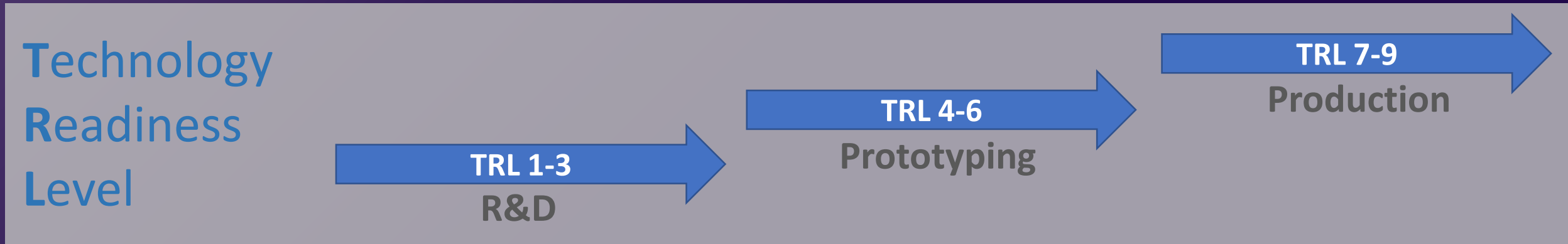


Compound Semiconductor Applications Catapult (CSAC)
£50+£100m





Compound Semiconductor Industry



Support



Llywodraeth Cymru
Welsh Government



Cardiff Capital Region
City Deal

Public Funding Bodies by TRL



Engineering and Physical Sciences
Research Council



Innovate
UK



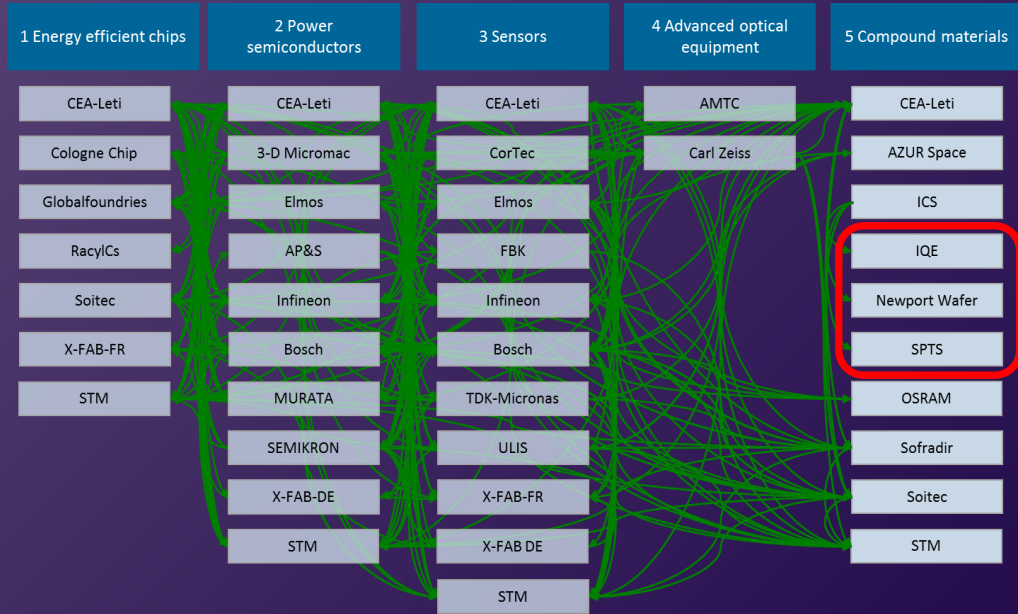
European
Commission



IPCEI
on Microelectronics



Collaboration – Active Network of Strategic Partners



Cluster Partners



● IPCEI founding countries
● IPCEI associated partners TF1
● IPCEI associated partners TF2
● IPCEI associated partners TF3
● IPCEI associated partners TF4
● IPCEI associated partners TF5

Important Projects of Common European Interest,

IPCEI Microelectronics is a €7.5Bn project

IPCEI Founding Countries – DE, FR, IT, UK

IQE's Role: Lead on TF-5 Compound Materials



- Key aspect is support for **“First Industrial Deployment”**
- Access to funding for **very high TRL** projects
- Underlying RD&I is crucial – many **“associated”** partners
 - Provide RD&I from academia, RTOs and SMEs (inc. Cluster)
- Major cross-collaboration across Technology Fields
- Major requirement of IPCEI = **Spillover**
 - e.g. Workshops, Techathons in non-IPCEI core countries

| Energy efficient chips | Power semiconductors | Smart Sensors | Advanced optical equipment | Compound materials |
|------------------------|----------------------|--------------------------|----------------------------|------------------------------------|
| CEA-Leti | 3-D Micromac* | CEA-Leti | AMTC* | AZUR Space Solar Power |
| Cologne Chip | AP&S International | CorTec | Carl Zeiss | CEA-Leti |
| Globalfoundries | CEA-Leti | Elmos Semiconductors | | Integrated Compound Semiconductors |
| RacylCs | Elmos Semiconductors | Fondazione Bruno Kessler | | IQE |
| Soitec | Infineon | Infineon | | Newport Wafer Fab |
| ST Micro-electronics | MURATA | Robert Bosch | | SPTS Technologies |
| X-FAB | Robert Bosch | ST Micro-electronics | | OSRAM |
| | <i>SEMIKRON</i> | TDK-Micronas | | LYNRED |
| | ST Micro-electronics | LYNRED | | Soitec |
| | X-FAB | X-FAB | | ST Micro-electronics |

Name in *“Italic”* = SME
*associated partner



Thank you



**Architects
of tomorrow**