UK Semiconductor Infrastructure Initiative Feasibility Study

Summary of findings

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UNIVERSITY OF CAMBRIDGE
Department of Engineering

IfM Engage

Strategic Technology & Innovation Management Consortium

UK Semiconductor Infrastructure Initiative

- The newly formed Department for Science, Innovation and Technology (DSIT) has commissioned a study to understand the **technical** and **economic** feasibility of developing specific capabilities to support commercial R&D, grow the UK semiconductor sector and contribute to supply chain resilience.
  - WP1 - Silicon manufacturing capability to support prototyping
  - WP2 - Advanced packaging capability
  - WP3 - Compound open-access foundry capability
  - WP4 - Design IP/tooling capability
  - WP5 - Strategic coordination capability that would provide an institutional framework around the infrastructure components
- There are several opportunities for stakeholders from across industry and academia to contribute to the project.

Funded by
UK Government

IfM Engage
Part of the Institute for Manufacturing

cambridge econometrics
clarity from complexity

Si SILICON CATALYST

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nmi

CATAPULT
Compound Semiconductor Applications

PHOTONICS
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UK Semiconductor Infrastructure Initiative Timeline

Review of International best practice to inform the appropriate institutional framework to deliver these capabilities

April – November 2023

Econometric analysis to provide evidence to inform the economic & financial case
Selection and costing of intervention scenarios

April – November 2023

Design and planning

March 2023

Methodology refinement
Survey design
Contacts identification
Logistics

1st survey launched to collect User Needs

May 2023

Invited participation from >180 UK organisations
Open invitation to all interested organisations via online platforms

2nd survey launched to map Existing Infrastructure

June 2023

Invited participation from >50 UK organisations
Open invitation to all interested organisations via online platforms

Workshops to validate survey findings

July 2023

Analysis of needs and capabilities
Proposed methods of intervention
Open invitation to all interested organisations via online platforms

Visits to all UK Semiconductor clusters

September 2023

Face-to-face visits to all UK Semiconductor clusters
Intervention scenarios
Discussion of preferences

Consultation with major UK end users

November 2023

Identify potential interest of major UK end users on supporting the infrastructure initiative
Prioritisation of intervention scenarios
Report to DSIT

Government analysis
Decisions
Implementations

- The IfM Engage consortium is acting independently based on the Tender brief.
- All data collected (from surveys, interviews etc.) are anonymous and protected.

Existing infrastructure provision – Academic institutions

Location	Open access	Clean room space			Current capacity / throughput levels per day?		Silicon processing	Compound Semiconductor processing	Other materials	Maximum Wafer size				
		< 5 ISO	5-7 ISO	>7 ISO	Users	Wafers				Lithography	Deposition	Etching	Packaging	Metrology
Northwest of England	Yes		1500		120 cleanroom users		🟩	🟦	2D materials, superconductors, ferromagnetic	150 mm (6'')	200mm (8'')	150mm (6'')	200mm (8'')	150mm (6'')
South of Enlgand	Yes		700			10	🟩	🟦	Nanomaterials	150 mm (6'')	100mm (4")	150mm (6'')	150mm (6'')	150mm (6")
Wales	Yes	100	900			20 (100 wafers per week)	🟩	🟦	Molecular semiconductors	200mm (8")	200mm (8")	200mm (8")	200mm (8")	200mm (8")
Southeast of England	Yes		140	600	10 (unspecified user or wafer)			🟦	Oxides, nitrides, metals	100mm (4")	150 mm (6'')	150 mm (6'')	150 mm (6'')	150 mm (6")
South coast of England	Yes	52	1116	402	200+		🟩	🟦	Limited compound semiconductor capability on certain tools	200mm (8")	200mm (8")	200mm (8")	200mm (8")	
North of England	Yes	35	165	400		25	🟩	🟦		150 mm (6'')	150 mm (6'')	75mm (3")	100mm (4")	200mm (8")
North of England	Yes	96	318		30		🟩	🟦	Glasses, piezoelectrics	150 mm (6'')	200mm (8")	200mm (8")	150 mm (6'')	150 mm (6'')
South of England	Yes	40	988	129			🟩	🟦	Broad range including: Organic semicondcutors (dedicated cleanrooms), 2D materials, damond	200mm (8")	150 mm (6'')	100mm (4")	150mm (6'')	150mm (6'')
Wales	Yes		1350			10	🟩	🟦		200mm (8")	300mm (12")	200mm (8")	200mm (8")	200mm (8")
Scotland	Yes		500		25	10	🟩	🟦						
Scotland	Yes	20	980		Over 1000 process steps per month		🟩	🟦	Lithium Niobate, Superconducting materials, Silicon Glass and Polymers	200mm (8")	200mm (8")	200mm (8")	300mm (12")	300mm (12")
Southwest England	Yes		200		8		🟩	🟦		150 mm (6'')	200mm (8")	100mm (4")	150 mm (6'')	150 mm (6'')
South of England	Yes		700			10	🟩	🟦	Nanomaterials	150 mm (6'')	100mm (4")	150mm (6'')	150mm (6'')	150 mm (6'')
South of England	Yes		200				🟩	🟦		100mm (4")	200mm (8")	200mm (8")	100mm (4")	150mm (6'')
Scotland	Yes						🟩	🟦	Superconducting					
Southeast of England	Yes		100		10		🟩	🟦	ALD deposition	100mm (4")	150mm (6'')	100mm (4")	100mm (4")	100mm (4")
Scotland	Yes		200			50	🟩		Glass, SiC	200mm (8")	200mm (8")	200mm (8")	200mm (8")	200mm (8")
Northwest of England	Yes	100	1000	400			🟩	🟦	2D materials					
East of England	Yes					3-5		🟦	2D semiconductors	50mm (2")	50mm (2")	50mm (2")	50mm (2")	50mm (2")
Southeast of England	Yes		260				🟩	🟦	Most semiconductors	150mm (6'')	150mm (6'')	100mm (4")		200mm (8")
Northern Ireland	Yes		200				🟩		Quartz, Germanium	150mm (6'')	150mm (6'')	200mm (8")	150mm (6'')	150mm (6'')

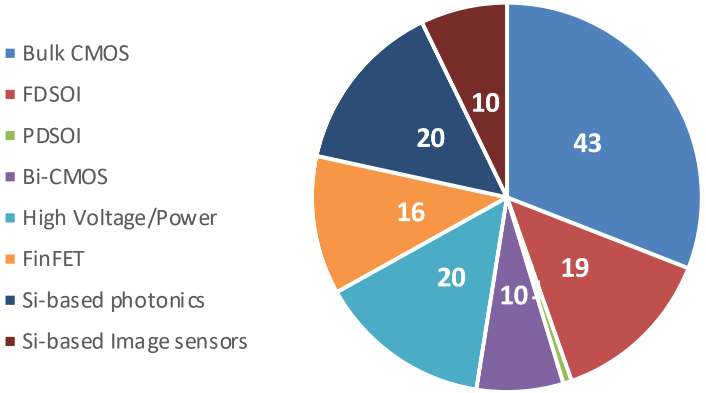
Existing infrastructure provision – Commercial institutions

Location	Open Access	Clean room space			Current capacity / throughput levels per day?		Silicon processing	Compound Semiconductor processing	Other materials	Maximum Wafer size that can be porcessed					Number of External Users
		< 5 ISO	5-7 ISO	>7 ISO	Users	Wafers				Lithography	Deposition	Etching	Packaging	Metrology	
Scotland	Yes		1200			55		🟦		150mm (6")	150mm (6")	150mm (6")	150mm (6")	150mm (6")	23
Scotland	Yes	259	802.5	120		200	🟩	🟦	Borofloat	150mm (6")	150mm (6")	150mm (6")	150mm (6")	150mm (6")	12
Northern Ireland	No		8000			20		🟦	Magnetic materials, gold, all rare earth materials	200mm (8")	200mm (8")	200mm (8")	200mm (8")	200mm (8")	
Scotland	No		2000			13		🟦		100mm (4")	100mm (4")	100mm (4")	100mm (4")	100mm (4")	
Scotland	Yes		300			20000	🟩	🟦					300mm (12")		70
South of England	No		225	100		2	🟩	🟦		200mm (8")	200mm (8")	200mm (8")	200mm (8")	200mm (8")	
Northeast (England)	No		9542			20		🟦	GaAs, InP	150mm (6")					
Scotland	Yes						🟩	🟦	Design devices for all above technologies						12
Scotland	Yes			100		12		🟦			100mm (4")			150mm (6")	11
Wales	Yes							🟦							100
Scotland	Yes						🟩		SIc, LTO, LNO, Sapphire, Diamond,SOI, Silicon	300mm (12")					
Southwest England	Yes		50			1-1000			Any optical or semiconductor material						40
Northeast England	Yes	771	691						Novel functional and semiconductor materials	300mm (12")	300mm (12")	200mm (8")	200mm (8")	300mm (12")	4
Northeast England	No		9542			20		🟦		150mm (6")	150mm (6")		150mm (6")	150mm (6")	

1. Silicon manufacturing capability to support prototyping – User Needs

Important process technologies

(values represent number of organisations)



59 organisations responded

Types of chips and the node sizes required

(Ignoring the totals, the figure in each cell represents number of organisations requiring a type of IC at a particular node size. The totals indicate overall level of need)

		Node sizes								
		>90nm	90-65nm	45-28nm	22-20nm	18-10nm	7-5nm	3nm	<3nm	Total
Type of IC	Analog/mixed signal	18	14	16	14	5	6	3	1	**77**
	Digital	7	8	12	14	8	9	7	4	**69**
	Photonics	7	5	3	4	1	0	0	0	**20**
	MEMS	6	2	2	2	1	0	0	0	**13**
	Memory (including next generation)	4	3	4	6	6	5	3	1	**32**
	Total	**42**	**32**	**37**	**40**	**21**	**20**	**13**	**6**	

45 organisations responded

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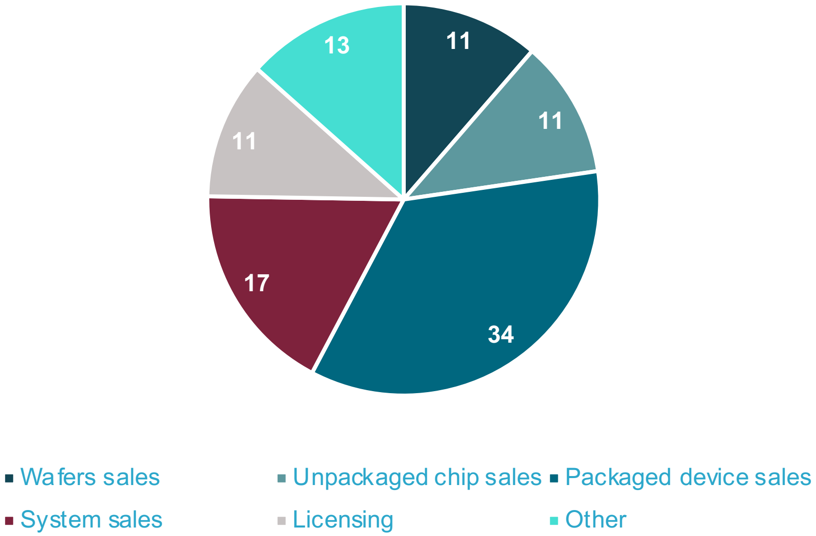
2. Advanced packaging capability – User Needs

74 companies responded to Advanced Packaging capability



NOW	Power	RF/Microwave	Photonics	Digital electronics	Sensors	Sum
Ceramic	5	6	7	2	4	24
Component	13	10	19	10	11	63
Metal	3	4	6	3	7	23
Plastics+	4	6	2	2	6	20
Grand Total	**25**	**26**	**34**	**17**	**28**	

FUTURE	Power	RF/Microwave	Photonics	Digital electronics	Sensors	Sum
Ceramic	2	3	3	0	1	9
Component	3	3	5	0	0	11
Hetro	1	1	1	0	0	3
Metal	1	0	2	0	0	3
Plastic+	1	2	2	2	2	9
Grand Total	**8**	**9**	**13**	**2**	**3**	

- The values represent the total number of entries of materials processed in each packaging application area.

3. Compound open-access foundry capability – User Needs

Category	Current Materials	Future Materials
1	GaAs, GaSb, InGaAsP, InGaSb, InGaP, InP, InSb, Other III:Antimonides	GaAs, GaSb, GaP, InGaAs, InP, InSb, Bismides, GaAs with quantum dot, InP with quantum dot, Other III:Antomonides, Superlattices T2SL
2	GaN, Cubic Gallium Nitride, SiN, AlGaN	GaN, GaN on Diamond, SiN, Composites of nitrides with other functional materials
Others (3, 9, 11)	Chalcogenide materials (3) Thin film Lithium Niobate (9) Diamond (11) Metamaterials Copper Indium Gallium Sulphide	Chalcogenide materials (3) Thin film Lithium Niobate (9) Diamond (11) Metamaterials
4	Doped Graphene	
5 & 8	Silicon Photonics, SiGe	Ge, Ge on insulator
6	CMT	
7	SiC, Cubic SiC	SiC, Si on insulator
10	Ga2O3, AgO, BTO	Ga2O3, Thin film BTO

Current Compound Semiconductor Materials and their Applications

Category	Power	Photonics	RF/ Microwave	Digital electronics	Sensors	**Total**
1	1	23	8	2	7	41
2	9	7	10	1	3	30
3	1	3	0	2	1	7
4	1	1	1	0	1	4
5	0	1	3	0	0	4
6	0	1	0	0	1	2
7	10	1	0	1	1	13
10	2	2	0	0	0	4
Total	25	39	22	6	14	110

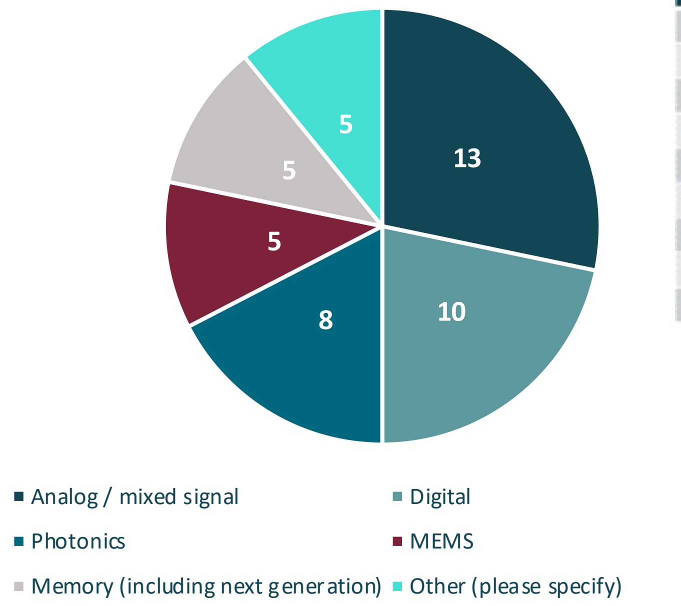
Future Compound Semiconductor Materials and their Applications

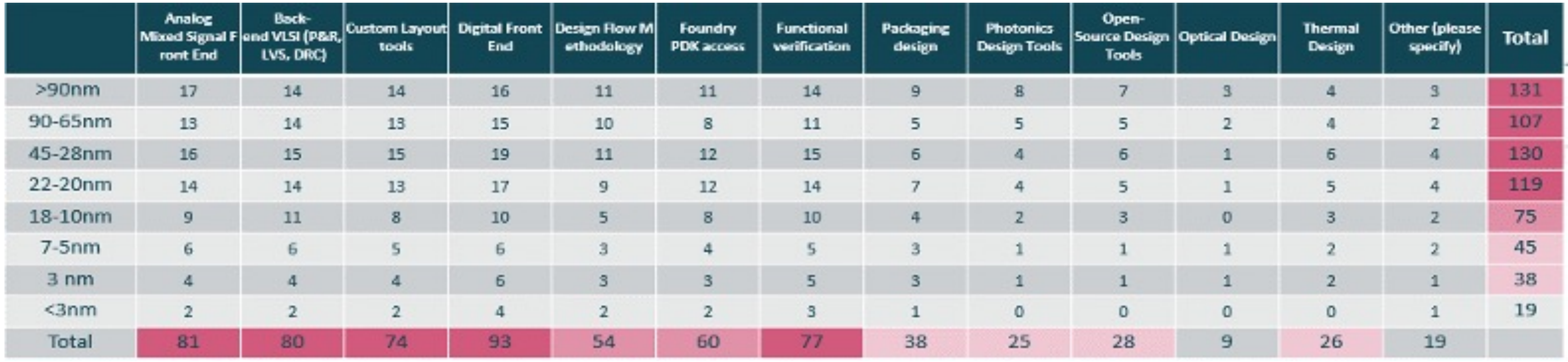
Category	Power	Photonics	RF/ Microwave	Digital electronics	Sensors	**Total**
1	1	3	10	1	5	20
2	9	11	4	0	2	26
3	1	1	3	1	1	7
5	0	0	1	0	1	2
7	9	1	2	2	2	16
10	3	0	2	0	0	5
Total	23	16	22	4	11	76

4. Design IP/tooling capability – User Needs

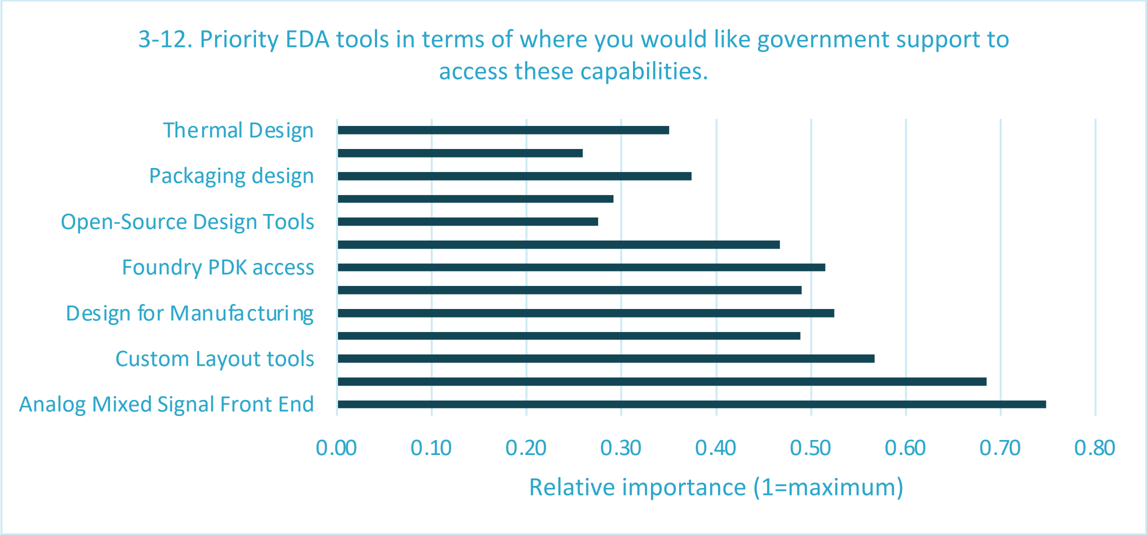
Types of chip(s) designed / developed

(Values represent number of organisations)





	Analog Mixed Signal Front End	Back-end VLSI (P&R, LVS, DRC)	Custom Layout tools	Digital Front End	Design Flow Methodology	Foundry PDK access	Functional verification	Packaging design	Photonics Design Tools	Open-Source Design Tools	Optical Design	Thermal Design	Other (please specify)	Total
>90nm	17	14	14	16	11	11	14	9	8	7	3	4	3	131
90-65nm	13	14	13	15	10	8	11	5	5	5	2	4	2	107
45-28nm	16	15	15	19	11	12	15	6	4	6	1	6	4	130
22-20nm	14	14	13	17	9	12	14	7	4	5	1	5	4	119
18-10nm	9	11	8	10	5	8	10	4	2	3	0	3	2	75
7-5nm	6	6	5	6	3	4	5	3	1	1	1	2	2	45
3 nm	4	4	4	6	3	3	5	3	1	1	1	2	1	38
<3nm	2	2	2	4	2	2	3	1	0	0	0	0	1	19
Total	81	80	74	93	54	60	77	38	25	28	9	26	19	



3-12. Priority EDA tools in terms of where you would like government support to access these capabilities.

Topics derived from User Needs Survey

1 – Silicon manufacturing capability to support prototyping	2 - Advanced packaging capability	3 - Compound open-access foundry capability	4 - Design IP/tooling capability
Si prototyping and piloting (low-volume manufacturing) facility for **65nm+ node size** (CMOS line with additional processing capabilities, e.g. for RRAM, Qubits, MEMS, etc.)	A specialist packaging facility, where the capital equipment for the **RF packaging** is located. This facility aims to support businesses and their R&D through provision of packaging capabilities.	An open access compound semiconductor foundry for the following materials GaAs, GaSb, GaP, INGaAsP, InGaSb, InGaP, InP, InSb, InGaAs, Bismides,GaAs with quantum dot, InP with quantum dot, Other III:Antimonides	Advanced CMOS design flow for high density, high performance digital devices for AI, telecoms etc.
Si prototyping and piloting (low-volume manufacturing) facility for **40nm+ node size** (CMOS line with additional processing capabilities, e.g. for RRAM, Qubits, MEMS, etc.)	A specialist packaging facility, where the capital equipment for the **Optoelectronics packaging** is located. This facility aims to support businesses and their R&D through provision of packaging capabilities.	An open access compound semiconductor foundry for Nitrides including GaN, GaN on Diamond, GaN on Silicon, AlGaN, SiN, Cubic Gallium Nitride…	Standard CMOS design flow for mainstream, wide range commodity digital and/or mixed signal, standard analogue, and high voltage power management for Automotive, Neuromorphic
Si prototyping and piloting (low-volume manufacturing) facility for **28nm+ node size** (CMOS line with additional processing capabilities, e.g. for RRAM, Qubits, MEMS, etc.)	A specialist packaging facility, where the capital equipment for the **Power packaging** is located. This facility aims to support businesses and their R&D through provision of packaging capabilities.	An open access compound semiconductor foundry for Silicon Carbide	Optoelectronics design flow for data comms, data storage, telecoms, co-packaged optics, quantum etc.
Si prototyping and piloting (low-volume manufacturing) facility for **<28nm node size** (CMOS line with additional processing capabilities, e.g. for RRAM, Qubits, MEMS, etc.)	A specialist packaging facility, where the capital equipment for the **Digital Electronics packaging** is located. This facility aims to support businesses and their R&D through provision of packaging capabilities.	An open access compound semiconductor foundry for oxides including Ga_20_3, Ag_20, BTO…	Stand-alone MEMS design flow
	A specialist packaging facility, where the capital equipment for the **Sensors packaging** is located. This facility aims to support businesses and their R&D through provision of packaging capabilities.		
	An integrated packaging facility with capital equipment for **all packaging application areas**(RF/Optoelectronics/Power/Digital Electronics/Sensors) **with a long-term thinking about heterogenous packaging**. This facility aims to support businesses and their R&D through provision of packaging capabilities.		

Some overall barriers where government intervention maybe required

- **Misalignment** between end-user requirements and manufacturing capabilities.
- Skills shortage and lack of **experienced** semiconductor **engineers** available. The UK is not attractive to international talent as it offers low salaries and it has a high cost of living.
- Lack of **collaboration** and **coordination** between R&D and industry.
- **Insufficient** allocation of **resources**/ investment especially for **scaling-up** and **manufacturing** on a large scale.
- Lack of an **ecosystem** and access to facilities. There are few skilled suppliers and access to existing laboratories is difficult.

Join us in the drop-in sessions…Room 223

1. What **unique capabilities** and competences (infrastructure, equipment, skills, knowledge, access to markets, supply chains etc.) does the UK **already have** in this area?

2. What would be the **competitive advantage for the UK** to have or to build the unique capabilities in this area?

3. What are the **barriers / challenges** for generating these advantages?