Urban Foresight

Advanced Material Electronics

Landscape map of the North East Sector

PREPARED FOR

Durham County Council and the Compound Semiconductor Applications (CSA) Catapult

Executive summary

The North East of England is home to an active advanced material electronics sector with significant growth potential.

About AME

Advanced material electronics (AME) are the building blocks of digital technologies. All sectors are dependent on electronics to some capacity. The report takes the definition of advanced material electronics to be:

> Electronic systems that use component materials processed for advanced properties to improve performance.

Innovation in these technologies, their application in different markets requires a full range of capabilities across R&D, commercialisation, testing and manufacturing. It is an interdisciplinary sector, which does not have a single sector definition, industry body, or policy focus.

But, AME is a high national priority in UK policy. It is seen as key for strengthening economic resilience, developing innovative products, addressing societal challenges and meeting global market demand, all of which can drive the UK's international competitiveness.

AME in the North East

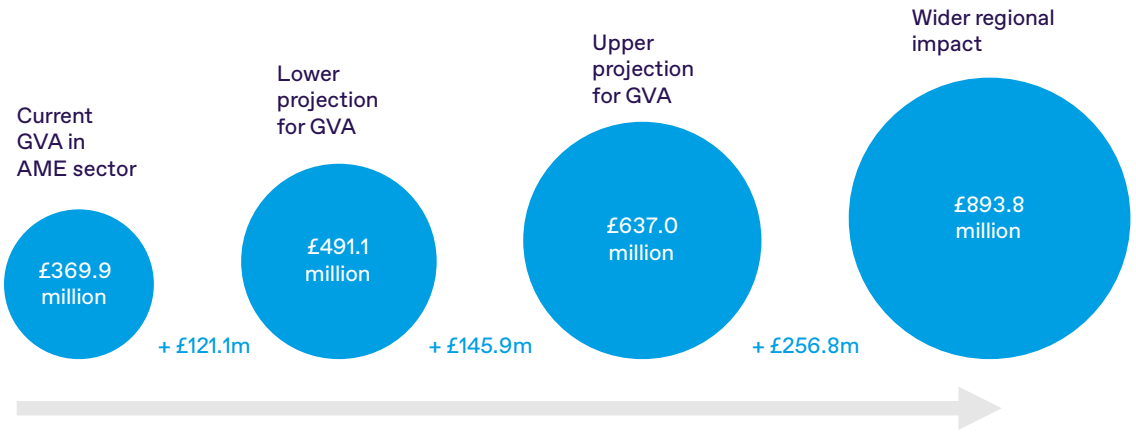
Advanced materials electronics has been recognised as a significant sector for the North East in a previous landscape report in 2020. This report updates these findings. Desk-based research and a business survey have found that:

- The North East produced 19% of the UK's total research outputs in AME.
- There are 58 active businesses in the sector in the North East, 96% of which are SMEs or microenterprises.
- These businesses are active across the full value chain of AME activities, from R&D to end-of-life management. The North East has unique capabilities in their level of customer service, bespoke solution development, and comprehensive service offer.
- A horizon scan of emerging technologies identified 8 key future technologies. North East businesses are active or planning to be active in all of these.
- Since the 2020 report, the number of jobs generated within the North East AME sector has increased from 1,800 to 2,798, GVA has increased from £183.9 million to £369.9 million.

46% of these new jobs and £50.6 million of the increased GVA is estimated to be due to the support from business growth support programmes. This includes the regional networking body, North East Advanced Material Electronics (NEAME).

Growth potential

The North East's AME sector is projected to grow by between £121.2 million and £267.1 million in the next five years. Accounting for wider economic impacts, the total projected GVA contribution to the North East economy is £893.8 million in the next five years.

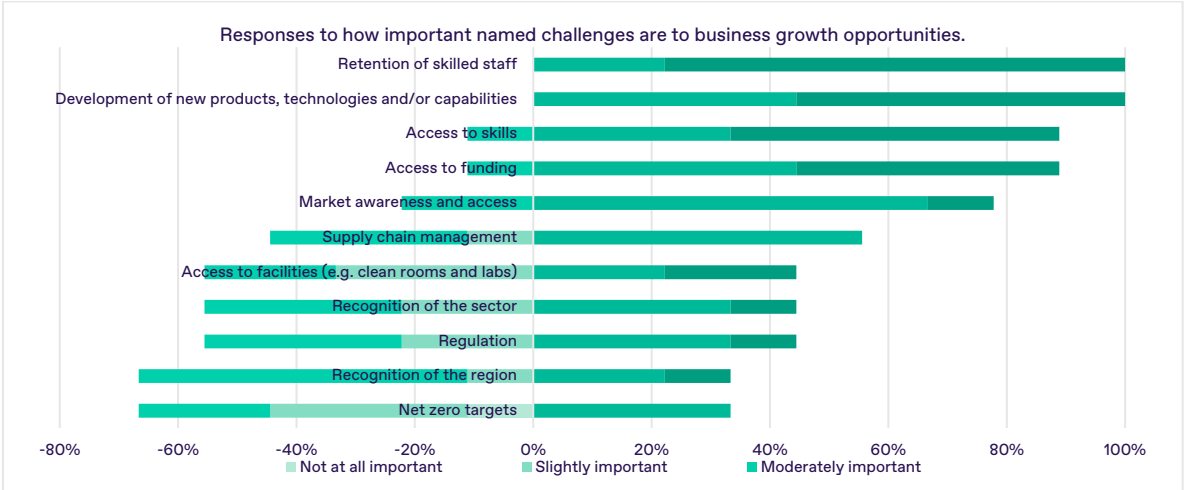


The specific market opportunities identified by AME businesses are in the development of their existing capabilities in sensors, microwave communications, and display technology in key high-growth sectors, particularly defence and aerospace, telecommunications, and healthcare.

This potential market growth is global. The sector is already actively exporting – 78% of surveyed businesses sell over 40% of their products abroad.

Barriers to growth

Despite having a number of key strengths, the North East AME sector faces several barriers to reaching its full potential. The main barriers revolve around skills, funding, and R&D.



However, businesses do not see access to facilities, recognition of the sector, or regulation as holding back their future growth. These are barriers that would require significant capital investment or national-level support to overcome.

The North East is therefore ideally placed to reach its growth potential through targeted support.

Contents

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The UK Shared Prosperity Fund aims to improve pride in place and increase life chances across the UK investing in communities and place, supporting local business, and people and skills.

For more information, visit https://www.gov.uk/government/publications/uk-shared-prosperity-fund-prospectus

Introduction

This landscape report defines and scopes the advanced materials electronics sector in the North East of England, its strengths, growth potential, and challenges.

Advanced material electronics (AME) are the building blocks of digital technologies. All sectors are dependent on electronics to some capacity. For example, service industries are enabled by connected, digital tools that use computing hardware and advanced manufacturing is dependent on automated machinery with component electronics.

Business and sector growth across industries is achievable with increases in the performance of these electronics, which is are largely accomplished through the performance of their component materials – their design, characteristics, and how they are processed.

Definition of the sector

The report takes the definition of advanced material electronics to be:

> Electronic systems that use component materials processed for advanced properties to improve performance.

Advanced materials are materials that have been engineered or processed to exhibit superior or enhanced properties compared to conventional materials.

These materials can belong to any class, including ceramics, metals, polymers, composites, and organic materials. The defining characteristic of advanced materials is their ability to deliver improved structural or functional performance, making them highly suitable for cutting-edge applications in industries such as electronics, manufacturing, and more.

Advanced Materials are often the result of innovative research and development, leading to new or significantly improved materials tailored for specific applications.

Electronics are systems that use the flow and control of electrons to process information or energy.

Semiconductors play a key role in electronics, using their mixed conductive and insulating properties to control electron flow in complex circuits. They are the building blocks of computer processors and therefore all digital hardware.

Other electronic system components may sense, capture or create light, electromagnetic waves, mechanical movement, and heat.

Scope of the sector

The extensive and intrinsic nature of advanced materials electronics means that there is not one single, accepted sector definition in use.

This research has found that 45 different SIC codes are used by businesses that self-identify as being part of the AME sector to describe their activities. A full list of these codes is provided as an appendix.

The sector can be defined and segmented across different dimensions: by technology, by application and by sector. This report has segmented the sector by all three, to develop as comprehensive a map as possible of sector activities in the North East.

Table 1 summarises the sectors deemed to be within the scope of advanced materials electronics for the purposes of this research.

Table 1. Sectors, technologies, and applications within scope of AME.

Technology	Application	Market
→ Semiconductor chips and integrated circuits (ICs) → Power electronics → Nanotechnology → Photonics → Radio frequency (RF) & microwave → X-ray & gamma ray → Sensors → Quantum → Ionic conductivity	→ Communications → Energy systems, including nuclear and battery systems → Clinical solutions → Computing → Positioning, Navigation and Timing (PNT) → Connected or smart devices, including packaging, IoT solutions, and robotics	→ Aerospace and space → Pharmaceutical → AgriTech and food → Telecommunications → Defence and security → Healthcare → Advanced Manufacturing → Mobility → Energy → FinTech → Data centres

Innovation in these technologies, their application and commercialisation in different markets requires a full range of capabilities. This landscape report has explored the capabilities of North East businesses against all processes involved in AME, as summarised in this list.

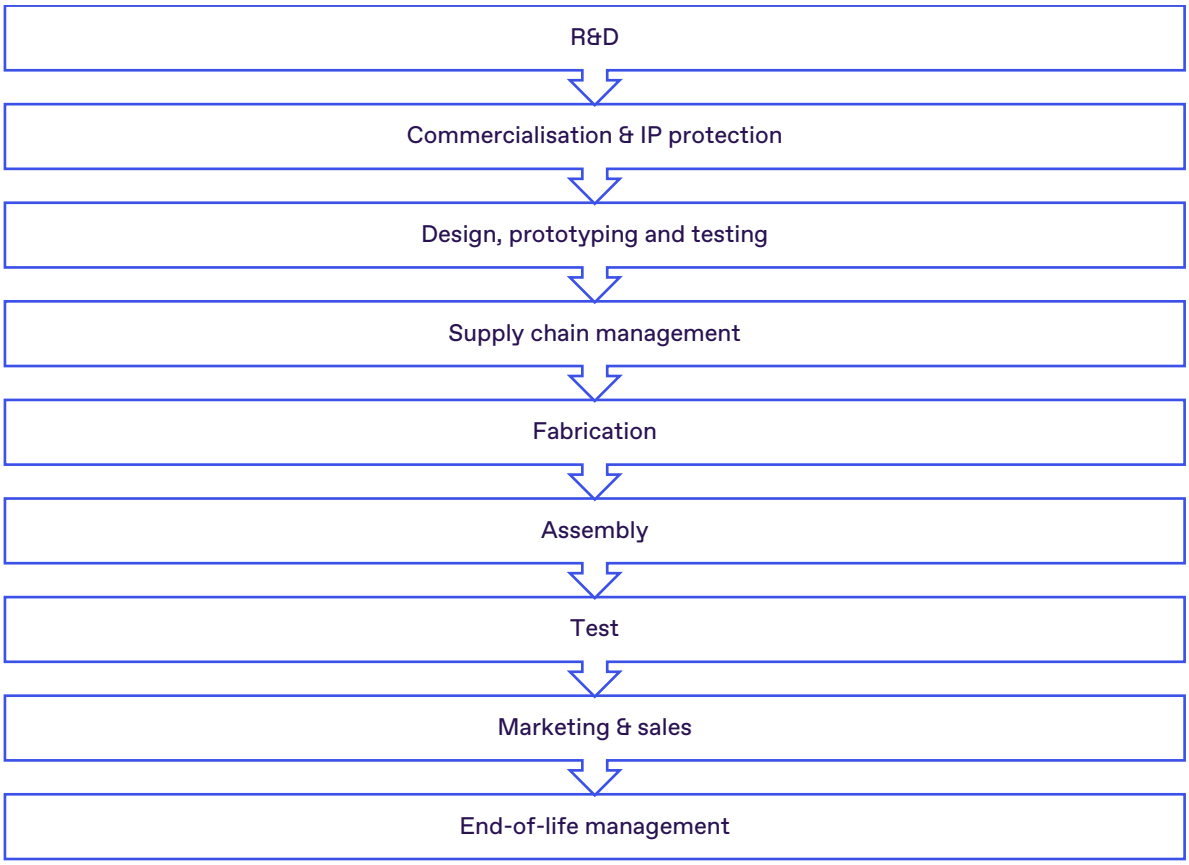

Figure 1. The value add processes considered to be in scope in this report's definition of AME business activity.

AME in UK policy

Advanced material electronics is a high national priority in UK science, technology and industrial policy.

But, materials are pervasive – every sector relies on them – and advanced materials electronics is an interdisciplinary sector that overlaps with engineering, chemistry, biology, and computer science.

For these reasons, AME does not benefit from a single, focussed strategy or policy body. AME businesses have a wide range of funding and support available to them – creating a relatively complex business environment.

National economic growth and resilience

AME technology is seen as key for strengthening economic resilience, developing innovative products, addressing societal challenges and meeting global market demand, all of which can drive the UK's international competitiveness.

The global advanced materials for electronics market was valued at US$30.4 billion in 2022, and with a compound annual growth rate of 7.4%, is estimated to reach US$57.8 billion by the end of 2031. Demand for lighter, more powerful and more sustainable products will drive this growth[1].

The Henry Royce Institute is the UK's centre for advanced materials and is in the process of develop a National Materials Innovation Strategy[2]. It has identified electronics as a core theme in this strategy – the materials for electronics, telecommunications, sensing and computing technologies theme includes the workstreams of materials for:

- Power electronics
- Organic electronics
- Optimised computing, including quantum and neuromorphic computing
- Data storage
- Telecommunications, including radio frequency and optical
- Advanced electronic sensors and instrumentation, including robotics, haptics, and the Internet of Things

The strategy also highlights that materials in general are a driver for economic growth in smaller, regional businesses. Over 2,500 materials innovation companies were identified, 90% of which are SMEs and 70% of which are outside of London and the South East.

Many electronic technologies are dependent on materials components that use precious metals and other critical minerals. The UK Government has taken steps to ensure that the supply of these materials is secure, shoring up the sector's resilience and potential to grow.

[1] Transparency Market Research (2023) Advanced Materials for Electronics Market
[2] The Henry Royce Institute (2024) Material Futures: Progress Report on the National Materials Innovation Strategy

The Critical Minerals Strategy was published in 2022 and includes objectives to secure international supply chains for vitally important mineral feedstocks[3]. Silicon is listed in the first assessment of minerals with high criticality for the UK economy due to its use in semiconductors – a key AME technology.

Compound semiconductors

The microchips that form electronic systems - the "building blocks of technology" – are predominantly produced from silicon wafers[4].

Silicon's semiconducting properties mean that it is not fully conducting or fully insulating. Its lattice structure is doped with other elements – such as boron or phosphorous – to either enhance or limit its conductivity[5].

These p-type or n-type silicon structures can be combined in different layouts to form diodes and transistors, which are themselves the components of arrays or circuits that modulate currents and process signals.

When a single semiconductor wafer has the resistors, capacitors, diodes and transistors of a circuit fabricated directly onto it, then it is a microelectronic circuit, microchip, chip, or integrated circuit[6].

80% of all semiconductors are silicon[7] and they are considered the foundation of the electronics industry. The remaining 20% are compound semiconductors.

Compound semiconductors are chips with two or more elements combined in their fabric to create unique properties and enable even more complex current modulation. For example, gallium-arsenide (GaAs) or silicon carbide (SiC) are common compound semiconductor substrates.

They are a less mature technology than the conventional semiconductor, as they are more complex, fragile, and sensitive to operating conditions[8]. However, they outperform silicon in power, speed and light processing potential.

For this reason, its assumed that advances in compound semiconductor design and manufacture will unlock the next wave of technological advances across all digitalised sectors. This would be in line with Moore's Law – first mooted in 1965 and proven to be robust – which states that microchips are becoming exponentially smaller, denser, cheaper, and more powerful overtime.

The UK has a significant role to play in these innovations. A recent study from the Department for Science, Technology and Innovation (DSIT) found that dedicated semiconductor companies

[3] UK Government (2022) UK Critical Minerals Strategy
[4] ASML (accessed 2024) The basics of microchips
[5] Next PCB (accessed 2024) What is P-type Semiconductor and N-type Semiconductor?
[6] Techtarget (2021) Definition integrated circuit
[7] Compound Semiconductor Applications Catapult (accessed 2024) What are compound semiconductors?
[8] University Wafer (accessed 2024) What is a compound semiconductor?

generate nearly £10 billion in annual revenues[9] and that, of all international semiconductor businesses, 72% undertake research, development, design and IP activity in the UK.

DSIT is actively supporting the compound semiconductor sector through:

- The National Semiconductor Strategy, published in May 2023, which focusses on the UK's existing strengths in R&D, design and IP, and compound semiconductors with the aim of increasing our international economic footprint and improving supply chain resilience.
- A study on the technical and economic feasibility of the infrastructure requirements to grow the sector.
- The UK Semiconductor Institute, an independent body that will act as a single point of content to enact the recommendations of the national strategy and promote the sector to investors.
- The launch of a £11.5 million series of projects to support the scaling of UK semiconductor businesses through Innovate UK.

The Compound Semiconductor Applications Catapult (CSA Catapult) was established in 2018 to accelerate and align the development and commercialisation of compound semiconductor technologies in the UK.

The Catapult has four areas of expertise – power electronics, photonics, radio frequency (RF) and microwave communications, and advanced packaging – but works across the sector to support a thriving innovation ecosystem that realises CSA innovations[10].

Horizon scan of emerging AME technologies

An initial search of Google Scholar results relating to "advanced material electronics" international research publications produced insight into emerging areas of interest in the application of novel electronic technologies that use advanced materials.

Table 2. Horizon scan of emerging AME technologies.

Emerging technology	Description
Flexible and soft electronics	Electronic conductors and circuits with mechanical flexibility, allowing them to bend and stretch without contorting.
Bioresorbable or biodegradable	Materials that are absorbed or decomposed in a biological environment, including insight the body, once it has served a purpose.
Advanced packaging	A compound semiconductor fabrication process that sees semiconductor components aggregated into a single electronic device for improved performance. It is considered to be the next

[9] Perspective Economics (2024) Department for Science Innovation & Technology: Semiconductor Sector Study

[10] The Compound Semiconductor Applications Catapult (retrieved 2024) Our expertise

	breakthrough technology for advancing semiconductor performance[11].
Metamaterials	The design of material structures to have properties not found in naturally occurring materials, which are derived not from their component material properties but from their newly designed structure.
Organic materials	Material components derived from carbon-based compounds from the natural environment.
Extreme environments	The application of electronics in extremely high or extremely low temperature, pressure, or irradiation environments – including in space and nuclear applications.
Micro- & nano-scale electronics	Electronic circuits on the scale of micrometres or nanometres.
Large-area electronics	Electronic circuits on the scale of several centimetres or more – much larger than a conventional circuit.

The domestic development and commercialisation of these future technologies will secure ongoing economic benefits for the UK, and their potential market opportunities will be of interest to all active in the AME sector, including policy-makers, funders and investors.

AME in the North East

The North East of England has an active and mature business innovation environment, strongly associated with its heritage industries of energy – including offshore – and automotive and machinery manufacturing.

North East businesses and policymakers have strong relationships with Teesside, which itself has historic strengths in energy and the process industries.

Advanced materials electronics has been recognised as a significant sector for the North East. The 2020 landscape map of compound semiconductor and resilient communications (that is, telecommunications and digital security) clusters in the North East identified 25 businesses in the region employing a total of 1,800 people and generating Gross Value Added (GVA) of more than £180 million to the regional economy.

Many of these businesses have an office, lab, or manufacturing facility at NETPark, the science and technology park in Sedgefield, County Durham, which was established in 2004. Run by the county council's business development agency, Business Durham, in partnership with Durham

[11] McKinsey (2023) Advanced chip packaging: How manufacturers can play to win

University and the Centre for Process Innovation (CPI), the park provides tenants with the infrastructure and networking opportunities required for high technology innovation.

In 2023, the CSA Catapult announced that it was establishing an office at NETPark[12]. That same year, Durham County Council included AME as a productivity strand in the Inclusive Economic Strategy (IES) from the County Durham Economic Partnership[13].

The Ministry of Defence recently acquired a semiconductor chip manufacturing facility in Newton Aycliffe, previously owned by Coherent and now named Octric, in order to sure up the UK's sovereign capability in a supply chain that is crucial to the defence sector[14].

NETPark will also see a £100 million extension open in 2025[15], providing more test, fabrication and R&D facilities for local businesses.

Whilst NETPark provides opportunities for growth and the AME sector has policy support from the local council, businesses in the North East also benefit from peer networks:

- Most notably, the North East Advanced Materials Electronics (NEAME) network, which was formed in 2022 to showcase, champion and develop regional AME capabilities[16].
- The Space North East England cluster is supported by the region's universities, Business Durham and Invest North East to build capacity in a sector that is dependent on advanced electronic communications.
- The North East Automotive Alliance is an industry-led cluster for automotive manufacturers to coordinate their growth and champion each other.

AME businesses in the North East of England are set to benefit from a supportive national and regional policy environment. With the facilities and infrastructure available to them, growth in this high-priority sector should be substantial.

[12] Compound Semiconductor Applications Catapult (2023) CSA Catapult to establish a presence in the North East
[13] County Durham Economic Partnership (2023) Inclusive Economic Strategy 2022 – 2035
[14] Sky News (2024) Government takes over chip factory 'crucial' to defence supply chain - safeguarding 'up to 100 jobs'
[15] North East Combined Authority (2024) Major milestone as first tenant signs up for £100million science park expansion
[16] Invest North East England (2022) New group launched to drive forward the advanced material electronics sector

Research in the North East

The nature of advanced materials mean that innovations often begin at a lab bench. Research organisations are key to breakthroughs, and the North East's researchers are active in AME.

The North East's research community includes four universities, neighbouring university Teesside, and the research and technology organisation (RTO) CPI, which has facilities at NETPark and Newton Aycliffe. Each undertakes research and offers research services in AME.

Notable research themes and the capabilities of these organisations are summarised here.

Durham University

- Advanced Materials and Electronic Devices is one of eight research nodes within the Department for Engineering.
- The Centre for Molecular and Nanoscale Electronics is a research centre that researches electronic devices enabled by molecular or nanoscale materials.
- The Centre for Advanced Instrumentation has particular expertise in the development of instrumentation for astronomy and biophotonics.
- The Centre for Communications Systems research all areas of wireless systems.
- The Durham Centre for Soft Matter includes research capabilities in organic electronics.
- The Condensed Matter Physics research centre explores advanced materials research topics including organic electronic materials, electronic structure methods and energy materials.
- The university has recently announced investments in quantum research hubs.

Newcastle University

- Within the School of Engineering:
    - The Advanced Materials and Electrochemical Engineering Group, with a particular focus on energy generation and storage materials.
    - The Microsystems research group specialises in systems architecture.
    - The Electrical Power research group is the UK's largest in this area.
    - The Intelligent Sensing and Communications research group explores communications, signal processing, and sensor systems.
    - The Design, Manufacture and Materials research group focusses on novel materials, structures and processes.
- The School of Mathematics, Statistics and Physics host the Emerging Technology and Materials research group, which has a focus area on emerging electronic technologies.

- nanoLAB is a designated research centre that aims to pursue new opportunities and innovations in nanoscience and nanotechnology.
- The Centre for Biomedical Engineering researches novel medical devices, including bioelectronic devices.

Northumbria University

- Research areas in the Mechanical and Construction Engineering departments include:
    - The Advanced Manufacturing Technology group whose areas of excellence include graphene-related materials and energy conversion & storage systems
    - The Engineering Materials and Mechanics Group (EM2G) which conducts materials engineering research into nanocomposites, graphene, functional materials, thin film coatings and high-entropy alloys.
- Research areas in the Department of Mathematics, Physics and Electrical Engineering include:
    - The Quantum and Molecular Photonics group with expertise in quantum optics and nanomanufacturing techniques.
    - The Northumbria Space Technology Laboratory (NSTL) works on the testing of small payloads, including optical system testing.
    - The Northumbria University Photovoltaics (NUPV) research group, which focusses on the development of new photovoltaic materials.
    - The Electrical Power and Control Systems research group handles all aspects of power and control for automotive and robotic systems.
    - The Optical Communications Research Group (OCRG) studies visible light communications, non-linear control systems and optical sensors.
    - The Renewable Energy Technology and Materials research group includes research into photovoltaics and energy system materials.
    - The Smart Materials & Surfaces Laboratory (SMSL) researches novel material structures including nanomaterials.

University of Sunderland

The University of Sunderland's engineering department focusses on advanced manufacturing technology applications – not the enabling technologies themselves – and materials science. Their materials science research is, however, more focussed on circularity and does not feature electronics research.

Teesside University

Teesside University is outside of the geographical boundary of the North East – it is in Middlesborough in North Yorkshire. However, it's research strengths are included here in recognition of its proximity to the North East business environment, particularly the cluster in the south of Durham. It has two relevant centres:

- → The Centre for Sustainable Engineering which designs, develops and optimises engineering systems, particularly off shore wind systems.
- → The Net Zero Industry Innovation Centre includes research into hydrogen energy systems, smart energy, and digital transformation.

CPI

CPI has four sites in the North East: R&D facilities at NETPark in Sedgefield, Newton Aycliffe, and Darlington, and an office in Newcastle upon Tyne.

- → The National Printable Electronics Centre is based in the North East and provides research services in Printed Electronics and Flexible Hybrid Electronics.
- → The National Formulation Centre is based in the North East and is focussed on process and chemical engineering, but includes capabilities in nanotechnology.
- → Their general Photonics capabilities include design, scale-up and optimisation.
- → Their general Battery materials capability includes material formulation and optimisation.

Research and development outputs

Searches for scientific research publications and patents from North East organisations indicate an active R&D community that is growing in influence and successfully commercialising innovations in materials for electronics.

Research publications

The research publication search used the ScienceDirect database to identify activity. The publication types available on ScienceDirect include review articles, research articles, book chapters and conference abstracts. They are assumed to be a representative sample of research publication activity.

The search term used in the "Title, abstract or author-specified keywords" was "electronic AND materials". This was determined to be the most suitable single search team after exploring the use of the terms electronic, electronics, device, and materials in various combinations.

Other searches produced false positives, such as research that electronic devices for engagement with research subjects or research into the migration or access of digital records in healthcare. These deviated too far from the advanced materials electronics scope to be considered relevant.

The "Author affiliation" field was then used to extract publication counts from UK organisations and research organisations active in the North East. That is, each of the universities and CPI.

Teesside University was included in the search due to its close proximity to the North East. Sunderland University was not included in the search – only one paper in 2009 appeared in the search, which when reviewed was not relevant to advanced material electronics, despite the earlier refinement of the search terms.

This search was completed on the 24th September 2024 and all figures are correct as of that date. Data was extracted for the years 2001 to 2024 only.

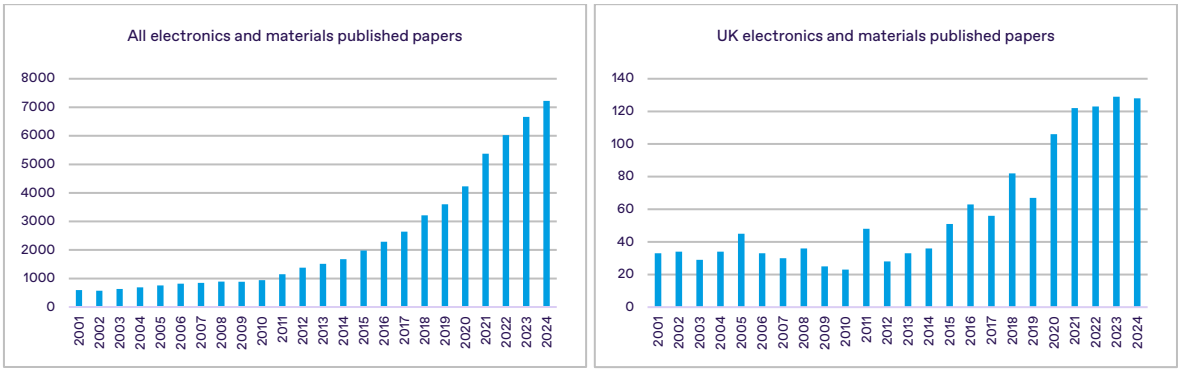

Figure 2. Paper publication rates globally and in the UK

This search identified 56,587 publications globally, and 1,394 from the UK. The number of publications globally is growing year-on-year at an increasing rate.

UK publication rates have also been increasing, but at a slower rate than the global trend.

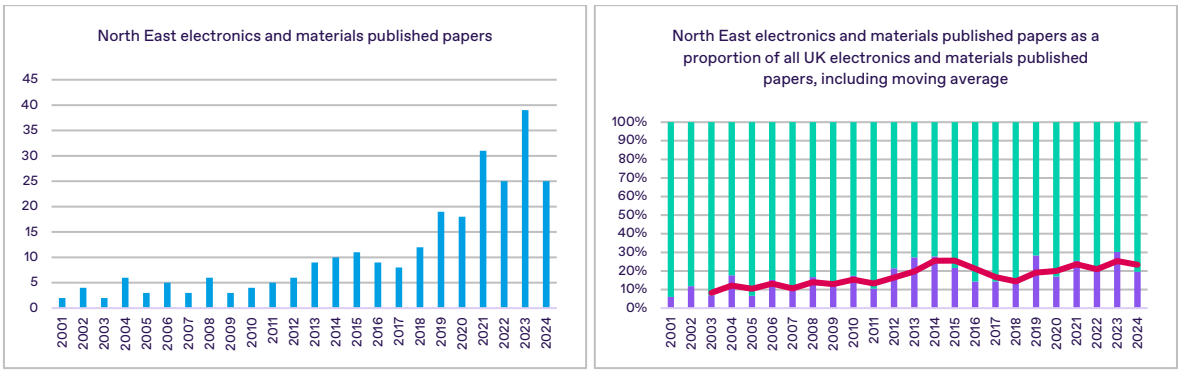

Figure 3. North East paper publication rates and publication rates as a proportion of all UK papers in electronics and materials.

The total publications identified from North East organisations is 264, or 19% of the UK's total research output in advanced materials electronics.

Further, the North East's publication rate is much more reflective of the global rate than the UK rate. This indicating that these organisations' research performance – in terms of output generation – is improving relative to the UK.

This is also demonstrated by the steady increase of its percentage contribution to total UK publications.

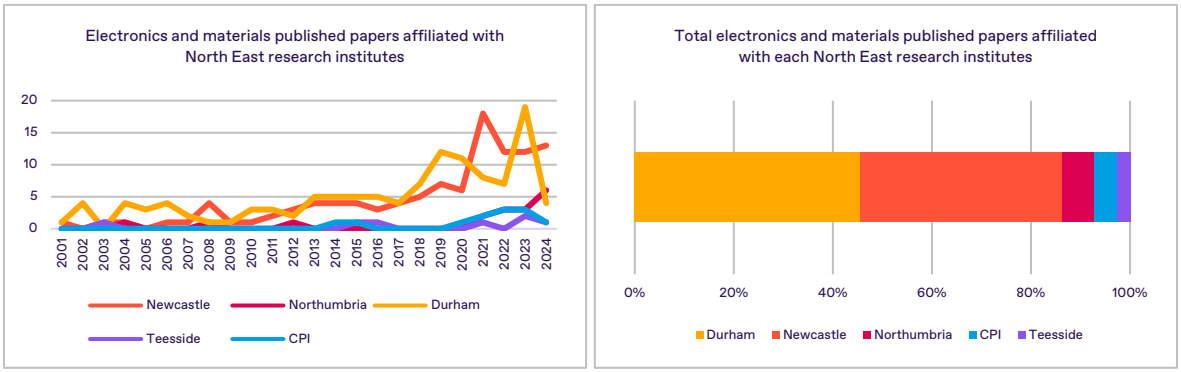

Figure 4. Electronics and materials published papers from North East research institutes.

Durham and Newcastle universities have higher publication rates. They are more research-focussed institutes, so this pattern was to be expected.

Overall, Durham is the most active research university in the North East, with a total of 120 publications appearing in the search from 2201 – 2024. Newcastle follows closely behind with 107 papers.

Patents

The patent search used the lens.org database to search for patents related to electronics, and those related to both electronics and materials. These search terms were informed by the terms used in the publication search, and the full syntax of the searched is included in the appendix.

The search looked only at patents raised by applicants from the UK, so as to understand the role of the North East within its policy environment.

This search was completed on the 24th September 2024 and all figures are correct as of that date.

A master list of businesses known to be active in advance material electronics in the North East was developed from the 2020 landscape map report, membership of the North East Advanced Materials Electronics group, membership of the Space North East England group, and responses to the research survey.

The full legal names and registered offices of these businesses were confirmed against Companies House records. This list was used to search the patent applicants, inventors and owners, in order to highlight where the North East community may have contributed to the commercialisation of an advance materials electronics innovation.

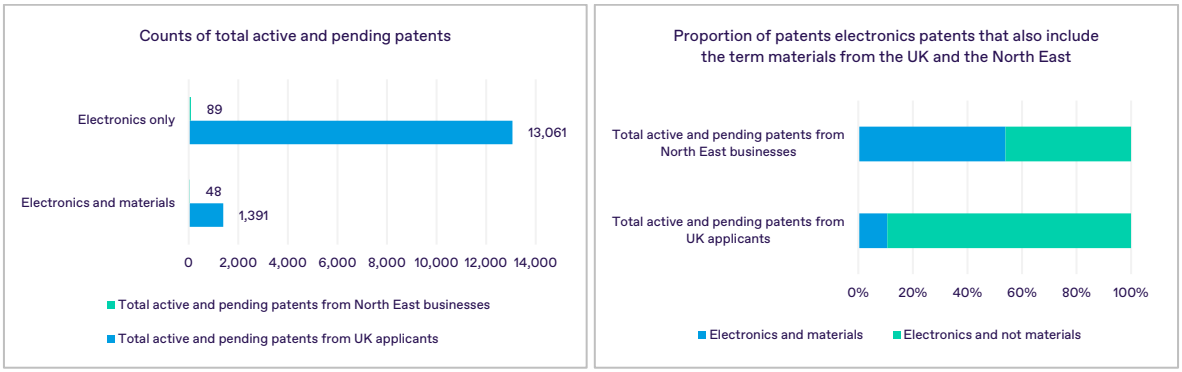

Figure 5. Results of patent searches for the terms "electronics" and "materials", from UK and North East applicants.

The search identified 13,061 total active and pending patents related to electronics, which reduced to 1,391 – just over 10% - when combined with the search term "materials".

For businesses active in the North East, there are 85 total electronics patents and 44 electronics and materials patents. These 44 patents represent a much more significant portion of the total North East patents than the UK rate at 52%.

This indicates a more active materials science commercialisation capability in the region, compared to the rest of the UK.

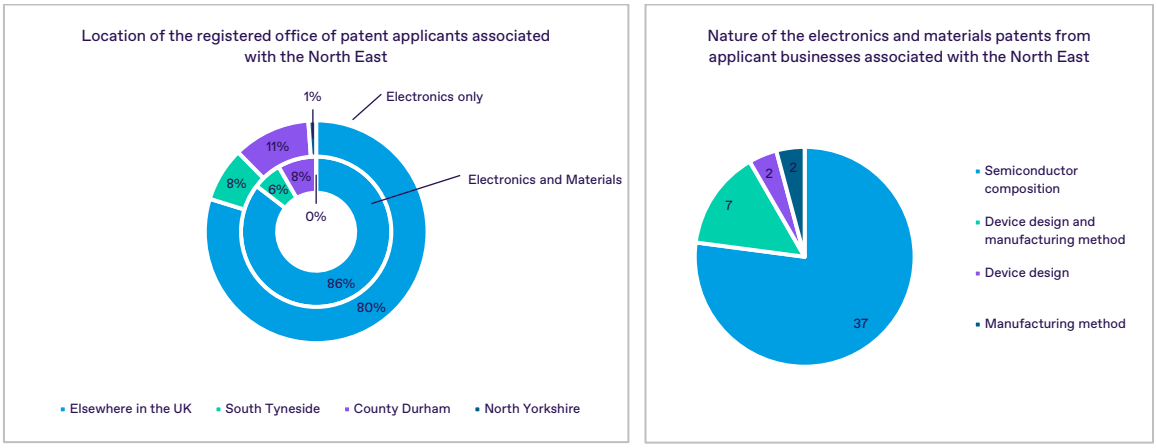

Figure 6. Location of the registered office of patent applicants associated with the North East and a categorisation of the nature of their patent abstracts.

Of those businesses active in the North East and applying for patents, there is a relatively small proportion of businesses that also have a registered office in the region, creating only 14% of electronics and materials patents and 20% of the electronics only patents.

Smartkem is the applicant with the most patents from North East businesses at 45% of the electronics only patents and 77% of the electronics and materials businesses. Smartkem has a site at NETPark in Sedgefield, a head office in Manchester and an international office in Taiwan. Whilst the patents have been filed and associated with the Manchester address, it is highly likely that the R&D activities took place in Sedgefield in County Durham.

A brief categorisation of the nature of the electronics and materials patents from North East applicants indicates strengths in both device design and manufacturing methods. The "semiconductor composition" category are all patents from Smartkem. Other categories of device design and manufacture were covered by Kromek, Power Roll, Pragmatic and Wootzano.

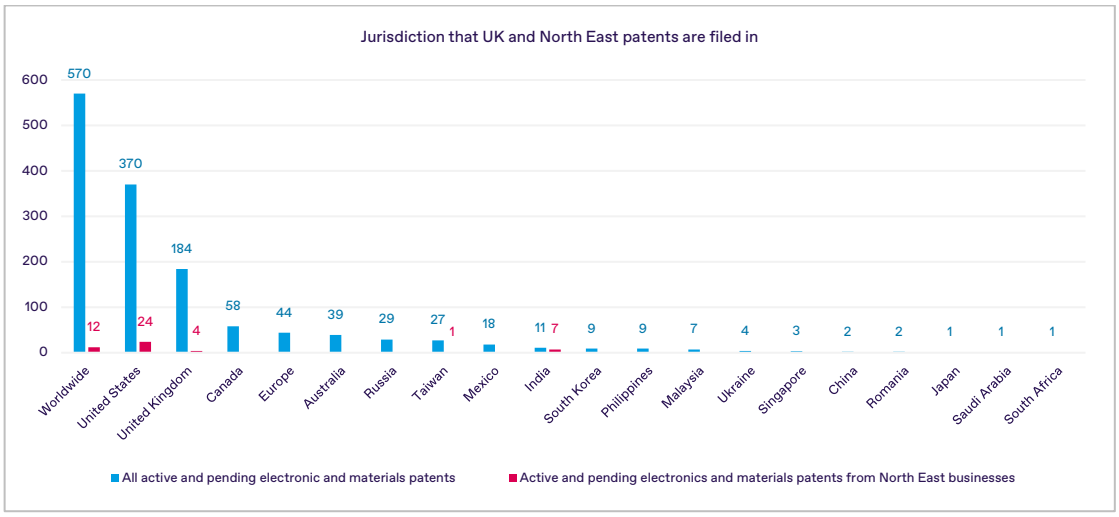

Figure 7. Jurisdictions that the electronics and materials patents filed from UK and North East businesses are filed in.

In terms of where these businesses are filing their patents and protecting their intellectual property, the North East businesses reflect the UK pattern of prioritising worldwide applications and those in the United States. The US has an IP protection system that favours and encourages patent applicants, and is a large, English-speaking market that attracts patent applications from UK businesses across sectors.

North East businesses are also targeting Taiwan and India with their applications. These are two markets with significant at-scale semiconductor and other advanced electronics manufacturing capabilities. This distribution reflects the focus of North East-associated innovators on manufacturing or process innovations found in the nature of the patents.

University spinouts

Of the AME businesses in the North East, there are four university spinouts, half of which are from North East universities:

- Kromek (Durham University)
- INEX Microtechnology (Newcastle University)
- PervasID Limited (University of Cambridge)
- Filtronic (University of Leeds)

Business activity in the North East

There are 58 active businesses identified as operating within the AME sector in the North East. 96% of these businesses are SMEs or microenterprises.

Business composition

In 2020, 29% of North East AME companies were micro-sized (0-9 employees), 35% were small-sized (10-49 employees), while 34% were medium-sized (50-249 employees). At the time, there was one large (250+ employees) company in the North East.

The business composition of the sector largely has not changed. In 2024, as Figure 8 shows, 30% of AME companies are micro-enterprises, 34% are small-sized, and 32% are medium-sized. There are now two large companies in the sector in the North East.

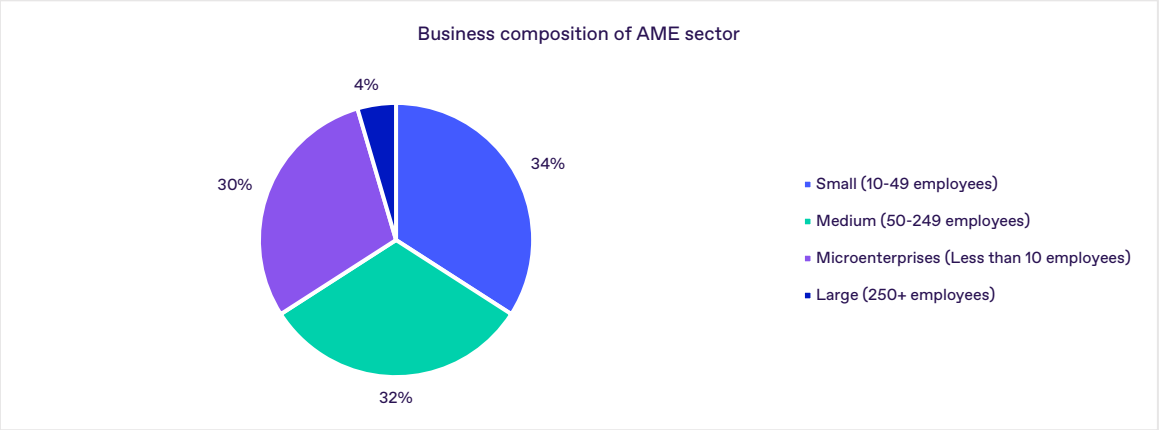

Figure 8. Business composition of AME sector in North East.

There are clusters of businesses in County Durham, in Newcastle and Gateshead, and in Cramlington and Ashington, as Figure 9 below shows.

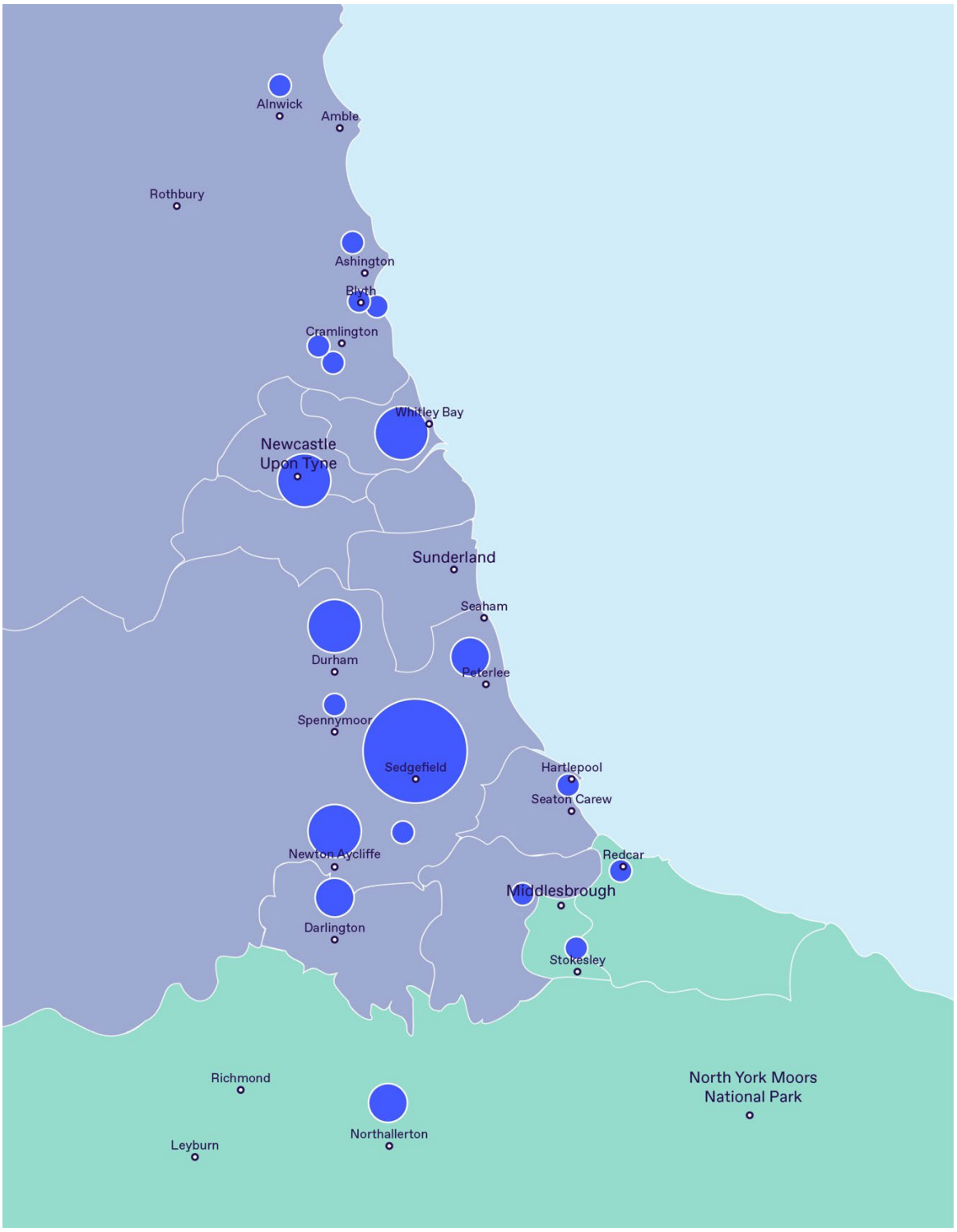

Figure 9. Map of clustered location of AME businesses identified in this research. The North East is shaded in blue, and North Yorkshire in teal. The size of the blue dots indicate the number of businesses in an area, showing clear clusters around NETPark in Sedgefield, Newton Aycliffe, Durham, Newcastle and North Shields. All AME businesses appear to be located along the North-South corridor of the A1 motorway.

Growth potential

There is significant growth potential for North East AME companies in the next five years. The average projected growth of employment within the AME sector according to survey respondents is 42% over the next five years, with 44% of survey respondents projecting growth in excess of 50%.

Growth projections for turnover are similarly optimistic with 55% of survey respondents projecting turnover growth of 75% or more over the next five years and 33% projecting growth of more than 500%.

R&D expenditure

According to the self-reported survey responses, companies are currently investing more than £15.7 million annually in R&D across the sector. At least £2.3 million to £6.3 million is projected to be invested into R&D over the next five years on top of existing expenditure, with 44% of companies expecting their R&D investment to increase by more than 25%.

Supply chain

The supply chain for AME businesses in the North East is currently reliant on imported materials, either from elsewhere in the UK or from internationally:

- All survey respondents reported that they source less than 40% of their materials from the North East, with 78% sourcing less than 20% of their materials from the North East
- 33% of survey respondents source more than 40% of their materials from elsewhere in the UK
- 44% of survey respondents source more than 60% of their materials from outside the UK

The amount of respondents sourcing materials from elsewhere in the UK indicates that there is an opportunity to improve on the resilience of the North East's AME sector supply chain. The general perception of businesses in the North East is that there is no local manufacturing capability, and this is why they must use foreign suppliers.

However, manufacturing capacity does exist in the North East. In addition to various small-scale microfabrication, there is a 310,000 ft^2 6-inch wafer fab in Newton Aycliffe with a 100,000 ft^2 clean room designed for high volume manufacturing of compound semiconductor devices based on GaAs, SiC and InP materials. The issue therefore is not necessarily that local or even domestic supply chains do not exist, but that they are weak, fragmented, or not well understood.

Key regional strengths

The AME sector in the North East has a particular focus on the defence, aerospace, communications, advanced manufacturing, and healthcare sectors.

Markets

The major market sectors being focused on by North East AME businesses are defence, aerospace, telecommunications, and advanced manufacturing. Figure 10 shows the market sectors that are prioritised by North East AME businesses.

The planned expansion of AME businesses in healthcare in the next five years is an opportunity for expansion of the sector, and can provide greater regional integration with the established health and life sciences industry in the North East. This planned expansion could be due to advances in the development of emerging technologies such as bioresorbable or biodegradable, organic, and flexible and soft materials.

Similarly the planned expansion of AME sector business presence in advanced manufacturing is important for the burgeoning electric mobility, energy, and aerospace sectors within the North East.

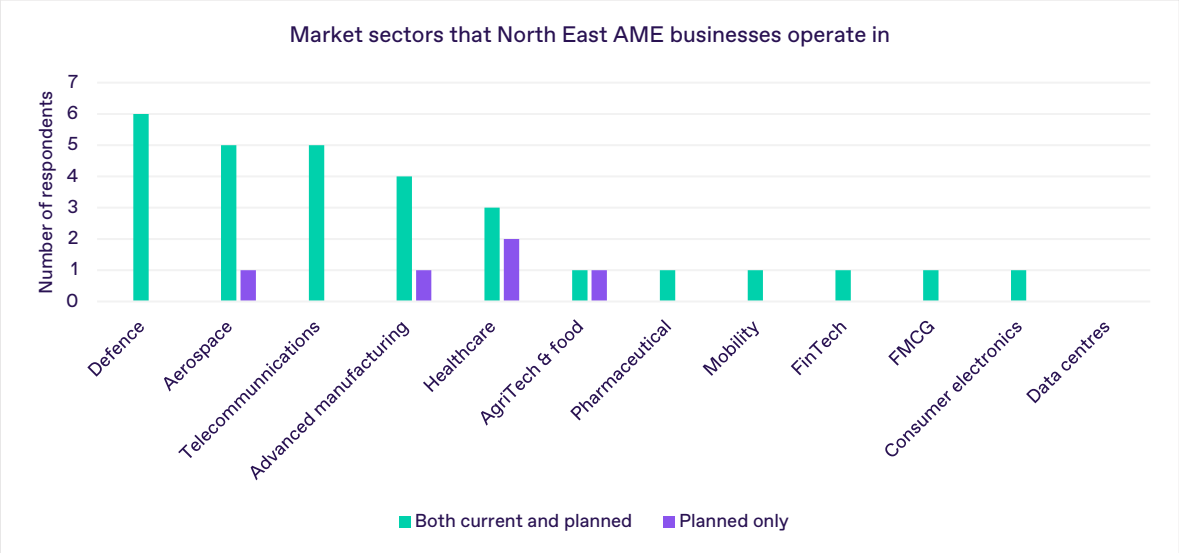

Figure 10. Market sectors that AME sector businesses in the North East operate within.

Key technologies

Figure 11 shows the main technology areas that AME sector businesses in the North East focus on. Semiconductor chips and ICs, sensors, and RF & microwave technologies are the major technology areas that businesses in the North East's AME sector are focusing on. In the future, sensors will be the most common technology areas that North East AME businesses will focus on.

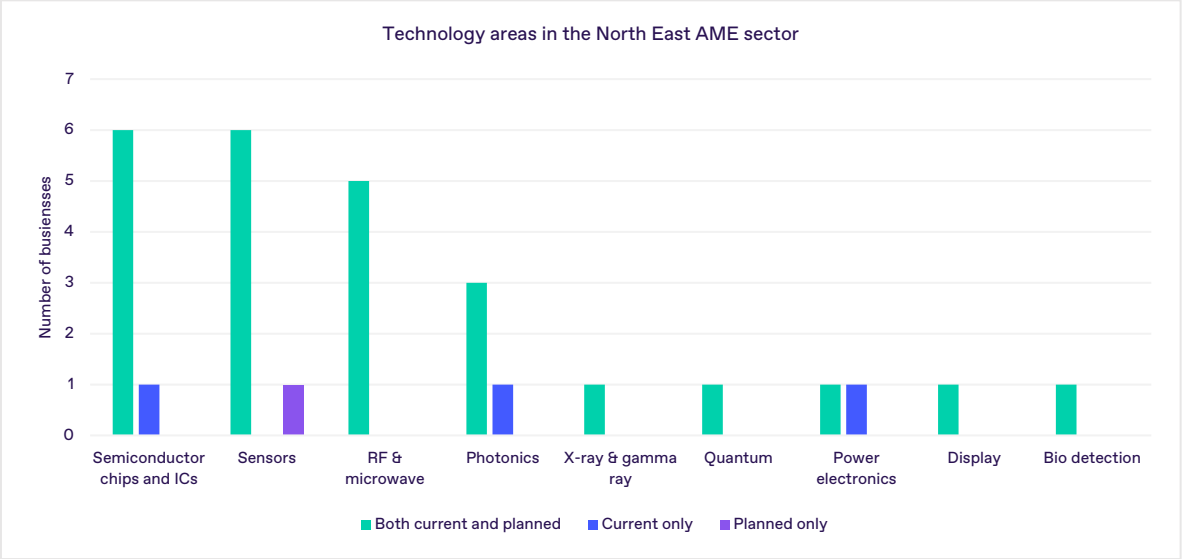

Figure 11. Technology areas operated within by North East AME businesses.

Figure 12 shows the range of technology applications being focused on by businesses within the North East's AME sector. The major technology applications being focused on are connected or smart devices, including packaging, IoT solutions, and robotics, and communications. The development and popularisation of VR and immersive technology has also created further opportunities within connected or smart devices, communications, and displays.

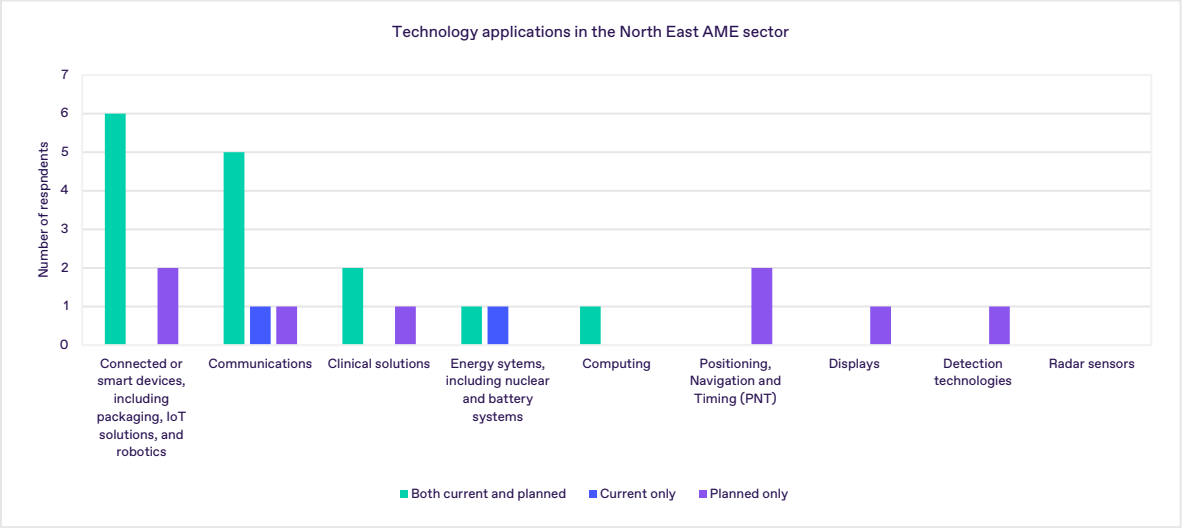

Figure 12. Technology applications being developed by North East AME sector businesses.

Emerging technologies

North East AME businesses are aware of emerging technology trends, and active in exploring and developing them. Figure 13 shows the activity of these businesses on different emerging technologies.

All emerging technology areas identified in the horizon scan are being activity explored, or intended to be explored by, a business in the North East.

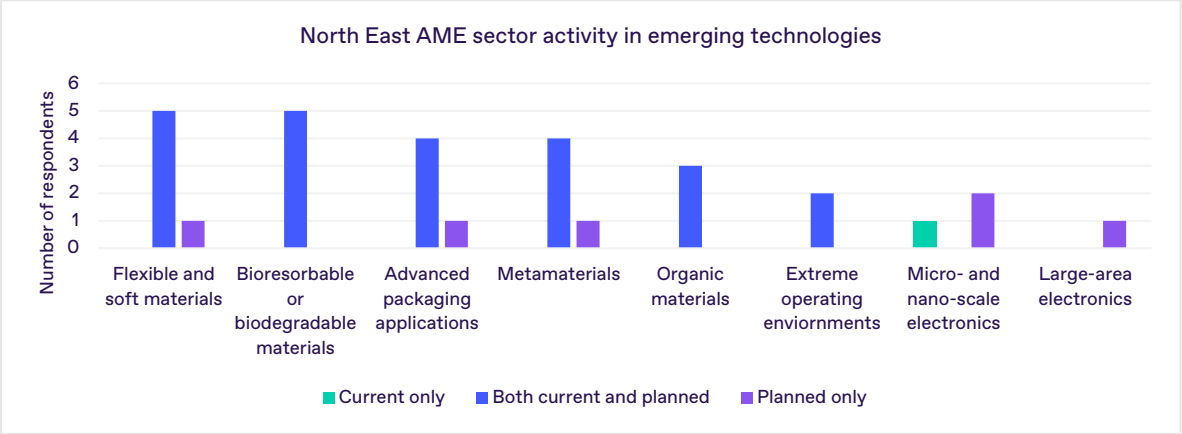

Figure 13. Self-reported activity in emerging technology areas within the North East AME sector.

The largest focus of the North East's AME sector is on flexible and soft materials, bioresorbable or biodegradable materials, advanced packaging applications, and metamaterials.

Capabilities

Figure 14 demonstrates the capabilities of North East AME sector businesses, both current and planned for the future.

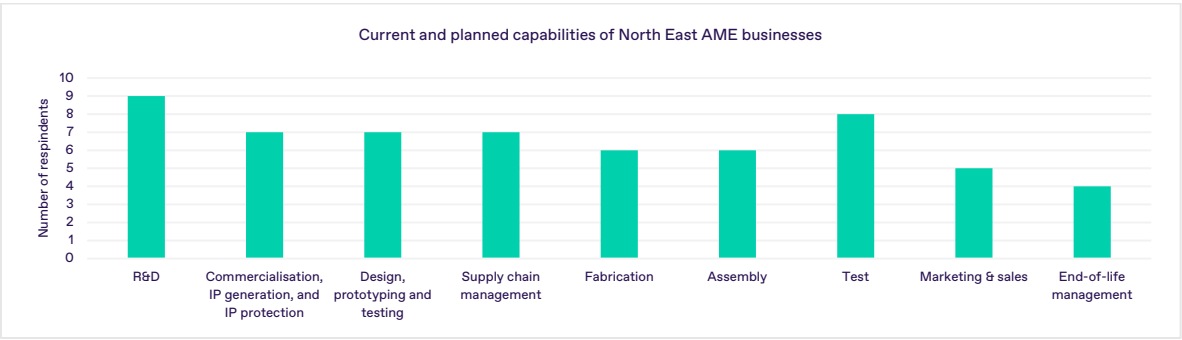

Figure 14. Current and planned capabilities of North East AME businesses.

There is business activity across the full value chain of AME activities in the North East. This represents a potentially impactful cluster of self-sufficient business that could progress an AME technology through its full lifecycle from discovery to reuse or recycle. The survey results show that slightly North East AME businesses have slightly more capabilities in the development of new AME solutions through R&D, commercialisation, design, prototyping, testing, and supply chain management.

A few of the survey respondents reported that they provide unique capabilities in the level of customer service, bespoke solutions, and comprehensive service offer that they provide. These soft skills and intangible value add could be considered a regional strength.

North East AME businesses are most lacking in capabilities surrounding end-of-life management, marketing and sales, and fabrication and assembly. This implies that North East businesses either do not themselves progress solutions through to manufacture and use, or that they outsource their fabrication and assembly needs, as well as marketing and sales, and end-of-life management. Promoting the development of local suppliers for these services could improve the efficiency and impact of cluster activities.

Economic impact of AME

Since the 2020 landscape report, the economic activity of the North East's AME sector has continued to grow.

- The number of jobs generated within the AME sector has increased from 1,800 jobs to 2,798 jobs over the last five years.
- The GVA created by the sector has increased from £183.9 million to £369.9 million.
- The presence of business support programmes and NEAME have enabled an additional 464 jobs and £50.6 million in GVA to be generated within the AME sector over the last five years.

Using a combination of primary data collected from a survey of AME sector companies in the North East and secondary data from annual reports and ONS data sets, the current and future impact of the AME sector through jobs and GVA over the last five years has been estimated. This approach is consistent with the previous landscape report to allow for comparison. A detailed methodology and breakdown of these calculations is provided in the appendix.

Performance in the last five years

Table 3 shows that the AME sector has performed in line with the projections made in the previous landscape report in its growth over the last five years. The number of jobs has increased by 55%, from 1,800 jobs to 2,798 jobs over the last five years. The GVA created by the sector has increased by 58%, from £183.9 million to £369.9 million.

To estimate the full benefits across the wider economy, a multiplier of 1.76 is then applied to the increase in jobs over the last five years. This multiplier is the average employment multiplier for the most common AME sector SIC designations taken from the latest ONS Supply and Use Tables for the UK.

This estimated an additional 1,756 jobs generated by the AME sector over the last five years in the North East, bringing the total AME sector dividend to 4,554 jobs. Similarly, the additional GVA generated for the wider North East from the multiplier effect is £191.5 million. This means that the total AME sector GVA generated in the North East over the last five years is £375.4 million.

Table 3. Total Jobs and GVA in the AME sector currently, and projected in the next five years.

	Total Jobs (FTE)		Total GVA (£ millions)	
	2020	2025	2020	2025
Total	1,800	2,798	183.9	369.9
Projected (Low)	2,770	3,907	292.9	491.1
Projected (High)	3,314	5,239	352.1	637.0

Potential growth

The AME sector is projected to continue to experience this strong organic growth over the next five years, as shown in Figure 15. Even in the absence of new or additional activities, total jobs is forecasted to increase by at least 40% from 2,798 to between 3,907 and 5,239. This growth is equivalent to an increase of between £121.0 million and £266.2 million in GVA over the next five years.

As before, a multiplier is applied to estimate the projected wider economy benefits of the AME sector. The AME sector could contribute an additional 2,344 jobs, and a further £256.8 million in GVA to the wider North East economy. The total projected number of jobs to be in the AME sector in the next five years is therefore 7,583 jobs, and the total projected GVA contribution to the North East economy is £893.8 million in the next five years.

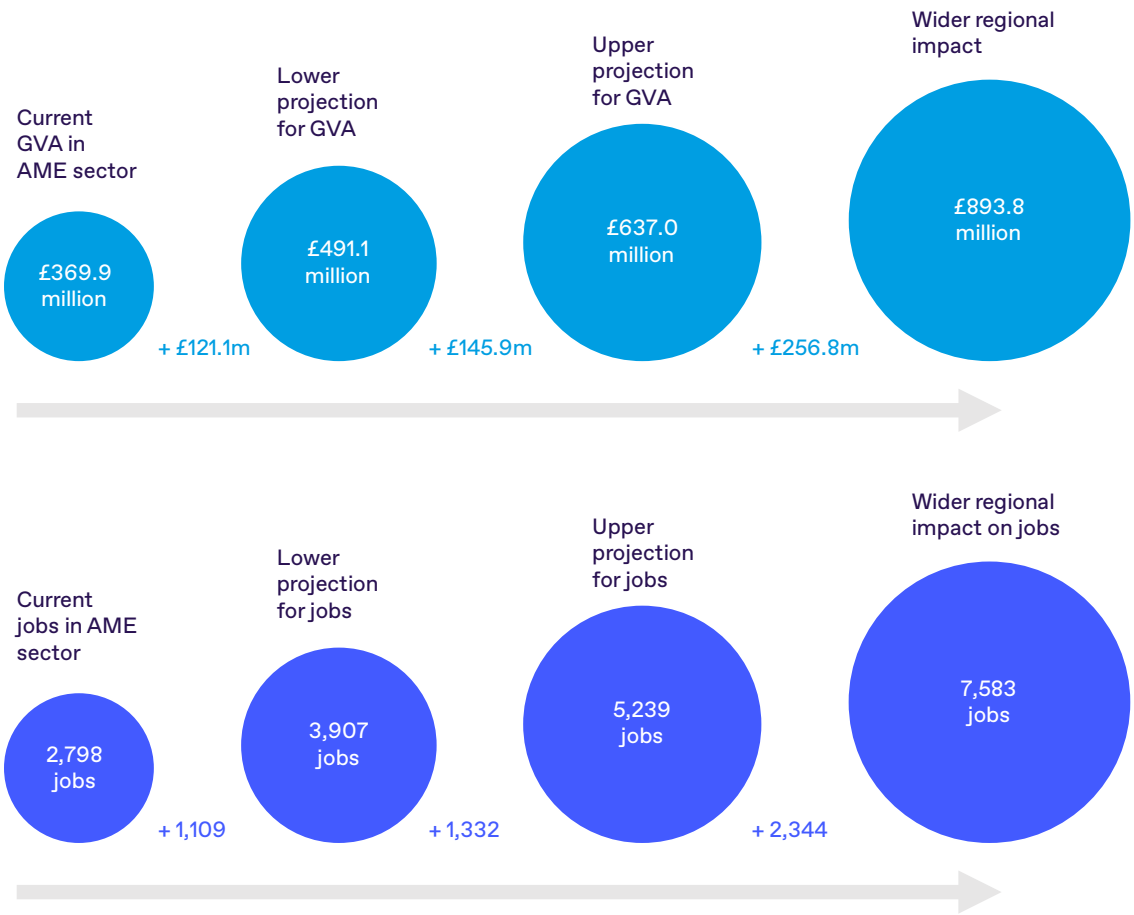

Figure 15. Projections for growth of jobs and GVA in the North East AME sector in the next five years.

Impact of business support programmes

It is estimated that 464 of the increase in jobs over the last five years in the North East's AME sector can be attributed to support from business growth support programmes, including NEAME. This is equivalent to 46% of the jobs created in the last five years. The presence of business support programmes and NEAME therefore have enabled a further £50.6 million in GVA to be generated.

To estimate the benefits across the wider economy, a multiplier of 1.76 is then applied to this figure. This multiplier comes from the latest ONS Supply and Use Tables for the UK. This brings the total figure to an estimated additional 817 jobs and £89.1 million in GVA generated by the business support programmes and NEAME over the last five years for the wider North East economy.

The continued success of these business support programmes and organisations therefore could enable the growth of the North East's AME sector to reach the upper projections of the economic model in the next five years. These support services must adapt to the needs of AME businesses in order to achieve this potential growth.

Growth potential

The North East's AME sector is projected to grow by between £121.2 million and £267.1 million in the next five years.

There are specific market opportunities that the AME sector can capitalise to achieve this growth potential.

Specific market opportunities

The survey respondents identified multiple opportunities for driving growth within AME businesses in the North East, as can be seen in Figure 16.

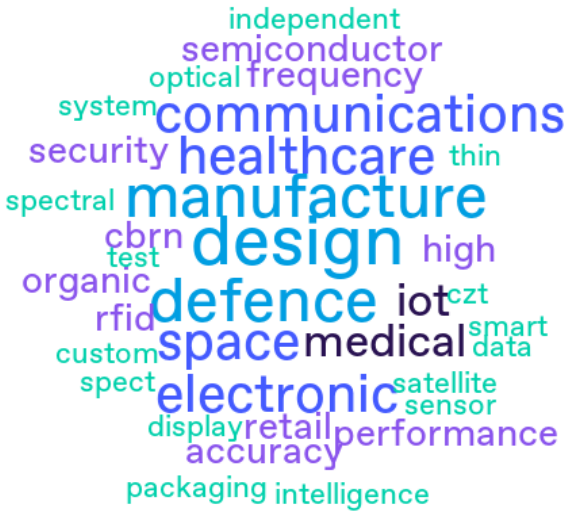

Figure 16. Word cloud of the unique value offer and key opportunities for growth identified by survey respondents.

The sectors reported by these AME businesses as having the most opportunities for future growth are:

1. Defence, security, space and aerospace
   The rapidly growing demand for faster, more secure communication and data access presents significant growth opportunities for companies focused on resilient communications in the North East. A significant growth area is in satellite communications and surveillance, driven by declining launch costs, advances in technology, and rising interest in national security.
   Space North East England is an established cluster network that demonstrates the region's ideal position for taking advantage of these rapidly expanding market opportunities.

2. Telecommunications
   Closely related to defence, satellite applications in telecommunications will provide significant opportunities for North East AME businesses, as demand grows for high-speed and secure data transfer in digitally-enabled sectors.
   The Telecommunications (Security) Bill 2021 introduced a new, stronger telecoms security framework and new national security powers that will favour domestic businesses.

3. Healthcare
   AME are fundamental to groundbreaking innovation across healthcare, from medical imaging systems for more accurate diagnoses, to wearable and connected devices for disease monitoring and management.
   The North East and neighbouring Teesside is home to key pharmaceutical manufacturing and health and life sciences innovation assets, including global leaders pharmaceuticals and biotechnology. The North East Combined Authority has identified health and life sciences as a sector of strategic importance for the region.

The businesses report focussing on developing their existing technologies into new applications for these high-growth sectors. These technology areas and applications, shown in Figure 11 and Figure 12, including sensors, microwave communications, and display technology.

In the North East, the energy and automotive sectors are of particular strategic importance. Mature supply chains and clusters of businesses mean that these sector hold additional potential for regional AME market growth.

International market opportunities

The customers for AME businesses in the North East tend to be located internationally, which demonstrates the AME sector's reputation internationally, and its importance as a key export sector for the UK.

- All survey respondents stated that they sell less than 40% of their products to customers within the North East, with 67% selling less than 20% of their products from the North East.
- 44% of respondents sell more than 60% of their products to international customers, with 78% selling over 40% of their products abroad.

Given the significant international customer base of the AME sector in the North East, more should be done to expand upon this further through interventions such as export support programmes.

The proportion of international customers to customers within the UK also indicates that more can be done to encourage upstream industry development. Increasing the number of customers available to the AME sector within the UK has benefits of both stimulating growth for the AME sector and also strengthening traditionally important industries within the UK such as healthcare and advanced manufacturing.

Barriers to growth

Despite having a number of key strengths, the North East AME sector faces several barriers to reaching its full potential. The main barriers revolve around skills, funding, and R&D.

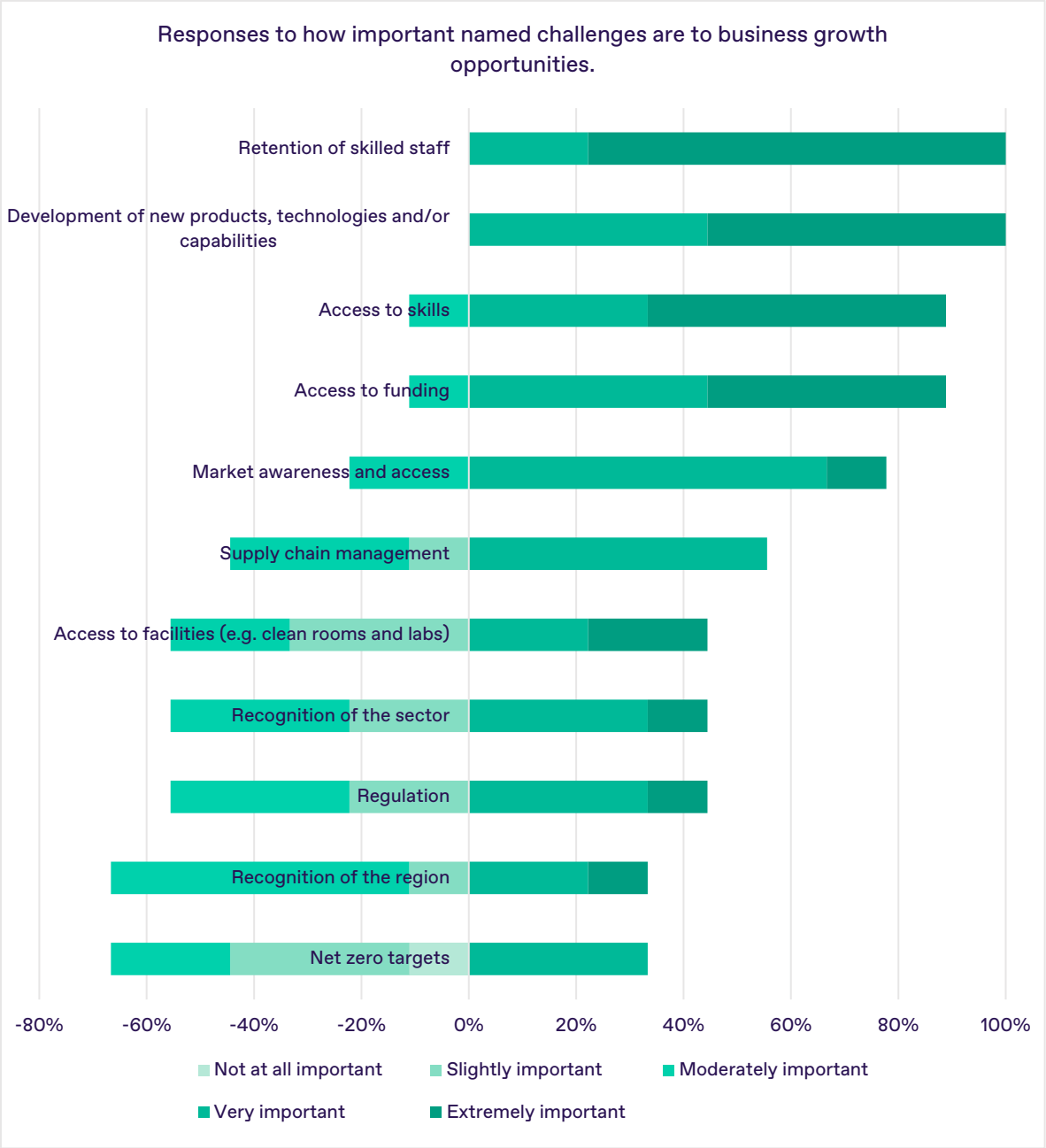

Figure 17. Survey responses on barriers to AME business growth.

The main challenges that businesses identify as being very or extremely important to overcome were:

1. Recruitment and retention of staff
   Survey respondents highlighted poor capacity and lack of staffing as barriers to their

future growth. Also, in relation to access to funding, support for the costs of apprentices, T-level training and other early career stage staff was highlighted as being required.

2. The development of new products, technologies and/or capabilities
   AME is a rapidly developing sector, and businesses are required to innovate to develop their offer accordingly. This requires investment and staff time, so is symptomatic of the other highly important barriers identified by the survey respondents.

3. Access to funding
   Business operating costs – such as rising energy costs – and development costs, like staff training, present a challenge to creating a competitive cluster. Survey respondents reported seeing their international competitors benefiting from policies and funding, including the EU Chip Act, that they do not benefit from.

There are encouraging conclusions from this result: businesses do not see access to facilities, recognition of the sector, or regulation as holding back their future growth. In terms of developing a regional cluster, these particular barriers are investments and developments that are relatively expensive and reliant on national-level policy.

The barriers that are presenting challenges to the North East AME sector are ones that could be alleviated by targeted activity by a regional body or business support service. This means that the North East AME sector is ideally positioned to reach its growth potential.

Appendices

APPENDIX I AME SIC designations

All SIC codes used by businesses that self-identify as being part of the AME sector.

These codes were gathered from survey respondents and annual company reports.

21100 - Manufacture of basic pharmaceutical products

23190 - Manufacture and processing of other glass, including technical glassware

23490 - Manufacture of other ceramic products n.e.c.

25110 - Manufacture of metal structures and parts of structures

25620 - Machining

25990 - Manufacture of other fabricated metal products n.e.c.

26110 - Manufacture of electronic components

26120 - Manufacture of loaded electronic boards

26301 - Manufacture of telegraph and telephone apparatus and equipment

26309 - Manufacture of communication equipment other than telegraph, and telephone apparatus and equipment

26511 - Manufacture of electronic measuring, testing etc. equipment, not for industrial process control

26512 - Manufacture of electronic industrial process control equipment

27110 - Manufacture of electric motors, generators and transformers

27320 - Manufacture of other electronic and electric wires and cables

27400 - Manufacture of electric lighting equipment

27510 - Manufacture of electric domestic appliances

27900 - Manufacture of other electrical equipment

28990 - Manufacture of other special-purpose machinery n.e.c.

29320 - Manufacture of other parts and accessories for motor vehicles

30990 - Manufacture of other transport equipment n.e.c.

32500 –Manufacture of medical and dental instruments and supplies

32990 - Other manufacturing n.e.c.

38320 - Recovery of sorted materials

43999 - Other specialised construction activities n.e.c.

45200 - Maintenance and repair of motor vehicles

46120 - Agents involved in the sale of fuels, ores, metals and industrial chemicals

46439 - Wholesale of radio, television goods & electrical household appliances (other than records, tapes, CD's & video tapes and the equipment used for playing them)

46510 - Wholesale of computers, computer peripheral equipment and software

46690 - Wholesale of other machinery and equipment

47510 - Retail sale of textiles in specialised stores

51220 - Space transport

61200 - Wireless telecommunications activities

61300 - Satellite telecommunications activities

62012 - Business and domestic software development

62020 - Information technology consultancy activities

62090 - Other information technology service activities

63110 - Data processing, hosting and related activities

71121 - Engineering design activities for industrial process and production

71129 - Other engineering activities

72110 - Research and experimental development on biotechnology

72190 - Other research and experimental development on natural sciences and engineering

74901 - Environmental consulting activities

74909 - Other professional, scientific and technical activities n.e.c.

82990 - Other business support service activities n.e.c.

84220 - Defence activities

APPENDIX II Publication search full results

Sciencedirect.com was used to search for relevant publications.

The field "Title, abstract or author-specified keywords" was restricted to "electronics AND materials".

The "Author affiliation" field was iterated with the terms: "UK", "Newcastle", "Northumbria", "Durham", "Teesside", and "Centre for Process Innovation". Note that Teesside University has been included in the search due to its close proximity to the North East.

"CPI" was queried and found to produce one result that is also captured in the "Centre for Process Innovation" search. "Sunderland" was queried and found to produce one result that is out of the scope of advanced materials electronics.

Year	All	UK	North East	Newcastle	Northumbria	Durham	Teesside	CPI
2001	593	33	2	1	0	1	0	0
2002	573	34	4	0	0	4	0	0
2003	632	29	2	1	0	0	1	0
2004	687	34	6	1	1	4	0	0
2005	759	45	3	0	0	3	0	0
2006	816	33	5	1	0	4	0	0
2007	845	30	3	1	0	2	0	0
2008	893	36	6	4	1	1	0	0
2009	887	25	2	1	0	1	0	0
2010	943	23	4	1	0	3	0	0
2011	1,147	48	5	2	0	3	0	0
2012	1,379	28	6	3	1	2	0	0
2013	1,515	33	9	4	0	5	0	0
2014	1,676	36	10	4	0	5	0	1
2015	1,982	51	11	4	0	5	1	1
2016	2,286	63	9	3	0	5	1	0
2017	2,644	56	8	4	0	4	0	0
2018	3,212	82	12	5	0	7	0	0
2019	3,603	67	19	7	0	12	0	0
2020	4,230	106	18	6	0	11	0	1
2021	5,374	122	31	18	2	8	1	2
2022	6,024	123	25	12	3	7	0	3
2023	6,665	129	39	12	3	19	2	3
2024	7,222	128	25	13	6	4	1	1
Total	**56,587**	**1394**	**264**	**108**	**17**	**120**	**7**	**12**

APPENDIX III Patent query text

Lens.org was used to search for relevant patents, using the following queries.

Electronics only:

```
(abstract:electronic OR abstract:electronics) AND applicant.residence:GB AND (legal_status.patent_status: Active OR legal_status.patent_status: Pending)
```

Electronics and materials:

```
(abstract:electronic OR abstract:electronics) AND (abstract:material OR abstract:materials) AND applicant.residence:GB AND (legal_status.patent_status: Active OR legal_status.patent_status: Pending)
```

APPENDIX IV Methodology for economic impact analysis

The economic impact analysis methodology used in this report was consistent with the methodology used in the previous landscape report to allow for comparison.

Jobs

Data on current employee numbers from companies in the North East operating within the AME sector was collected from a combination of survey responses and company annual reports. This identified a total of 2,798 jobs across the two sectors, including companies that operated in both industries.

Data on five-year employment growth projections was collected from survey responses. These responses provided a lower and upper growth projection.

Where current employment numbers were taken from company annual reports (and therefore no growth projections were provided), it was assumed that employment would grow in line with the average growth calculated from survey responses.

GVA

Current GVA generated by the North East AME sectors was calculated by applying average GVA per job to the employment data collected from survey responses and company annual reports. This is supplemented by data from the business survey responses about R&D expenditure, expenditure in the local area, and turnover to form projections and to ensure robustness.

Average GVA per job was calculated from the latest Annual Business Survey (2022), using the SIC codes collected from survey responses and company annual reports. For companies operating in the AME sector, an average GVA per job was applied (£109,080) from across the common SIC designations.

This identified a total of £369.9 million in GVA across the AME sector. The survey respondents reported their expectations for business growth over the next five years. An average of these projections was taken to then project GVA growth over the next five years.

Additionality from business support activity and NEAME

To assess the additionality from NEAME and business support activity in the North East, leakage, displacement, substitution, and deadweight must be considered to form a business-as-usual scenario.

Leakage, displacement, substitution, and deadweight

Deadweight is the change in jobs that would have happened in the absence of NEAME and business support programmes. This is accounted for by forming a business-as-usual scenario.

Displacement describes the amount of activity that is reduced in other areas of the AME sector as a result of business support and NEAME activities. The Department for Business, Energy & Industrial Strategy (BEIS) offer guidance for displacement for interventions surrounding business development and competitiveness. Due to the overlap of the nature of the AME sector to similar industries in the North East, there is likely to be some displacement, although the targeted nature of support reduces this. The analysis therefore assumes that 29.3% of the total impact of the business support programmes and NEAME are displaced, which is in line with the average displacement for such interventions.

Substitution occurs when businesses change their behaviour as a result of the intervention, and as such the intervention's effects are displaced within the business, instead of in addition to within-business activities. This analysis assumes that substitution is 3.4%, in line with guidance from BEIS.

Leakage is the amount that those outside the North East and the AME sector benefit. As the nature of business support and NEAME is strictly targeted at the AME sector in the North East, it is assumed that leakage is very small. In line with BEIS guidance, the analysis therefore assumes that leakage is 10%.

The additionality factor (AF), which is to account for the effects described above, is therefore 61.4%. This means that 38.6% of the impact of the business support programmes are not realised within the North East.

Business-as-usual

The average rate of growth of employment in the most common SIC codes in the AME sector in the North East is 17.2% over the last five years. This offers a baseline for the business-as-usual scenario.

The difference in the growth rate between the average rate of growth of similar businesses in the North East, and the projected growth rate from the 2020 landscape report can be explained by unexpected changes in macroeconomic circumstances. For example, the effects of Brexit and COVID-19 pandemic were not known.

In 2020, there were 1,800 people employed in the AME sector. At a 17.2% growth rate, it is estimated that without business support and the presence of NEAME, there would be 2,106 people employed in the AME sector.

Additionality

Eight of the nine survey respondents from the survey previously used business support programmes. All of those eight respondents answered that they would not have been able to achieve the same growth without that support.

These calculations assume that the same proportion of businesses in wider the AME sector (8/9) received business support. From this it is possible to calculate the additional impact (AI) of business support programmes on AME sector growth.

$$Business\ support\ AI = AF \times \left(\left(Current\ situation \times \frac{8}{9}\right) - Business\ as\ usual\right)$$

Using this methodology, it is therefore estimated that 234 of the increase in jobs over the last five years can be directly attributed to support from business growth support programmes. The additional 234 jobs identified as being created in addition to expected business growth represents a 23% of the increase in employment over the last five years. This is equivalent to £25.5 million in GVA, 14% of the increase in GVA contributed by the AME sector.

Slaper and Zheng (2018)[17] estimate that a 1 percent increase in industrial cluster employment is associated with a nearly 30 percent increase in FDI employment. As such, the additional impact of NEAME on jobs can also be calculated.

It is therefore assumed that for every 1% of employment a cluster would generate (organic growth), an additional 0.3% of employment would be created through inward investment brought about by the presence of a formal cluster organisation such as NEAME.

$$NEAME\ AI = (2024\ Jobs - 2020\ Jobs) - (\frac{2024\ Jobs - 2020\ Jobs}{1.3})$$

The multiplier estimated by Slaper and Zheng (2018) therefore implies that an estimated additional 230 jobs have been created through inward investment brought about by the presence of NEAME over the last five years. The additional 230 jobs identified as being created in addition to expected business growth represents a 23% of the increase in employment over the last five years. This is equivalent to £25.1 million in GVA, 14% of the increase in GVA contributed by the AME sector.

As such, the direct additional impact of business support, including NEAME combined for the AME sector was calculated to be 464 jobs and £50.6 million.

To estimate the benefits across the wider economy, a multiplier of 1.76 is then applied to this figure. This multiplier is the average multiplier for the most common AME sector SIC designations taken from the latest ONS Supply and Use Tables for the UK. The indirect job creation from the increase in AME sector employment from business support and NEAME is therefore 353 jobs. The indirect GVA from the growth of the AME sector from business support and NEAME is therefore £38.5 million.

This brings the total figure to an estimated additional 817 jobs and £89.1 million in GVA generated by the business support programmes, including NEAME over the last five years for the wider North East economy.

[17] Indiana Business Review (2018) Firms of a feather cluster together: The role of industry clusters on attracting additional investment

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