Materials Landscaping Study

Final Report

Innovate UK

30th March 2018

J2963/IUK

Head Office: **Optimat Limited** Torus Building, Rankine Avenue, Scottish Enterprise, Technology Park, Glasgow G75 0QF, United Kingdom
Tel: +44 (0)**1355 272 800** Email: resource@optimat.co.uk Web: **www.optimat.co.uk**
Registered Office: 21 Hunter Street, East Kilbride G74 4LZ Registration No: 141727

Executive Summary

This report details the scale, geographical distribution and competitiveness of the UK materials sector. It is based on a database of the UK materials companies that was extracted in a bottom-up approach from a wide range of company datasets and sources of information. This first of a kind analysis provides consistent and comparable data across all segments of materials.

Materials is defined as ***"the manufacture of materials in their primary form"*** and does not, therefore, include subsequent processing of these materials. By necessity, there had to be a degree of interpretation of this definition for certain materials sub-sectors but, in essence, any processes that involve the production of a new material, whether it is an alloy, a polymer, a composite or a coating are included. On this basis, the scope of the materials sector can be defined as follows:

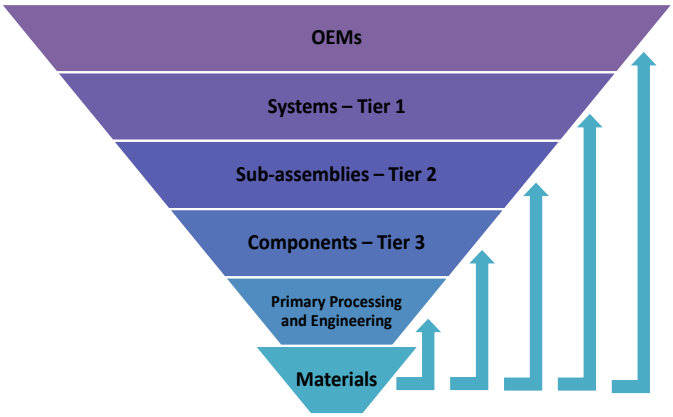
Metals		Polymers	Ceramics	Glass	Composites	Cements & Concrete	Biomaterials	Technical and Industrial Textiles	Optical, Electronic and Magnetic Materials	Emerging Materials
Ferrous Alloys	Other non-ferrous Metals and their Alloys	Commodity Polymers	Refractory Products	Flat Glass	Polymer Matrix Composites	Cement	Organic	No further segmentation	Optical	Graphene
Aluminium and its Alloys	Precious Metals	Engineering Polymers	Technical Ceramics	Blown Glass	Metal Matrix Composites	Ready Mixed Concrete	Inorganic		Electronic	Carbon NanoTubes
Titanium and its Alloys	Cast Metal	Synthetic Rubbers	Household Ceramics	Glass Treatment	Ceramic Matrix Composites	Mortar			Semiconductor	Metal Organic Frameworks
Nickel and its Alloys	Forged Metal	Biopolymers	Ceramic Coatings	Glass Fibre	Bio-composites	Fibre Cement			Compound Semiconductor	Nanomaterials
Copper & its Alloys	Powder Metallurgy	Carbon Fibre		Glass Coatings	Nano-composites				Magnetic	
Lead, Zinc and Tin and their Alloys	Metal Coatings	Masterbatch / Compounders							Fibre Optic	
Magnesium and its alloys		Polymer Coatings							Thin Film Coatings	

The scale of the UK materials sector is significant. It is comparable with other major UK manufacturing sectors, such as aerospace, automotive and chemicals and pharmaceuticals.

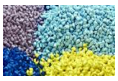
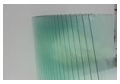
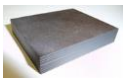
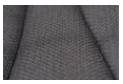
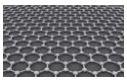
Sector	Number of Employees	Turnover	Exports
Materials Manufacture	***141,158***	***£33.49 billion***	***£15.49 billion***
Aerospace	128,300	£31.1 billion	£27 billion
Automotive	169,000	£77.5 billion	£40.2 billion
Chemicals and Pharmaceuticals	158,000	£50 billion	£45.4 billion

Materials industries are important, however, the impact of materials is of critical importance to all manufacturing sectors. The global market for materials is estimated to soon exceed over £3,000 billion per annum, based on demand from a number of key sectors, particularly aerospace, automotive, construction, electronics, energy, medical devices and packaging. The supply chains of

these markets all need materials to deliver products. Furthermore, they need materials innovations to develop the enhanced products necessary to meet their future market requirements. Materials are at the start of most manufacturing supply chains and feed into every stage of the production process.

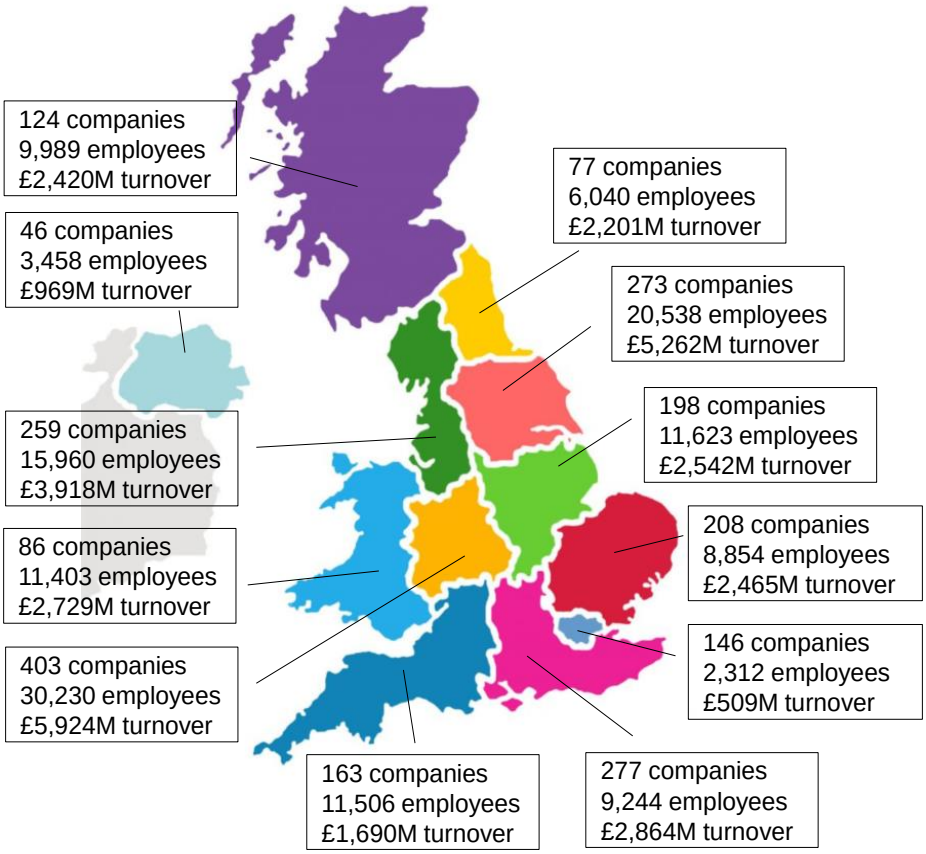


The segmentation of the UK materials manufacturing sector by material shows that the metals sub-sector is, by far, the largest followed by composites and polymers.

		Companies	Employment	Turnover
Metals		1040	56829	£14,090,461,064
Polymers		278	11652	£4,257,389,076
Glass		144	11773	£2,450,594,282
Ceramics		143	7814	£941,369,611
Composites		412	33250	£7,155,739,815
Cement & Concrete		52	9049	£2,894,780,745
Biomaterials		8	1430	£175,528,368
Technical Texiles		121	7057	£1,021,838,140
Optical, Electronic and Magnetic Materials		33	1538	£422,501,519
Emerging Materials		30	766	£84,762,969

Further, each of these UK sub-sectors is in the top 10 in Europe in its category, in terms of size, and companies in these sub-sectors are very active in international markets. Exports vary by material, but are significant at almost 50% of turnover. On a global basis, however, the UK and Europe are becoming minor players with the dominance of the Far East and, in particular, China increasing. As a result the UK has a trade deficit for the more established materials like steel, aluminium and plastics.

There is activity in all regions of the UK, with the West Midlands, Yorkshire and the Humber and the North West of England being the largest regions in terms of employment and turnover. This reflects a longstanding tradition of materials manufacture in these regions. Across the UK, the materials sector is a major part of the manufacturing economy, accounting for over 10% of manufacturing employment and turnover in regions such as the West Midlands and Yorkshire and the Humber.



Market growth rates vary by material, ranging from modest figures of around 5% per year for established materials, such as metals, to estimates of over 40% per year for emerging materials like graphene. The growth rates in all materials subsectors are a result of the drivers and demands of companies in downstream supply chains and key user sectors as they strive to meet future challenges such as light-weighting, energy efficiency, enhanced functionality and operating lifetimes, and how effectively existing and new materials enable these challenges to be met. Light metal alloys, composites, plastics and organic electronic and battery materials are identified by several end user sectors as being key materials to enable many end-user sectors to meet their customer needs. Analysis of these challenges highlights a number of opportunities for materials:

Challenge	Customer Sectors	Materials Development Opportunities
Durability	Nuclear Aerospace Construction Oil and gas Renewables Power generation	Advanced, high performance alloys for extreme environments Engineering polymers based on advanced formulation and additives Advanced, high temperature coatings New concrete formulations to withstand harsh environments New and improved carbon and glass fibre polymer composite formulations Advanced metal matrix and ceramic matrix composites Nanomaterials, carbon nanotubes and graphene as additives to improve strength, toughness and durability
Lightweighting	Aerospace Automotive Renewables Oil and gas Maritime Defence	Advanced, lightweight alloys Engineering polymers based on advanced formulation and additives New and improved carbon and glass fibre polymer composite formulations Advanced, aluminium based metal matrix composites Super tough, ultra-thin glasses
Functionality	Aerospace Automotive Medical devices Electronics Construction Consumer products Industrial manufacturing Maritime Energy Packaging	Self-healing composites Smart glazing solutions (self cleaning, thermo-chromic) Smart textiles for health / wearables Biocompatible and drug eluting materials / coatings for medical implants and devices Carbon nanotube and graphene based materials for electronics, batteries and super-capacitors Innovative nanomaterials to enhance performance or functionality of existing materials Optical materials and functional thin films for advanced display technologies Novel ceramic materials for next generation electronics and communications Multi-functional coatings with the ability to "switch" functionality
Sustainability and Recyclability	Construction Automotive Alternative power generation Consumer products Packaging	Advanced concretes and cements with reduced environmental impacts Development and application of secondary raw materials High performance, natural fibres Bio-derived polymers and composites New and improved nanomaterials and coatings for renewable power generation (e.g. photovoltaics) Metal organic frameworks for hydrogen storage and fuel cells

These market driven opportunities and challenges will encourage the development of a range of new and improved materials across all segments of the materials manufacturing sector. On-going investment in materials related RD&I, by both industry and public sector funding bodies, will be essential to ensure it can respond to market requirements. This will enable the UK materials manufacturing industry to continue to develop and grow, building on its current scope and scale.

This landscaping study has established that the materials manufacturing industry in the UK is significant in scale, comparable in size to key UK sectors such as aerospace, automotive and chemicals and pharmaceuticals, and scope, covering all materials categories. It has also shown that it underpins all UK manufacturing sectors, contributes to economic activity across the UK and delivers significant exports. Further, it has identified that new and improved materials are critical to enabling end user sectors to meet their future market demands, offering significant opportunities for the UK sector to develop and exploit innovative materials.

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Prepared By: Deborah Creamer and Iain Weir	**Date:** 26th April 2018
Approved By: Angus Hunter	**Date:** 27th April 2018

1. Introduction

Materials have been identified as critically important to underpin high value manufacturing, drive innovation and address socio-economic "grand challenges"[1]. It is, therefore, important that Innovate UK and the Department of Business, Energy, Innovation and Skills (BEIS) understand the scope of the materials sector in the UK, its importance for key UK sectors and, as a result, better target innovation support and investment to enable sector growth. This report summarises work, carried out from October 2017 to February 2018, to define the size, shape and capabilities of the materials sector in the UK and its key constituent subsectors.

1.1 Objectives

The key objectives of this work were:

- Define the materials industry, its component materials and its relationship to the manufacturing supply chain, important end users and potential future end users
- Develop and populate a functional database of UK materials companies
- Prepare an overview of the materials industry in the UK, defining its size, segmentation, international activity, global competitive position and importance to the high value manufacturing sector
- Identify development opportunities

These are all addressed in this report.

1.2 Definitions – The Materials Sector and its Sub-sectors

An important first step in this study was to define the scope of the materials sector and its constituent parts. This was considered in terms of its breadth and depth, i.e. the range of materials categories and the "links" in materials value chain for user sectors that are included.

The agreed scope of the sector can be presented as follows:

[1] A review of international public sector strategies and roadmaps: a case study in advanced materials, Dr Charles Featherston & Dr Eoin O'Sullivan, University of Cambridge for the Government Office of Science & the Department for Business, Innovation & Skills, March 2014

Metals		Polymers	Ceramics	Glass	Composites	Cements & Concrete	Biomaterials	Technical and Industrial Textiles	Optical, Electronic and Magnetic Materials	Emerging Materials
Ferrous Alloys	Other non-ferrous Metals and their Alloys	Commodity Polymers	Refractory Products	Flat Glass	Polymer Matrix Composites	Cement	Organic	No further segmentation	Optical	Graphene
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Copper & its Alloys	Powder Metallurgy	Carbon Fibre		Glass Coatings	Nano-composites				Magnetic	
Lead, Zinc and Tin and their Alloys	Metal Coatings	Masterbatch / Compounders							Fibre Optic	
Magnesium and its alloys		Polymer Coatings							Thin Film Coatings	

Figure 1: Segmentation and Breadth of the Materials Sector

The "depth" of the sector, i.e. the parts of materials supply chains for end user sectors that are included in the definition, was specified as ***"the manufacture of materials in their primary form".*** As an example, for the aerospace supply chain, this is highlighted in the diagram opposite[2], showing that materials manufacture is included, but subsequent materials processing within the supply chain is excluded. It is recognised that this definition had to be interpreted differently for different segments of the materials industry, but it is considered to offer a consistent definition for the sector.

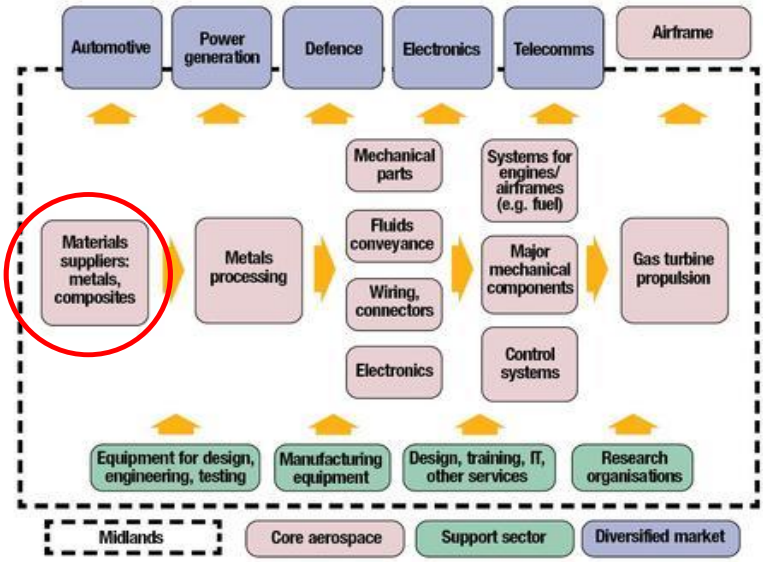

Figure 2: Typical Aerospace Supply Chain

[2] Adapted from http://www.midlandsaerospace.org.uk/aerospace/supply-chains, accessed 31/01/2018

2. Methodology

The methodology used can be described in five stages as follows:

2.1 Database Development and Compilation

There were four key parts to the development and population of the database:

1. Development of the Database Structure

The database has been developed in Excel and includes the following fields for each company[3]:

- Unique identification number
- Company name
- Registration number
- Primary SIC Code
- Material(s) manufactured
- Primary segmentation (based partially on the UK SIC (2007) description)
- Trade description
- Incorporation date
- Legal form
- Status (active / in administration)
- Number of branches and subsidiaries
- Organisation type (independent, parent or subsidiary)
- Address, telephone number, email and website
- NUTS1, NUTS2 and Local authority (LEP) region
- Number of employees (5 year trend)
- Turnover (5 year trend)
- SME Status
- Export (5 year trend)
- Gross profit, profit margin, EBIT margin, EBITBA, EBITDA margin and gearing ratio (5 year trends)
- Profit /loss before tax, interest paid, return on capital employed and return on total assets (5 year trends)
- Wages and salaries, social security, pension, other staff costs, directors' remuneration and directors' fees (5 year trends)
- Total assets and total liabilities (5 year trends)
- Research and development costs (5 year trend)
- Materials sector segment and sub-segment (based on the Primary SIC Code and material(s) manufactured

A more detailed description of the database structure and functionality is included in Appendix A.

[3] This list was compiled based on requirements specified by both Innovate UK and BEIS

2. Identification of Materials Companies

Companies were identified in a number of ways:

- Where available, appropriate SIC codes were used to identify companies in commercial databases, e.g. MINT UK and Fame[4]
- Companies House data[5]
- Input from trade and sector organisations
- Analysis of a wide range of materials and customer sector databases
- Review of company websites

The organisations that provided input and the databases we reviewed are detailed in Appendix B.

As a result an initial database of over 17,000 companies was collated. However, this needed to be carefully reviewed to identify the companies that met our definition of the sector and exclude those that did not. In particular a vast number of companies that are simply processing materials (e.g. changing the shape of materials) have classified themselves as manufacturers of materials. Following this review, the database consists of around 2,300 companies. This highlights issues with the SIC codes that companies identified themselves with.

3. Compilation of Company Data

For the refined database of companies, the data listed above was sourced from the commercial databases listed above.

For SMEs much of the data listed above is not reported. Data on employees and turnover for each company was essential for some of the analysis carried out and this was estimated using published data for UK manufacturing SMEs[6], as follows:

- Average number of employees 9.84
- Average turnover £167,508 per employee

Further, data for exports is only available for the larger companies in line with UK company reporting requirements, therefore, subsequent data presented on materials sector exports are considered to be underestimates.

The refined database of 2,261 companies was used for subsequent analyses.

4. "Cleaning" the Company Data

Four major issues with the data collated were identified and addressed:

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4 https://www.bvdinfo.com/en-gb/our-products/data/national/mint-uk?gclid=CjwKCAiAqvXTBRBuEiwAE54dcMBctyxr1Ogg_VmueZBTU0AVVXirVkt2pc6BqbaRMtDX2NZ6_kEiNhoCeZIQAvD_BwE and https://www.bvdinfo.com/en-gb/our-products/data/national/fame

5 https://beta.companieshouse.gov.uk/

6 BEIS Statistical Release: Business population estimates for the UK and regions 2017 published 30th Nov 2017

a) Companies with complex corporate structures and numerous subsidiaries. For all large companies (those with >500 employees) these have been investigated and data rationalised.

b) Companies which are active in materials manufacturing and also in manufacture of downstream products and services within their business portfolio. It was assumed that larger companies in the database are more likely to be vertically integrated, hence, large companies in the database (again those with > 500 employees) have been reviewed and their materials related activity estimated.

c) Companies with international operations, with performance reported through their UK headquarters. Again for the larger companies (>500 employees) their business structures have been assessed to include UK activity only.

d) Companies with a number of manufacturing facilities, sometimes spread across the UK, but reporting all data through their head office or registered office. This is a particular issue for companies with a London headquarters. The geographic distribution of the 41 largest companies (>£2 million annual turnover) in the database has been assessed and their employment and turnover allocated, as appropriate across the regions.

These companies are listed in Appendix C.

The results in the following section present the scale of the UK materials manufacturing sector once these issues were addressed.

2.2 Analysis of the UK Materials Sector

This was carried out by interrogating the database to identify the scale and characteristics of the materials sector by sub-sector and by region. The results are presented in Section 3.

2.3 Market and Competitive Analysis

Market and competitive analysis was carried out by desk research, using a wide range of public sector and commercial reports. The results of this are summarised in Section 4.

2.4 Economic Analysis

Economic analysis has been carried out for the materials sector and its ten main subsectors, building on the employee and turnover data compiled in the database. GVA has been calculated from both employees and turnover data using commonly available multipliers[7] and indirect and induced GVA calculated using published multipliers on a sector by sector basis[8].

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[7] Nominal and Regional Gross Value Added (balanced) by Industry, 20th December 2017, Office for National Statistics, https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry,

[8] UK input-output analytical tables, 9th March 2017, Office for National Statistics, https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltablesdetailed

3. The UK Materials Sector

3.1 The Scale of the UK Materials Sector

The combined scale of the companies involved in the UK materials manufacturing sector, based on the definitions used in this study, and after addressing the issues listed in Section 2, is as follows:

Number of Employees	141,158
Turnover	£33.49 billion
Exports	£15.49 billion

Figure 3: The Scale of the UK Materials Sector

This indicates that the scale of the materials manufacturing sector is comparable with other major UK sectors. This is demonstrated by the comparative data for selected major UK manufacturing sectors, as shown below:

Sector	Employees	Turnover	Exports
Aerospace[9]	128,300	£31.1 billion	£27 billion
Automotive[10]	169,000	£77.5 billion	£40.2 billion
Chemicals and Pharmaceuticals[11]	158,000	£50 billion	£45.4 billion

Figure 4: Comparative Data for Selected UK Manufacturing Sectors

3.2 The UK Materials Industry by Region

The distribution of the UK materials sector by NUTS1 region[12], based on the number of companies, employees and turnover is shown below. These figures include the reallocation of employment and turnover for large companies as discussed in Section 2.1.

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9 UK Aerospace Outlook, 2016, ADS Group Ltd., 2016

10 SMMT Motor Industry Facts 2017, SMMT

11 UK Chemical and Pharmaceutical Industry Facts and Figures, The Chemical Industries Association, January 2015

12 The Nomenclature of Territorial Units for Statistics (NUTS) is a geocode standard by Eurostat for referencing the subdivisions of the United Kingdom of Great Britain and Northern Ireland for statistical purposes. NUTS1 regions consist of 9 English regions, Scotland, Wales and Northern Ireland

Region	Companies	Employees	Turnover (£)
South West (England)	163	11,506	1,689,882,275
South East (England)	277	9,244	2,863,581,648
London	146	2,312	508,851,532
East of England	208	8,854	2,464,790,469
Wales	86	11,403	2,728,558,227
East Midlands	198	11,623	2,542,116,725
West Midlands	403	30,230	5,924,201,188
Yorkshire and The Humber	273	20,528	5,262,482,529
North West (England)	259	15,960	3,917,510,019
North East (England)	77	6,040	2,201,313,316
Northern Ireland	46	3,458	969,388,246
Scotland	124	9,989	2,420,910,417
Channel Islands	1	12	1,379,000
TOTAL	**2261**	**141,158**	**33,494,965,590**

Figure 5: Regional Distribution of UK Materials Companies[13]

This data can be presented graphically as follows:

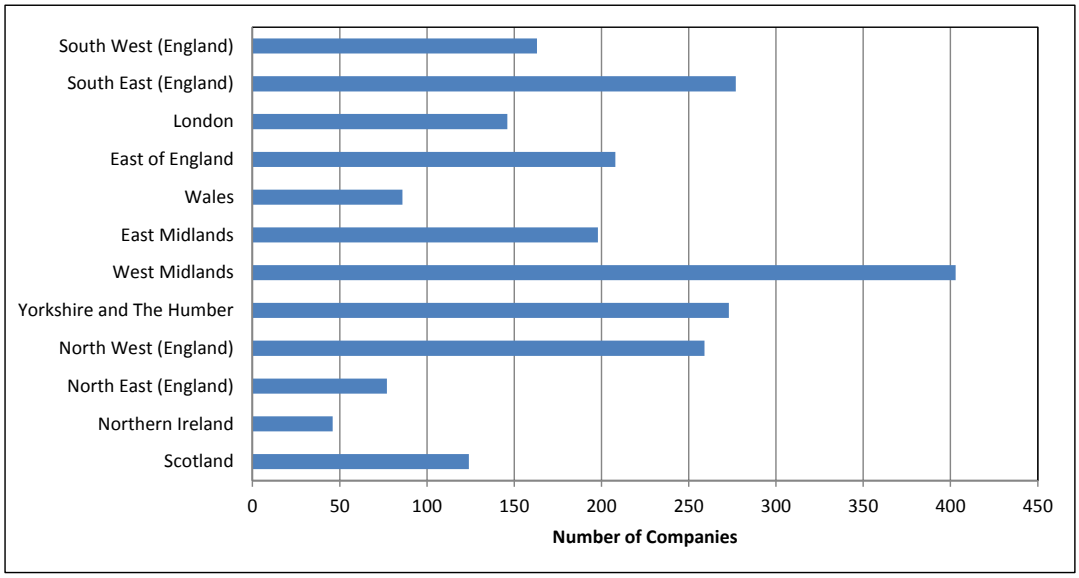


Figure 6: Distribution of UK Materials Companies by Region

[13] Regional distribution of number of companies is based on head office location only. Channel Islands data (1 company) is excluded

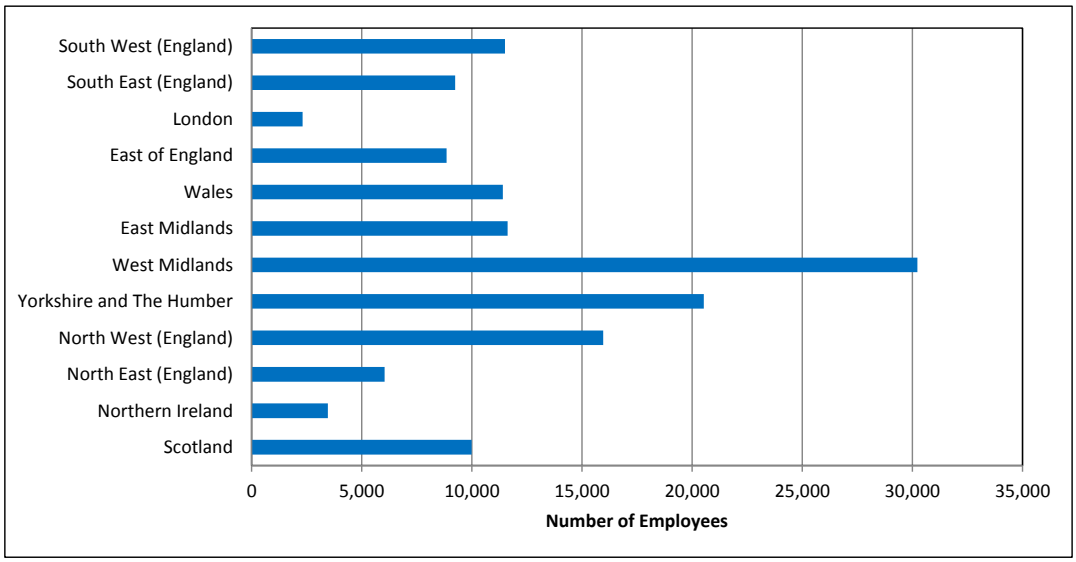


Figure 7: Distribution of UK Materials Sector Employment by Region

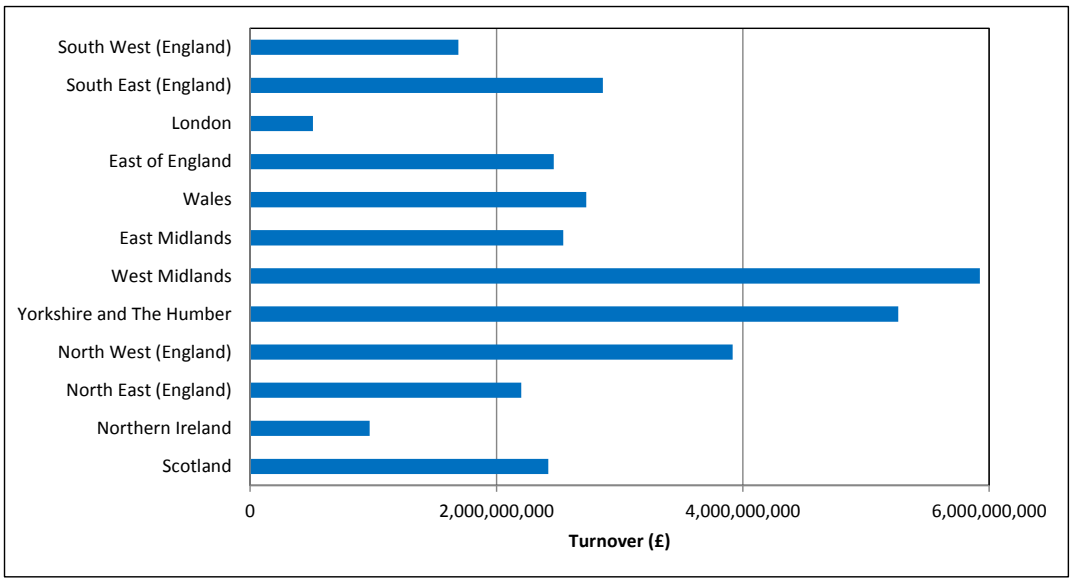


Figure 8: Distribution of UK Materials Sector Turnover by Region

A comparison can be made between the scale of materials activity and the total economic activity in each region.

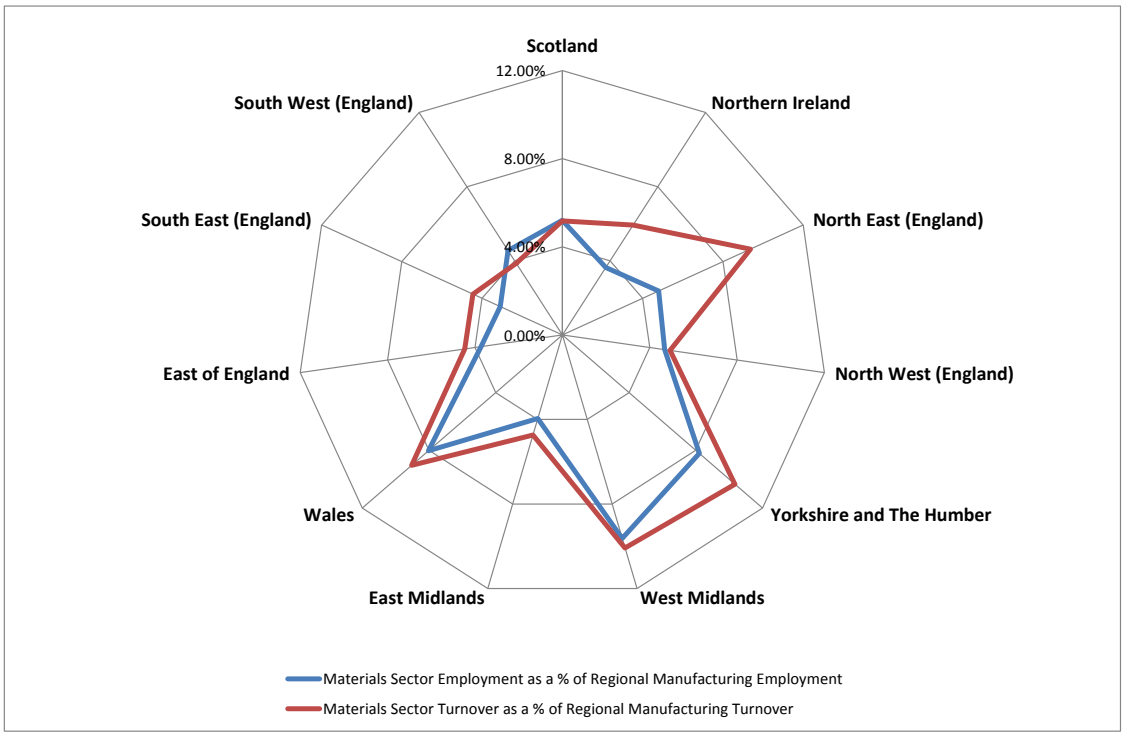


Figure 9: Comparison of Regional Materials Sectors with Wider Regional Economic Activity

This is based on

- Comparing regional materials sector employment with total regional employment[14]
- Comparing regional materials sector turnover with total regional GVA data[15]

This analysis provides some important observations on the relative amount of regional economic activity that is due to the materials sector. These are:

- The materials sector in the West Midlands and Yorkshire and Humberside are a more significant part of local employment and the local economy than the materials sector in other regions
- The materials sector in the North East of England and Yorkshire and Humberside have a significantly higher share of turnover compared to employment. We believe that this is due to a larger share of larger efficient, often multinational, manufacturing plants in the regions.

[14] JOBS05: Workforce jobs by region and industry, Office for National Statistics, December 2017, see https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/workforcejobsbyregionandindustryjobs05

[15] ONS Statistical bulletin, Regional gross value added (income approach), UK: 1997 to 2015, office of National Statistics, see https://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedincomeapproach/december2016#the-north-west-was-the-fastest-growing-nuts1-region-in-the-uk-in-2015

3.3 The UK Materials Industry by Subsector

The segmentation of companies by materials sub-sector is as follows:

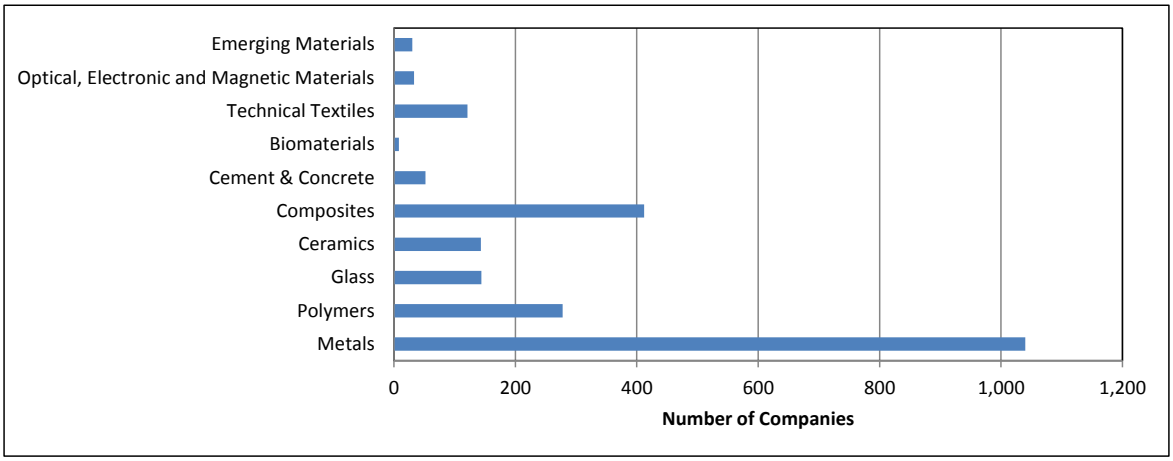


Figure 10: Materials Sector Segmentation by Number of Companies

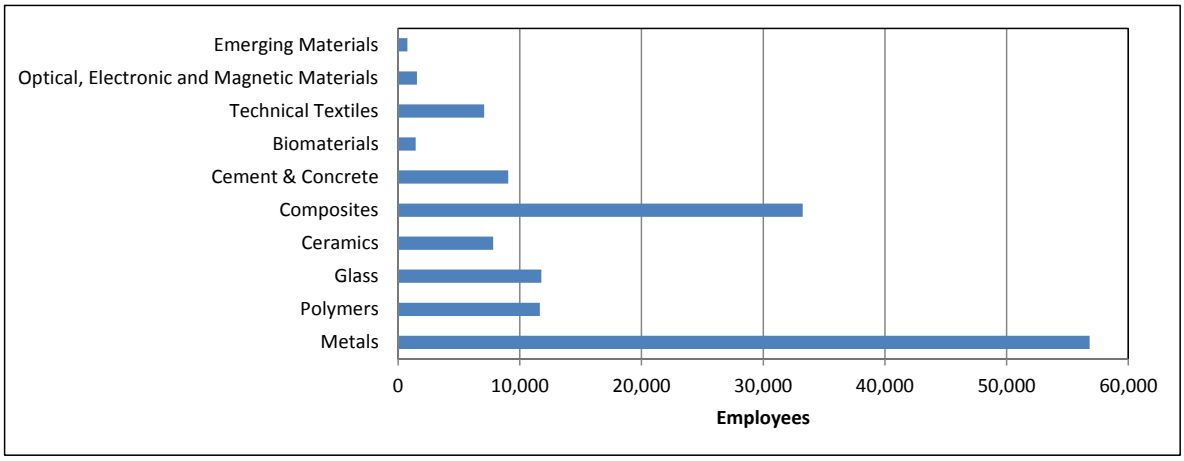


Figure 11: Materials Sector Segmentation by Number of Employees

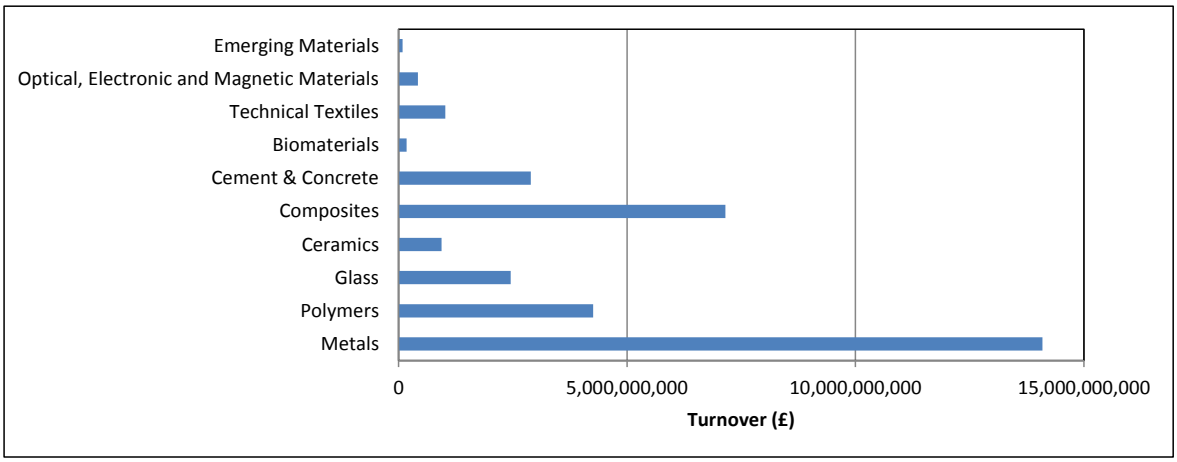


Figure 12: Materials Sector Segmentation by Turnover

It must be noted that there are a number of companies that are active in more than one materials sub-segment. For these companies, they have been allocated to the most relevant materials sub-sector.

These sub-sector comparisons are summarised in the following diagram:

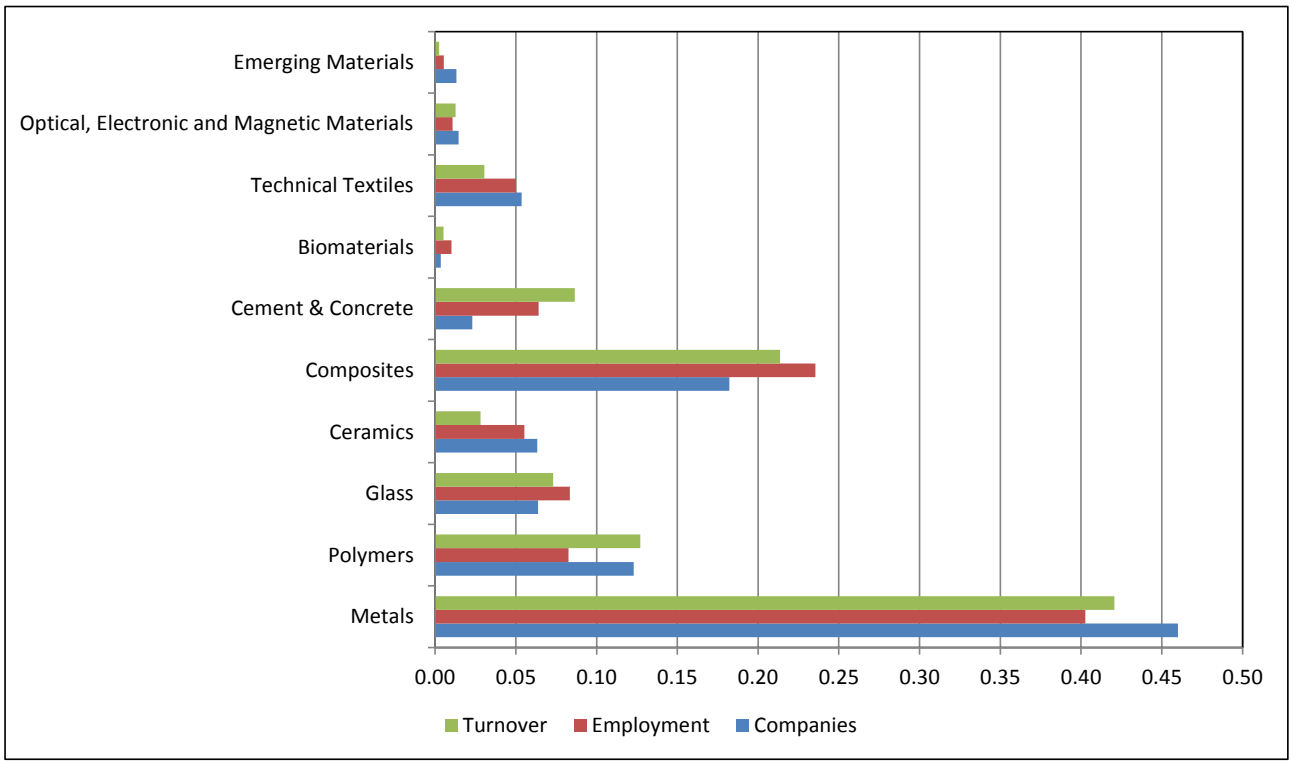


Figure 13: Segmentation of UK Materials Companies

This shows the dominance of metal companies for all three metrics, followed by composites and then polymers companies. The data does suggest however that metals and polymer companies deliver

comparatively higher output per employee than composites companies. This is expected, based on the comparative hands-on nature of composites manufacture.

The emerging materials and biomaterials are the smallest sectors for all three metrics.

The segmentation of the materials sector and its regional distribution are discussed in more detail below.

3.4 UK Materials Subsectors and Regional Clusters

The relative scale of the main materials sub-sectors, based on turnover in each UK region, excluding the Channel Islands, can be presented individually as follows. The Channel Islands is excluded due to its small scale of activity (one small company).

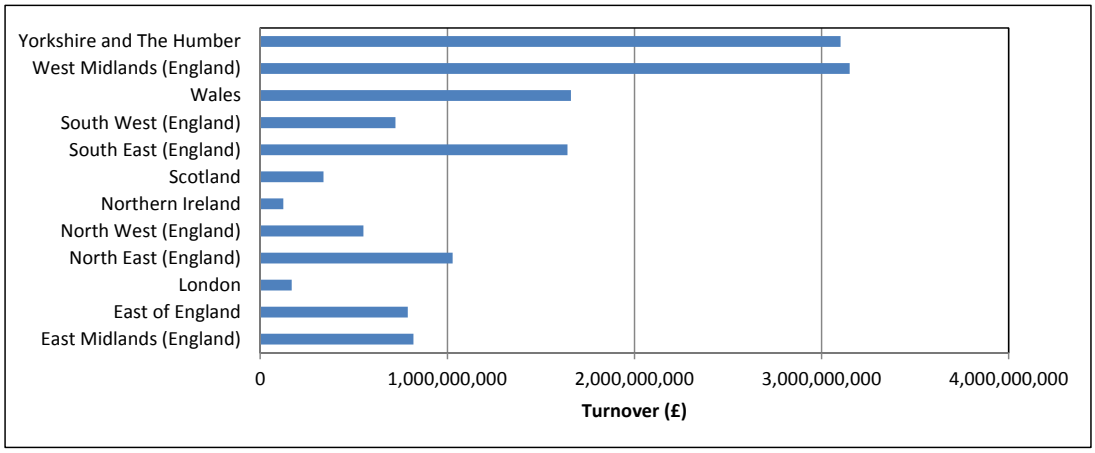


Figure 14: Relative Scale of Regional Metals Sectors

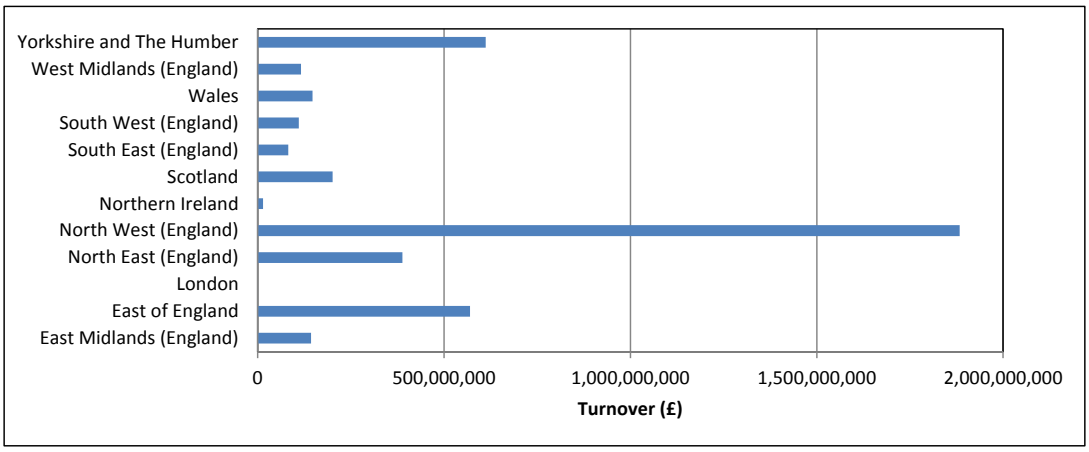


Figure 15: Relative Scale of Regional Polymers Sectors

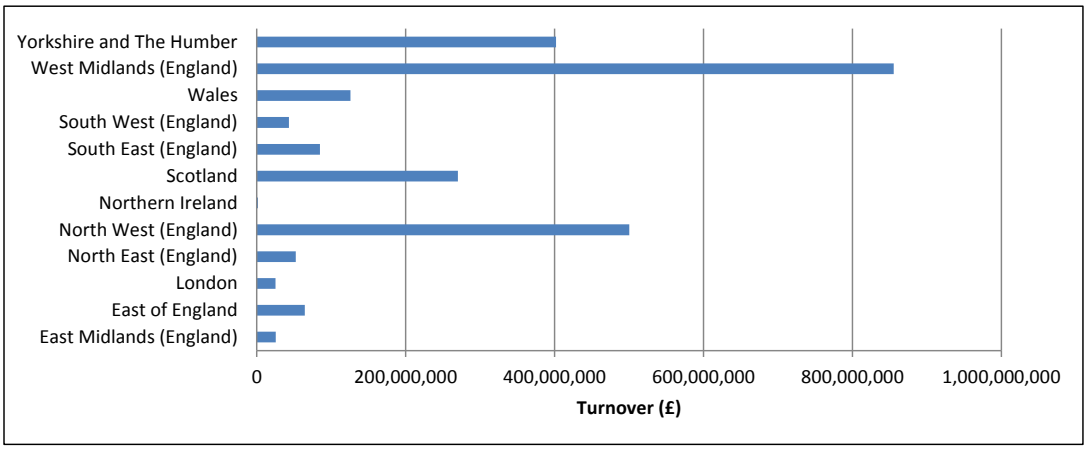


Figure 16: Relative Scale of Regional Glass Sectors

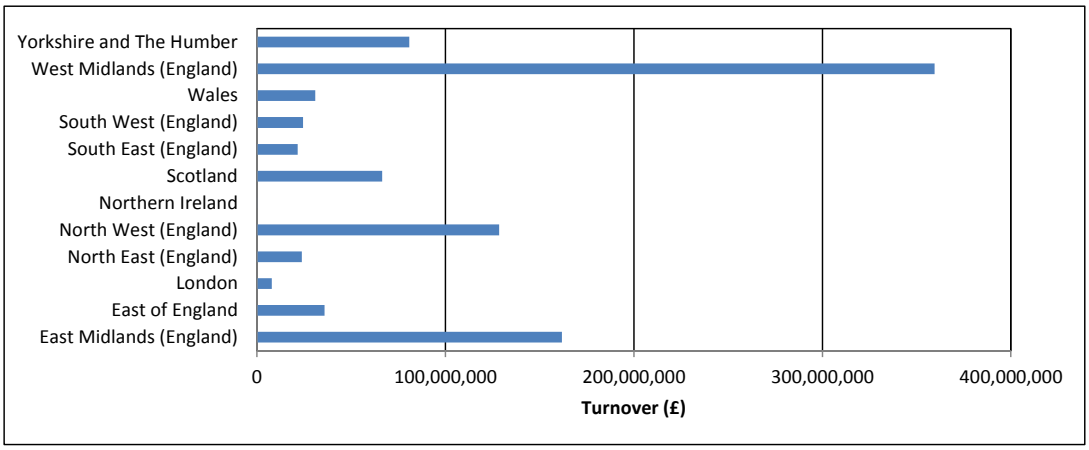


Figure 17: Relative Scale of Regional Ceramics Sectors

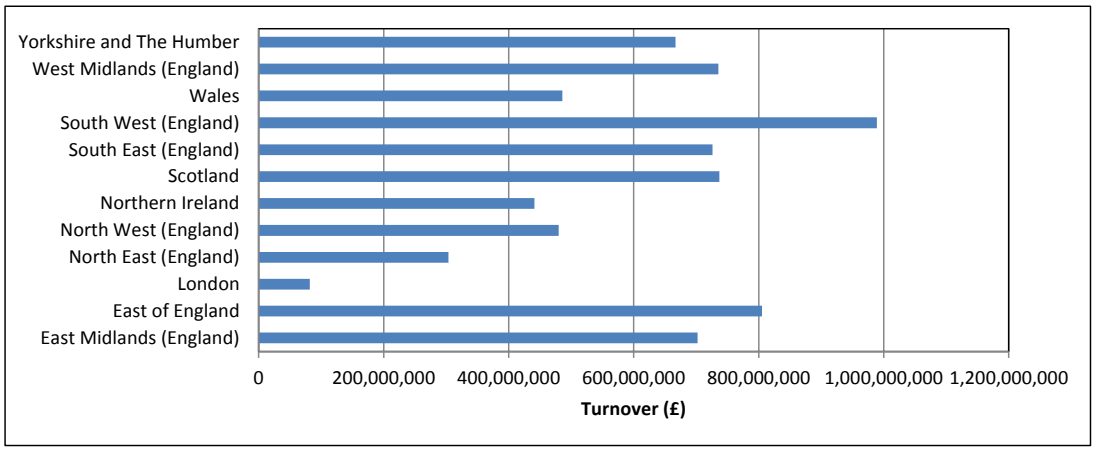


Figure 18: Relative Scale of Regional Composites Sectors

The key points that these graphics, ***based on regional turnover***, highlight are:

Metals - the West Midlands and Yorkshire and Humberside have, by far, the largest scale of activity, reflecting traditional metal industries in these regions. The distribution of metals companies across the UK is shown opposite:

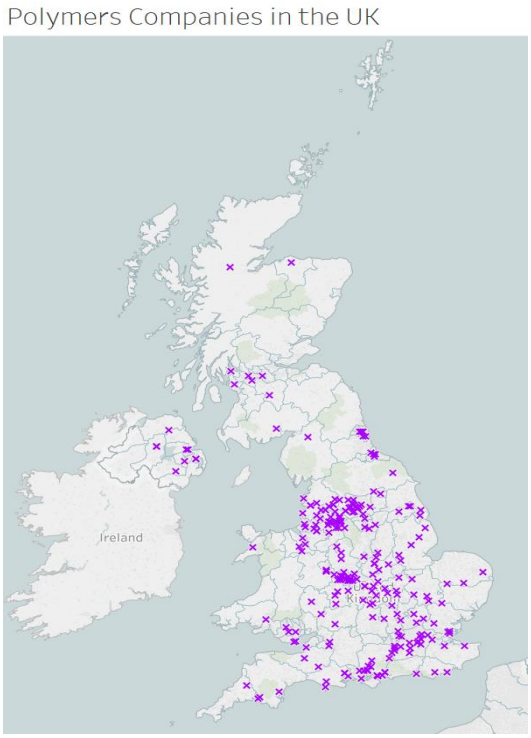
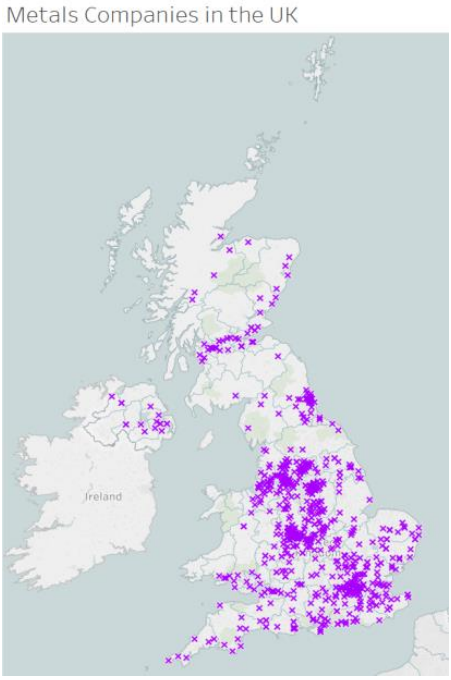


Figure 19: Geographic Distribution of Metal Companies



Polymers – the North West of England has the largest turnover by a significant amount. It is assumed that this builds on the very well-established chemicals industries in the region

Figure 20: Geographic Distribution of Polymer Companies

Glass - the West Midlands, North West of England and Humberside and Yorkshire have the largest turnovers, reflecting the history of glass making in the areas and the legacy of e.g. The Pilkington Group

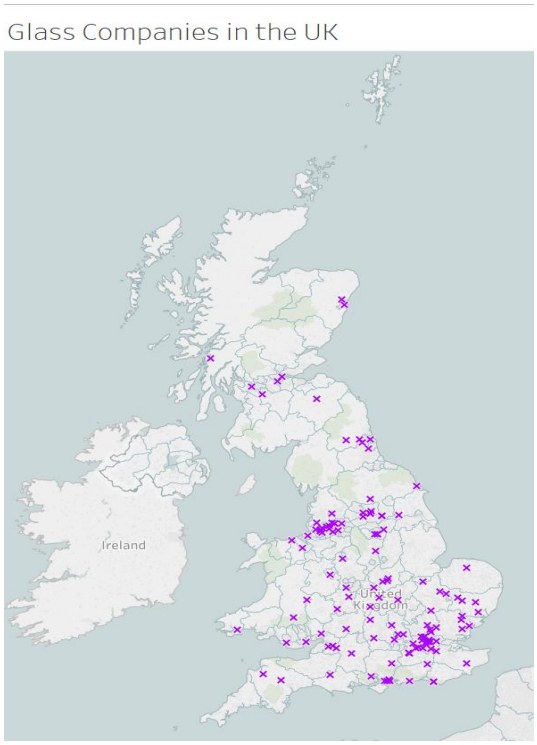
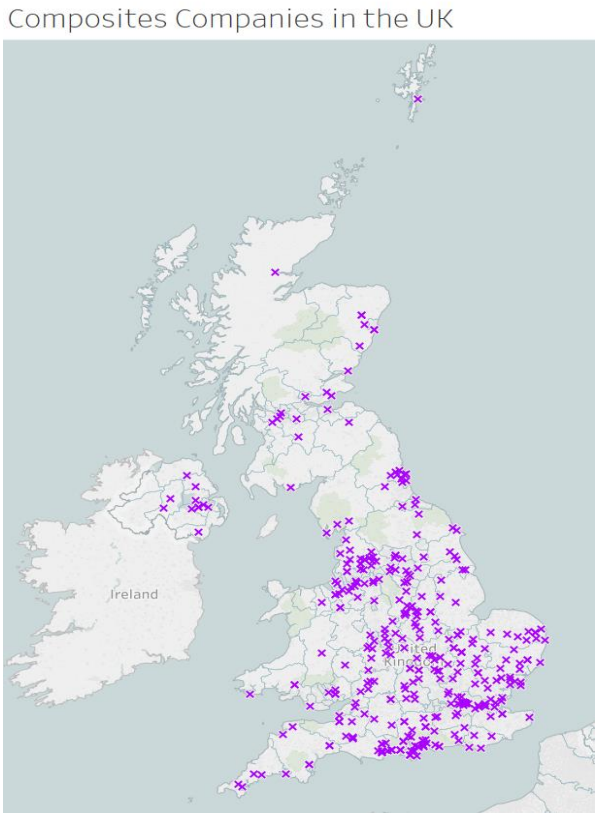


Figure 21: Geographic Distribution of Glass Companies



Composites – the West Midlands and the South West are the most significant players in composites, linking to the major activities in aerospace, automotive and rail in these regions.

Figure 22: Geographic Distribution of Composites Companies

Ceramics – the West and East Midlands are the major regions. It is assumed that this is based on the historic ceramics activities in Stoke and Staffordshire in the West Midlands

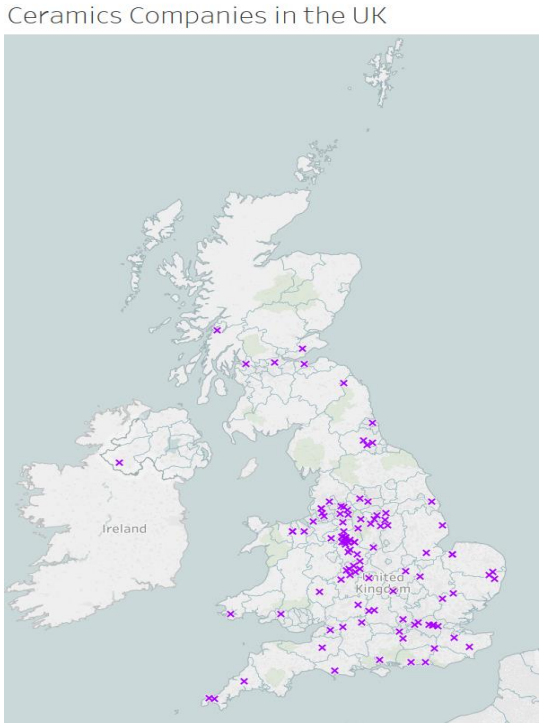


Figure 23: Geographic Distribution of Ceramics Companies

3.5 Economic Impact

The economic impact, in terms of employment, turnover and gross value added (GVA), of the UK materials sector can be presented by sub-sector, as shown below:

	Employment	Turnover (£)	Turnover to GVA Multiplier	Direct GVA (£)	GVA Multiplier	Indirect GVA (£)	Total GVA (£)
Metals	56,829	14,090,461,064	0.26	3,606,710,745	1.300	1,082,013,224	4,688,723,969
Polymers	11,652	4,257,389,076	0.25	1,045,327,835	1.300	313,598,351	1,358,926,186
Glass	11,773	2,450,594,282	0.35	868,774,966	1.400	347,509,986	1,216,284,953
Ceramics	7,814	941,369,611	0.26	242,774,268	1.400	97,109,707	339,883,975
Composites	33,250	7,155,739,815	0.25	1,788,934,954	1.400	715,573,982	2,504,508,935
Cement & Concrete	9,049	2,894,780,745	0.20	571,842,321	1.500	285,921,161	857,763,482
Biomaterials	1,430	175,528,368	0.25	43,882,092	1.400	17,552,837	61,434,929
Technical Textiles	7,057	1,021,838,140	0.39	403,574,457	1.300	121,072,337	524,646,795
Optical, Electronic and Magnetic Materials	1,538	422,501,519	0.25	105,625,380	1.400	42,250,152	147,875,532
Emerging Materials	766	84,762,969	0.25	21,190,742	1.400	8,476,297	29,667,039
Total	**141,158**	**33,494,965,589**		**8,698,637,761**		**3,031,078,033**	**11,729,715,794**

Figure 24: Estimated GVA for the UK Materials Sector, by Sub-sector

These estimates are based on employment and turnover data from this analysis. Direct GVA is calculated using published[16] turnover to GVA multipliers and indirect GVA[17] is calculated using published type 1 multipliers[18].

It shows that the GVA of the UK materials sector is over £11.7 billion, over one third of the sector turnover. As with previous metrics for the sector, the metals sub-sector is the major contributor to the overall sector data, followed by the composites and polymers sub-sectors.

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16 The turnover to GVA multiplier is calculated from UK Annual Business Survey, Office of National Statistics, 2015 data – see https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/datasets/annualbusinesssurveyuknonfinancialbusinesseconomy2015provisionalresultssectionsaspayeunitsincluded, using relevant sector data. For those sectors where there is no obvious sector data typical data for other sectors is used.

17 The additional economic impact on the supply chain of materials manufacturing activity

18 Type 1 GVA multipliers are sourced from Scottish Government Input-Output Analytical Tables, 2014, see http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads Again, for those sectors where there is no obvious sector data typical data for other sectors is used.

4. International Competitiveness

4.1 European Benchmarking of Key UK Materials Sub-sectors

The well-established[19] UK materials sub-sectors have been compared to their main European competitor nations, based on the value of production output, as presented in the following diagram.

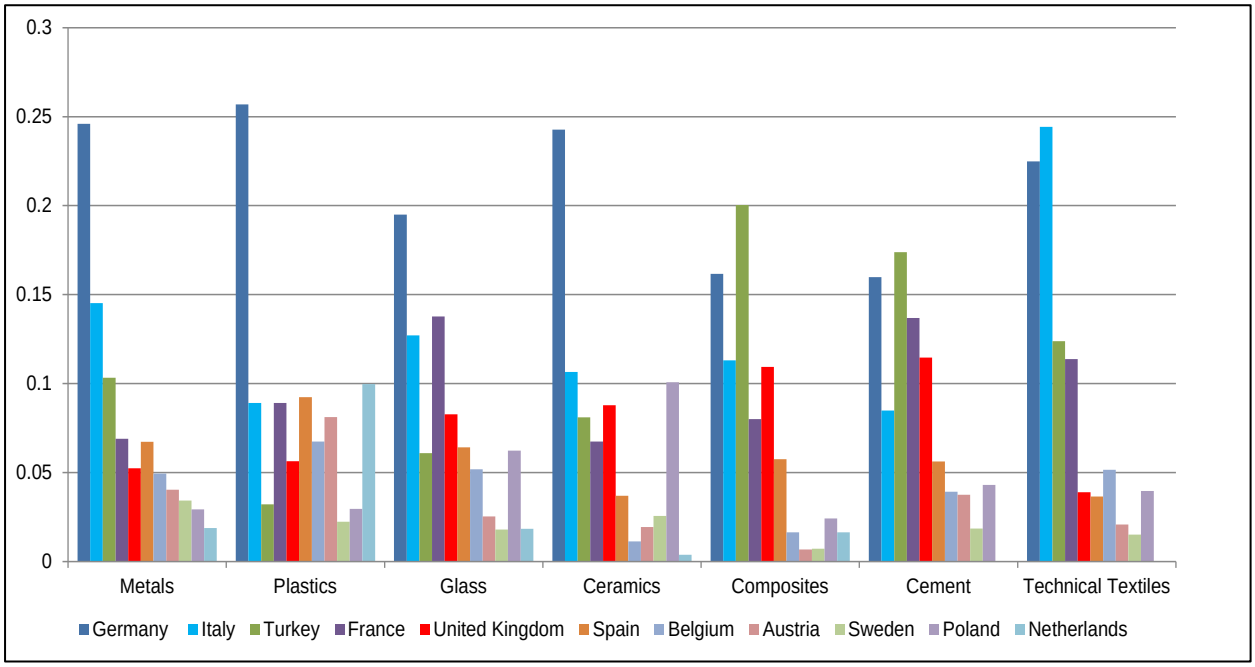

Figure 25: Comparison of the Share of European Production of Leading Nations for Key Materials Manufacturing Subsectors[20]

For four of these materials subsectors, Germany is the largest producer and second largest in the other three. Italy, Turkey and / or France are typically the other largest national producers.

This data does show that the UK is a leading producer in all categories. It is the 4th largest producer for glass, ceramics, composites and cement and concrete, 6th largest for metals and technical textiles, the 8th largest producer for plastics and, therefore, a competitive nation on the European stage. In comparison,

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19 Appropriate data was only available in Eurostat for established sectors with recognised SIC Codes

20 Annual Detailed Enterprise Statistics for Industry (NACE Rev. 2, B-E), Eurostat, see http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_ind_r2&lang=en, accessed 19/02/2018. The data used for these comparisons are: Metals: NACE Code 24 (manufacture of base metals), Plastics: NACE Code 2016 (manufacture of plastics in primary form) and Glass: NACE Code 231 (manufacture of glass and glass products). Data is predominantly for 2016, with 2015 data used where required.

total UK manufacturing output is the 4th largest in Europe, behind Germany, France and Italy and 9th largest globally[21].

4.2 Global Competitiveness

Widening the scope of the analysis to a global level indicates that both the UK and Europe are becoming smaller and smaller players in the global landscape as the scale of activity in the Far East, particularly China, continues to grow. This can be shown for several of the materials categories as follows:

1. **Steel**

   The increase in the scale of steel manufacture over the last 50 years and the changing nature of global production are significant[22]. The growing dominance of China and the decline in European manufacture is very evident. China has grown from holding a 2.1% share of global production in 1967 to over 49.5% in 2016. Over the same period the European share of production has declined from 33.5% to 12.3%. At a national level the UK is the 21st largest producer in terms of volume with a 0.5% share of output.

   This reflects the dramatic growth of the Chinese economy and the strong dependence of the construction sector on steel.

2. **Aluminium**

   The situation with primary aluminium production is similar, as shown in the figure below[23].

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21 Manufacturing: international comparisons, House of Commons Briefing Paper, number 05809, January 2018

22 World Steel in Figures, 2017, World Steel Association, 2017

23 World Aluminium, see http://www.world-aluminium.org/statistics/, accessed 15th March 2018

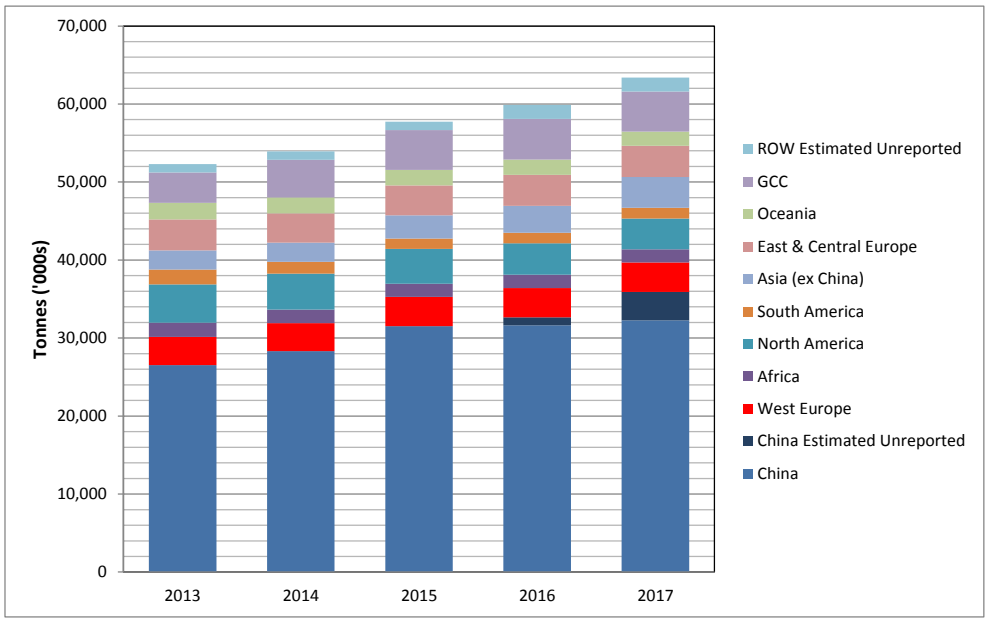

Figure 26: Global Trends in Primary Aluminium Production

Again China produces around 50% of global output with Europe producing around 6%.

3. Plastics

The situation with plastics manufacture is similar with Asia dominating production with a 50% share in 2016, although in this case China's position is less dominant, as shown below[24].

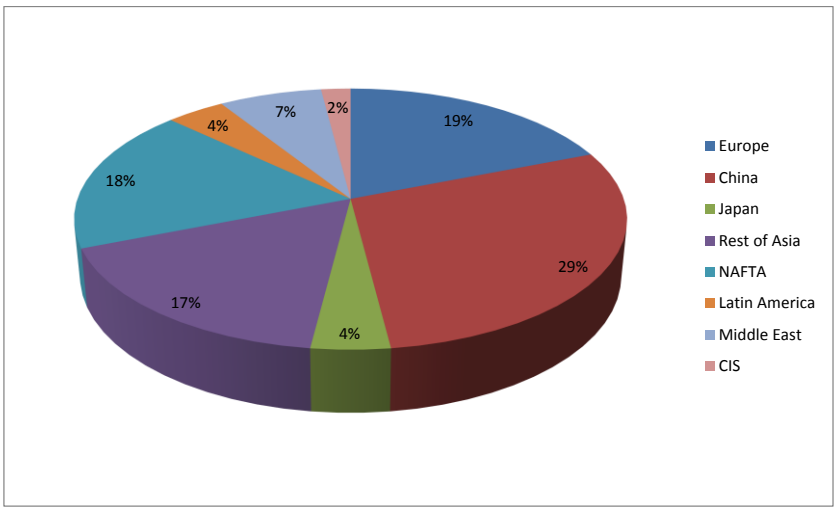

Figure 27: Distribution of Global Plastic Materials Production

[24] Plastics – the Facts 2017. An analysis of European plastics production, demand and waste data, Plastics Europe, 2017

4. Glass[25]

Global manufacturing of float glass has changed significantly in the period since 2005, with, large declines in European and North American capacity and massive growth in the Far East, especially China. This is reflected in China's share of worldwide demand for flat glass expected to exceed 50% in 2018.

These four examples clearly show the dominance of China in terms of production of each material, mainly to satisfy dramatic growth in the Chinese economy. Similar evidence could be presented for other materials. For example, Asia is expected to have a 47.7% share of the global composites market by 2021[26] and even in the emerging materials, China is a leader in research activities. For example, in graphene Chinese research groups have been co-authors in around 50% of all publications and in 48% of highly cited publications[27].

Therefore, although the UK is a leading player in Europe, this is not reflected on a global basis with both the UK and Europe claiming a smaller and smaller market share as the emerging economies, particularly China continues to grow.

4.3 Export Performance

Despite its reducing share of global activity the UK demonstrates strong export performance. It exports a significant share of its of output – valued at over £15 billion per annum for the overall materials sector as shown in Figure 3, over 45% of total sector turnover. As already highlighted, this is based on data reported by the larger companies only and should be considered an underestimate of the total exports for each subsector and the overall materials sector. However, this data is still worthy of review and it can be presented by materials subsector as follows:

	Export (£)	Turnover (£)	Share of Turnover (%)
Metals	£6,789,175,000	14,090,461,064	48.2%
Polymers	£1,533,343,352	4,257,389,076	36.0%
Glass	£370,010,725	2,450,594,282	15.1%
Ceramics	£878,986,883	941,369,611	93.4%
Composites	£3,822,328,876	7,155,739,815	53.4%
Cement & Concrete	£59,385,000	2,894,780,745	2.1%
Biomaterials	£140,751,372	175,528,368	80.2%
Optical, Electronic and Magnetic Materials	£294,725,009	422,501,519	69.8%
Emerging Materials	£33,571,562	84,762,969	39.6%
All Materials	**£15,488,362,293**	**33,494,965,590**	**46.2%**

Figure 28: Estimated Value of UK Exports by Material Sub-sector

25 The World of Glass, Katy Devlin, https://glassmagazine.com, 14th February 2016
26 Growth Opportunities in the Global Composites Industry, Lucintel, June 2017
27 An analysis of peer-reviewed graphene publications using Web of Science, March 2018

This is presented graphically below:

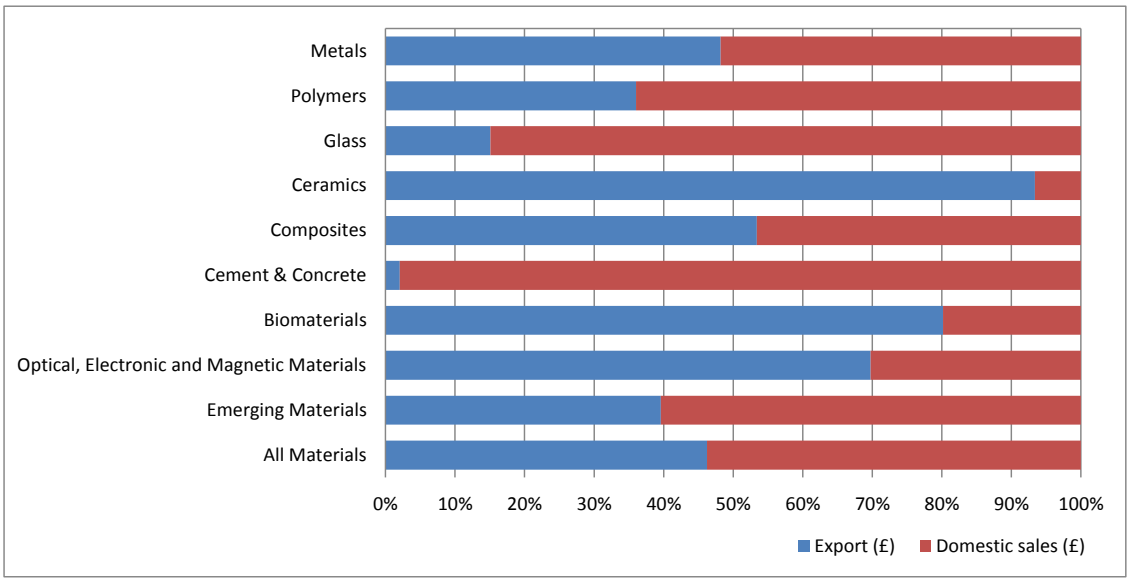

Figure 29: Share of Exports for the Materials Sector and its Sub-sectors

This shows significant exports in almost all materials sub-sectors. Export levels of between 35 and 50% of turnover are shown for metals, polymers, composites and emerging materials and much higher levels shown for composites, biomaterials and optical, electronic and magnetic materials. Cement and concrete shows very low exports as would be expected for a lower value, high weight material.

However, the UK is a net importer for a number of these materials. For example the trade deficit for three key materials can be presented as follows[28],[29],[30]:

[28] Global Steel Trade Monitor, Steel Exports and Imports Reports: United Kingdom, US Department of Commerce, February 2017

[29] Competitiveness impacts of carbon policies on UK energy-intensive industrial sectors to 2030: Aluminium Deep Dive, Cambridge Econometrics, March 2017

[30] About the British Plastic Industry, the British Plastics Federation, see http://www.bpf.co.uk/industry/default.aspx#Exports

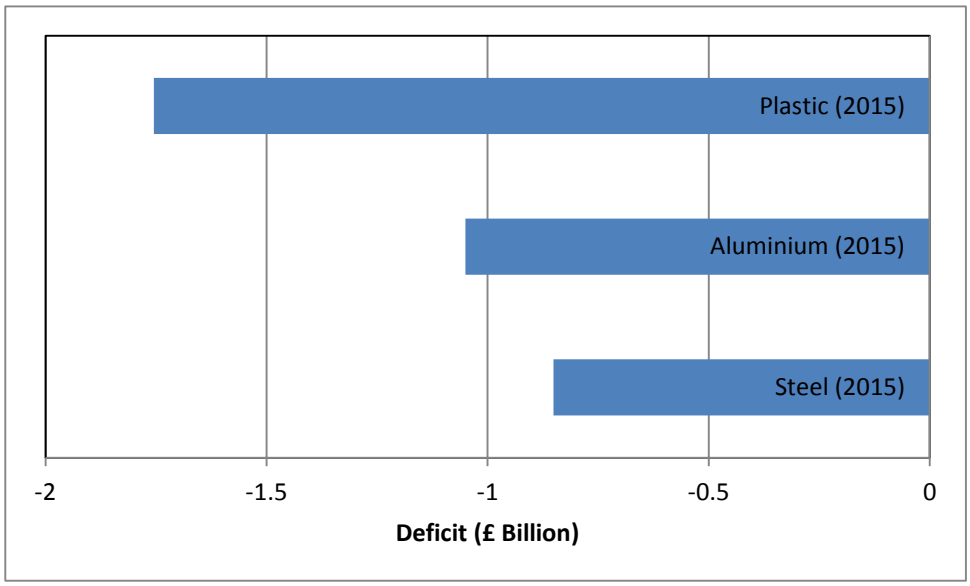

Figure 30: Example UK Trade Deficits – Key Materials

These figures on UK export performance and the trade deficit in key materials simply reflect that the UK materials manufacturing sector operates within international markets.

5. Market Demand

5.1 Global Materials Market

As already highlighted, materials underpin high value manufacturing and are essential to other key areas of the economy, particularly healthcare. The following diagram schematically shows how original equipment manufacturers (OEMs) across all manufacturing sectors, especially advanced manufacturing sectors are critically dependent on materials.

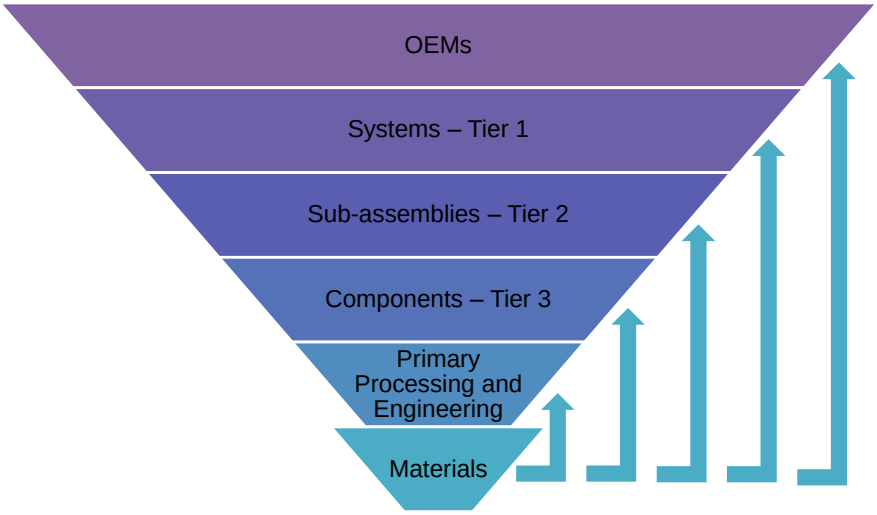

Figure 31: The Dependence of the Manufacturing Industry on Materials

This underlines the ubiqitous nature of materials and the dependence of advanced manufacturing and other sectors. The key customer sectors for each material are therefore wide-ranging, as shown below[31,32,33,34,35,36,37,3839].

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31 Steel, the Backbone of Sustainability in Europe, EUROFER Sustainability Vision paper, 2016

32 Aluminium Innovation Hub: Mapping key objectives and R&D challenges along the aluminium value chain, European aluminium, May 2016

33 Plastics – the Facts 2017. An analysis of European plastics production, demand and waste data, Plastics Europe, 2017

34 Production Breakdown by Sector, Glass Alliance Europe, https://www.glassallianceeurope.eu/en/statistical-data, accessed 23rd February 2018 and Flat Glass Market Analysis By Product (Tempered, Laminated, Basic Float, Insulating), By Application (Automotives, Construction) And Segment Forecasts To 2022, Grand View Research June 2015

35 Ceramics Market Analysis By Product (Traditional, Advanced), By Application (Sanitary Ware, Table & Ornamental Ware, Abrasives, Technical Ceramics, Bricks, Roof Tiles & Pipes, Refractory, Tiles, Decorative Tiles, Packaging, Fine Art), By End-use (Housing & Construction, Industrial, Medical) And Segment Forecasts To 2022, Grand View Research, 2016

36 Technical Ceramics Market by Material (Oxide, Non-oxide), Product (Monolithic Ceramics, Ceramic Matrix Composites, Ceramic Coatings), End-Use Industry (Electronics & Semiconductor, Automotive, Energy & Power, Medical, Others), and by Region - Global Forecast to 2021

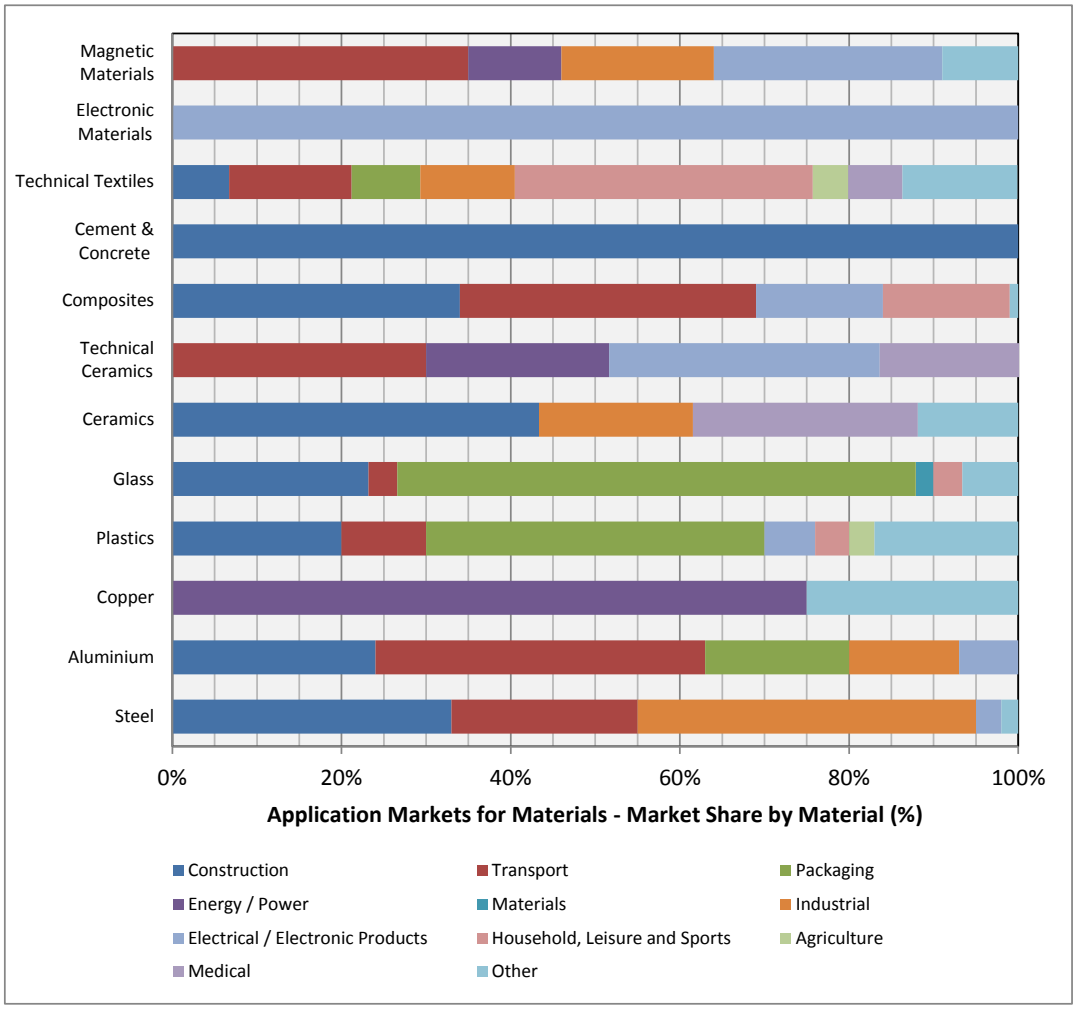

Figure 32: Market Applications for Materials Categories[40]

This highlights the ubiquitous nature of materials and demand across all major sectors.

As a result, the global market size for materials is significant. It is estimated that its value will soon exceed £3,000 billion[41] and it can be segmented as follows.

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37 Composites Market Report 2017, Market developments, trends, outlook and challenges, AVK< federation of Reinforced Plastics, 2017

38 Technical Textiles Market – Global Industry Analysis, Size, Share and Forecast, 2018, Transparency Market Research, September 2017

39 Global Magnetic Materials Market, 2017-2021, Technavio, May 2017

40 The application market sectors have been presented at a high level (e.g. transport rather than aerospace, automotive and rail sectors) to enable comparison of data from a number of different sources.

41 This is based on data from a number of sources and several assumptions. These are detailed in Appendix C.

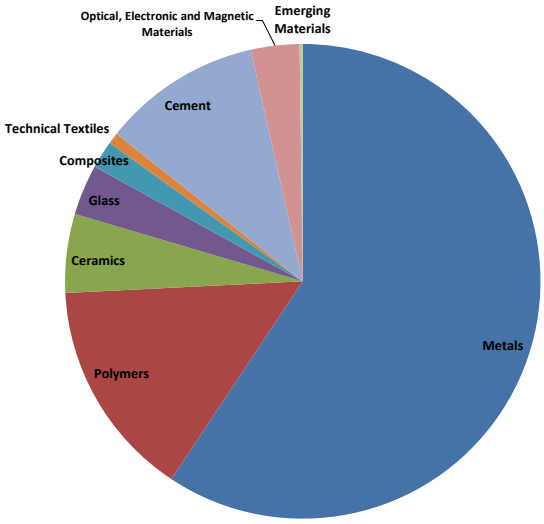


Figure 33: Segmentation of Global Materials Market (£ billion)

This shows the dominance of the metals segment, accounting for 56% of the global materials market, with polymers the next biggest market segment at 15% while the current scale of emerging materials markets are modest.

Market growth rates [42], however, show that significantly higher growth is expected for the emerging materials, as shown opposite.

These growth rates suggest that there is significant potential for the growth of the UK materials manufacturing sector and its constituent subsectors.

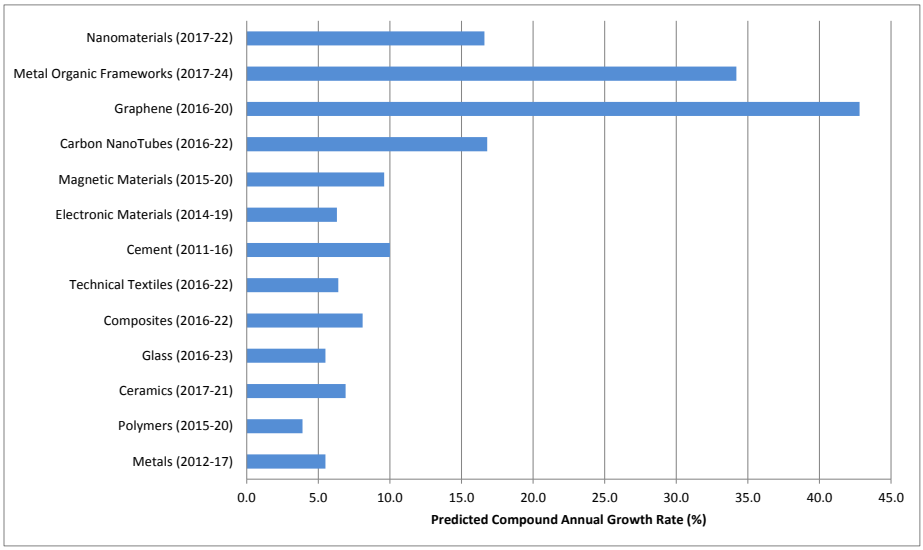


Figure 34: Predicted Compound Annual Growth Rates for Key Materials Sector Segments

[42] These are also based on data from a number of sources and some assumptions and are detailed in Appendix C

5.2 Market Challenges and Opportunities

The growth rates in all materials subsectors are a result of the drivers and demands in key user sectors as they strive to meet future challenges and the ability of existing and new materials to enable these challenges to be met. This can be demonstrated for a selection of product examples as follows.

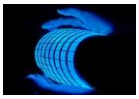
Key End User Market	Growth Predictions	Key Challenges	Underpinning Materials
 **Aircraft**	39,000 new aircraft by 2035 $6.2 trillion market Dominated by Airbus and Boeing	Lightweighting Energy efficiency Functionality	Composites Novel alloys Battery materials
 **Electric Vehicles**	$100 billion market by 2020 Over 28% growth rate p.a. Over 10 million vehicles by 2026	Lightweighting Energy efficiency Operating lifetime	Plastics Composites Aluminium alloys
 **Drones**	$25 billion market by 2023 18% annual growth rate Numerous applications	Lightweighting Operating lifetime Functionality / Safety	Plastics Composites Battery materials
 **Smartphones**	$479 billion market in 2017 Over 1.77 billion units by 2021 Market growth of 3.8% p.a.	Enhanced functionality Energy efficiency Operating lifetime	Battery materials Barrier films Organic electronics
 **Flexible Displays**	$15 billion market by 2022 34% growth rate p.a. to 2022 Wearables driving growth	Enhanced functionality Durability Energy efficiency	Battery materials Barrier films Organic electronics

Figure 35: Demand for Materials to Deliver Enhanced Future Products[43]

This shows that the key challenges are similar across different market sectors, so the pan-sector challenges are analysed here, rather than focusing on individual market characteristics. These market-focused challenges include:

[43] Current Market Outlook 2016- 2035, Boeing, 2016, see http://www.boeing.com/resources/boeingdotcom/commercial/about-our-market/assets/downloads/cmo_print_2016_final_updated.pdf
Growing Horizon 2017/2036, Global Market forecast, Airbus 2017, see http://www.airbus.com/aircraft/market/global-market-forecast.html
Global Electric Vehicles Market & Volume, Renub Research, May 2016
Global Electric Vehicles Market, Analysis & Forecast – 2017-2026, BIS Research, 2017
Drone Market : Global Demand, Growth Analysis & Opportunity Outlook 2023, Research Nester, February 2018
Smartphones - Statistics & Facts, Statista, 2018, see https://www.statista.com/topics/840/smartphones/
Worldwide Smartphone Forecast, 2017–2021, IDC Corporate, March 2017
Flexible Display Market by Application, Technology, Panel Size, and Geography - Global Forecast to 2022, MarketsandMarkets, May 2017

1. Durability

There is demand in numerous sectors for new and improved materials with enhanced engineering properties (yield strength, ductility and toughness) and improved performance and durability. Structures are being deployed in more extreme and challenging service environments but must continue to demonstrate their reliability and performance.

Some of the most challenging environments on Earth can be found in operational nuclear reactors and, as a result, there has been extensive effort to develop materials that can withstand high operating temperatures, high levels of irradiation and highly aggressive chemicals[44]. Similarly, operators in the oil and gas industry are continuing to explore in deeper waters and drill deeper wells requiring materials to withstand huge temperature differentials (from the high downhole temperatures to the extremely low deep sea water temperatures); be resistant to the high corrosive well environments and demonstrate excellent fatigue strength to minimise the risk of cracking as structures are subjected to tidal motions and currents. In addition to improved materials performance, this is also facilitating developments in innovative combinations of materials, such as metallics with advanced coatings (polymeric, metallic and ceramic). These developments are also expected to be highly relevant to emerging opportunities in deep sea mining.

Cyclic loading, both thermal and mechanical, is also a significant challenge across many industries including, for example, aerospace where materials are exposed to temperature extremes and construction where freeze-thaw process and structural movement due to high winds can be particularly damaging to materials over the long term[45].

This increasing drive for improved materials durability has opened up a whole new field of research where materials are designed with tailored performance criteria for specific applications, rather than just being discovered. This is putting the emphasis on design and modelling tools, high throughput combinatorial methodologies and advanced data analytics to predict materials performance, rather than the traditional hardware based approach. Indeed, in the USA, the National Science and Technology Council, in its Materials Genome Initiative, Strategic Plan, puts modelling and data at the heart of materials research.

The desire for improved durability is not, however, just about the development of new materials, it is also about optimising the performance characteristics of existing materials taking into consideration environmental and mechanical conditions as well as time. To be truly durable, materials must retain their performance characteristics, at least for the duration of the structure's design life.

2. Lightweighting

Global trends in resource efficiency and CO_2 reduction are two of the key drivers behind the growth in the development and deployment of new and improved lightweight materials across industry.

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44 Status Report on Structural Materials for Advanced Nuclear Systems, 2013, OECD Nuclear Energy Agency

45 Grand Challenges in Structural Materials, John L. Povis, Frontiers in Materials, April 2015

These include, for example, aerospace, automotive, construction, and renewable energy.

The aerospace industry is, currently, the biggest user of lightweight materials with almost 80% of all materials used in aircraft being lightweight, e.g. aluminium, magnesium, plastics, composites, etc. Nonetheless there is a continuing drive to reduce weight and increase aircraft efficiency. For example:

- There is significant investment under the Aerospace Technology Institute to develop novel aerostructures and more efficient propulsion technologies. Much of the R&D activity is focused on advancing technologies relating to the processing and application of a range of lightweight, high temperature metallic and composite materials[46]
- Airbus's "Wing of the Future" programme has been set up to explore the best materials, manufacturing and assembly techniques and new technologies in aerodynamics to improve fuel efficiency but, more importantly, to meet new production rates[47]

The automotive industry is expected to make rapid gains in the use of lightweight materials as OEMs strive to reduce overall vehicle weight to improve fuel consumption and reduce emissions. These materials will also underpin the transition to hybrid and fully electric vehicles. Together, these are creating opportunities across the supply chain for companies with the relevant skills and capabilities. For example:

- The UK automotive council has identified[48] lighter structures and engine components, energy storage technologies and novel power electronics as three key areas for development
- The investment by Magna in the new aluminium casting facility in Telford is a prime example of the automotive supply chain addressing a specific need.

The figure below shows the predicted growth in the use of lightweight materials in three key industry sectors, namely aerospace (aviation), wind energy and automotive.

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46 http://www.ati.org.uk/portfolio/projects/ accessed 19 Feb 2018

47 http://www.airbus.com/newsroom/news/en/2017/01/Wings-of-the-future.html accessed 20 Feb 2018

48 Automotive Technology Roadmaps, The Automotive Council UK, 2013, accessed at https://www.automotivecouncil.co.uk/2013/09/automotive-technology-roadmaps/ on 15/02/18

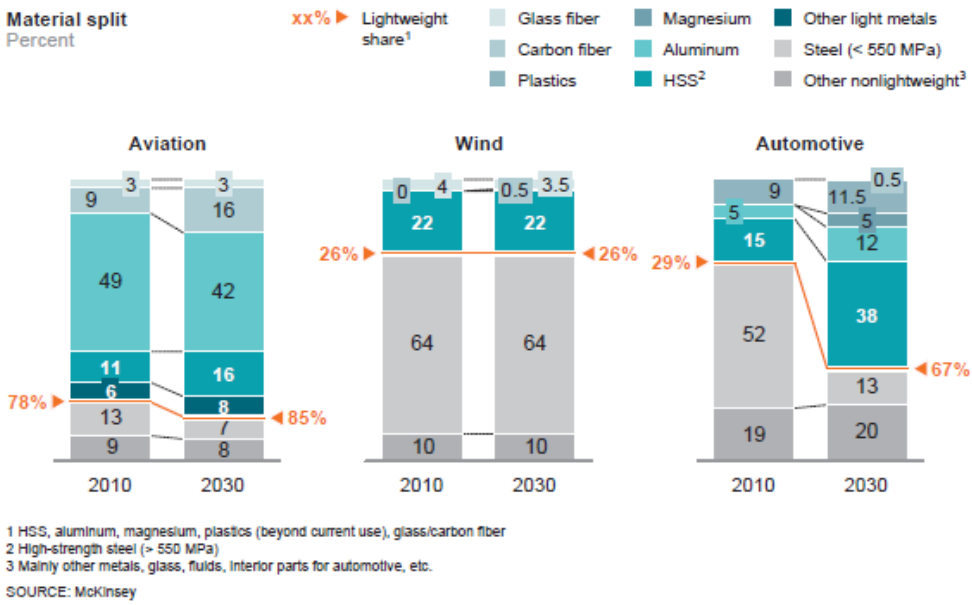

Figure 36: The Use of Lightweight Materials in Aerospace, Wind Energy and Automotive[49]

This clearly shows the predicted level of growth of these materials in automotive and clearly demonstrates the shift away from traditional steel to a range of other lightweight materials.

3. Functionality

Functional materials already play an important role in a number of sectors, particularly IT where they facilitate computation, communication, storage and the display of information. They are, however, becoming increasingly important in sectors such as aerospace, automotive, medical devices, packaging and construction. The functionality of a material is generated by the specific properties of the material as shown opposite.

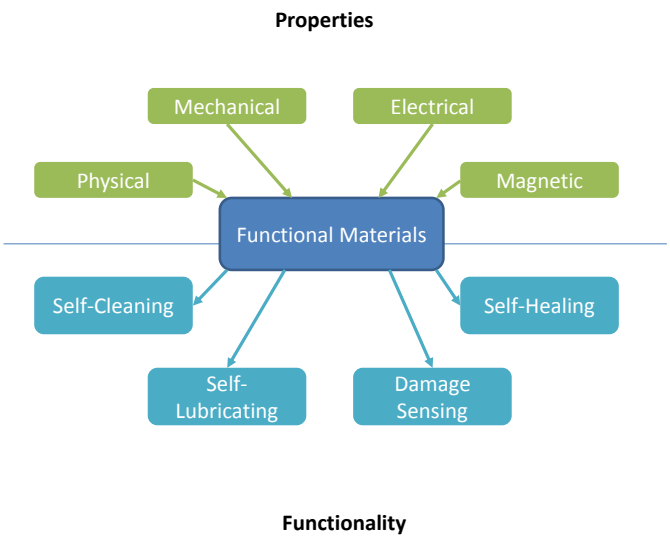

Figure 37: Some Examples of Materials Functionality

[49] Lightweight, Heavy Impact, Dr Ruth Heuss, McKinsey & Company, 2012

Damaging sensing and self-healing functionality, for example, will be of interest to the aerospace industry whilst self-lubrication will be of interest to engine and machinery manufacturers whilst self-cleaning will be of interest to automotive and construction[50].

There is also strong interest in functional materials in the medical sector and, already, they play a significant role across a number of applications including coatings, drug delivery and biocompatibility of devices. An ageing global population, increasing demands for extended medical care, higher patient expectations and a desire by governments and healthcare providers to reduce the cost burden of addressing these needs are, together, driving demand for new and improved functional materials in healthcare[51]. The development of new materials that support fast healing by, for example, facilitating tissue restoration and restructuring; reduce inflammation arising from exposure to incompatible devices; and limit the incidence of implant associated infections will present many opportunities.

As well as functionality of the bulk material, there have been significant on-going developments in functional coatings and this is an area where there will be numerous opportunities across a wide range of sector and applications. Surface technology and, in particular, functional surfaces, support optimal materials selection and innovative product design. The German Society for Surface Treatment carried out a survey to identify the surface technology needs of industry; the outcomes were as follows[52]:

- Active layers (e.g. photovoltaic technology, catalytic surfaces)
- Switching surfaces (e.g. switching between hydrophobic/hydrophilic behaviour, colours, electrical conduction/non-conduction)
- Anti-fouling surfaces (e.g. lotus effect, photocatalytic self-cleaning, non-toxic maritime anti-fouling)
- Self-repairing surfaces (long-term surface protection, e.g. wind turbines, heavy-duty corrosion protection)
- Hybrid materials with complex morphology (e.g. anti-reflective glass coatings)
- Brand protection

Opportunities would exist for material suppliers, production line equipment suppliers and developers of core, enabling smart technology

4. Sustainability and Recyclability

Many of the above challenges and the opportunities they present will, by their very nature, focus on technical performance. However, sustainability is becoming an increasingly important aspect of materials design and a requirement to “do more with less” is underpinning a branch of materials research focusing on materials recycling, reuse and substitution[45].

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50 Metal and Poly Matrix Composites: Functional Lightweight Materials for High Performance Structures, Nikhil Gupta and Muralidharan Paramsothy, Journal of Materials, Vol 66, No 6, 2014

51 New Functional Biomaterials for Medicine and Healthcare, Elena P Ivanova, Kateryna Bazaka and Russell J Crawford, Woodhead Publishing Ltd, 2014

52 https://www.european-coatings.com/var/StorageVincentz/VN.../517_Leseprobe.pdf accessed 20 Feb 2018

Metallic materials, in particular, are inherently recyclable and a well-established supply chain already exists for the collection, processing and resale of many of these valuable materials. Other secondary raw materials, such as secondary plastics and aggregate from constructions / demolition waste, still account for only a small proportion of materials used in the EU and, indeed, across the world. There are important barriers to their uptake, due to, for example inadequate collection systems or the uncertainty of their sources, composition, quantity and quality. In many cases it is too complicated to transport waste from one country to another due to different rules, standards and legislation[53].

There are technical barriers to the recycling of certain materials too. As has been noted previously, composites are being applied with increasing frequency in sectors where high strength and low weight is a requirement but, at the end of life, these materials are very difficult to recycle. Considering, specifically carbon reinforced polymer composites, the following example demonstrates the opportunities that these difficult to recycle materials present to companies that have the skills and capabilities to develop innovative processes.

ELG-CF has developed a process to recycle the expensive carbon fibre from carbon fibre composites. The recycling of carbon fibres, particularly those impregnated with resin, presents a significant challenge. The majority of composites are made using thermoset matrices, such as epoxy, that cannot be melted or reshaped after they are cured. ELG-CF's process is able to address this issue and is claimed to be both efficient and affordable. The recycled carbon fibre, typically, costs 40% less than that of virgin fibre, and similar weight savings can be achieved through its use. Another important point is that the use of recycled carbon fibre has a reduced impact on the environment. ELG-CF indicates that its recycled fibre uses only around 10% of the energy required for the manufacture of virgin fibre. The company produces a range of fibre, sheet and mat products for the manufacture of composites.

Sustainable materials are of particular interest in the construction industry and there is significant innovation activity in the materials field to reduce the carbon footprint of this sector. Portland cement, for example, contributes around 8% of the global, man-made CO2 emissions as a result of the carbon-intensive production processes and extremely high production volumes[45] and much research is being done into alternatives.

The Buildings Research Establishment's Materials Research Group is active in a number of key areas relating to new and improved, sustainable materials for construction, namely[54]:

- New materials – the suitability, durability and risks of innovative building materials, such as composites and new aggregates
- Industrial by-products and recycled materials – new applications for by-products of manufacturing processes that would usually go to landfill, and of materials generated by recycling
- Natural materials - such as lime, hemp and wood fibre board

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53 https://ec.europa.eu/growth/industry/sustainability/circular-economy_en accessed 15th February 2018

54 http://bregroup.com/services/research/materials-research/ accessed 16 Feb 2018

- Traditional materials – the innovative use of traditional, natural and recycled construction materials and investigations into the durability and sustainability of commonly used materials – such as metal, timber and concrete
- Low-impact materials – new materials being developed to reduce waste and the environmental impacts of manufacturing and construction

Across the range of industries where sustainability and recyclability is important, there are numerous opportunities for companies that can develop new materials and associated recovery processes and develop recovery processes for existing materials that are difficult to treat, meeting the needs of end-users but also taking into account environmental impacts.

These examples of the challenges being pursued in key user sectors highlight the importance of materials to underpin the products of the future and also reflect a strong emphasis on the use of novel materials.

6. Development Opportunities

In section 5.2, the demand for materials to address future opportunities began to be explored and, at the same time, overarching themes, such as durability and lightweighting were discussed. More in-depth analysis of the opportunities has revealed a long list of new and improved materials[43] that will be required by industry now and in the future, to support the development of new products; improve the performance of existing products; or reduce environmental impact by doing more with less, cutting CO_2 emissions and increasing use of secondary raw materials. These are:

Challenge	Customer Sectors	Development Opportunities
Durability	Nuclear Aerospace Construction Oil and gas Renewables Power generation	Advanced, high perfomance alloys for extreme environments Engineering polymers based on advanced formulation and additives Advanced, high temperature coatings New concrete formulations to withstand harsh environments New and improved carbon and glass fibre polymer composite formulations Advanced metal matrix and ceramic matrix composites Nanomaterials, carbon nanotubes and graphene as additives to improve strength, toughness and durability
Lightweighting	Aerospace Automotive Renewables Oil and gas Maritime Defence	Advanced, lightweight alloys Engineering polymers based on advanced formulation and additives New and improved carbon and glass fibre polymer composite formulations Advanced, aluminium based metal matrix composites Super tough, ultra thin glasses
Functionality	Aerospace Automotive Medical devices Electronics Construction Consumer products Industrial manufacturing Maritime Energy Packaging	Self-healing composites Smart glazing solutions (self cleaning, thermo-chromic) Smart textiles for health / wearables Biocompatible and drug eluting materials / coatings for medical implants and devices Carbon nanotube and graphene based materials for electronics, batteries and super-capacitors Innovative nanomaterials to enhance performance or functionality of existing materials Optical materials and functional thin films for advanced display technologies Novel ceramic materials for next generation electronics and communications Multi-functional coatings with the ability to "switch" functionality
Sustainability and Recyclability	Construction Automotive Alternative power generation Consumer products Packaging	Advanced concretes and cements with reduced environmental impacts Development and application of secondary raw materials High performance, natural fibres Bio-derived polymers and composites New and improved nanomaterials and coatings for renewable power generation (e.g. photovoltaics) Metal organic frameworks for hydrogen storage and fuel cells

Figure 38: Materials Development Opportunities

A number of these opportunities will underpin the development of new and improved materials across a number of industry sectors to address one or more of the market challenges. Others are opportunities to develop niche, high value solutions for specific applications and technologies. As has already been demonstrated, the UK industry has a very strong and successful base on which it can continue to develop. On-going investment in materials related RD&I, by companies and by public sector funding bodies will ensure that the UK maintains its competitive position in the global materials industry.

Appendices

Appendix A: Database Structure

The main sections of the database can be summarised as follows:

WORKSHEET TAB NAME	CONTENT
Master	Company Data
Corrected Export	Pivot Tables, Summary Table and Chart by Materials category
Nos Co's	Pivot Table - Summary by NUTS region and Materials category
Turnover	Pivot Table - Summary by NUTS region and Materials category
Employees	Pivot Table - Summary by NUTS region and Materials category
Employees Turnover & Exports	Pivot Table of Totals
Subsidiaries	List of Subsidiary companies
Materials	Segmentation for Materials Landscaping Project (includes summary analysis)
SICCodes	List of SIC Codes used for data collection and classification of Materials (includes summary column). This includes some new SIC Codes defined by the project team for use in the categorisation in this study
SME DEF	Table with definition of SME's according to European Union
Master Fields	List of fields in Master data worksheet, includes Colour Key

Details on specific fields in the database are as follows:

FIELD NAME	FORUMLA
Materials	=VLOOKUP(E2,SICCodes!A:B,2,0)
Primary Segmentation (based partially on UK SIC (2007) description)	=VLOOKUP(E2,SICCodes!A:E,5,0)
Organisation Type	=IF(AND(M2<=0,N2<=0),"Independent",IF(AND(M2>0,N2>0),"Parent & Subsidiary",IF(AND(M2<=0,N2>=0),"Subsidiary","Parent")))
Corrected Employee number	=AH2*AG2/100
Number of employees Last avail. Yr	=IFERROR(INDEX(AI2:AO2,MATCH(TRUE,INDEX((AI2:AO2<>0),0),0)),)
Subsidiary - Number of employees	=SUMIF(Subsidiaries!B:E,C2,Subsidiaries!E:E)
Headcount (incl Subsidiaries)	=IF(AH2+AP2>250,">250",IF(AH2+AP2<50,"<50","50-250"))
SME Status (headcount + turnover)	=IF(OR(AQ2=">250",AT2>45000),"No","Yes")
Corrected Turnover	=AT2*AG2/100
Turnover £'000s Last avail. Yr	=IFERROR(INDEX(AU2:BA2,MATCH(TRUE,INDEX((AU2:BA2<>0),0),0)),)
Turnover £'000s 2017	=AH2*167.508 [only where no figure is available]
Corrected Exports	=BC2*AG2/100
Export turnover £'000s Last avail. Yr	=IFERROR(INDEX(BD2:BJ2,MATCH(TRUE,INDEX((BD2:BJ2<>0),0),0)),)
Profit margin % Last avail. Yr	=IFERROR(INDEX(BL2:BR2,MATCH(TRUE,INDEX((BL2:BR2<>0),0),0)),)
Gearing ratio % Last avail. Yr	=IFERROR(INDEX(BT2:BZ2,MATCH(TRUE,INDEX((BT2:BZ2<>0),0),0)),)
EBIT margin % Last avail. Yr	=IFERROR(INDEX(CB2:CH2,MATCH(TRUE,INDEX((CB2:CH2<>0),0),0)),)
EBITDA £'000s Last avail. Yr	=IFERROR(INDEX(CJ2:CP2,MATCH(TRUE,INDEX((CJ2:CP2<>0),0),0)),)

EBITDA margin % Last avail. Yr	=IFERROR(INDEX(CR2:CX2,MATCH(TRUE,INDEX((CR2:CX2<>0),0),0)),)
Gross profit £'000s Last avail. Yr	=IFERROR(INDEX(CZ2:DF2,MATCH(TRUE,INDEX((CZ2:DF2<>0),0),0)),)
Wages & salaries £'000s Last avail. Yr	=IFERROR(INDEX(DH2:DN2,MATCH(TRUE,INDEX((DH2:DN2<>0),0),0)),)
Social security costs £'000s Last avail. Yr	=IFERROR(INDEX(DP2:DV2,MATCH(TRUE,INDEX((DP2:DV2<>0),0),0)),)
Pension costs £'000s Last avail. Yr	=IFERROR(INDEX(DX2:ED2,MATCH(TRUE,INDEX((DX2:ED2<>0),0),0)),)
Other staff costs £'000s Last avail. Yr	=IFERROR(INDEX(EF2:EL2,MATCH(TRUE,INDEX((EF2:EL2<>0),0),0)),)
Directors' remuneration £'000s Last avail. Yr	=IFERROR(INDEX(EN2:ET2,MATCH(TRUE,INDEX((EN2:ET2<>0),0),0)),)
Directors' fees £'000s Last avail. Yr	=IFERROR(INDEX(EV2:FB2,MATCH(TRUE,INDEX((EV2:FB2<>0),0),0)),)
Pension contribution £'000s Last avail. Yr	=IFERROR(INDEX(FD2:FJ2,MATCH(TRUE,INDEX((FD2:FJ2<>0),0),0)),)
Research & development £'000s Last avail. Yr	=IFERROR(INDEX(FL2:FR2,MATCH(TRUE,INDEX((FL2:FR2<>0),0),0)),)
Total assets £'000s Last avail. Yr	=IFERROR(INDEX(FT2:FZ2,MATCH(TRUE,INDEX((FT2:FZ2<>0),0),0)),)
Current liabilities £'000s Last avail. Yr	=IFERROR(INDEX(GB2:GH2,MATCH(TRUE,INDEX((GB2:GH2<>0),0),0)),)
Total assets less cur. liab. £'000s Last avail. Yr	=IFERROR(INDEX(GJ2:GP2,MATCH(TRUE,INDEX((GJ2:GP2<>0),0),0)),)
Investments £'000s Last avail. Yr	=IFERROR(INDEX(GR2:GX2,MATCH(TRUE,INDEX((GR2:GX2<>0),0),0)),)
Profit/Loss before tax £'000s Last avail. Yr	=IFERROR(INDEX(GZ2:HF2,MATCH(TRUE,INDEX((GZ2:HF2<>0),0),0)),)
Interest paid £'000s Last avail. Yr	=IFERROR(INDEX(HH2:HN2,MATCH(TRUE,INDEX((HH2:HN2<>0),0),0)),)
Return on Capital Employed Last avail. Yr	=IFERROR(INDEX(HP2:HV2,MATCH(TRUE,INDEX((HP2:HV2<>0),0),0)),)
Return on Capital Employed 2017	=IFERROR(GZ2/GJ2,)
Return on Capital Employed 2016	=IFERROR(HA2/GK2,)
Return on Capital Employed 2015	=IFERROR(HB2/GL2,)
Return on Capital Employed 2014	=IFERROR(HC2/GM2,)
Return on Capital Employed 2013	=IFERROR(HD2/GN2,)
Return on Capital Employed 2012	=IFERROR(HE2/GO2,)
Return on Capital Employed before 2012	=IFERROR(HF2/GP2,)
Return on Total Assets Last avail. Yr	=IFERROR(INDEX(HX2:ID2,MATCH(TRUE,INDEX((HX2:ID2<>0),0),0)),)
Return on Total Assets 2017	=IFERROR(GZ2/FT2,)
Return on Total Assets 2016	=IFERROR(HA2/FU2,)
Return on Total Assets 2015	=IFERROR(HB2/FV2,)
Return on Total Assets 2014	=IFERROR(HC2/FW2,)
Return on Total Assets 2013	=IFERROR(HD2/FX2,)
Return on Total Assets 2012	=IFERROR(HE2/FY2,)
Return on Total Assets before 2012	=IFERROR(HF2/FZ2,)
Ferrous Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IE$1,"Yes","")
Aluminium and its Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IF$1,"Yes","")
Titanium and its Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IG$1,"Yes","")
Nickel and its Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IH$1,"Yes","")
Copper & its Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=II$1,"Yes","")
Lead, Zinc and Tin and their Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IJ$1,"Yes","")

Magnesium and its alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IK$1,"Yes","")
Other non-ferrous Metals and their Alloys	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IL$1,"Yes","")
Precious Metals	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IM$1,"Yes","")
Cast Metal	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IN$1,"Yes","")
Forged Metal	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IO$1,"Yes","")
Powder Metallurgy	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IP$1,"Yes","")
Metal Coatings	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IQ$1,"Yes","")
Total Metals	=COUNTIF(IE2:IQ2,"Yes")
Commodity Polymers	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IS$1,"Yes","")
Engineering Polymers	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IT$1,"Yes","")
Synthetic Rubbers	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IU$1,"Yes","")
Biopolymers	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IV$1,"Yes","")
Carbon Fibre	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IW$1,"Yes","")
Masterbatch / Compounders	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IX$1,"Yes","")
Polymer Coatings	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=IY$1,"Yes","")
Total Polymers	=COUNTIF(IS2:IY2,"Yes")
Refractory Products	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JA$1,"Yes","")
Technical Ceramics	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JB$1,"Yes","")
Household Ceramics	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JC$1,"Yes","")
Ceramic Coatings	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JD$1,"Yes","")
Total Ceramics	=COUNTIF(JA2:JD2,"Yes")
Flat Glass	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JF$1,"Yes","")
Hollow Glass	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JG$1,"Yes","")
Technical Glass	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JH$1,"Yes","")
Glass Fibre	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JI$1,"Yes","")
Glass Coatings	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JJ$1,"Yes","")
Total Glass	=COUNTIF(JF2:JJ2,"Yes")
Polymer Matrix Composite	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JL$1,"Yes","")
Metal Matrix Composite	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JM$1,"Yes","")
Ceramic Matrix Composite	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JN$1,"Yes","")
Biocomposites	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JO$1,"Yes","")
Nanocomposites	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JP$1,"Yes","")
Total Composites	=COUNTIF(JL2:JP2,"Yes")
Cement	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JR$1,"Yes","")
Ready Mixed Concrete	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JS$1,"Yes","")
Mortar	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JT$1,"Yes","")
Fibre Cement	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JU$1,"Yes","")
Total Cement & Concrete	=COUNTIF(JR2:JU2,"Yes")
Organic	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JW$1,"Yes","")
Inorganic	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JX$1,"Yes","")
Total Biomaterials	=COUNTIF(JW2:JX2,"Yes")

Technical and Industrial Textiles	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=JZ$1,"Yes","")
Total Textiles	=COUNTIF(JZ2,"Yes")
Optical	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KB$1,"Yes","")
Electronic	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KC$1,"Yes","")
Semiconductor	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KD$1,"Yes","")
Compound Semiconductor	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KE$1,"Yes","")
Magnetic	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KF$1,"Yes","")
Fibre Optic	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KG$1,"Yes","")
Thin Film Coatings	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KH$1,"Yes","")
Total Optical, Electronic and Magnetic	=COUNTIF(KB2:KH2,"Yes")
Graphene	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KJ$1,"Yes","")
Carbon NanoTubes	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KK$1,"Yes","")
Metal Organic Frameworks	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KL$1,"Yes","")
Nanomaterials	=IF(VLOOKUP($E2,SICCodes!$A:$C,3,0)=KM$1,"Yes","")
Total Emerging	=COUNTIF(KJ2:KM2,"Yes")
Total Materials	=SUM(+KI2+KA2+JY2+JV2+JQ2+JK2+JE2+IZ2+IR2+KN2)

Appendix B: Acknowledgements / Data Sources Accessed

We acknowledge and thank the following organisations for their support during this study:

- Midlands Local Enterprise Partnerships
- Scottish Enterprise
- Knowledge Transfer Networks
  - Materials KTN
  - Electronics Sensors and Photonics KTN
- Trade Associations
  - British Ceramic Confederation
  - British Coatings Federation
  - British Glass Manufacturers' Association
  - British Plastics Federation
  - British Precast Concrete Federation Ltd
  - British Rubber and Polyurethane Products Association
  - British Stainless Steel Association
  - Cast Metals Federation
  - Composites UK
  - Confederation of British Metal Forming
  - Copper Development Association
  - European Powder Metallurgy Association
  - Galvanisers Association
  - International Glassfibre Reinforced Concrete Association
  - Minor Metal Trade Association
  - Surface Engineering Association
  - The Performance Textiles Association
  - UK Steel
- UK Metals Councils
- Catapult Organisations
  - High Value Manufacturing Catapult
- We also reviewed a number of customer sector databases to identify potential customers. These include
- Society of Motor Manufacturers and Traders (see https://www.smmt.co.uk/)
- The ADS Group (https://www.adsgroup.org.uk/)
- The Midlands Aerospace Alliance (http://www.midlandsaerospace.org.uk/)

Appendix C: Large Companies

Large Companies where corrections to UK materials activity were applied	
Advanced Medical Solutions Group PLC	Meggitt PLC
Ahlstrom-Munksjo Chirnside Limited	Minteq UK Limited
Airbus Operations Limited	Monarch Aircraft Engineering Limited
Allied Glass Group Limited	Montupet (U.K.) Limited
Andrew Industries Limited	Morgan Technical Ceramics Limited
Ardagh Glass Limited	Northstone (NI) Limited
B.E. Wedge Holdings Limited	NSG UK ENTERPRISES LIMITED
Babcock International Group PLC	O-I Manufacturing UK Limited
Babcock Vehicle Engineering Limited	Outokumpu Stainless Limited
BAE Systems PLC	Pilkington Automotive Limited
Balmoral Group Holdings Limited	Pilkington United Kingdom Limited
Basf Performance Products Limited	Porvair PLC
Breedon Cement Limited	PPG Industries (UK) Limited
Brett Concrete Limited	Rolls-Royce PLC
British Steel Holdings Limited	Safran Electrical & Power UK Ltd
BWF - The Fiber Company UK Limited	Safran Nacelles Limited
Castings Public Limited Company	Saint-Gobain Glass (United Kingdom) Limited
Castle Cement Limited	Scott Bader Company Limited
Cemex UK Operations Limited	Sheffield Forgemasters International Limited
Coats Group PLC	Siemens Gamesa Renewable Energy Limited
Cobham PLC	Special Metals Wiggin Limited
Coorstek Limited	Specialist Building Products Limited
Devro PLC	Speciality Fibres And Materials Limited
Fibergrate Composite Structures Limited	Spirit Aerosystems (Europe) Limited
Firth Rixson Forgings Limited	Steelite International Limited
GKN PLC	Sunseeker International Limited
Glass Solutions [2]	Superglass Insulation Limited
Grainger & Worrall Limited	Synthomer PLC
Hexcel Composites Limited	Tarmac Building Products Limited
Ineos Chemicals Grangemouth Limited	Tarmac Cement And Lime Limited
Invista Textiles (U.K.) Limited	Tata Steel UK Limited
Ipeco Holdings Limited	Timet UK Limited
John Cotton Group Limited	Tods Aerospace Limited
Johnson Matthey PLC	Twickenham Plating Group Limited
Knauf Insulation Limited	Twickenham Plating Limited
Liberty Bridge Aluminium Limited	Vale Europe Limited
Liberty Performance Steels Limited	Victrex PLC
Lucite International UK Limited	W.L. Gore And Associates (U.K.) Limited
Mastermelt Limited	Weartech International Limited
MAT Foundry Group Limited	WWRD UNITED KINGDOM, LTD.

Appendix D: Sources of Market Data

The market data presented in Section 4.1 was obtained from the following sources:

Metals

1. Growth Opportunities in the Global Metal Market, Lucintel, August 2012, see http://www.lucintel.com/metal-market-2017.aspx
2. Metal Coatings Market by Type (Polyester, Plastisol, Siliconized Polyester, Fluropolymer, Polyurethane), Process (Coil, Extrusion, Hot Dip Galvanizing), Technology (Liquid, Powder), End Use Industry, and Region - Global Forecast to 2026, MarketsandMarkets, December 2016, see https://www.marketsandmarkets.com/Market-Reports/metal-coating-market-96303322.html

Polymers

3. Plastics Market Analysis by Product (PE, PP, PVC, PET, Polystyrene, Engineering Thermoplastics), By Application (Film & Sheet, Injection Molding, Textiles, Packaging, Transportation, Construction) and Segment Forecasts to 2020, Grand View Research Inc., July 2015, see http://www.grandviewresearch.com/industry-analysis/global-plastics-market
4. Growth Opportunities in the Global Polymer Market, Lucintel, March 2015, see http://www.lucintel.com/polymer-market-2020.aspx

Ceramics

5. Ceramics Market Analysis by Product (Traditional, Advanced), by Application (Sanitary Ware, Table & Ornamental Ware, Abrasives, Technical Ceramics, Bricks, Roof Tiles & Pipes, Refractory, Tiles, Decorative Tiles, Packaging, Fine Art), by End-use (Housing & Construction, Industrial, Medical) and Segment Forecasts To 2022, Grand View Research, July 2016, see https://www.grandviewresearch.com/industry-analysis/ceramics-market
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Business Growth | Economic Development | Technology Commercialisation

Head Office:

Optimat Limited

Torus Building, Rankine Avenue,

Scottish Enterprise Technology Park,

East Kilbride

G75 0QF, United Kingdom

Tel: +44 (0)1355 272 800

Email: resource@optimat.co.uk

Web: www.optimat.co.uk