Advanced Ceramics

An industry of the future

Sector Profile for the Midlands (UK) - 2021

MICG Midlands Industrial Ceramics Group

Introduction

This sector profile evidences demand for the rapid expansion of advanced ceramics, and the Midlands is well positioned to grow and create jobs in this industry.

This report was commissioned by the Midlands Industrial Ceramics Group (MICG) (an academic and industrial consortium) in partnership with the Midlands Engine Observatory[1] . Its purpose is to raise awareness of the importance of advanced ceramics to UK industry and highlight the opportunities for growth in the Midlands.

Advanced ceramics, which are also referred to as technical ceramics, underpin many industries. They are embedded in numerous high-performing products owing to their high strength, high operating temperatures, wear resistance and tailorable properties and are replacing metals in applications where advantageous. They make an important contribution to the global competitiveness of the United Kingdom's (UK's) manufacturing sector.

The sector is growing rapidly across the world. The Midlands has key strengths in advanced ceramics owing to its growing advanced ceramics supply chains, large end user manufacturers and its leading academic institutions. These strengths provide the Midlands with a significant opportunity to increase its global competitiveness and grow jobs.

This sector profile answers the following key questions:

- What are advanced ceramics, why are they important, what key challenges are they solving?
- What is the size of the global market and its expected growth rates?
- What are the Midlands' strengths in this sector and why do we propose it has comparative / competitive advantage?
- What are the challenges facing the sector and what are the proposals in the Midlands to tackle these?
- What are the expected benefits of investing in advanced ceramics in the Midlands?

This report has been informed by sixty in-depth consultations with industry representatives conducted in 2018 and 2020 by SQW and City-REDI (City-Region Economic Development Institute) at the University of Birmingham. It draws on qualitative analysis and quantitative data to summarise the global opportunities and the strengths in the Midlands.

1. The Midlands Engine Economic Observatory is a part of the Midlands Engine, providing comprehensive and contemporary data, analysis and intelligence on the whole Midlands economy. The Midlands Engine partnership brings together public sector partners and businesses to complement the activity of local and combined authorities, LEPs, universities, businesses and others. We are generating added value for the whole of the Midlands, its communities and the wider UK.

What are Advanced Ceramics?

Introducing Advanced Ceramics

Advanced ceramics are inorganic, non-metallic materials which exhibit an extensive range of high-performing properties and behaviours.

They can be divided into two categories:

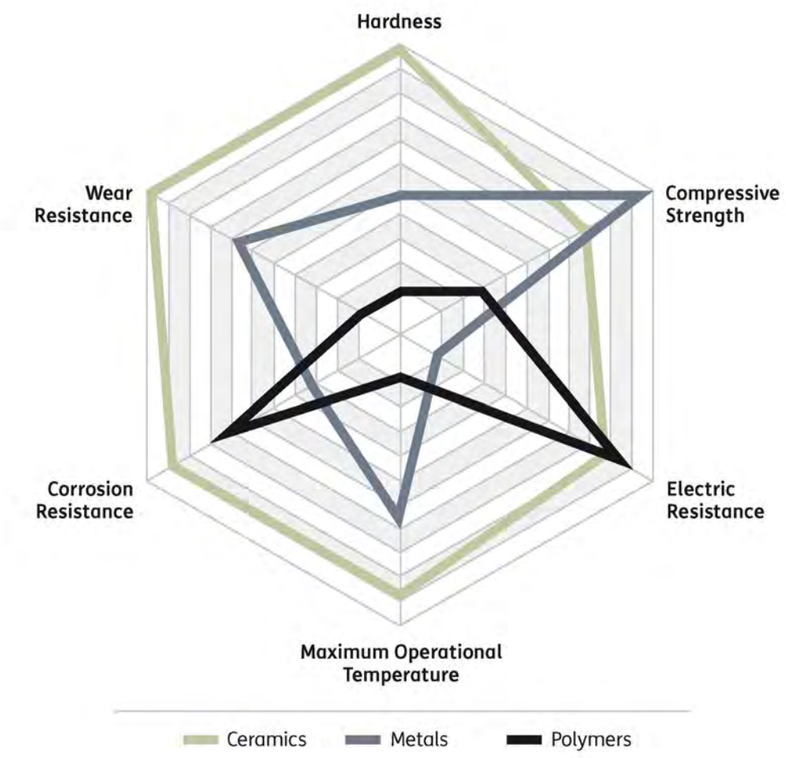
- **Functional ceramics** – which display specific electrical, electronic, magnetic or optical properties and performance
- **Structural ceramics** – which display advantageous mechanical and thermal properties and behaviours.

With the development of new ceramics these boundaries are becoming increasingly blurred, as can be seen, for example, in bio-ceramics which exhibit both structural and functional properties.

Materials are increasingly required to operate in ever more demanding environments. Their unique set of properties make ceramics the material of choice in many applications.

Ceramics are often used in hidden, niche or specialist components but are hugely important to the UK in that they unlock performance in a wide range of high-tech industries, including aerospace (jet engines) energy (fuel cells, batteries), automotive (brakes, sensors and engine components), telecommunications and IT (electronics), defence (rocket parts, antennas and armour), healthcare (artificial hips, teeth, etc.) and many other sectors where they are identified as the 'only material that will work'.

Figure 1: Composition of Advanced Ceramics



Why Ceramics?

Ceramics provide a combination of hardness, chemical resistance, strength and high temperature operation not found in alternative materials such as metal, alloys and polymers, (Figure 1).

A good example of the benefits of ceramics are ceramic matrix composites (CMCs). These comprise a ceramic body reinforced by ceramic fibres, and typically exhibit significantly enhanced toughness.

In addition, they have the attractive ceramic properties of low density, good compressive strength and excellent thermal and chemical resistance.

This makes CMCs ideal as lightweight replacements for alloys in high temperature aggressive environments, such as turbine engines and exhaust systems, where they can bring significant improvements in performance, emissions, and fuel consumption.

Future Sector: the role of Advanced Ceramics in Space

The Space sector is an important contributor to the UK Economy, delivering approximately £15 billion Gross Value Added (GVA) per annum with a strong rate of growth. Its importance is recognised by the UK Government in the Industrial Strategy and the ambition is to grow the sector to £40 billion per annum by 2030, capturing a significant share of the global market and creating 100,000 new jobs.

The Midlands has key strengths in the space sector with the ambitions for Space Park Leicester (aligned to Leicester University) and a number of high-profile advanced manufacturers growing into the space sector. It is anticipated the growing advanced ceramics sector in the Midlands will both benefit from the growing demand from the space sector, and help to reinforce the competitiveness of UK space companies through the development of innovative high-performing materials.

The benefits of advanced ceramics for the space sector is their ability to respond to the distinctive engineering challenges posed by the 'hostile' outer space environment, intense pressure caused during space craft launch and collisions with 'space junk'.

Precision Ceramics based in Birmingham have designed and manufactured a series of highly technical ceramic components using Shapal for the unmanned space-craft Cassini–Huygens sent to the planet Saturn. Shapal Hi-M Soft™ is a ceramic which combines good heat resistance, high mechanical strength and bending strengths of 30 kg/mm2 giving a perfect combination of properties for space-craft. Precision Ceramics is the principal UK distributor for Shapal which forms an important part of the company's wide portfolio of technical ceramics available for an ever-increasing array of worldwide applications.

The Moog Space and Defence Group is another example of a business exploring the use of advanced ceramics in the development of their space vehicles including high reliability cost effective spacecraft buses, and propulsive secondary payload adapters.

Size of the Opportunity

The advanced ceramics sector is growing rapidly across the world. Grandview Research estimated that the advanced ceramics sector achieved annual global revenues of £42 billion in 2015 and projected the sector would reach £143 billion by 2025.

The sector is rapidly growing in the UK: Grandview Research estimated that the UK market for advanced ceramics is expected to grow at 12.8% per annum until 2024 (Table 1). By comparison Grandview[2] estimates the global biotechnology market will grow by 7.4% per annum to 2025.

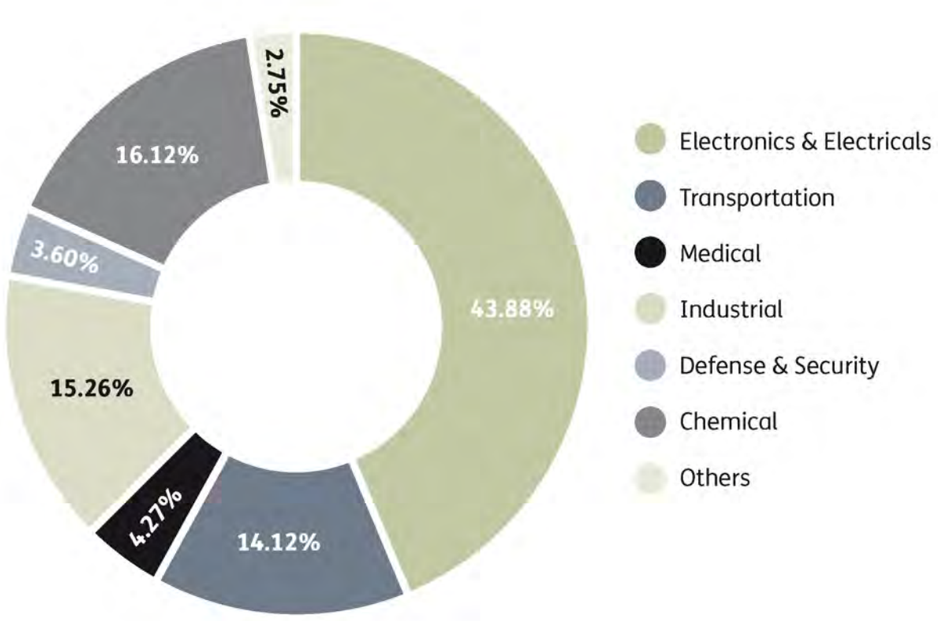
Advanced ceramics are used in a variety of key UK strategic industrial sectors. Table 2 provides estimates of revenues generated by businesses providing advanced ceramics and support in their adoption by end user.

Collectively, these sectors - such as Aerospace, Medicine and Energy - make a substantial contribution to the national and regional economy.

In terms of revenue, the electronics end-user industry segment is estimated to have the largest share, with nearly 44% of the total market (Figure 2), in 2020.

However, the medical end-user segment is expected to register the highest growth during the forecast period. In the medical industry, advanced ceramics are used in all kinds of medical devices and equipment, such as ultrasonic tools, infusion pumps, dialysis machines and diagnostic equipment.

Figure 2: Advanced Ceramics Market (Revenue share % by end-user)



Source: Mordor Intelligence Analysis

2 Grandview (2017). Biotechnology Market Size, Share & Trends Analysis Report By Application (Health, Food & Agriculture, Natural Resources & Environment, Industrial Processing Bioinformatics), By Technology, And Segment Forecasts, 2018 – 2025.

Table 1: Estimated advanced ceramics market revenue, by end user industries, 2013-2024 ($m US)

End use	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR[1] (2016-24)
Electrical and electronics	505	568	638	717	807	910	1025	1157	1306	1476	1669	1887	12.90%
Automotive	101	112	125	138	153	171	190	211	234	261	291	324	11%
Machinery	54	58	63	68	73	79	85	91	98	104	112	119	7.30%
Environmental	104	120	137	157	180	207	238	274	314	361	415	478	14.90%
Medical	79	90	103	117	134	153	175	200	229	262	301	345	14.50%
Other	15	16	17	18	20	21	23	25	27	29	30	33	7.50%
Total	858	963	1082	1215	1367	1541	1736	1958	2208	2493	2818	3186	12.80%

Source: Grandview Research. [1]Compound annual growth rate

Table 2: Size of key sectors in 2018 where advanced ceramics enables product innovation (Total GVA £millions)

	SIC	United Kingdom	East Midlands	West Midlands	Midlands	Percentage Share Midlands
Aerospace	30	10,406	1,129	958	2,087	9.2%
Medicine	21	13,464	402	111	513	0.8%
Automotive	29	16,347	929	7084	8,013	43.3%
Defence	84	87,893	4265	5,900	10,165	6.7%
Electronic	26	14,772	877	755	1,632	5.1%
Energy	D	25,335	2531	2,568	5,099	10.1%
Environmental	81	10286	408	975.00	1,383	9.5%

Source Table 1b. Regional gross value added (balanced) by industry: all NUTS level regions (ONS 2019)

International Export Opportunities

Internationally the export opportunities for UK advanced ceramics are substantial and are expected to grow. The major factors driving the growth of the advanced ceramics market are the growing demand in the medical industry and the rise in use as an alternative to metals and plastics.

The UK is competing with other major economies to supply products and gain a share of the global advanced ceramics market. The ambition of many UK suppliers is to become not only a domestic leader but an international competitor.

Measured by revenue, the Asia-Pacific region (predominantly made up from China, Japan and South Korea) is estimated to have the largest share of the global market, with 54% of the total market in 2020, followed by the USA with 26%, compared to Europe's share of 17%. The markets that dominate advanced ceramics production are generally characterised as developed economies with strong innovation capabilities and a highly skilled workforce.

The City-REDI and SQW consultation with UK businesses evidenced the widely held view that for the UK to be internationally competitive with the industry in the United States, Germany and the Far East, it needs to embrace and support the innovation process and facilitate effective R&D. Supporting R&D in the industry will break new ground and help to innovate new practices to enable the creation of products for the various sectors it supports.

Alan McLelland of Morgan Advanced Materials said: 'The advanced ceramics sector is forecast to continue to grow globally at a rapid rate which provides the organisation with significant potential to create additional jobs and exports, including at our key operational sites within the Midlands'.

'Midlands advanced ceramics innovation and production will help us grow our supply chains locally and improve the competitiveness of our products, all of which would help the balance of trade for the UK.'

– Ian Edmonds, Rolls-Royce PLC

Advanced Ceramics Assets in the Midlands

The UK advanced ceramics industry has a significant cluster in the Midlands, with a clear opportunity to grow. This is confirmed by research undertaken in 2020 by City-REDI and SQW. No other UK region has the equivalent mass of advanced ceramics specialist suppliers, end users and researchers.

The Midlands has the largest cluster of advanced ceramics producers in the UK. These producers form an integral part of the Midlands manufacturing supply chain, as well as exporting specialist products across the world. These companies include **Morgan Advanced Materials, Mantec Technical Ceramics, Prince Materials, CDS group, Precision Ceramics, PCL Ceramics, Foseco and Trelleborg** who are all founding members of the **Midlands Industrial Ceramics Group** (this is not an exhaustive list of active companies in the Midlands).

In the Midlands there is a concentration of manufacturers that will increasingly use advanced ceramics in their products, creating a critical mass of advanced ceramics customers. These include companies within the automotive and aerospace sectors; and companies within the rapidly growing energy and med-tech sectors, (Table 2). Three end users, **Rolls-Royce and JCB**, and **AEON Engineering** are founding members of the MICG and have a keen interest in improving their advanced ceramic supply chains and collaborating to deliver ceramics technology improvements.

Lucideon is a private company based in Stoke-on-Trent and is a gla global leading development, testing and commercialisation business. A subsidiary company of Lucideon, AMRICC, houses pilot lines that helps companies exploit new advanced ceramics technologies and commercialise new products. Its ambition is to significantly grow these facilities. Through AMRICC, Lucideon is also leading on the vocational curriculum development for advanced ceramicists with leading Midlands skills providers.

The Midlands is home to three world-class universities that are at the forefront of research into advanced ceramics and who are investing in research scientists of the future by supporting PhD students and post-doctoral students supported by leading academics in the field.

The University of Birmingham has extensive experience of processing and characterising ceramics, including the use of techniques such as additive manufacturing, green forming and sintering amongst many others. There are several research groups within the University with interests in ceramics, including biomaterials, engineering ceramics, functional ceramics and electronic ceramics - the latter with particular expertise in battery technology. The groups interact with a wide range of organisations, including Rolls-Royce, BAE Systems, DSTL and many others.

The University of Leicester is home to the Mechanics of Materials (MoM) Research Group which has expertise in advanced ceramics including biomaterials and medical devices, digital twin of ceramic processing (computer stimulations) and corrosion of engineering systems. Within MoM are located a number of specialist centres and facilities including the Advanced Microscopy Facility which has equipment and sophisticated software for image analysis, image processing and X-ray characterisation of materials, with facilities for rapid report generation.

Loughborough University provides access to research infrastructure, with particular strengths in ceramics, which includes the Loughborough Materials Characterisation Centre (LMCC), Additive Manufacturing, Field Assisted Processing, and the HPC-Midlands, a Tier-2 High Performance Computing centre with a focus on Engineering and Physical Sciences, funded by EPSRC. The University is also host to the Loughborough University Science and Enterprise Park - a thriving and collaborative innovation community of over 80 knowledge-based companies and world-class research centres.

Figure 3: Location of members of the consortium within the region [Source MICG 2020]

Size of Advanced Ceramics in the Midlands

The Midlands has a significant share of national employment in both traditional and advanced ceramics. Table 3 shows the number of jobs that general and technical (advanced) ceramics employs across the region's Local Enterprise Partnership geographies. The 7,050 advanced ceramics jobs are helping to support 176,975 jobs in sectors that use ceramics.

In Stoke-on-Trent and Staffordshire, the historical heart of the ceramics industry in the UK, there are nearly 8,000 jobs in the ceramics industry and an estimated 670 jobs in technical ceramics.

Employment concentration is an indicator of a cluster's strength. This is measured using location quotients (LQ) which summarises a sector's share of employment in an area against national employment figures for that sector.

A LQ score less than 1 means that sector has a smaller share of employment than nationally and a score greater than 1 occurs where a sector contributes a larger share to local employment. Table 3 shows both the number of employees in the Midlands and is shaded to show LQs for sectors by Local Enterprise Partnership (LEP).

Industry users of advanced ceramics are prominent in the LEP areas with above national employment levels in general manufacturing, ceramic consuming manufacturing[3] and automotive and transport manufacturing.

The region has successfully attracted large amounts of Foreign Direct Investment (FDI) in some of the region's high productivity priority sectors that use advanced ceramics. An example is Geely investment in London Taxis in Coventry for the development of electric taxis, which are dependent on improved battery technology that relies on advanced ceramics.

MICG Midlands Industrial Ceramics Group

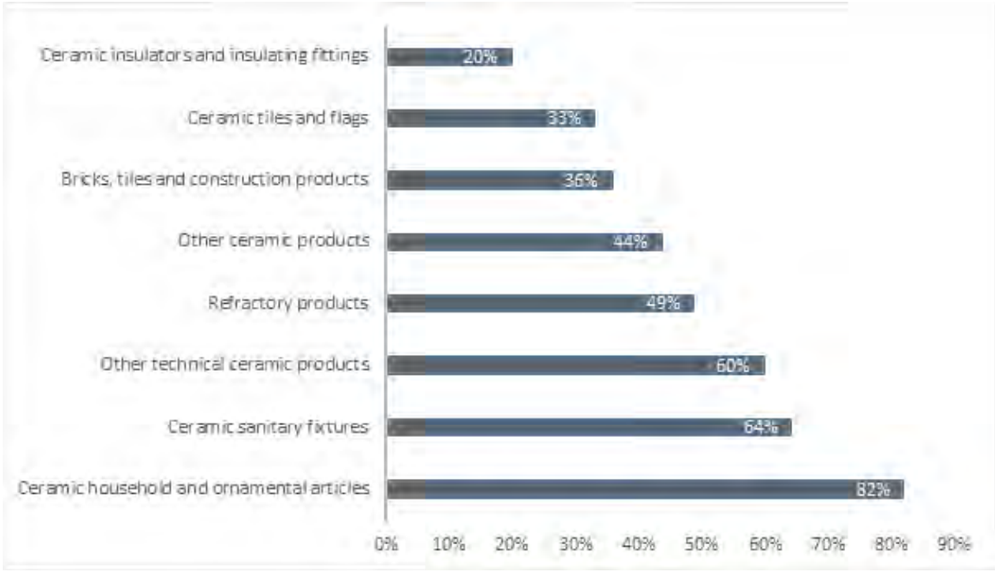
The Midlands Industrial Ceramics Group (MICG) is a collaborative partnership that draws together the advanced ceramics suppliers, users, professional services and academic base from across the Midlands. The MICG has been established to ensure advanced ceramics help drive the competitiveness and success of Midlands advanced manufacturing by tackling key innovation challenges.

Its aims are to:

- Make the Midlands the go-to location for global R&D and production of advanced ceramics
- Increase the competitiveness of the Midlands industrial base
- Enhance industrial ability to develop innovative ceramic technologies with speedy marketplace adoption
- Deliver a multi-sectoral approach with rapid translation of new technologies for the advantage of a whole range of industrial sectors
- Strengthen the UK advanced ceramics supply chain for the benefit of the Midlands' advanced manufacturing sector.

3 Ceramic Consuming Manufacturing is a composite classification of sectors we consider to be prominent consumers of advanced ceramics and includes the SIC codes: 23, 26, 27, 28, 29, and 30.

Figure 4: Midlands share of national employment in the ceramic industry (2018)



Source: ONS, (2019)

Table 3: Size of key sectors in 2018 where advanced ceramics enable product innovation (Total GVA £millions)

	General ceramics	Technical ceramics	General manufacturing	Automotive & Transport manufacturing	Ceramic consuming manufacturing
Black Country	840	375	65,000	5,000	18,200
Coventry and Warwick	1,410	650	55,000	23,500	33,100
D2N2	4,910	1,750	126,000	23,500	39,000
Greater Birmingham & Solihull	1,360	2,425	92,000	22,250	41,250
Leicester and Leicestershire	1,610	270	60,000	3,500	13,425
Stoke on Trent & Staffordshire	6,700	670	63,000	5,900	19,400
Worcestershire	270	910	34,000	3,250	12,600
Midlands	17,100	7,050	495,000	86,900	176,975
East Midlands	7,650	2,500	268,000	33,000	71,150
West Midlands	9,775	4,450	307,000	61,000	120,000
Great Britain	*49,000*	*41,000*	*2,435,000*	*293,000*	*686,000*

Key: Location quotient scores

1 or below	1.0 to 1.2	1.2 to 1.8	1.8 to 2.2	>2.2

Case Study: Lucideon

Lucideon is an independent, international materials technology company that focuses on innovation, sustainability and quality assurance of materials. It is a global company with operations in Japan, USA and the UK with its global headquarters in Stoke-on-Trent.

It is a development and commercialisation organisation (DCO), specialising in materials technologies and processes. Its application of cross-industry insight, materials science expertise and innovative thinking allows industry to develop and implement disruptive technology platforms more quickly, providing cost and / or product performance benefits and enabling real market differentiation.

In addition to a multi-disciplinary team of scientists, engineers and commercial analysts, Lucideon has world-leading testing and characterisation laboratories and a combination of pilot and feasibility plant to enable the rapid commercialisation of new products as well as a management and certification division.

Lucideon works in all markets where ceramics are applied (Healthcare, Construction, Aerospace, Energy) with expertise in a range of materials (e.g. metals, polymers), advanced technical ceramics are central to what the organisation does.

Lucideon's current advanced ceramics development work includes:

- Ceramic thermal barrier coatings for aircraft engines so that both energy and emissions are reduced by allowing metals to operate above their melting temperature.
- A world leading ceramic sintering (firing) technology that will help manufacturers to significantly reduce firing temperature and time (and thereby energy and emissions), saving energy for the world.
- Sintering of novel ceramic electrodes that could be crucial in the development of a sodium based alternative to Lithium batteries – a scarce and dangerously produced raw material.
- A ceramic-based technology to prevent the abuse of opioids and other addictive substances.

LUCIDEON

Case Study: Rolls-Royce

Rolls-Royce has invested more than £15m in R&D related to oxide ceramic composites and has 40 staff in the UK and 120 worldwide specialising in advanced ceramics. The use of advanced ceramics, such as oxide-oxide composites instead of nickel superalloys in its aerospace products provides a competitive advantage through the creation of lighter-engines.

The company faces commercial pressures in terms of its UK-based activities, including the cost of some advanced ceramic materials being higher in the UK because there is not a critical mass of other industrial users in other sectors for UK production.

There are also potential concerns around security of supply should export controls on materials with potential military uses currently sourced from North America be introduced.

A more significant challenge Rolls-Royce faces is the availability of skills it needs to incorporate advanced ceramics in its products. The proposed Advanced Ceramics Campus and services proposed by MIGC are seen as a timely intervention to address these challenges which is why Rolls-Royce is supporting the proposed MICG interventions.
If the proposal takes too long to materialise, Rolls-Royce will need to grow this activity in Germany, Singapore or North America to service its demand.

Case Study: Precision Ceramics

Precision Ceramics is a company dedicated to the engineering of technical ceramics that grew out of McGeoch Technology. It is based in Birmingham with a subsidiary in Florida. McGeoch first introduced technical ceramics into their product range when it became the principal UK distributor for Macor®, a unique glass ceramic that can be machined. It has since become the UK distributor for a wider range of advanced ceramic products which has afforded the company a detailed understanding of their technical properties and potential applications.

Technical ceramics account for half the parent company's turnover of £17m and the company's investment in R&D is significantly above the government target. It sees itself 'in the business of solving problems by creating products that meet specific needs rather than pushing specific technology' and is therefore an example of a Midlands business that supports commercialisation and the adoption of new advanced ceramic technologies by other sectors. It does this by providing its clients with solutions at the right price point across a range of sectors and the ability to produce custom units within a short time scale.

Because they provide bespoke products they do not see themselves as competing with other companies operating in advanced ceramics but competing against more established technologies. Non-lubricated advanced ceramic pistons is an example of one of their products. These help reduce contamination in food and pharmaceutical sectors from abrasion. They are also more durable helping to derive benefits associated with the circular economy (reducing replacement costs and machine down-time).

Case Study: Morgan Advanced Materials

Morgan Advanced Materials has been identified as one of the top five global companies in the advanced ceramics sector with several sites across the Midlands, including at Stourport-on-Severn and Rugby.

Morgan can trace its heritage back to the mid-19th century. It has world-leading competencies in materials science, specialist manufacturing and applications engineering. It is a diversified supplier of high performance structural ceramic material components and sub-assemblies to the semiconductor, automotive, aerospace, industrial, medical, energy, renewable and transport sectors.

Morgan's breadth of market capabilities underscores the sheer diversity of sectors in which advanced ceramics can play an important role. Morgan focuses on differentiating itself by engineering solutions to meet demanding customer-specific technical challenges and ever more stringent performance requirements, through advanced material formulations and material joining technologies.

Morgan undertakes R&D in the Midlands (including the Technical Ceramics division at Stourport-on-Severn) and at several locations in the USA.

Accessing skills in the UK is an issue that Morgan faces given that there are few specialist degrees in ceramics and where ceramics comprise only a small part of materials science degrees. To address this, and in addition to the new MICG designed undergraduate program in Materials, Morgan Advanced Materials works closely with undergraduate and postgraduate students and staff at universities such as Loughborough and Birmingham. It believes that the Advanced Ceramics Campus could be a focal point of a pipeline for skills development while helping to raise awareness of the potential of advanced ceramics amongst manufacturers and users across the supply chain.

Morgan is a founding member of the MICG and foresees the advances made through its collaborative research as having the power to enhance its own materials and manufacturing processes within the Midlands and more widely across its global business.

The Needs of Advanced Ceramics in the Midlands

The MICG came together to work collaboratively on promoting and improving the Midlands' competitiveness in advanced ceramics. It commissioned SQW and City-REDI to extensively consult key industrialists and academics in the sector, not just those based in the Midlands, but also those who have a significant presence in the sector internationally. Through this research a strong consensus on critical challenges and opportunities facing the Midlands' advanced ceramics businesses was established. Key findings were:

- **The UK is well placed to compete in this sector** – the advanced ceramics sector is specialist and global. The competitor countries are industrialised nations who compete on the quality and innovative properties in their products. The UK should be well positioned to compete, but must ensure it keeps pace, or better leads, in innovation in this sector.
- **The Midlands is the right place to focus on advanced ceramics** – those consulted understood the Midlands' strengths in this sector, and there was consensus that the Midlands would be the perfect home for national research facilities and aligned activity.
- **The speed and pace of innovation is particularly important in this sector** - in an increasingly competitive international market place the pace at which new products and processes can be brought to the market is critical. Currently the development of new advanced ceramics products is expensive and needs to follow iterative trial and error techniques. Anything that could improve the costs and speed of developing new products would significantly lower barriers of firms investing in innovation.
- **Costs of production in advanced ceramics is critical and needs to improve** – advanced ceramics can currently be expensive to produce relative to other materials. Advanced ceramics can have higher failure rates in production resulting in wastage and costs. Improved processes that lower costs would not only make the businesses that adopt these techniques more competitive, it would also result in an increase in take-up of advanced ceramics products (which would boost the performance of products across many industrial sectors owing to the higher-performing characteristics of advanced ceramics).
- **A dedicated research programme is needed** – many advanced ceramics businesses are facing common challenges associated with production costs and pace of innovation. A collaborative programme led by business, alongside the Midlands' leading Universities, would be the most effective and cost efficient means of tackling these.
- **Increasing the adoption of new technologies and techniques requires dedicated facilities and promotion** – there is currently a lag in the adoption of new techniques and products across the industry. Dedicated pilot line facilities would help speed up and de-risk this process. There is also a need to better communicate new technologies and processes across the industry to increase take-up. The MICG founding companies recognised the need for leadership and so came together to create the Group.

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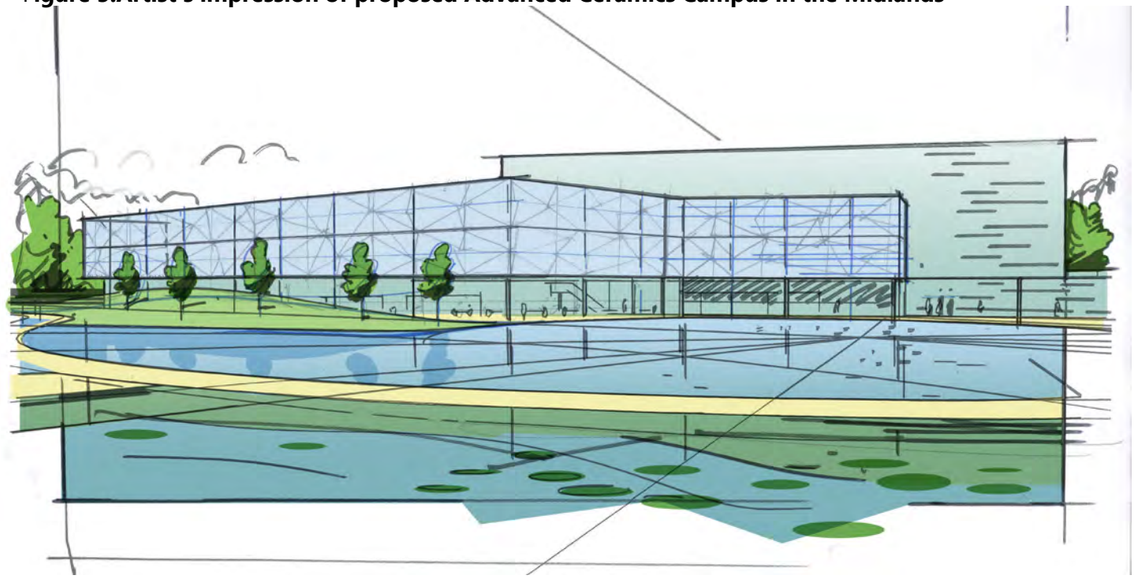
Proposals to Grow the Advanced Ceramics Sector in the Midlands

In order to capture the opportunities in advanced ceramics and respond to the challenges facing local companies the MICG and partners are working to create a holistic programme to facilitate growth. This includes:

- **MICG led collaborative R&D** – the MICG is working together on a five-year research programme that would see £30m+ of public and private investment dedicated to overcoming some of the critical challenges facing the advanced ceramics sector.
- **Commercialisation and pilot-line facilities** – Lucideon, via their subsidiary company AMRICC, is seeking to establish an R&D facility in North Staffordshire. This would provide pilot line facilities to enable the commercialisation of the innovation created in the region to be more easily pulled through by industry.
- **Advanced ceramics campus** – Partners in North Staffordshire are promoting the vision of an advanced ceramics campus, which would be the UK home for R&D in advanced ceramics as well as a commercial business park for firms wanting to expand in the Midlands. This would create over 120,000 sqft of dedicated R&D facilities and commercial floorspace in a first phase.
- **Skills development** – the MICG led R&D programme will create a legacy of skilled researchers. In addition, Lucideon is working on technical levels skills to support the sector. A degree apprenticeship in Materials Science has been approved and is being rolled out via Sheffield Hallam University and the University of Derby.
- **Promoting the Midlands** – the MICG and LEPs are working together to promote the Midlands as a destination for global investment. The ambition is for an annual symposium for the sector to be held in the region. Proactive marketing of investment opportunities across the Midlands will be put to the global sector (whilst not exclusive to these areas, the promotion is expected to highlight opportunities across Science Parks aligned to the Universities of Birmingham, Loughborough and Leicester, the Ceramic Valley Enterprise Zone and Infinity Park Derby).

Figure 5:Artist's impression of proposed Advanced Ceramics Campus in the Midlands



Benefits of Public Investment in the Advanced Ceramics Sector

The growth in advanced ceramics builds on the historic industrial strengths of the Midlands, and in particular North Staffordshire. It offers the opportunity to create highly skilled jobs across the Midlands, helping towards the UK government's ambitions of levelling up the UK economy. The investment and interventions that the MICG is proposing would have many benefits:

- **Unlocking private R&D investment** - the collaborative research programme proposed, and that requires government investment, would unlock private sector R&D investment of £40m+ over the next decade.
- **Increasing the pace and efficiency of ceramics innovation in the Midlands** - The results of the research are expected to increase the speed and lower the costs of developing new advanced ceramics products. Allowing Midlands companies to be globally competitive in developing new products in this fast-paced industry will ultimately lead to increased employment across the sector.
- **Skills legacy -** the research programme will grow a body of researchers across our academic institutions and private sector companies that will provide a legacy of skilled advanced ceramics specialists that can tackle the future challenges the industry faces, some of which are not yet known.
- **Direct employment** - investment in unlocking the advanced ceramics campus would result in the retention and creation of 400+ advanced ceramics jobs, as well as unlocking up to 1,500 other jobs on aligned developments.
- **Inward investment** - it is anticipated that the enhanced Midlands innovation base will attract further international investment as companies seek to benefit from the technical advancements and skills available in the Midlands[4].

Table 4: BCR: benefit cost ratio. SQW's quantification of the impact of the MICG proposed research programme

Impacts	Advanced Ceramics Campus	Advanced Ceramics Sector	Total
Gross jobs (FTE)	400	206	606
Net GVA (£m)	86.3	39.4	125.7
BCR on SIPF investment	4.7	2.2	6.9

4 City-REDI modelled the potential increase in GVA of demand doubling for "manufacture of other non-metallic mineral products" in the aerospace (SIC30), Medicine (SIC 21), automotive (SIC29), defence (SIC 84) and electronics (SIC 26) for the Midlands region and for the United Kingdom. The impact would be an additional £2,142m GVA at the national level and £426m at the regional level per annum based on 2018 GVA figures. This shows the enormous potential for the regional and wider UK economy if the advanced ceramics industry is supported to grow.

Quantifying the Impact

Each separate intervention proposed will require its own detailed business case that quantifies the impact and costs. For the MICG research programme business case (the subject of the SIPF funding bid), SQW estimated 600+ jobs would be created or safeguarded and an additional £125 million of gross value added in the Midlands would be created, resulting in a return on public sector investment of nearly £7 for every £1 spent. It can be clearly evidenced there is a strong return on the targeted government investments into advanced ceramics. The growth of advanced ceramics in itself will have spill over impacts on the wider economy.

In City-REDI's consultations, advanced ceramics manufacturers emphasised that improving their productivity and competitiveness would lead to knock-on improvements for their customers, many of whom are Midlands based manufacturers.

Using City-REDI's own input-output economic model it is estimated that a doubling in size of the UK's consumption of advanced ceramics sector would lead to a per annum increase in GVA of £2.1 billion across the UK and £0.4 billion in the Midlands.

The conclusions of this sector summary are that advanced ceramics are increasingly important for improving product performance across a wide spectrum of advanced manufacturing sectors. The growth in their use offers a global opportunity for the UK to innovate and sell new products. Within the UK, the Midlands is especially well positioned to do this due to its ceramics legacy, prominent advanced manufacturing base and the strength of its academic institutions. There are key challenges to overcome to accelerate the Midlands' development in this sector. Led by industry the MICG is working together to address these and is seeking government and investor support to make it happen.

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