EBOOK

Advanced Materials and Applications:

Tackling New R&D and Engineering Challenges

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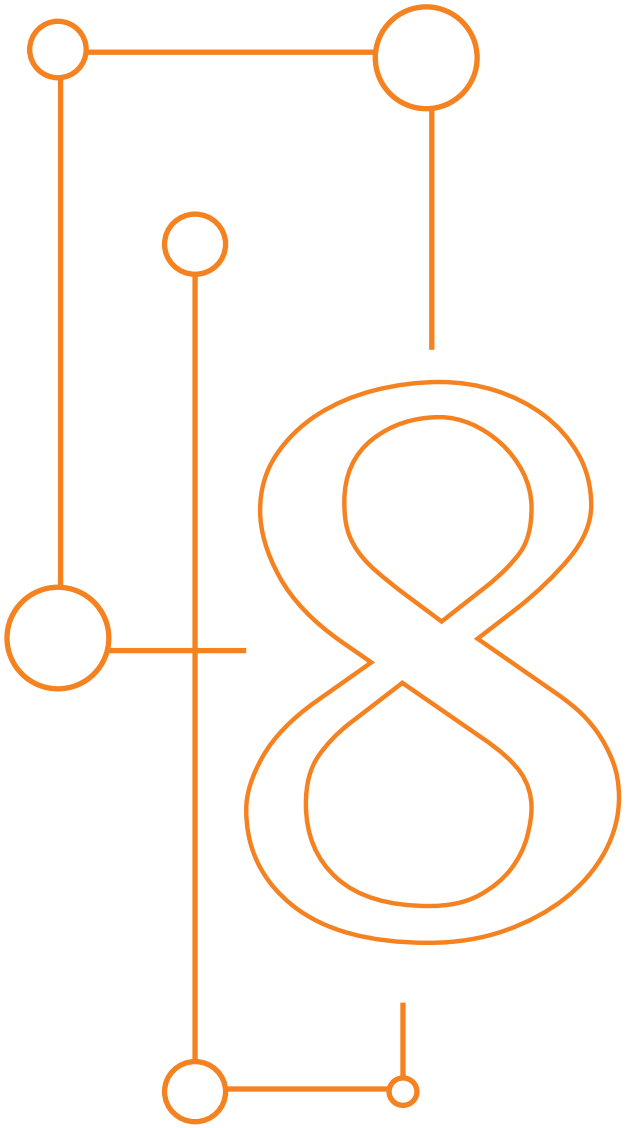
INTRODUCTION

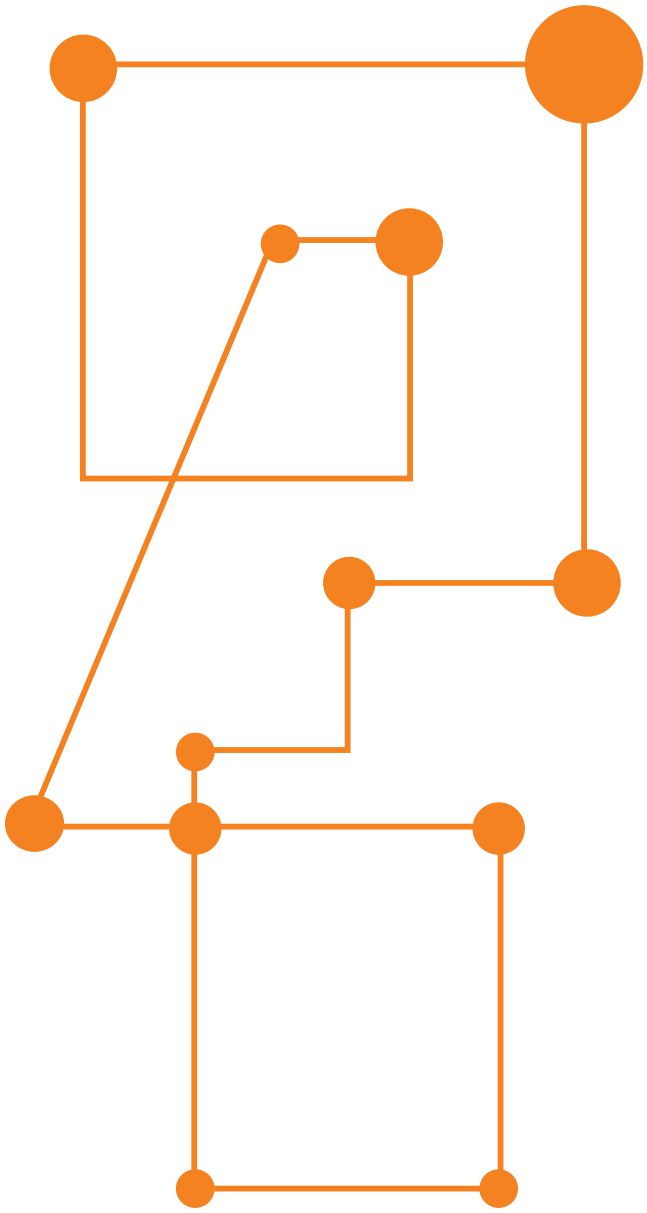
Like composites to the Boeing Dreamliner or Gorilla Glass to the Smartphone, the application of an advanced material may be the key to revolutionizing a product line. But, if you are an engineer or researcher, how do you keep pace with accelerated market change and technology developments? How can companies ensure that new concepts become commercial successes? This e-book presents key insights to consider when kick starting R&D and engineering initiatives involving advanced materials and applications.



Faster, Stronger and More Sustainable

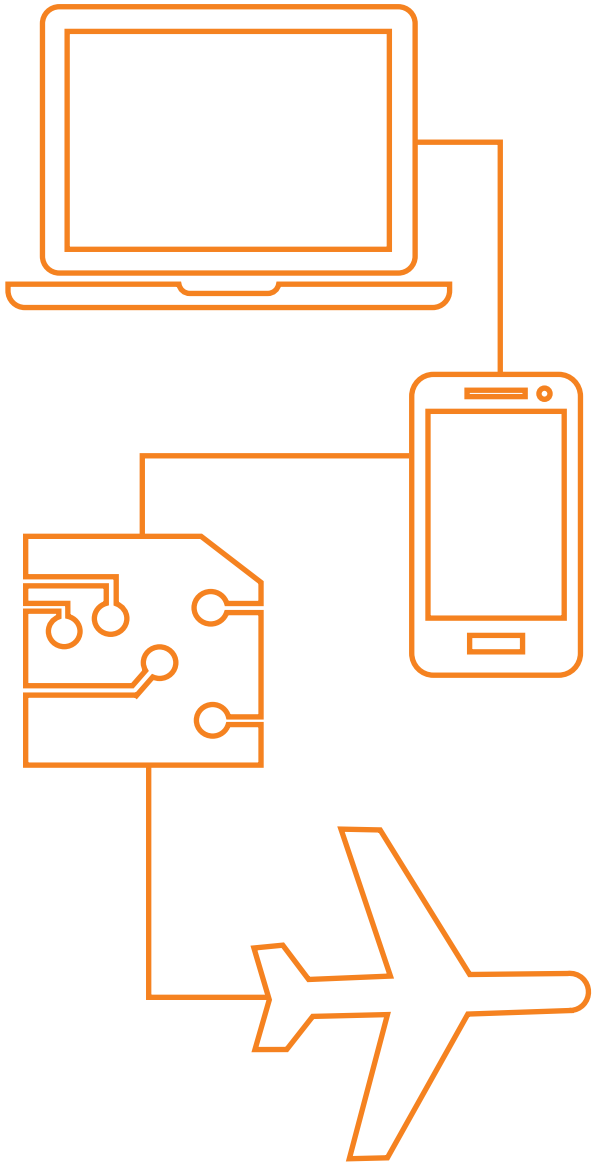
ADVANCED MATERIALS are revolutionizing the way companies do business and demanding that R&D and engineering teams keep up. **At any given time, a company or its competitors may launch a new material or application that unlocks revenue potential and market share, meets unmet customer needs, achieves profitability goals or satisfies sustainability and regulatory requirements.**

Differentiation can be achieved from the molecular level and up—as new materials utilize the research community's understanding of chemical compound structures and other properties, and can be used to improve product performance, capability and efficiency of production processes.



The potential for R&D and engineering advancements to make an impact is limitless, and accelerating technology developments require that companies constantly pay attention. For instance:

- Companies can now incorporate advanced materials into thermoplastics that can be used to build fully functional product components using 3-D printers. Small production runs of these components can either be sold directly to customers or further developed to leverage in manufacturing customized, differentiated products at scale.
- Polymer matrix composites offer manufacturers the opportunity to create lighter, stronger and more corrosion resistant products—improving conductivity and durability of products and ultimately positively impacting manufacturing and commercial success.
- Graphene, with its extraordinary and unique combination of properties, offers significant potential applications in the field of electronics, aerospace, automotive, coatings and paints, energy storage and more.



2.

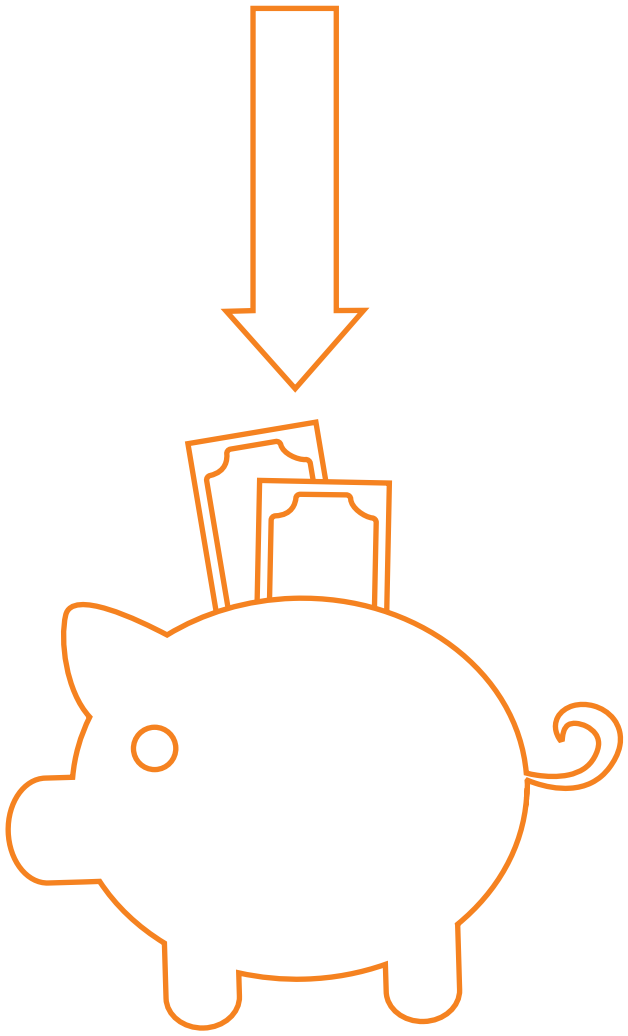
Long-term Success and Profitability

THERE ARE MANY REASONS why companies focus on advanced materials development or applications. Some common examples:

Reduced costs and increased profitability. Advanced materials that are stronger, lighter and more durable will last longer and save money on replacing parts or can compensate for operational and manufacturing challenges unsolved by relatively less functional materials.

Increased customer satisfaction and loyalty. Because of their inherently improved properties, advanced materials can lead to final products that better fulfill customer requirements and contain fewer defects, which will translate into increased competitiveness.

Regulatory compliance and sustainability. Newer and more stringent regulations are making manufacturing and production more and more arduous. Using advanced materials should help companies comply with regulations without sacrificing performance objectives.

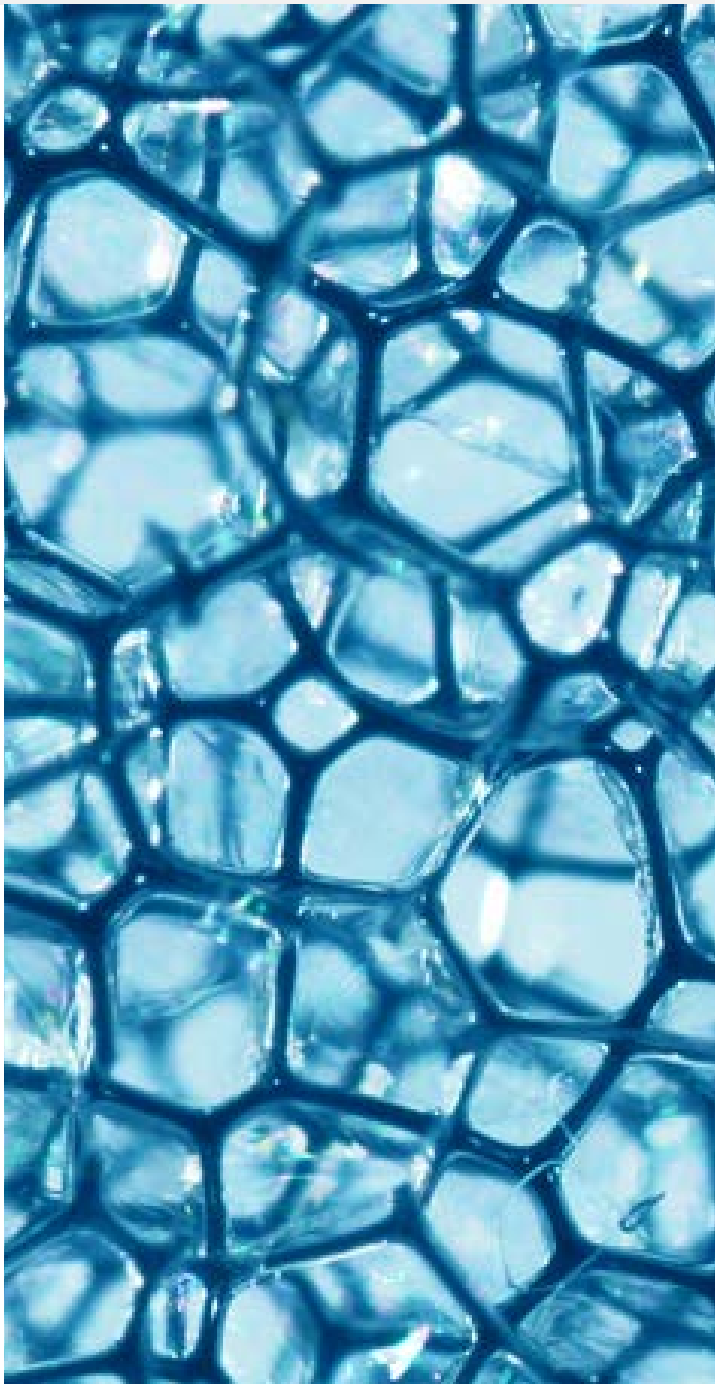


3.

A Worthy Investment

WHEN PROPERLY APPLIED, the successful synthesis, use and commercialization of advanced materials can help us tackle humanity's grand challenges and even improve the human condition.

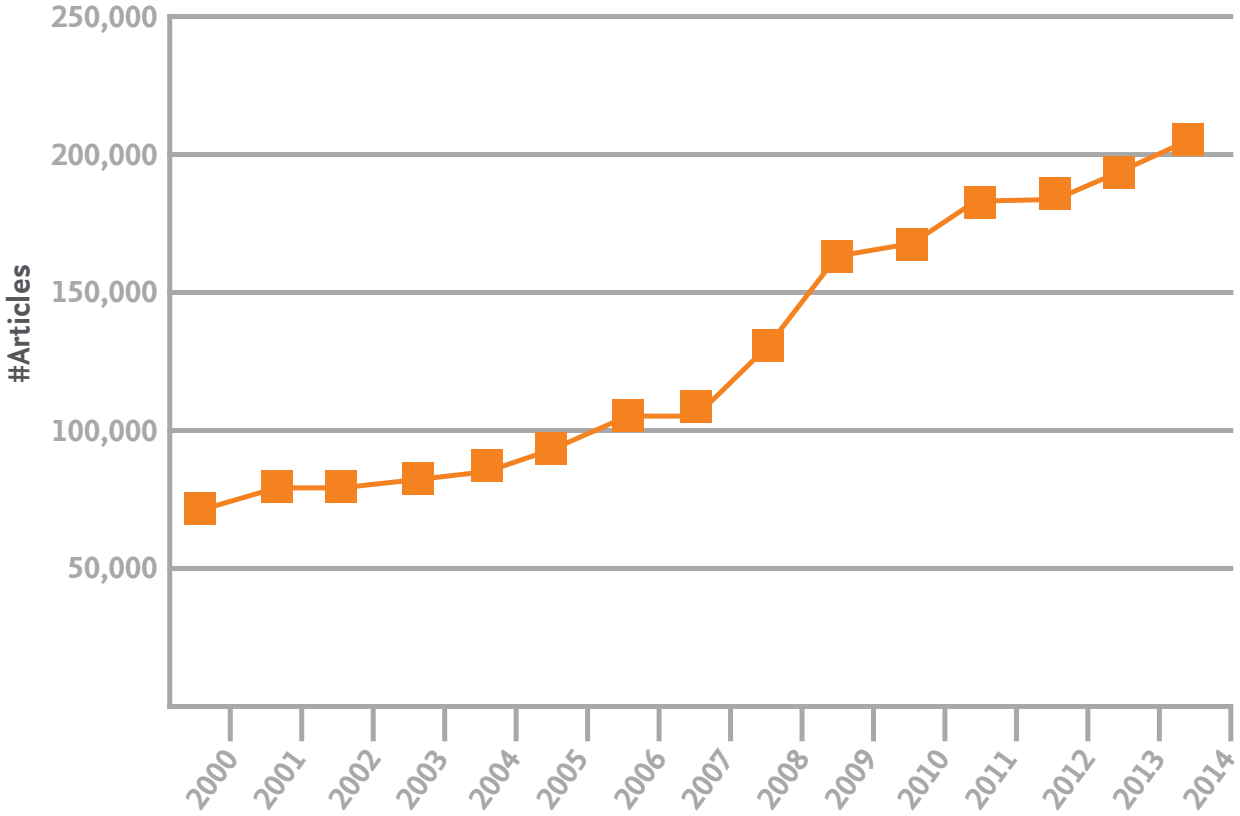
On a global scale, substantial evidence in recent years shows that both public and private organizations are willing to invest in this area and are dedicating resources to research and develop new materials that produce and commercialize better finished products.



Inside the Advanced Materials Explosion:

Global research output is increasing in materials science, showing a 140% growth from 2004 to 2014

COUNTRY	INCREASE	2014 ARTICLES
China	360%	64470
USA	112%	28947
India	260%	12536
Japan	15%	122279
Germany	76%	11869

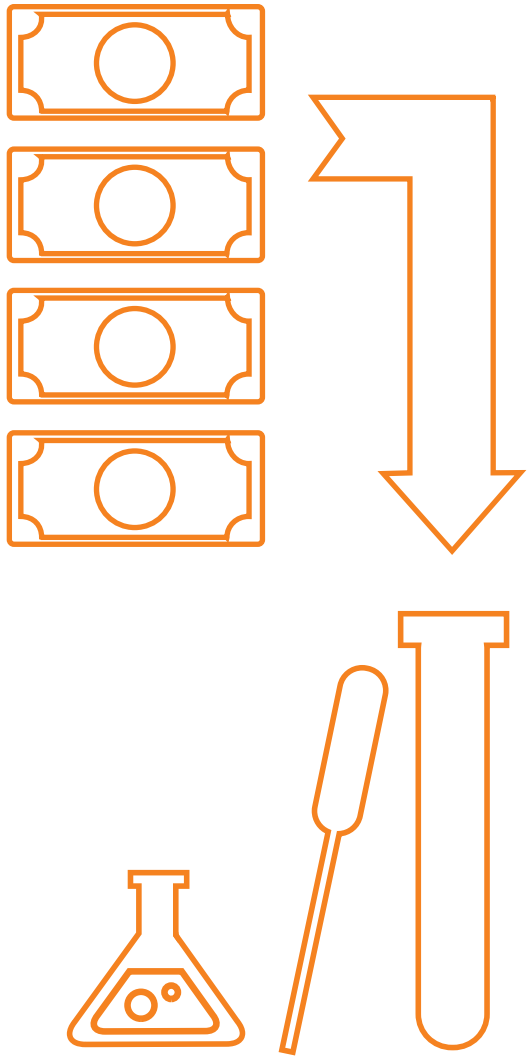


Source: Dr. Stewart Bland, Senior Publisher and Editor of Materials Today. Data derived from Scopus.

Investment in New Materials Research

In 2013, the Graphene Flagship, the EU's largest research initiative in history, launched with a budget of 1 billion euros. The initiative brings together academic and industrial researchers to take graphene from the realm of academic laboratories into European society within this decade.

In October 2014, this movement received further support from the U.S. government, when President Barack Obama announced a $300 million investment in emerging technology. Much of this funding went to the Departments of Defense, Energy and Agriculture, along with NASA, to invest in bio-based materials, advanced sensors and digital manufacturing.



4.

Tackling Key Challenges

WHILE THE USE OF ADVANCED MATERIALS offers a wide variety of potential benefits, there are still operational and development roadblocks that the industry must overcome.

Some key questions remain unanswered:

1. How can researchers, scientists and engineers uncover the data they need to innovate and problem-solve quickly and efficiently?

2. How will companies better ensure that their new products and applications are commercially viable?

3. How can business leaders ensure that they are tackling the transition of a new material or application from concept to manufacturing effectively, to meet customer, production and profitability goals?

5.

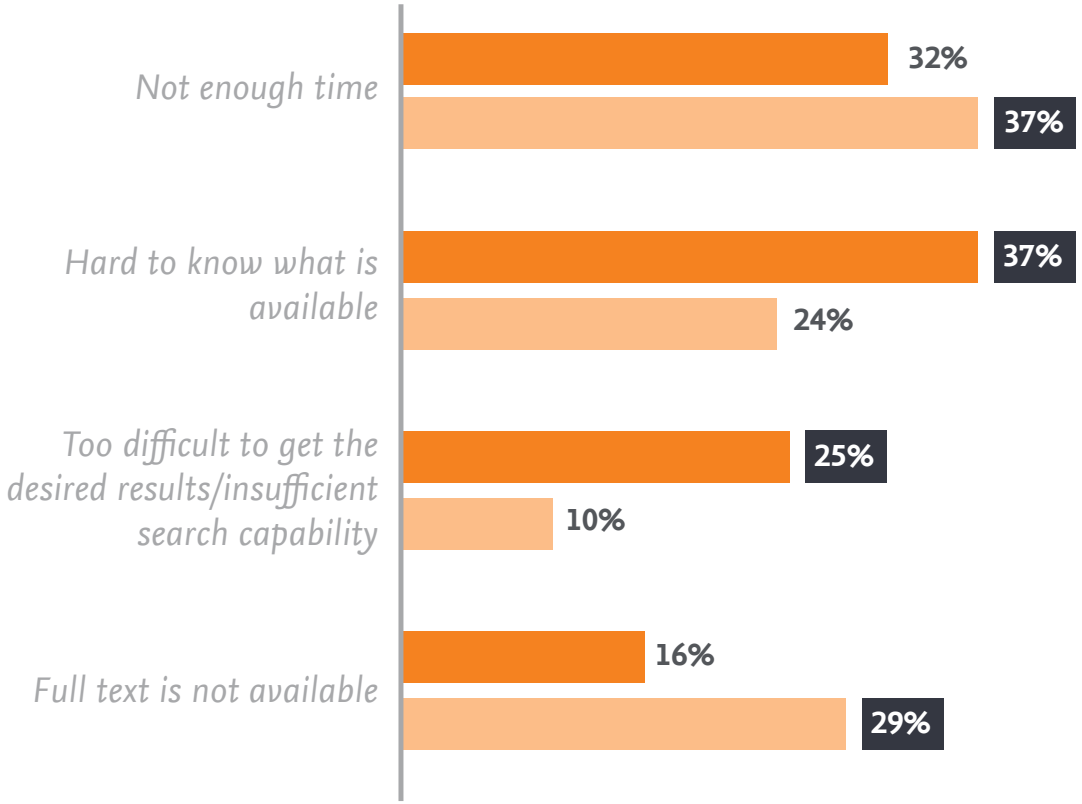
Fueling Innovation With Insights

R&D AND ENGINEERING TEAMS encounter numerous problems when taking proofs of concept for advanced materials and applications, and attempting to manufacture them at scale and commercialize. One such challenge involves accessing reliable data at the right time, for ensuring the technical feasibility of a new material or application through the stages of the development and manufacturing process.

Lack of sufficient ways to garner insights from data is a common issue for scientists and engineers. A late 2013 study conducted by Outsell of 200 scientists and engineers revealed that not having enough time, not knowing what is available, insufficient platforms and lack of access to full text literature are major problems and obstacles when garnering information for their work.

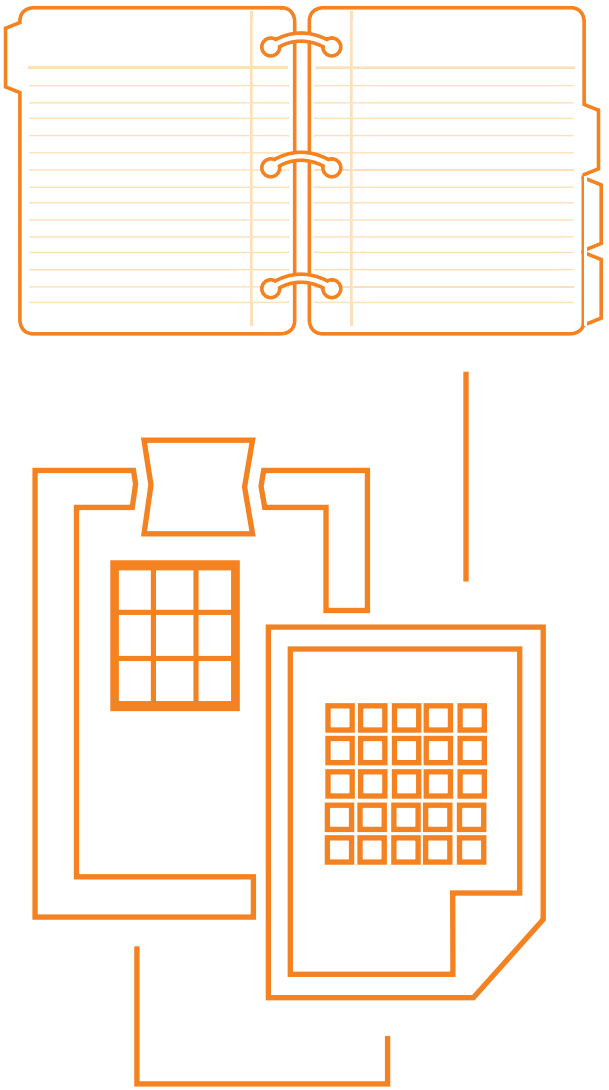
Smarter data analysis processes and content databases are crucial in enabling R&D and engineering teams. For example, there is an exponentially increasing body of knowledge that is growing from the exponentially increasing pool of known materials and compounds. Much of this data is in publications, databases, notebooks and spreadsheets--and must be linked, integrated and made accessible to scientists and engineers.

Problems and Obstacles for Engineers and Scientists



Q20. [Ask to All]: In general, which of the following factors do you consider to be the three major problems or obstacles to getting the information you need to do your work? Base: Engineers (n=100). Scientists (n=100). Source: Outsell's End-User Study 2013.

This need for uncovering insights from unstructured data is also echoed more broadly beyond industry, as can be seen from broad initiatives like the U.S. government's Materials Genome Initiative, which aims to *"create a new era of policy, resources, and infrastructure that support US institutions in the effort to discover, manufacture, and deploy advanced materials twice as fast and at a fraction of the cost."*



Having **a clear strategy for how data is made accessible, discoverable and usable** for R&D and engineering teams can significantly help companies more easily and quickly determine the manufacturability and economic feasibility of their new products and applications. A sound and systematic data management strategy impacts important levers such as testing time and speed to market, employee productivity and product quality.

6.

Putting Customer Value First

STRATEGIC COMMERCIALIZATION has become a key focal point and challenge, especially as many new product and application ideas can fail without adequate market demand. Commercial viability requires effectively integrating market needs with R&D and engineering throughout the development process.

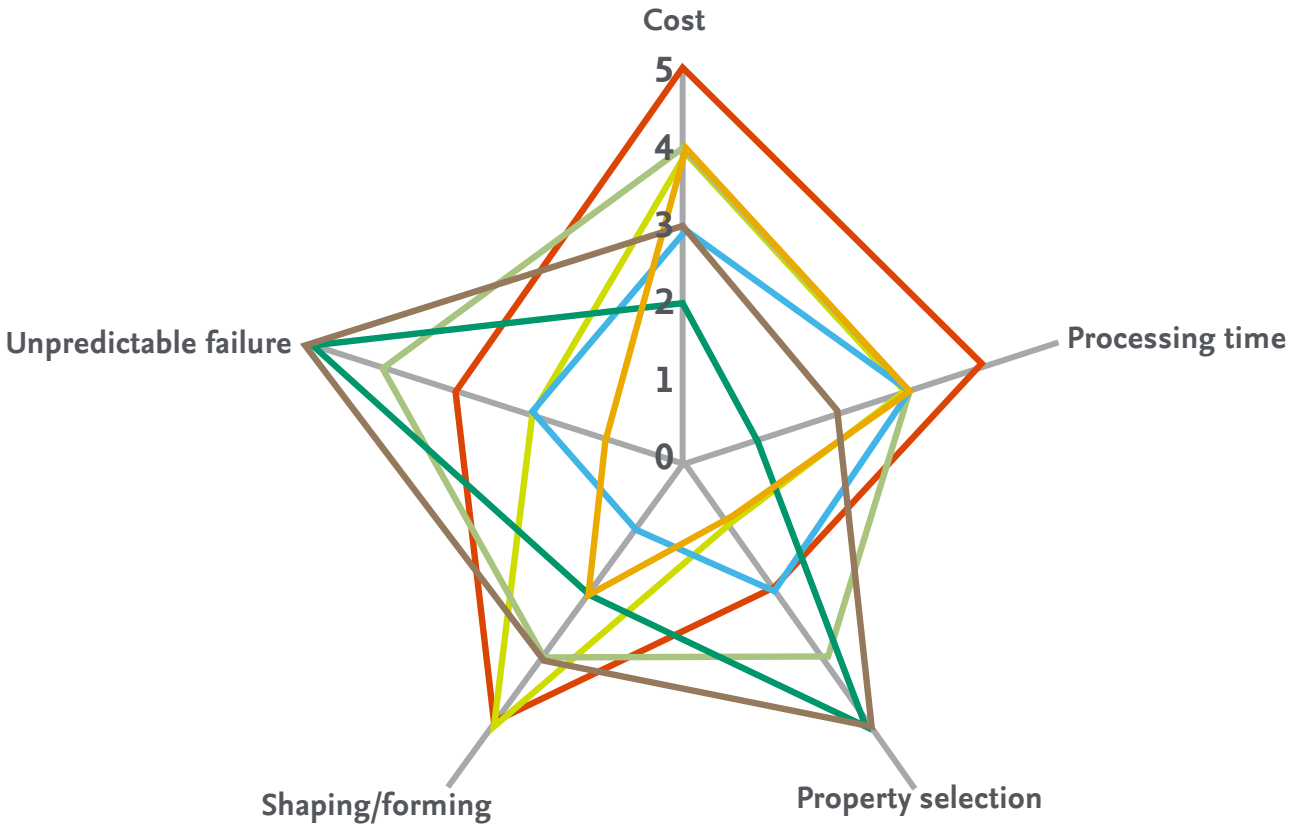
According to a McKinsey and Company article from 2012 entitled "The path to improved returns in materials commercialization," the most successful commercialization project leaders approach this challenge differently than others, digging deeper into the value proposition of their products and adapting strategic processes to select the markets they pursue. A practical example of this effort is a tactic known as "strategic segmentation"—a structured process in

which technical experts and strategic marketers collaborate to find the best possible market for a new material. This can potentially turn a mere idea into a major commercial success.

Another way to tackle commercial viability is to understand what particular commercial challenges with a new material or application are ripe for development and manufacturing challenges. For example, an article by Lux Researcher analyzes the various demands on Ceramics by industry and reveals several areas where small changes could have major disruptive impacts in the market. Enterprises that solve barriers to commercialization such as cost, processing time, unpredictable failure, shaping/forming capabilities and property selection challenges with Structural Ceramics stand to gain significant market success.

This can potentially turn a mere idea into a major commercial success.

Analyzing Challenges Reveals Diverse Areas for Disruption



Source: Machinedesign.com

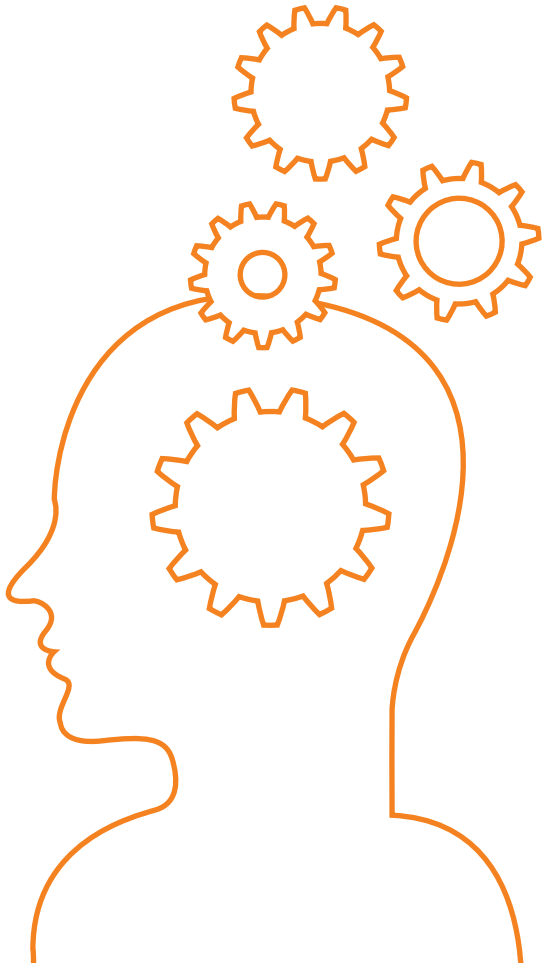
Analysis by Lux Researcher into the various demands being placed on ceramics by industries shows several areas where small changes could have major disruptive impacts.

7.

Harnessing Expertise for Technical Feasibility

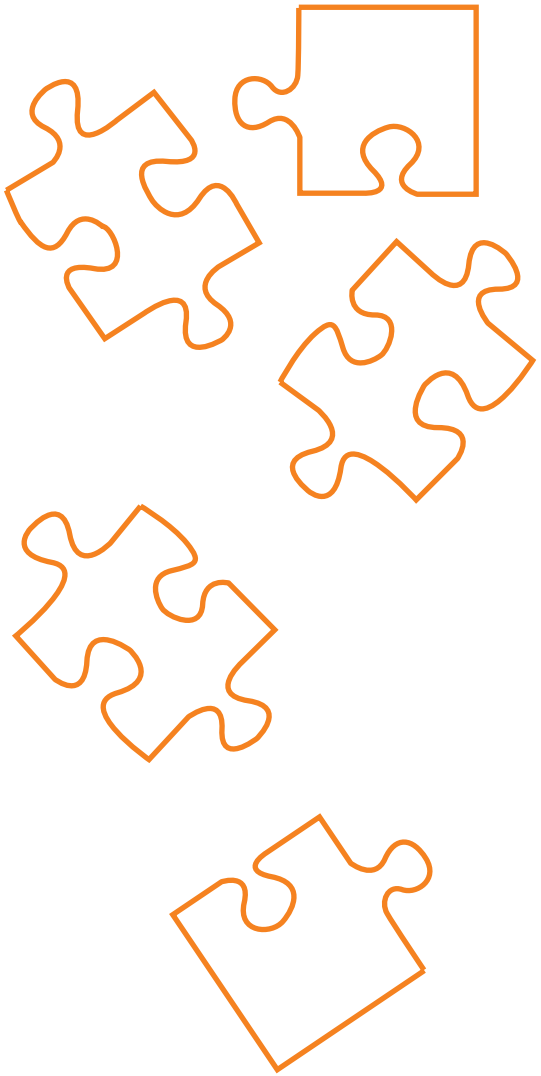
INDUSTRY IS EAGER TO TAP into the potential of advanced materials but driving technical feasibility from concept to market is complex. Proper due diligence from concept to manufacturing is a must.

To achieve success, companies must be able to **tap into a combination of in-house and external R&D and engineering experts** who collectively represent an understanding of cutting-edge advanced materials research, the know-how to design and build solutions, best practices on running and maintaining operations, experience manage teams and businesses, and skills to engage with customers and internal stakeholders.



In this context, industry groups that leverage and partner with bright academic minds and experienced professionals who can develop cutting-edge technologies in relevant materials and science engineering fields are at a competitive advantage. In particular, it is vital that R&D and

engineering team leaders pay attention to what is going on in the academic community and encourage their scientists and engineers to do the same. This can be done through **formal collaboration projects or even informal research and networking** through access to research databases and platforms and attending conferences and webinars.



An excellent example of a formal collaboration project can be found in the joint development agreement between the University of Manchester, where graphene was first discovered, and Morgan Advanced Materials, a company that has 150 years of carbon processing experience. The result is a mutually-beneficial partnership that explores the full commercial potential of graphene, with particular focus on key areas such as **optimizing the relationship between the manufacturing process and materials science** behind the super material.

What's Next for Advanced Materials?

ACCORDING TO THE EMERGING TECHNOLOGIES AWARENESS COMMITTEE (ETAC) at ASM International, a survey of 300 ASM member respondents identified a number of materials-related technologies and process-related developments that members believed will significantly impact the world of materials science and engineering in the future.

Emerging Technology Awareness Committee Survey

Surveyed several hundred ASM members:

- **3 *materials-related technologies* expected to have significant impact**
- **3 *process-related developments* expected to have significant impact**

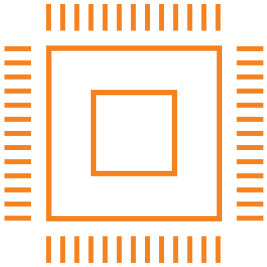
Category	Topics	% of categorized responses
High-Perform	Light weight, high strength, high temp	22%
Energy	Energy materials: fuel cells, batteries, solar PV	17%
Additive	Additive manufacturing, 3D printing	13%
Nano	Nanomaterials, nanomanufacturing	12%
ICME	ICME and computational modeling	9%
BIO	Biomedical or bio-based materials	6%
SMART	Smart or multifunctional materials	5%
ENVIRON	Materials for recovery/reuse or substitution	5%
SURFACE	Surface coatings, surface engineering	5%
METALWORK	Metals processing technologies	4%
JOIN	Welding, joining	3%

Journal publications also offer a good window into materials science and engineering trends and rapidly growing areas of interest and technology development. Dr. Stewart Bland, Senior Publisher and Editor of Materials Today, also flags a few important materials-related technologies to watch, based on what he is seeing in research trends:

What to Watch?

Energy storage and generation

Next generation Li based batteries
Hydrogen storage
Photovoltaics



Electronics

Two-dimensional materials
Organic electronics
Spintronics
Plasmonics

Biomaterials

Regenerative medicine
Drug delivery
Imaging

As advanced materials continue to pave the way for revolutionizing business processes, companies must likewise adapt innovation, development and manufacturing processes. New lessons learned and opportunities will undoubtedly arise—and the most successful enterprises will be those that are able to help their R&D and engineering experts **recognize and harness the right insights, expertise, processes and resources** to support successful development and commercialization.

To learn more about trends, challenges and opportunities impacting the world of chemicals and materials, visit: elsevier.com/createwhatsnext

materialstoday
Connecting the materials community