Imperial College London

Institute for Molecular Science and Engineering

Briefing Note – summary of Briefing Paper No 2 September 2017

The value of additive manufacturing: future opportunities

Read the full paper: http://hdl.handle.net/10044/1/53611

Executive summary

- Additive manufacturing (AM), popularly known as '3D printing', is an umbrella term for techniques in which three-dimensional objects are built from sequential layers of material. There are a number of different existing AM methods that can be used with a range of materials to fabricate a multitude of products (Table 1).
- The global AM industry was valued at $6 billion for 2016, and is predicted to grow to more than $26 billion by 2022.
- AM has evolved from a prototyping tool to an end-product fabrication method in some commercial high-value manufacturing applications, including in the aerospace, medical device and automotive industries.
- Relative to traditional manufacturing approaches, AM can decrease production costs and times, offer flexible and bespoke production, and reduce energy usage and waste. This requires improved design software, faster printing technology, increased automation and better industry standards.
- AM research breakthroughs will require involvement of a wider range of scientific and engineering expertise, as well as a closer working relationship between academia and industry. The concept of molecular science and engineering provides an excellent framework for 'cross pollination' of research ideas, optimisation of the route to functional end-use products, and transdisciplinary training of scientists and engineers to address the current AM skills gap in industrial settings.
- Imperial College London's portfolio of AM-based research is varied and encompasses problems across the entire design-to-end-use-product chain.
- Ongoing AM research will be of benefit to a range of additional disciplines (e.g., quantum technology and photonics) and will play a critical role in tackling many societal challenges.

What is the UK's position in the global AM market?

The UK is at the forefront of AM technological advancements. The UK has a strong foundation of companies who apply AM in prototyping and tooling. Researchers in the UK are leading the transition of AM to the production of end-use parts, and contributing to commercial success at Rolls-Royce, GSK, GKN and HiETA. The UK's nascent AM supply chain also includes some of the world's leading AM machine, material, part and technology suppliers, as well as software developers, e.g., Renishaw and LPW Technology.

Major challenges to AM progression

- high cost (purchase, operation, maintenance and depreciation) of AM machines and materials
- the need for faster operating speeds, better resolution and accuracy, larger build volumes, as well as more-optimized loading and unloading procedures
- the lack of consistency and maturity in quality assurance practices
- design tools (e.g., software) that do not adequately exploit the full potential of AM
- a general scarcity of suitably trained personnel working in AM
- inadequate IP protection and security procedures.

Imperial College London

Institute for Molecular Science and Engineering

The UK's growing AM research landscape

Public funding for AM research in the UK rose from £8 million in 2007 to almost £55 million in 2016. The majority of this funding comes from general Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK programmes. Several cross-community AM-related initiatives have been set up, including:

- The EPSRC Centre for Innovative Manufacturing in Additive Manufacturing (2012–2017)
- The High Value Manufacturing (HVM) Catapult
- The National Centre for Net Shape and Additive Manufacturing at the Manufacturing Technology Centre. The Centre is the focal point for AM innovation within the HVM Catapult.
- Manufacture using Advanced Powder Processes (MAPP)
- Additive Manufacturing UK (AM-UK).

AM has also recently been recognised as an integral part of the UK's Industrial Strategy and will undoubtedly play a critical role in meeting the six named Industrial Strategy Challenge Fund challenges.

AM research at the junction with molecular science and engineering

Major AM science and engineering needs can be addressed through the molecular science and engineering approach. This brings scientists together with engineers (i.e., those focused on fundamental research and on industrial-scale end-use products and solutions, respectively) at all stages along the AM-process chain, including relevant input from industrial partners. This will achieve a faster and more cost-efficient route from research concept to industrial application, recognising and rectifying potential late-stage and expensive pitfalls early in the lifetime of a project. Examples of molecular science and engineering in AM at Imperial include:

- Dr Ajit Panesar (Aeronautics) developed a design framework for combining gradients of single or multiple materials, so that electronic, electromagnetic, optical, fluidic, actuation, chemical or thermal features of the material are embedded as part of the 3D printing process (multifunctional AM).
- Dr Minh-Son Pham (Materials) examined the process–microstructure–performance relationship of 3D-printed stainless steel, which helps to explain its outstanding mechanical properties.
- Dr Billy Wu (Design Engineering) and Professor Nigel Brandon (Earth Science and Engineering) developed a novel strategy for electrochemical AM for metals using a meniscus-confined electrode.
- Professor Julian Jones (Materials) and colleagues at Reading and Nottingham produced a novel series of biocompatible polymer systems that are capable of self-assembly into infinite networks. These have the complex pore structures for biomedical scaffolds in regenerative medicine.

Imperial College London

Institute for Molecular Science and Engineering

AM at Imperial College London

Imperial College London is a science-based institution consistently rated amongst the world's best universities. Imperial is investing in AM facilities around College, including the Additive Manufacturing Network, the Imperial College Advanced Hackspace and the Invention Rooms. Other ongoing AM work at Imperial College London includes:

- Professor Stepan Lucyszyn (Electrical and Electronic Engineering) are using novel 3D printing techniques to produce inexpensive high-precision THz-frequency waveguides for communications applications.
- Dr Mirko Kovac (Aeronautics) leads the ESPRC-funded Aerial Additive Building Manufacturing project which is developing autonomous 3D printing of building structures by aerial robots.

Contact us

Billy Wu and Dr Connor Myant, co-directors of the Additive Manufacturing Network

Further information and contact: imse@imperial.ac.uk