BSGN Advanced Materials Accelerator

Your route for new materials development in space

Key theme: Polymers

Polymers make up the foundation of the advanced materials sector and are considered as critical innovation drivers in diverse systems in different applications. Their long chain structures and unique molecular architecture make them distinct from metals and ceramics and provide them with a very wide range of properties.

Polymers are an ever evolving material class,with advances in performance and application. Polymers are often integrated into space systems such as rockets, vehicles, thermal blankets, coatings, adhesives, seals, as well as structural systems etc. Space and microgravity offers a unique opportunity to control and or tailor the microstructure of polymers leading to production of materials which would not otherwise be possible. Microgravity R&D leads to advantages for companies to develop products with characteristics otherwise unobtainable terrestrially.

Applications:

- space habitation
- space construction
- transportation
- insulation
- protective garments
- aerospace components
- flexible electronics
- long-duration space exploration missions
- in-situ resource utilisation

Opportunity 1 (Click here for more info)

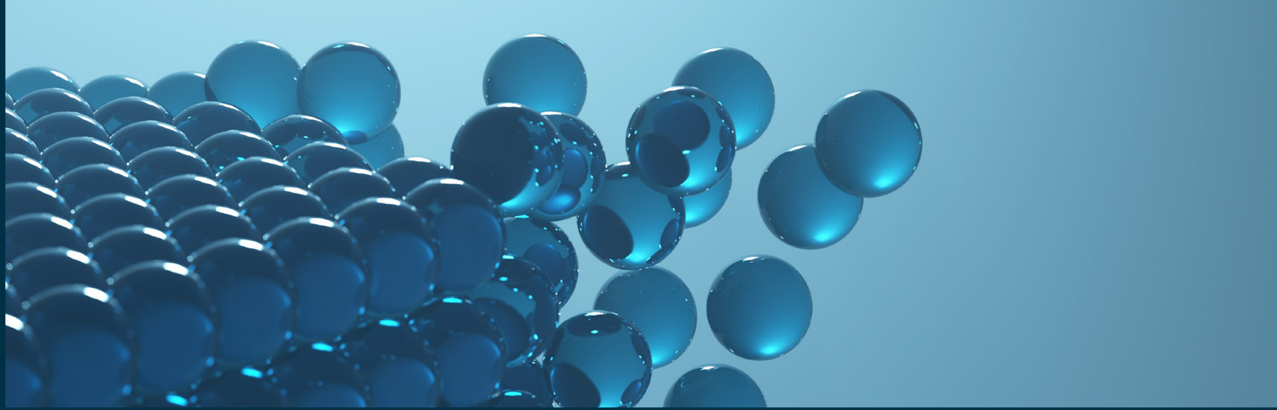
In-space additive manufacturing offers the opportunity to leverage the 3D printing of polymer-based large structures as well as the exploration of new polymer inks and feedstocks. The lack of convection in microgravity provides an opportunity to improve directional solidification and microstructure of polymer systems, resulting in new formulations with new functionalities and properties.

Opportunity 2 (Click here for more info)

A polymer foam is essentially a polymer-and-gas mixture, which has a microcellular structure. **Polymer foams** are used mainly for their low weight, cost efficiency, thermal and acoustic insulation, mechanical and shock absorption properties. On Earth, foams are quite susceptible to influences from buoyancy. Microgravity enables examination of the microstructures of foams and emulsions due to the elimination of the influence of gravity-related factors such as buoyancy of particles.

Polymers Opportunities:

1. In-space additive manufacturing



1. Market opportunity

3D printing of polymer-based large structures and exploration of new polymer inks and feedstocks

2. Why space is of benefit

Advantages of in-space R&D manufacturing with polymers:

• In-space R&D and manufacturing offers the opportunity to manufacture larger and more complex 3D printed structures.
• Microgravity additive manufacturing opens up new material options such as soft materials (e.g., elastomers, foams, and rubbers), low-viscosity inks, new polymer options
• To use novel processes such as multi-axis printing technologies that enable the fabrication of large, sparse structures that are challenging to produce on Earth.

Opportunities to explore new polymer formulations in space:

• In microgravity, thermoset materials retain their shape longer without slumping, eliminating the need for rapid-cure materials. The slower curation could result in improved materials or open the door to new thermosets not otherwise possible for additive manufacturing.
• In microgravity, viscosity is no longer the driving parameter, reducing issues involving sedimentation and improving the shelf life of polymers for ink-based printing.
• Evaluate the effects of the low-Earth orbit environment on different formulations of polymers/co-polymers.

3. Previous experiments in space/successful case studies

• Mitsubishi Electric is Enabling Freeform 3D Printing of Satellites in Outer Space

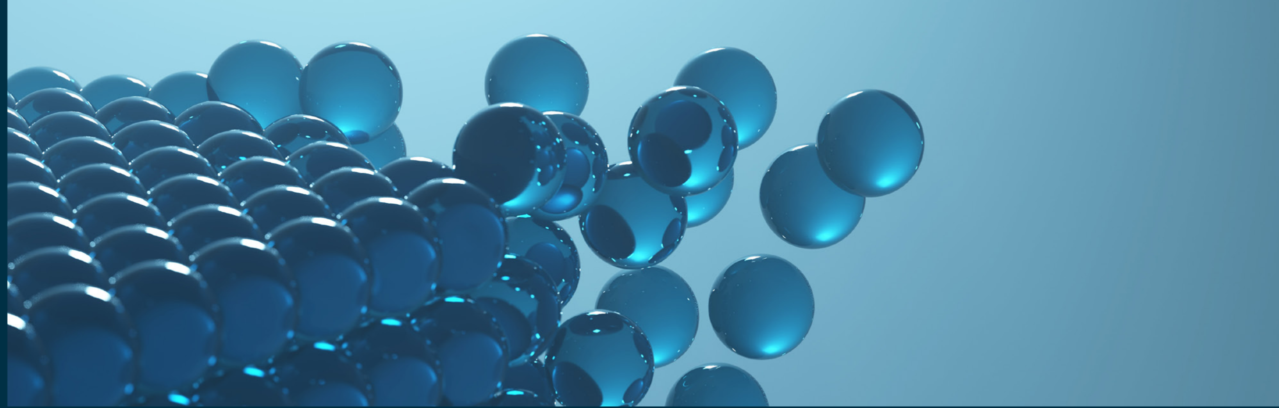
• Two Years on the ISS: Additive Manufacturing Facility Celebrates Nearly 100 3D Printed Parts.

4. Applications

• Aerospace components
• Flexible electronics
• Space habitation
• Long-duration space exploration missions
• In-situ resource utilisation.

Polymers Opportunities:

2. Microgravity processing of polymer foams



1. Market opportunity

A polymer foam is essentially a polymer-and-gas mixture, which has a microcellular structure. Depending on the cell geometry, open or closed, polymer foams can be flexible or rigid.

Polymer foams are used mainly for their low weight, cost efficiency, thermal and acoustic insulation, mechanical and shock absorption properties.

Nano-modification of foams where nanoparticles are introduced as nucleating agents in the polymer matrix, are effective in improving the mechanical, physical, and chemical properties of polymer foams. Graphene and carbon nanotube reinforced polymers represent opportunities for the development of light-weight foams with high electrical conductivity.

2. Why space is of benefit

On Earth, foams are quite susceptible to influences from buoyancy. The mixture of gas and liquid that make up a foam can undergo drainage; as the liquid is drawn downwards due to gravity, the bubbles lose their strength and rupture, collapsing back to a liquid state.

In the weightlessness of space, foams are more stable as the liquid does not drain to the bottom. Microgravity enables examination of the microstructures of foams and emulsions due to the elimination of the influence of gravity-related factors such as buoyancy of particles.

Because morphology-disturbing effects such as drainage and coalescence of bubbles can be eliminated, an examination of other effects during foaming, e.g. driven by surface tension or by external magnetic and electrical fields can be examined.

Polyurethane foams formed in a microgravity have near perfect structures. The resulting structures provide the potential for the preparation of lightweight structures in space for use in space.

The current limits for isolation materials are given by the well-known aerogel structures. To go beyond this limit, low gravity will allow a new era in the control of foam porosity, giving the opportunity to explore new impossible morphologies and thus unexpected properties.

3. Previous experiments in space/successful case studies

- Multifunctional Graphene Nanocomposite Foams for Space Applications
- Noble-gas-infused neoprene closed-cell foams achieving ultra-low thermal conductivity fabrics

4. Applications

Application areas are very broad for polymer foams:

- Transportation
- Construction
- Automotive components
- Bedding
- Acoustic insulation
- Sport
- Thermal insulation
- Biomedical
- Space habitation/construction
- Wearable fabrics/protective garments.

The BSGN Advanced Materials Accelerator Call for Proposals is now open. Apply by 30 Nov 2022.

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About the BSGN Advanced Materials Accelerator
The BSGN Advanced Materials Accelerator has been established to support innovators and enterprises developing new products, technologies, and services at the intersection of advanced materials and microgravity engineering. The accelerator promotes opportunities for engineering novel materials in microgravity, and the contract is carried out under the BSGN programme of and funded by ESA, the European Space Agency.
The accelerator is coordinated by the Satellite Applications Catapult in collaboration with Innovate UK KTN, the National Composites Centre (NCC), the Technological Institute of Plastics (AIMPLAS), the DLR Institute of Material Research (DLR) and the Centre for Process Innovation (CPI). Learn more about BSGN here.

For inquiries, please get in touch at BSGNmaterials@sa.catapult.org.uk.

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