BSGN Advanced Materials Accelerator

Your route for new materials development in space

Key theme: Thin Films and Coatings

Advanced functional coating and thin film systems play a vital role in performance, durability, and service life of critical applications in both space and Earth.

Furthermore, growing uptake of new composite & thermoplastics materials with different substrates in the design of products, calls for new surface technology coating solutions. There are opportunities for novel R&D to take place in microgravity for development and optimisation of surface technologies, and knowledge and understanding that can be gained to be transferred to earth-based solutions, while advancing the development of coating systems for space applications.

Applications:

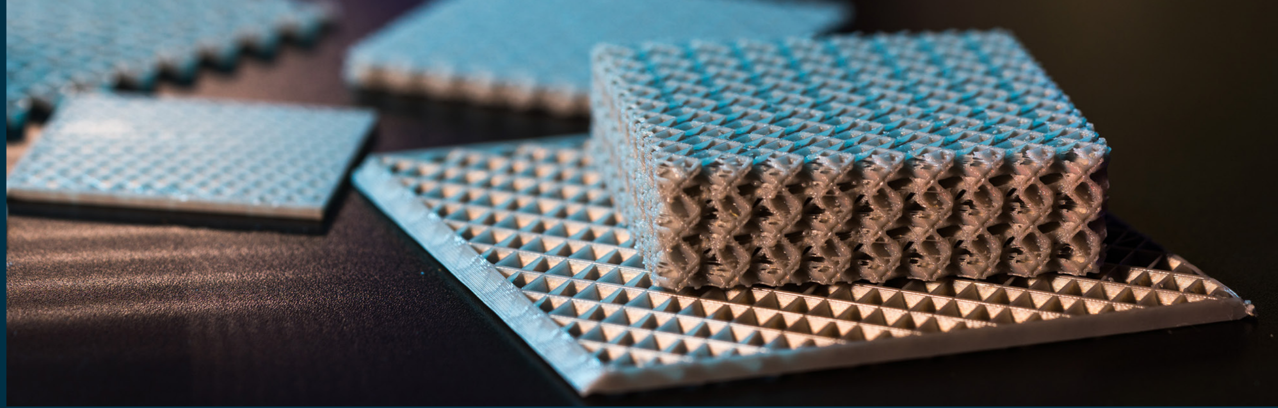
- flexible/embedded electronics
- electrolysers
- communication systems
- hydrogen generation and storage
- defence
- semiconductors
- optical metasurfaces
- sensor arrays
- energy generation

Opportunity 1 (Click here for more info)
There are opportunities for novel R&D to take place in microgravity for development and optimisation of surface technologies and coatings for the design of materials and systems for **energy generation and storage in space**.

Opportunity 2 (Click here for more info)
In-orbit production of microelectronic materials for both terrestrial and space applications presents a two-fold opportunity – materials and processes for microelectronics. Microgravity can enhance commercial crystal growth techniques and offer the promise of superior quality crystals in bulk quantities.

Opportunity 3 (Click here for more info)
Coatings with controlled morphology can be used to influence the chemical, physical and photoelectronic properties of materials and structures. Metamaterials and metasurfaces can be engineered to have different architectures or geometries for the desired properties and functionalities. Microgravity R&D offers an exciting platform that could potentially unlock new properties for these designer materials.

Thin Films & Coatings Opportunities:



1. Thin films & coatings for materials and systems for energy generation and storage

1. Market opportunity
Global macro trends around Net Zero, the hydrogen economy and efficient energy generation and storage are not just limited to Earth. There is an opportunity to research thin films and coatings for materials and systems for energy generation in space.

Thin films systems, highly adjacent to advanced coating systems, are becoming critical material systems with the advent of flexible electronics, and their adoption in critical products such as sensors and energy devices. This is an area where it is expected, for the next decade, significant R&D investments will be made by industry players to develop and bring innovative, proprietary techniques in which the process and integration of multiple materials are intertwined.

2. Why space is of benefit
• Microgravity-enabled manufacturing can lead to improved crystal quality by reducing the defectivity, leading to performance of photovoltaic devices.

• Phase separation is affected by the microgravity environment. Studying new segregation phenomena on different timescales could lead to new organic structures and thin films with improved photoabsorption for use in organic solar cells.

• Microgravity conditions can be used to further research into the charge/discharge mechanisms of energy storage devices and leverage the development of fast-charging chemistries.

• Convection and buoyancy effects can complicate electrodeposition of metals, alloys and compounds, with long and short range irregularities in the deposits . Microgravity would allow improved electrodeposition and further the development of new electrolyser and catalytic materials.

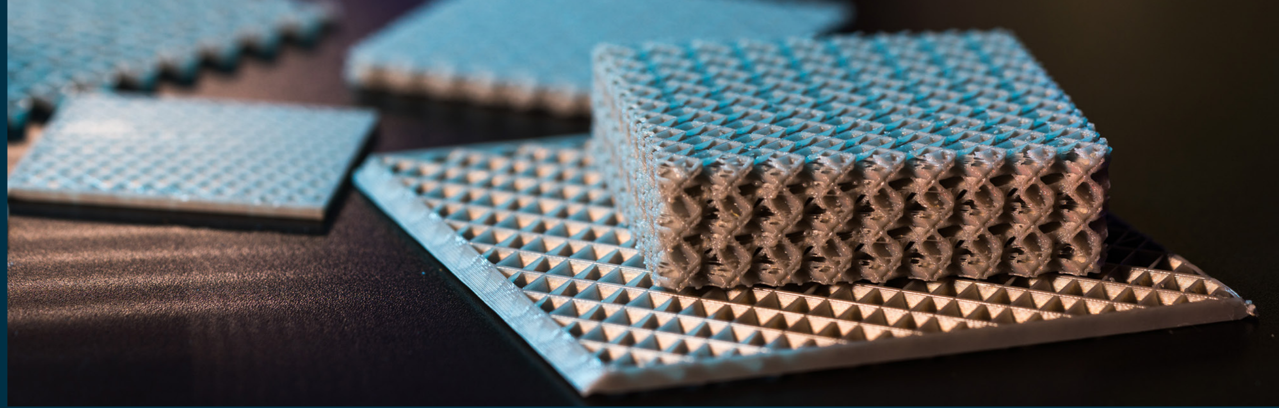
3. Previous experiments in space/successful case studies
• Photoelectrochemical cell with semiconductor with nanostructured electrocatalyst for efficient solar hydrogen generation in microgravity environment

• Electrodeposition Observation in Microgravity.

4. Applications
• Hydrogen generation and storage
• Electrolysers
• Photovoltaics
• Power production from renewable sources
• Energy storage as non-C based fuel
• Thermal energy storage from solar power
• Life revitalisation systems
• Batteries
• Flexible electronics
• Catalysis.

Thin Films & Coatings Opportunities:

2. In orbit production of microelectronic materials in space



1. Market opportunity

• In-orbit production of microelectronic materials for both terrestrial and space applications. The opportunity is two-fold – materials and processes for microelectronics.

• Enhanced crystal growth and quality of silicon and gallium as well as their compounds or faster, higher power density & more efficient electronics.

• Printed electronics in space can be used for in-situ manufacture and maintenance of functional devices during the long duration and endurance of space exploration with crewed spaceflight

2. Why space is of benefit

• Microgravity can enhance the commercial crystal growth techniques for GaAs – the terrestrial growth techniques involve phase transformations from liquid to solid state, which means density and temperature gradients are present. These gradients coupled with gravity-driven convection currents can interfere with the crystal growth interface. Microgravity where such currents are eliminated, offer the opportunity of superior quality crystals in bulk quantities.

• To enable radiation detection in photonic crystals used for scintillators, small quantities of dopant must be distributed uniformly throughout the crystal in liquid phase. On Earth, convection causes continuous and unpredictable movement as the melt crystallises, which disturbs dopant distribution. Microgravity reduces this motion, allowing for a more homogeneous distribution of dopants.

• Silicon used for electronic devices must be extremely pure and virtually defect-free – a microgravity environment allows for containerless processing and a contaminant-free environment during crystal growth. The reduction of gravity-driven forces (e.g., convection, sedimentation, and buoyancy) allows for more consistent and uniform crystal growth as well as larger crystals – which could improve the operational performance of silicon-based semiconductor devices.

• Manufacturing in space can speed up the production of advanced high-reliability microelectronics and help resolve supply chain challenges on Earth.

3. Previous experiments in space/successful case studies

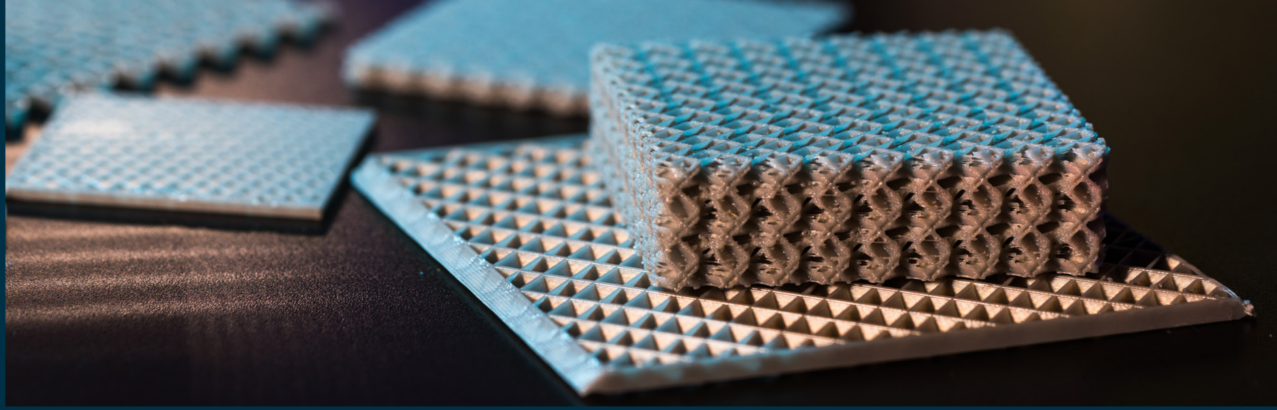
• Industrial Crystallization Facility for Nonlinear Optical Materials, Phase I
• Crystals Grown Aboard Space Station Provide Radiation Detecting Technology
• Printable Spacecraft: Flexible Electronic Platforms for NASA Missions.

4. Applications

• Semiconductor crystal growth
• Scintillator crystal growth for radiation detection
• Smart mobility - small electric vehicles, battery management systems, EV charging
• Connectivity and communications (including inter-planet communication.)
• Defence
• Embedded electronics e.g. sensors embedded in composites, for remote structural assessment
• Internet of things (IoT) – big data collection, embedded security, connectivity
• In-orbit fabrication for flexible, reconfigurable sensor arrays.

Thin Films & Coatings Opportunities:

3. Coatings with controlled morphology & metamaterials



1. Market opportunity

Coatings with controlled morphology can be used to influence the chemical, physical and photoelectronic properties of materials and structures.

• The morphology can be tailored by controlling deposition parameters in physical vapour deposition (PVD), chemical Vapour deposition (CVD) and other thin film deposition and patterning methods.

• Metamaterials are a novel class of functional materials that are designed around unique micro- and nano-scale patterns or structures, which cause them to interact with light and other forms of radiation in ways not found in nature.

• Metamaterials offer the potential to precisely control the path of light in a material. This allows the transformation of traditionally bulky optical systems to extremely small forms. Metamaterials can also be customised to support novel properties that currently are not accessible with existing optical hardware, leading to entirely new optical systems.

• Metasurfaces are the two-dimensional counterpart of metamaterials. Metasurfaces are ultra-thin films composed of arrays of nanostructures modulating the amplitude, phase, and polarisation of radiation (e.g. light, radio frequency. Infra-red radiation).

2. Why space is of benefit

• In a gravitational field, the gravitational force act parallel to the flow thereby creating stresses in the film and introducing 3D instabilities (waves, ribs, streaks) that interfere with the manufactured device performance. In microgravity, the surface tension forces and viscous forces in the meniscus region would lead to smooth, uniform and highly accurate thin films.

• Combining the thin film growth in microgravity with 3D nanostructured substrates (nanoindentation structuring as well as nanoshadowing lithography), a better-controlled surface area is created for higher catalytic efficiency.

• Metamaterials derive their properties from a combination of chemical composition found in natural materials and internal micro- and nanostructures. As a result, metamaterial structures enable properties and capabilities, which are generally not possible to create using conventional material discovery or chemical manufacturing technologies. Microgravity studies on the formation of metamaterial/metasurface microstructures could potentially unlock new properties of these designer materials with regards to their light manipulation and interaction with electromagnetic radiation.

3. Previous experiments in space/successful case studies

• Metalenz is commercialising its revolutionary metasurface technology and transforming optical sensing in consumer electronics and automotive markets. Built on a foundational innovation in meta-optics from Harvard University, Metalenz's technology enables significant reduction in the complexity and size of optical modules while improving system performance and moving optics manufacturing into the semiconductor foundry.

• NASA contract leads the way for metamaterials in space

• Optical metasurface enables light-powered microscopic 'vehicle'.

4. Applications

• Optical metasurfaces/metalenses
• Photovoltaic coatings/improved solar cells
• Manufacture of semiconductor components
• Magnetic information storage systems
• Photoresistant microelectronics.

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.