Space Science 101 – Materials Science & Biophysics

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Why is Materials Science research important?

- It leads to new, better materials for consumers and space applications by studying three key variables: Materials Properties, Structures/Microstructure, Processing/How a material was made.

Why is this research important to space exploration?

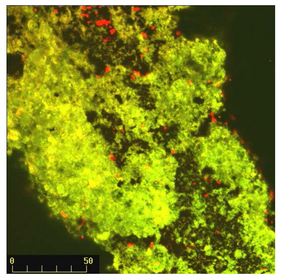
- NASA's Materials Science research can contribute to leadership and advances in space by identifying:
  - New materials needed for extreme environments and requirement for space:
    - Long-duration spaceflight
    - Advanced space-related power and propulsion
  - New processes:
    - In-space manufacturing and repairs
    - Advanced life support systems
- Example: Materials Development: New alloy developed to support a flight experiment was used as a detector material in the collector array used in the Genesis exploration mission.

Genesis spacecraft in collecting mode

Genesis collector array

What do we need to know to support space exploration?

- Impact of gravity on processes in space.



Left: Biofilm, Right: LMM instrument

Biofilms are of significant concern to NASA and also a growing health concern. The presence of potentially harmful microorganisms is often found inside the crew cabin, the Environmental Control and Life Support Systems (ECLSS), or growing in the water pipes. Joint experiments are planned with Space Biology to understand biofilm growth in space to prevent problems.

- How to make the best materials for optimal performance in space.

Bulk Metallic Glasses (BMG's) are a new class of materials being studied on ISS. These materials have many exciting properties, for example they do not get brittle in extreme cold.

NASA is researching the use of BMG's for applications including gears for rovers in extreme environments, such as cryogenic temperatures.

Why is space research important to Materials Science?

- Microgravity-related research has the potential for near-term breakthroughs in biopharmaceuticals and materials science.
- The International Space Station enables this research by providing a microgravity environment that greatly reduces buoyancy-driven convection and sedimentation in fluids.

On Earth more dense materials (or liquids) settle.

A container with an oil and water mixture of different densities on Earth. Photo credit: ESA.

In space things are different.

An Astronaut floating through the ISS.

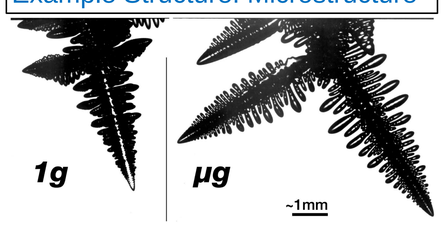
Why is Materials Science & Biophysics research important to Earth?

- Applications of microgravity materials science and biophysics research include
  - Better turbine blades for aerospace engines
  - Higher quality steel
  - New materials for medical lasers
  - Improved semiconductor devices
  - New pharmaceuticals

Example Properties: High Temperature Materials

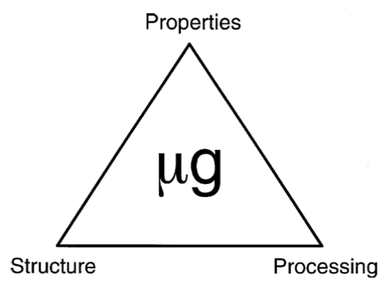
Sample Cartridge Assembly (SCA) used to conduct high temperature materials experiments (including semiconductors, metals, and alloys) on ISS.

Example Structure: Microstructure



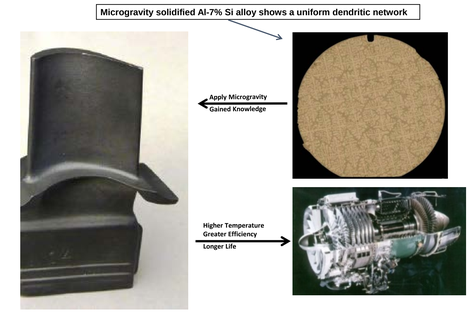
Dendrites grown in Isothermal Dendritic Growth Experiment (IDGE).

Comparing Earth-based and space-based dendrite growth velocity, tip size and shape provides a better understanding of the fundamentals of dendritic growth, including gravity's effects.



Establishing quantitative and predictive relationships between the way a material is produced (processing), its structure (how the atoms are arranged), and its properties is fundamental to the study of materials.

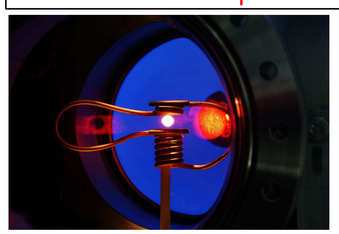
The path to better materials for applications including exploration



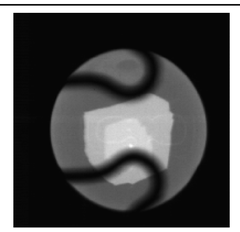
What have we learned that could only be revealed in space?

- NRC reports which included materials science and biophysics state: "Research in the physical sciences generated an impressive number of peer-reviewed publications, landmark measurements, and discoveries, all of which could only be achieved through access to space."[1,2]
- Key topics include:
  - Crystal growth
  - dendritic solidification
  - Coarsening
  - directional solidification
  - semiconductors.[1]

Example Processing: Levitation



A sample being heated in ESA's electromagnetic levitator.



ISS-EML image of molten iron-chromium-nickel steel casting alloy showing solidification of primary ferrite and subsequent conversion to secondary austenite.

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https://asgsr.org/SpaceScience101

TBD QR

[1] PDF of the Midterm decal is available at http://nap.edu/24966

[2] PDF of NRC microgravity report is available at https://doi.org/10.17226/9452