



Overview of Materials Science & Biophysics Research From The SLPSRA Program at MSFC

Jan Rogers
Michael SanSoucie
Pam Twigg
Shawn Reagan



- **Microgravity Investigation of Cement Solidification (MICS)**
– Dr. Aleksandra Radlińska, Penn State



*Penn State doctoral candidate
Juliana Neves with box
containing MICS samples
returned from the ISS*

- The International Space Station (ISS) provides a long-duration spaceflight environment for conducting microgravity experiments
- The microgravity environment greatly reduces buoyancy-driven convection, pressure head and sedimentation in fluids.

- More than 40 current Grants and activities
- International Partners including:

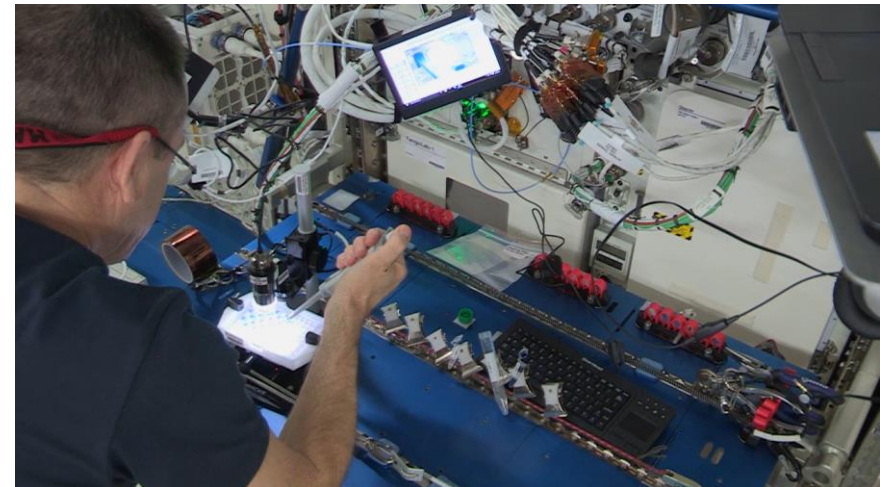


- International collaborators including:

- Austria
- Belgium
- Canada
- Germany
- Japan
- Russia
- South Korea



Group photo during an ISS-EML International Working Group (IWG) meeting in Cologne, Germany



An Astronaut performing protein crystal growth experiments on the ISS.

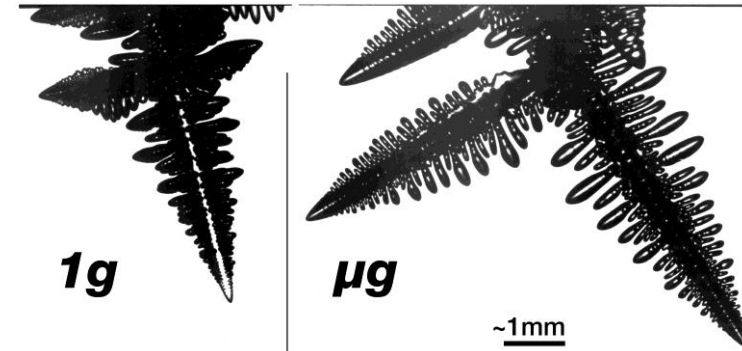
- **A large variety of Materials Science research is either ongoing or planned on ISS**

- **Metals & Semiconductors research**

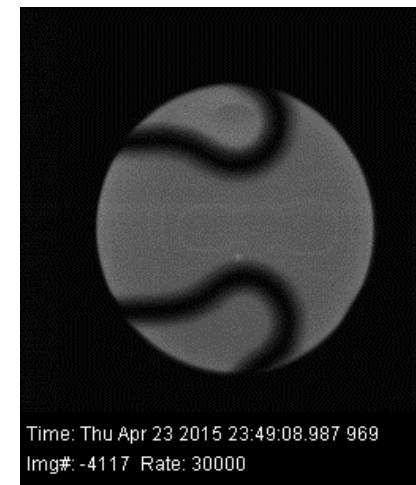
- Isothermal Processes
 - Current Experiments: GEDS, FAMIS, DECLIC DSI
- Directional Solidification
 - Current Experiments: SETA, CETSOL
- Crystal Formation
 - Current Experiment: GTS
 - Solidification Microstructure, Cement, Brazing and Freeze Casting Reference Experiments

- **Thermophysical Properties research**

- ESA Electromagnetic levitation (ISS-EML)
- JAXA Electrostatic Levitation Furnace (ELF)
- Low to near zero fluid flow in levitated samples in microgravity
- Measurements of density, specific heat, surface tension, and viscosity
 - On metals, semiconductors, oxides, and glasses
- Current ISS-EML experiments: ELFSTONE, ICOPROSOL, PARSEC, THERMOLAB, QUASI
- Current ELF experiment: Modeling and Simulation of Electrostatically Levitated Multiphase Liquid Drops
 - Goal: measure the interfacial tension between molten iron and slag. The results of the project could help with more efficient production of higher quality steel
- Planned ELF experiment: MaterialsLab Thermophysical Properties Reference Experiment

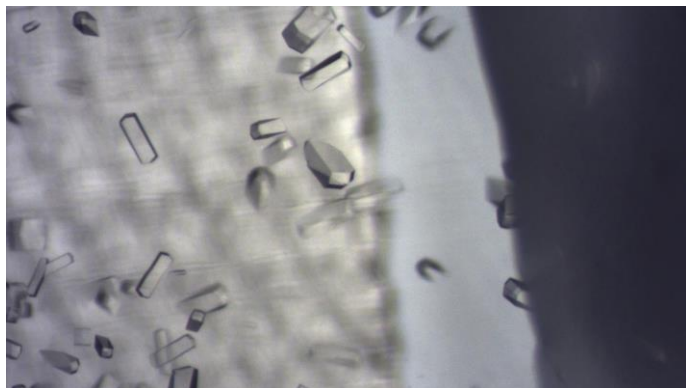


Dendrites grown in Isothermal Dendritic Growth Experiment (IDGE).

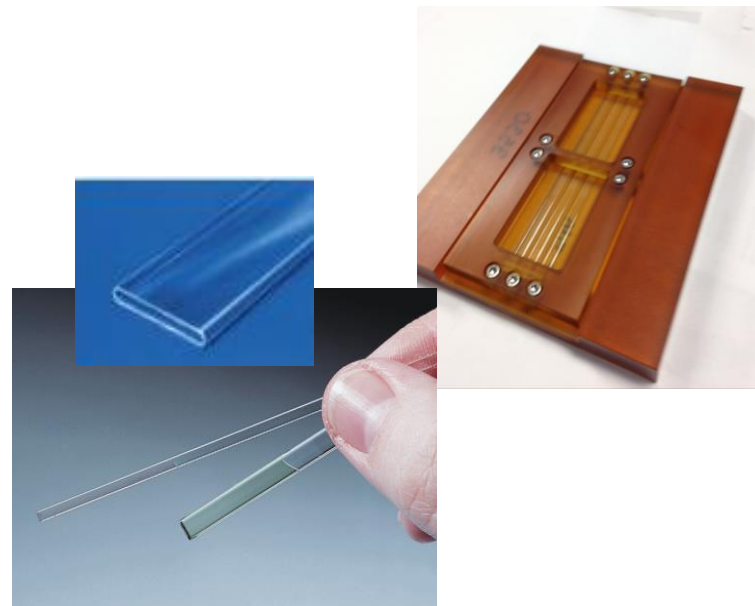


ISS-EML image of molten iron-chromium-nickel steel casting alloy showing solidification of primary ferrite and subsequent conversion to secondary austenite.

- An example of biophysics research is protein crystal growth (PCG).
- Microgravity missions have shown that crystals of some proteins (and other complex biological molecules such as viruses) grown on orbit are larger and have fewer defects than those grown on Earth.



Lysozyme crystals grown on ISS during ops in July 2018/ Returned on SpaceX-15.



PCG hardware used in space.

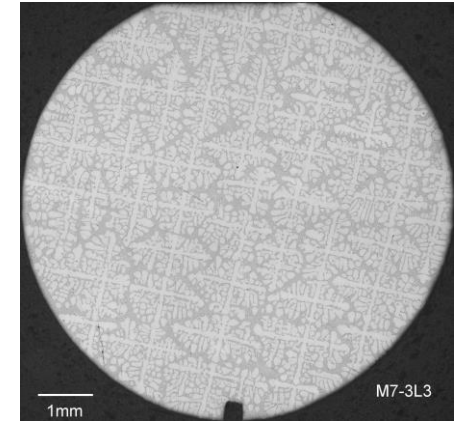
- The improved data from the space-grown crystals significantly enhance scientists' understanding of the protein's structure and this information can be used to support structure-based drug design.

- **Our materials research programs study materials with these applications:**

- Semiconductors
- Welding
- Casting
- Alloy development
- Glass processing
- New materials for optical devices, lasers, and photonics
- New materials needed for extreme environments (i.e. space or celestial surfaces)



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.



An aluminum-7wt% silicon sample directionally solidified on the ISS. The applications of this science are solidification castings that are used in gas turbine “jet” engines.

Microgravity solidified Al-7% Si alloy shows a uniform dendritic network

- **Our PCG research efforts are focused on understanding:**

- The physics of improved protein crystal quality in microgravity
- Establishing protocols for setting up and optimizing crystallization experiments on ISS.
- High quality crystals can be used to help develop new pharmaceuticals.



Apply Microgravity
Gained Knowledge



Higher Temperature
Greater Efficiency
Longer Life



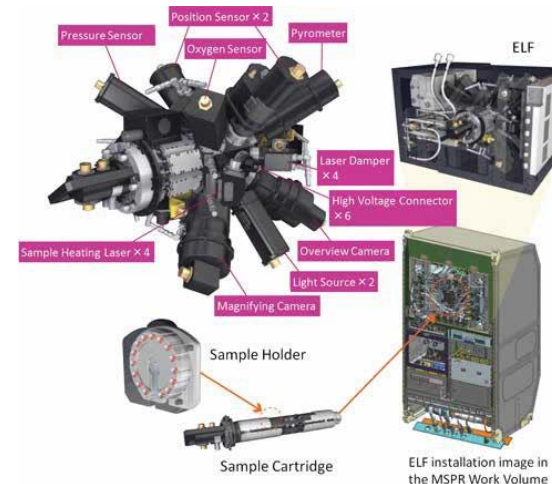
- **Ongoing and near-term operations on ISS including:**

- ESA ISS-EML
- JAXA ELF
- MSRR
- Glovebox
- SUBSA
- CNES DECLIC
- PCG & Biofilms

- **Future**

- SLPSRA is planning a joint Materials Science Workshop with CASIS at the ISS R&D conference in Atlanta, July 29 – August 1, 2019. Workshop details TBD.
 - We anticipate developing a new NASA Research Announcement (NRA)

- **Acknowledgment: NASA Space Life and Physical Sciences Research and Applications (SLPSRA)**



Electrostatic Levitation Furnace (ELF)



Materials Science Research Rack (MSRR) ground unit.