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ADVANCED MATERIALS RESEARCH AT THE ISS U.S. NATIONAL LABORATORY

Abstract

Microgravity in low Earth orbit affords unique capabilities to synthesize and study materials in ways that are difficult or impossible to do at the Earth's surface. Materials research in space began in earnest with metal welding experiments performed by cosmonauts Valeri Kubasov and Georgi Shonin on board Soyuz 6 in 1969 and has flourished over the intervening fifty years with investigations hosted on Salyut, Skylab, Mir, the Space Shuttle, sounding rockets, and the International Space Station (ISS).

At present, the ISS is unique as an Earth-orbiting, routinely-accessed, human-tended research platform, used by hundreds of scientists worldwide to advance fundamental and practical knowledge of materials. NASA, ESA, JAXA, Roscosmos, and others, maintain facilities on board the ISS for research on colloids, liquid crystals, electronic and photonic materials, metal alloys, glasses, and ceramics. The Materials Science Research Rack (MSRR), jointly developed by NASA and ESA, is an automated, modular system hosting the Materials Science Laboratory (MSL) with its Low Gradient Furnace (LGF) and Solidification and Quenching Furnace (SQF) inserts. The Microgravity Science Glovebox (MSG) is equipped to support purpose-built hardware including the Coarsening of Solid-Liquid Mixtures (CLSM), Pore Formation and Mobility Investigation (PFMI), Solidification Using a Baffle in Sealed Ampoules (SUBSA), and other equipment. High-temperature furnaces, such as ESA's Electro Magnetic Levitator (EML) and JAXA's Electrostatic Levitation Furnace (ELF) allow containerless melting and solidification of samples for high-accuracy measurements of thermophysical properties.

NASA and the ISS U.S. National Laboratory (ISS NL) have complementary materials research campaigns on board the ISS with their respective objectives of enabling exploration and creating value. Through its curated research portfolio, including programs sponsored by NSF, NIH, and others, the ISS NL promotes academic research and commercial innovation. To illustrate, university researchers working on InI and CLYC radiation detectors are attempting to grow larger, higher quality crystals in microgravity. Three private companies plan to manufacture ZBLAN optical fiber on the ISS as an ultra-low-loss alternative to silica fibers used in today's fiber-optic networks. Metal casting, a common industrial process on Earth, is being investigated at the ISS NL to find ways to avoid deleterious hot tearing of cast parts. Multi-layer protein/photoreceptor deposition experiments in microgravity are targeting biomaterials for retinal implants to restore sight in vision-impaired and blind patients. Many other advanced materials studies are ongoing or planned for the ISS National Laboratory that use microgravity to explore innovative pathways to scientific and economic returns.