

Levitation Technology in International Space Station Research. Y. Guinart-Ramirez, V.M. Cooley, and J.E. Love. ISS Research Integration Office, NASA Johnson Space Center, Houston, TX, USA.

The International Space Station (ISS) is a unique multidisciplinary orbiting laboratory for science and technology research, enabling discoveries that benefit life on Earth and exploration of the universe. ISS facilities for containerless sample processing in Materials Science experiments include levitation devices with specimen positioning control while reducing containment vessel contamination. For example, ESA's EML (ElectroMagnetic Levitator), is used for melting and solidification of conductive metals, alloys, or semiconductors in ultra-high vacuum, or in high-purity gaseous atmospheres. Sample heating and positioning are accomplished through electromagnetic fields generated by a coil system. EML applications cover investigation of solidification and microstructural formation, evaluation of thermophysical properties of highly reactive metals (whose properties can be very sensitive to contamination), and examination of undercooled liquid metals to understand metastable phase convection and influence convection on structural changes. MSL utilization includes development of novel light-weight, high-performance materials. Another facility, JAXA's ELF (Electrostatic Levitation Furnace), is used to perform high temperature melting while avoiding chemical reactions with crucibles by levitating a sample through Coulomb force. ELF is capable of measuring density, surface tension, and viscosity of samples at high temperatures. One of the initial ELF investigations, Interfacial Energy-1, is aimed at clarification of interfacial phenomena between molten steels and oxide melts with industrial applications in control processes for liquid mixing. In addition to these Materials Science facilities, other ISS investigations that involve levitation employ it for biological research. For example, NASA's "Magnetic 3D Culturing and Bioprinting" investigation uses magnetic levitation for three-dimensional culturing and positioning of magnetized cells to generate spheroid assemblies for biomedical applications. Levitation is also used as a modeled microgravity ground analog in the NASA OsteoOmics ISS investigation, which tests whether magnetic levitation accurately simulates microgravity conditions by studying gravitational regulation of osteoblast and osteoclast genomics and metabolism. Elucidating the cellular mechanisms of bone loss in microgravity contributes to the understanding of bone loss in medical disorders on Earth, which may lead to development of preventive or therapeutic countermeasures. Thus, the ISS state-of-the-art laboratory offers various levitation capability platforms with applications for innovative research in Materials and Life Sciences disciplines, with benefits for humanity.