National Aeronautics and
Space Administration

Marshall Space Flight Center

Materials Levitation Laboratory

MSFC's Materials Levitation Laboratory (LevLab) is a national resource for researchers developing advanced materials for new technologies. Levitation minimizes gravitational effects and allows materials to be studied without contact with a container or instrumentation, avoiding any container-sample interaction.

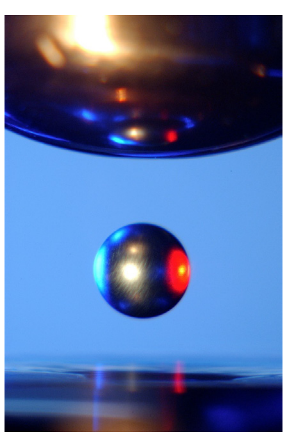
MSFC's LevLab hosts investigators from academia, government, and commercial or industrial partners. NASA invests in levitation systems to develop new high-temperature materials for better rocket engine nozzles, radiator panels, habitat surfaces, alloy development, and advanced manufacturing. Researchers have used MSFC's LevLab to improve medical and industrial lasers, develop metallic glasses stronger than steel, and create materials with memory.

The keystone of the LevLab are the two electrostatic levitators that feature a broad range of capabilities, including high-temperature heating in both vacuum and neutral gas environments with or without rotation. Using its non-intrusive data-gathering accessories, these levitators have been instrumental in many pioneering materials investigations of thermophysical properties and process understanding. They are also used to probe the structure of both liquids and metals, to measure creep, to view solidification, and to validate computed phase diagrams.

On-site scientific/engineering experts assist with planning and operation of experiments and modify the levitators to support specific research goals.

High-Temperature Measurements

Data that can be obtained with equipment in the LevLab include liquid density, surface tension, viscosity, heat capacity, nucleation rate, undercooling, and creep deformation. Processed analysis of this data can provide nucleation temperature and rate as well as solidification velocity. Publication topics include phase behavior/equilibrium, phase diagrams, time-temperature-transformation diagrams, metastable phase transformations, alloy and metallic glass development, thermophysical properties as input for additive manufacturing (AM) process simulations, and crystallization rate of saturated liquids.



Titanium-zirconium-nickel alloy sample in the Main ESL. A laser begins heating the sample. Pyrometry provides non-contact spot temperature measurement of the levitated sample

Technician setting up the Main ESL

Equipment Capabilities

Electrostatic Levitation (ESL)

The Materials Levitation Laboratory has two electrostatic levitators: the main electrostatic levitator (main ESL) and the portable electrostatic levitator (portable ESL). Samples between 1 – 3 millimeter (0.039 – 0.12 inch) diameter that can be processed in the ESL include refractory metals, superalloys, ceramics, oxides, glasses, elemental metals, tertiary alloys, and high entropy alloys. Samples can be processed in vacuum (10^{-8} Torr) in both systems, and with neutral gases to less than or equal to 5 atmospheres in the main ESL.

Both systems include a pyrometer and ultra-high speed Phantom camera. The main ESL has an oxygen partial pressure control system, a quenching system, and has a magnetic rotation device with controlled sample spin (up to 30,000 Hertz). The portable ESL has beryllium ports for use at synchrotrons.

Styrofoam levitating between the transducers of the acoustic levitator. Sound waves create nodes that the material floats in.

Acoustic Levitation

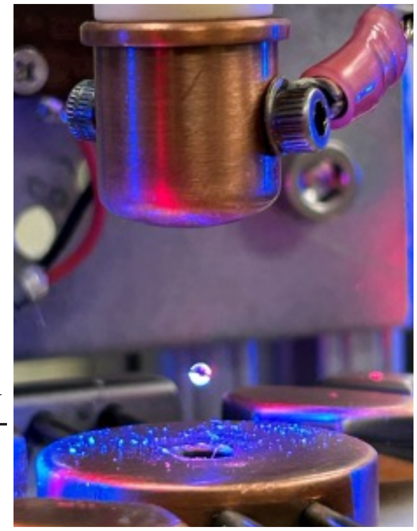
Acoustic levitation utilizes high frequency sound waves to levitate particles through the development of high-pressure zones and pockets of induced low pressure, otherwise known as nodes. Low density materials, such as extruded foams, powders, and liquids, with sizes up to 3 – 8 millimeter can be tested in either 1 atmosphere plain air or inert gas at temperatures up to 70 °C and humidities between 0 – 95%.

The system is augmented with high resolution and infrared cameras, environmental sensors, and is capable of crystallization time-lapse. Developmental features include hybrid system developments with electrostatic, electromagnetic, and aerodynamic levitation as well as an arrayed system for sorting materials.

Aqueous Levitation

Aqueous levitation is an electrostatic based levitation system for studying the crystallization, surface tension, density, and more of soft matter. Ionic liquids, saturated solutions, and other forms of soft matter with sizes between 1 – 3 millimeter (0.039 – 0.12 inch) diameter can be tested in 1 atmosphere of a selected gas at temperatures up to 70 °C and humidities between 0 – 95%.

The system is augmented with a pyrometer, infrared and ultra-high-speed ultra-high-speed cameras, has beryllium ports for use at synchrotrons, and is capable of crystallization time-lapse.



A liquid droplet levitating in the aqueous levitator

Electromagnetic Levitation (EML)

Electromagnetic levitation (EML) utilizes magnetic fields to levitate materials that include refractory metals, superalloys, elemental metals, tertiary alloys, high entropy alloys, and generally most metals with sizes between 4 – 10 millimeter (0.16 – 0.39 inch) diameter at a vacuum (10^{-8} Torr) atmosphere or neutral gases to less than or equal to 2 atmospheres. Developmental features include 3-D printed copper coils, dual heating applications, alloying during levitation, and emissivity measurements.

Sample Preparation Capability

Samples for the LevLab can be fabricated on-site using either elemental raw material or pre-alloyed stock with the following methods:

- Arc melting with zirconium getter
- Laser hearth with a 200 Watt carbon dioxide laser
- Vacuum hearth for casting samples
- Aerodynamic levitator with both a fiber optic laser and a carbon dioxide laser for heating of a variety of sample materials

National Aeronautics and Space Administration

Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/center/marshall

www.nasa.gov/

MSFC-02-2025-G-657270 (16)

Doing Business With MSFC