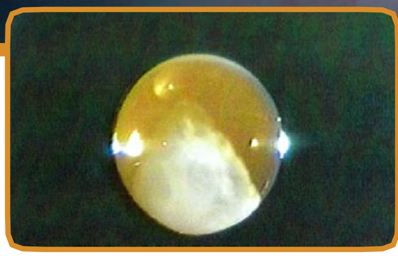
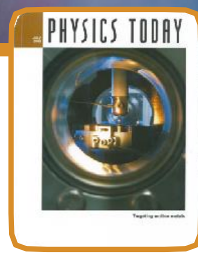
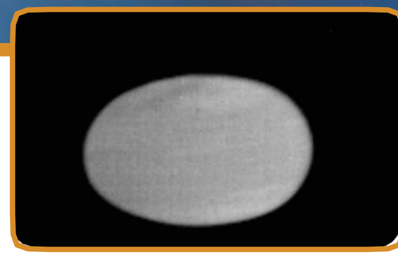
National Aeronautics and
Space Administration

Marshall Space Flight Center
Electrostatic Levitation Laboratory





Credit: Physics Today, July 2003



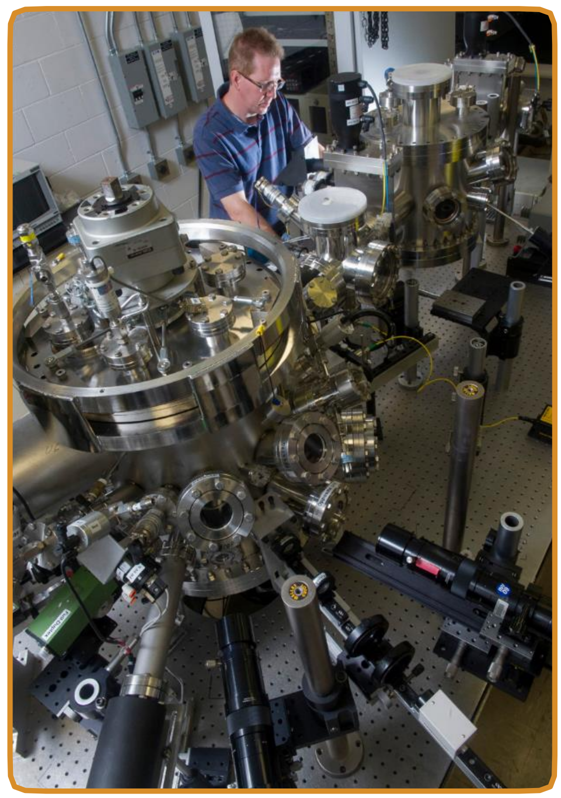
Engineering Solutions for Space Science and Exploration

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

MSFC's ESL Laboratory hosts government, academic, and commercial investigations. NASA invests in electrostatic levitation 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 ESL Laboratory to improve medical and industrial lasers, develop metallic glasses stronger than steel, and create materials with memory.

The keystone of the ESL Laboratory 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 has been instrumental in many pioneering materials investigations of thermophysical properties and process understanding. These levitators have been 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.



Capabilities

Main Electrostatic Levitator

Samples: refractory metals, superalloys, ceramics, oxides, glasses, elemental metals, tertiary alloys, and HEAs

Sample size: 1–3 mm (0.039–0.12 in.) diameter

Atmosphere: vacuum (10^{-8} torr); neutral gases to ≤5 atm

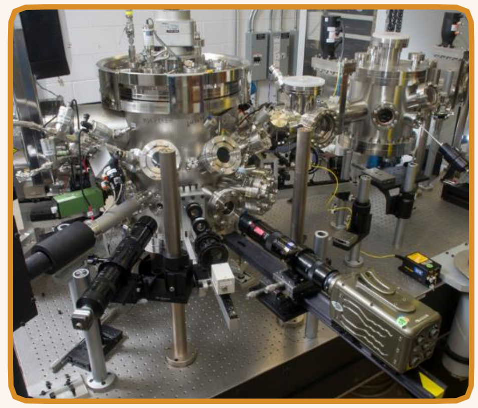
Heating:

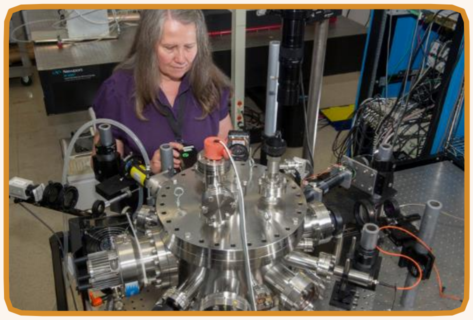
- Focused, steerable 200-W laser
- 1–100% power control
- 0.5- to 10-mm (0.02- to 0.4-in.) spot size

Positioning control: 3-dimensional digital laser feedback

Augmentations:

- Pyrometer
- Infrared camera
- Ultra-high-speed Phantom camera
- Oxygen partial pressure control system
- Quenching system
- Magnetic rotation device with controlled sample spin (30,000+ Hz)





Portable Electrostatic Levitator

Samples: refractory metals, superalloys, ceramics, oxides, glasses, elemental metals, tertiary alloys, and HEAs

Sample size: 1–3 mm (0.039–0.12 in.) diameter

Atmosphere: vacuum (10^{-8} torr)

Heating:

- Focused 60-W laser
- 1–100% power control
- 0.5- to 10-mm (0.02- to 0.4-in.) spot size

Positioning control: 3-dimensional digital laser feedback

Augmentations:

- Pyrometer
- Beryllium ports for use at synchrotrons
- Ultra-high-speed Phantom camera

Sample Preparation Capability

Samples: refractory metals, superalloys, ceramics, oxides, elemental metals, tertiary alloys, and HEAs

Methods:

- Arc melting with Zr getter
- Laser hearth
- Aerodynamic levitator and CO_2 Laser Levitated (under development):

Precursors: from elemental raw material or pre-alloyed stock

Heating range:

- 600–2,700 °C

High-Temperature Measurement Capabilities

Raw Data Products

- Liquid density
- Surface tension
- Viscosity
- Heat capacity
- Nucleation rate
- Undercooling
- Creep deformation

Processed Data Products

- Nucleation temperature and rate
- Solidification velocity

Publications Topics

- Phase behavior/equilibrium
- Phase diagrams
- Time-temperature-transformation diagram
- Metastable phase transformation
- Alloy and metallic glass development
- Thermophysical properties as input for AM process simulations

For additional information, please contact:

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