Electrostatic Levitation for Studies of Materials for Additive and In-Space Manufacturing

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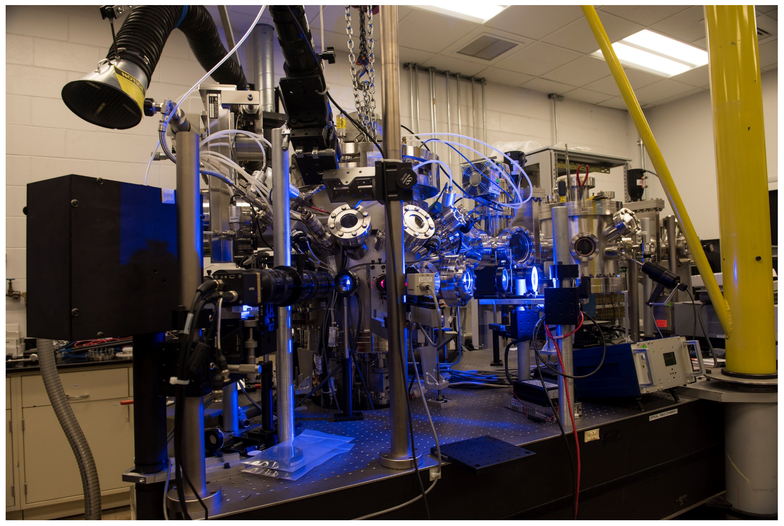
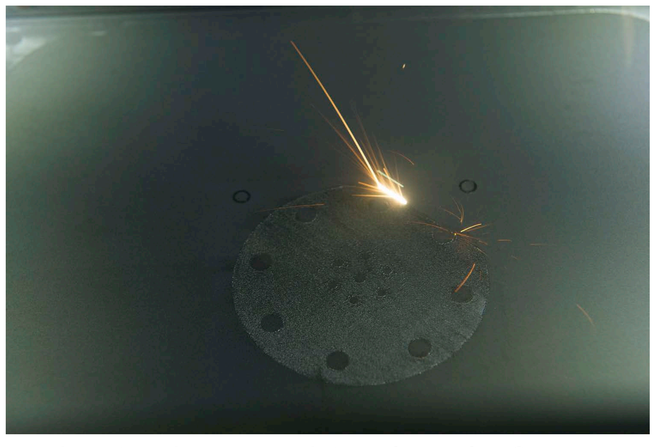
The electrostatic levitation (ESL) laboratory at NASA's Marshall Space Flight Center (MSFC) is a unique facility for investigators studying high-temperature materials. Electrostatic levitation minimizes gravitational effects and allows materials to be studied without contact with a container or instrumentation.



The NASA Marshall Space Flight Center (MSFC) Electrostatic Levitation (ESL) Laboratory's main levitation chamber.

Modeling of additive and in-space manufacturing processes is necessary for the control of their resulting materials properties. Unfortunately, there is very little data for the properties of these materials, especially of the materials in the liquid state. Some method to measure thermophysical properties of additive and in-space manufacturing materials is necessary.

The ESL lab is ideal for these studies. The lab can provide density, surface tension, and viscosity of molten materials, emissivity measurements, and even creep strength measurements. The ESL lab can also provide these properties in a relevant environment (i.e., high vacuum).



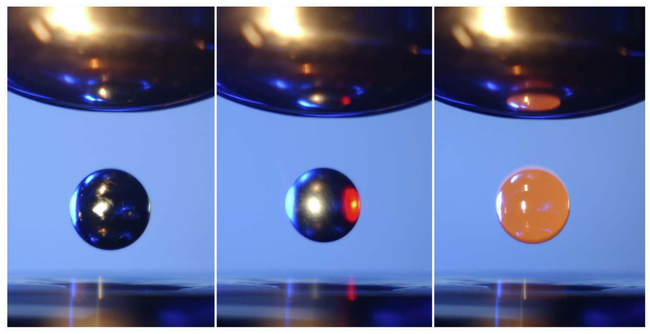
Selective laser melting (SLM) of a part. Image courtesy of NASA.

The ESL lab has been instrumental in many pioneering materials investigations of thermophysical properties, including:

- creep measurements
- solidification velocity
- triggered nucleation
- emissivity at high temperatures

Research in the ESL lab has led to the development of advanced high-temperature materials for aerospace applications, including:

- coatings and structural materials for rocket nozzles
- improved medical and industrial optics
- metallic glasses
- ablatives for reentry vehicles
- materials with memory



A levitated 2-mm (0.08-in.) diameter sample of titanium-zirconium-nickel (Ti-Zr-Ni) using ESL. This figure shows the sample levitated, heated, and then melted.

In-Space Manufacturing (ISM) has the potential to reduce the up-mass required for repairs and maintenance, as well as utilize in-situ resources for even greater up-mass savings. Furthermore, ISM will provide flexibility and capabilities to adapt to unforeseen circumstances that are certain to occur during in-space missions.

In-Space Manufacturing does not have the luxury of time for mistakes, requiring repeat builds, or a steep learning curve. Studies of the thermophysical properties (e.g. density, surface tension, and viscosity) is necessary to minimize risk and ensure ISM success. The MSFC electrostatic levitation (ESL) laboratory can serve as a "test bed" for these studies as well as provide the necessary material properties for accurate models of ISM processes.

Research Programs

Thermophysical Properties

- Emissivity
- Surface tension
- Viscosity
- Density
- Undercooling
- Creep Strength

Solidification

- Nucleation temperature and rate
- Solidification velocity

Other

- Phase behavior/equilibrium
- Time-temperature-transformation diagrams
- Metastable phase transformation