RAPID QUENCH IN AN ELECTROSTATIC LEVITATOR

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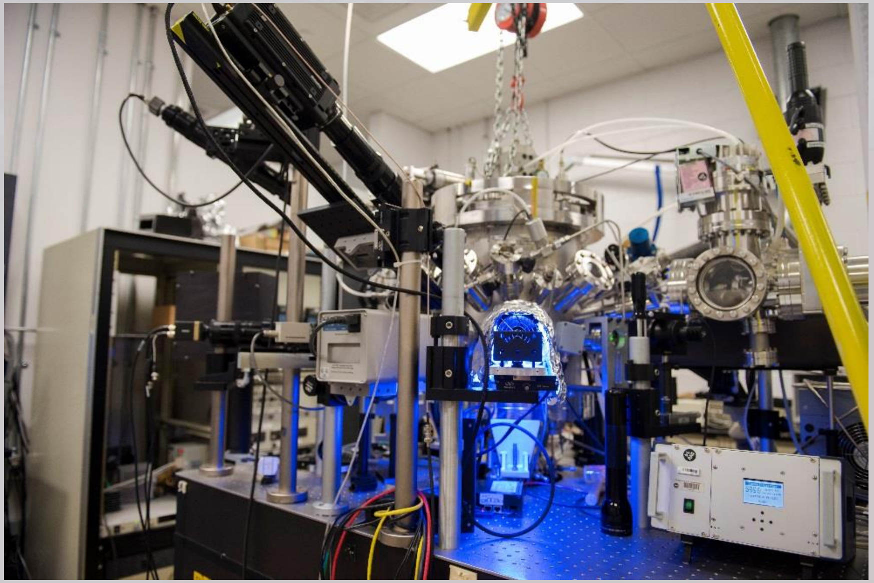
Outline

- MSFC Electrostatic Levitation (ESL) Laboratory
- Rapid Quench System
- Motivation
- Quench Medium
- Quench Videos
- Future Work

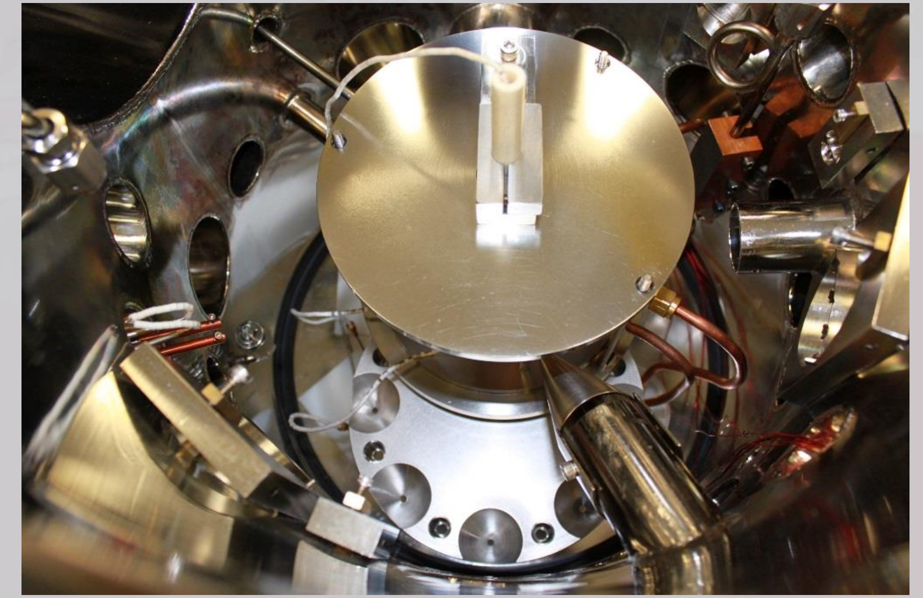
The MSFC Electrostatic Levitation (ESL) Laboratory

- The MSFC ESL Lab is a national resource for researchers developing advanced materials for new technologies
- Can process elements, alloys, refractory metals, superalloys, ceramics, oxides, and glasses
- The lab typically measures thermophysical properties
  - Density
  - Surface tension
  - Viscosity
- Provides ground-based support for US investigators with levitation experiments on ISS
  - ESA's Materials Science Laboratory Electromagnetic Levitator (MSL-EML)
  - JAXA's Electrostatic Levitation Furnace (ELF)
- Recently upgraded with a rapid quench system

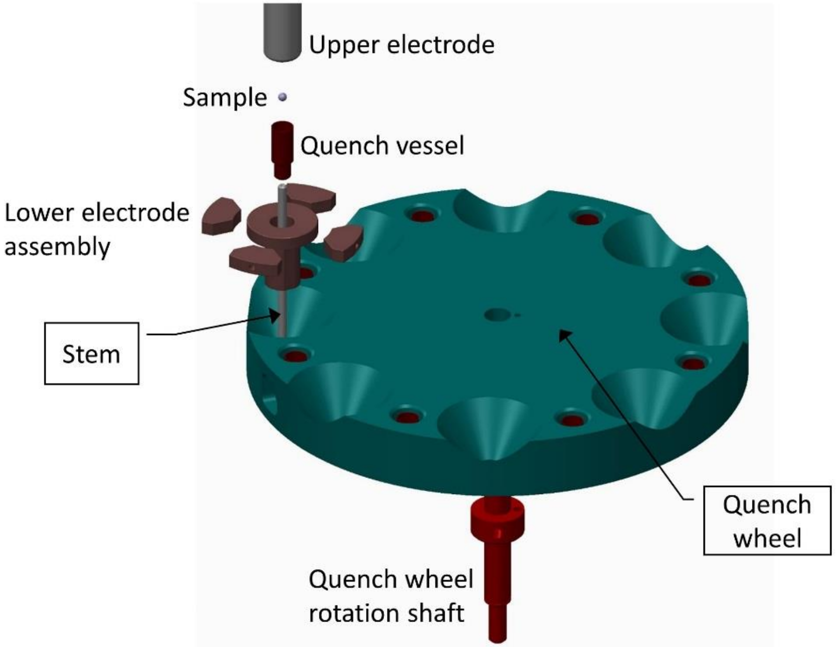


Rapid Quench System

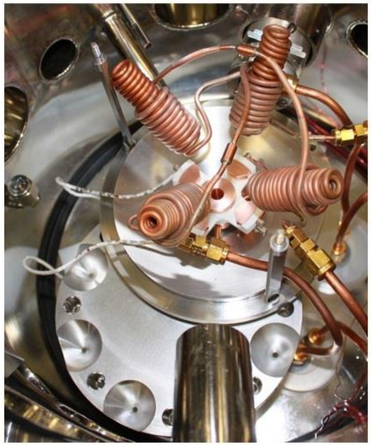
- **First submersion quench system inside an electrostatic levitator**
- **Allows samples to be dropped into a quench vessel that can be filled with a low melting point material, as a quench medium**
- **Thereby allowing rapid quenching of undercooled liquid metals**
- **Quench vessels can be raised or lowered using the same stem that is used to launch samples**
- **Up to 8 quench vessels can be loaded into the quench wheel**
- **Wheel is indexed with servo motors that are controlled with LabVIEW software**



Exploded View of Rapid Quench System



(a)



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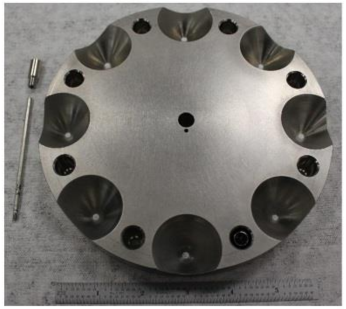
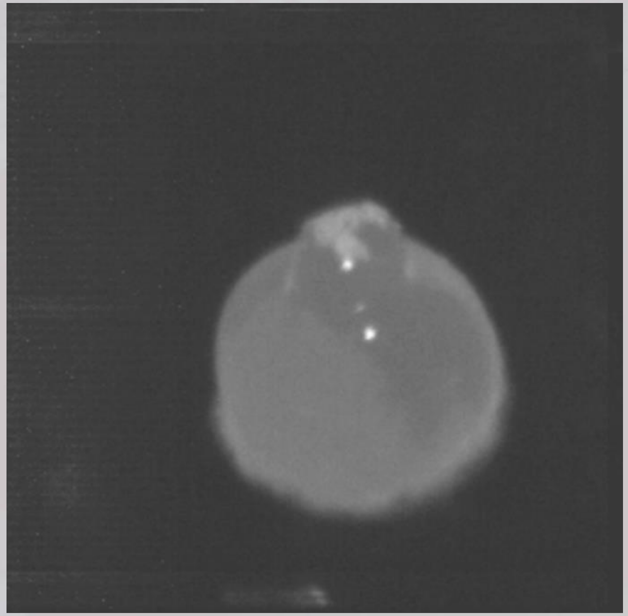


(c)

Motivation

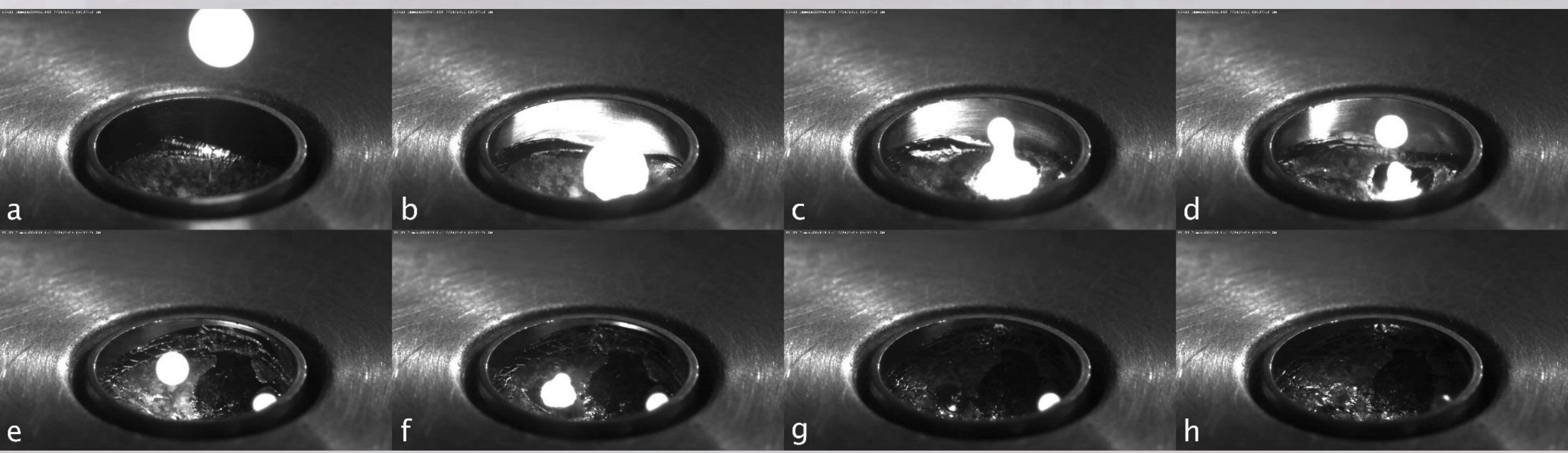
- To preserve transient microstructures for quantitative metallographic analysis
- To freeze-in metastable phases for solidification path determination
- To rapidly solidify reactive melts while minimizing internal fluid flow
- To reduce fragmentation of structures associated with splat quench techniques
- To eliminate coarsening of microstructures to define as-solidified dendrite shape
- To reduce both solid and liquid diffusion processes to observe partitioning in-situ



Quench Medium

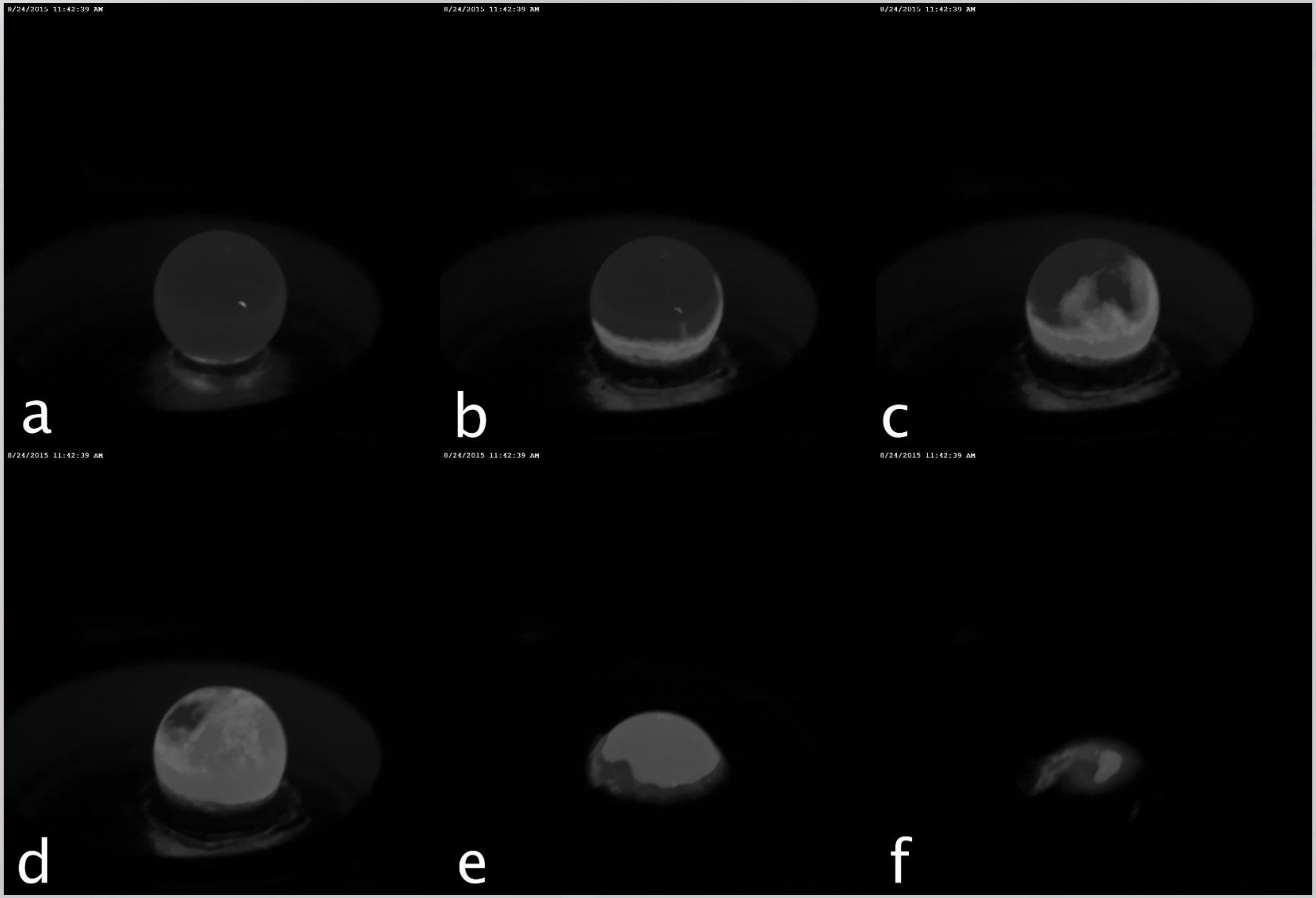
- **Indalloy 46L**
  - **61.0Ga - 25.0In - 13.0Sn - 1.0Zn**
  - **Liquidus = 7.6 C**
  - **Thermal Conductivity = ~15 W/mK (estimated by manufacturer)**
- **Gallium-Indium alloys have been proposed for similar studies by Koseki and Flemings**
  - **T. Koseki and M.C. Flemings, "Solidification of Undercooled Fe-Cr-Ni Alloys III: Phase Selection in Chilling", *Metallurgical and Materials Transactions A*, 28A (11) (1997), 2385-2395.**

Quench Sequence



Video

Quench Sequence – Si58Co42



Video of Si58Co42 Quench

Future Work

- Eliminate surface dross
- Improve tracking of surface features to locate impact point/fluid closure point
- Calibrate quench rate as a function of depth below sample surface
- Optimize quench fluid removal from sample surfaces post-test
- Improve timing of droplet release from levitation field to minimize flight time