RAPID QUENCH IN AN ELECTROSTATIC LEVITATOR

Michael P. SanSoucie and Jan R. Rogers
NASA Marshall Space Flight Center

Douglas M. Matson
Tufts University
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) Exploded View Diagram

(b) Actual Image of Rapid Quench System

(c) Isolated Component Image
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**
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