Hybrid Polymetal Fabrication Using Programmable Alloys

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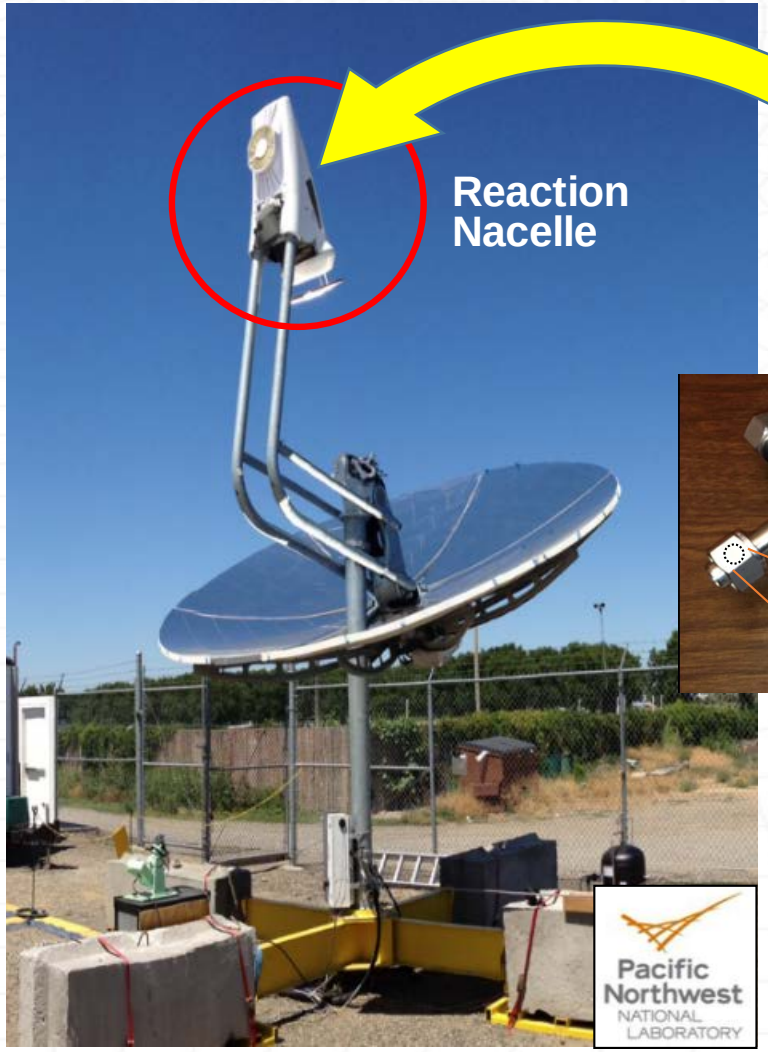
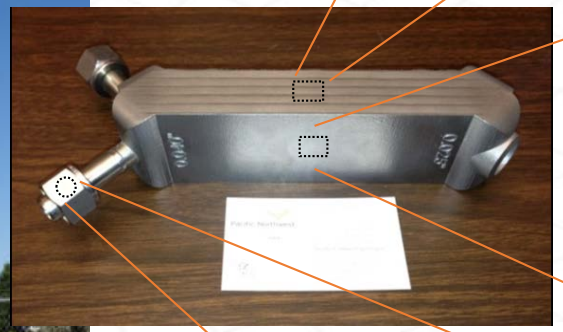
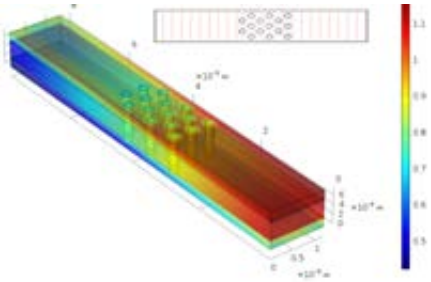
Convergent Manufacturing

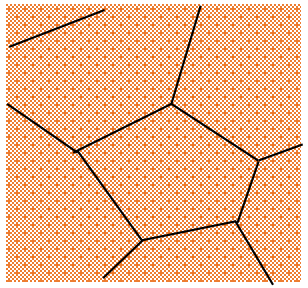
Polymetal Fabrication for Solar Thermochemical Processing



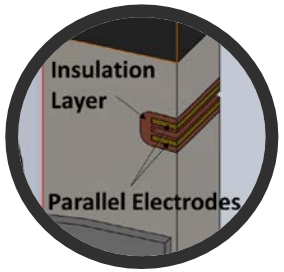




Thermally-enhanced pins to direct heat transfer vertically, minimizing axial heat transfer within compact HXs



Metal matrix composites enables further lightweighting of the HXs with higher strength at equivalent density

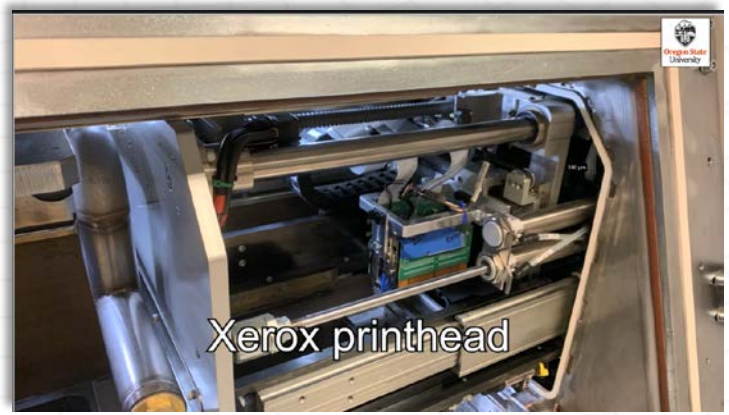


Integrated capacitive sensor for measuring flow-induced vibrations to avoid high cycle fatigue

Programmable Alloys

Oxide Dispersion Strengthened 304 SS (Paul et al. 2019)

OSU Hybrid Laser Powder Bed Fusion



Programmable Machine Tool

+

Materials

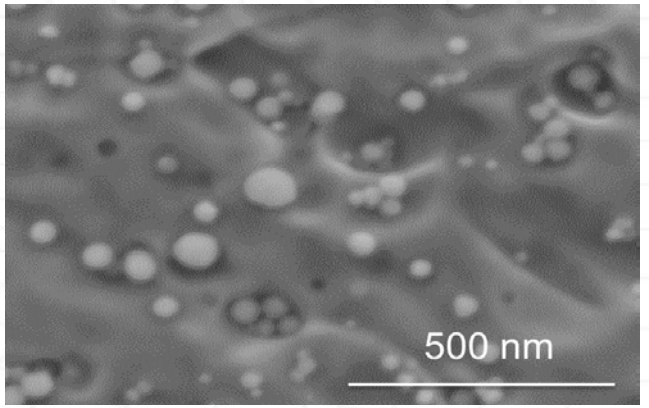
304 SS

+

yttrium nitrate + alcohol

Primary Alloy and Dopant

=

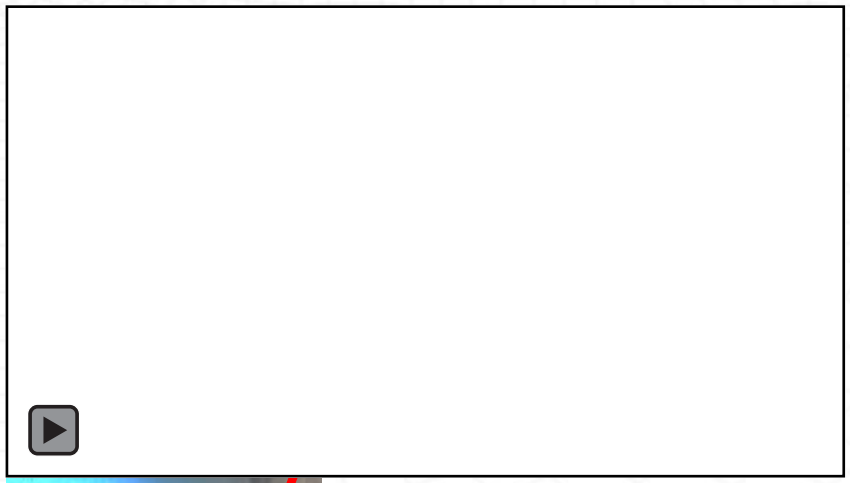


100X ↓ in Creep Rate at 700°C

(30% reduced cost)

Programmable Alloys

Inc625/GRC42 Transitional Alloy (Paul et al. 2021)



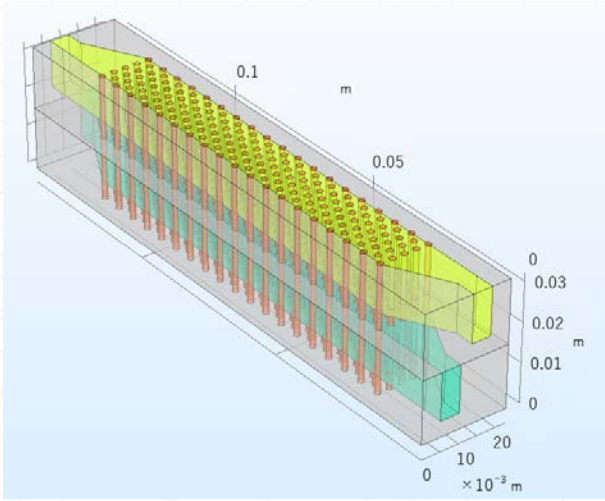
Simultaneous Hot Wire-Fed and Powder-Fed Laser Directed Energy Deposition (Meltio M450)

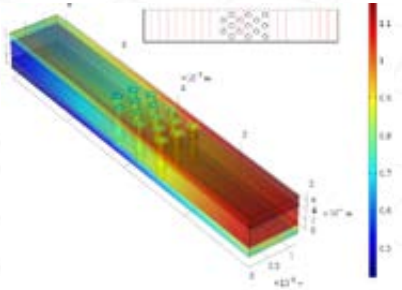
Materials

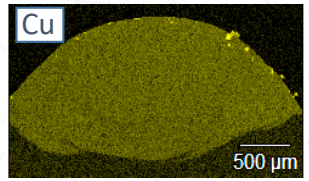
Inconel 625 (70 wt%)

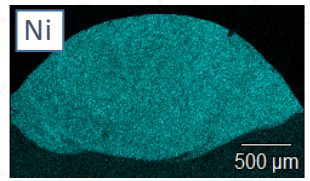
+

GRCop 42 (30 wt%)









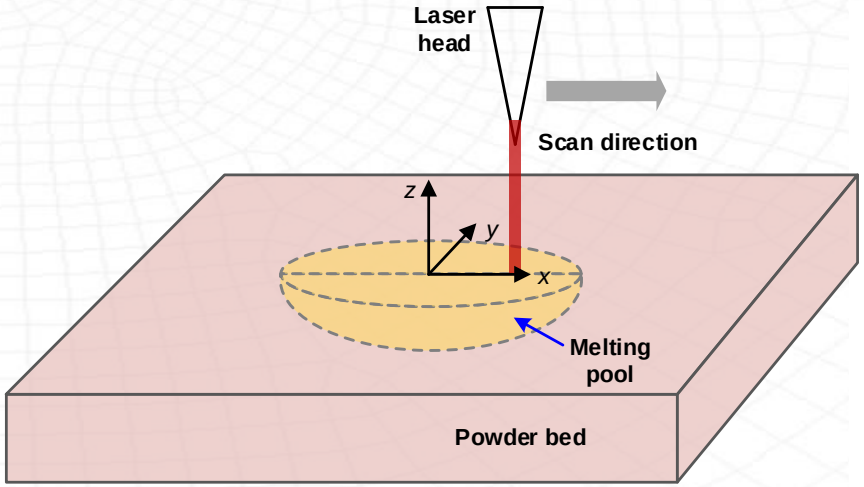
Programmable Machine Tool + **Primary Alloys** = **13X ↑ in Thermal Conductivity (30X reduced size)**

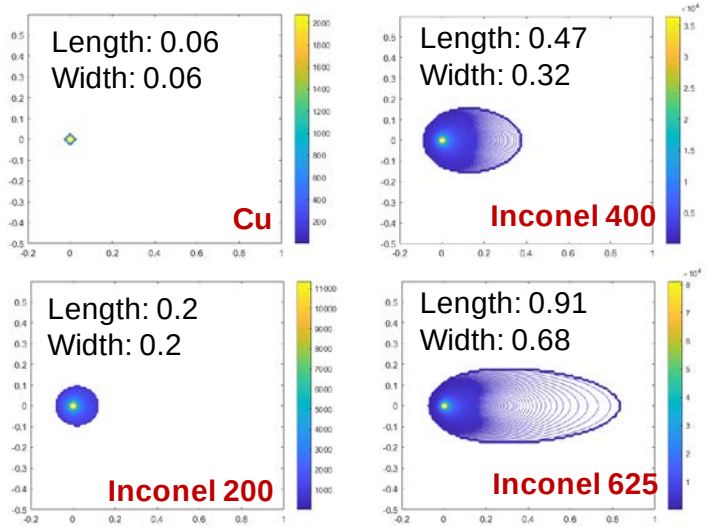
Knowledge Gaps

1. Design and materials
   a. Design methodologies to exploit voxel-level properties
   b. Characterizing graded materials
   c. Predicting microstructure based on process conditions
2. Processing
   a. Decouple mixing from process parameters
   b. Resolution and composition tolerance for graded transitions
   c. Controlling voxel size while changing composition
   d. Estimating properties needed for process models
3. Process control and data to support certification
4. Electromechanical integration

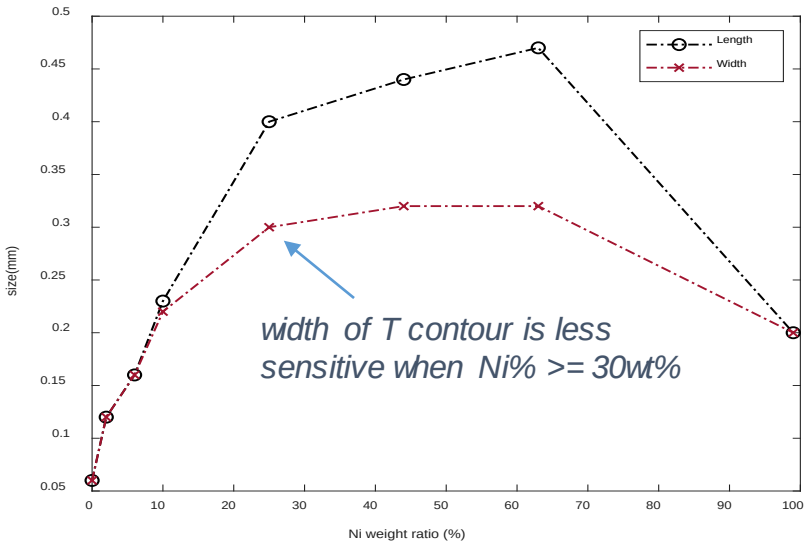
Process Control

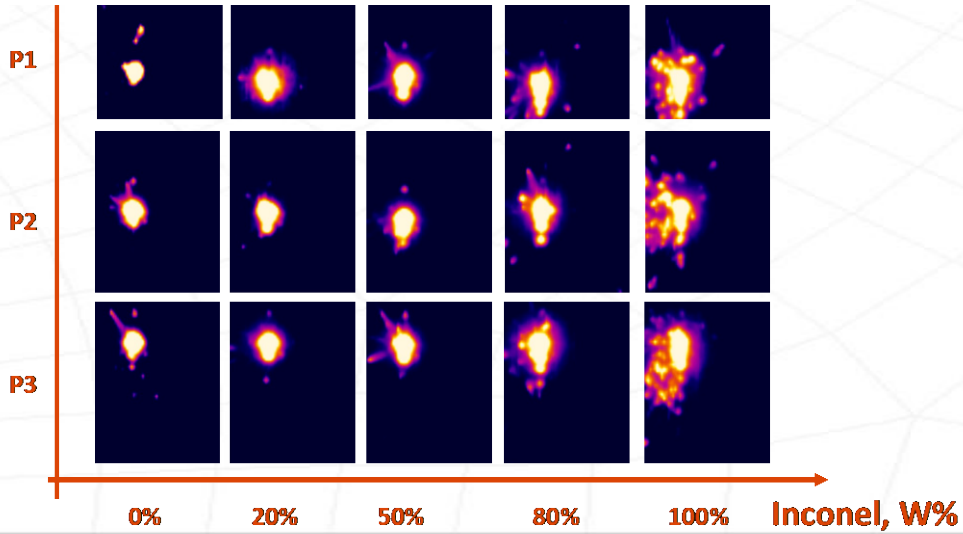
Material Composition Detection (Fan 2021)



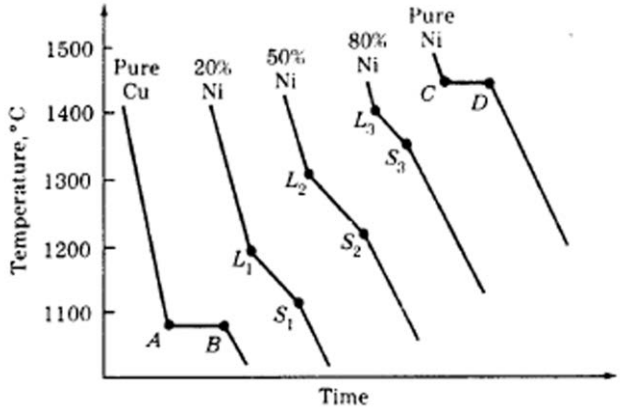


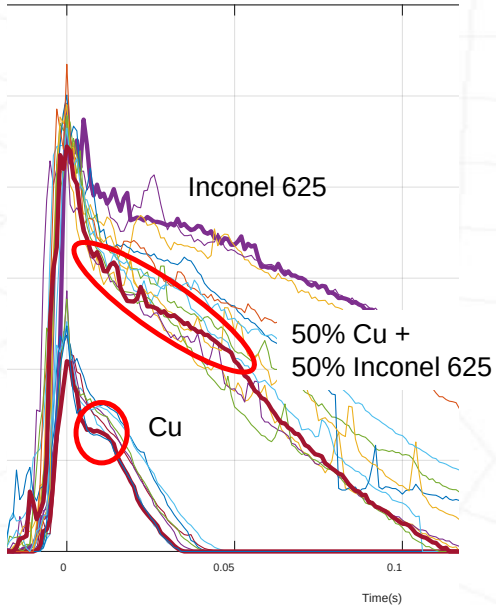
Weld Pool Dimensions





Physical Properties





Moonshot Projects

1. Chemical Reactors (hierarchical and heterogeneous)
   - Thermal circuits to direct the flow of energy between exothermic and endothermic events (Cu, mm-scale)
   - Integrated catalyst scaffolds (ferrous, micro-scale)
   - Catalyst loading (noble metal & metal-oxide, nano-scale)
2. Electromechanical Systems
   - Large-scale programmable alloys with integrated sensing
   - Equipment health monitoring
   - Space, nuclear, aerospace and defense