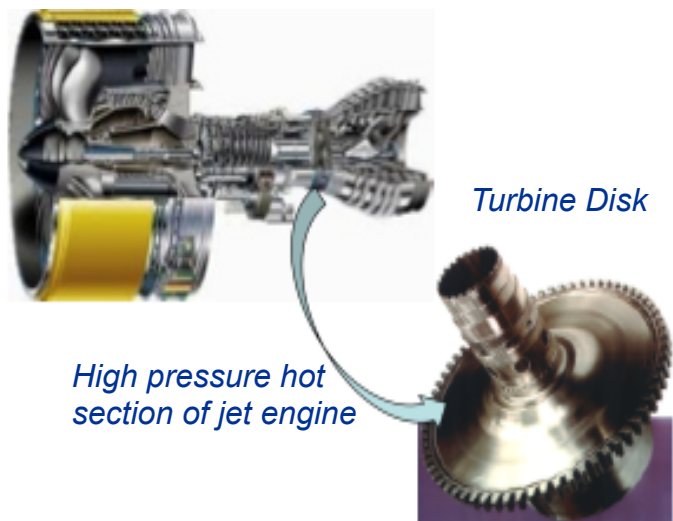




NASA/ORNL/AFRL project work on EBM LSHR: Additive manufacturing of high-temperature gamma- prime strengthened Ni-based superalloys



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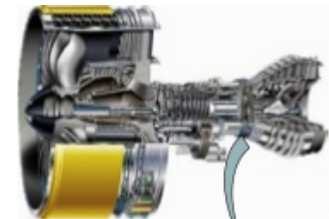
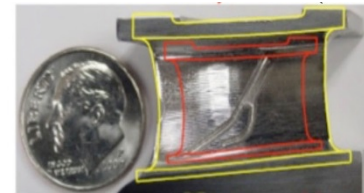
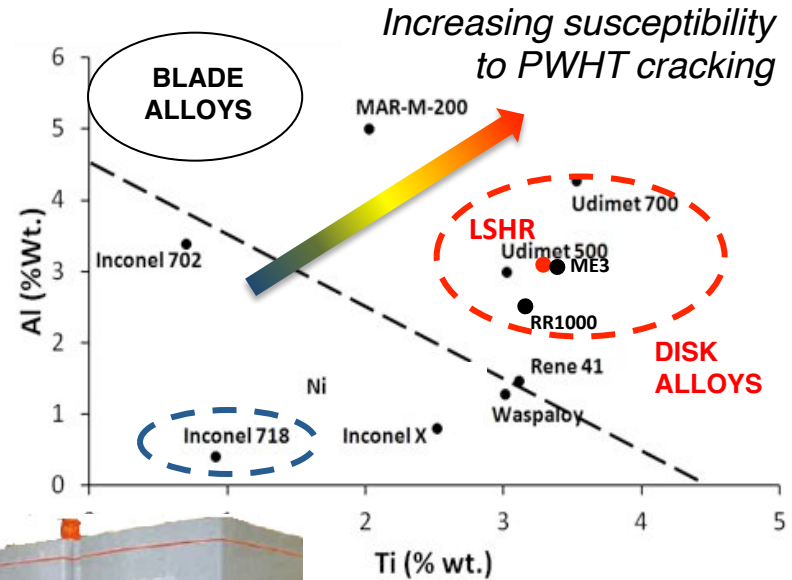
High Temperature Gamma' Strengthened Superalloys



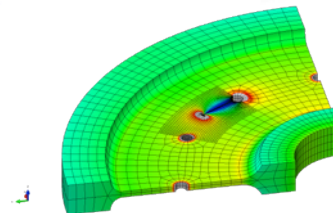
Work initiated as a CIF, has continued with ARMD, and SLS Engine Office funds

Applications: Rocket Engines, Turbomachinery for commercial & military aircraft

- **Objective:** Expand Additive Manufacturing to high temperature gamma' superalloys. Overcome the technical barriers due to poor weldability in these alloys.
- **Process:** Electron-beam melting
 - Heated powder-bed for reduced residual stresses and slower cooling rates
 - Multiple beam for faster builds
 - Vacuum for lower risk of contamination
- **Multi-Agency Team:**
 - ORNL- State-of-the art fabrication with in-situ monitoring, Arcam development center on-site
 - NASA GRC (PI)- Powder properties, analytical chemistry, microstructure evaluation, mechanical behavior
 - AFRL- microstructural modeling



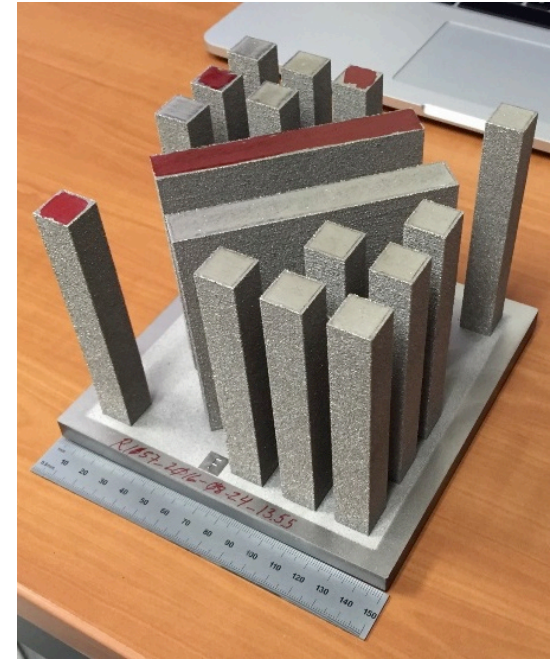
Turbine Disk



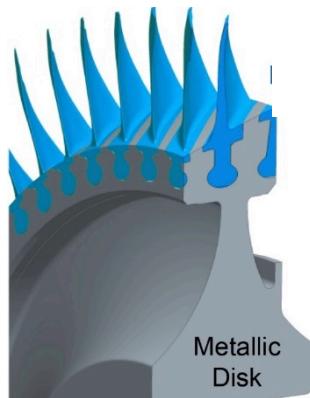
High Temperature Gamma' Strengthened Superalloys



- Technical Approach:
 - Benchmarking of A.M. feedstock
 - We are using Low Solvus High Refractory (LSHR) disk alloy
 - Identify preferred manufacturing pathway
 - Optimization of processing & post heat treatments
 - Durability assessment and detailed characterization
 - Differentiate properties of AM from conventional PM and casting technologies
- Long-range vision:
 - Development of new alloys that leverage AM capabilities and mitigate cracking
 - May extend beyond gamma-prime strengthened...
 - Tailored material properties for light weight and durability
 - Chemistry and microstructural gradients.



Test Specimens built at ORNL



<u>Location</u>	<u>Key Property</u>
1500 °F rim	Need high creep life and crack growth resistance
1300 °F web	Creep/fatigue interaction
800 °F bore	Need high tensile strength and low cycle fatigue life

