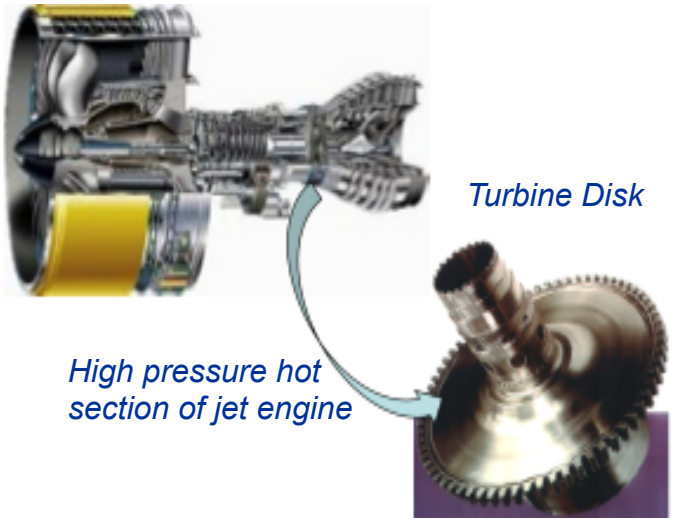
NASA/ORNL/AFRL project work on EBM LSHR: Additive manufacturing of high-temperature gamma-prime strengthened Ni-based superalloys



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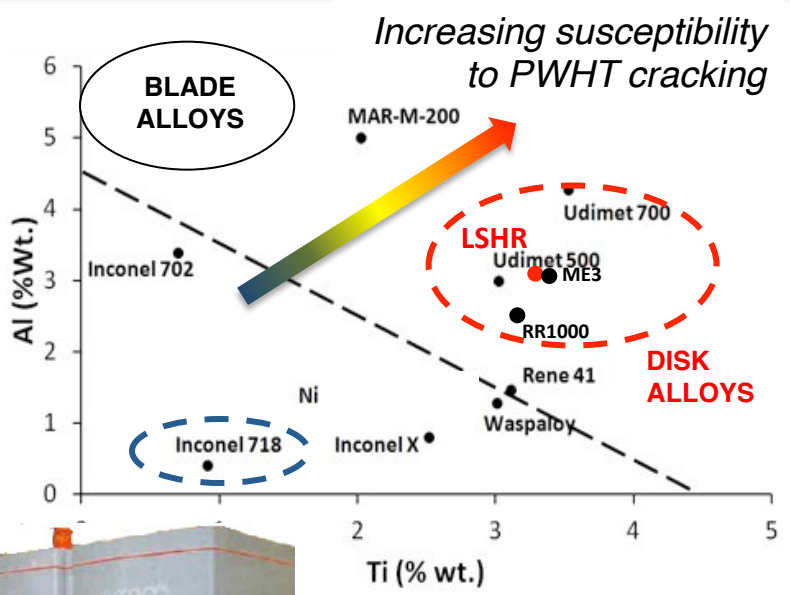
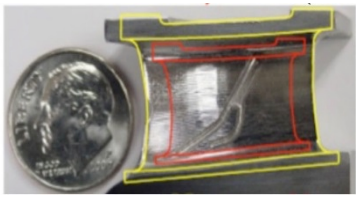
High Temperature Gamma' Strengthened Superalloys

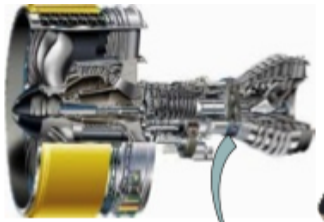
Work initiated as a CIF, has continued with ARMD, and SLS Engine Office funds

Applications: Rocket Engines, Turbomachinary for commercial & military aircraft

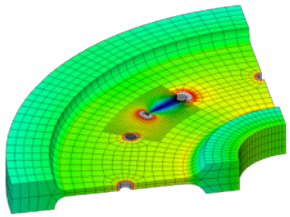
- Objective: Expand Additive Manufacturing to high temperature gamma' superalloys. Overcome the technical barriers due to poor weldability in these alloys.
- Process: Electron-beam melting
  - Heated powder-bed for reduced residual stresses and slower cooling rates
  - Multiple beam for faster builds
  - 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





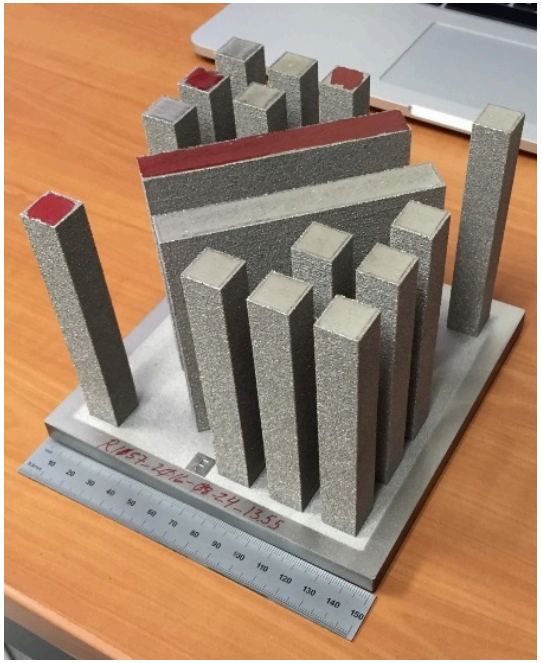


Turbine Disk

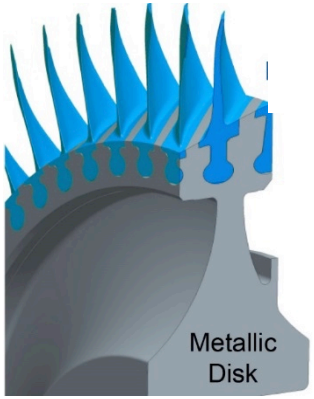


High Temperature Gamma' Strengthened Superalloys

- 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



Location	Key Property
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