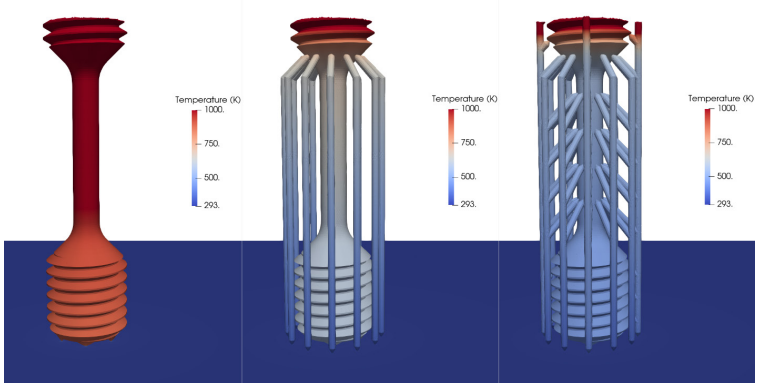
ENHANCED FUNCTIONAL ALLOYS WITH HIGH STRENGTH AND DUCTILITY

Patent Pending
SD 15173
Technology Readiness Level: 4
Key elements demonstrated in a laboratory environment

A technique for tailoring the mechanical properties of traditionally low-strength and low ductility alloys using laser beam powder bed fusion (LB-PBF) additive manufacturing

Additive manufacturing (AM) offers unprecedented design freedom that can lead to novel materials development. Intermetallic alloys have useful magnetic properties such as high permeability, low coercivity, and high saturation induction that are ideal for electromagnetic devices, particularly those in aerospace applications. However, when they are conventionally manufactured, these alloys are notoriously brittle and have poor mechanical properties that have impeded their commercialization in bulk form.

Researchers at Sandia National Laboratories and Lehigh University developed a technique to tailor the mechanical properties of traditionally low strength and low ductility alloys by introducing removable heat sink artifacts using laser beam powder bed fusion (LB-PBF) additive manufacturing. The technology enables the end-user to circumvent dependence on conventional manufacturing to achieve the desired material structure and function. This potentially impacts aerospace technologies and industries that would benefit from high strength and high ductility soft magnetic alloys, such as power generating units, internal generators for propulsion engines, and magnetic bearings.



A representation of the different thermal histories for the three designs at a location well within the upper grip at 20,000 s into the simulation. Notably the V0 design had a higher temperature throughout the specimen height compared to V1 and V2.

Technical Benefits

- Improved strength and ductility of brittle alloys
- Improved yield strength up to 300%
- Increased ductility up to an order of magnitude

Relevant AM Approach

- Laser Beam Powder Bed Fusion (LB-PBF)

Industries & Applications

- Aerospace
- Electromagnetic devices, i.e. transformers, motors, and switches
- Internal generators for propulsion engines
- Magnetic bearings
- Power generating units

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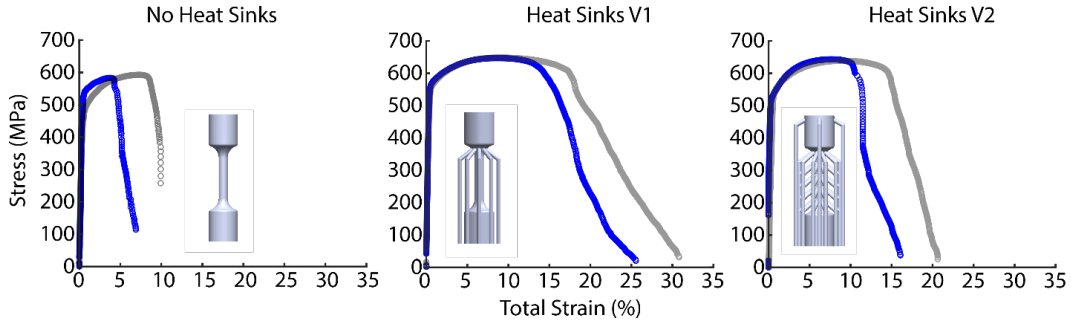
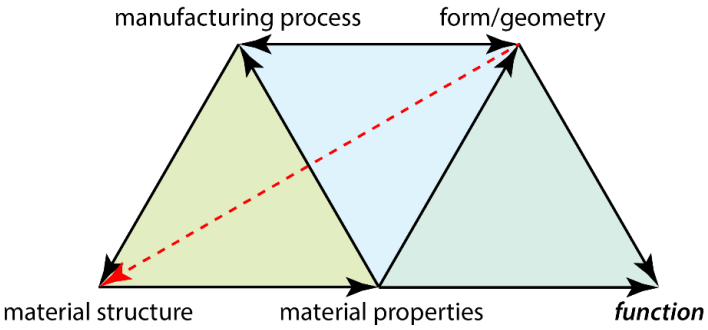
Additional Figures



Tensile stress vs. strain curves for the three AM design approaches. Specimens processed without heat sink struts exhibited significantly lower ductility than those produced with artifacts. Note: Blue and gray tensile curves are representative tensile tests.



Material, form, and function relationships constitute the conventional design space. The red dashed arrow is the new design pathway enabled by AM processing, wherein the form/geometry of the component can now directly control the material structure and thus material properties and function.

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