Continuous Bending-mode Elastocaloric Composite Refrigeration System for Compact, Lightweight, High-Efficiency Cooling

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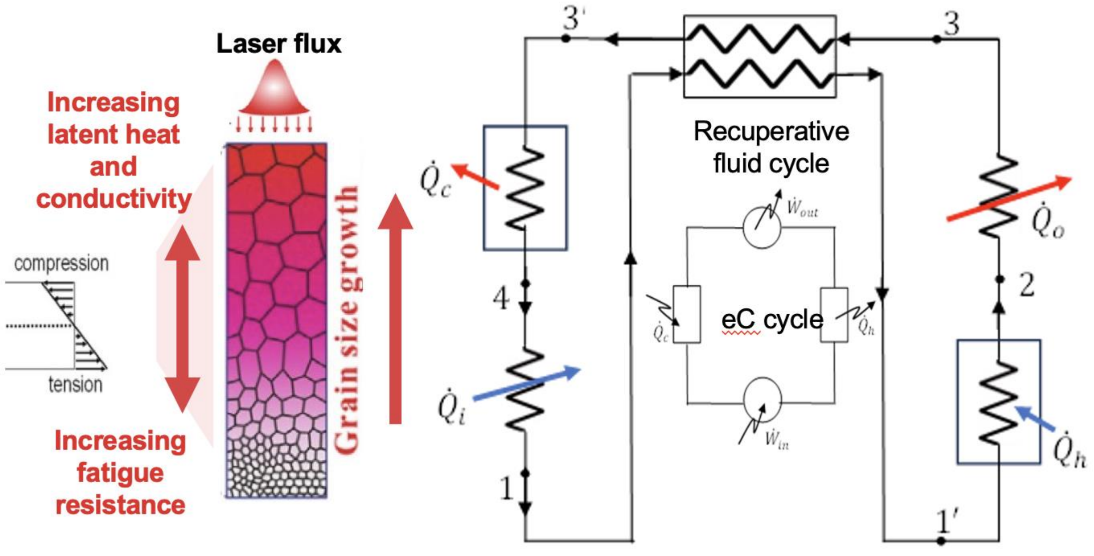
Research Approach

- Cold work and localized laser surface annealing to produce a gradient grain structure in commercially available superelastic nitinol
- Measure material properties before and after modification using Differential Scanning Calorimetry, Time-Domain Thermo Reflectance, four-point bending, fatigue life as a function of maximum strain, and adiabatic temperature change with InfraRed (IR) thermography
- Block diagram-based graphical programming environment thermodynamic model
- Computation fluid dynamic (CFD) design of microchannel heat exchanger
- IR thermography, thermocouples, differential pressure transducers, and mass flowmeters to characterize heat exchanger performance

Research Objectives

- Modify commercially available superelastic nitinol by producing a grain size gradient to create a novel metamaterial optimized for bending-mode elastocaloric cooling, using large grains in areas subject to compression to maximize latent heat and thermal conductivity and small grains in areas subject to tension to maximize fatigue resistance
- Model and optimize a novel refrigeration system architecture with work recovery and a recuperative heat exchanger in a secondary zero-GWP fluid loop
- Produce and test a critical function prototype microchannel heat exchanger integrated into a roller for bending actuation of the elastocaloric material
- Advance the material and system concept from TRL 1 to TRL 3



Caption: (Left Image) Grain gradient demonstrating the gradient in grain size in superelastic nitinol. (Right Image) Regenerative refrigeration cycle and elastocaloric cycle

Potential Impact

- Development of a zero-GWP, non-flammable, lightweight and energy efficient cooling for NASA exploration applications
- Broad commercial applications and opportunities for technology transfer and continued development