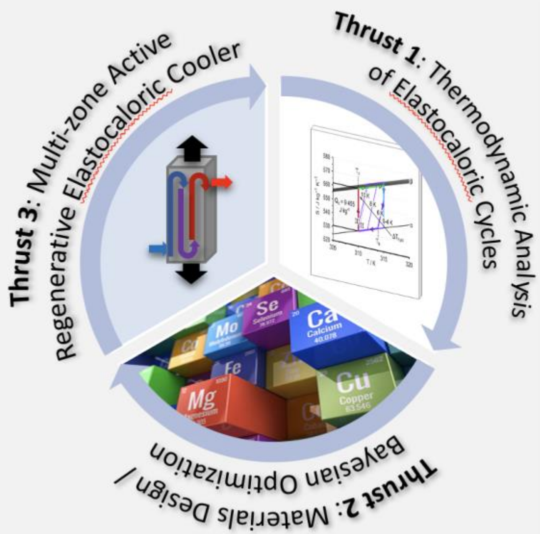
Advancing Elastocaloric Refrigeration through Co-design of Materials and Systems

PI: P. Shamberger[1] Co-PI: D. Antao[2], R. Arroyave[1], I. Karaman[1]
[1]Texas A&M University, Materials Science & Eng.
[2]Texas A&M University, Mechanical Eng.

Proposed co-design scheme integrates evaluation of materials performance and system design, unified by irreversible thermodynamic analysis of ECE refrigerant cycles.



Approach:

1. Evaluate elastocaloric effect (ECE) alloys using **irreversible thermodynamic models** based on the Preisach hysteresis formalism to quantify materials response to active regenerative cycles,
2. **Data-enabled materials design** of ECE alloy compositions and microstructures utilizing Batch Bayesian Optimization and multi-information fusion techniques,
3. **Co-design of a multi-zone active regenerative elastocaloric effect system** to evaluate the interaction between materials properties and system-level performance.

Research Objectives:

1. Quantify interactions between intrinsic materials properties, non-ideal aspects (ΔT_{hyst}, ΔT_{width}) of the phase transformation and cycle σ-T path.
2. Data-enabled design, fabrication, and processing of high-performance ECE material compositions to improve key performance metrics, validated by multi-scale characterization of their properties.
3. Demonstrate a path towards high gravimetric and volumetric cooling power density ECE refrigeration system through design/testing of a multi-zone elastocaloric device

TRL Start: X; TRL End: X

Potential Impact:

1. A validated strategy to scale the volumetric and gravimetric energy density of ECE refrigerators,
2. A set of new ECE alloys optimized for irreversible refrigerant capacity, and
3. High power density prototype elastocaloric refrigerator which aims to increase gravimetric power density by 2× to 10× over state of the art.