Title

Self-Organized Nanostructured Bonds through Transient Liquid Phase Dealloying

Research Team

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Research Objectives:

- This proposal aims to overcome major challenges in joining shape memory alloys through a controlled reaction between nanostructured laminates: interlayers made up of thousands individual layers, 10s of nm thick.
- The proposed bonding technique, **transient liquid phase dealloying (TLPD)**, relies on spontaneous pattern formation during selective interdiffusion to form nanoscale features that span the joint. Our initial work will focus on understanding fundamental reaction kinetics and processing-structure-relationships on bond strength and shape memory/superelastic performance (TRL 1), and progress to bulk interlayer fabrication and demonstration (TRL3) by the end of the effort.

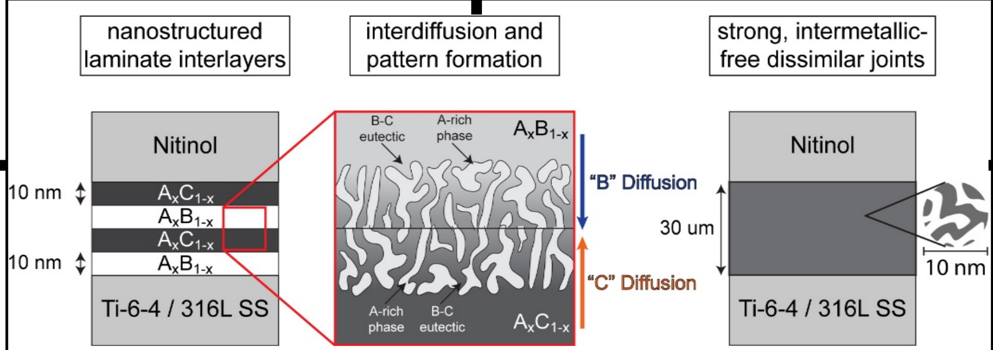

Figure 1. Illustration of transient liquid phase dealloying in nanostructured laminates. Upon heating, the layers undergo selective interdiffusion (elements B and C), driving pattern formation (in element A, which does not interdiffuse) to produce a strong joint.

Approach

Thrust 1**: **Thermodynamic Path Planning to Control Phase Evolution. Design compositional gradients within joints, *via* computational thermodynamics and path planning algorithms, to avoid intermetallic formation between dissimilar materials.

Thrust 2: Optimal Interlayer Architecture. Determine the ideal interlayer architectures (layer thickness, composition, and modulation) that produce strong, tough joints between NiTi and other materials.

Thrust 3: Scalable Fabrication of Bulk Interlayers. Establish and demonstrate powder fabrication, post-processing, and consolidation protocols to produce free-standing bulk interlayers.

Potential Impact

TLPD will enable the design and fabrication of strong, tough, and intermetallic free joints between shape memory alloys without impeding their functional performance

- Targeting > 90% joint efficiency, >10% strain to failure, with limited impact on shape memory and superelastic response, between Nitinol and: i) two Nitinol-base alloys, ii) Ti-6Al-4V, iii) Inconel 718; and iv) 316-L stainless steel.
- Our interlayers will be beneficial to any dissimilar material joining process where intermetallic formation and cracking is a concern.
- Insights into efficient functional grading can be applied to any layer-by-layer process (e.g., deposition or additive manufacturing).