Modeling of Shape Memory Alloy – MAX Phase Ceramic Composites Considering the Interaction of Multiple Inelastic Mechanisms
Doctoral Dissertation Defense

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Abstract

Shape memory alloy (SMA) – MAX phase ceramic composites (e.g, NiTi-Ti_2AlC) have recently been developed to take advantage of the unique combination of nonlinear constitutive responses. Behaviors associated with reversible martensitic transformation in the SMA phase and both recoverable and irrecoverable kinking deformations of the MAX phases have been shown to produce a material with interesting thermomechanical properties such as improved mechanical damping. To explain and analyze many of these behaviors, a series of models are developed and used to investigate this novel material system.

Specifically, models for the composite using Eshelby-based micromechanics and image based finite element techniques are constructed. Effective transformation characteristics and the response of the composite through isobaric, actuation loading cycles are explored. It is shown that thermally induced transformation results in a stress redistribution and the combination of inelastic mechanisms can induce a potentially beneficial residual stress state. A multimechanism constitutive model capable of capturing the MAX phase constitutive response is also developed and a 3D numerical solution scheme is implemented. The resultant model is used to analyze the impact of various mechanisms on the composite response.

Brian T. Lester is a PhD candidate in the Aerospace Engineering Department working under the supervision of Professor Lagoudas. His research interests focus on constitutive and micromechanical modeling of nonlinear materials and their composites. Upon completion, Brian will join Sandia National Laboratories as a post-doctoral research associate.