ABSTRACT

The dissertation presents a comprehensive understanding developed on the small-scale deformation behaviors of a Ni-rich NiTi based shape memory alloy. This material exhibits pseudoelastic characteristics at room temperature. Accordingly, the alloy undergoes reversible stress induced phase transformations between the parent austenite (high-symmetry *B2*-crystal-structure) and the product martensite (low-symmetry *B19′* monoclinic-crystal-structure) phases. To appreciate this functional mechanism of NiTi at sub-micron scale, nanoindentation is used as a primary characterization tool. In a unique approach, experimental parameters including the indenter tip configurations (Berkovich and spherical) and sizes (10, 20 and 50 μm) as well as applied load levels (1 mN to 7 mN) are varied systematically. It is noticed that, a combination of spherical nanoindenter tip of radius 20 μm and indentation-load level of 5 mN is optimum to assess pseudoelasticity in NiTi at sub-micron scale. This dissertation reports for the first time a simplified and specialized approach for converting nanoindentation *P-h* curves to the corresponding indentation stress-indentation strain ($\sigma_{ind\text{-}S}$ - $\varepsilon_{ind\text{-}S}$) responses. The obtained stress-strain curves replicate all the unique characteristic features of a pseudoelastic system. The insight on the localized deformation behaviors of NiTi system is extended further by investigating the crucial roles played by various crystallographic-phases as well as the indenter tip configurations. Significant modifications in the thermal, structural and functional properties are realized owing to the occurrence of different phases as well as the associated indentation-induced strain generated and stress mis-match in the heat-treated NiTi alloys. Detailed study is pursued next to investigate the influence of crystallographic orientations on deformation behavior of NiTi alloy upon application of multi-axial stress-state via nanoindentation. It is noted that crystallographic orientation significantly modifies the mechanical properties, particularly pseudoelastic characteristics of the alloy system. The most favorable one for best pseudoelasticity in Ni-rich NiTi alloy is identified. The novel procedure developed in this dissertation to assess pseudoelasticity of materials, is validated next on *additively manufactured* NiTi based *SMA*s. It is observed that microstructural and phase evolution as well as the related thermal and functional characteristics of NiTi alloys change significantly upon altering the processing parameters of additive manufacturing. The novel nanoindentation protocol succeeded to identify the optimum processing conditions of *Laser-Engineered-Net-Shaping* to manufacture NiTi alloy with superior pseudoelasticity.

***Keywords*:** Shape memory alloys; Pseudoelasticity; NiTi; Nanoindentation; Crystallographic-phase; Crystallographic-orientation; Additive manufacturing.