

# Materials Science & Engineering Doctoral Defense

## Synthesis and Mechanical Behavior of NiTi Films with Controlled Microstructures

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### Abstract

Thin films are widely used for a variety of applications such as electrical interconnects, sensors, as well as optical, mechanical, and decorative coatings. Thin films made of NiTi, commonly referred to as nitinol, have generated recent interest as they are highly suitable for high frequency thermal actuation in microelectromechanical devices because of their small thermal mass and large surface-to-volume ratio. The functional properties of NiTi arise from a diffusionless phase transformation between two of its primary phases: austenite and martensite. This transformation leads to either the shape memory or pseudoelastic effect, where inelastic deformation is recovered with and without the application of heat, respectively. It is well known that the mechanical properties of NiTi are highly dependent on the microstructure, but few studies have been performed to examine the mechanical behavior of thin NiTi films (thickness below 200 nm), which are expected to have grain sizes in a similar range. The primary intent of this work is the synthesis of NiTi thin films with controlled microstructures, followed by characterization of their microstructure and its relationship to the mechanical properties. Microstructural control was achieved by utilizing a novel synthesis technique in which amorphous precursor films are seeded with nanocrystals, which serve as nucleation sites during subsequent crystallization via thermal annealing. This technique enables control of grain size, dispersion, and phase composition of thin films by varying the parameters of seed deposition as well as annealing conditions. The microstructures and composition of the NiTi thin films were characterized using X-ray Diffraction, Electron Microprobe Analysis, High-resolution Transmission Electron Microscopy, Secondary Ion Mass Spectroscopy, Differential Scanning Calorimetry, as well as other complementary techniques. Mechanical properties of the films were investigated using uniaxial tensile testing performed using a custom microfabricated tensile testing stage. The NiTi thin films exhibit mechanical behavior that is distinct from bulk NiTi, which is also highly sensitive to small changes in microstructure and phase composition. These findings are rationalized in terms of the changes in deformation mechanisms that occur at small grain sizes and sample dimensions.



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Zoom Link: <https://asu.zoom.us/j/83687630511>