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Multi-Scale Experimental Studies of Shape Memory Alloys

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Abstract: Shape memory alloys (SMAs) are a group of metallic alloys that can revert to a previously defined size or shape when deformed and then heated past a set transformation temperature. This "shape memory" behavior is due to a shear-dominated diffusionless transition between crystalline phases of different symmetries, termed austenite and martensite. SMAs display other unusual mechanical properties that make them highly useful, including superelasticity, high vibration damping, high yield stresses, and high power to weight ratios. Nickel-Titanium is a promising SMA used in a wide variety of applications, including advanced biocompatible and MEMs devices.

This talk will discuss two experimental investigations into the propagation of stress-induced martensite through thin sheets of Nickel-Titanium. The first, performed at the meso- and macro-scale, investigates the phase transformation behavior as a function of material texture and cycling. This will include a discussion of the characteristics of the phase fronts and evolution of martensitic volume fraction, as well as evidence of a remarkable cyclic strain memory on the microscale. The second investigation utilizes a novel method to examine phase transformation at the grain level. This is achieved by combining an optical technique known as digital image correlation with scanning electron microscopy, an approach termed here as SEM-DIC. The development of the methodology will be discussed, including new SEM-DIC patterning techniques for the reduced length scale and an approach to correct micrographs for the complex distortions inherent in SEM imaging. Using the DIC-calculated displacements, the progression of phase transformation and its relation to the underlying crystallography is examined at the grain level in mechanically loaded tensile samples.