ON THE CHARACTERIZATION OF THIN SHEETS OF NICKEL-TITANIUM USING DIGITAL IMAGE CORRELATION

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Shape memory alloys (SMAs) are a group of metallic alloys that are able to 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 diffusion-less transition between crystalline phases of different symmetries. SMAs display other unusual mechanical properties that make them highly useful, including pseudoelasticity, high vibration damping, high yield stresses, and high power to weight ratios. In addition, the alloys are durable and corrosion resistant. Nickel-Titanium, commonly referred to as Nitinol, is a promising shape memory alloy used in a wide variety of applications, including advanced biocompatible and MEMS materials.

This paper presents an experimental investigation into the propagation of a martensitic phase boundary through thin sheets of austenitic Nitinol. The phase boundary is observed using Digital Image Correlation (DIC). DIC is a full-field optical correlation method used to measure strain on the surface of an object by optically tracking a speckle pattern on the sample surface. Correlation software is then used to translate discrete speckle motion to strain fields that directly relate to phase boundary nucleation and propagation. Strain fields indicating phase transformation are investigated in a solid dogbone specimen, and around surface features including a center hole and a side notch. We have evidence that there exists strain localization before band formation, depending on the geometry of the specimen. In addition, by using techniques including chemical etching, optical microscopy, and XRD, we have found that the crystallography of the specimen affects the mesoscopic behavior. Although it was previously known that strain inside of Nitinol localizes and forms bands during change of phase, our experimental technique clearly maps the quantitative strain measures inside the shear bands and the distribution of that strain for the first time.

In addition to these experiments, we have been able to determine previously unknown fracture properties of thin sheets of Nitinol, including average fracture toughness and dependence of K_{IC} on crack length. Using DIC, strain fields directly relating to phase boundary nucleation and propagation around the crack tip are observed. The DIC technique has the potential to be extended to several other classes of materials as an aid in the characterization of material instabilities.

Keywords: Nickel-Titanium, DIC