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AEROSPACE AND MECHANICAL ENGINEERING

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TOPIC: Stress-induced Transformation during Deformation and Fracture of a Shape Memory Alloy, Nitinol

DATE: Tuesday, October 2, 2007

TIME: 3:30 p.m.

PLACE: 138 DeBartolo Hall

ABSTRACT

Nitinol is a shape-memory alloy with numerous biomedical and other applications due to its superelastic nature and its ability to revert to a previously defined shape when deformed and then heated past a set transformation temperature. While the crystallography and the overall phenomenology are reasonably well understood, much remains unknown about the deformation and failure mechanisms of these materials. This talk will describe the investigation of the stress induced transformation during deformation and failure of nitinol using the in-situ optical technique of digital image correlation (DIC). With this technique, full-field quantitative maps of strain localization have been obtained for the first time in thin sheets of nitinol under tension. These experiments provide new information connecting previous observations on the micro- and macro- scale. They show that martensitic transformation initiates before the formation of localized bands, and that the strain inside the bands does not saturate when the bands nucleate. The effect of rolling texture, the validity of the widely used resolved stress transformation criterion, and the role of geometric defects are examined. An experimental investigation of fracture will be presented, including the observed saturation and transformation zones around the cracktip, as well as a determination of the fracture toughness for thin sheets of nitinol. A small scale transformation analysis of a crack in a shape memory alloy, namely nitinol under plane stress conditions through analytical and numerical modeling will be discussed. A fully transformed region immediately around the crack tip, a transition region, and a far-field untransformed elastic region are found. The nature of the stress and strain fields in the various regions, and the relationship between Jtip and Japplied in light of the transformation process are discussed. Scaling relations are proposed for the size of the saturation and transition regions as a function of the applied stress intensity factor. The analysis introduced here could provide a foundation for understanding the fracture mechanics of nitinol and other shape memory alloys.