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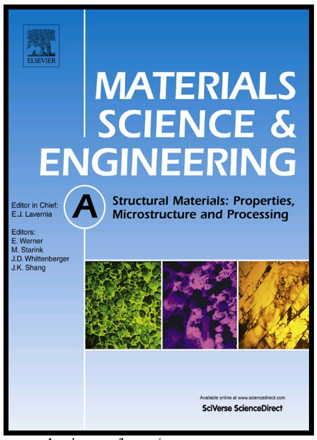

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Effect of Machined Feature Size Relative to the Microstructural Size on the Superelastic Performance in Polycrystalline NiTi Shape Memory Alloys

Partha P. Paul[a,*], Harshad M. Paranjape[b], Behnam Amin-Ahmadi[b], Aaron P. Stebner[b], David C. Dunand[c], L. Catherine Brinson[a,c]

[a]*Mechanical Engineering, Northwestern University, Evanston, IL. 60201.*
[b]*Mechanical Engineering, Colorado School of Mines, Golden, CO. 80401.*
[c]*Materials Science and Engineering, Northwestern University, Evanston, IL. 60201.*

Abstract

This study demonstrates a transition from a structure-dominated response to a microstructure-dominated response around machined features in a polycrystalline NiTi shape memory alloy (SMA), as the size of the features relative to the mean grain size is varied. The specific structural features considered are a pair of holes of varying separation and size in the 100-500 micrometer range. The local deformation around the holes is experimentally characterized during superelastic loading and compared with the predictions of a macro-scale phenomenological model for phase transformation. This comparison, coupled with a microstructural analysis reveals two key results. In the case when the holes are much larger than the grains, the local strain fields are predominantly determined by the stress concentrations around the structural features, and they are adequately predicted by the phenomenological model. However, when the holes and the grains are of comparable size, microstructural heterogeneity and fine-scale microstructural features such as precipitates determine the local superelastic response. The prediction of the macro-scale model in this case significantly deviates from the experimental observation. A key outcome of this work is a criterion in terms of the microstructure and the relative structural feature size in SMAs for determining the applicability of macro-scale models vs. micromechanical models of phase transformation for predicting the local deformation response.

Keywords: Nickel Titanium, Shape Memory Alloys, Digital image correlation, Electron back scattering diffraction, Size Effects

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1. Introduction

Shape Memory Alloys (SMAs), which derive their remarkable properties from a martensitic phase transformation, have received broad attention to understand the mechanics and

*Corresponding author:
Email address: parthapaul2018@u.northwestern.edu (Partha P. Paul)

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