Local composition and microstructure control for multiple pseudoelastic plateau and hybrid self-biasing shape memory alloysFC

Andrew Pequegnat, Boyd Panton, Y. Norman Zhou, M. Ibraheem Khan

PII: S0264-1275(15)30937-0
DOI: doi: 10.1016/j.matdes.2015.12.078
Reference: JMADE 1102

To appear in:

Received date: 20 July 2015
Revised date: 11 December 2015
Accepted date: 14 December 2015

Please cite this article as: Andrew Pequegnat, Boyd Panton, Y. Norman Zhou, M. Ibraheem Khan, Local composition and microstructure control for multiple pseudoelastic plateau and hybrid self-biasing shape memory alloysFC, (2015), doi: 10.1016/j.matdes.2015.12.078

Local Composition and Microstructure Control for Multiple Pseudoelastic Plateau and Hybrid Self-Biasing Shape Memory Alloys

Andrew Pequegnat[1], Boyd Panton[2,3], Y. Norman Zhou[2,3], M. Ibraheem Khan[1]

[1]*Smarter Alloys Inc., 75 Bathurst Drive, Suite B, Waterloo, ON, N2V 1N2, Canada*
[2]*Centre for Advanced Materials Joining, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada*
[3]*Centre of Bioengineering and Biotechnology, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada*

Abstract

Shape memory alloy (SMA) materials with multiple pseudoelastic (PE) plateaus, and hybrid components with both the PE and the shape memory effect (SME) have been designed with a newly developed processing protocol. This protocol utilised a pulsed laser based vaporization process to precisely alter the local composition of NiTi based SMAs. Each laser pulse decreased local Ni composition by 0.16 at. %., leading to controlled changes in transformation temperatures. Control of the local composition enabled strengthening by cold work and heat treatment, while maintaining distinct SMA properties throughout the material. The combined cold rolling and annealing used in this study significantly increased the yield strength of the materials allowing for tuneable performance offerings. These included the multiple PE plateau stresses, or combined SME and PE properties in a monolithic tensile specimen. The synergistic behaviour of adjacent locally processed regions demonstrated a significant increase in SMA functionality and their potential in future application. These novel technologies are now being applied in a multi-force orthodontic archwire capable of simultaneously applying biomechanically optimized tooth moving forces to each tooth along the dental arch.

Key words: Shape memory alloy (SMA); NiTi; multifunctional materials, Laser processing; Post-processing; Cold work; Heat treatment; Composition; Microstructure; Shape memory effect (SME); Pseudoelasticity (PE)

1. Introduction

The exceptional performance offerings of NiTi based shape memory alloys (SMAs), which includes the shape memory effect (SME), pseudoelasticity (PE) and biocompatibility have led to widespread acceptance of these alloys as valuable engineering materials. Over the past several decades the complex metallurgy behind the SME and PE properties has for the most part been uncovered [1] and the design and engineering knowhow demonstrated [2, 3]. This work has facilitated successful application of NiTi devices in numerous industries. Specifically, the implementation of SMA actuators in the aerospace and automotive industries is currently very attractive as a green technology for light weighting, yielding