**Characterizing Microcleanliness in Superelastic Nitinol Wires and Effects on Lifetime Performance**

Gbur, J.[1] and Lewandowski, J.[1]

[1] Department of Materials Science and Engineering, Case Western Reserve University, United States

Janet L. Gbur and John J. Lewandowski
Case Western Reserve University, Department of Materials Science and Engineering

Miniaturization of medical devices requires increased performance from less material, and therefore necessitates investigation of the connection between material processing and performance. Moreover, it is imperative to understand how impurities that result from processing affect the lifetime performance of that material. Research on the microcleanliness of fine (< 0.150 mm) Nitinol wires and its effect on fatigue performance are not frequently found in literature.

This study compared standard purity (SP) and high purity (HP) superelastic Nitinol fine wires. The nominally equiatomic nickel and titanium wires were provided with bright (SP) and black oxide (HP) finishes. Non-metallic inclusions were generally titanium-rich nickel oxides with varied morphology, occurred with and without pores, and as stringers along the wire drawing direction. Combined inclusion/pore area percentages ranged from 0.08% (HP) to 1.4% (SP) when measured with scanning electron microscopy while plasma focused ion beam serial sectioning and x-ray microscopy volume percentages ranged from 0.1% (HP) to 1.7% (SP).
Microindentation hardness measurements showed gradients across the wire diameter and were compared to strength and fatigue behavior. Higher tensile and upper plateau strengths were observed in SP Nitinol with greater reduction in area for HP Nitinol. Fatigue enhancement was observed in HP Nitinol wires in flex bending fatigue at strain amplitudes from 0.67-11%. Rotating bending fatigue only tested from 1.2-1.5% strain amplitude due to machine limitations. Fractography showed crack initiation attributed to a pore or inclusion at the surface or sub-surface with fatigue initiation feature areas ranging from submicron to nearly 20 squared micrometers.
Overall, HP Nitinol contained less large-dimension inclusions/pores than SP Nitinol leading to less potential stress concentrations and points for crack initiation. These differences in microcleanliness were reflected in higher HP uniaxial tensile ductility and in the fatigue results. The HP Nitinol exhibited enhanced fatigue resistance in both low cycle fatigue and high cycle fatigue regimes.