FATIGUE BEHAVIOR OF NiTi BASED SHAPE MEMORY ALLOYS

PS&ED 2014-2015 Doctoral Cluster Program

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Motivation

- Nitinol is a widely popular biocompatible SMA that has biomedical applications such as **heart valves and vascular stents.**
- **Fatigue life** is the critical performance criterion and is mainly affected by the non-metallic **carbide** and **oxide** inclusions
- Accurately model the minimum fatigue life of the device made of these SMA's

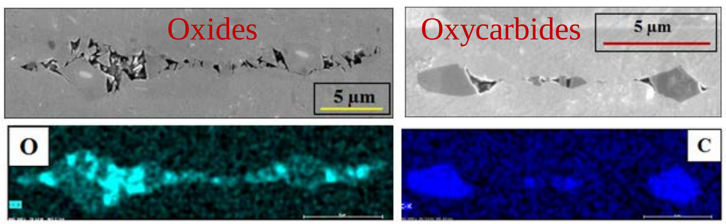
Design Objectives

- Develop an accurate finite element model based on **actual 3D microstructure** to predict fatigue life
- Investigate the effect of **inclusions' size** and percentage of debonding on fatigue life
- Study the effect of **inclusion type** on the overall fatigue life

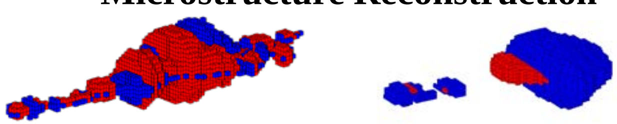
Methods

- Fine and coarse reconstruction of the **3D structure** FIB/SEM images by intrapolating the information from 2D slices
- FEA model utilizes crystal plasticity to predict **Fatigue Indication Parameter (FIP)** at different strain levels
- FIP calibrated to minimum Nf via **Weibull analysis** of experimental fatigue data

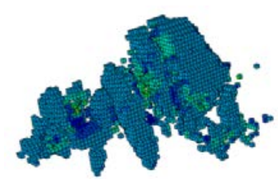
Microstructure characterization (SEM & EDS)



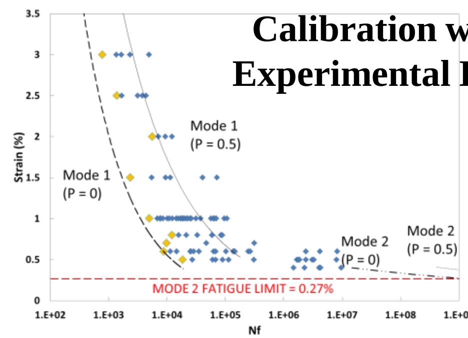
Microstructure Reconstruction



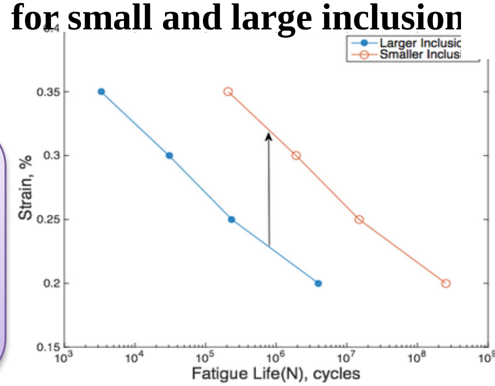
Finite Element Simulation for Fatigue



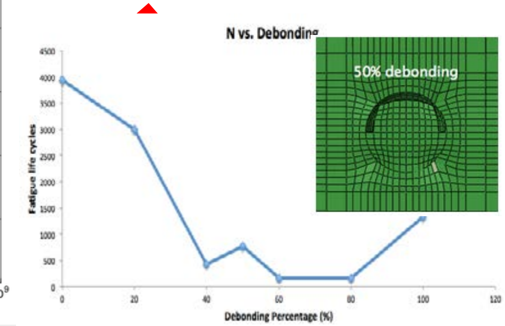
Calibration with Experimental Data



Strain vs. Fatigue Life for small and large inclusion



Fatigue Life vs. % debonding for 1% strain level



Conclusions

- Finite element modeling predicted a 60 times increase in fatigue life for a one third reduction in inclusion size.
- The increase in Fatigue Life due to size reduction of inclusions was seen to be independent of the applied strain level.
- Increase in inclusion debonding with the matrix decreased the fatigue life till about 60% debonding.