ENVIRONMENTALLY ASSISTED FATIGUE OF SUPERELASTIC NiTi

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Superelastic NiTi implants transforming cyclically in body fluids suffer from fatigue failures which are extremely difficult to predict. This clearly points out towards environmental effects promoting surface dominated fatigue degradation. The specialty of phase transforming NiTi shape memory alloy is that either the parent austenite or the product martensite phase exist at the excessively deforming metal/liquid interface covered by the thin TiO2 surface. In order to explore the environmental effects at such mechanically active metal/liquid interface, we have developed dedicated electrochemical apparatus and methods combining electrochemical cell, mechanical tester and thermal chamber. We are able to follow and/or control the mechanically triggered periodical breakdown/passivation process on the metal/liquid interface occurring during cyclic tensile tests on NiTi wires and springs in fluids. In this way we are able to analyze the effect of surface finishing treatments on fatigue performance and/or control it electrochemically. In this talk, we will introduce two in-situ electrochemical methods especially open circuit potential and potentiostatic polarization applied during fatigue testing. We will focus on the problem of non-stationary thermodynamic equilibrium established at the mechanochemically loaded wire surface. Kinetics of the surface reactions encountered during this type of environmental fatigue testing will be revealed. SIMS depth profile analysis and chemical imaging of the surfaces of fatigued wires was employed to prove the assumed electrochemical activity upon cycling, particularly to the hydrogen absorption and growth of passive oxide layer within cracks. Microcracks forming on the surface of fatigued wires were observed by 3D SEM/FIB sectioning method. Based on the results, mechanisms of environmental fatigue degradation of NiTi implants deforming cyclically in body fluids will be proposed.