SFB499 Young Investigator Group: Microreliability

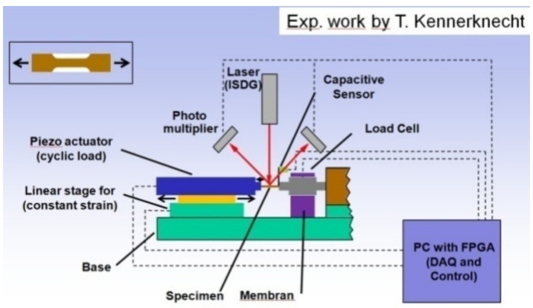
C. Eberl, T. Kennerknecht, T. Straub, M. Funk, S. Burger

Reliability of micro-molded components – T. Kennerknecht, T. Straub (since Jan. 2008)

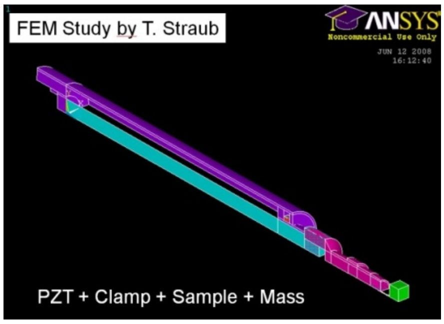
This research focuses on the fatigue behavior of micro-molded samples (cross section down to 30µm x 100µm), made of materials such as gold alloys and bronze. During manufacturing micro-molded components cool down quickly due to their small volume and the large surface to volume ratio. This leads to a very fine micro structure, similar to MEMS and coating materials. Therefore, size effects and scaling laws are expected to dominate reliability of micro-molded components.

A custom built micro-sample fatigue setup is assembled in order to conduct life-time experiments as shown in Fig. 1a. Cyclic loads up to 1 kHz are applied using a piezostack with a resolution down to 0.6 nm. Strain can be determined by means of digital image correlation, laser interferometry and capacitive displacement measurement. Therefore local plasticity and crack propagation can be detected and analyzed.

Extensive Finite Element simulations of the resonant micro-fatigue setup were carried out and an example of the FE model is shown in Fig. 1b. The results from these simulations will help design a novel resonant fatigue setup allowing the application of mean stresses while working in resonance, allowing for higher strain amplitudes at 1 kHz. SEM and FIB will be used to characterize the microstructure and defect morphology in these samples. The interpretation of the fatigue experiments will help to understand the active fatigue mechanisms and their sensitivity on sample geometry and frequency in micro-molded specimens as well as in metallic MEMS and coating materials.



(a)



(b)

Fig. 1: a) The sketch shows the custom built micro-fatigue setup consisting of a linear stage, a piezostack, the sample and a load cell. Strain can be measured by the use of a laser interferometric technique as well as with a camera and digital image correlation and tracking. Fig. 1b shows the FEM model of the used piezostack (blue) in a steel casing (violet) and a sample attached to the sample grip (pink) with a small mass (green) at the end that is designed to work at 1kHz

Fatigue in thin film alloys – S. Burger (since Sept. 2008)

Fatigue in thin film material differs strongly from bulk material behavior. As pure thin films have been investigated almost nothing is known how different alloying systems influence the fatigue mechanisms. As thin films in modern applications, e.g. microprocessors or automotive electronics, are always based on alloys there is a need to understand the fatigue mechanisms to be able to predict lifetimes of these materials.

Reliability of nanocrystalline *materials - M. Funk (since Aug. 2008)*

Due to the outstanding mechanical properties of nanocrystalline materials, nc-Ni was chosen as a first model material to study fatigue processes since the simple deposition process makes it very valuable as coating material. Even though deformation processes in nanocrystalline materials are not fully understood, nc-Ni is one of the deepest investigated nc-metals. Since the fatigue mechanisms are not well understood, we will investigate frequency, grain size and scaling effects on the lifetime and the fatigue mechanisms.

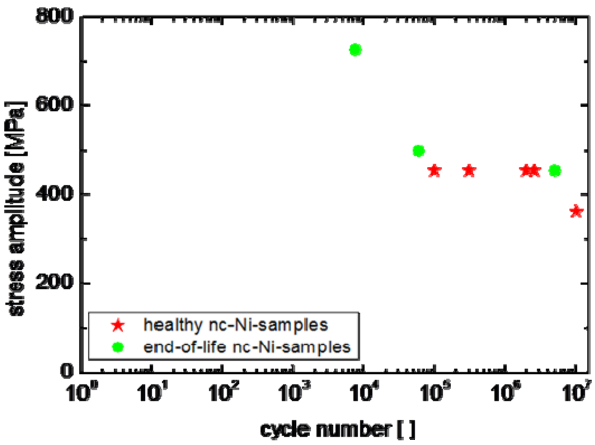


Fig. 2: Wöhler-diagram of nc-Ni samples. To be able to observe ongoing damage mechanism, the experiments were interrupted to conserve different states in the lifetime of these samples

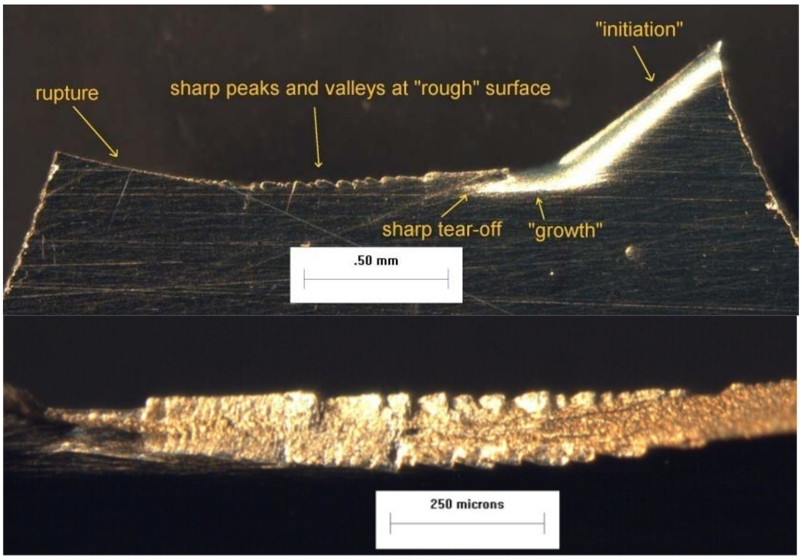


Fig. 3: Optical micrographs show the fracture surface of an nc-Ni fatigue sample