Time dependent mechanics in metallic MEMS

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Time-dependent mechanics in metallic MEMS

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1. Introduction

Creep and fatigue failure of metals in radio-frequency micro-electromechanical systems (RF-MEMS) impede their reliable application [1, 2]. Micro-scale studies of these mechanisms are scarce [3].

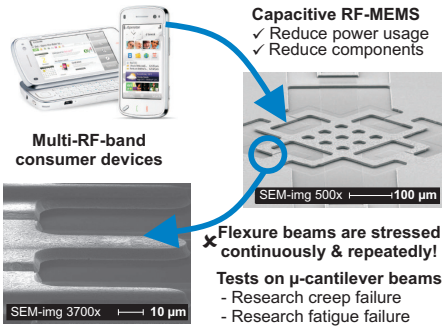

Figure 1: An exemplary application of RF-MEMS.

2. Objective

- Develop a method to characterize creep behavior of μm-sized aluminum MEMS cantilevers.
- Correlate this behavior to statistics of grain size, orientation and boundaries.

3. Methods

- A numeric-experimental method is developed for mechanical characterization, see fig. 2.
- Grain structure characterization is done with orientation imaging microscopy (OIM) utilizing electron backscatter diffraction.

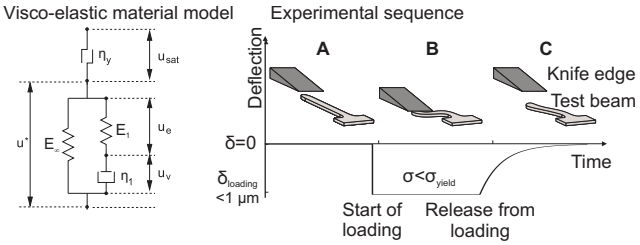

Figure 2: (l) A finite element model of the exact beam geometry based on a standard-solid visco-elastic material model is used to extract parameters from experimental data of creep behavior. (r) Schematic of the experiment in which a micro-manipulated knife edge deflects a cantilever. A confocal optical profilometer captures the deflection δ as function of time.

4. Results

- Numeric-experimental parameter characterization yields 20% accurate determination of time constant, see fig. 3.
- Preliminary OIM maps indicate great variation in grain sizes and boundary orientations, see fig. 4.

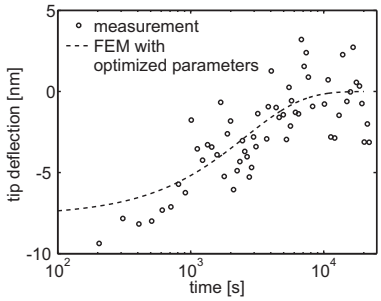

Figure 3: Resulting prediction by FEM of a different experiment based on material parameters determined from a previous measurement.

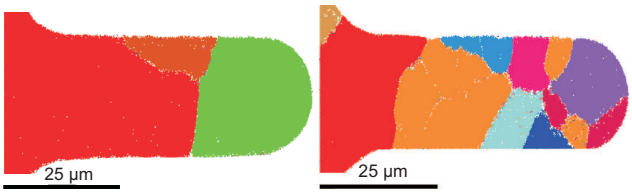

Figure 4: Grains in cantilever beams visualized by OIM maps for a specimen containing (l) few grains and (r) many grains. The colors indicate different grains.

5. Future work

- Investigate size-effects: correlate grain texture and statistics to observed behavior using OIM.

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References

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[3] T. Connolley, P. E. McHugh, M. Bruzzi, Fatigue Fract. Eng Mater. Struct. **28**, (2005) 1119-1152