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COMPARING SIMULATIONS AND MEASUREMENTS OF PRESTRESSED MEMS

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ABSTRACT

Microbridges are a special type of microsystems, which are very small structures. Normally their dimensions range from several micrometers to about a tenth of a millimeter. They are created on the same type of wafers with the same type of technologies as microchips. Figure 1 shows such a microbridge, figure 2 gives a 2D schematic picture. The total geometry has two electrodes: the bottom electrode located at the 'ground' below the bridge and the top electrode creating the span. They are operated by applying an electric potential difference between the electrodes, causing a nett positive charge in one of the electrodes and a nett negative charge in the other electrode. Due to the forces that these charges exert on each other the bridge will be attracted to the ground.

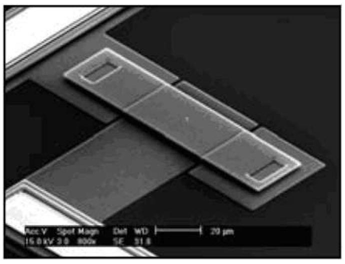

Figure 1: Microbridge.

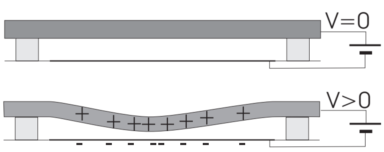

Figure 2: Schematic microbridge.

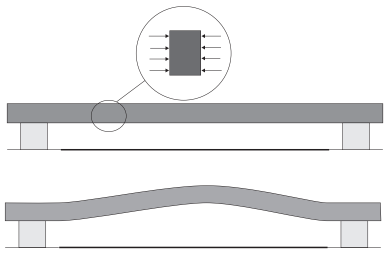

Figure 3: Effect of prestress.

A particular problem for micro-fabricated bridges is that due to the used fabrication processes the suspended part of the bridge 'wants' to expand, but the bridge is constrained by the design, therefore it cannot expand, which causes compressive stresses [1]. When these stresses are high enough the beam will actually expand to a curved initially deformed configuration as in figure 3. If such an initially deformed bridge is subsequently electrically actuated it will be very likely to buckle or snap somewhere during the loading procedure [2,3].

Buckling is an effect that can only be described by a geometrically non-linear model. Therefore these microbridges provide an interesting case to validate the coupling between geometrically non-linear structural FEM Models and electrostatic FEM models. First the used coupled formulation presented by Rochus et.al. [4] is verified by comparing it to the well known commercial code *Comsol Multiphysics* on the test case in figure 4. Some important differences between these approaches have already been summarized in [5]. In figure 4 symmetry is used to reduce the number of degrees of freedom.

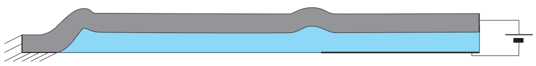

Figure 4: A 2d model of the bridge in figure 1.

Next an attempt is made to validate both FEM approaches by comparing the modeling results for the beam in figure 4 to experimental results. The results in figures 5 and 6 show that the curve is very sensitive to the anchor model. A slightly changed model gives a load-displacement curve that significantly diverges from the measured curve. Because it is very difficult to determine the realized anchor for real microsystems before or after production, this effect has to be considered during MEMS modeling.

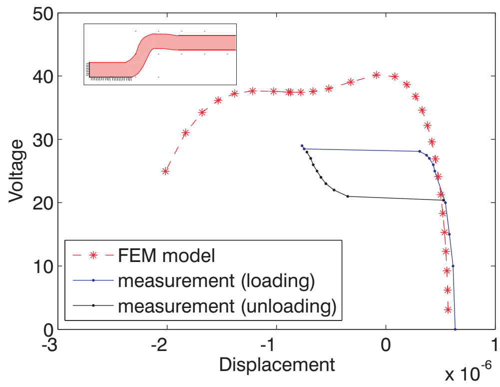

Figure 5: Load displacement curve with a flexible clamp.

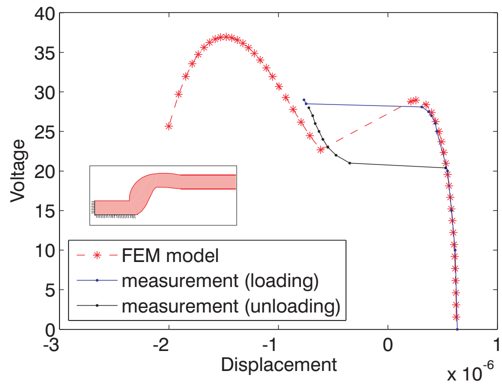

Figure 6: Load displacement curve with a stiff clamp.

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