Subproject A1: “Design of micromechanical components”

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The goal of the subproject A1 is to design micromechanical components that are used within the SFB 379 and to predict their behaviour. This work comprises the following topics:

- Development of design algorithms and tools to capture the specific behaviour of array structures (coupled electromechanical and fluidmechanical fields, interactions between array cells, warping of thin plates caused by thermomechanical and intrinsic stress)
- Modelling and simulation of new micromechanical components used by other subprojects
- Fracture strength of in-plane parallel spring arrays etched from silicon
- Design of new shape elements needed for mechanical and optical applications

Modelling and Simulations

Micromechanical array components consist of many cooperating cells, which are arranged to realize a common function. Demand for complexity and high integration density lead to narrow separation between each other. As a consequence there occur growing interactions among adjacent cells due to the non rigid suspension, electrostatic leakage fields, displaced air below the movable structures and thermal conductivity of laser heated cells etc. Those effects are considered in the physical domain by coupled partial differential equations within the finite element toll ANSYS, fig. 1. As a second method, ordinary differential equations are used to describe the component at a higher abstraction level within MATLAB or PSPICE.

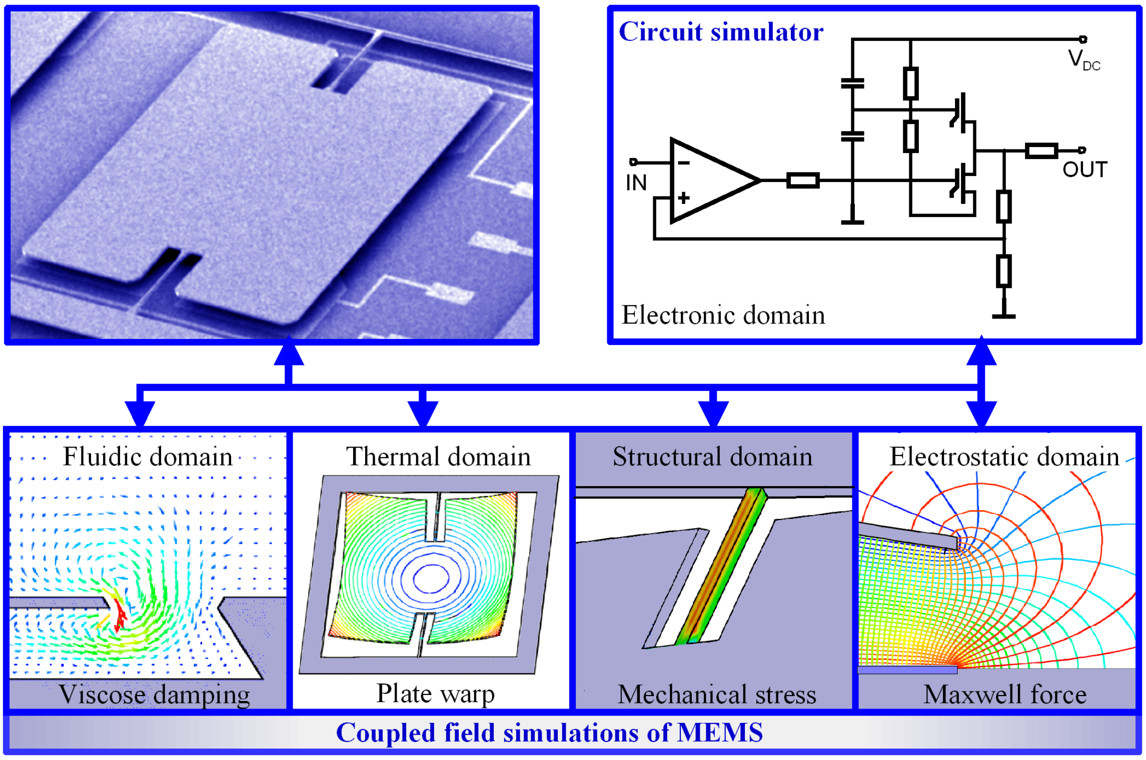

Fig. 1: Influence of different physical domains on the mechanical behaviour of micromirrors

Fracture Strength of In-plane Parallel Spring Arrays Etched from Silicon

Silicon is a suitable material for flexural hinges and similar spring elements. Especially its high elastic deformability in connection with the high bending fracture strength at small strained volumes makes it possible to fabricate these elements.

Several in-plane spring arrays were designed using the tools EMADE and SIMODE and prepared by anisotropic wet chemical etching (fig. 2). In order to reach vertical {100}-sidewalls with smooth surfaces the structures were arranged along the <100>-direction on an {100}-Si wafer. The design and surface quality of the transition zone between the flexible part and the frame of the spring (fig. 3) is of special importance for the fracture strength because the maximum of bending stresses arises at this point. By an overetching of the {111}-sidewalls it is possible to create a design where a multiaxis stress state and stress concentrations can be reduced.

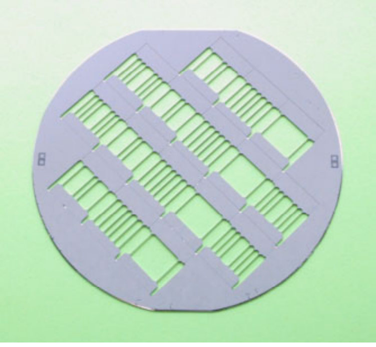

Fig. 2: Complete etched Si-wafer with several parallel springs

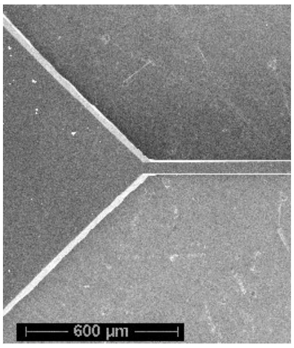

Fig. 3: Transition zone between frame and spring element

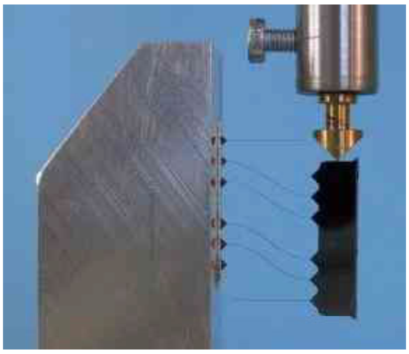

Fig. 4: Loading of a parallel spring array with 2*3 springs (height: 30 µm)

The bending fracture strength of the prepared parallel springs was tested in a micro-force-length testing instrument using an electronic compensation balance for the force measurement (fig. 4). In first experiments the fracture strength and the maximum of bending of parallel springs with spring heights of 30 to 100 µm and with length of 9 and 10 mm respectively were measured. The results are presented in fig. 5 and 6.

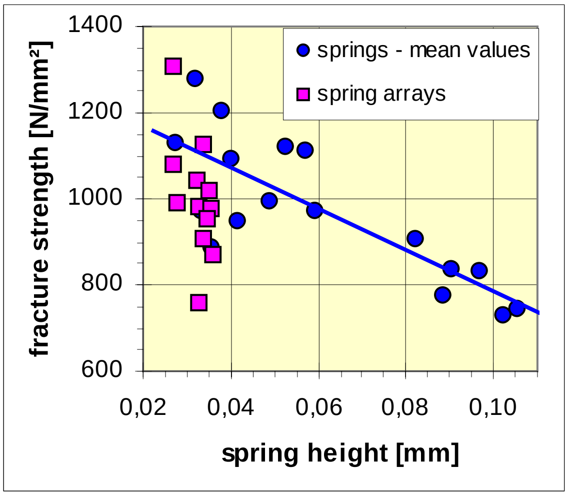

Fig. 5: Dependence of fracture strength on spring height of parallel springs

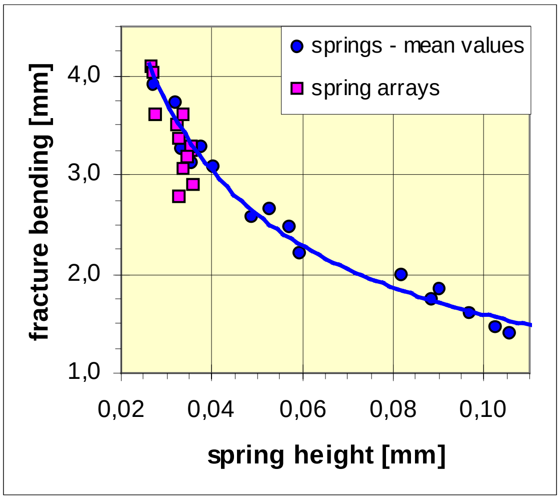

Fig. 6: Dependence of fracture bending on spring height of parallel springs

The fracture strength grows with decreasing cross section of the springs, that means a low cross section leads to higher elastical deformability. The parallel spring arrays can be optimized and adapted for several applications by the variation of the length, the cross section and the number of the springs.