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MODELLING NEW DESIGN OF FLUIDIC MICROVALVES

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Summary. *We propose a new design of PDMS fluidic microvalves based on bistable configurations of the intra-channel thin membranes.*

1 PDMS MICROVALVES

Soft Lithography is a microfabrication technique based on replication molding, i.e. an elastomer (PDMS) is patterned by curing in a micromachined mold. In particular, Multilayer Soft Lithography (MSL) consists in bonding multiple patterned elastomer layers together[1]. The resulting monolithic microstructure precludes interlayer adhesion and thermal stress problems. The softness of the material, which requires small actuation forces, makes MSL devices suitable for passive-sensing and active micromechanical systems in general. A two-layer crossed-channel architecture is used to fabricate on-off microvalves and peristaltic micropumps, where the fluidic pressure plays the role of activation agent. The performance of such microvalves is strongly related to the two-channel geometry (width, height, and sectional shape) and to the interlayer membrane thickness.

In order to define new geometries and new activation procedures, we make recourse to numerical simulations. We built a finite element model which allows to obtain a complete understanding of the mechanical behavior of the microvalves. The numerical model has been validated versus experiments with a parametric study, by varying the membrane thickness and the width of one of the channels[2]. From experiments and calculations, we observed that the microvalve behavior is greatly affected by the geometric parameters.

PDMS elastomers are sensitive to several chemical solvents, which may induce changes in the mechanical properties and swelling of the material. By using a soft rubber constitutive model accounting for the presence of eigendeformations, we numerically analyze the possibility to realize new design of microvalves and microfluidic systems, able to reduce the magnitude of the activation pressure and the duration of the activation time. The new design may considerably increase the performance of the currently used fluidic microvalves. Finite element analyses account for large displacements and strains, material non-linearities, and non-smooth contact[3].

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