Analytical, Numerical and Experimental Analysis of Capacitive Transducers Damping Constant

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Designing a tailored transducer for specific applications needs the knowledge of mechanical system parameters like mass, spring constant and damping constant. Latter one can be determined analytically, numerically and by setting up an experimental design. Numerical and analytical solutions have the advantage that they don't afford expensive manufacturing of test samples and don't need test equipment. However, mathematical solutions have to be accurate in order to be of advantage for the design process.

To investigate the benefit of analytical and numerical damping calculations for the design process of micromachined transducers, capacitive MEMS prototypes with varying damper geometries were produced and an experimental setup was engineered. The setup contains a custom made vacuum chamber and a custom made shaker unit. Both allow the analysis of the damping behavior in the continuum flow and in the slip flow regime. Especially the latter regime is important for capacitive transducers as it is an often found condition in microstructures due to small geometry dimensions.

The analytical solution of the damping behavior shows differences compared to experimental data. This is in consequence of tight boundary conditions in order to solve analytical equations. Furthermore, not all conditions in the prototyped microstructure are regarded in state of the art solutions. Despite this, analytical equations are a sufficient method for the first designs iteration of micromachined transducers. In contrast to the analytical data, numerical data are corresponding with experimental data. This is due to the fact that the boundary conditions of the prototype devices are mainly included in the simulations model. However, configuration parameters of the numerical Navier-Stokes simulation are based on analytical calculations. Therefore, both approaches, analytical and numerical, are necessary for the design of tailored transducers, especially if complex geometries with a broad set of boundary conditions are used.