MEMS Based Mass Sensor with Uniform Sensitivity for Biological Applications

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Abstract

MEMS sensors exhibit rapid response with minimum sample volume at higher sensitivities. This makes them suitable for detection of Micro/nanoparticles and can also use to monitor their physical process at that scales. Micro-cantilevers based sensing is widely used in the detection of mass in various chemical and biological entities where sensitivity is a major challenge. The sensitivity of the microcantilever depends upon their dimensional, structural and material scalabilities. For a given dimension the sensitivity can be altered by their structural variations and materials. In rectangular based cantilevers having the non-uniform sensitivity with respect to the differential position of the binding molecule, the precise mass sensing, in this case, is a difficult challenge at the micro and nano scales. And in parallel targeting the binding molecule precisely at fixed on the cantilever is a difficult process in terms of assembly over a small surface area of the cantilever region which is at the higher sensitive note. In order to overcome this challenge a uniform mass sensing device which forms a circular disc with four cantilevers attached on four equidistant points of the circumference is designed using COMSOL Multiphysics®. This MEMS structure is exhibiting the uniform mass Sensitivity over its surface area with and without the mass added. This sensor is self-oscillator devices which subject to a dynamic mode of actuation technique where frequency shift is measured for added Mass. The cantilevers on four sides act as the spring which incorporates the uniform deflection so that proof mass at centre has uniform deflection.

The structure is incorporated using COMSOL® geometry where structural analysis is applied with Eigenfrequency analysis. The Eigen Mode frequency for Flexure bending of the proof mass is determined and this is subject to no load and load conditions to determine the shift in the frequency. The parametric and switch case is used for a material sweep to compute the frequency of Flexure bending with different materials that correspond MEMS material Library.

The parametric sweep of the geometric variations and material are extracted from the computations along with the measurement of the stress under different load conditions. The same geometry is subjected to stationary analysis where piezoelectric nodes are placed to calibrate the added mass on the devices. A complete study of the device is made for incorporating the feasible actuation method to use the device for mass Sensing of Biological Entities.