Design and Optimization of Highly Sensitive Single Axis Accelerometer Using COMSOL Multiphysics®

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Abstract

Accelerometers were one of the successfully commercialized MEMS devices. Their large scale production and demand was a result of numerous design concepts, simulation and optimization of the devices, their validations in practical environments etc. Even though being a highly saturated area in MEMS designing, there is still scope to make optimized and highly sensitive devices to measure very low vibrations, shocks etc. which are required for the sophisticated equipment. This paper aims at designing a highly sensitive single axis accelerometer with optimized design specifications. Theoretical designing would help in realizing the device operation, unless optimization in terms of device performance characteristics is not studied. COMSOL Multiphysics® tool plays the major role in simulating the designed model to various kinds of inputs expected to occur in real world scenario, and to study the behavior and performance of the device for the given inputs. Modeling and simulation also go hand in hand so that any deviation in the performance can be averted by modifying the model as per the requirement. The investigation and the study in this paper involve simulations of piezoresistive accelerometer system. COMSOL Multiphysics® has been used in the modeling, simulation and optimizing of the design. The piezoresistive accelerometer is made up of square shaped proof mass with flexures supporting it. The piezoresistors are placed near the proof mass and frame ends of the flexure and the springs. There is an elongation or shortening of suspension beam and springs when the support frame moves relative to proof mass. Three different structural models were modeled, simulated and studied for their performance characteristics in terms of von Mises stress, displacement, Eigen frequency , and conductivity change in the piezoresistors. Figure 1 shows the optimized model with perforated flexure. Figure 2 shows von Mises stress experienced by the structure on application of a small acceleration. Figure 3 shows the modified double gimbal model accelerometer with serpentine flexures. Figure 4 shows the displacement field of the double gimbal model on applying a small acceleration. It can be visualized that ends of flexures experience maximum of stress and the piezoresistors are placed in optimal positions so as to experience this maximum stress to bring about maximum change in the output. The device characteristics have been enhanced by designing perforations in the flexures to achieve flexible flexures to sense very low vibrations.

Reference

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Figures used in the abstract

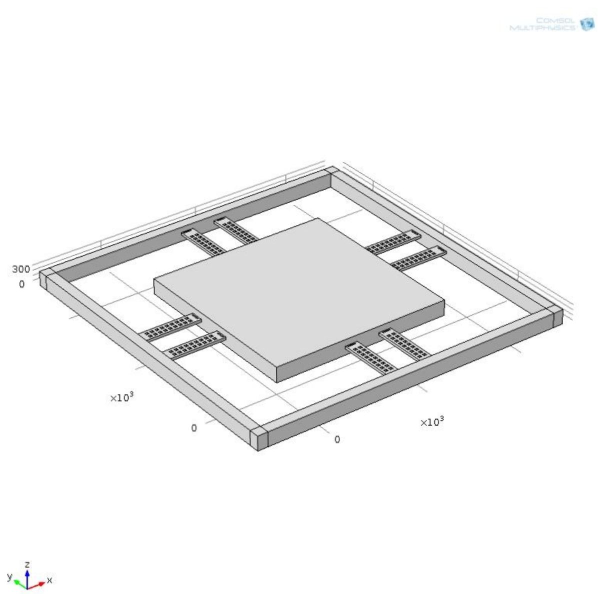

Figure 1: Perforated Single Axis Accelerometer

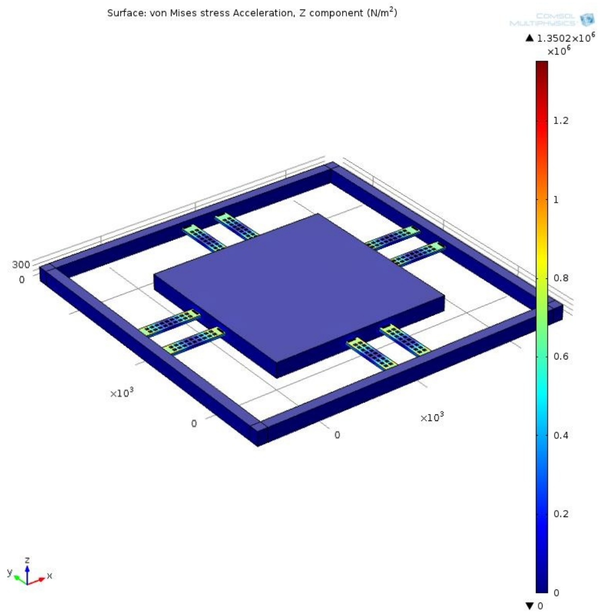

Figure 2: Von Misses Stress Profile

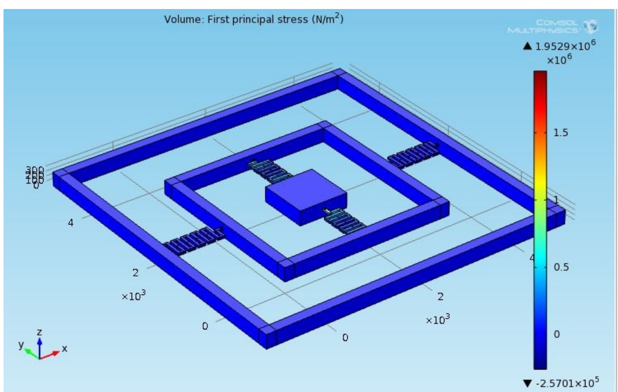

Figure 3: Principal Stress in Double Gimbal Model

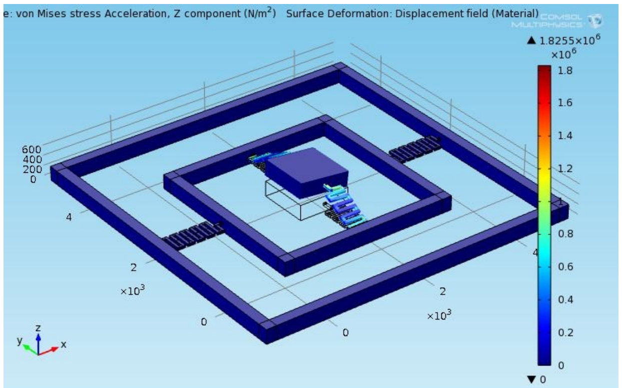

Figure 4: Von Misses Stress Profile for Double Gimbal Model