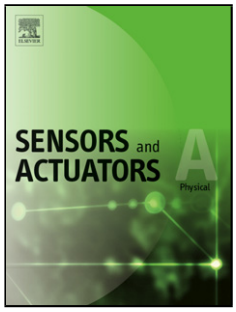

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Design, Fabrication and Calibration of a High-G MEMS Accelerometer

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The significance

This paper focus on the design, fabrication and calibration of a high G-shock MEMS accelerometer.

Highlight

1. The anti-high-G shock structure is proposed and the parameters are optimized.
2. The manufacture process is designed and applied for the accelerometer structure.
3. The high-G shock experiment is finished by using Hopkinson bar, and the shock is over 100 000g.

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Abstract

This paper presents a high-G MEMS accelerometer (HGMA). HGMA employs our-beams and central-island mass silicon structure, which features a robust stability in shock environment. Theoretical analysis is conducted to investigate the influence of structure parameters on the Von Mises stress distribution, mechanical sensitivity and natural frequency. With consideration of smaller stress, higher mechanical sensitivity and natural frequency, the structure parameters are optimized and the theoretical sensitivity of HGMA is calculated as 0.488μV/g. Then, the optimized structure is analyzed with finite element analysis software, which shows a maximum stress of 23.19 MPa and a frequency response of 408.19 kHz when a 100 000g shock is loaded. Finally, a processing flow is designed and the structure is fabricated. Hopkinson bar is utilized to calibrate HGMA sample, and shows an experimental sensitivity of 0.5611μV/g. Long-term static bias and temperature experiments are arranged to evaluate HGMA. Test results verify the presented theoretical analysis, processing flow, and experiment method, which are of great value for guiding the design, fabrication and calibration of other HGMAs.

Keywords: high-G MEMS accelerometer; theoretical simulation; frequency response; dynamic sensitivity; processing technology; high G calibration

1. Introduction

Piezoresistive-based high-G MEMS accelerometer (HGMA) has been widely used in many harsh environments, such as seismic exploration, gun-hard MIMU. Endevco company developed a high-g accelerometer having a sensing range up to 200 000 g and a resonant frequency of 150kHz, whose structure employed four side L-shaped beams to support the center mass[1],[2]. A double-side piezoresistive MEMS accelerometer structure with four straight beams was developed by Indian Institute of Technology[3],[4], which was manufactured with the SOI wafer, and had a high sensitivity of 4mV/g by employing a Wheatstone bridge. A tri-axial MEMS accelerometer based on film-island structure was presented in [5], and the direction and amplitude of the input acceleration can be decoupled by calculating a sixteen piezoresistance matrix. A novel double-side piezoresistive sensing bridge structure was proposed in [6] and [7], which also employed a Wheatstone bridge and had a sensitivity of 25μV/g when the sensing range was set as 2000g. A high-G accelerometer employing a film plane capacitance was proposed in [8] and [9], which has a sensing range of 10 000g and a nature frequency of 118 KHz. A novel accelerometer using 16-beam-mass structure was developed in [10], 16 straight beams were distributed on four corner of the mass on both sides, with an aim