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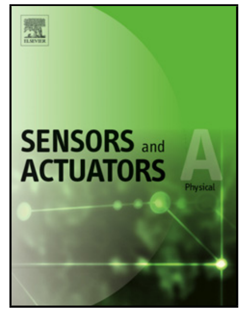

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Author: Wenguo Chen Yan Wang Guifu Ding Hong Wang Xiaolin Zhao Zhuoqing Yang

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Simulation, Fabrication and Characterization of an All-metal Contact-enhanced Triaxial Inertial Microswitch with Low Axial Disturbance

Wenguo Chen, Yan Wang, Guifu Ding, Hong Wang, Xiaolin Zhao and Zhuoqing Yang

National Key Laboratory of Science and Technology on Micro/Nano Fabrication,
Shanghai Jiao Tong University, Shanghai 200240, People's Republic of China

Corresponding author: gfding@sjtu.edu.cn, wyyw@sjtu.edu.cn

Abstract

An all-metal inertial microswitch that is sensitive to three axial accelerations (+x, +y and +z) is fabricated by low-temperature photoresist modeled metal-electroplating technology. The inertial switch consists of four main parts: a quartz wafer with anti-stiction strips as the substrate; a proof mass suspended by conjoined serpentine springs as the movable electrode; two *L*-shaped flexible cantilevers and a multi-hole crossbeam as horizontal and vertical fixed electrodes, respectively; two anchors located in the middle of proof mass as limit blocks. ANSYS software is used to simulate the dynamic contact process in the microswitch, and the simulation results reveal that the flexible fixed electrode can prolong the contact time and eliminate the rebound during the contact process. The axial disturbance among different sensitive directions has been discussed by dynamic simulation. The modal analysis, crosstalk between horizontal and vertical directions, cross-axis sensitivity, and the disturbance under overload shock along the reverse sensitive direction are also simulated and discussed. The suspension and gap in the device structure can be precisely controlled utilizing the photoresist modeled metal-electroplating technology to reduce the axial disturbance effectively. Finally, the prototype is fabricated successfully and tested by dropping hammer system. It's shown that the test threshold acceleration is 255-260g in horizontal directions (+x and +y), ~75g in vertical direction. The contact time of the switch with elastic contact point is ~60μs in horizontal direction and ~80μs in vertical direction. The crosstalk between horizontal and vertical direction, cross-axis and overload disturbance have been also demonstrated by test results, which indicate the axial disturbance is low in the present inertial switch.

Key words: All-metal, contact time, axial disturbance, triaxial inertial switch, microelectromechanical system (MEMS)

1. Introduction

An inertial switch is essentially both a threshold sensor and an actuator, which has functions of both threshold detection and closing action. With the development of implantable devices, inertial switch has the second largest sales volume after pressure sensors due to the distinctive characteristics of small size, lightweight and low power consumption and manufacturing cost. The inertial switch fabricated by micromachining technology is frequently used in many industrial applications such as accessories, toys, health monitoring and automobiles [1-4]. Especially in recent years internet of things (IOT) has grown rapidly, the inertial switch is used for detecting the vibration shock and then sending corresponding overload signal [5-6]. The reported inertial switch had been fabricated on the silicon substrate with etching technology mainly [7-11]. Compared with all-metal device, the elastic-plastic property of silicon is poor. The switch fabricated using metal (i.e., nickel) could withstand higher impact due to the lower brittleness. In addition, the contact resistance of all-metal device is lower and hence it can minimize the heat loss [12].

In our previous work, a serious of inertial switches with unidirectional or omnidirectional sensitivities had been reported [13-17]. However, some of them still used a rigid block without elastic contact structure as the fixed electrode has only ~5μs short contact time, which will be an obstacle for circuit analyzing in many applications. In the report [7], a latching acceleration switch had been proposed, where the movable electrode is latched by fixed electrode when the applied acceleration reaches to its threshold, and the contact time can be prolonged enough. But this system is very difficult to be restarted after pre-measurement. T. Matsunaga et al [18] have proposed an acceleration switch utilizing squeeze film effect to extend holding time and it can be