Sensors and Materials, Vol. 26, No. 2 (2014) 95–108
MYU Tokyo

S & M 0974

A Three-Axis Single-Proof-Mass CMOS-MEMS Piezoresistive Accelerometer with Frequency Output

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(Received June 10, 2013; accepted October 8, 2013)

Key words: accelerometer, CMOS MEMS, piezoresistive, frequency output, RC oscillator

Accelerometers have been used in a wide range of applications such as automobiles, mobile phones, and game controllers. In this paper, we present a monolithic complementary metal-oxide-semiconductor micro-electromechanical systems (CMOS-MEMS) accelerometer with frequency output. The output oscillation frequency can be converted to a digital code by using a counter so that the sensor can be easily integrated with digital signal processing units on the same chip. The accelerometer is composed of a single proof mass suspended by four suspension beams. Polysilicon piezoresistors are placed at the ends of the beams to sense the displacement of the proof mass. The piezoresistors are used in RC oscillators whose oscillation frequencies vary owing to the change in resistance upon application of an external acceleration. Acceleration components in three axes can be obtained by the proper combination of signals from the piezoresistors at different locations. The accelerometer was fabricated by standard CMOS processes followed by backside and frontside dry etching postprocessing. The measured mechanical resonant frequency is 464 Hz. The oscillation frequency of the *z*-axis oscillator is about 70 MHz. The measured absolute sensitivity, relative sensitivity, and resolution along the *z*-axis are 198 kHz/*g*, 2.8×10^{-3} $\Delta f/f_0/g$, and 10.9 mG/$\sqrt{\text{Hz}}$, respectively, for a sampling rate of 400 Hz and acceleration of 6 *g* at 27 Hz.

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