ピエゾ抵抗型微小振動センサの開発

エンジニアリング

■ Introduction

Wireless sensor networks (WSN) plays extremely important role in health conditions of infrastructure monitoring for reducing the damage from nature disasters, i.e. earthquake, hurricane and so on. Piezoresistive sensor is one of great interest and presently under investigation for applications in WSN due to its high reliability, long-term stability and non-sensitive to environmental influence. However, sensitivity and processing consumption are always contradictory when considering practicability of the piezoresistive sensor. In this work, a piezoresistive vibration sensor with die size of less than $2\times2mm^2$, reasonably high sensitivity (Min. detectable acceleration: <0.05g) was successfully developed by using FEA by ANSYS® to optimize piezoresistive gauge and a novel cavity-first process to reduce proof mass loss and processing consumption. The presented sensor also exhibits easy integration capability both physically and electrically because of its simple signal processing circuit and front-side released structure, which is attractive characteristic for low cost assembly of above sensors into WSN.

■ Procedure and results

Figure 1 describes our projected wireless infrastructure monitoring system. The distributed sensor nodes are usually in sleep mode with minimum current flow into RF-LSI for demand-waiting, therefore no power consumption by vibration sensor. To reduce its power consumption to the lowest possibility, the sensor nodes work only on-demand when requested by Earthquake Early Warning (EEW) or other emergency messages. This system is believed practically and industrially valuable to those countries, i.e. Japan, since >20% of the earthquakes with magnitude of >6 in the world are happening in Japan every year.

Figure 2 shows the SEM image of the vibration sensor structure and insert is the zooming of piezoresistors unit. The sensor was designed for the detection of weak vibration (<2g) within low frequency range.

FEA was carried out to configure the layout of those piezoresistors for the pursuit of comparable sensitivity achieved by capacitive sensors or by complicated 3D ion-implantation process. By using a novel cavity first fabrication approach, proof mass (1 mm radius and 60° included angle) loss due to front-side releasing process by vapor HF dry etching was dramatically reduced from >30% to <5%, which contributes to sensitivity of the device as well as low production cost.

Figure 3 shows the time domain vibration response of transient time history (TTH) wave by a commercial available sensor (3035B, Dytran Instruments Inc.) and the planar sensor with 8 μm-width and 20 μm-length flexure beam. As the result shown, by comparing with the response results for the weak vibration signal, the vibration sensor exhibited performance comparable to a high price commercial sensor device. Based on the previous vibration signal was measured well, the vibration sensor was used to measure the recorded earthquake wave signal.

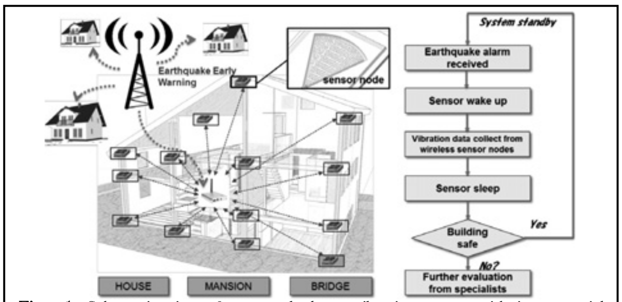

Figure1. Schematic view of proposed planar vibration sensor with its potential applications.

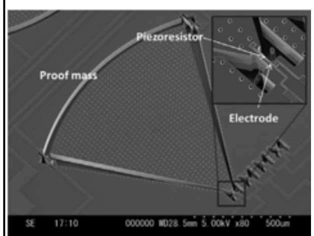

Figure 2. SEM image of planar vibration sensor structures.

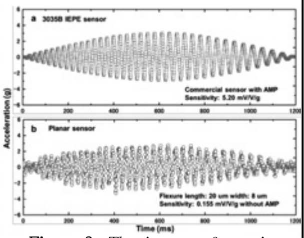

Figure 3. The images of transient time history wave outputs measured by commercial and planar sensors.

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(2) Vibration
(3) Piezoresistive