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Proceedings of Symposium on Ultrasonic Electronics, Vol. 36 (2015)
5-7 November, 2015

Study of Composite-Type Vibration Sensor for Detection of Two-Axis Acceleration and One-Axis Angular Velocity

２軸加速度及び１軸角速度検出用の複合型振動センサーの研究

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1. Introduction

Now, the vibration sensor suitable for a MEMS structure which can detect acceleration and also angular velocity is required for application to the attitude control and navigation systems of moving objects such as a vehicle and a robot.

Various kinds of sensor construction are proposed as such a sensor. For example, the sensor which detects acceleration and angular velocity by using only one vibrator is proposed. In such construction, although the sensor can be miniaturized, the use of a complicated and expensive signal-processing circuit is indispensable. Moreover, if a trouble arises in the sensor, both of acceleration and angular velocity will become undetectable in many cases. In such case, it will be more desirable if the signal of acceleration or angular velocity is detected. As such a vibration sensor, the sensor for detection of one-axis acceleration and one-axis angular velocity was proposed.[1)] The authors have considered about a low frequency angular velocity sensor,[2)] and also the frequency-change-type two-axis acceleration sensor.[3-11)]

In this study, the new piezoelectric composite-type vibration sensor which can detect two accelerations and one angular velocity is proposed, the sensor is designed by using the finite element analysis and the sample of trial production is realized.

2. Structure of Vibration Sensor

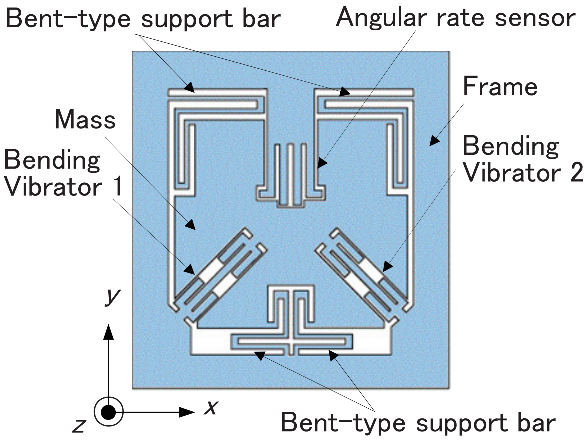
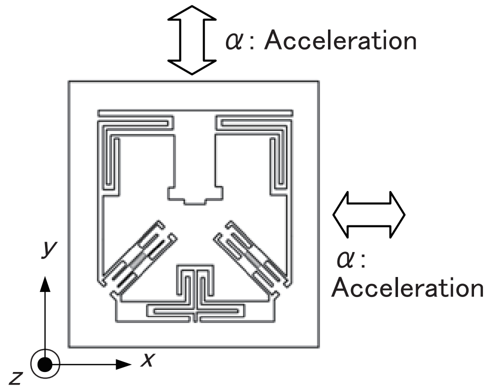


Fig. 1 Structure of vibration sensor.

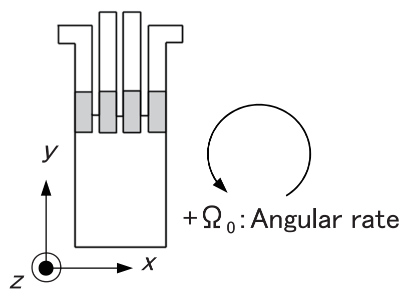
Fig. 1 shows the structure of the new composite-type vibration sensor[12)] which can detect the two accelerations along the x and y directions and also the angular velocity around the z axis. This is realized by combining the frequency-change-type two-axis acceleration sensor and the one-axis angular velocity sensor so as to become a flat structure. Therefore, the new composite-type vibration sensor has the characteristics which combine the characteristics of the two sensors.

3. Design and Sensor of Trial Production

The vibration sensor proposed here can be divided into the two parts of acceleration and angular velocity sensors as shown in **Fig. 2**. The part of acceleration sensor is shown in the figure (a), the upper part of the mass is cut by the contour of one-axis angular velocity sensor shown in the figure (b). In the sensor having such an asymmetrical mass to the x axis, because the mass causes a rotational motion around the z axis by acceleration along the x axis direction, the sensor is



(a) Two-axis acceleration sensor



(b) One-axis angular velocity sensor

Fig. 2 Two-axis acceleration sensor and one-axis angular velocity sensor.

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designed so that the mass moves linearly to the x axis direction by adjusting the dimensions of the two support bars connected at the lower part of mass. Here, the sensor is made of stainless steel (SUS304), the external dimensions are about 95.8×90×10.5 mm^3.

Fig. 3 shows the top view of the sample of trial production of the proposed vibration sensor. A drive and detection for these sensors are realized by bonding piezoelectric ceramics as shown in the figure. The frame of the vibration sensor is fixed to the support unit. When the thickness of these vibrators is 0.5 mm, the resonance frequencies of

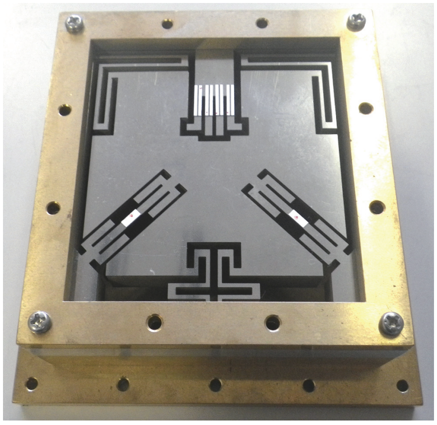
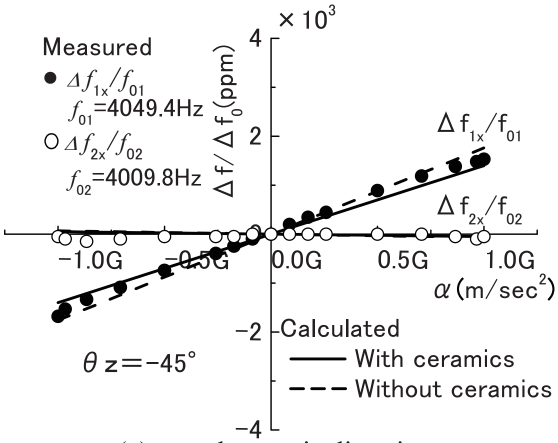
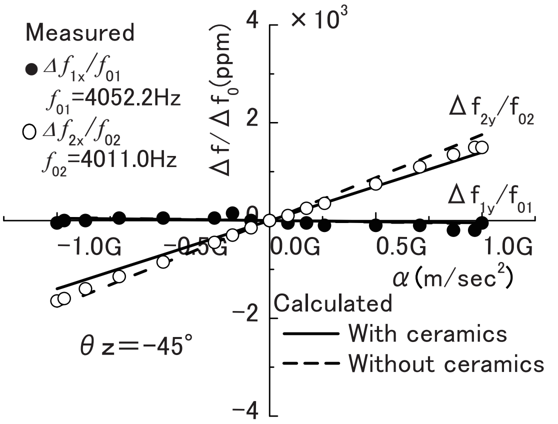


Fig. 3 Angular velocity sensor of trial production.



(a) α to the x axis direction



(b) α to the y axis direction

Fig. 4 Characteristics of two-axis acceleration sensor constructing vibration sensor.

the two sensors become about 4 and 9 kHz, respectively. **Fig. 4** shows the characteristics of the two-axis acceleration sensor constructing the vibration sensor. The solid lines show the calculated characteristics with piezoelectric ceramics, and the broken lines show the calculated ones without ceramics. The experimental characteristics agree with the calculated ones with ceramics. The sensitivity of the sensor increases by decreasing the thickness of the vibrator. The characteristics of the angular velocity sensor are not shown here for want of space.

5. Conclusions

The new piezoelectric composite-type vibration sensor which can detect two accelerations and one angular velocity was proposed here. The design method of the sensor was clarified using the finite element analysis, and the example of trial production of the sensor was shown. The sensor is constructed using the frequency-change-type two-axis acceleration sensor and the one-axis angular velocity sensor, and becomes a flat and simple structure suitable for a MEMS device. Because the sensor can detect acceleration and angular velocity individually, the interference between both signals is not observed and therefore signal-processing becomes quite easily.

Acknowledgements

This work was partially supported by a Grant-in-Aid for Scientific Research (No. 22560055, No. 25390118) from the Japan Society for the Promotion of Science.

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