Silicon-on-insulator 구조를 갖는 실리콘 압저항 가속도계

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A Silicon Piezoresistive Accelerometer with Silicon-on-insulator Structure

梁 義 爀*·梁 翔 植**
(Eui-Hyeok Yang·Sang-Sik Yang)

Abstract—In this paper, a silicon piezoresistive accelerometer is designed and fabricated using a silicon direct bonded wafer. The accelerometer consists of a seismic mass and four cantilevers, and is fabricated mainly by the anisotropic etching method using EPW as an etchant. The measured sensitivity and the resonant frequency are 0.02 mV/V·g and 3.4 kHz, respectively. The nonlinearity is less than ±0.3% of the full scale of the output.

Key Words : Silicon Piezoresistive Accelerometer, Silicon-on-insulator

1. Introduction

Since 1979 when Roylance and Angell[1] presented a silicon accelerometer, it has been fabricated in many different ways. Of the silicon accelerometers, the piezoresistive accelerometers are very suitable for simple and low cost fabrication. Most of the piezoresistive accelero-meters consist of a seismic mass and one or several cantilevers. Yamada et al.[2] proposed an accelerometer with a surrounding mass structure to achieve the extreme reduction in the size of the sensor. Burrer et al.[3] fabricated an accelerometer with a twin-mass structure. These piezoresistive accelerometers are fabricated mainly by electrochemical etch stop method. For the fabrication of a highly reliable accelerometer, the uniformity of the thickness of the cantilever is of importance. In general, the electrochemical etch stop method has been used to fabricate thin and uniform diaphragms. However, it is not adequate to the mass-production.

In this paper, a silicon piezoresistive accelerometer with four cantilevers of uniform thickness is designed and fabricated using SDB(silicon direct bonded) wafer.

2. Sensor Fabrication

The accelerometer consists of a seismic mass and four cantilevers of silicon-on-insulator structure. For the measurement of acceleration in low frequency band, the structural parameters are determined as M=20mg, l=400μm, b=260μm, and h=10μm, where M is the seismic mass, l is the length of the cantilevers, b and h are the width and thickness of the cantilevers, respectively.

The starting material is SDB(silicon direct bonded) wafer which has been made by Shin-Etsu Handotai Co.. The silicon substrate has a resistivity of 1-10 Ωcm. The thickness of the buried oxide is 2μm. The bonded layer is 10μm thick n-type (100) oriented silicon with a

*正 會 員 : 亞洲大 大學院 電子工學科 博士課程
**正 會 員 : 亞洲大 工大 制御計測工學科 副敎授·工博
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resistivity of 5−8 Ωcm. The wafers are etched at 115±2℃ in an anisotropic etchant(Ethylendiamine, Pyrocatechol, DI water mixed at the rate of 250 ml:40 g:80 ml). The etch rate of this etchant for (100) silicon is about 1.0 μm/min. Silicon dioxide layers of 0.5 μm are grown thermally. The patterns of the cantilevers and the alignment holes are etched through the 10 μm thick layer in EPW etchant. After the residual oxide layer is etched off, again silicon dioxide layer of 0.5 μm is grown thermally. The buried oxide layer is selectively etched in buffed oxide etchant. The alignment holes are fully etched out in EPW etchant. Boron predeposition with BN1100 solid source in N_2 ambient gas to fabricate the piezoresistors is followed by drive−in diffusion in O_2 ambient gas. After opening the contact windows, Cr and Au films are deposited by thermal evaporation. The metal pattern to connect the piezoresistors into the bridge circuit is formed by lift−off technique. After completion of the frontside process, deep anisotropic etching of the backside to form the seismic mass is performed. In order to avoid undercutting of the convex corners of the seismic mass, a proper compensation pattern is used in the backside etching mask. After the wet etching, the exposed buried oxied layer is etched out in a mixed solution of H_2O:CH_3COOH:NH_4=6:5:1 in volume ratio. The SEM photograph of the backside of the accelerometer is shown in Fig. 1.

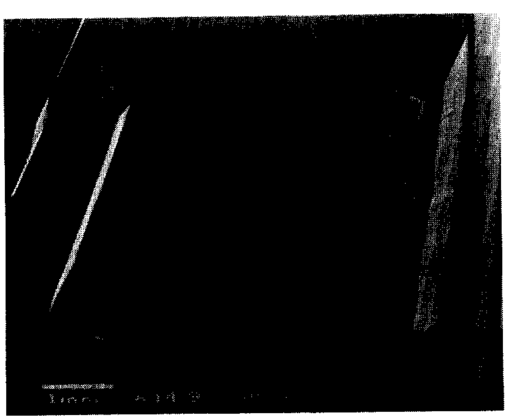

Fig. 1 The SEM photograph of backside of the accelerometer.

3. Experimental Results

The measurements of the sensitivity and the frequency response are carried out with laboratory equipments such as a high precision power supply, a laser vibrometer with its digital FFT analyzer, a vibration exciter, differential amplifier and a spectrum analyzer. Fig. 2 shows the measured output signal of the accelerometer. The measured sensitivity is 0.02 mV/Vg. The sensitivity to cross acceleration is 1.5 %, and the nonlinearity of the sensor is less than ±0.3 % of the full scale output. The measured frequency response in the range of 50 Hz∼10 kHz is shown in Fig. 3. The first resonant frequency is 3.4 kHz.

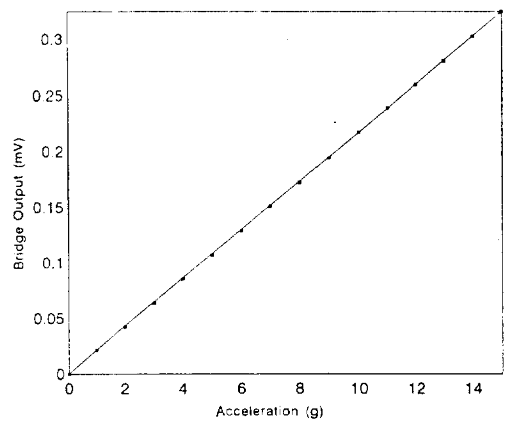

Fig. 2 The bridge output voltage as a function of the applied acceleration.

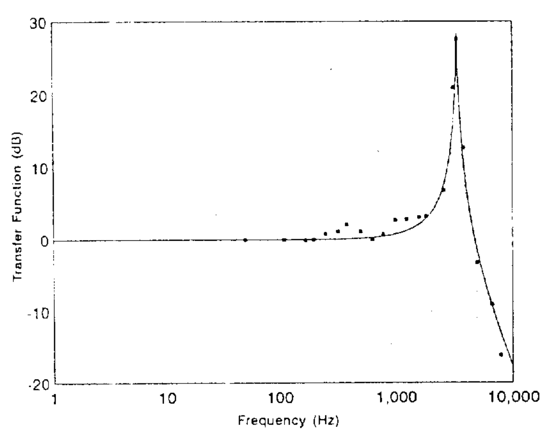

Fig. 3 The frequency response of the accelerometer.

4. Conclusions

In this paper, a silicon piezoresistive accelerometer of silicon−on−insulator structure is fabricated and characterized. It is confirmed that the linearity of this accelerometer is improved by fabricating with SDB wafers, and it has advantage over other piezoresistive accelerometers fabricated mainly by the electrochemical etch stop method with respect to the mass−production.

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