Intelligent detector of internal combustion engine cylinder pressure and sensitivity temperature coefficient compensation

B.R. Zheng, C.Zhou, X.M.Pan, W. Xue

College of Mechanical and Electrical Engineering, Wenzhou University, Wenzhou 323035, China

The detecting device based on mechanical mechanism is far from the measurement of internal combustion engine cylinder explosion and compression pressure. This pressure detection is under the environment of pulsed gas (over 500 times one minute) and mechanical impactive vibration. Piezoresistive detection with silicon on insulator (SOI) strain gauges to pressure seems to be a good solution to meet such special applications. In this work, SIMOX (separation by implanted oxygen) wafer was used to fabricate the high temperature pressure sensor chip[1]. For high accuracy and wide temperature range application, this paper also presents a novel pressure sensitivity temperature coefficient (*TCS*) compensation method, using integrated constant current network. A quantitative compensation formula is introduced in mathematics. During experiments, the absolute value of the compensated *TCS* is easy to be $10\times10^{-6}/℃\sim100\times10^{-6}/℃$ by individual adjustment and calibration of each device's temperature compensation. Therefore the feasibility and practicability of this technology are tested. Again, the disadvantages are discussed after the research of the experiment data and the improvement methods are also given in the designing period. This technology exhibits the great potential practical value on internal combustion engine cylinder pressure with volume manufacturing.

Figure 1(a) is the high temperature pressure sensor gauge chip based on SIMOX SOI wafer. One circular shape diaphragm is taken as the sensitive structure layer. The chip still retains silicon as the sensing material but has silicon oxide as an electrically isolating layer between it and the substrate. The sensor packaged with this kind of sensing chip is presented with high accuracy and a good long-term stability in high temperature testing experiments. The designed chip film thickness is 0.04 mm and effective radius of diaphragm is 2 mm. It is easy to know the theoretic natural frequency is 44.22 kHz, compared well with dynamic calibrated frequency of shock tube of 38.46 kHz in Figure 3. It fulfills the requirement of high frequency measurement.

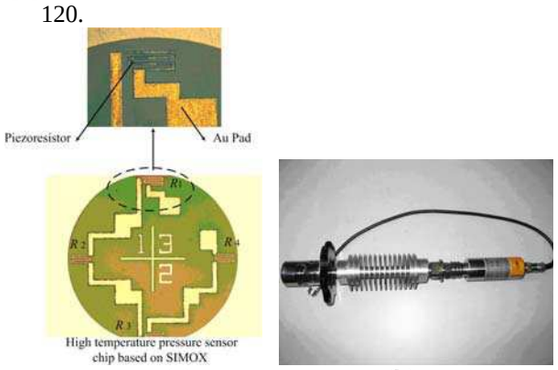
Piezoresistive pressure sensor is sensitive to the ambient temperature change. The temperature dependence of sheet resistance is one of the main limiting factors to improve the accuracy of the device and extend its application [2]. Integrated constant current network, shown in Figure 2, is conducted to compensate *TCS* as it does not involve non-linear elements. Zero point stability for a long term is also an important parameter to internal combustion engine cylinder pressure detector. The detector zero point output under the ambient environment for 12 hours is measured in Figure 4. It demonstrates the variation of output voltage so that the detector has a strong anti-interference ability and can meet the requirement of high accuracy tests.

The intelligent detector of internal-combustion engine cylinder pressure is shown in Figure 1(b).It was packaged with high temperature piezoresistive pressure sensor to get the high frequency response as well as to perform under harsh environment. Equipped with preamplifier circuit, it was convenient to read the testing results and the operating performance is reliable.

References

[1] Y. Watanabe, Y .Watanabe, T.Hanajiri, T. Toyabe, T. Sugano, IEEE Electr. Device L 32(2011)237

[2] D. D. Bruker, R. Puers, Sensors Actuat A 82 (2000) 120.



(a) (b)

Figure 1(a) High temperature sensor chip based on SIMOX was used for strain gauges in detecting internal-combustion engine cylinder pressure; (b) Intelligent detector of internal-combustion engine cylinder pressure with sensitivity temperature coefficient compensation based integrated constant current.

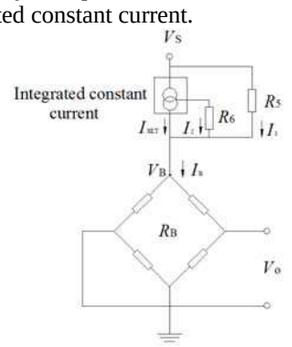


Figure 2 Sensitivity temperature coefficient compensation based integrated constant current.

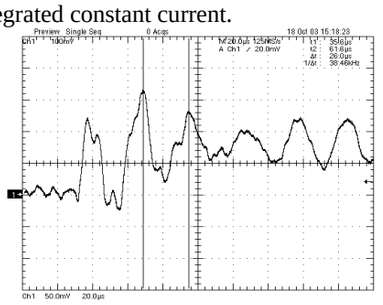


Figure 3 Dynamic response of the intelligent detector with the SIMOX silicon chip to meet mechanical impactive vibration.

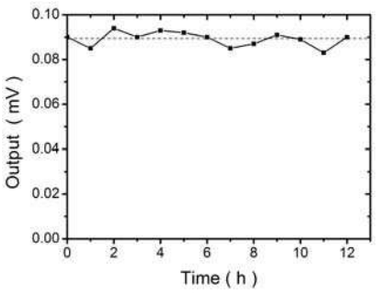


Figure 4 Intelligent detector's zero point stability under room temperature.