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Optimization of Temperature Coefficients for MEMS Based Piezoresistive Pressure Sensor

Authors : Vijay Kumar, Jaspreet Singh, Manoj Wadhwa

Abstract : Piezo-resistive pressure sensors were one of the first developed micromechanical system (MEMS) devices and still display a significant growth prompted by the advancements in micromachining techniques and material technology. In MEMS based piezo-resistive pressure sensors, temperature can be considered as the main environmental condition which affects the system performance. The study of the thermal behavior of these sensors is essential to define the parameters that cause the output characteristics to drift. In this work, a study on the effects of temperature and doping concentration in a boron implanted piezoresistor for a silicon-based pressure sensor is discussed. We have optimized the temperature coefficient of resistance (TCR) and temperature coefficient of sensitivity (TCS) values to determine the effect of temperature drift on the sensor performance. To be more precise, in order to reduce the temperature drift, a high doping concentration is needed. And it is well known that the Wheatstone bridge in a pressure sensor is supplied with a constant voltage or a constant current input supply. With a constant voltage supply, the thermal drift can be compensated along with an external compensation circuit, whereas the thermal drift in the constant current supply can be directly compensated by the bridge itself. But it would be beneficial to also compensate the temperature coefficient of piezoresistors so as to further reduce the temperature drift. So, with a current supply, the TCS is dependent on both the TCπ and TCR. As TCπ is a negative quantity and TCR is a positive quantity, it is possible to choose an appropriate doping concentration at which both of them cancel each other. An exact cancellation of TCR and TCπ values is not readily attainable; therefore, an adjustable approach is generally used in practical applications. Thus, one goal of this work has been to better understand the origin of temperature drift in pressure sensor devices so that the temperature effects can be minimized or eliminated. This paper describes the optimum doping levels for the piezoresistors where the TCS of the pressure transducers will be zero due to the cancellation of TCR and TCπ values. Also, the fabrication and characterization of the pressure sensor are carried out. The optimized TCR value obtained for the fabricated die is 2300 ± 100ppm/°C, for which the piezoresistors are implanted at a doping concentration of 5E13 ions/cm³ and the TCS value of -2100ppm/°C is achieved. Therefore, the desired TCR and TCS value is achieved, which are approximately equal to each other, so the thermal effects are considerably reduced. Finally, we have calculated the effect of temperature and doping concentration on the output characteristics of the sensor. This study allows us to predict the sensor behavior against temperature and to minimize this effect by optimizing the doping concentration.

Keywords : piezo-resistive, pressure sensor, doping concentration, TCR, TCS
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