A MEMS capacitive pressure sensor employing 3C-SiC diaphragm with operating temperature of 500^{o}C

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This project develops the prototype of a MEMS capacitive pressure sensor employing 3C-SiC diaphragm. The details of the design can be read from this article[1], and is realized as shown in Figure 1. The fabrication steps to back-etched the bulk Si to leave SiC thin film by applied ProTEK PSB coating on 3C-SiC-on-Si wafer as photosensitive layer. The ProTEK PSB is exposed using photolithography process to pattern the front side of the wafer to be used as pressure sensor diaphragm[2]. The fabricated sensor is packaged for high temperature and characterized under static pressure of 5 MPa and temperatures of up to 500 °C in a stainless steel chamber with direct capacitance measurement. The stability and performance has been measured by using LCR meter from the schematic experimental setup in Figure 2.

Figure 3 shows the measured results that are obtained using the 3C-SiC diaphragm that has the thickness of 1.0 μm and the size 200 μm x 200 μm. At room temperature (27 °C), the sensitivity of the sensor is 0.774 pF/MPa in the range of (1.0 – 5.0 MPa), with nonlinearity of 0.78% and hysteresis of 0.67%. At 300 °C, the sensitivity is 1.289 pF/MPa, and the nonlinearity and hysteresis of 0.99 % and 1.73%, respectively. The sensitivity decreased by 2.1 pF/MPa (0.515 % decreased from room temperature); corresponding temperature coefficient of sensitivity is 0.058%/°C. At 500 °C, the maximum temperature coefficient of output change is 0.073 %/°C being measured at 5 MPa.

The main impact of this work is the ability of the sensor to operate up to 500 °C, compare to the previous work[3] using similar 3C-SiC diaphragm that can only operates up to 300 °C. In addition, a reliable stainless steel o-ring packaging concept is proposed as a simple assembly approach to reduce the manufacturing cost, as shown in Figure 1. There is an o-ring seal at this sensor is designed for high reliability, small size, lightweight, smart interface features and easy cleaning service in the field which is relatively easy to replace without the need for special skill or tools in short period of time.

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[1] N. Marsi, B. Y. Majlis, A. A. Hamzah and F. Mohd-Yasin. 2013. *The Capacitance and Temperature Effects of the SiC- and Si- Based MEMS Pressure Sensor*. IOP Science, Journal of Physics: Conference Series, Vol 431(1) 012022, pp. 1 - 9.

[2] N. Marsi, B. Y. Majlis, A. A. Hamzah and F. Mohd-Yasin. 2014. *Characterization of ProTEX PSB Thin Film as Photosensitive Layer of MEMS Capacitive Pressure Sensor Diaphragm Based on SiC-on-Si Wafer*. Key Engineering Materials, Trans Tech Publication, Switzerland, Vols. 594-595, pp. 1083 - 1086.

[3] L. Chen and M. Mehran. 2008. *A Silicon Carbide Capacitive Pressure Sensor for In-Cylinder Pressure Measurement.* Sensors and Actuators, vols. 145-46.

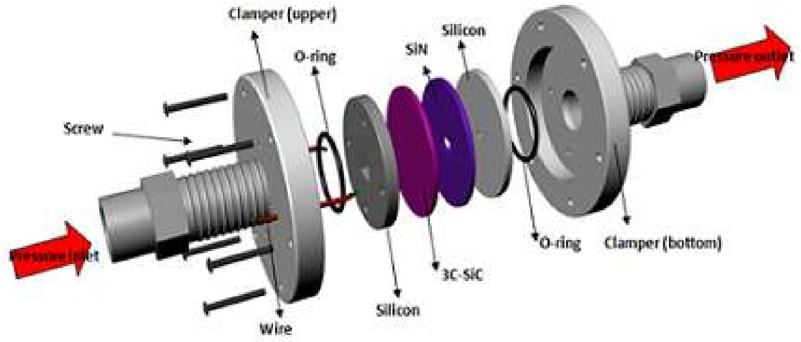


Figure 1: 3D view of MEMS capacitive pressure sensor structure

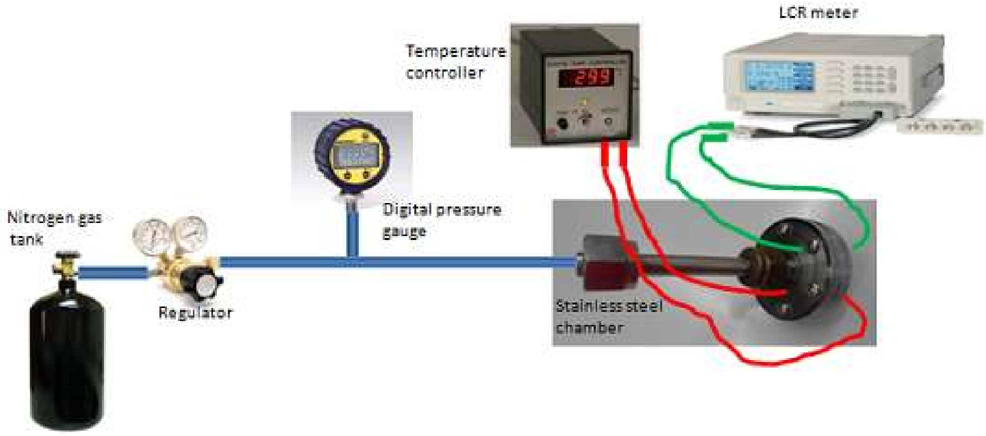
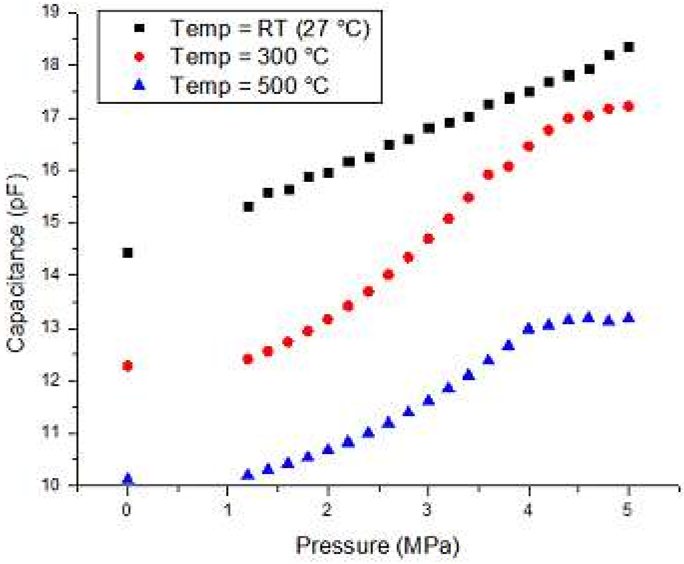


Figure 2: Schematic diagram of experimental setup for measurement of MEMS capacitive pressure sensor



Temperature	RT	300 °C	500 °C
Sensitivity (pF/MPa)	0.774	1.289	0.826
Nonlinearity (%)	0.78	0.99	0.61
Hysteresis (%)	0.67	1.73	3.13
Temp. Coeff. (%)	N/A	0.058	0.073

Figure 3: The graphs of maximum capacitance versus differential pressure under different temperatures of 3C-SiC-based sensor.