

Multi-Sensor Comprising Capacitive, Resistive and Conductive Micro-sensors

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Abstract:

Multi-sensor was fabricated based on micro-heater and capacitive, resistive and conductive operation method with low power consumption and CMOS compatible process. In the structure of micro-heater, the resistances of two semi-circled Pt heaters are connected to the spreader for thermal uniformity. Based on the above design, low power consumption air quality gas sensor was fabricated by using CMOS compatible MEMS process. Bridge type micro-heater based on Si substrate was fabricated by surface micromachining technique. SnO₂ based thick film for a gas sensing material was deposited using screen printing technique on the Si substrate in the form of slurry. And polyimide thick film was deposited using ink jetting method. Micro multi-sensor showed temperature, humidity and gas sensing properties simultaneously.

Key words: multi-sensor, capacitive, resistive, conductive, CMOS, MEMS.

Introduction

Various sensors are widely used for industrial applications, environmental monitoring and air conditioning, etc, in the form of Internet of Things (IoT). Necessary sensors for the above applications were temperature sensor, humidity sensor and gas sensor, etc. In most real cases, individual sensor was embedded in the sensor node. And this limit the form factor of sensor node.

The next multi-sensor based on Si wafer is application of micromachining technique for low power consumption, mass production, and integration of multi-function. In this paper, fabrication and characteristics of multi-sensor comprising capacitive, resistive and conductive function using CMOS compatible MEMS process is going to be presented [2-4]. paragraphs.

Experimental Results

In the structure of a micro-heater, the resistances of two semi-circular platinum (Pt) heaters are connected to a track for power supply. The resistance of each heating element becomes an electrically equal Wheatstone-bridge, which is divided in half by a heat-spreading structure. The generated heat diffuses from the circled heating elements through the heat spreaders to promote thermal uniformity at the central area where a sensing material will be located, which is thermally isolated by air using a bridge structure. The

power consumption of the micro-heater device and the thermal distribution on the micro-heater device are simulated using the COMSOL software.

Based on the aforementioned design, multi sensor having temperature sensor, humidity sensor and low power consumption air quality gas sensor was fabricated using CMOS-compatible MEMS process, as shown in Figure 1. Multiple layers were initially deposited on a 675 μm thick one-side-polished 6 inch Si wafer, where a SiO₂/Si₃N₄/SiO₂ (O/N/O) structure of multiple layers was used for stress compensation and thermal isolation. A Wheatstone-bridge-type resistive Pt with an O/N/O structure was adopted to heat the sensing material, so as to reduce the conduction loss and to compensate for stress. After forming the multiple layers, the heating part was patterned using the lift-off process. The heating element, the heat spreader and temperature sensing structure were made of Pt, which has good endurance at a high temperature and under repetitive operations. To attain electrical insulation between the heater and the gas sensing electrode, a SiO₂ passivation layer was used.

SnO₂ based thick film for a gas sensing material was deposited using screen printing technique on the Si substrate in the form of slurry. A Si dry etching process with XeF₂ gas was used for micro gas sensor fabrication process. After Si etching process, polyimide

thick film was deposited using ink jetting method to catch humidity molecule, all the device fabrication processes were CMOS-compatible based on 6 inch Si substrate.

The photograph of the fabricated MEMS multi-sensor is shown, in Fig. 2, which had a square shape with dimensions of about 10 mm on each side. In the figure, two temperature sensor, two humidity sensor and four gas sensor are embedded in the multi-sensor.

The HCHO sensing performance was shown in Fig. 3, and the measured response for fabricated sensor was about 0.4 for air based 0.5 ppm HCHO gas with 30 mW power consumption,

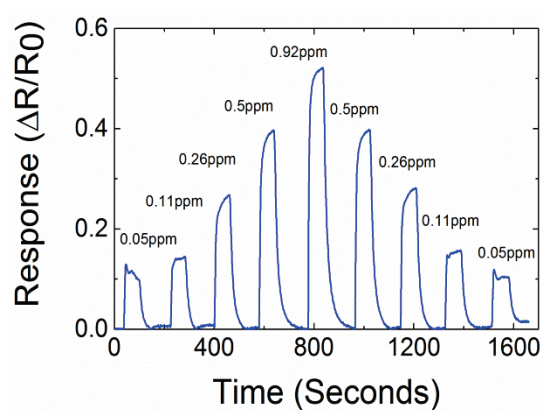


Fig. 2. HCHO gas sensing properties of MEMS multi-sensor.

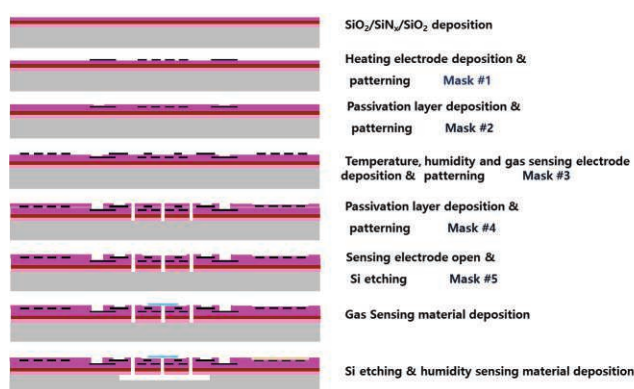


Fig. 1. MEMS multi-sensor fabrication process.



Fig. 2. Photograph of MEMS multi-sensor.

References

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