A new type of a MEMS pressure sensor with mechanical micro-switch array

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Over the past 20 years, the microelectro-mechanical systems (MEMS) sensor industry has made continuous improvements. Several years ago, for example, Motorola integrated additional signal conditioning with the sensing element. Most recently, the company redesigned its line of integrated pressure sensors with on-chip compensation and amplification. However, a fundamental drawback for the currently available pressure sensor comes from the sensing mechanism employed in the MEMS pressure sensors[1-2]. Most of the pressures available in a market use the piezoresistive phenomena or the capacitive methods to measure the change of pressure. However, it needs to be improved from a point of view of low stress strength, offset drift with temperature, complicated electric circuits to amplify a feeble signal and so on[3-4].

This paper describes a MEMS pressure sensor based on micro-switch array. It consists of a silicon substrate that has a thin metal-deposited diaphragm and an array of micro-switch patterned on a Pyrex glass[5]. The micro-switch array to measure the change of a pressure is formed on a micromachined resistor made by indium tin oxide (ITO). The distance of each electrode on the ITO resistor is about 10μm. When a pressure is applied to the diaphragm of the sensor, the Si diaphragm with a conductive layer starts to contact onto the micro-switch of the ITO resistor at a certain pressure level. The number of the micro-switch to be contacted to the diaphragm is changed due to increase of a contact area. The change of the electrical resistance between both ends of the ITO resistor is measured using a very simple electrical circuit. Basic characteristics of the fabricated prototype pressure sensor are successfully evaluated and the validity of the proposed pressure sensor is verified.

Figure 1 and 2 show a schematic diagram and an operation principle for the novel pressure sensor. Figure 3 (a) and (b) show optical images of a fabricated Pyrex glass part and a prototype pressure sensor, respectively. An effective size of the digital pressure sensor is about $11\times11\times1$ mm^3. The diaphragm size with a thickness of 15 μm is 8×8 mm^2. The size of the diaphragm can be easily reduced down to several tens of μm using a different mask. For the fabrication of the thin silicon diaphragm and micro-switches, conventional micromachining technologies such as photolithography, anisotropic wet etching, sputtering and anodic bonding are used. Optimization of the pressure sensor is conducted using a finite method. The simulation results such as displacement and stress analyses of the diaphragm and contact area characteristics are presented as shown in Fig. 4. Experimental setup to characterize the fabricated pressure sensor is shown in Fig. 5. Basic characteristics of the fabricated prototype pressure sensor, shown in Fig. 6 and 7, are successfully evaluated and the validity of the proposed pressure sensor is verified. Details for the novel pressure sensor with integrated micro-switch array will be presented at the conference.

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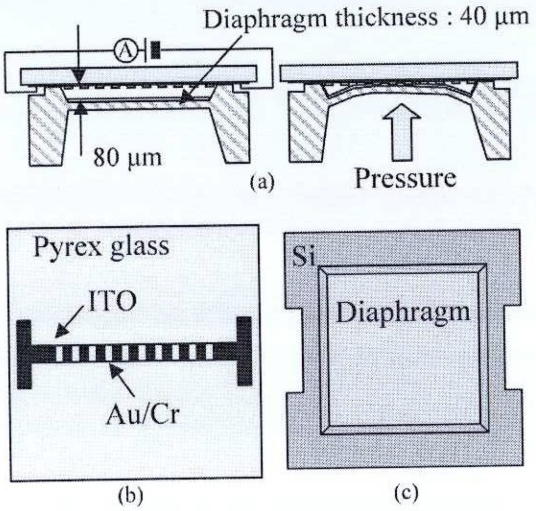

Figure 1. Schematic diagrams of (a) a pressure sensor, (b) pyrex glass and (c) silicon part.

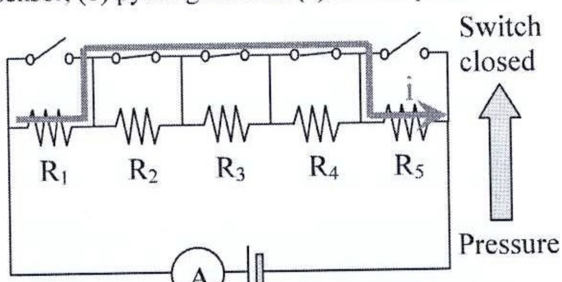

Figure 2. Operation principle of the pressure sensor.

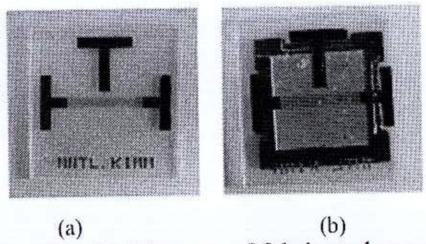

Figure 3. Optical images of fabricated pressure sensor based on micro-switch array ; (a) a pyrex glass and (b) a silicon part anodically bonded to the pyrex glass part.

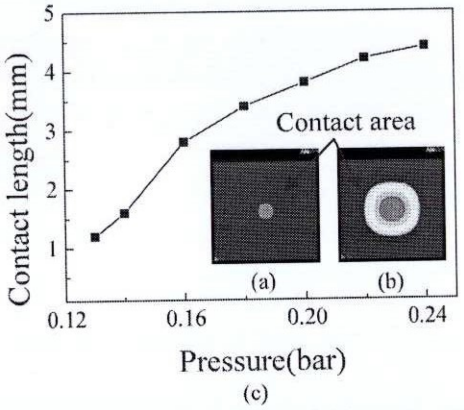

Figure 4. Simulation results of (a) contact area ; 0.13 bar, (b) 0.24 bar and (c) contact length as a function of pressure.

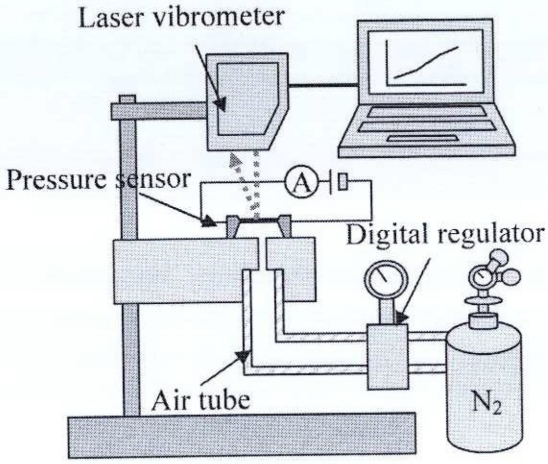

Figure 5. A schematic diagram of a measurement setup.

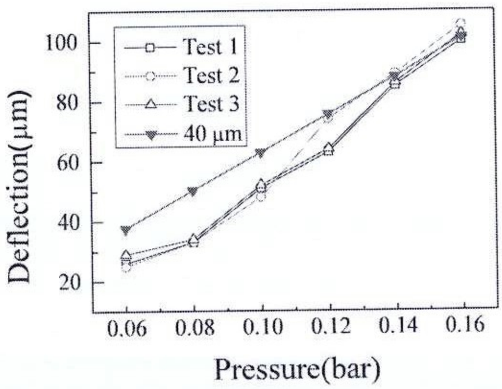

Figure 6. Si Diaphragm deflection according to applied pressure.

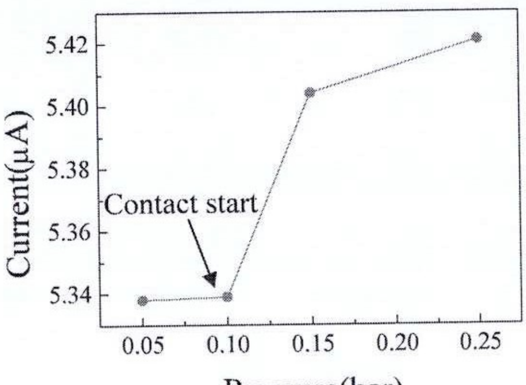

Figure 7. Output current as a function of pressure.