Piezoresistive Pressure Sensor

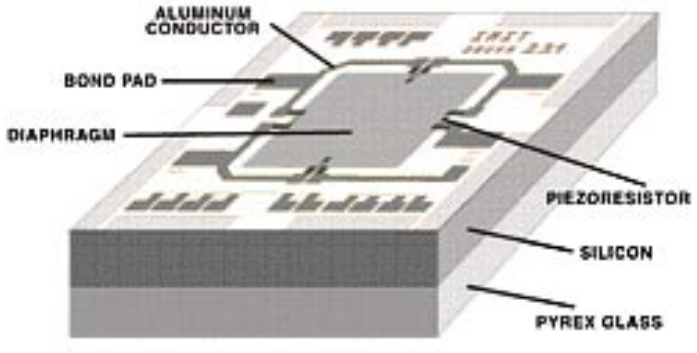
Objective: Study the characteristics of piezoresistive pressure sensors and the structure of tire pressure gages

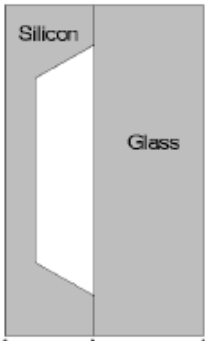
Preparation: Tire pressure gage, Pressurized tire, Pressure calibration standard, Multimeter

Introduction:

The piezoresistive pressure sensor, or silicon cell, consists of a micro-machined silicon diaphragm with piezoresistive strain gauges diffused or implanted into it, fused to a silicon or glass backplate. Though manufactured with semiconductor technology, they also operate on the resistive principle. Conductivity in a doped semiconductor is influenced by strains and causes the resistance change that is substantially higher than that in standard strain gauges, whose resistance changes with geometrical changes in the structure.

Via aluminum conductors, the semiconductor resistors are joined together in a Wheatstone bridge configuration and attached to the bond pads for circuit interconnection. The resistors are placed on the diaphragm such that two experience mechanical tension in parallel and the other two are perpendicular to the direction of current flow. Thus, the two pairs exhibit resistance changes opposite to each other. These pairs are located diagonally in the bridge such that applied pressure produces a bridge imbalance. The output of the Wheatstone bridge is directly proportional to the pressure.





A digital tire pressure gage is a small system that contains a pressure sensing element as one of the major parts. Figure 1 shows the detail structure of a tire pressure gage. This gage equipped with a silicon piezoresistive pressure sensor. The circuit of the silicon pressure sensor is shown in Fig. 2. Strain gages composed of piezoresistors are orange-colored. The range of this tire pressure gage is 15 - 700kPa.

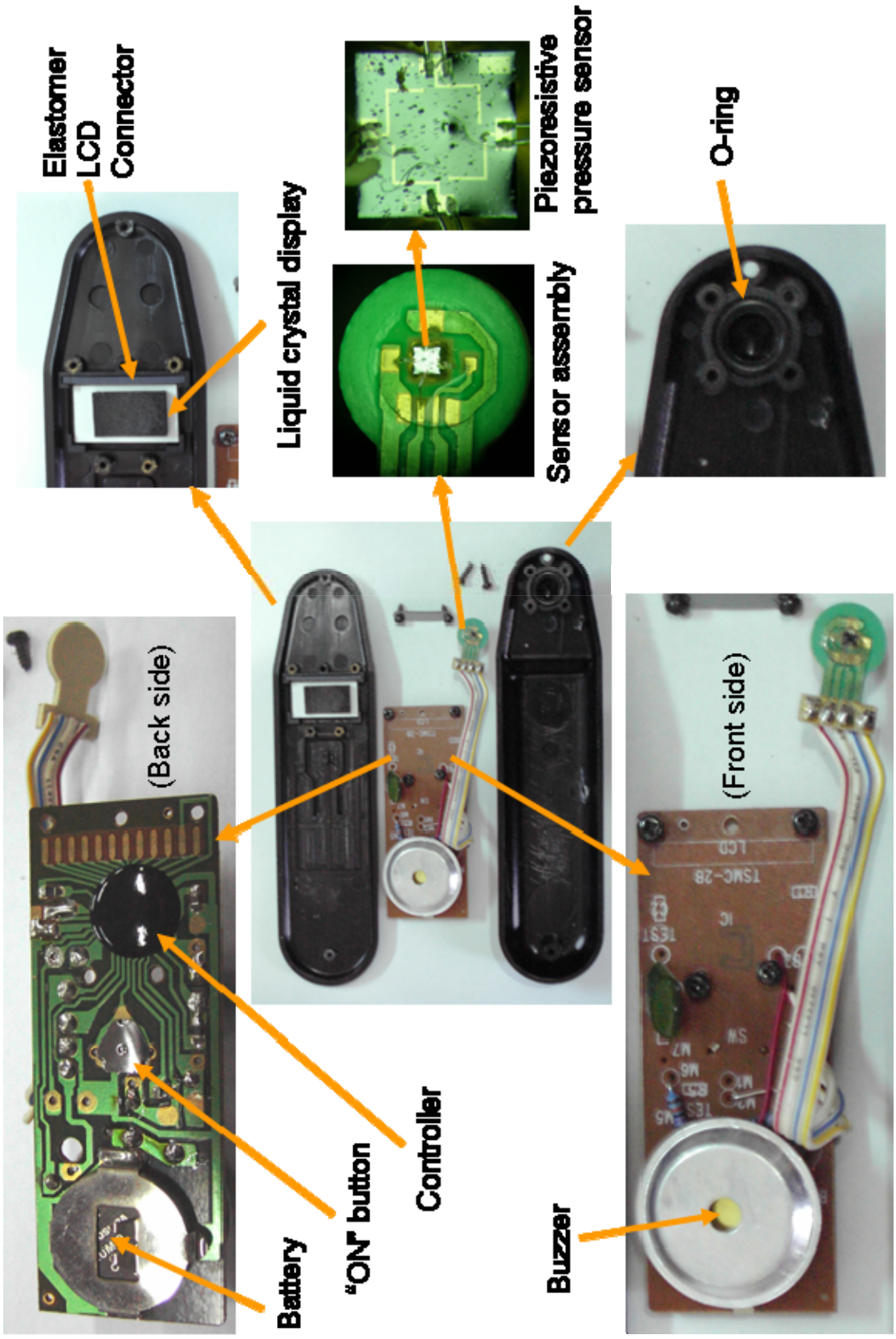

Elastomer
LCD
Connector
Liquid crystal display
Piezoresistive
pressure sensor
Sensor assembly
O-ring
(Back side)
(Front side)
Battery
"ON" button
Controller
Buzzer

Fig. 1

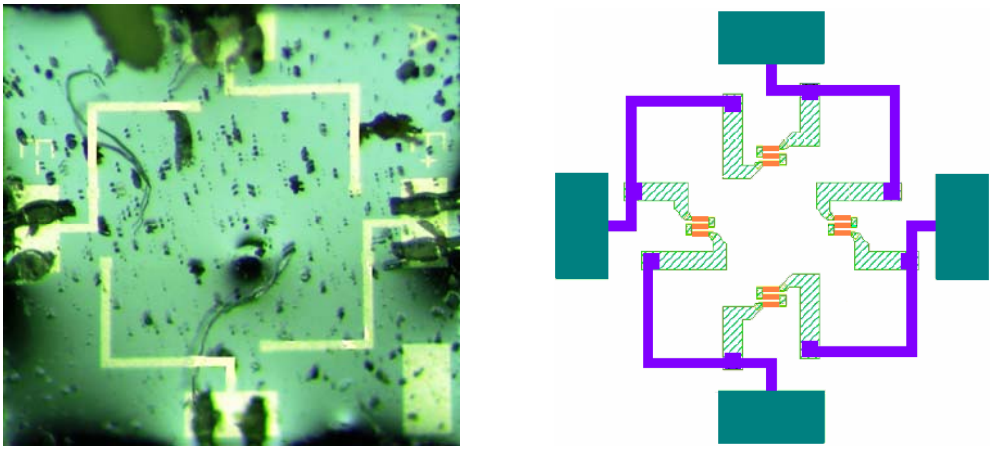
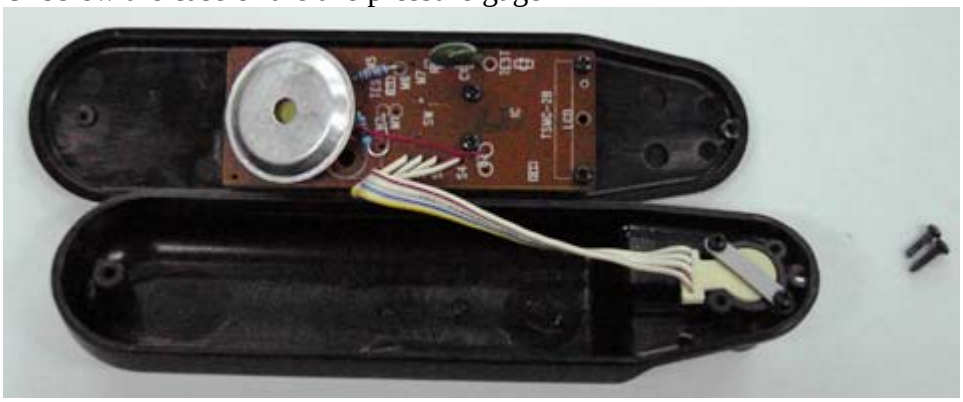


Fig. 2

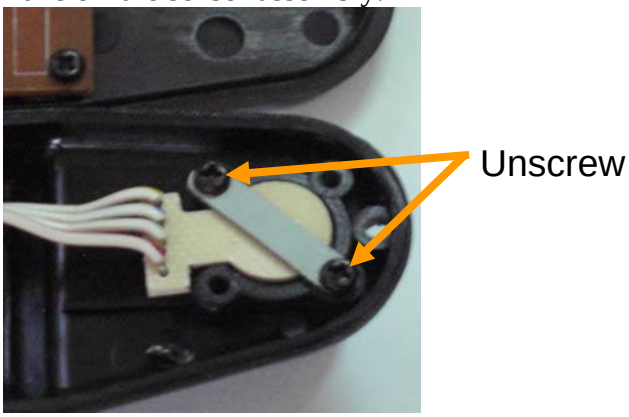
Procedures:

I. **Calibration of the tire pressure gage**
   1. Familiar with the operation of the tire pressure gage.
   2. Pressurize the tire from 0 to 300kPa with a step of 20kPa. Record both readings of the tire pressure gage and the calibration standard for each step.
   3. Depressurize the tire from 300 to 0kPa with a step of 20kPa. Record both readings of the tire pressure gage and the calibration standard for each step.

II. **Determine the resistance of piezoresistors**
   1. Unscrew the case of the tire pressure gage



   2. Take off the sensor assembly.



   3. Measure the resistance R_{ij} between all the terminals pairs Si and Sj.

4. Assemble the tire pressure gage and make sure it works well.

Report:

The report should contain the following works at least.

1. Curve fit the calibration data with least square method to obtain the relationship between the gage reading and the true pressure.
2. Taking 300kPa as the full scale, discuss the nonlinearity of the tire pressure gage. (Ref.: *Measurement Systems* by E. O. Doebelin)
3. Assuming the four piezoresistors are identical, calculate their resistance.