CAPACITIVE TRANSDUCERS

The change in capacitance in response to a measurand has many applications in physical transducers. Displacements, velocity, acceleration, force, pressure, vacuum, flow, fluid level, audio sound field, and relative humidity can be measured using capacitive transducers.

The capacitance between parallel conducting plates with a dielectric material between them is given by

$$C_s = \frac{\varepsilon_0 \varepsilon_p A (n - 1)}{d}$$

where Σ_0=permitivity of free space
=8.854X10-12 farad /m
Σ_r=relative permitivity or dielectric constant of the material, the value
Usually tabulated in handbooks (Σ_r=1 for air)
A=area that is common to both plates (overlap area, m2)
d=separation between plates, m
n=number of plates
Cs=capacitance, farads

Equation indicates that the capacitance varies linearly with the area A and the dielectric constant of the material, but it varies inversely with the separation between plates. Any changes in the above-mentioned parameters caused by a measurand, and taken one at a time, provide practical transduction mechanisms.

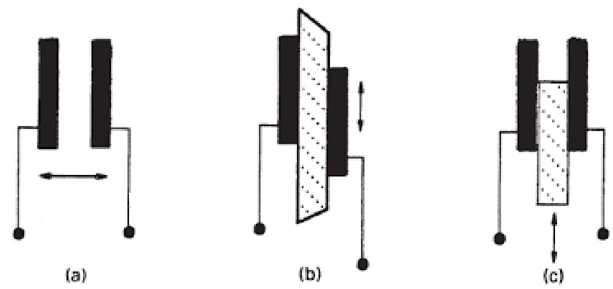

Fig 5.2 Capacitive Displacement transducers.

Figure 5.2 shows some of the configurations where the changes in Cs are used to measure physical measurands. The first two lend themselves to the measurement of displacement, force, flow, vacuum, and pressure, and the third configuration could be used to measure the changes in the dielectric constant brought about by the absorption of moisture13 or a chemical reaction with the dielectric material.

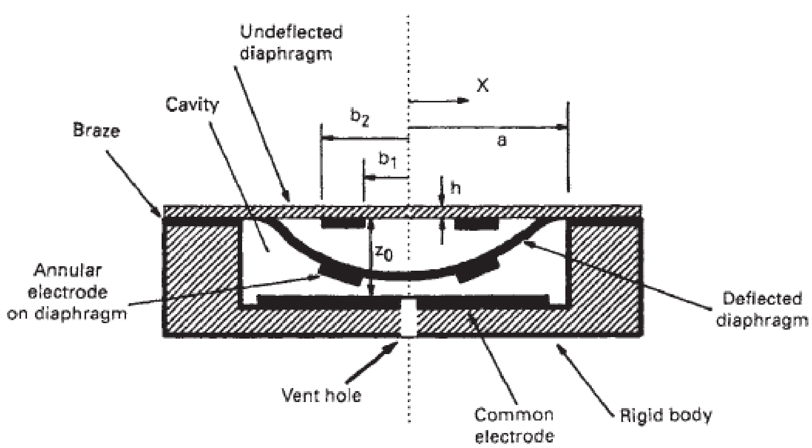

Fig 5.3.Capacitive pressure Transducer

Figure 5.3 shows the diametrical cross section of a pressure transducer constructed totally from fused quartz, which has a very small temperature coefficient of expansion. The transducer consists of a circular diaphragm rigidly clamped by brazing it to a fused quartz body. A very shallow cavity has been sputter etched in the body to provide the separation Zo between the capacitor plates. This cavity is vented to the atmosphere by a small hole in the body of the structure, allowing the transducer to measure Gage pressure.

The diaphragm has an annular electrode of metalized chrome and gold on the inside face, and a common electrode is deposited on the bottom of the etched cavity. The capacitance of this transducer as a function of the applied pressure is given by

$$C_R = \frac{8.85\pi K_2}{2Z_0} \log_e \left\{ \frac{K_2 - (a^2 - b_2^2)[K_2 + (a^2 - b_1^2)]}{K_2 + (a^2 - b_2^2)[K_2 - (a^2 - b_1^2)]} \right\}$$

Where

$$K_2 = \left\{ \frac{Z_0 h^3}{3/16[(1-\mu^2)/E]P} \right\}^{1/2}$$

and *CR*=capacitance, pf

μ=Poisson's ratio (0.17 for fused quartz)

E=Young's modulus (745×103 kg/cm3 for fused quartz)

A =radius of etched cavity, m

h=thickness of diaphragram, m

Z0=depth of etched cavity, m

P=applied pressure, kg/cm2

The units of b1 and b2 are meters. Using the Eq. the capacitance of a circular electrode transducer in the center of the diaphragm can be obtained by setting b1 equal to 0 and b2 equal to the desired radius. This construction is currently used in an invasive blood pressure transducer shown in Fig. 5.4.

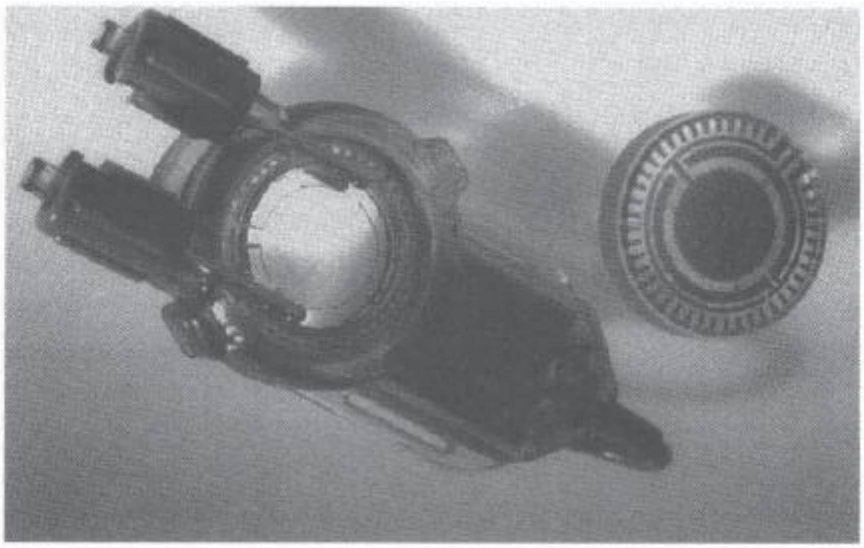

Fig 5.4. Blood Pressure Transducer

It has a circular sensing electrode in the center of the diaphragm, an annular reference electrode very close to the clamped edge of the diaphragm, and a full electrode at the bottom of the etched cavity. The reference capacitor changes very little with pressure.

A monolithic capacitor-type accelerometer made from silicon by microma-chining results in a rugged transducer with excellent thermal and elastic stability. Techniques is shown in Fig. 5.5a.

It is made up of several differential capacitors, and each capacitor section consists of two fixed outer plates and a center plate that is movable.

Fig. 5.5b shows the deflected position of the center plate when the transducer experiences acceleration. The deflection, and consequently the capacitance change, is proportional to the acceleration.

In many applications, capacitive transducers are connected in an ac bridge circuit to obtain an electrical output proportional to the measurand. In others it can be made a part of an LC oscillator, where the oscillator frequency is proportional to the magnitude of the measurand. When differential sensing is used, the sensitivity can be doubled and the temperature sensitivity reduced.

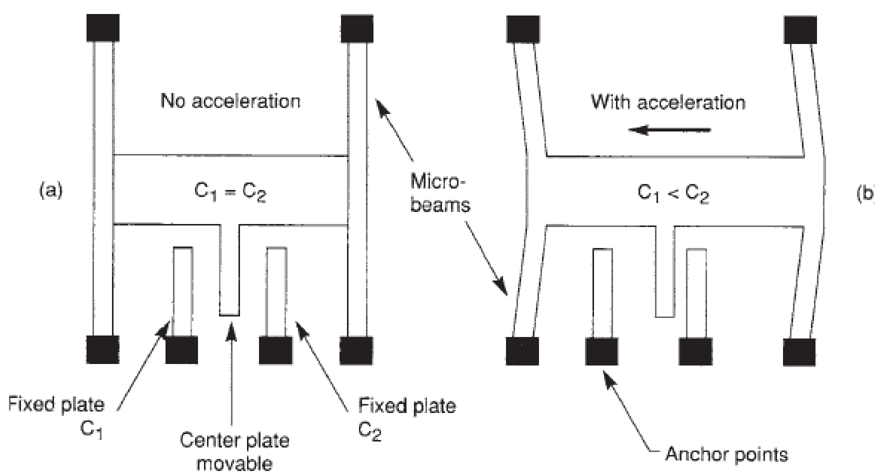

Fig 5.5.Capacitive Micro Machined Accelerometer

Source: http://mediatoget.blogspot.in/2012/05/capacitive-transducers.html