A full-bridge capacitive sensor has double transducer sensitivity of a half-bridge. Higher transducer sensitivity improves the signal-to-electrical noise ratio. At the same time, since the full-bridge capacitive sensor has differential output, it has better ability to reject common mode noise. The undercut of silicon in the release step (Figure.2) constrains the placement of sensing circuits to at least 15 µm away from the microstructures. Compared to most commercialized polysilicon micromachining technology, the MEMS to electronics interconnect in CMOS-MEMS is shorter, and suffers less parasitic capacitance. Such parasitic on high impedance wiring can be made small relative to input capacitance of interface circuits, so the transducer sensitivity is larger when capacitive sensing is employed.

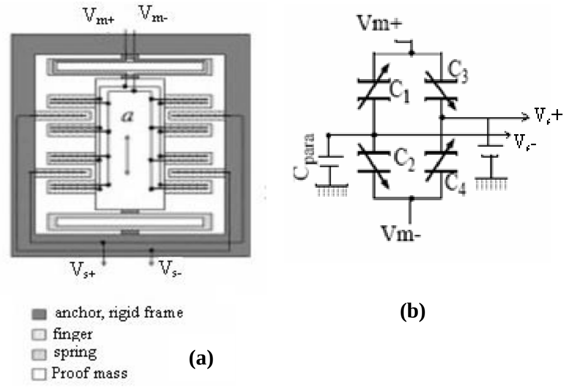

Figure.2.

C_{para}: is the parasitic capacitance and C_1,C_2,C_3,C_4 represent the differential capacities between the movable fingers and the sensing fingers.

Figure.2.a and Figure.2.b represent the schematic of accelerometer and the equivalent model. The topology used here is that of a single axis, common centroid, fully differential, capacitive sensing lateral accelerometer [3]. The proof mass is suspended using four serpentine springs attached to its corners. Interdigitated comb drives are used for differential capacitive sensing as shown in Figure.2.a. Each finger consists of two electrical nodes, one each for the two capacitors on the half capacitive bridge; and the sense nodes are located on the stator fingers. This is used to create a common centroid configuration, which is not possible in polysilicon MEMS. In order to counter out of plane curl mismatch between the comb fingers, the fingers are attached to a peripheral frame rather than being anchored to the substrate.

3. Principle of operation

A schematic of a capacitive micro accelerometer simplified is shown in Figure.4. The central part of the accelerometer is a suspended micromechanical proof mass. When an external acceleration is applied, the proof mass will move with respect to the moving frame of reference which acts as the sensing element [3].

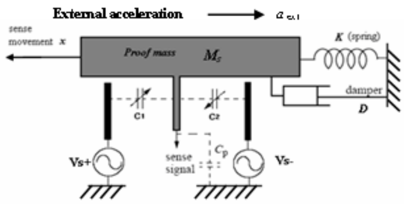

Figure.4.

The displacements of the proof mass imply an acceleration which can be measured by several methods. For the capacitive sensing approach, the displacement is detected by measuring the capacitance change between the proof mass and adjacent fixed electrodes. Low parasitic capacitance achieved from monolithic integration is the key to maximizing the performance with this technique.

On the basis of the mechanical parameters schematic for the sensing element shown in Figure.4, the differential equation for the displacement x as a function of external acceleration is that of a second-order mass-spring-damper system [2], [3]:

$$M_s \cdot \frac{d^2x}{dt^2} + D \cdot \frac{dx}{dt} + K_s \cdot x = M_s \cdot a_{ext} \qquad (1)$$

Where K_s is the spring constant, D is the damping coefficient, M_s is the proof mass and a_{ext} is the external acceleration.

With Laplace transform notation, the above equation converts to a second-order transfer function:

$$\frac{X(s)}{A(s)} = \frac{1}{s^2 + s \cdot \frac{D}{M_s} + \frac{K_s}{M_s}} = \frac{1}{s^2 + s \cdot \frac{\omega_r}{Q} + \omega_r^2} \qquad (2)$$

ω_r: is the resonant frequency,

Q: is the quality factor.

At low frequency ($\omega \ll \omega r$):

$$\frac{X}{A} \approx \frac{1}{\omega_r^2} \qquad (3)$$

The sensitivity is inversely proportional to the square of the resonant frequency which means the lower the resonant frequency the higher the sensitivity. But actually, the lower limit of resonant frequency is bounded by many factors such as the mechanical shock resistance, the achievable lowest spring constant, the highest possible effective mass, and manufacturability.

4. Device Design

The structure design of a poly-silicon surface-micromachined MEMS comb accelerometer is shown in Figure.5.

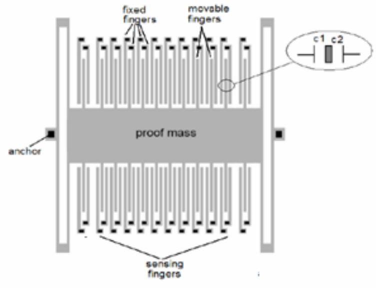

Figure.5.