The movable parts of this MEMS comb accelerometer consist of four folded-beams, a proof mass and some movable fingers. The fixed parts include two anchors and some left / right fixed fingers. The central movable mass is connected to both anchors through four folded beams.
In the right and left side of the each movable finger, there are left and right fixed fingers. The movable fingers constitute the differential capacitance pair C_1 and C_2 with left and right comb fingers [6].
If is no acceleration ($a = 0$) , the movable fingers are resting in the middle of the left and right fixed fingers, the left and right capacitance pairs C_1 and C_2 are equal. When is any acceleration a along horizontal direction parallel to the device plan, the proof mass M_s experiences an inertial force become $-M_s \cdot a$ along the opposite direction. However, the beams deflect and the movable mass and movable fingers move for a certain displacement x along the direction of the inertial force. That automatically changes the left and right capacitance gaps; hence the differential capacitances C_1 and C_2 will also be changed. One can know the value and direction of acceleration one measuring the difference of the capacities change.
When there is no acceleration, a driving voltage V_d is applied to the left or right fixed driving fingers.
The electrostatic force will attract the movable fingers toward the left or right direction. By measuring this displacement and comparing with good device response, one knows whether the device is good or faulty.

5. Mechanical Suspension

The topology of folded beam with turns can provide a lower spring constant, and thus higher sensitivity.

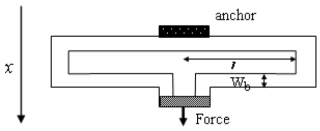

Figure.6.

The spring constant of this structure is:

$$K_s = \frac{1}{2} \cdot E \cdot h \cdot \left(\frac{w_b}{l_b} \right)^3 \tag{4}$$

The four folded beam can be treated as four springs connected in parallel. Therefore, the spring constant along the Δx direction for a suspension structure as shown in Figure.6, can be determined as:

$$K_{total} = 2 \cdot E \cdot h \cdot \left(\frac{w_b}{l_b} \right)^3 \tag{5}$$

Where:
Ks: is the constant of spring for one folded beam.
l_b: is the beam length,
w_b: is the beam width,
h: is the beam thickness,
E: is the Young's modulus of the structural material.

6. Damping and Quality Factor

There are two categories of damping mechanisms. First, structural damping is caused by friction within composite structural layers [3]. The second is viscous air damping at atmospheric pressure. For the lateral accelerometer, squeeze film damping which occurs when the air gap between two closely placed parallel surfaces changes, is not critical either.

The damping coefficient between a single comb finger gaps is giving by [8]:

$$D = N_f \cdot \eta_{eff} \cdot l_b \cdot \left(\frac{h}{d_0} \right)^3 \tag{6}$$

N_f : total sensing finger number.
η_{eff} : is the effective viscosity of air.
d_o: capacitance gap.

However the quality factor is given by:

$$Q = M_s \cdot \omega_r / D \tag{7}$$

Where:
$\omega_r = \sqrt{K_s / M_s}$
Reducing the damping increases the possibility of resonant behavior (high Q).

7. Basic Knowledge for Capacitive MEMS Devices

A typical MEMS differential capacitance structure is shown in Figure.7 where M_s represent the movable plate mass; F_1 and F_2 denote fixed or fingers plates, while B_1 and B_2 are both beams of the MEMS device [9].

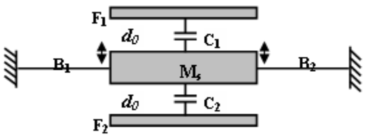

Figure.7.

The movable plate M_s is anchored to the substrate through two flexible beams B_1 and B_2. It constitutes differential capacitances C_1, C_2 with the top and bottom fixed plates. In the static mode, the movable plate M_s is located in the center between F_1 and F_2, therefore:

$$C_1 = C_2 = \frac{\varepsilon_0 \cdot S}{d_0} \tag{8}$$

Where
ε_0 : is the dielectric constant of air.
S: is the overlap area between M_s and F_1, F_2.
d_0: is the static capacitance gap between M_s and F_1, F_2.

When there is acceleration will result in the deflection of beams and a certain displacement of movable plate M_s along the vertical direction. Assume the central movable mass moves upward