MECH 4370, EE4371, Introduction to MEMS

Homework #5 (updated)

Due: March 6, 2019

- Consider a parallel plate capacitor with electrode area of 1,200 µm x 1,200 µm, air gap of 2 µm. What is the capacitance? If 5 V applied between two electrodes, what is the stored energy?

- Consider a capacitive Wheatstone bridge circuit with two fixed capacitors ($C_0$) and a differential capacitor pair ($C_{w1}$ & $C_{w2}$) also with parasitic capacitance $C_p$. The fixed capacitor’s electrode is 200 µm x 200 µm and two parallel electrodes are overlapped 100%. The gap between two electrodes is 3 µm and it is filled with air. If $\Delta C$ is 1 fF, $C_p$ is 1 pF, V is 1 V, what is the Wheatstone bridge circuit’s output voltage ($V_{out} = V_2 - V_1$)?

- Consider a differential capacitive accelerometer that is similar to Analog Devices’ ADXL series, but made of aluminum and packaged in air. Assume that thickness of all suspended structure is 20 µm, widths of tethers, center plate and fixed outer plates (refer to the schematics below) are 5 µm, width (W) of the proof mass (marked as “beam” in the schematic below) is 100 µm, length (L) of the proof mass is 1.5 mm, and 50 center plates each side (a total of 100 center plates) which are attached to the proof mass. The tether length ($L_{tether}$) is 1.5 mm. The center plate is exactly at the middle of the two fixed outer plates at rest and the gap between the fixed outer plates and the center plate is 5 µm at rest. The overlapped length of the center plate and the fixed outer plates is 200 µm. Assume that the force of the proof mass can be considered as a point load at the center of the tether. Density of aluminum is 2.6 g/cm$^3$ and Young’s modulus is 70 GPa. Neglect the mass of the tether and the center plates. Assume that squeeze film damping is negligible. Determine the differential capacitance ($C_{s2} - C_{s1}$) at 50 g acceleration. Determine the sensitivity (capacitance change in farad per 1 g acceleration) of this accelerometer accounting for all 100 individual capacitors. All 100 individual capacitors are connected in parallel.
- Exercise 5.1 (Chapter 5) in Practical MEMS.
- Exercise 5.4 a), b), and c) (Chapter 5) in Practical MEMS.