Assignment 3

Problem 1:

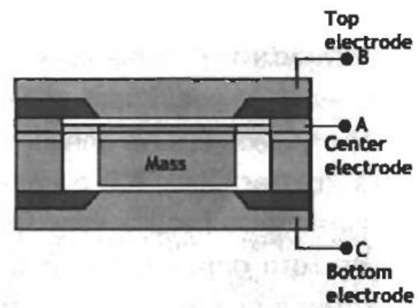
Calculate the mean-free path for argon atoms ($d_g = 360\ pm$) and helium atoms ($d_g = 190\ pm$) in atmospheric pressure and $T = 20°C$.

Problem 2:

A surface micromachined accelerometer has the intrinsic mechanical quality factor $Q_{intrinsic} = 50{,}000$, the anchor quality factor $Q_{anchor} = 1{,}000$, and the air damping quality factor $Q_{air} = 40$. Calculate the total quality factor.

Problem 3:

Consider the capacitive accelerometer shown below. Calculate the squeeze film spring constant, damping coefficient, and the accelerometer quality factor as a function of pressure in the pressure range of $10\ Pa$ to $10^5 Pa$ at $f = 1Hz$. Assume the mechanical quality factor $Q_{mech} = 10$ and for air ($d_g = 3.65\ A,\ \mu = 1.8 \times 10^{-5}\ Pa.s$). For the given accelerometer the nominal gap is $d = 2.5\ \mu m$ and the area is $A = 1200\ \mu m \times 1200\ \mu m$, its thickness $t = 550\mu m$ and the stiffness of the mechanism $K = 40\ N/m$.



Problem 4:

Considering the previous problem. Assuming that the accelerometer is operated in atmospheric pressure and there is no perforation to reduce damping, how large must the electrode gap d be to obtain quality factors greater than $Q > 0.1$?

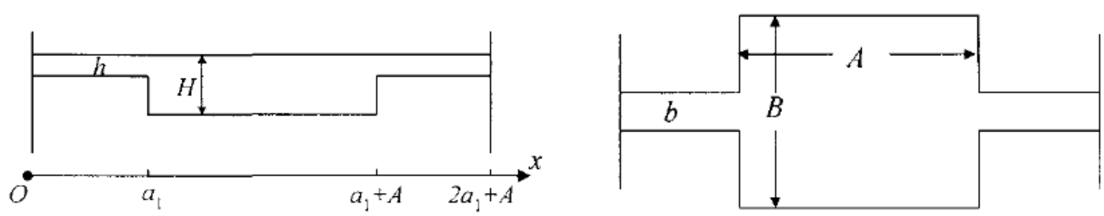
Problem 5:

A square micro-mirror that moves up and down is made of SOI wafer. The mirror thickness is $t = 5\ \mu m$ and the gap under the mirror is $d = 10\ \mu m$. Estimate the maximum mirror size if the desired quality factor is $Q = 1$ and the desired resonant frequency is $f_0 = 500\ Hz$.

Problem 6:

A double-supported beam-mass silicon structure is shown in the figure below, where $a_1 = 500\mu m, b = 50\mu m,\ h = 10\mu m,\ A = B = 4mm,\ H = 300\mu m$ and the total damping coefficient $c = 1\ N.sec/m$. The mass is subjected to a harmonic excitation $F = F_o \sin(\omega t)\ , F_o = 1mN$ in in the lateral direction. If the mass of the beam and the bending of the mass are negligible, find:

1- The undamped natural frequency in the lateral direction.
2- The damping ratio of the system.
3- The amplitude of oscillation of the mass as a function of the excitation force.
4- The amplitude of oscillation at resonance.
5- The amplitude of oscillation at $\omega = 3\omega_o$.
6- The Quality factor of the system.
7- The bandwidth of the system.



(a) cross sectional view (b) top biew