Assignment 1

Problem 1:

Explain the effect that scale factor reduction has on mechanical system parameters of mass, stiffness, and natural frequency.

Problem 2:

Figure 1 shows a resonator made with a single level surface micro-machine process that oscillates in the x axis. The layer thickness is t= 2.5 µm. The width of the springs is 2 µm. This system can be idealized as a lumped spring mass system, in which the total spring stiffness of the resonator can be calculated from the equation in Figure 1. is the area moment of inertial of the spring.

Assume the mass of the springs is negligible and consider only the mass of the central oscillating plate. Calculate the natural frequency of the resonator for several spring lengths: L = 10 mm, 1 mm, and 100 µm. Does this follow the approximate scaling for natural frequency?

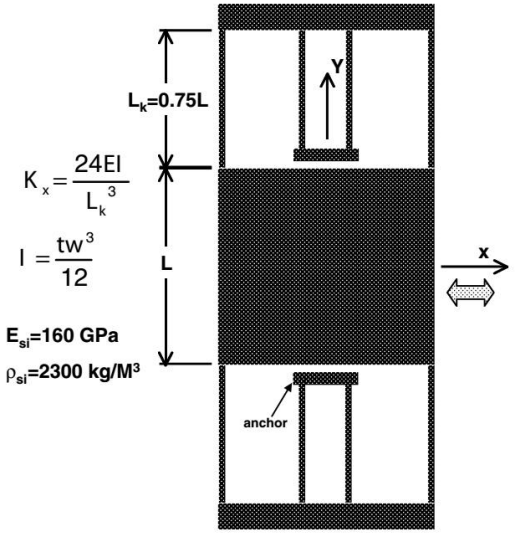

Figure 1: Double folded spring and mass resonator.

Problem 3:

The electrodes shown in Figure 2 are to be used to produce an actuation force of 10 µN with an applied voltage of less than 10 V. A gap of 1 µm is the smallest that can be manufactured. Plot the obtained force vs. the gap for 10 V applied. What gap size is recommended? If the gap cannot be made small enough, what are the possible alternatives?

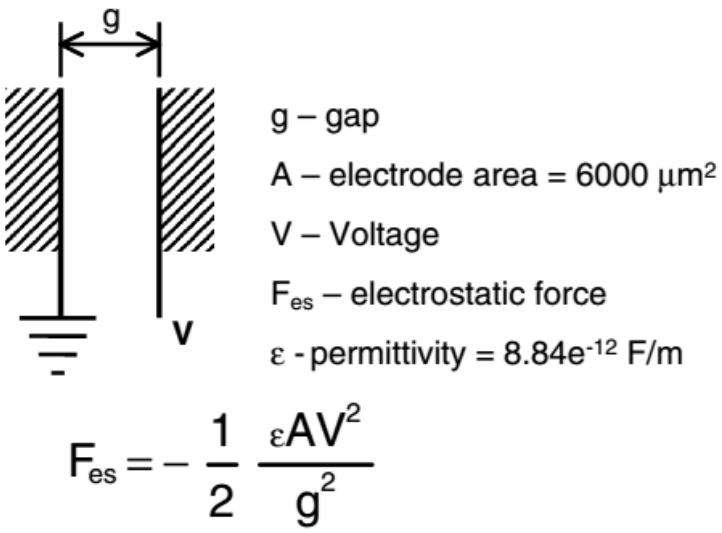

Figure 2: Electrostatic gap for actuation

Problem 4:

Using bulk micromachining, design a process to fabricate the MEMS-based pressure sensor shown in Figure 3, sketch and list the polarity of all masks and photoresists used.

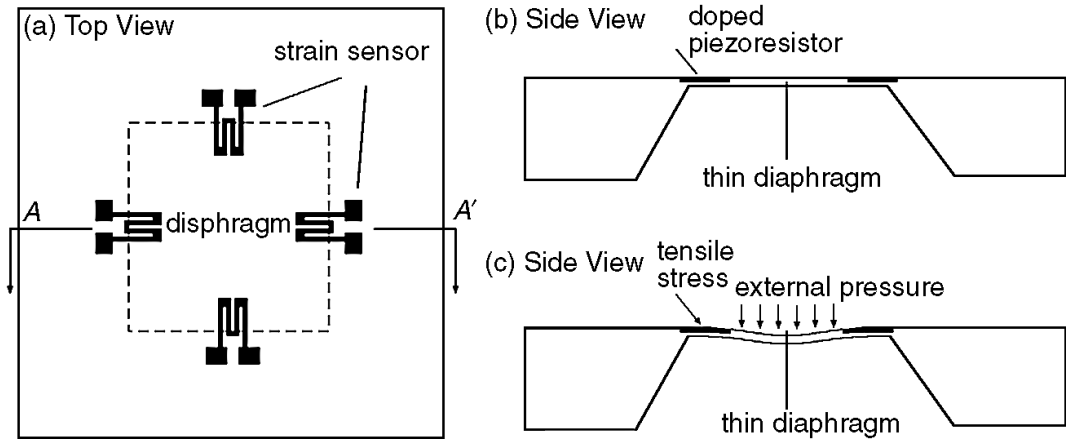

Figure 3: MEMS pressure sensor

Problem 5:

Using surface micromachining, design a process to fabricate the MEMS-based hinge shown in Figure 4, sketch and list the polarity of all masks and photoresists used.

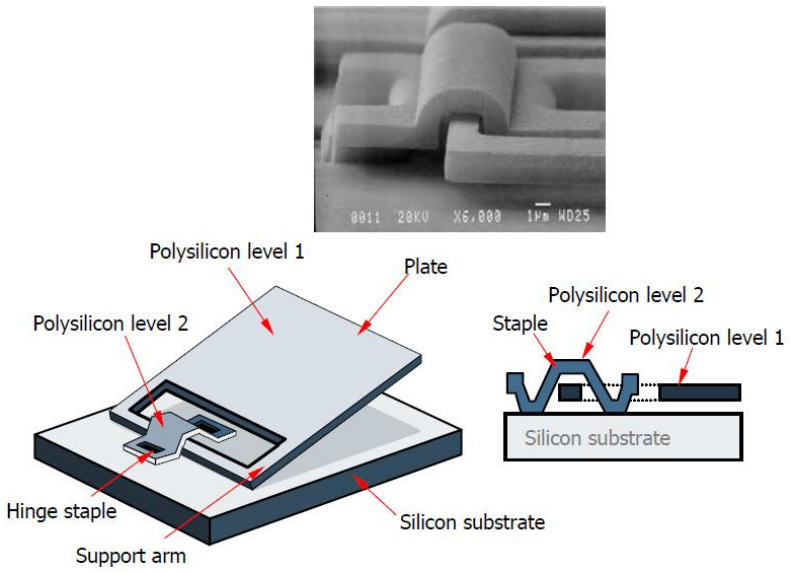

Figure 4: A MEMS-based Hinge

Problem 6:

A thermal bimorph can be used as an actuator. Design a process to fabricate a silicon-based cantilever thermal bimorph with an integrated heater as shown in Figure 5.
The cantilever includes a silicon structure on top of it is an integrated heater to actuate the bimorph, and either nitride or oxide layer(s) to keep the heater from shorting out to the bimorph.

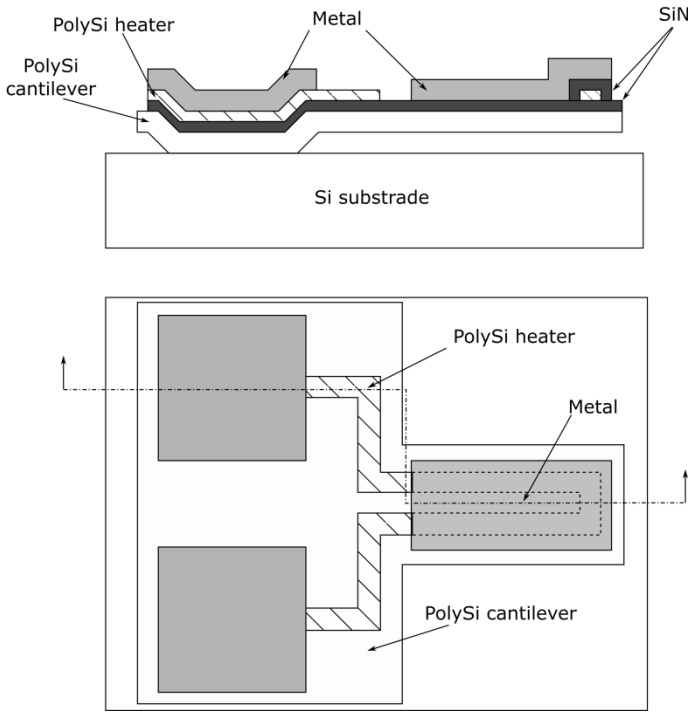

Figure 5: Top view for a thermal bimorph actuator

Problem 7:

Design a process to fabricate the MEMS-based hot wire anemometer shown in figure 5, sketch and list the polarity of all masks and photoresists used.

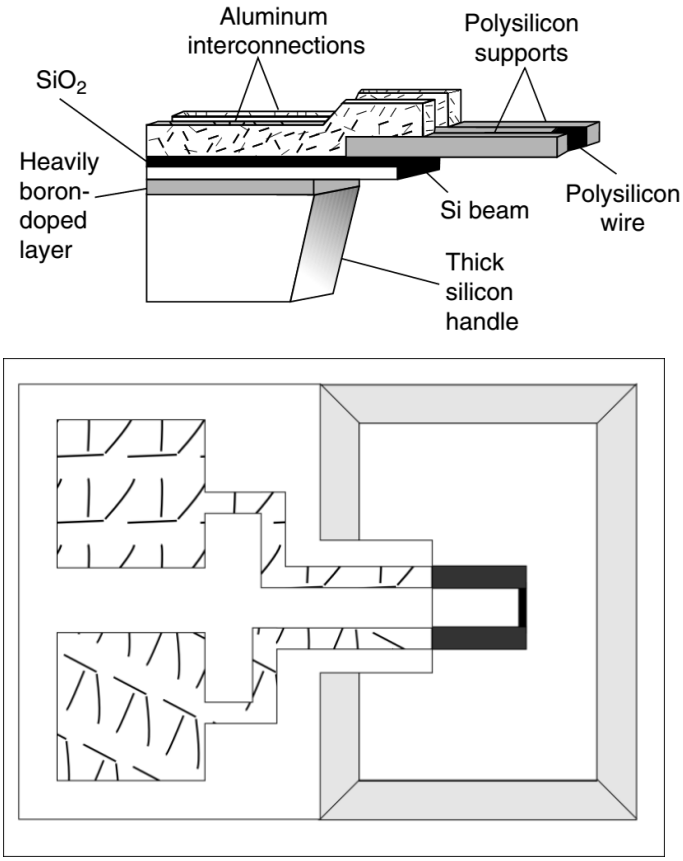

Figure 6: MEMS Hot Wire Anemometer