PROBLEM SET #4 (w/ added problem)

Issued: Thursday, Oct. 9, 2008

Revised Due Date (at 5 p.m.): Tuesday, Oct. 21, 2008

1. Suppose you would like to fabricate the suspended cross beam structure below using the process outlined in Problem Set #3. The structure is constructed entirely of doped polysilicon, i.e., the yellow and green layers are both doped polysilicon. Dimensions for most of the features are indicated in Figs. 2-4, as are points of interest to be explored in subsequent parts of this problem. The structure itself (in green) is meant to be 2 μm thick, and the interconnect layers beneath (in yellow) are meant to be in a thin doped polysilicon layer.

(a) Use Cadence to generate a layout that achieves the structure of Figs. 2-4 using the process flow outlined in Problem Set #3. In addition, add a contact to the substrate ground plane with sufficient area to allow bond wiring to this contact. Also, add interconnect and a bond pad that allows the structure to be biased to a specific voltage during testing. Make sure the spacings for the bond pads are sufficient to allow wire bonding. [Note that not all masks from the Problem Set #3 process flow need to be used in this part.]

(b) Using the material properties give in the table below, determine if this structure will buckle after fabrication by the given process flow? Show your work and clearly state the reasons behind your conclusions.

(c) Suppose the deposited polysilicon film has a vertical stress gradient as shown in the curve of Fig 1, where $\sigma_1 = 10^7$ Pa. How high above the substrate are the bottoms of the tips of the "wing" structures after fabrication by the given process flow?

Material Properties	Si Substrate	PolySi
Young's modulus [GPa]	160	150
Thermal Expansion Coeff. [10^{-6} / °C]	2.6	2.2
Poisson Ratio	0.17	0.23

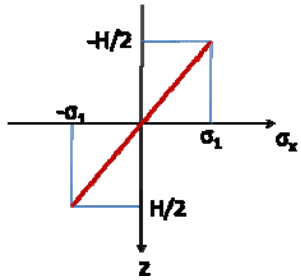


Fig 1 – z-directed stress gradient in PolySi for part (c)

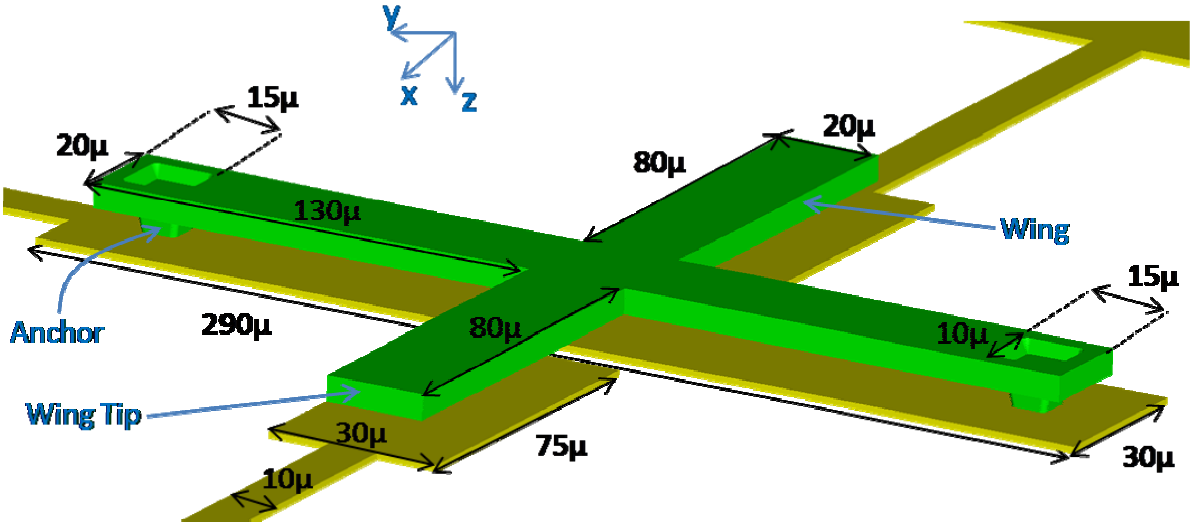


Fig 2 – Suspended cross-beam

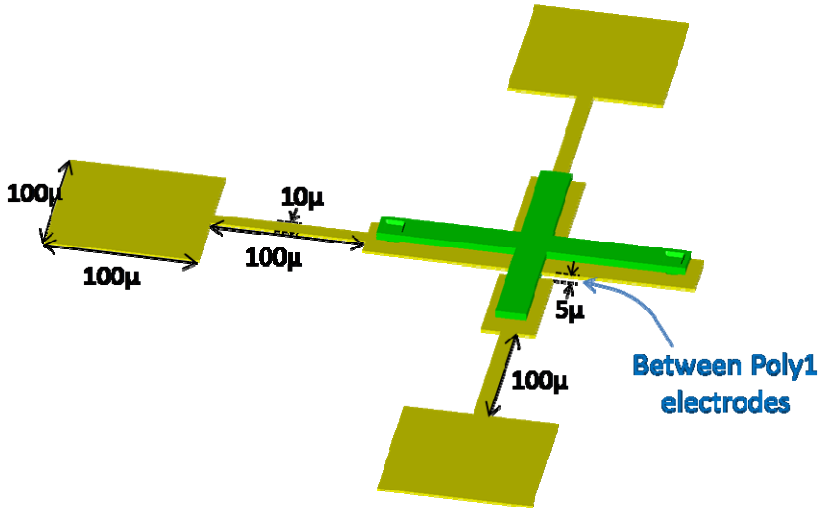


Fig 3 – Wide-view schematic with electrode dimensions

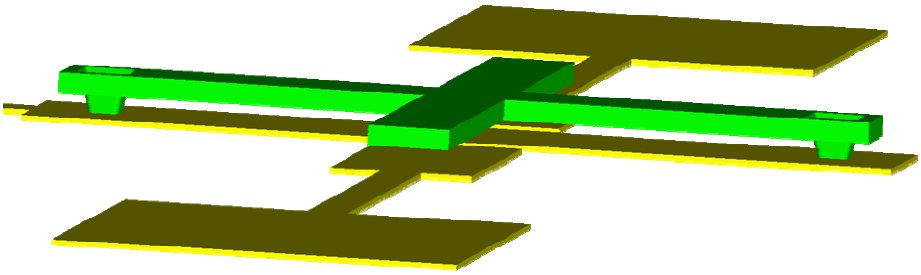
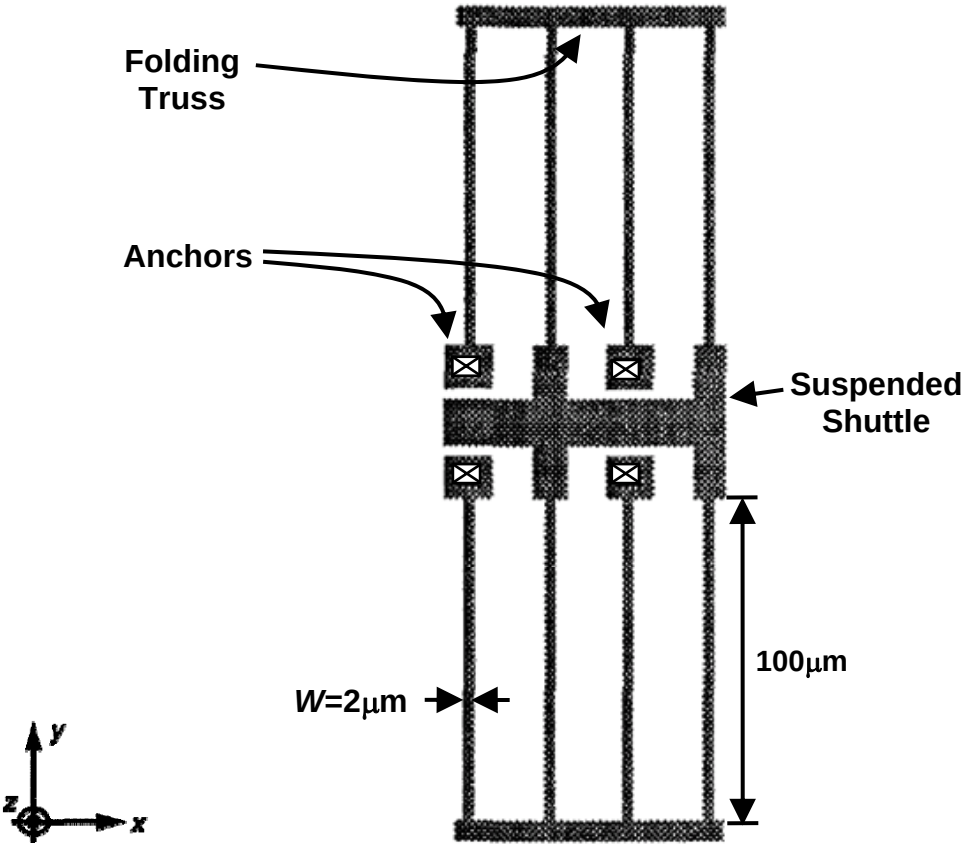


Fig 4 – Side view showing anchor points

2. The figure below presents the top view of a shuttle mass suspended 3μm above a substrate by a folded beam suspension and achieved via a surface micromachining process with a 2μm-thick structural layer. Data on the structural material used in this problem is given in the box below the figure. Also, assume that the shuttle and all folding trusses are rigid in all directions, including the vertical (i.e., *z*) direction.



Structural Material Properties:
Young's Modulus, E = 150 GPa; Density, ρ = 2,300 kg/m^3; Poisson ratio, ν = 0.226

(a) Write an expression for the static spring constant in the *x*-direction at a location on the shuttle and calculate its numerical value (with units).

(b) Write an expression for the static spring constant in the *x*-direction at a location on the top folding truss and calculate its numerical value (with units).