PROBLEM SET #5

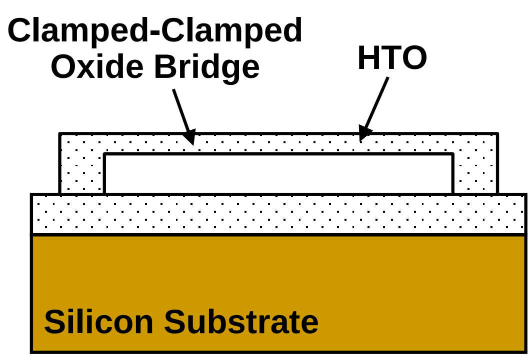
Issued: Tuesday, Oct. 16, 2007

Due (at 5 p.m.): Tuesday, Oct. 23, 2007

1. Suppose you would like to fabricate the oxide bridge shown in the figure below using the following process flow:

(i) Deposit 1 μm of high temperature oxide (HTO) via LPCVD at 920^{o}C. This is oxide1.
(ii) Deposit 1 μm of undoped polysilicon via LPCVD at 600^{o}C.
(iii) Pattern the polysilicon layer via lithography and RIE to form anchors for the eventual bridge.
(iv) Deposit 0.5 μm of HTO at 920^{o}C to serve as the bridge structural material. This is oxide2.
(v) Pattern the oxide bridge via lithography and RIE to delineate the bridge structure.
(vi) Etch away all the undoped polysilicon via XeF_2 gaseous etching.

In answering the questions below, use the material properties in the table and assume that only thermally induced stresses are important (i.e., ignore intrinsic stress) and ignore the effect of anchors geometry and step up.



	Si	poly-Si	HTO
Young's Modulus (GPa)	160	150	73
Thermal Coefficient of Expansion (10^{-6}/°C)	2.3	2.6	0.9
Poisson Ratio	0.17	0.23	0.27

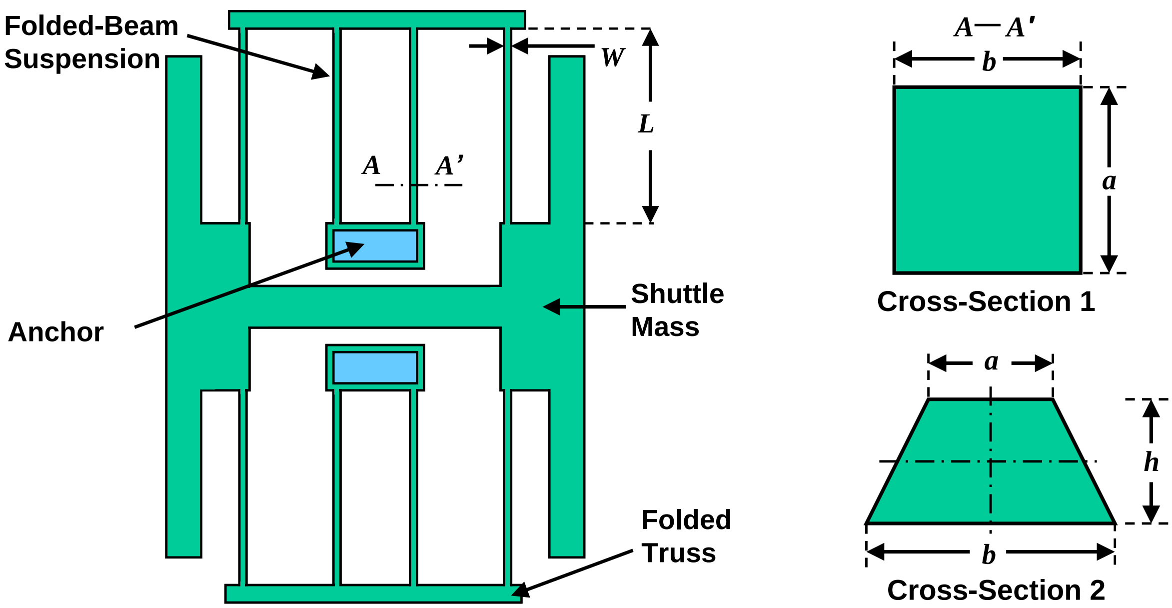
(a) Determine the type (tensile or compressive) and magnitude of stress in the oxide1, polysilicon, and oxide2 layers, immediately after the deposition ends in step (iv), i.e., at 920^{o}C.

(b) Determine the type (tensile or compressive) and magnitude of stress in the oxide bridge layer at the beginning of step (v), i.e., at 25^{o}C.

(c) If the bridge structure is 4 μm-wide and 20 μm-long, will it buckle after release?

(d) If the bridge structure is 4 μm-wide and 30 μm-long, will it buckle after release?

2. The polysilicon surface-micromachined structure below utilizes folded-beam suspensions to relieve axial residual stresses induced during fabrication. Ideally, the cross-section of the suspending beams would have vertical sidewalls, as shown in cross-section 1. However, due to a lack of 100% anisotropy when etching these features, the actual suspending beam cross-sections often end up looking more like that shown in cross-section 2.



(a) For the case where the A-A′ is as shown in cross-section 1, and assuming that L= 80μm, W=b=2μm, and a=2μm, write an expression for the spring constant at a shuttle location and calculate its numerical value (with units).

(b) For the case where the A-A′ is as shown in cross-section 2, and assuming that a=2μm, b=3μm, and h=2μm, write an expression for the spring constant at a shuttle location and calculate its numerical value (with units).

3. The "crab-leg" supported structure shown below is used in MEMS to allow a designer to tailor the ratio of stiffnesses in the x and y directions by merely adjusting dimensions. Assuming the dimensions in the figure below are L_1=40μm, L_2=20μm and the cross-section of the support beams are square (as in cross-section 1 of Problem 2), write expressions for the y-directed spring constant k_y, the x-directed spring constant k_x, and their ratio k_y/k_x, for a location on the shuttle mass. Then calculate their numerical values.