

PROBLEM SET #5*Issued: Tuesday, March 29, 2016**Due: Wednesday, April 13, 2016, 8:00 a.m. in the EE C247B homework box near 125 Cory.*

1. Figs. PS5.1-1 to PS5.1-6 show a dual-axis x-y accelerometer manufactured via the following 3-mask surface micromachining process. Assume all materials are stress-free at room temperature and have the material properties listed in Table PS5.1-1
 - i. Deposit 1.0 μm of SiO_2 on a silicon wafer
 - ii. Deposit 300 nm of Si_3N_4 via LPCVD
 - iii. Deposit 200 nm of in-situ doped polysilicon
 - iv. Lithographically define and etch polysilicon interconnects (anisotropic)
 - v. Deposit 2.0 μm of SiO_2 (LTO)
 - vi. Lithographically define and then etch anchor openings in SiO_2 (anisotropic)
 - vii. Deposit 3.0 μm of in-situ doped polysilicon
 - viii. Lithographically define and then etch the polysilicon structure (anisotropic)
 - ix. Etch SiO_2 completely using an HF etch, releasing structure (isotropic)

Table PS5.1-1

Material	ρ_m (kg/m^3)	E (GPa)	ν (-)	α_T ($\mu\text{strain/K}$)	σ_0 (MPa)	Comment
Polysilicon	2300	150	0.20	2.8	Varies	Random Grains
Silicon Dioxide	2200	69	0.17	0.7	-300	Amorphous
Silicon Nitride	3170	270	0.27	2.3	1100	Stoichiometric

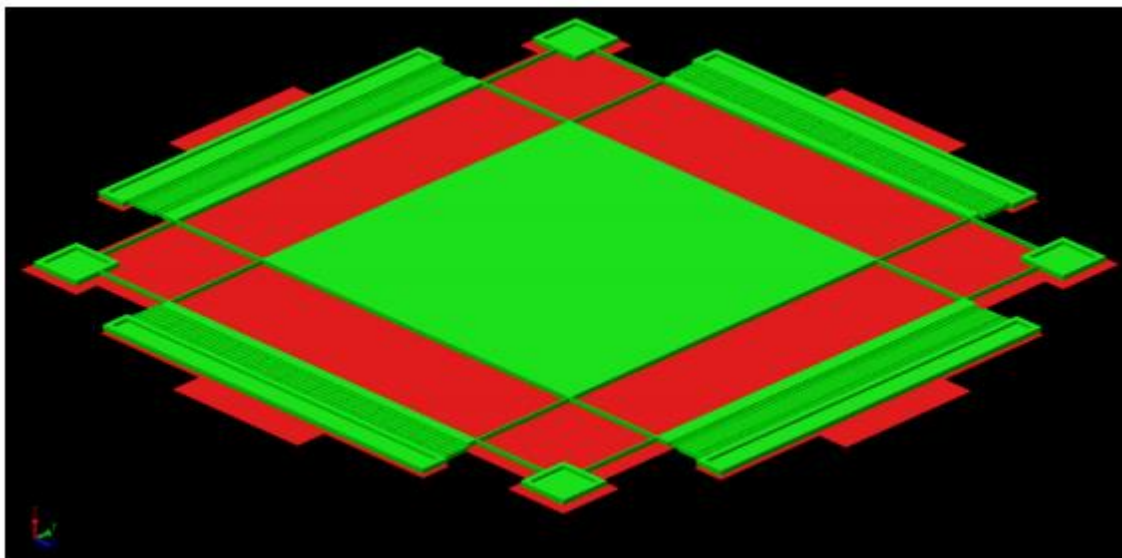


Fig. PS5.1-1 – Perspective view of the accelerometer

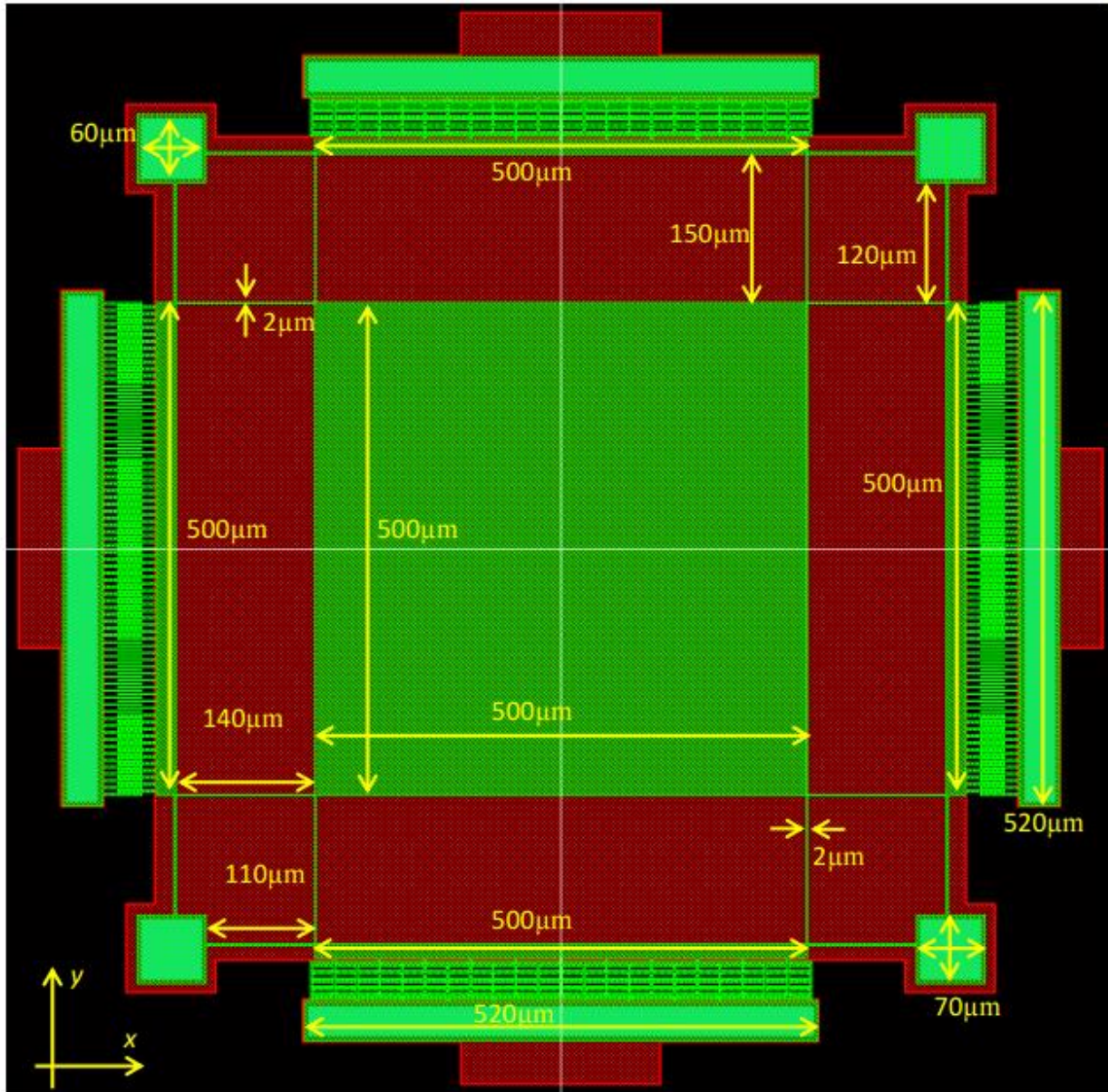


Fig. PS5.1-2 – Top view of the accelerometer

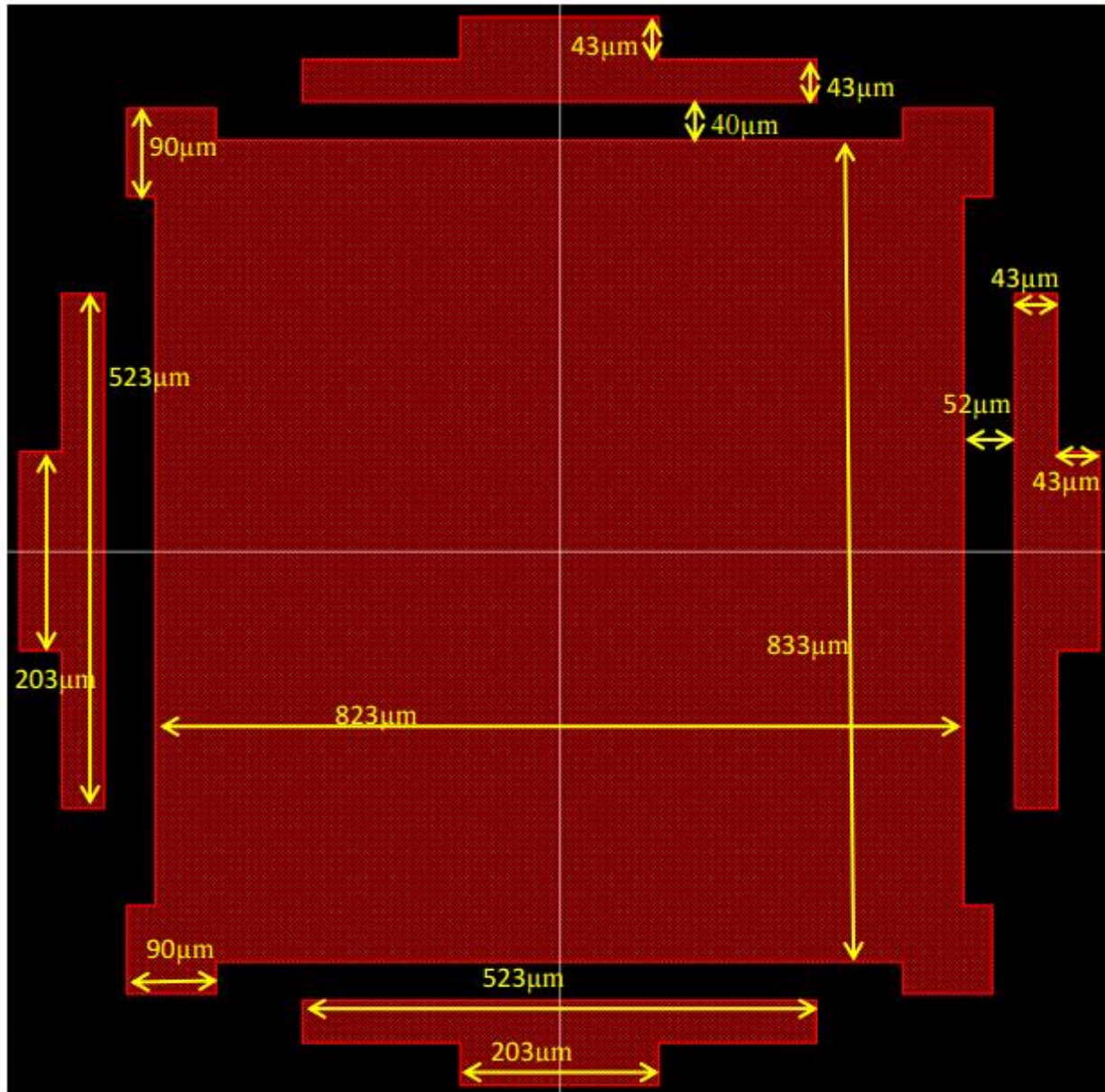


Fig. PS5.1-3 – Top view of accelerometer showing only the interconnect layer

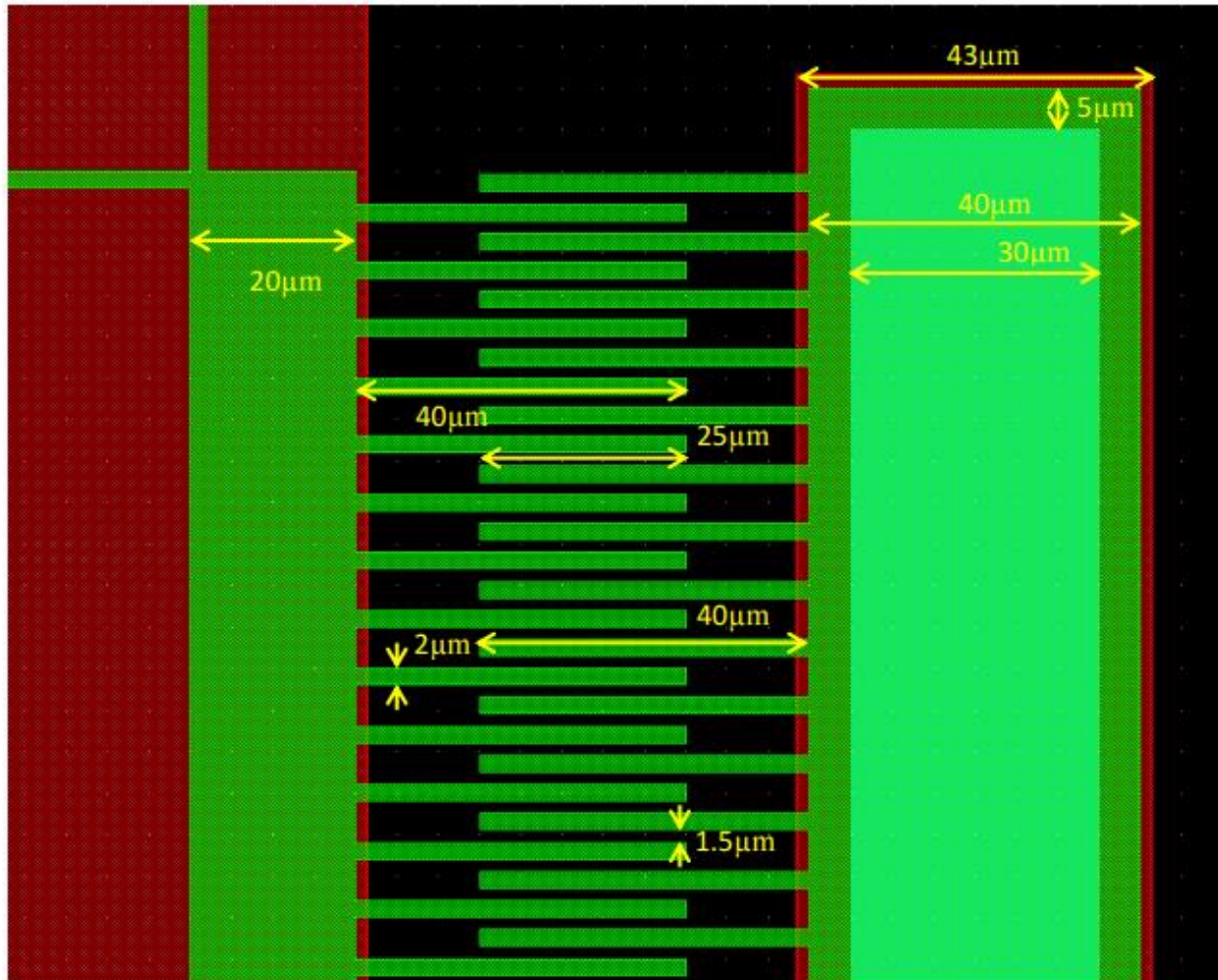


Fig. PS5.1-4 – Zoom-in view of the x-direction interdigital comb finger structure. There are 71 fingers on each side of the proof mass.

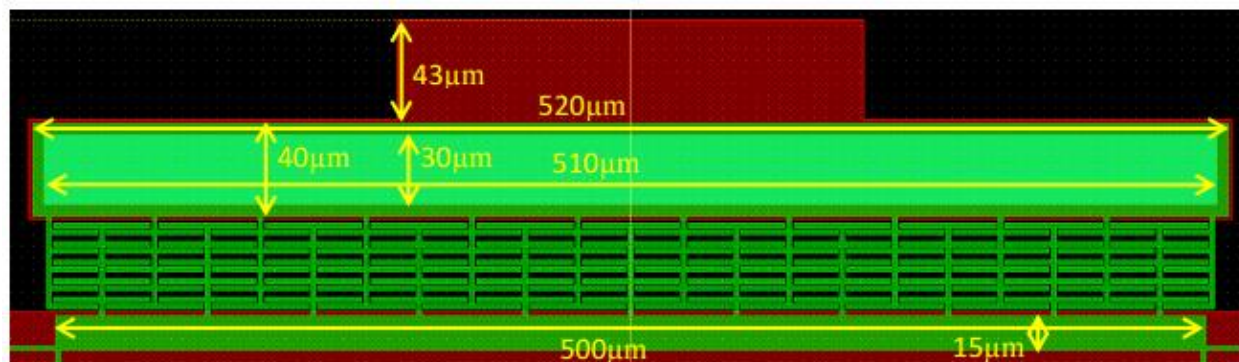


Fig. PS5.1-5 – Top view showing the y-direction capacitor structure.

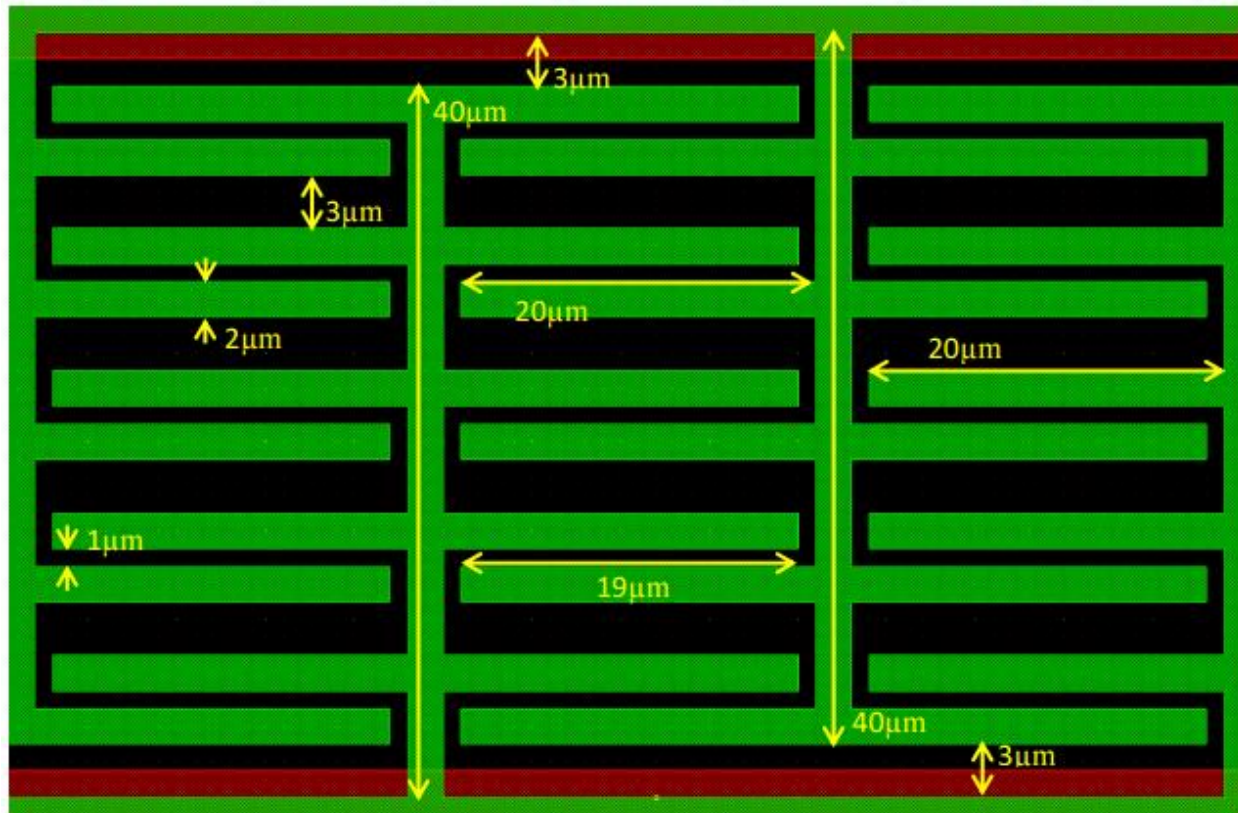


Fig. PS5.1-6 – Zoom-in view of the y-direction capacitor structure

- Calculate the x - and y -directed resonance frequencies of the accelerometer structure making simplifying assumptions as necessary. Do NOT neglect the beam masses in these calculations. Assuming a quality factor Q of 5 in both directions, draw the frequency response for the accelerometer in both the x - and y -directions.
- Generate a 3-mask layout for this device using Cadence and email it to your GSI before the homework due date. You should use the technology file HW5_tech.tf and display file display.drf to specify the names and colors of the masks. Output your layout as a .gds file titled: "EEC247B_MEC218_HW5_yourlastname.gds". Note that POLY1 and POLY2 are clear-field masks and ANCHOR is a dark-field mask. Where dimensions have not been exactly specified or cannot be otherwise calculated from specified dimensions, please choose a reasonable value based on the figures given above. (Hint: The accelerometer structure is composed of four quarter-sections, which are mirror images of each other).