PROBLEM SET #5

Issued: Wednesday, March 29, 2017

Due: Thursday, April 13, 2017, 10:00 a.m. in the EE C247B homework box near 125 Cory.

1. The following pages comprise a surface micromachining process flow for a free-free micromechanical beam with perspective view shown below in Fig. PS5.1. This process traveler spares no details, as even equipment names are given, as are diagnostic steps used to verify certain process steps. Furnace program names (for equipment in the Berkeley Marvell Nanolab) are also given. These details are included to present a more realistic situation and to give an example of what a valid process traveler ought to look like. In doing this problem, you must sift through the extraneous information and concentrate on the recipe information, i.e. temperatures, times, doses etc.

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 the figure, as are points of interest to be explored in subsequent parts of this problem. The structure itself (in green) is meant to be 2μm thick, and the interconnect layers beneath (in yellow) are meant to be in a thin doped polysilicon.

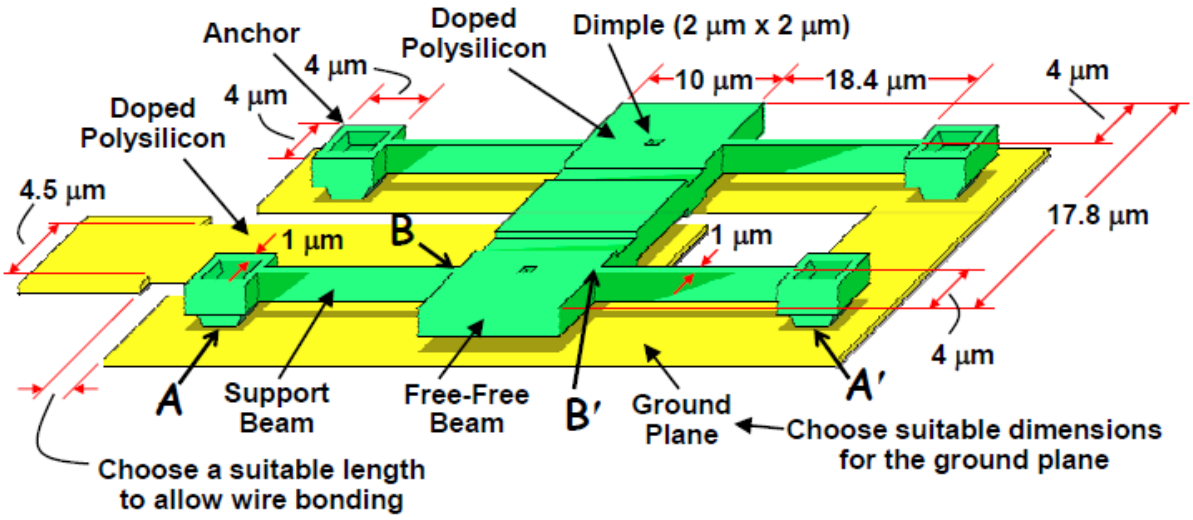

Fig. PS5.1

(a) Use Cadence to generate a layout that achieves the structure above using the process flow outlined below. In addition, 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. Export your layout as a gds file titled: "EEC247B_MEC218_HW5_YourfirstnameYourlastname.gds" and email it to your GSI.

(b) Suppose the sheet resistance of the doped polysilicon is 2 Ω/□. What is the total resistance of the structural polysilicon (not including the underlying interconnect layers) from point A to A' in the figure? Give an estimate that is accurate to within 5%.

Free-Free Beam

µMechanical Resonator Process Flow

0.0 Starting Wafers: 8-12 Ω-cm, n-type, (100) prime or just n-type test wafers.
Control Wafers: PSGIF, PSGIB (Si)
NITIF, NITIB (Si)
POLY1F, POLY1B (tylan11 ctrl)
PSG2F, PSG2B (Si)
POLY2F, POLY2B (Si)
PSG3F, PSG33 (81)

1.0 $POCl_3$ Doping:
Tystar13, recipe 13POCL3A
Flows (slm): N_2: 5, $POCl_3$ (in N_2): 1
Time = 1 hour

1.1 Strip Oxide
Sink8 BHF, 1 minute

2.0 PSG1 Deposition: target = 2µm
(immediately after n+ diffusion)
Tystar12, recipe 12VDLTOA
Flows (sccm): SiH_4 = 60, PH_3 = 10.3 (entered), O_2 = 90
Time (2µm) = 1hr 40min (1000A per 5min)
Include etching controls: PSG1F and PSG1B

3.0 Nitride Deposition: target = 300nm
Deposit stoichiometric nitride:
Tystar17, recipe STDNITA.017
Temp. = 800°C, Flows (sccm): SiH_2C_{12} = 25, NH_3 = 75
Time = 1hr 22min (220nm per hour)
Include etching controls: NIT1F and NIT1B

4.0 (Optional) Substrate Contact Mask: SNC (chrome-df)

4.1 Spin, expose, develop, inspect, descum, hard bake.
PR thickness: 1.6µm

4.2 Etch nitride in Centura-Mxp.
SF_6 = 175sccm, He = 50sccm

4.3 Etch oxide in Lam6.
For 2µm oxide: [press. = 2.8Torr, power = 350W, gap = 0.38cm, CHF_3 = 30sccm, CF_4 = 90sccm, He = 120sccm, time = 1min], [power = 0, same gases, time = 1min] 3X

4.4 Wet dip in 10:1 BHF for 20s to remove native oxide.

4.5 Remove resist, piranha clean wafers.

5.0 µStructure Poly1 Deposition: target = 300nm
Phosphorous-doped polysilicon deposition:
Tystar16, recipe 16VDPLYA
Time = 2hr 30min, Temp. = 650°C (~120nm per hour)
Include etching controls: POLY1F, POLY1B

6.0 µStructure Poly1 Definition Mask: SP1 (emulsion-cf)

6.1 Spin, expose, develop, inspect, descum, hard bake.
PR thickness: 1.1µm

6.2 Plasma etch polysilicon in Lam8 etcher, inspect (Cl_2/HBr at 300W, 12 mTorr)

6.3 Remove PR, piranha clean wafers along with PSG2F and PSG2B.

7.0 Sacrificial PSG Deposition: target = 200nm
Tystar12, recipe 12VDLTOA
Flows (sccm): SiH_4 = 60, PH_3 = 10.3 (entered), O_2 = 90
Time (200nm) = 10min (1000A per 5min)
Include etching controls: PSG2F and PSG2B

8.0 Sacrificial PSG Densification
RTA in Heatpulse1: 30sec @ 950°C
(also do PSG2F and PSG2B controls)

9.0 (Optional) Dimple Photo Mask: CD1 (chrome-df)

9.1 Spin, expose, develop, inspect, descum, hard bake.

9.2 Timed wet etch in 5:1 BHF.
(estimated etch rate ~300nm per min)

9.3 Remove resist, piranha clean wafers.

10.0 µStructure Anchor Photo Mask: SG1 (chrome-df)

10.1 Spin, expose, develop, inspect, descum, hard bake.
PR thickness: 1.1µm

10.2 Etch oxide in Lam6.
For 1µm oxide: etch as usual.
For 2µm oxide: [press. = 2.8Torr, power = 350W, gap = 0.38cm, CHF_3 = 30sccm, CF_4 = 90sccm, He = 120sccm, time = 1min], [power = 0, same gases, time = 1min] 3X
For both cases, overetch with 700W recipe.

10.3 Check contact using IV probe station.

10.4 Wet dip in 5:1 BHF for 10sec.

10.5 Remove resist, piranha clean wafers.

11.0 µStructure Poly2 Deposition: target = 2µm
Phosphorous-doped polysilicon deposition:
Tystar16, recipe 16SDPLYA
Time = 16hr 0min, Temp. = 650°C (~120nm per hour)
Include etching controls: POLY2F, POLY2B (tylan11 controls).

12.0 Oxide Mask Deposition: target = 500nm
Tystar12, recipe 12VDLTOA

Flows (sccm): SiH_4 = 60, PH_3 = 10.3 (entered), O_2 = 90
Time (500nm) = 25min (1000A per 5min)
Include etching controls: PSG3F and PSG3B

13.0 RTA Anneal
Heatpulse1: 1min @ 1100°C

14.0 µStructure Poly2 Definition Mask: SP2 (emulsion-cf)
Align to µStructure Poly1.

14.1 Spin, expose, develop, inspect, descum, hard bake.
PR thickness: 1.6µm

14.2 Etch oxide mask in Lam6.

14.3 (optional) Remove resist:
Technics-c, 10min 02 plasma B 300W

14.4 Etch Poly2 in Lam8: [press. = 280mTorr, power = 300W, gap = 1.5cm, CCl_4 = 130sccm, O_2 = 15sccm, time = 1min] then [power = 0, same gases, time = 1min] 5 or 6X, depending upon etch rate (etch rate usually 4000A per min).

14.5 If haven't already removed resist, remove resist.
Technics-c, 10min 02 plasma B 300W

15.0 µStructure Release

15.1 Piranha clean in sink8.

15.2 Wet etch in 5:1 BHF (~600nm per min) in sink8.
Etch for whatever time is needed to remove all exposed oxide including oxide underneath structures.
Slowly agitate, rinse.
Spin dry or N_2 gun dry.

15.3 Piranha clean in sink8 for 10min. Follow with standard DI rinses. No HF dip. Spin dry or N_2 gun dry.
