PROBLEM SET #3

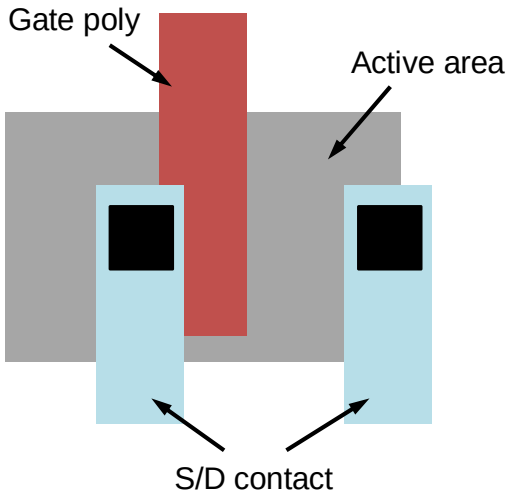
Issued: Thursday, Feb. 11, 2010

Due: Thursday, Feb. 18, 2010, 7:00 p.m. in the EE 143 homework box in 240 Cory

I. Lithography

1. Consider the overhead-view NMOS device pattern below obtained after S/D and gate lithography.

   Circle the misaligned areas. For each misalignment, state whether or not the error is catastrophic (i.e., it will lead to a non-functional or "dead" device) and explain why or why not.



2. The linear coefficient of thermal expansion of the glass used for a photolithography mask is given by the expression

$$TC_F = \frac{1}{L}\frac{\partial L}{\partial T} \approx \frac{\Delta L}{L}\frac{1}{\Delta T}$$

   where L is a length on the mask and T is temperature. Let TC_F=3 ppm/^{o}C for a given mask. Suppose that an alignment accuracy of 0.5 μm across a 6-inch silicon substrate is required from one layer to the

next. Assume the thermal expansion of silicon is negligible in comparison and that all previous masking steps were done with masks at the same temperature as the silicon wafer.

a) Assuming that a scanning 1:1 projection printer with global alignment is used, how close should the temperature of the mask be kept relative to the silicon wafer during alignment in order to achieve this accuracy? (i.e., what is the maximum allowable temperature deviation?)

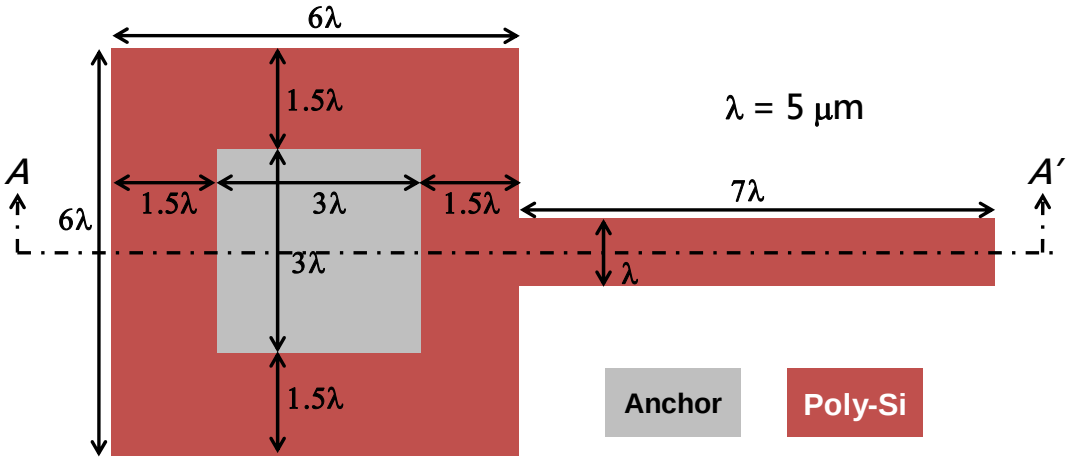
b) Repeat (a) for the case of a 5:1 projection stepper with die-to-die alignment. Assume the die size is 1 cm^2. Is this better than for the 1:1 projection printer?

II. Process Flow/Layout to Cross Section

3. Suppose you applied the following fabrication process flow to the layout of a cantilever shown below:

1) Wet oxidation 0.5 μm on silicon substrate
2) Do lithography of anchor mask: spin and expose resist with the "Anchor" mask layer shown below.
3) Wet etch the SiO_2 using buffered hydrofluoric acid (BHF) for 6 minutes, where the etch rate of thermal oxide in BHF is 100 nm/min.
4) Remove photoresist.
5) Deposit 0.3 μm of p-type doped polysilicon.
6) Do lithography of anchor mask: spin and expose resist with the "Poly" mask layer shown below.
7) Wet etch the polysilicon using a premixed silicon etchant for 2 minutes, where the etch rate of polysilicon in this etchant is 200 nm/min.
8) Remove photoresist.

9) Release the structure by dipping the wafer in 10:1 buffered hydrofluoric acid (BHF) for 5 minutes, where the etch rate of wet oxide in 10:1 BHF is 500 nm/min.



Draw the final cross-section of the structure after release along *A-A'* with dimensions labeled.

Note: For this problem, assume that wet etching only etches vertically and laterally with 100% isotropy for simplicity, i.e., draw the etch front is as a straight sidewall, such as: