Assignment #4: Due: 9/29/2011

1) Read Jaeger Chapter 6

2) Your lab has a Karl Suss contact aligner that has a calibrated 12mW/cm2 UV source for i-line wavelengths. Your lab uses Fujifilm "OiR 906-17" positive photoresist.

A) What spin speed do you need to use to get an approximate thickness of 2.0 um for your film?
B) How long will you need to expose this photoresist using this contact aligner?
C) What is the minimum **theoretical** linewidth you expect to achieve with this film?

Please explain how you arrived at your answer (feel free to use online resources).

3) A PMOS typically has a cross-section shown in the Figure 1 below. Please draw a set of masks to enable a device like this. Number the masks in the order that they will be used. For each mask, please include and indicate:

i) Alignment marks
ii) Kind of printing mask (assuming you are allowed to use different printing techniques)
iii) Type of photoresist used for the mask

Explain your answers.

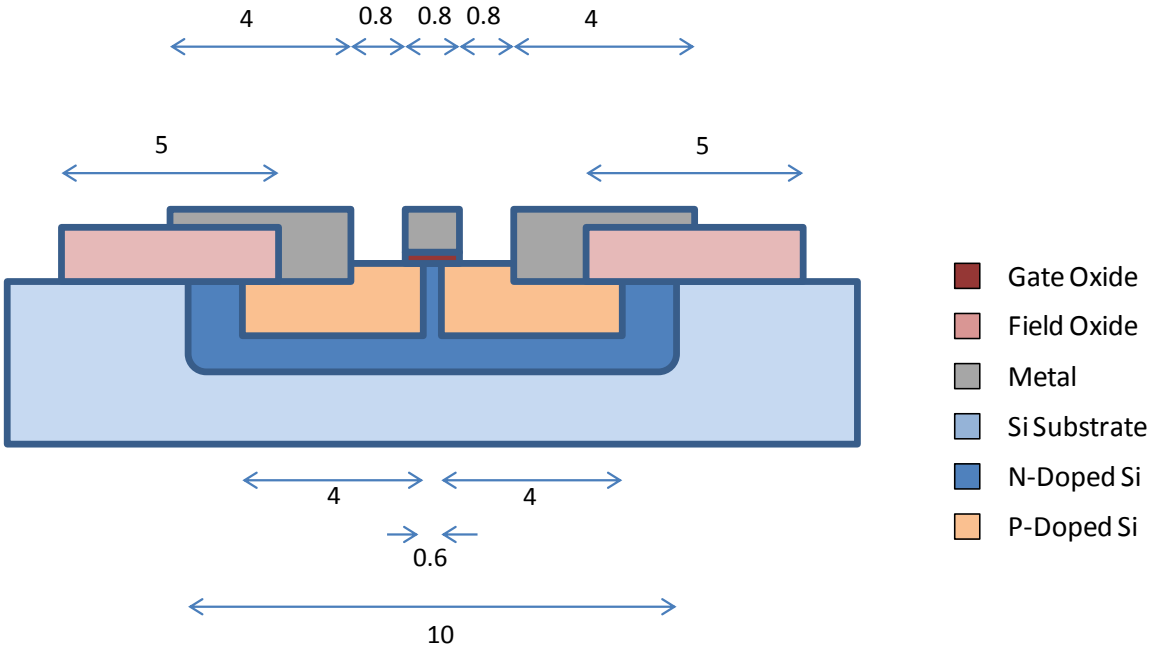

Figure 1. Cross section of a simplified PMOS structure (All dimensions are in microns)

4) This is an open-ended problem intended to develop your critical thinking regarding problems that you might encounter when doing photolithography. This is taken from actual research work. The intention was to fabricate holes in a thick **negative** photoresist deposited on a gold-coated silicon wafer so that metallic materials can fill the holes after. The holes were 15 µm in diameter with a 30 µm pitch (center to center spacing). He spun the resist to an intended thickness of roughly 80 µm and exposed with a hard contact aligner as in the previous problem. A cross-section Scanning Electron Microscopy image of the structures after photolithography is presented below. You can observe that the process was not successful in creating holes everywhere in the resist.

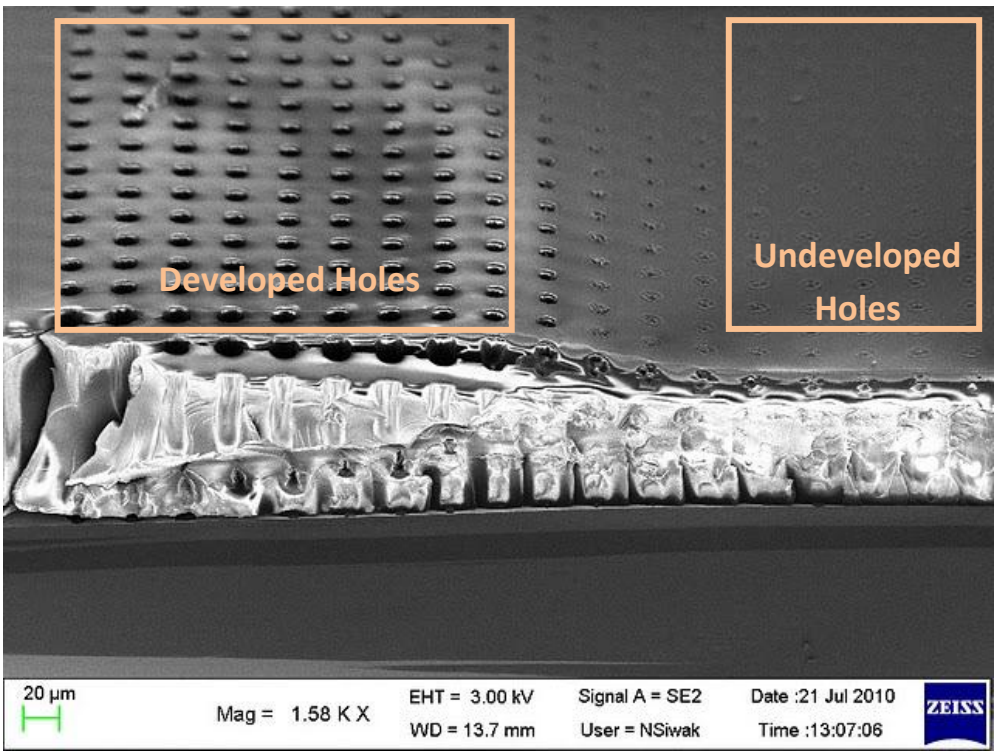

Figure 2. A SEM image of an unsuccessful negative photoresist patterning [1]

i) Given that the resist is negative, draw a top view of what the mask he used looks like by indicating opaque and transparent regions as well as dimensions. Since the mask contains a periodic array of structures, you can show only a few repeating units.

ii) Based on the photoresist profile in the image shown above, can you provide a possible reason to explain why the holes were not successfully developed? (Hints: take into account which masking technique was using, what happens when you expose a negative photoresist, as well as any limitations regarding resolution of photolithographic processing that you could also identify in the image).

5) There are **<u>at least</u>** 5 steps (photoresist spin, pre-bake, exposure, post-bake, and develop) that are involved in patterning a positive photoresist using photolithography. For every step:

i) Use 3-4 sentences to describe the fundamentals and the purpose of each step. Are there any additional steps that you can think of?
ii) List 1 challenge/issue that is involved in each step
iii) The challenges/issues listed in (ii), are they also applicable in a negative photoresist? Why and why not? Are there any additional steps needed for negative photoresist patterning?

6) Problems from Group Activity #2:

i) Write two advantages of electron beam lithography (EBL) compared with photolithography.
ii) How are X-rays and electron beams better alternatives than UV light for lithography?
iii) Describe the major differences between EBL and X-ray lithography.
iv) What are the major limitations of using X-ray lithography?

References:

[1] K. Gerasopoulos, Private communication, July 2010.