EE6601 - Lithography I

1. List the various steps for a photolithography process. Give a short explanation for each processing step. What are the consequences of overbaking and underbaking during a soft bake process?

2. A basic photolithography process using automatic track systems has the following steps: vapor prime, photoresist spin coat, dehydration bake, soft-bake, develop, alignment and exposure, hard-bake, develop inspect and post-exposure bake.
   (i) Rearrange these steps in a proper sequence.
   (ii) What chemical is used in the vapor priming and what is the purpose of this step?
   (iii) What is the purpose of the dehydration bake?
   (iv) What is the purpose of the soft-bake step?
   (v) What is the purpose of the hard-bake step?

3. Figure 1 shows the various steps in a lithographic process. What are the two process steps indicated in boxes (3) and (4)? Provide typical process parameters used in these steps.

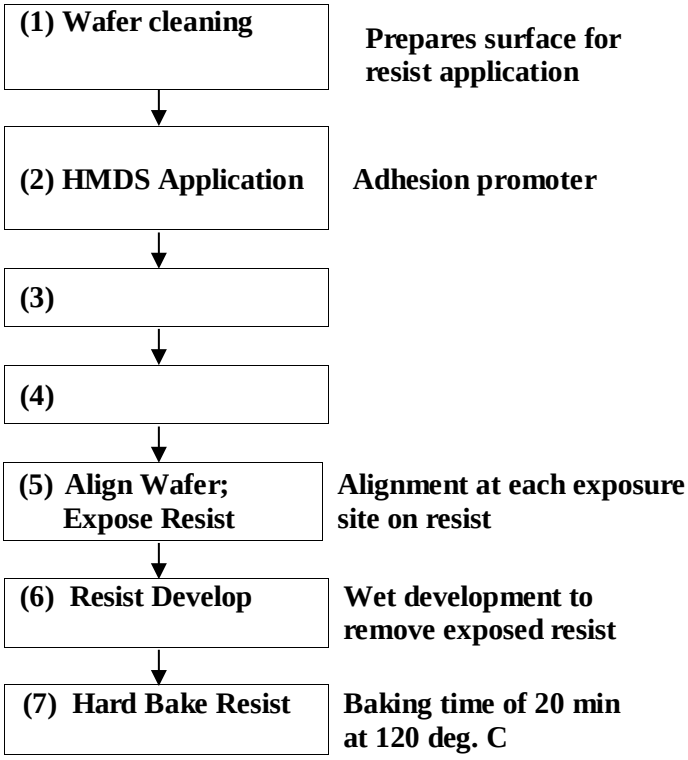

Figure 1

4. Figure 2 shows a wafer undergoing the various steps of a photolithography process.

   (i) List the steps involved in the process from (a) to (d).

   (ii) Identify the type of resist used.

(iii) Recommend a suitable method from Step (e) to Step (f). Explain your recommendation.

(iv) Identify the type of exposure system used and briefly explain its relevance in today's semiconductor manufacturing.

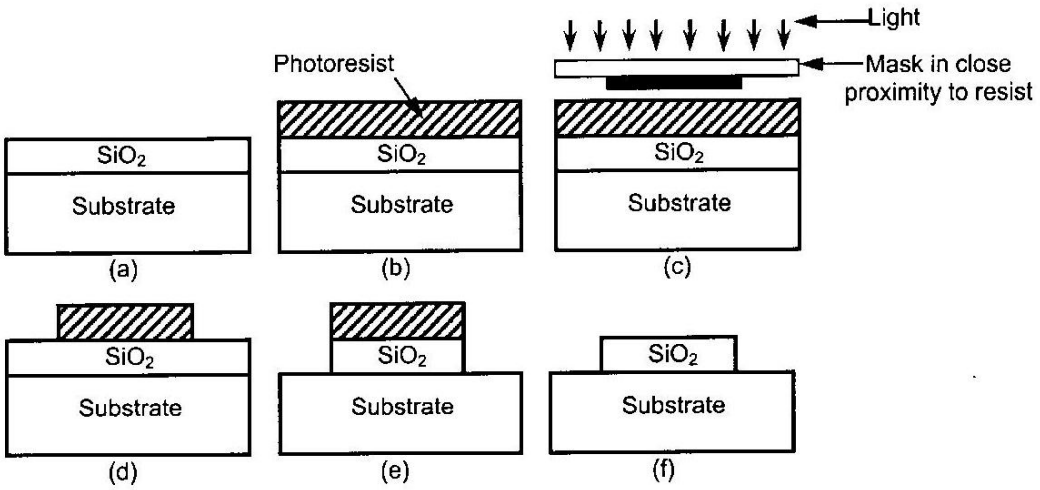

Figure 2

5. Given that:
   (i) A Hg lamp with dominated photon energy of 7.936×10^{-19} J,
   (ii) An ArF excimer laser with frequency of 1.55×10^{15} Hz, and
   (iii) X-rays produced by a 50 kV X-ray machine

   Construct a table of the wavelength of these sources. Given that the proximity gap of 10 µm, predict the proximity printing diffraction limited minimum feature size for each source, if the resists used have k_1 value of 1.
   (Plank's constant, $h = 6.625 \times 10^{-34}$ J.s, electron charge, $e = 1.602 \times 10^{-19}$ C, and electron mass, $m = 9.11 \times 10^{-31}$ kg, speed of light, $c = 3 \times 10^{8}$ ms^{-1})

6. An exposure is performed using a step-and-repeat aligner printing system with a light source that has a wavelength of 365 nm (I-line of a mercury lamp). The pattern obtained is a grating with a line-to-line spacing of 1 µm. Assume that the resist constant k_1 *and* $k_2 = 1$.

   (i) Calculate the value of the numerical aperture that will provide contrast at the image plane (i.e. the plane of the resist).

   (ii) Determine the depth of focus (DOF) of the image.

   (iii) Explain how the DOF of the exposure system is influenced by the numerical aperture of the imaging lens and the wavelength of the exposing light. How will an improvement in DOF affect the resolution of the system?