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1. (20 pts maximum) Indicate T for true, F for false or X for no answer for each question. Correct answers earn 1 point, the X response earns 0 points and incorrect answers earn -1 point. The maximum score for the question is 20 points and a minimum score is 0 points.

   a) __F__ By definition, G values are always positive.

   b) __T__ The slope of a plot of thickness remaining after development vs log dose defines the contrast of a negative resist.

   c) __T__ Ellipsometry can be used to measure dissolution rate.

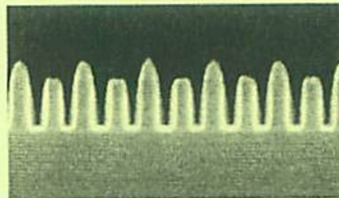
   d) __F__ The process stability problem in chemically amplified resists was the result of airborne base contamination that occurred in the interval between the exposure and the post exposure bake steps.

   e) __T__ BARCs are more commonly employed than TARCs.

   f) __F__ The solubility of airborne bases in chemically amplified resists is a nearly linear function of the Ohnishi Number of the polymer component.

   g) __T__ In DTD, the order of development is first aqueous base then organic solvent.

   h) __F__ The pattern in the image below has the characteristics of having been made by the LFLE pitch doubling process.



   i) __F__ The dissolution rate of diazonaphthoquinone - novolac resists is directly proportional to the post apply bake temperature.

   j) __F__ The famous KTFR resist is comprised of polyisoprene rubber and diazonaphthoquinone.

   k) __T__ Flood exposure improves the Fuji Film DTD process

   l) __T__ A fully transparent TARC placed on top of a thin film can either increase or decrease the amount of monochromatic light that enters the thin film.

   m) __F__ Novolac and poly(p-hydroxystyrene) are both soluble in water.

   n) __T__ SADP is an acronym for Self Aligned Double Patterning.

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o) F LFLE, LELE and SADP all require two exposure steps.

p) T Soft Lithography was first used to pattern gold.

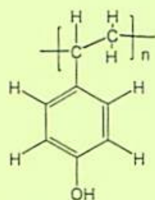
q) T The final step in the dual damascene process is CMP.

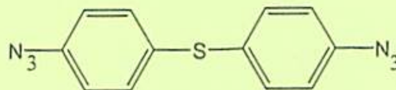
r) F The photoacid generators used in 248 and 193 nm resist formulations bleach upon exposure.

s) F The G value of polymers that undergo random scission upon exposure to radiation is the slope of a plot of number average molecular weight of a sample (M_n) vs log dose.

t) T The etch rate of a polymer is directly proportional to its Ohnishi Number. That is, polymers with low numbers etch slowly.

2. (10 Pts) An important principle was taught by the Hitachi negative tone, crosslinking, Deep UV resist that was comprised of a bis-azido aromatic and p-hydroxy styrene.





a. What was the important principle?

Dissolution by "etching" allows one to avoid swelling

Since the . . . . . .

b. Why did the material fail in the market place?

Opaque

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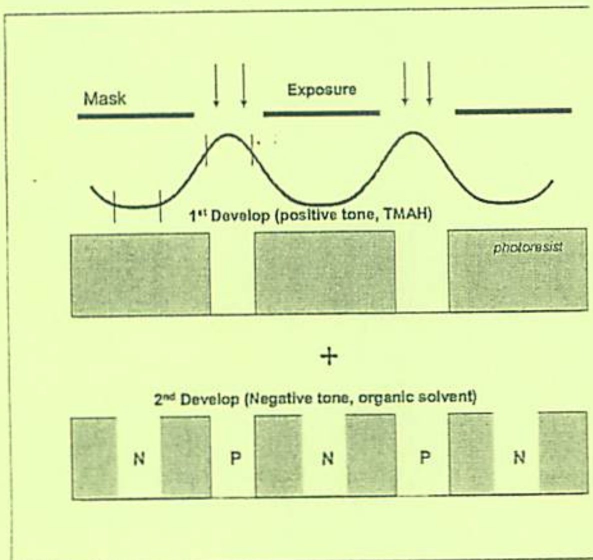
3. (10 pts) Qingjun taught us how the DTD process works. Below is a copy of a key diagram from his presentation. Please explain how this process works. We need to know why pitch doubling is achieved by double development. You may refer to Qinjun's diagram if you choose.



Dr. Willson's got it

4. (15 pts) End capped poly(phthalaldehyde) formulated with an appropriate onium salt provides a remarkably sensitive imaging system.

   a. List two important design principles taught by this resist.

   1) CAR works! wow.
   2) Entire wafer doesn't deprotect

   b. Why is this resist not used in manufacturing today?

   Not etch resistant

5. (10 pts) Dr. Resnick described the use of "programmed defects". Please explain the role of these defects and how they are employed in mask process development.

   Inspection techniques!
   → detection & repair

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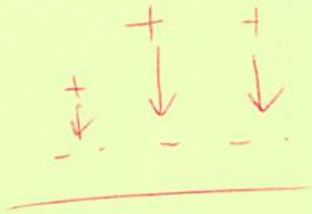
6. (15 pts) Wet etching generally produces isotropic etching which limits the resolution of image transfer processes. Fortunately, Reactive Ion Etching can provide highly anisotropic etching and provide structures with very steep and vertical side walls. Please explain the basic principle that allows reactive ion etching to provide anisotropic etching.

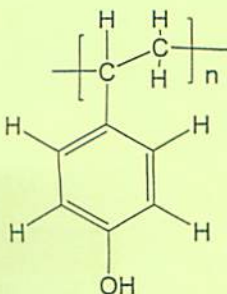


Charge + straight lines

7. (10 pts) List two applications of MEMS that ae found in modern automobiles.

Lots of sensing things

8. (10 Pts) Calculate the Ohnishi number for the polymer structure below. Please show some work.



C + O

8 1

$\left(\frac{n}{c-o}\right)$

$\frac{17}{7}$