CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
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Lecture 51 Lithography: Chemically Amplified Resists, part 1

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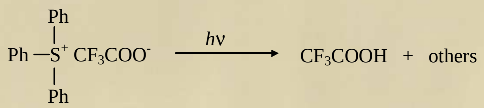
Chemically Amplified Resists

- Conventional Resist (g-line and i-line)
  - Exposure generates product which causes a direct change in the resist solubility
- Chemically Amplified Resist (CAR)
  - Exposure generates acid, but does not directly affect dissolution rate
  - Acid catalyzes a reaction during PEB (called amplification) which changes solubility
  - Important effects: acid diffusion and acid loss

Exposure Reaction

- A Photoacid Generator (PAG) undergoes a photo-induced reaction to release a strong acid.



Triphenylsulfonium salt

(Simplified PAG and photogenerated acid)

Exposure

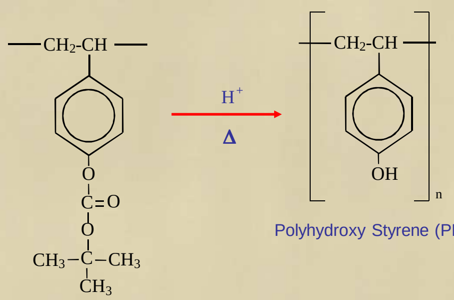
- Direct photon absorption by the PAG releases an acid in a first order reaction:

$$\frac{\partial G}{\partial t} = -CGI \qquad G = G_o e^{-CIt} \qquad H = G_0 - G = G_0\left(1 - e^{-CIt}\right)$$

where G = PAG concentration
G_o = initial PAG concentration
H = acid concentration
I = intensity
C = exposure rate constant
t = exposure time

Amplification Reaction

(during post-exposure bake, PEB)



Polyhydroxy Styrene (PHS)

Amplification

- The acid catalyzes a reaction which consumes a reactive site (protected/blocked site) M to produce a reacted site (deptrotected/deblocked site).

If H is locally constant,

$$\frac{\partial M}{\partial t_{PEB}} = -k_4 MH \qquad M = M_o e^{-k_4 H t_{PEB}}$$

where M = blocked site concentration
M_o = initial blocked site concentration
k_4 = amplification rate constant
t_{PEB} = bake time

Normalized Concentrations

- Concentrations can be normalized to initial values:

$$h = \frac{H}{G_o} \qquad m = \frac{M}{M_o}$$

$$h = 1 - e^{-CIt}$$

$$m = e^{-\alpha_f h}$$

where $K_{amp} = G_o k_4$ = normalized rate constant
$\alpha_f = K_{amp} t_{PEB}$ = amplification factor

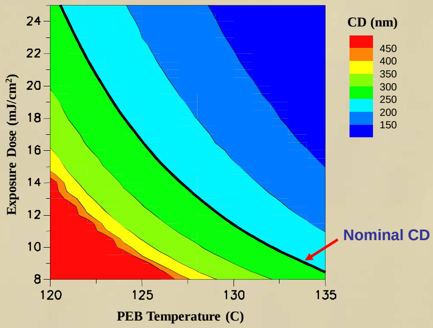
Amplification Factor

- The amplification factor (α_f) varies linearly with bake time
- It varies exponentially with temperature *T* through an Arrhenius equation

$$K_{amp} = A_r e^{-E_a/RT}$$

where A_r = Arrhenius coefficient
E_a = Activation energy
R = Universal gas constant

Photon/Thermal Dose Trade-off



Lecture 51: What have we Learned?

- How are chemically amplified resists different from conventional (g-line and i-line) resists?
- What acts as the catalyst for the PEB amplification reaction?
- Why are these resist systems called “chemically amplified”?
- What are the two types of “dose” used to affect change in a CAR?

