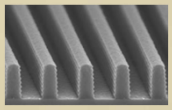
CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Lecture 49
Lithography:
DNQ Photoresists

Chris A. Mack
Adjunct Associate Professor

www.lithoguru.com

Photoresist



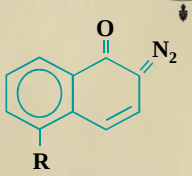
- Photoresist Tasks
  - Form an image ("photo")
  - Resist etch/implant ("resist")
- Photoresist Components
  - Photoactive Compound (PAC)/Sensitizer
  - Polymer Resin
  - Solvent
- Conventional Resist: DNQ/Novolac (g-line, i-line)
- Modern Resist: Chemically Amplified (248, 193 nm)

Resist Types

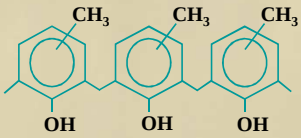
- Cross-linking Negative Resist
  - Exposure causes a cross-linking agent to react with polymer, increasing the molecular weight
- Conventional (DNQ/Novolac) Resist
  - Exposure generates product which causes a direct change in the resist solubility
- Chemically Amplified Resist
  - Exposure generates acid, but does not directly affect dissolution rate (needs a post-exposure bake)
  - More on this later

DNQ/Novolac Resist

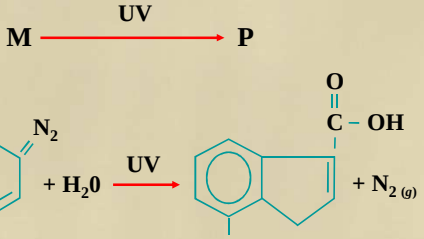
Diazonaphthoquinone (DNQ)
(sensitizer or PAC)



Novolac Resin



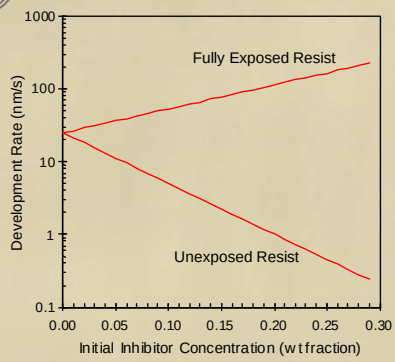
Exposure Reaction



Diazonaphthoquinone
(dissolution inhibitor)

Carboxylic Acid
(dissolution enhancer)

DNQ/Novolak Meyerhofer Plot



Exposure Kinetics

- Kinetics: the study of how fast a reaction proceeds

First Order Kinetics: $$\frac{dM}{dt} = -CIM$$

where M = Sensitizer Concentration
I = Light Intensity
t = Exposure Time
C = Exposure Rate Constant

Exposure Kinetics

If I is constant with time,

$$M = M_o \exp(-CIt)$$

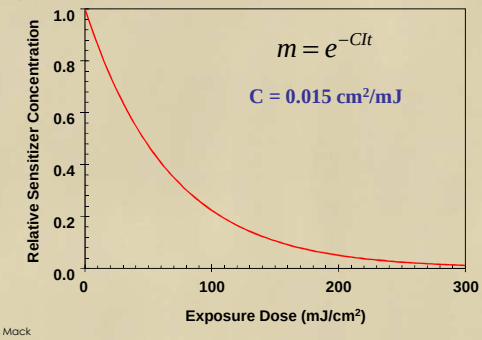
M_O = initial (unexposed) sensitizer concentration

$$m = \frac{M}{M_o} = \exp(-CIt)$$

relative sensitizer concentration

It = exposure dose

Exposure Kinetics



Reciprocity

- For first-order exposure kinetics, resist exposure exhibits reciprocity
  - Neither light intensity nor exposure time matter; only their product (dose) affects the amount of chemical change
  - Lithography tools control exposure by controlling the integrated dose, allowing intensity to vary
    - Mercury arc lamps decrease in intensity with time
    - Excimer lasers exhibit pulse-to-pulse energy variations

Lecture 49: What have we Learned?

- What are the two main tasks of a photoresist?
- What are the three major components of a photoresist?
- Name three types of photoresists that have been used in semiconductor manufacturing
- How does DNQ exposure affect resist solubility in developer?
- What is reciprocity?