CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
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Lecture 54 Lithography: Resist Contrast

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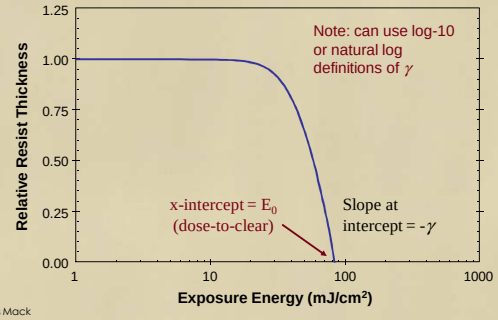
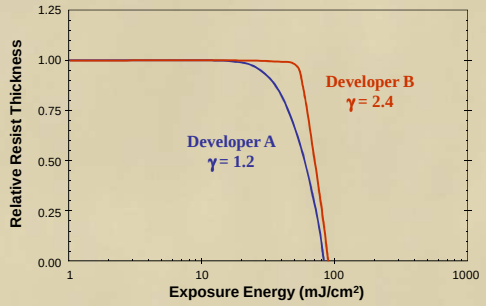
Photoresist Contrast (H-D) Curve

(also called the characteristic curve)



 2

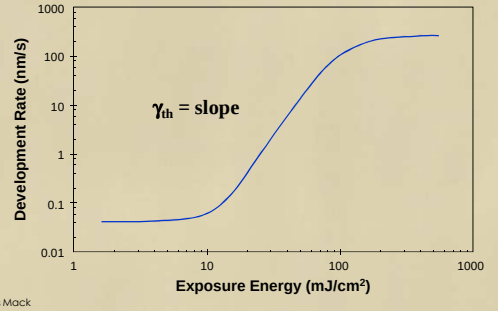
H-D (Contrast) Curve



 3

New Definition of Contrast

How does development rate respond to dose?



 4

Theoretical Photoresist Contrast

$$\gamma_{th} = \frac{d \ln r}{d \ln E}$$

- Note that theoretical contrast is a function of dose. Often the max value of γ_{th} is used.
- Questions:
  - How does this definition relate to lithographic quality?
  - What is the relationship of theoretical contrast to measured contrast?

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Photoresist Contrast

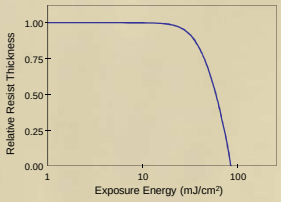
$$\frac{d \ln r}{dx} = \gamma_{th} \frac{d \ln I}{dx}$$

- The contrast "amplifies" the image gradient to give a development rate gradient
- This is called the "Lithographic Imaging Equation"

 6

Conventional "Definition" of Resist Contrast

$$\gamma_m = \frac{1}{D}\frac{d\tau}{d\ln E}\bigg|_{E=E_0}$$



τ = resist thickness remaining, D = initial resist thickness

Photoresist Contrast: γ_{th} vs. γ_m

Development Rate: $R = \frac{dz}{dt} \rightarrow \int_0^{t_{dev}} dt = t_{dev} = \int_0^z \frac{dz}{R(z)}$

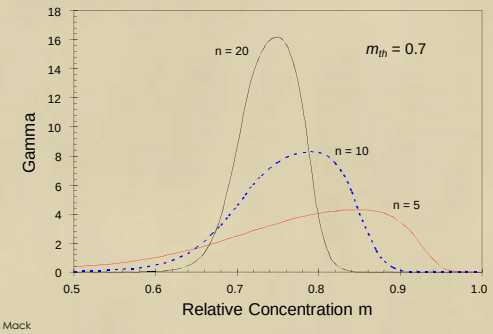
(R = development rate, z = depth into the resist)

Now take the derivative with respect to ln(dose):

$$\gamma_m = \frac{R_{bottom}}{D}\int_0^D \gamma_{th}\frac{dz}{R(z)}$$

Theoretical Contrast

$$r = r_{max}\frac{(a+1)(1-m)^n}{a+(1-m)^n} + r_{min} \qquad a = \frac{n+1}{n-1}(1-m_{th})^n$$



Resist Contrast Review

- Theoretical contrast converts the image log-slope into a development rate log-slope
- Measuring resist contrast is tricky using the conventional characteristic curve method – it is almost never worth using
  - Anything that causes the development rate to vary with depth into the resist (e.g., absorption, surface inhibition) causes an error in contrast measurement
- Theoretical contrast can be measured using a development rate monitor

Lecture 54: What have we Learned?

- How is the conventionally measured contrast defined?
- How is the theoretical contrast defined?
- When do the conventionally measured and theoretical contrasts give the same result?
- How is contrast related to the dissolution selectivity parameter n?