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

Lecture 53
Lithography: Resist Development

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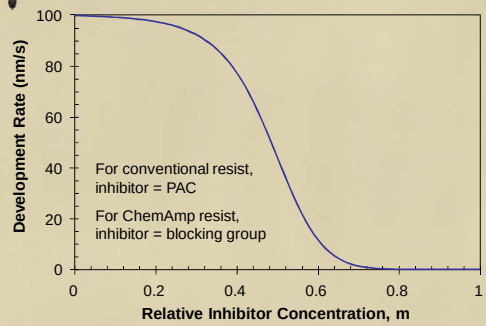
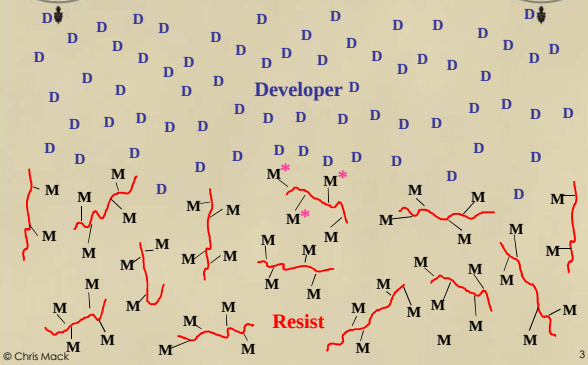
Development



Development Mechanism



Development Mechanism

- Diffusion of developer to resist surface
- Reaction at resist surface *(rate limiting step)*
  - dominated by the number of exposure events (or amplification events) required to trigger one dissolution event (called n, the *dissolution selectivity*)
- Diffusion of dissolved resist into developer

Development Mechanism

- Diffusion of Developer to Resist Surface:

$$r_D = k_D (D - D_s)$$

where r_D = rate of diffusion
k_D = rate constant
D = bulk developer concentration
D_S = surface developer concentration

Development Mechanism

- Reaction at Resist Surface:

$$r_R = k_R D_s P^n$$

where r_R = rate of reaction
k_R = rate constant
D_S = surface developer concentration
P = exposed PAC concentration (or deblocked polymer concentration)
n = reaction order (dissolution selectivity)

Development Mechanism

- At steady state:

$$r_D = r_R = r$$

where r = resist (steady state) dissolution rate.

$$k_D(D - D_s) = k_R D_s P^n$$

Now solve for D_s and eliminate from equation.

Development Mechanism

- Eliminating D_S and solving for r :

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

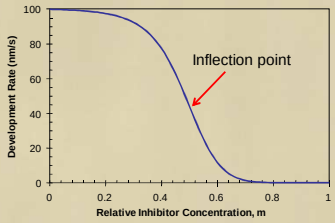
This is called the Mack development model

where r_{max} = maximum development rate
r_{min} = minimum development rate
n = dissolution selectivity parameter
a = $[(n+1)/(n-1)](1-m_{th})^n$
m_{th} = threshold inhibitor concentration

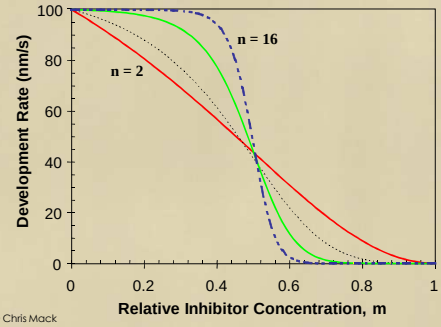
Development Model

- Definition of threshold inhibitor concentration, m_{th}:

Value of m at which $d^2r/dm^2 = 0$.

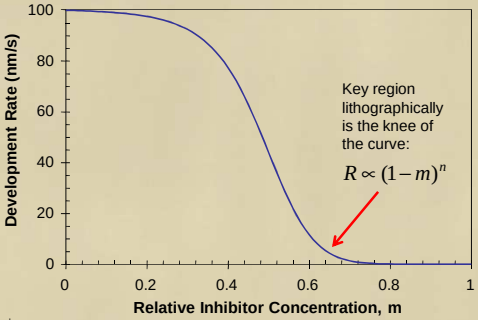


Development Model



r_{max} = 100 nm/s
r_{min} = 0.1 nm/s
m_{th} = 0.5
n = 2, 4, 8, 16

Development Knee



Lecture 53: What have we Learned?

- What are the three steps in the Mack kinetic development model used here?
- What development parameter controls the performance of the resist?
- What is the physical meaning of the dissolution selectivity parameter, n?
- What is the development knee and why is it important?