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

Review Questions by Lecture (38-60)

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Lecture 38: Lithography: Introduction

- Give two important reasons why lithography is one of the most critical technologies in semiconductor manufacturing?
- What are the basic steps in a lithography sequence?
- What are the ingredients (tools and materials) of a lithography process?

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Lecture 39: Lithography: Process Overview

- How many requirements for lithography can you name?
- What are the two main tasks of a photoresist?
- How does an adhesion promoter work?
- What is the relationship between resist thickness and spin speed?
- What is an edge bead, why does it occur, and what do we do about it?
- What is the purpose of a post-apply bake?
- Explain the two tones of photoresists

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Lecture 40: Lithography: Imaging Tools

- What are the advantages and disadvantages of contact printing?
- What are the advantages and disadvantages of proximity printing?
- What are three ways of filling a wafer with exposed chip patterns during projection printing?
- What are the two most common mercury arc lamp wavelengths?
- What are the two common excimer laser types and wavelengths?

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Lecture 41: Lithography: Diffraction, part 1

- Define “diffraction-limited imaging”
- What is a “spatial frequency”?
- Explain Huygens’ Principle
- How does one calculate the Fraunhofer diffraction pattern from a mask?

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Lecture 42: Lithography: Diffraction, part 2

- Define constructive and destructive interference
- What is Bragg’s Condition?
- What is a delta function, and what does it represent physically?
- What is a diffraction order and when do they show up in diffraction patterns?
- How does the size of a mask pattern affect its diffraction pattern?

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Lecture 43: Lithography: Projection Imaging, part 1

- Define “numerical aperture”
- What are the entrance and exit pupils of an imaging lens?
- How can one determine which diffraction orders pass through an imaging lens?
- What is the pupil function of a lens?
- Explain the concept of Fourier Optics

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Lecture 44: Lithography: Projection Imaging, part 2

- How can you determine which diffraction orders make it through the lens?
- Can you take the inverse Fourier transform of a sum of delta functions (diffraction orders)?
- A point of light (diffraction order) at the lens produces what type of wave at the wafer?
- What happens to the image if the lens captures more diffraction orders?

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Lecture 45: Lithography: Illuminating the Mask

- How does oblique illumination affect the diffraction pattern?
- What is the Rayleigh resolution criterion?
- What are the minimum values of k1 for 2-beam and 3-beam imaging?
- Define coherent, incoherent, and partially coherent illumination
- What is off-axis illumination?

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Lecture 46: Lithography: Defocus and DOF

- How does defocus affect the optical path difference (OPD) of light exiting the imaging lens?
- What is the “paraxial approximation”?
- Name three things that happen to an image as it goes out of focus
- What is the Rayleigh depth of focus equation?
- What assumptions used in the Rayleigh DOF don’t often apply to lithography today?

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Lecture 47: Lithography: Standing Waves and Swing Curves

- What causes a standing wave?
- Why are photoresist standing waves bad?
- Name four ways to reduce standing waves in resist. Which way is most commonly used?
- What is a swing curve?
- What is reflective notching?

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Lecture 48: Lithography: Resolution and Immersion

- What are the three ways to improve resolution in optical lithography
- Which of those three ways has had the biggest impact on resolution over the years?
- What currently limits our ability to improve each of these three factors?
- What is the current resolution limit for single patterning?

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Exam #3 Review

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Lecture 49: Lithography: DNQ Photoresists

- 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?

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Lecture 50: Lithography: Photoresist ABCs

- What are the ABC parameters?
- How can one increase the value of B?
- How are the ABC parameters typically measured?
- What are typical values of A for 248-nm and 193-nm resists?

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Lecture 51: Lithography: Chemically Amplified Resists, part 1

- 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?

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Lecture 52: Lithography: Chemically Amplified Resists, part 2

- Explain the concept of reaction-diffusion
- What is the diffusion point spread function (DPSF)?
- What is the reaction-diffusion point spread function (RDPSF)?
- What causes T-topping in chemically amplified resists?
- Why are base quenchers used in chemically amplified resists?

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Lecture 53: Lithography: Resist Development

- 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?

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Lecture 54: Lithography: Resist Contrast

- 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?

Exam #3 Review

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Lecture 55: Lithography: Linewidth Control

- How does transistor gate CD variation affect the device?
- What two generic factors determine the resulting variation in CD?
- Name two process variables that result in quadratic rather than linear CD response
- Explain the difference between bottom-up and top-down CD error analysis

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Lecture 56: Lithography: Lithographic Quality

- What are the four categories of lithographic quality?
- Why is linewidth versus dose often characterized on a log-log scale?
- What metric best characterizes the quality of an aerial image?
- For an infinite contrast (threshold) resist, how is CD sensitivity to dose related to NILS?

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Lecture 57: Lithography: Resolution Enhancement Technologies, part 1

- What are the two types of resolution?
- What are the three main RET approaches?
- Why is OPC needed in optical lithography?
- What are the two main types of OPC, and what are their advantages and disadvantages?

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Lecture 58: Lithography: Resolution Enhancement Technologies, part 2

- What are the three main RET approaches?
- How does OAI improve resolution?
- How does OAI improve depth of focus?
- What phase-shift do we want in a mask to produce destructive interference?
- Which PSM approach is most common in manufacturing today?
- Explain the phase conflict problem for alternating PSM

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Lecture 59: Lithography: Double Patterning

- What is the current resolution limit of single patterning?
- Name three double-patterning approaches
- What are the main advantages and disadvantages of each double patterning approach?
- Essay question: do you think there is a future for quadruple patterning? Why or why not?

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Lecture 60: Lithography: Extreme Ultraviolet

- What is the current resolution limit of single patterning?
- Why does EUV imaging use only mirrors in the projection system?
- What are the main challenges in EUV masks?
- What are the main challenges in EUV sources?
- What are the main challenges in EUV resists?

