Courses in Optical Lithography by Chris A. Mack
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Optical Lithography: Art or Science?

(1 day class)

1. Optics of Projection Tools

1.1. Diffraction

Purpose: The purpose of this section is to provide a simple description of diffraction and its relationship to imaging.

Objectives: Upon completion of this section, you will be able to:

- Describe the principle of diffraction
- Describe how a basic imaging system works
- Understand the impact of the mask on diffraction orders

1.2. Image Formation

Purpose: The purpose of this section is to describe how an image is formed.

Objectives: Upon completion of this section, you will be able to:

- Define numerical aperture and describe its effect on image formation
- Describe the concept of Fourier Optics

1.3. Mask Illumination

Purpose: The purpose of this section is to describe how masks are illuminated in lithographic imaging systems and how this illumination affects image formation.

Objectives: Upon completion of this section, you will be able to:

- Describe the effect of illumination angle on the diffraction pattern
- Define partial coherence
- Describe the impact of illumination on resolution
- Define Köhler illumination

1.4. Aberrations and Defocus

Purpose: The purpose of this section is to describe lens aberrations (including defocus) and how they affect the aerial image.

Objectives: Upon completion of this section, you will be able to:

- Describe aberrations in both geometrical and wavefront terms
- Understand the use of the Zernike polynomial
- Describe the causes of aberrations
- Describe how aberrations affect current lens designs

2. Standing Waves and Swing Curves

2.1. Standing Waves

Purpose: The purpose of this section is to describe how standing waves come about and how to reduce them.

Objectives: Upon completion of this section, you will be able to:

- Describe the basic principle of standing wave formation
- Describe the four ways to reduce the standing wave effect

2.2. Swing Curves

Purpose: The purpose of this section is to describe how thin film interference effects cause swing curves and how to reduce them.

Objectives: Upon completion of this section, you will be able to:

- Describe how thin film interference effects cause swing curves
- Describe the four ways to reduce swing curves

3. Photoresist Chemistry

3.1. Exposure and Absorption

Purpose: The purpose of this section is to describe the kinetics of photoresist exposure and absorption.

Objectives: Upon completion of this section, you will be able to:

- Define the major tasks and components of a photoresist
- Describe first order exposure kinetics
- Describe the Lambert and Beer laws of absorption
- Understand the definition and measurement of the resist ABC parameters

3.2. Chemically Amplified Resists

Purpose: The purpose of this section is to describe the chemistry of chemically amplified resists and understand the lithographic consequences of this chemistry.

Objectives: Upon completion of this section, you will be able to:

- Describe the basis of “chemical amplification”
- Describe the impact of acid diffusion
- Describe the detrimental effects of acid loss

3.3. Development

Purpose: The purpose of this section is to describe the chemistry of photoresist dissolution.

Objectives: Upon completion of this section, you will be able to:

- Provide a simple mechanistic description of photoresist dissolution
- Understand the nature and possible causes of surface inhibition

4. Aerial Image

4.1. Image Quality Metrics

Purpose: The purpose of this section is to define an appropriate metric for image quality and demonstrate its use.

Objectives: Upon completion of this section, you will be able to:

- Explain the problems with image contrast
- Define the image log-slope and the NILS
- Explain the importance of the log-slope defocus curve

4.2. Using the Image Log-Slope

Purpose: The purpose of this section is to demonstrate the use of the image log-slope for optimizing lithographic imaging.

Objectives: Upon completion of this section, you will be able to:

- Explain how NA and wavelength affect image quality
- Use the log-slope to optimize NA and sigma

5. Exposure Optimization

5.1. Latent Image Gradient

Purpose: The purpose of this section is to define the latent image gradient and describe its relationship to the image log-slope.

Objectives: Upon completion of this section, you will be able to:

- Define the latent image gradient
- Understand how the latent image gradient relates to the image log-slope

5.2. Optimum Exposure

Purpose: The purpose of this section is to show how the use of the latent image gradient leads to an optimum exposure dose.

Objectives: Upon completion of this section, you will be able to:

- Explain why there exists an optimum exposure dose
- Understand the built-in contrast enhancement effect of photoresist bleaching

6. Development Optimization

6.1. Theoretical Contrast

Purpose: The purpose of this section is to define the theoretical contrast and explain its use.

Objectives: Upon completion of this section, you will be able to:

- Understand the problems with conventional contrast measurement techniques
- Define the theoretical contrast and explain why it is important

6.2. Development Path

Purpose: The purpose of this section is to show how the development path affects resist profile formation.

Objectives: Upon completion of this section, you will be able to:

- Understand the nature of the development path
- Explain what controls photoresist sidewall angle