Poster 075

Efficient Simulation of Multilayer Defects on 2D and 3D EUV Masks

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Introduction

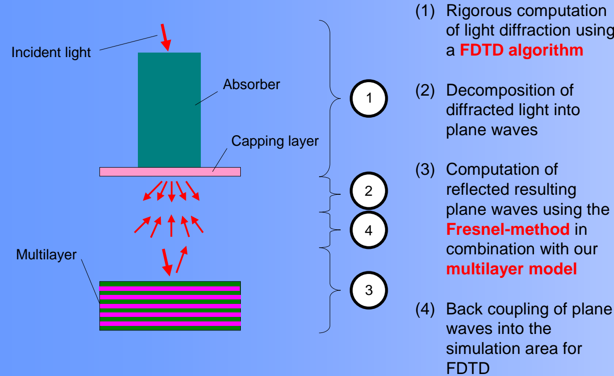
Defect free 2D lines and spaces and 3D contacts, posts, etc. can be effectively simulated by a combination of rigorous computation of the light diffraction from the absorber and of analytical transfer matrices for the description of light reflection from the multilayer. In the case of a defect free multilayer the application of domain/field decomposition techniques can extremely speed up the simulation of 3D geometries.

This contribution reports on the generalization of the model for defective multilayers. 3D simulations using the new model can be carried out on state-of-the-art personal computers.

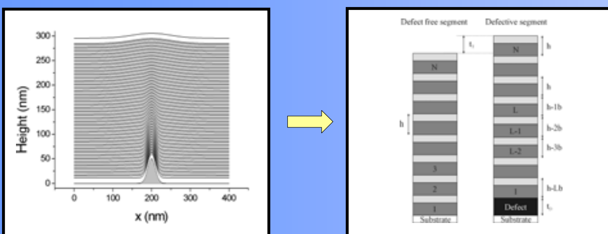
The proposed model is used for a study of the impact of two and three dimensional EUV multilayer defects on the reflected near fields, the aerial images, and the resulting process windows. Typical 2D and 3D mask structures in combination with various defect sizes and positions are investigated.

Light Diffraction from EUV Masks

- Off-axis illumination: 4-6°
- Absorber thickness large compared to the wavelength: 6-8 λ
- Multilayer reflectivity



The Multilayer Model



- Cross section of a defect-caused deformed multilayer with 40 approximately 7 nm thick molybdenum-silicon doublelayers (black lines)
- **Gaussian shaped defect** (gray) onto the bottom layer
- **Gaussian shaped top level layer**

- **Lateral decomposition** of the multilayer structure into discrete segments (dark gray/light gray=one MoSi doublelayer)
- Computation of the defect-caused segment deformation
- Analytic computation of the segment reflectivity using the **Fresnel-method**
- Topography-caused incident light **angle and phase correction**

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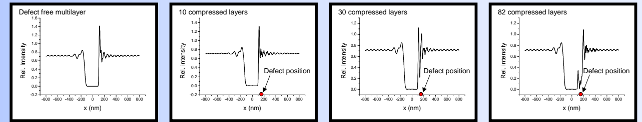
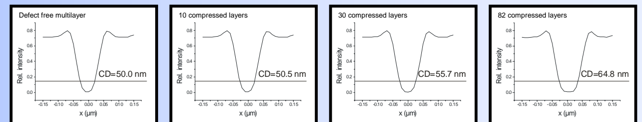
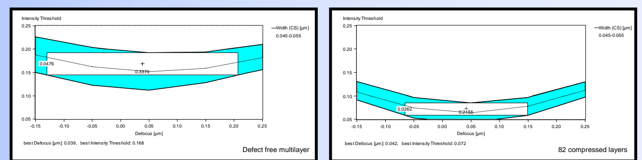
2D Simulations



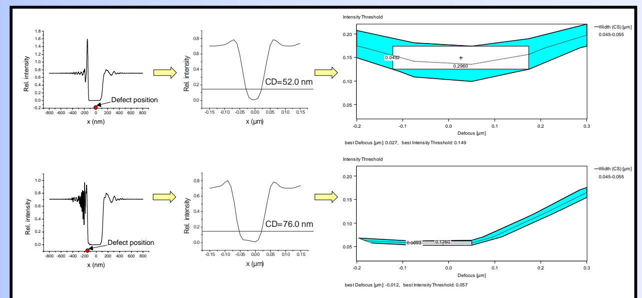
Near fields (intensity) of a defective EUV mask: One isolated line (200 nm Cr absorber), 5° illumination angle from the right hand side, λ=13.4 nm, Gaussian shaped multilayer defect, height=20 nm, FWHM=50 nm, onto substrat, defect center at position x=150 nm, defect-caused compression of the whole multilayer: 20 nm, **number of compressed layers above the defect: First image (leftmost): Defect free multilayer, second image: 10, third image: 30, fourth image: 82**



Aerial images of the near fields above: NA=0.2, coherence=0.52, 4x, CD at intensity level 0.15

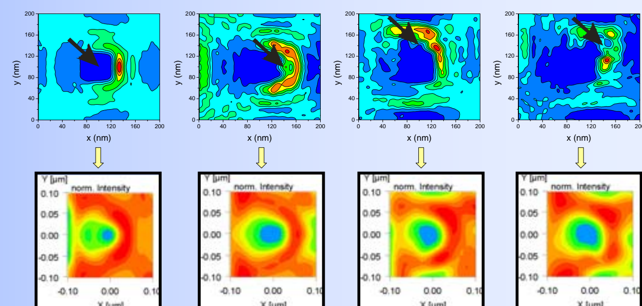


Left window: Correspondent process window of the leftmost aerial image (defect free multilayer), right window: Correspondent process window of the rightmost aerial image (82 compressed layers)



From left to right: Near fields (intensity), aerial images, and process windows of a defective EUV mask, one isolated line (200 nm Cr absorber), 6° illumination angle from the left hand side, λ=13.4 nm, Gaussian shaped multilayer defect, height=20 nm, FWHM=21 nm, onto substrat, defect-caused compression of all layers of the multilayer, NA=0.25, coherence=0.65, 4x, CD at intensity level 0.15, **first row: Defect center at position x=0 nm, second row: Defect center at position x=-140 nm**

3D Simulations



First row: Near fields (blue=minimum intensity, red=maximum intensity) of a defective EUV mask, one Cr absorber (50 nm x 50 nm), 5° illumination angle from the right hand side, λ=13.4 nm, Gaussian shaped multilayer defect, height=20 nm, FWHM=21 nm, onto substrat, defect-caused compression of all layers of the multilayer, **the arrows indicate the different positions of the defect center**, second row: Aerial images (blue=minimum intensity, red=maximum intensity) of the near fields above, NA=0.2, coherence=0.52, 1x