EUV photomasks utilize a multilayer stack to provide high and uniform EUV reflectance and a patterned absorber which defines the features on the mask. Illuminating at an oblique angle as necessary in a stepper gives rise to horizontal-vertical print differences and through-focus pattern placement errors due to shadowing. These 3D mask effects depend on the full 3D mask structure. Characterization by EUV Scatterometry may use zero order specular reflection to assess the multilayer and absorber stack homogeneity. For structured areas the zero order reflectance depends on structure details like CD and can be used to check patterning homogeneity. Intensity measurements of several diffraction orders can be used for the reconstruction of the line shape.

We present data obtained at EUV photomasks featuring large periodic lines & spaces fields suitable for scatterometry with the instruments of PTB which are not specially designed for small measurement spots. We use an FEM-based Maxwell solver for the evaluation of the data with respect to the geometrical parameters and exemplary AFM measurements. Examplary EUV diffraction measurement and FEM grid layout of the ATMC mask test structures.

References

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Actinic characterization of EUV Photomasks by EUV Scatterometry

C. Laubis¹, F. Scholze¹, V. Soltwisch¹, A. Ullrich², V. Philipsen³ and S. Burger⁴

1: PTB, 2: AMTC, 3: IMEC, 4: JCMwave

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Material characterization

For improved imaging, highly absorbing thin layers are required. TEM image of an advanced layered absorber stack. [1, 2]

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Metrology comparison of CD measurement by EUV scatterometry and AFM

Image of a flared AFM tip for CD metrology.

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Instruments: Ellipso-Scatterometer

Material characterization

Measured reflectance of a layered absorber stack (black grid) coated onto a Si wafer. A calculation using the nominal stack parameters is shown as a colored surface. Although not all details are matched (compare the slightly irregular structure in the TEM image) the overall reflectance near normal incidence in the relevant wavelength region around 13.5 nm fits reasonably well.

Left: Measured reflectance (black grid) in a reduced wavelength range and a calculation using a single layer model (colored), mimicking the stack by a layer with an effective index of refraction. The data for higher A01 fit well, near normal incidence the calculated reflectance is too low. The calculated transmittance of the layer stack (right), for a single layer model (black grid) and the layered stack (colored surface) show good agreement.

It is possible to derive reasonably good transmittance values for a layered absorber stack using effective optical constants.

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Polarization resolved diffraction efficiency

Polarization resolved diffraction efficiency of absorber lines on an EUV test reticle from AMTC, pitch 160 nm and CD 85 nm. [3]

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Comparison of measurement data from AFM (red) and EUV scatterometry (blue). Error bars are 2σ-value. [5]

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References