Engineering novel EUV mask absorbers at imec

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The EUV mask started its career in lithography with Tantalum as the opaque layer carrying the pattern, on top of the EUV reflective multilayer mirror. The scanner's low numerical aperture of 0.25 and the technology nodes for 90nm pitch at the start of the EUV era, allowed the mask industry to drive the fabrication of the Ta-based EUV mask to perfection.

As the understanding of the EUV lithography grew, its different components – e.g., resist, scanner optics, source - are being tailored to create the perfect aerial image and robust resist pattern. Since recent years, the attention is moving more and more to the EUV mask. Mask specific challenges involve mask deficiency induced stochastic failures, the anamorphicity of high-NA EUV lithography and mask 3D effects. Mask 3D effects, as a common denominator for inherent pitch- and orientation-dependent wafer observations, are identified to limit wafer performance for current and future technology nodes of 32nm pitch and below. Initial solutions are proposed by source-mask optimization, where the illumination and mask design are compensating these wafer effects, which are in fact due to the choice of the mask materials.

At imec we started several years ago to target the mask material as the parameter to control the mask 3D effects on wafer. Our strategy towards a material down-selection for a mask technology change evolves on two levels, demonstrating improvements from lithographic perspective and validating compatibility with essential mask absorber requirements [1]. Through simulations we mapped EUV n&k regions with their expected imaging benefit. Experimental determination of the EUV optical properties of the actual mask material is essential to enhance the simulation predictions. Various patterning strategies of the proposed films are investigated. Our simulation approach and material properties knowledge directed our engineering and characterization of novel absorber films. In this effort imec actively drives collaboration with suppliers, stakeholders, and institutes to explore the EUV mask space.

[1] V. Philipsen, et al., Proc. SPIE 10810, 108100C (2018).