

CD SEM measurements on EUV photomasks

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The continuous scaling of semiconductor devices has driven the adoption of Extreme Ultraviolet (EUV) lithography in advanced nodes. The precision and accuracy of Critical Dimension (CD) measurements on EUV masks become increasingly critical.

A particular challenge in CD measurement on EUV masks is to minimize the influence of the linearity of the CD-SEM on the measurement results. Especially at very small feature sizes, even slight non-linearities in the measurement chain can lead to significant deviations. To ensure high measurement accuracy and reproducibility, both the CD-SEM scan parameters (e.g., beam current, acceleration voltage, pixel size, and averaging of scans) and the image evaluation parameters (such as threshold settings, edge detection, and filtering algorithms) have been specifically optimized. These measures reduce systematic sources of error and enable more precise capture of the actual feature dimensions. To calibrate and validate CD measurements, the Advanced Mask Technology Center (AMTC) utilizes an EUV photomask calibration standard provided by the Physikalisch-Technische Bundesanstalt (PTB). This calibration standard contains CD feature line/space patterns with minimum CD sizes down to 47.4 nm. However, this limit no longer encompasses the smallest features present on current EUV masks, which can be below 30 nm.

Another growing challenge is the increasing presence of curvilinear structures in modern mask designs. Traditional CD measurement methods, which typically rely on linear edge-to-edge distances, are no longer sufficient for accurately characterizing these complex shapes. For such non-rectilinear features, classical CD metrics lose relevance, and instead, shape-based metrology must be applied. One effective approach is the use of Edge Placement Error (EPE) measurements, which compare the actual feature contours on the mask to the intended design. Further improvements in the accuracy of EPE-based metrology have been achieved through refinement of CD SEM scan parameters. These enhancements enable reliable quantification of both global and local deviations.