Establishing SI Traceability for Scatterometry

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ABSTRACT

Scatterometry, sometimes referred to as optical critical (CD) dimension metrology, combines reflectometry or ellipsometry with electromagnetic simulations to measure dimensions of features in periodic structures. Optical scatterometry has become an attractive tool for dimensional metrology in the semiconductor industry, due in large part to its inline potential for providing critical feedback information necessary for tight process control. Unlike atomic force microscopy (AFM), which measures the dimensions of a target by physically contacting it, scatterometry measures those dimensions by obtaining an optical signature and comparing that signature to a theoretical parametric model. Until recently, however, little attention has been given to establishing absolute accuracy for optical scatterometry.

I will discuss the development of an independent uncertainty budget for optical scatterometry, an important step toward establishing traceability to the International System (SI) meter. One of the key developments has been a methodology for propagating systematic uncertainties and signal noise through a regression analysis. The regression analysis optimizes a set of floating parameters (e.g., CD, side wall angle, and height) under a set of fixed assumptions (e.g., optical constants and instrument conditions). A scatterometry sensitivity analysis program, OCDSense, has been developed that implements this methodology for any grating structure and measurement scheme. OCDSense propagates the noise in the reflectance measurement and the uncertainties in the fixed parameters (assumptions) to the covariance matrix of the floating parameters. Uncertainties in incident angle, wavelength, finite target size, roughness, beam focusing, channel cross-talk, and radiometric accuracy also contribute to the measurement uncertainty, and to some extent, these uncertainties can be included in OCDSense as well. Ultimately, an uncertainty budget for line profile needs to specify not just uncertainties in a single number (such as CD or sidewall angle), but an uncertainty in the profile function. Figure 1, below, shows a set of profiles that are consistent with the uncertainty covariance for a virtual measurement. An uncertainty budget for a specific scatterometry measurement of a silicon trench grating will be presented.

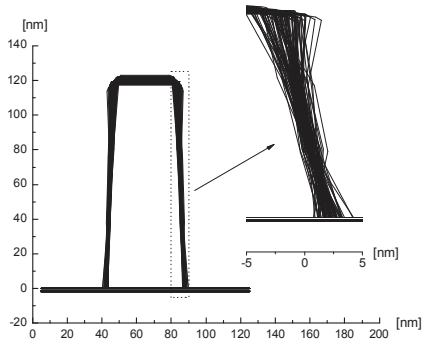

FIGURE 1. Example of a scatterometry uncertainty analysis yielding an ensemble of profiles consistent with measurement uncertainties. The inset expands the horizontal scale within the dashed rectangle to better view the various profiles.

Keywords: Scatterometry, Traceability, Optical Critical Dimension Metrology