Kernel Based Parametric Analytical Model of Source Intensity Distributions in Lithographic Tools

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In recent years, CD (critical dimension) control and model based lens aberration monitoring have become increasingly important in subwavelength optical lithography[1,2]. Computational models that are used in OPC (optical proximity correction) require description of the imaging system, photoresist, and etching[3]. One of the critical components of the optical lithography tool that desires thorough modeling is the source intensity distribution which is physically defined as a pupil illumination function.

The physical parameters in the pupil illumination function including tilt, ellipticity, shift of the center, etc., are increasingly important in describing and revealing source intensity distributions on CD uniformity. The traditional top-hat approximation for the pupil illumination function is thus insufficient for stringent CD control required in low-k1 applications. Moreover, the pupil illumination profile can change across the exposure field, and this change needs to be included in the computational models to compensate the ACLV (across-chip linewidth variation) when OPC is carried out. Therefore, there is a need for the manufacturers of lithographic tools to develop a parametric model to accurately approximate and characterize source intensity distributions.

This paper proposes a parametric analytical model for overall representation of the physical distribution property of partially coherent illumination sources in lithographic tools. A set of kernels are adopted to construct the analytical model for the multiple mainstream illumination sources. Corrected parametric terms are subsequently presented for characterization of different physical distortions and deviations of source intensity distributions. The corrected parametric terms can be decomposed into Fourier series which have the special physical meaning of respectively indicating different distortion types including shift of the center, tilt, ellipticity, etc. The proposed analytical model provides both simulation condition and theoretical basis for the OPC and the related research fields, thus has important applications.

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[3] F. M. Schellenberg, Opt. Rev. **12**, 83 (2005).

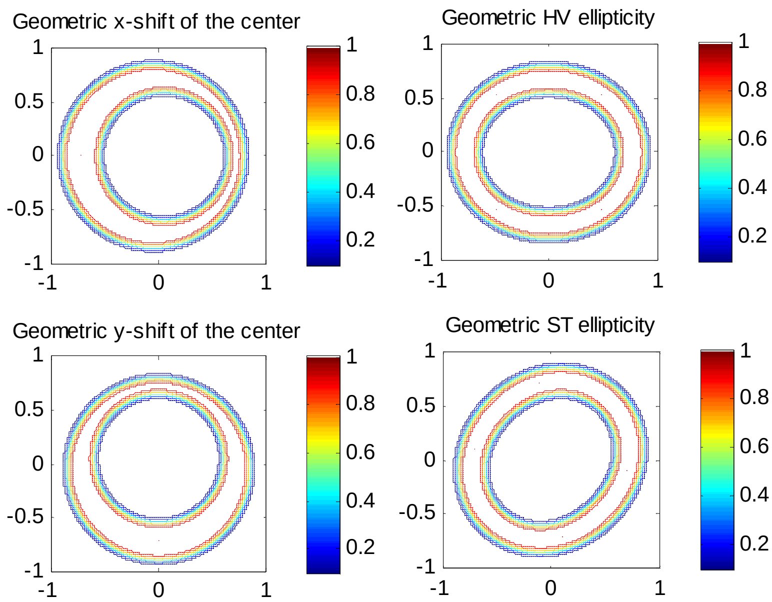

Figure 1: An example for the kernel based parametric analytical model in characterizing the source intensity properties of ellipticity and center shift in the pupil plane.

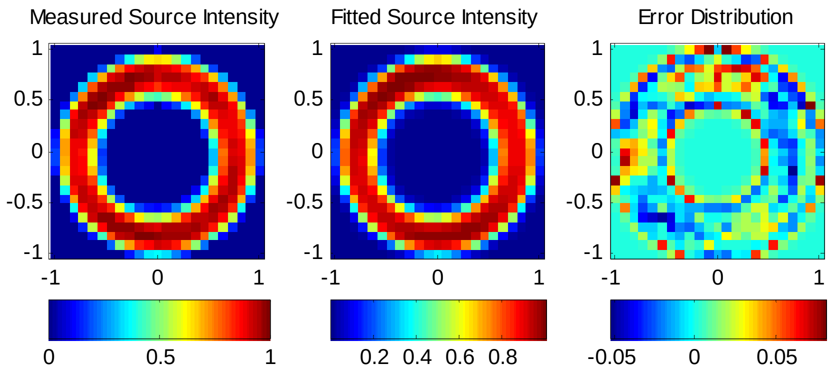

Figure 2: A comparison of measured and fitted annular source. Source intensity distribution is complete in the pupil plane.

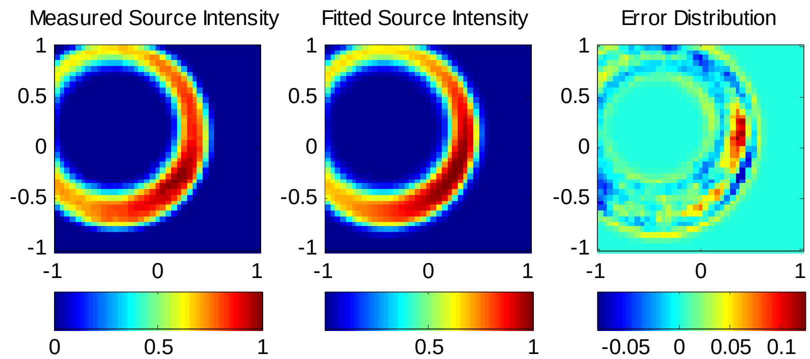

Figure 3: A comparison of measured and fitted annular source. Source intensity distribution is incomplete in the pupil plane.