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van den Hurk, D.P.M.; Habets, M.B.I.; Weiland, S.

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D.P.M. van den Hurk\textsuperscript{1} \hspace{1cm} M.B.I Habets\textsuperscript{1} \hspace{1cm} S. Weiland\textsuperscript{1}
d.p.m.v.d.hurk@tue.nl \hspace{1cm} m.b.i.habets@tue.nl \hspace{1cm} s.weiland@tue.nl

\textsuperscript{1}Department of Electrical Engineering, Eindhoven University of Technology
P.O. Box 513, 5600 MB Eindhoven, The Netherlands

1 Background

Chipmakers all over the world try to produce ever smaller chips with increased functionality. This could not be possible without the tools that enable them to print consistently smaller features on a wafer. The smallest feature size, or resolution, that can be projected on a wafer is limited by the Rayleigh criterion, given by

\[ R = k_1 \frac{\lambda}{NA}. \]  

(1)

Here, \( k_1 \) is a process specific parameter, \( NA \) is the numerical aperture, and \( \lambda \) is the wavelength of the light that is used in the lithography tool. In the latest lithography machines extreme ultraviolet light (EUV), with a wavelength \( \lambda = 13.5\text{[nm]} \), is used for exposures. This light is directed from a source to the wafer using mirrors instead of traditional lenses. Due to the limited reflectivity of these mirrors, a fraction of the input power will heat up the mirrors which eventually will result in optical aberrations and reduced performance of the lithography tool.

2 Multiphysics mirror heating model

In order to predict, and possibly correct for these thermal induced aberrations, a multiphysics mirror heating model was created in [1][2][3]. This model computes, based on illumination settings, mask pattern and optical prescription, an irradiance profile. From this, the resulting thermal distribution and mechanical deformations of all mirrors in the optical path are computed using a finite element (FE) package, such that the optical performance of the aberrated optical system can be evaluated using a ray-tracing algorithm.

3 Problem description

In this presentation we consider the problem of parameter estimation and sensitivity analysis of the large scale multiphysics mirror heating model. In order to validate the correctness of the derived model, it is tested against measurement data of a test-setup. To achieve maximal congruence between the simulation result and measurement, parameter values of the model need to be calibrated. While some parameters can be measured directly, others will have to be estimated using other methods.

4 Sensitivity-based FE model updating

For the parameters that have to be estimated, a sensitivity analysis is performed. Based on the result of this analysis a FE model updating method is used to estimate the uncertain parameters. The model updating process is graphically represented in Figure 1. The method works by iteratively simulating the FE model, comparing the simulated and measured output, and computing new parameter values based on an optimization problem.

![Figure 1: Model updating strategy](image)

References