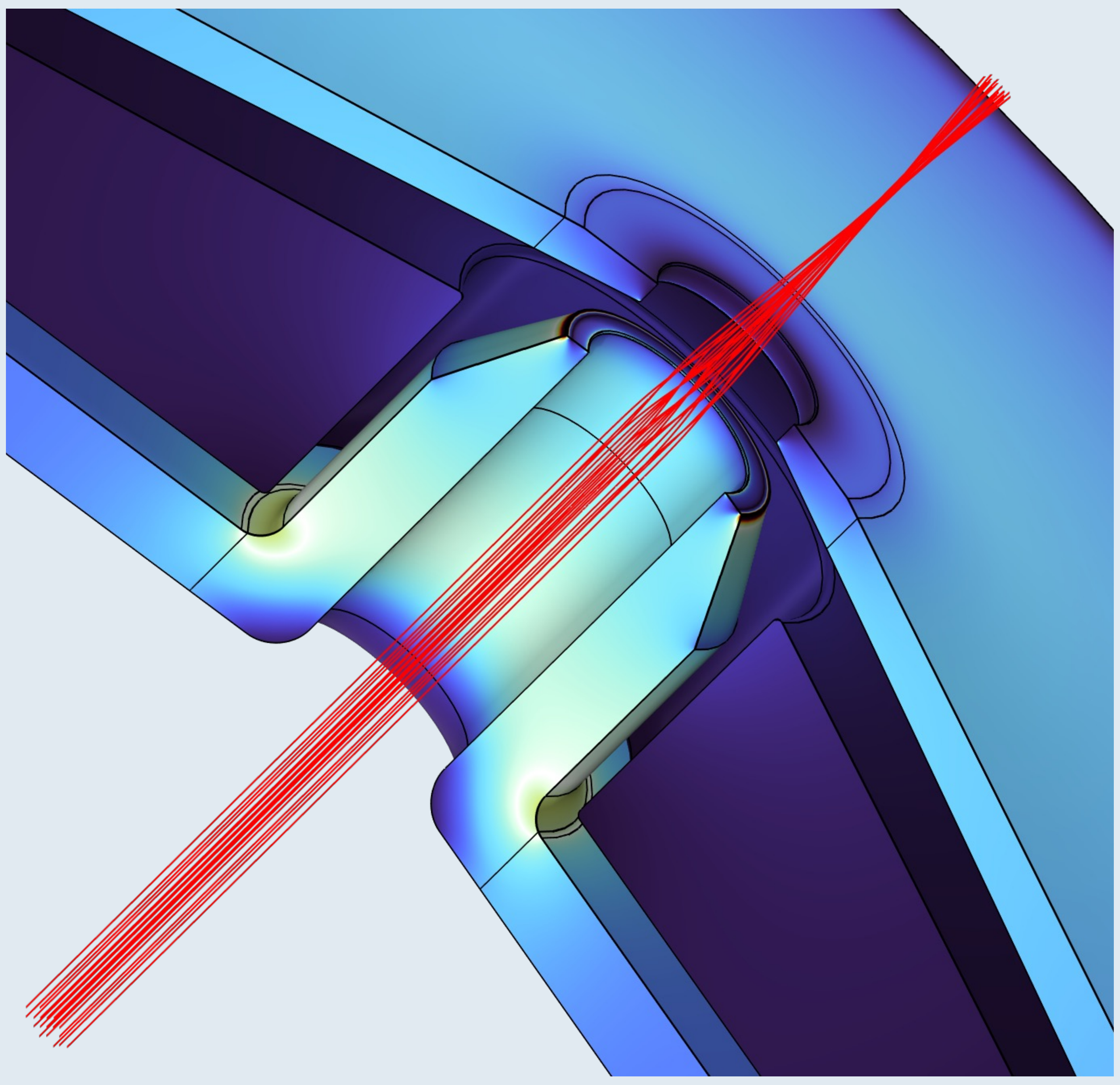

Multi-Beam Mask Writer Lens Optimization with COMSOL®

Developing next generation mask writer optics to facilitate the upcoming semiconductor technology nodes.

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Introduction

In order to facilitate semiconductor production in the upcoming technology nodes (3nm, 2nm, 14A) our state-of-the-art multi-beam mask writer (MBMW[1]) needs constant improvement in throughput and writing precision. As these two goals contradict each other, adaption of the electron optical system is required for each future tool generation.

The aim of this work is to minimize lens aberrations that are unavoidable in rotational symmetric electron lenses while maintaining their imaging properties such as principal plane location and focal length. Lens aberrations in the projection system result in an increased electron beam blur that again limits pattern fidelity.

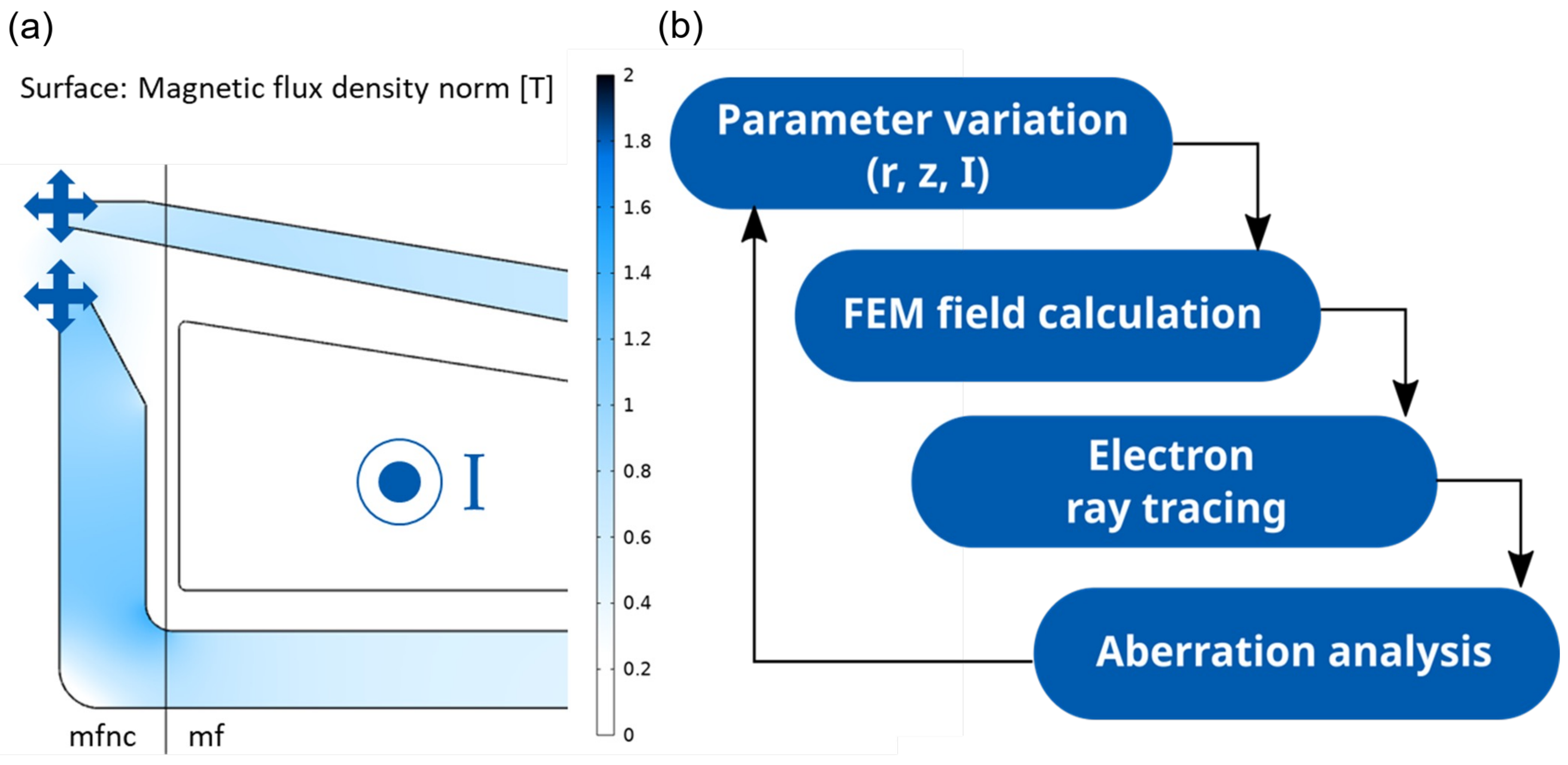

FIGURE 1. (a) Lens optimization parameters: Pole piece geometries and current. (b) Aberration optimization workflow.

Methodology

The COMSOL® model is used in the Java programming mode, allowing the integration with existing software and analysis tools in our company. Model input parameters, e.g. geometries and coil current of a lens system can be accessed and controlled by the automation software.

Fast FEM calculation with high accuracy is a key factor in the optimization procedure as the number of input parameters can be up to 20 for the full optical system. A combination of magnetic field (mf) and magnetic fields, no currents (mfnc) physics nodes is used in order to utilize the quintic discretization of the latter, resulting in the required accuracy (Figure 1(a)).

Results

Optical simulations using COMSOL FEM results yield remarkably accurate models of the MBMW system. Figure 2(a) illustrates the agreement between simulated and experimentally measured image field blur data. Voltage and current target values can be reliably estimated by the models for all operation modes, enabling the development of precise tuning procedures.

By following the optimization approach as illustrated in Figure 1(b), we have successfully designed next-generation MBMW optics. Lens aberrations and hence image field blur along with resolution limits have been significantly reduced as shown in Figure 2 (b, c).

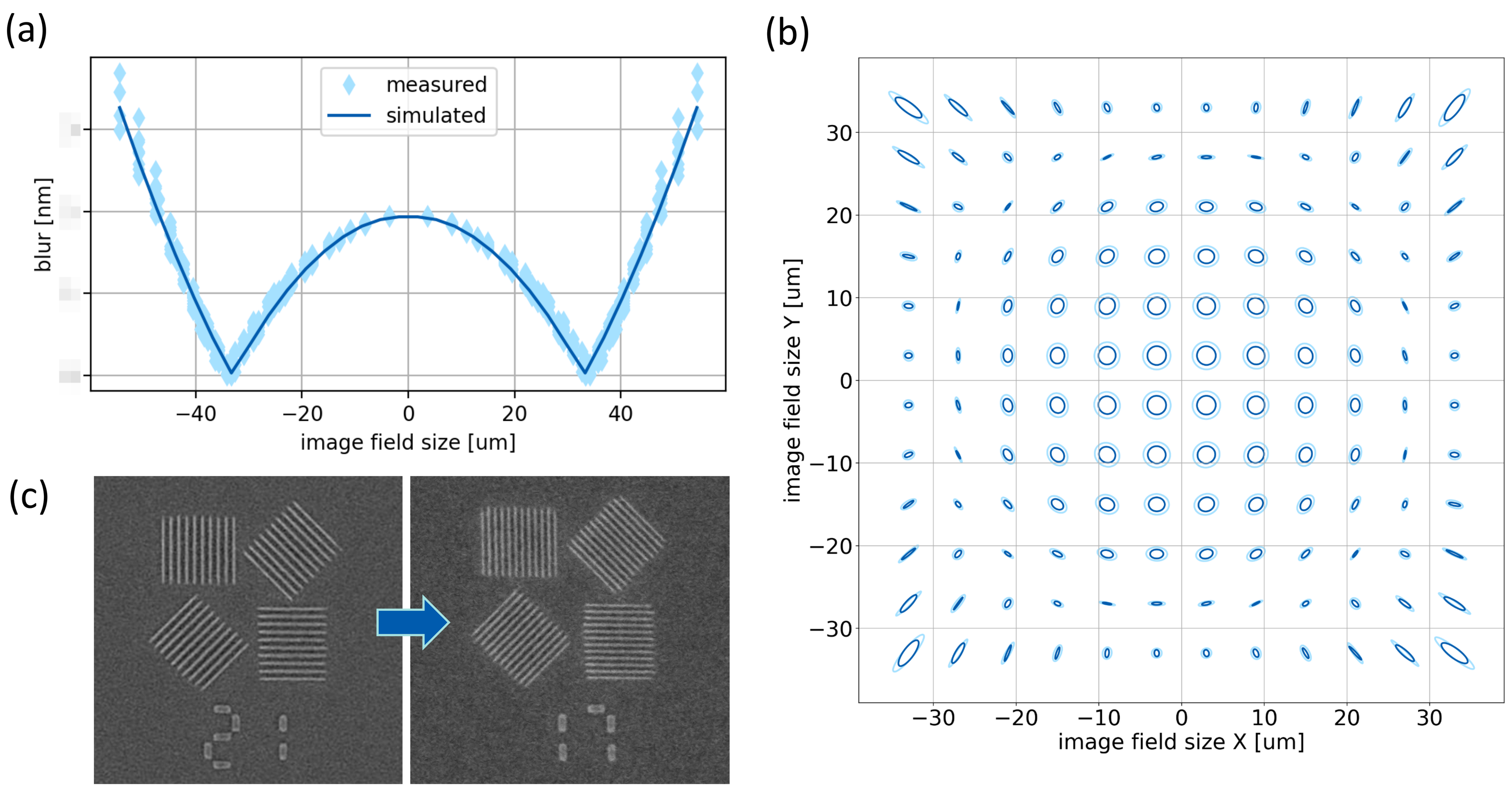

FIGURE 2. (a) Simulated vs. measured image field blur.
(b) Improved blur distribution of the MBMW by 30% with the presented optimization procedure. (c) Improved resolution [nm].

REFERENCES

1. MBMW-101: World's 1st High-Throughput Multi-Beam Mask Writer
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