# Modelling Of Meta-optics Based On Electron Beam Lithography And RIE Patterning Process

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## Abstract

Binary meta-optical structures offer many new possibilities in the efficient manufacturing of products like diffractive beam splitters, phase correction elements, gratings and many more. At JENOPTIK we manufacture a variety of optical elements, based on electron beam lithography (EBL) patterned nanostructures. The exposed and developed layout is transferred via reactive ion etching (RIE) that leads to a certain spatial formation of trenches, staircases, holes or any other shapes within the substrate.

Typically, tight and challenging specifications of the final product require the exact knowledge and control of our sub-micron etch-profiles, especially at the design-stage. For that purpose, we utilize the COMSOL Multiphysics Wave Optics Module to model the nanostructure after etching and its optical properties to further optimize the layout and parameters like depth, critical dimensions or the layer material.

In this paper, we like to present a feasibility study for a blazed grating using a meta-optic design approach, i.e. generating a spatially modulated effective refractive index. Starting with the parametrized geometry of etched patterns, we fitted latter ones to scanning electron microscopy images (SEM) as depicted in Figure 1. The sample preparation of the cross-section was done by focused ion beam cutting technique (FIB).

For optical modelling, an input port boundary condition from the „Electromagnetic Waves, Frequency Domain Interface" is applied to simulate the effect of incoming planar waves of wavelength λ and TE- as well as TM-polarization, respectively. Floquet-periodicity is used as periodic boundary condition, and a second port is added to calculate the output properties such as the transmittance depending on the diffraction order or the diffraction efficiency depending on the geometric settings and etch profiles. Additionally, the model is then used to identify and optimize the highest possible numerical aperture given the underlying technical constrains.

This study aims to define a reasonable parameter space for the gratings later being manufactured and helps to accelerate the process development and additionally to determine the process window as well as the limits of certain optical performance with respect to specifications and process capabilities.

## Figures used in the abstract

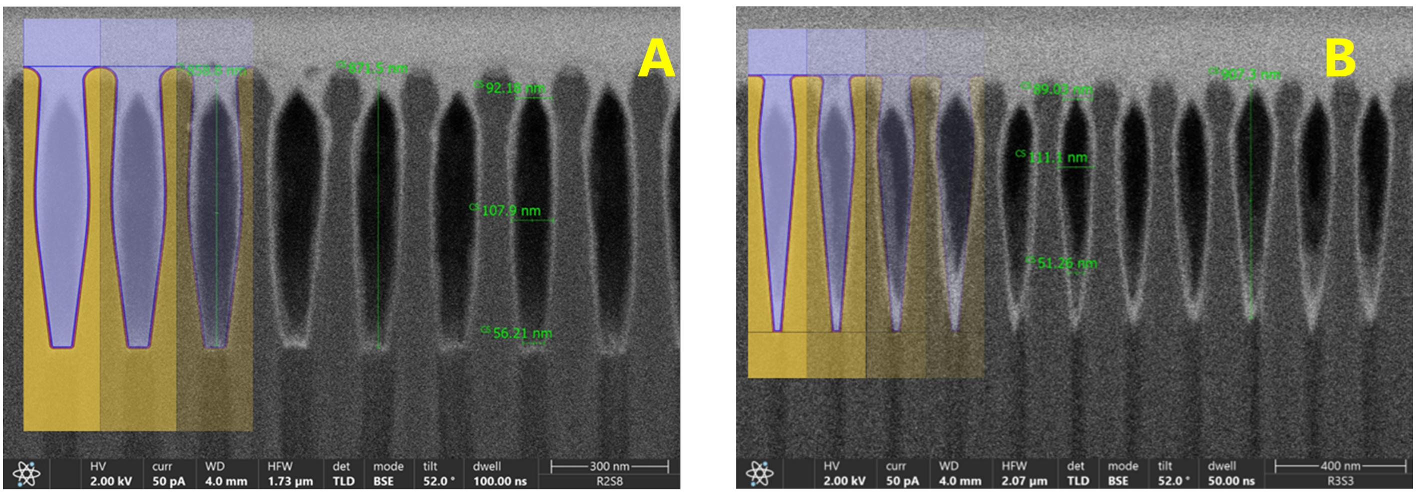


**Figure 1** : SEM images of etched trench profiles A (200nm periodicity, 90nm trench and ~870nm depth) compared to etch profile B (180nm periodicity, 80nm trench and ~900nm depth) superimposed with COMSOL model geometry.