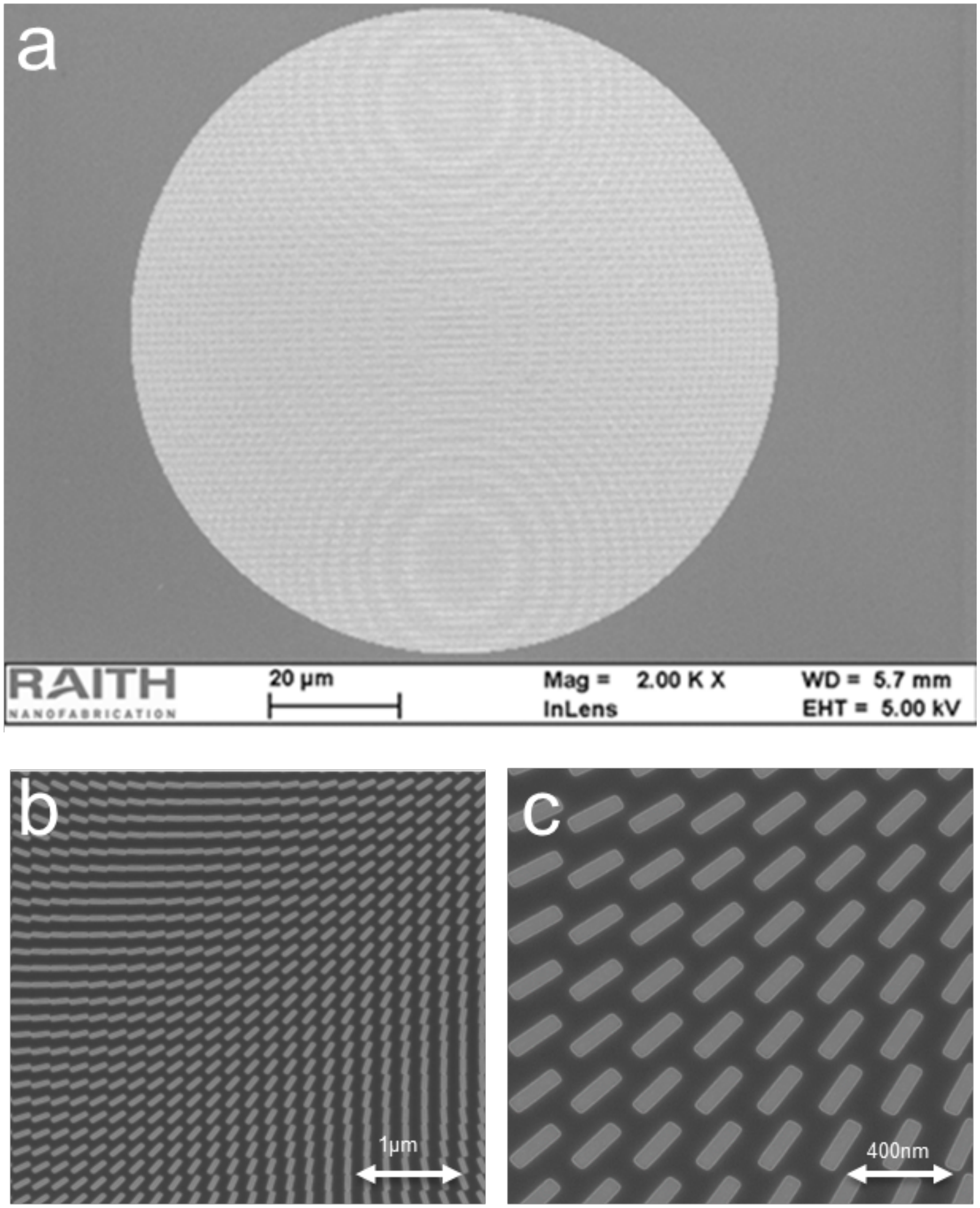
# Enabling Nanofabrication of a 1mm$^2$ Metalens in less than a Minute by innovative algorithmic EBL Patterning Strategies

F. Nouvertné, G. Piaszenski, J. Münchenberger, C. Aulbach and V. Boegli
*Raith GmbH Dortmund, Konrad-Adenauer-Allee 8, 44263 Dortmund*
*frank.nouvertne@raith.com*

Metalenses are based on new 2D lens concepts exploiting dielectric or plasmonic effects. This technology is very promising for sensing and imaging applications in consumer electronics, medicine, autonomous vehicles, AR/VR displays, and more. Metalenses are "flat" and made by optical components that use metasurfaces to focus light without the need for bulky classical optical lenses thus allowing for miniaturization of all devices mentioned above. Typically, metalens patterns extend over multiple mm$^2$ if not cm$^2$ and consist of an extremely high number of unique, irregularly and separately arranged design elements like rectangles, circles, ellipses or similar with a few 100nm in size.

Corresponding CAD designs can grow up to data file sizes of several hundreds of GB making it extremely challenging if not impossible to be processed efficiently with conventional EBL systems. Exemplarily, for a metalens with ~1cm$^2$ diameter and ~200nm sized elementary functional elements like nanofins, the entire design consists of several hundred million individual design elements, that cannot be treated hierarchically or in a repetitive way within the EBL system´s data handling architecture. They rather need to be sequentially and individually processed (including design fracturing, data transmission and exposure pixel sequence calculation) within the EBL system´s entire data processing path. This requires highest computational power and most efficient data transmission capabilities in both the workstation and the pattern generator, which is still very challenging even in view of modern and powerful electronic infrastructure embedded in nowadays EBL systems.

Here, we present a lean, fast and extremely efficient innovative EBL workflow that circumvents the necessity for generating a flat GDSII design by exploiting the algorithmic (formula-based) description of the metalens pattern. The pattern information contained in the mathematical formula is translated into an EBL job, that directly creates the relevant pixel stream for the pattern generator "on-the-fly" only as soon as the exposure has been started. This new concept results in much reduced overhead. So, time consuming generation of intermediate GDSII design or machine code files with potential file size limitations is eliminated and throughput is increased by a factor of up to 10. Finally, a metalens design described in [1] with 1mm diameter has been exposed in less than a minute. This new approach can also be applied to fabrication of unhandy and irregular large area gratings for AR/VR applications.




*Figures a-c:* Metalens pattern in resist, manufactured by using algorithmic patterning and metalens design as described in ref. [1]. a) Overview of an ~100µm diameter metalens. b) zoom in a; c) zoom in b.

References

1. Mohammadreza Khorasaninejad, Federico Capasso et al., “Metalenses at visible wavelengths: Diffraction-limited focusing and subwavelength resolution imaging”, Science, Vol. 352, issue 6290, 1190–1194, 2016