Fraunhofer ENAS

Technologies

2.5D Patterning via i-Line Grayscale Exposure for Photonic Structures and Micro Lens Arrays

Fast Facts

- i-line grayscale lithography with NIKON NSR2205i11D
- Specialized positive tone resist ma-P 1215G & 1275G
- Grayscale reticles using half-toning technique
- Rapid 2.5D patterning for structures like:
  - Lenses
  - Frustums
  - Ramps
  - Fresnel lenses

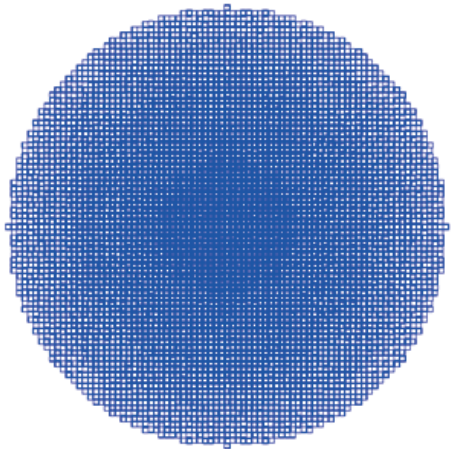

Figure 1: Typical GDS modulation for a convex lens.

Background

Patterning technologies for 2.5D structures such as micro lens arrays (MLAs), photonic integrated circuits (PICs) and MEMS are in high demand. Especially MLAs playing an important role for the integration of micro LED arrays. Also tuning the slope of the sidewalls of modern MEMS is a field of application. Those 2.5D structures can be achieved by using grayscale lithography, which can be done with maskless tools like electron beam (e-beam), or direct laser writing. These tools offer a high resolution, but the downside of these sequential exposure tools are low writing speeds, which hampers scalability to high volume. To overcome those limitations in writing speed and enable higher volume manufacturing, i-line stepper lithography can be used. For enabling grayscale lithography with i-line tools, specialized reticles and photoresists are necessary.

In cooperation with Micro Resist Technologies and Benchmark Technologies (USA) the Fraunhofer ENAS developed a grayscale process for i-line stepper lithography.

Each grayscale level is modulated using a half-toning technique by filling pixelated sub resolution features to adjust the exposure dose passing through the mask. By using this method, it is possible to create different grayscale levels on the reticle instead of using common binary masks with 0 % or 100 % of transmittance. Figure 1 shows a typical GDS modulation for a convex lens using this technique. The reticle for this project was fabricated in a commercial mask shop using a vector shaped e-beam system.

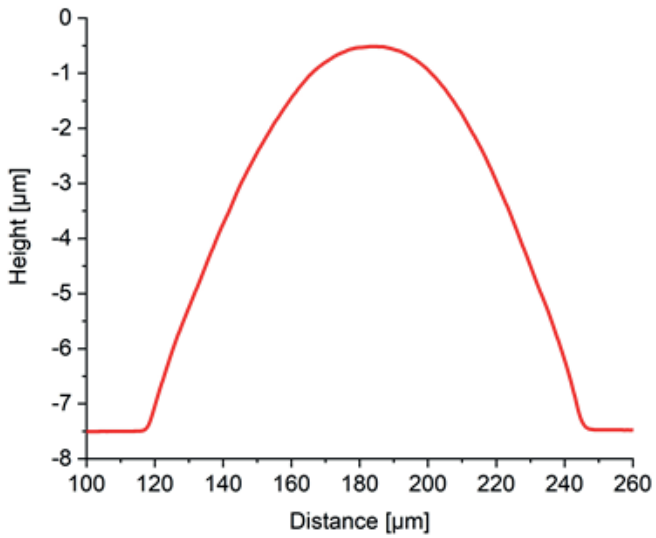

Figure 2: Profilometer measurement of a convex lens with a radius of 64 µm (1903 grayscale level) in 8 µm thick ma-P 1275G resist. Exposure Dose 380 mJ/cm2, Focus 0 µm.

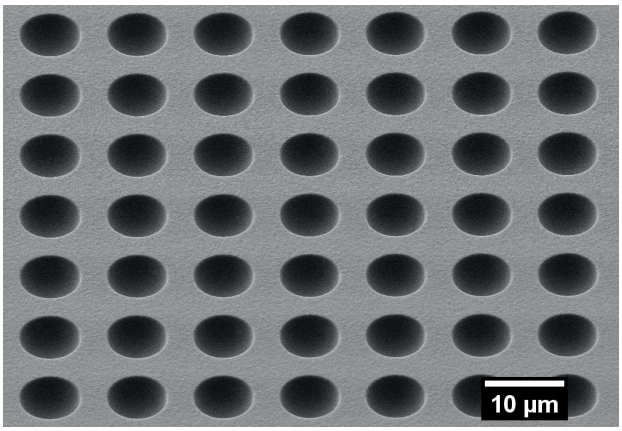

Figure 3: Lens array of concave lenses with a radius of 2.4 µm in 8 µm thick ma-P 1275G resist.

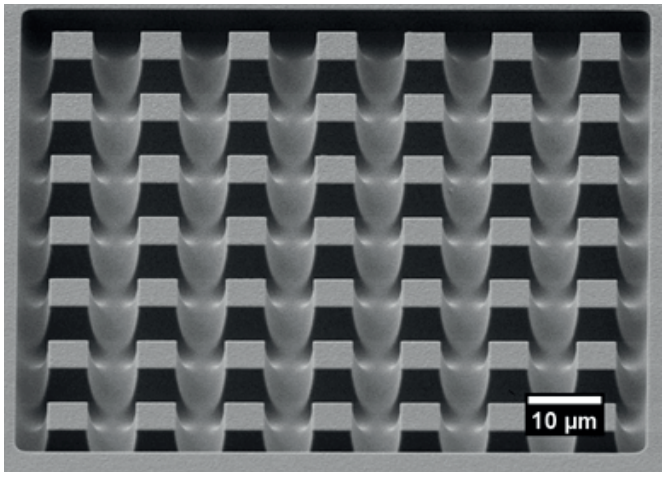

Figure 4: SEM Image of frustums in 8 µm ma-P 1275G

Advantages of i-line Grayscale Lithography

- Makes use of established i-line tool
  - No new tools are needed
- Fast writing speed compared to maskless tools
  - Good scalability to high volume
- Useable for all kind of 2.5D structures like:
  - Micro Lens Arrays
  - MEMS (tuning slope of sidewalls)
  - Micro-Fluidics

In cooperation with

ZfM Zentrum für Mikrotechnologien

Technische Universität Chemnitz

Benchmark Technologies

micro resist technology

Fraunhofer ENAS is part of

Forschungsfabrik Mikroelektronik Deutschland

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Photo acknowledgments: Fraunhofer ENAS