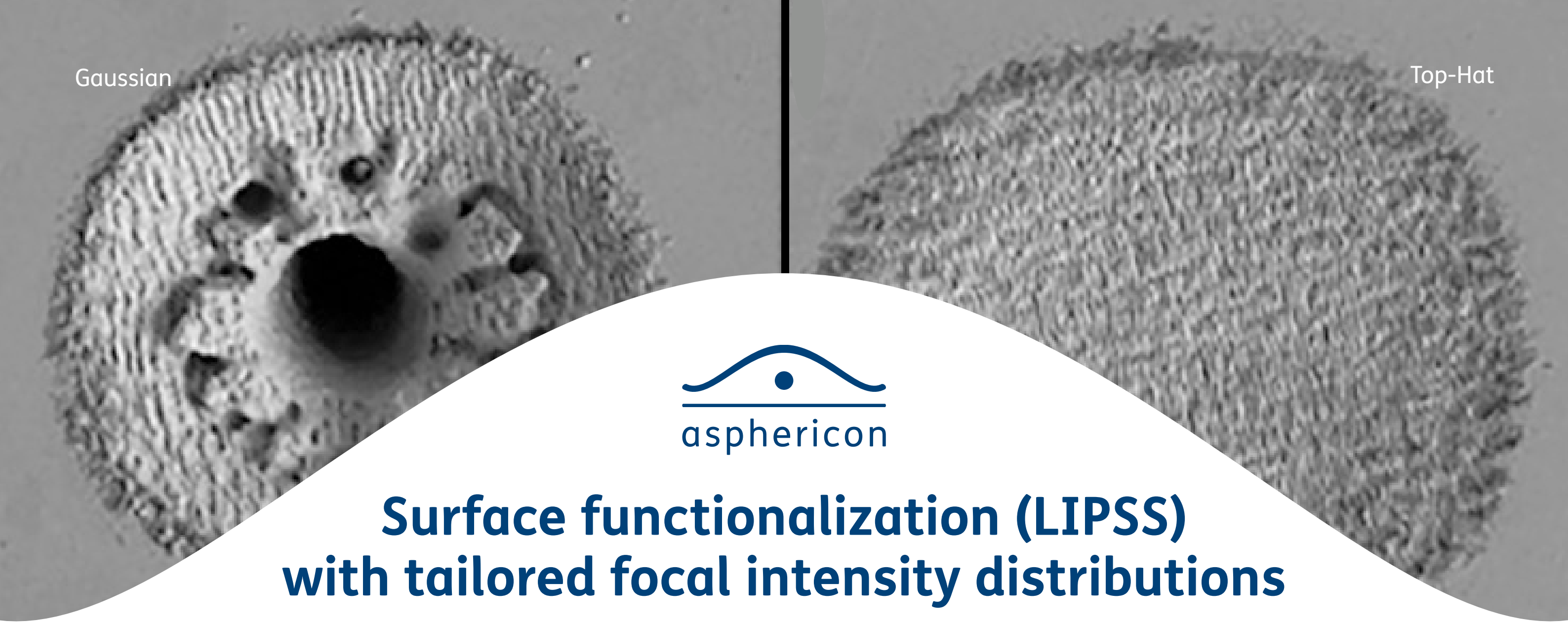


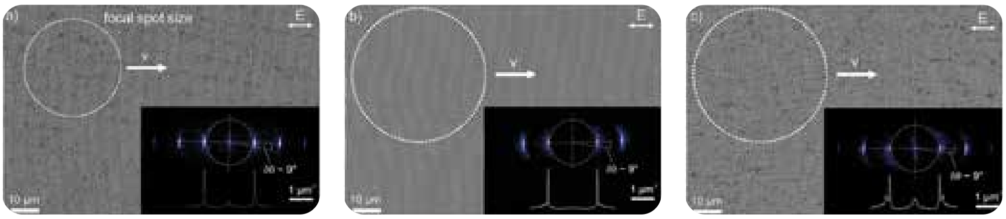
asphericon

Surface functionalization (LIPSS) with tailored focal intensity distributions

Project description: Although Gaussian intensity distributions can be used for direct surface functionalization, there are weaknesses regarding the quality. The intensity decreases at the edges of the beam and thus causes inhomogeneity. An adaptation of the focal intensity distribution offers great potential. The beam shaping component a|AiryShape ensures that several intensity distributions can be generated in different working planes with one set-up. In cooperation with Otto Schott Institute of Materials Research (OSIM) in Jena, asphericon analyzed various tailored intensity distributions (e.g. Top-Hat, Donut) with respect to their suitability for the generation of laser-induced periodic surface structures (LIPSS) on stainless steel.

Project realization: LIPSS are created by interference effects in the spot of the focused laser beam on the material surface. They are much smaller than those realized by direct material ablation and act as a grating while their period is close to the initial laser wavelength. Figure a shows an LIPSS pattern produced by unidirectional scanning of the surface between two adjacent scan lines and the Gaussian beam profile in the beam waist. The corresponding focal spot diameter $2w_f = 34$ µm is indicated by the circle in the SEM micrograph. It becomes evident that the generated grating like structures consist of highly regular LIPSS oriented perpendicular to the linear polarization. The micrograph reveals that LIPSS can be coherently written over a large area despite the line wise scanning process. The properties of the grating with respect to the spatial period, orientation, and homogeneity can be quantitatively described by 2D-FT of the SEM micrograph. The Top-Hat profiles (Fig. b and c) were generated with the a|AiryShape. The SEM micrograph in Fig. c demonstrates that the scanning velocity can be doubled without further optimization of the processing parameters. The calculated Fourier transformation shows that the quality of the surface pattern remained almost constant, while reducing the processing time by a factor of 2 (approx. 30 s per cm^2), resulting in a significant advantage for the economic scaling of the structuring process to large surface areas.

Scanning electron micrographs (SEM) of stainless-steel surface structured with LIPSS



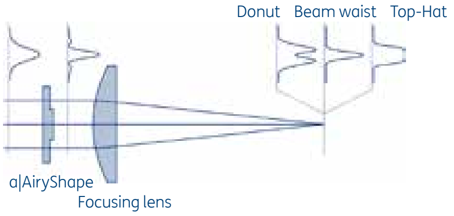
Gaussian profile
$2w_f \sim 34$µm, $E_{imp} = 2.6$ µJ, v = 0.67 m/s, Δx = 6µm

Top-Hat profile
$2w_f \sim 47$µm, $E_{imp} = 6$ µJ, v = 0.67 m/s, Δx = 6µm

Top-Hat profile
$2w_f \sim 47$µm, $E_{imp} = 6$ µJ, v = 1.2 m/s, and Δx = 6µm

- Respective focal spot beam diameter illustrated by white circles & direction by white arrow
- Insets correspond to 2D-FT of SEM micrographs and corresponding cross sections, which quantify homogeneity and orientation of LIPSS

Principle layout of a|AiryShape



Consisting of phase plate and focusing lens, with correlated intensity distributions in the focal region

Stainless steel sample

- Structural colors on a stainless steel sample of (10 × 10) mm^2 obtained from white light illumination
- Structured with a Top-Hat focal intensity distribution

A. Möhl, S. Kaldun, C. Kunz, F. A. Müller, U. Fuchs, St. Gräf: „Tailored focal beam shaping and its application in laser material processing“, In: Journal of Laser Applications, Volume 31, Issue 4, Nov 14 2019, https://doi.org/10.2351/1.5123051

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