Midel | YOUR SOLUTION
Photonics | PROVIDER FOR
BEAM SHAPING

3D-TOP-HAT BEAM SHAPERS

STABLE TOP-HATS FOR REAL INDUSTRIAL
PRODUCTION CONDITIONS.

Also available from our Partners

Edmund optics | worldwide   **CourierTronics** measurement. optics. imaging.   AYIN Technology Ultimate Laser Solutions

Beam Shaper

New 3D-Top-Hat	Existing Shapers

2x Rayleigh Length (DOF)

nOK
OK
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In laser micro-machining applications like **precision marking, laser lift-off, precision drilling, fine cutting, or surface structuring**, shaping Gaussian laser beams to **smallest Top-Hat** profiles creates significant benefits in quality or speed. **Yet in production their stability is often limited**. Tight process windows and high sensitivity to focus position make robust operation challenging.

3D-Top-Hat Beam Shapers are designed to extend the usable working range and support more stable top-hat processes under real industrial conditions.
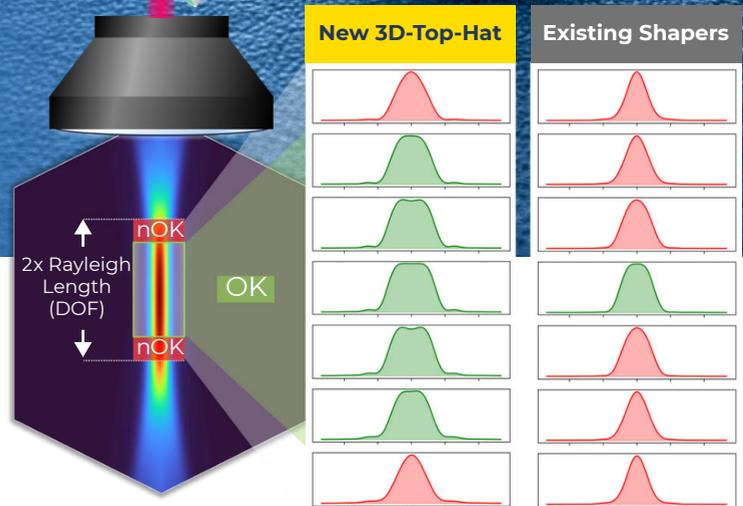
INDUSTRIAL CHALLENGE

Top-Hat beams are typically stable only very close to the focus position.

In industrial environments this leads to:

- tight alignment tolerances
- frequent re-adjustment
- limited process windows
- reduced yield stability and rejects

Result:
Higher scrap rates, longer setup times and increased cost per part.

OUR APPROACH

3D-Top-Hat Beam Shapers address this challenge by **engineering the depth of field** of the top-hat profile.
Instead of changing the principle of Top-Hat shaping, we focus on making it **more robust for 24/7 production use.**

BENEFITS

Up to 5x larger usable process window
→ less downtime, less rework

Lower sensitivity to focus shifts and alignment
→ stable results across shifts and machines

Consistent energy distribution for smallest spot sizes → higher process quality and yield

Designed for industrial laser systems
→ not only for ideal lab setups
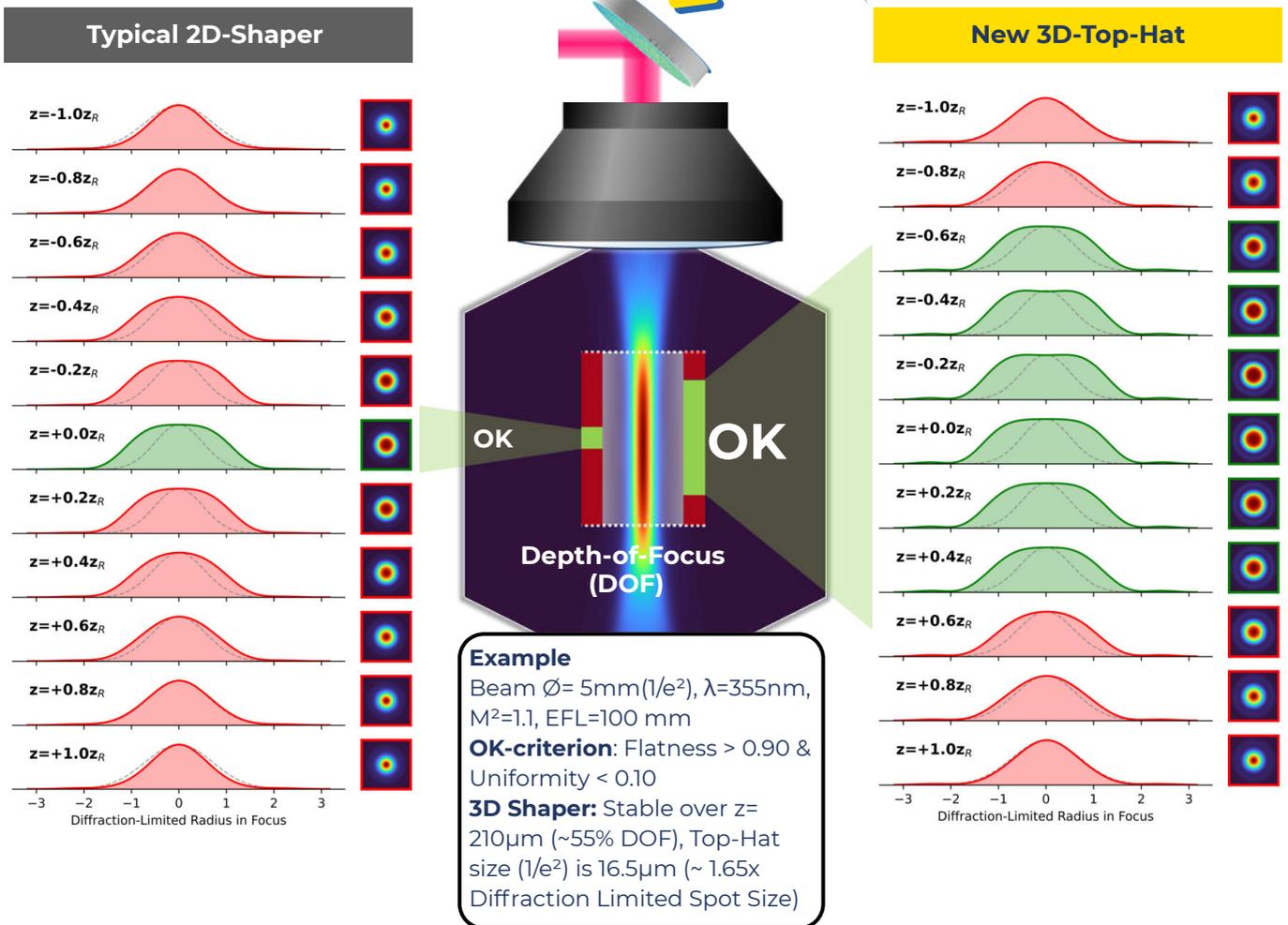
IS THIS THE RIGHT BEAM SHAPER FOR YOU?

3D-Top-Hat Beam Shapers are made for you if:
- Your top-hat is stable in the lab - but not in production
- Your process is sensitive to focus position
- You need reproducible results across shifts and machines
- You work with small spot sizes and tight tolerances

Then it is time for depth-of-field engineered Top-Hat shaping.

DEPTH-OF-FIELD ENGINEERED TOP-HAT SHAPING

Conventional Top-Hat solutions shape the beam mainly in the focus plane. In production, however, process stability depends on behavior across depth of field. 3D-Top-Hat Beam Shapers are designed to keep the top-hat stable over a defined axial range - extending the usable working range under realistic system conditions.

Typical 2D-Shaper

z=-1.0z_R
z=-0.8z_R
z=-0.6z_R
z=-0.4z_R
z=-0.2z_R
z=+0.0z_R
z=+0.2z_R
z=+0.4z_R
z=+0.6z_R
z=+0.8z_R
z=+1.0z_R

Diffraction-Limited Radius in Focus

New 3D-Top-Hat

z=-1.0z_R
z=-0.8z_R
z=-0.6z_R
z=-0.4z_R
z=-0.2z_R
z=+0.0z_R
z=+0.2z_R
z=+0.4z_R
z=+0.6z_R
z=+0.8z_R
z=+1.0z_R

Diffraction-Limited Radius in Focus

OK

OK

Depth-of-Focus (DOF)

Example
Beam Ø= 5mm(1/e^2), λ=355nm, M^2=1.1, EFL=100 mm
OK-criterion: Flatness > 0.90 & Uniformity < 0.10
3D Shaper: Stable over z= 210μm (~55% DOF), Top-Hat size (1/e^2) is 16.5μm (~ 1.65x Diffraction Limited Spot Size)

PERFORMANCE

- **Usable DOF:** stable top-hat across ±60 % $z_{Rayleigh}$
- **Flatness**: > 0.9 across usable DOF
- **Plateau uniformity**: < 0.1 across usable DOF
- **Beam shaping efficiency**: > 82 %
- **Side lobes**: < 5 % of $I_{Tophat-Plateau}$
- **Reflectivity**: > 99.9 % (Dielectric-HR-coating)

(values refer to aberration-free optical systems, M^2 = 1.0, System aberrations and beam quality may influence the achieved results)

FOR INDUSTRIAL CONDITIONS

3D-Top-Hat Beam Shapers are made for real industrial laser systems.

- **Input beam**: M^2 ≤ 1.3, TEM_{00}, CW to ultrashort pulses down to 300 fs
- **Optical design**: Continuous DOE based on micro-structured mirror (All reflective approach, dielectric HR coating)
- **Made for Power** → See specs on our website
- **Dimensions**: Ø 25.0 mm x 6.35 mm

WHAT YOU GAIN IN PRACTICE

- Larger usable process window compared to conventional Top-Hat solutions
- Lower sensitivity to small focus shifts and alignment tolerances
- More consistent energy distribution in smallest spot applications
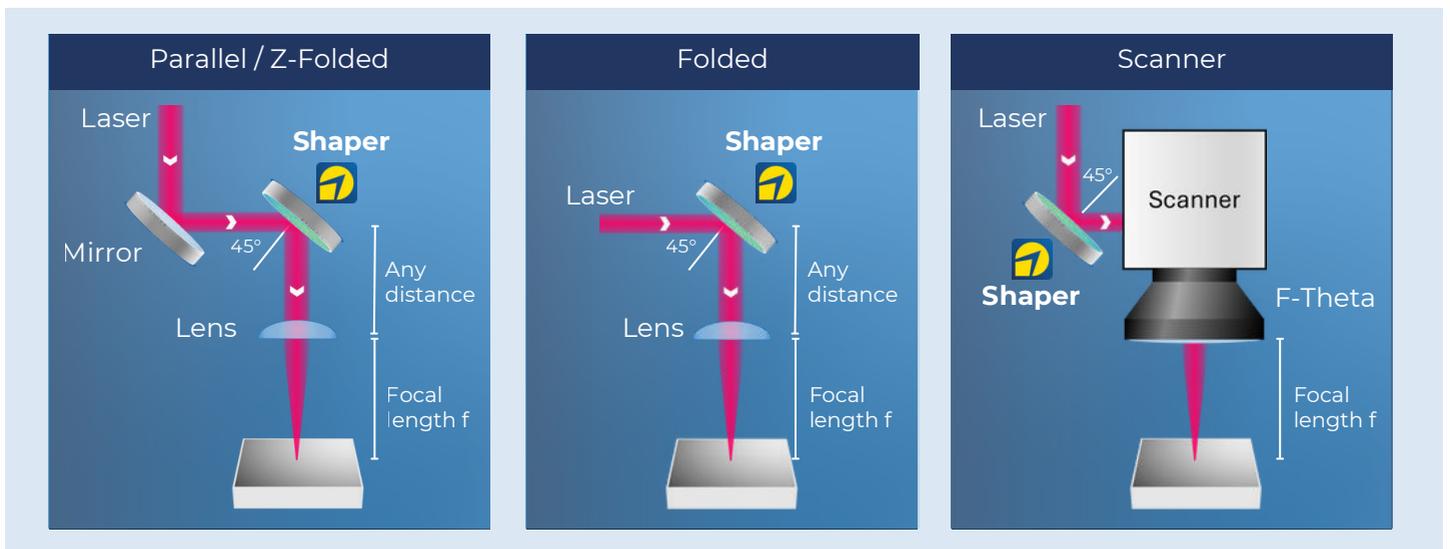- Higher confidence when scaling from pilot to series production
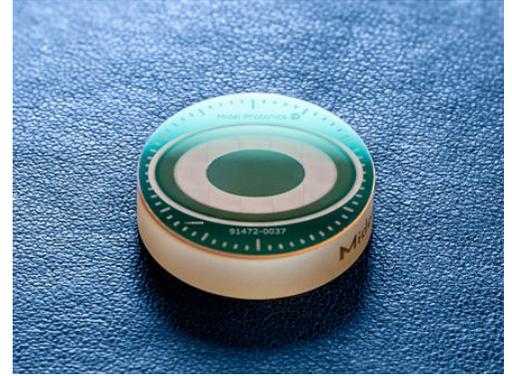
WHERE STABLE TOP-HATS MATTER

Stable Top-Hat profiles are especially critical in applications that require uniform energy delivery, small spot sizes and challenging tight process windows.

3D-Top-Hat Beam Shapers are typically used in the following scenarios:

Application	Usecase	Key Industries
High-Quality (Black) Marking	Deep, uniform contrast; no hot spots → premium quality	Consumer electronics, Automotive
Laser Lift-Off (LLO)	Controlled delamination; homogeneous energy delivery	Displays (OLED, µLED, flexible)
Precision Drilling	Minimal taper; minimal heat-affected zone	PCB, Semiconductor packaging, TGV, Glass
Surface Microstructuring	Repeatable textures; functionalized surfaces	Medical devices, Automotive, PV
Fine Cutting	Smooth edges; minimal recast/burr	Wafer Dicing, Medical Tech, Displays

INTEGRATION OPTIONS

TOP-HAT PARAMETERS

Output Shape	Round Top-Hat (Gaussian to Top-Hat Conversion)			
Shaped Beam Diameter (x Diffraction Limit of Unshaped Beam)	For M^2=1.0 1.8 x DL (1/e²)	M^2=1.1 1.7 x DL (1/e²)	M^2=1.2 1.6 x DL (1/e²)	M^2=1.3 1.5 x DL (1/e²)
Efficiency	≥ 85% (Encircled energy (1/e⁴)/ Total Energy)			
Top-Hat Quality	Plateau Uniformity ≤ 0.1 & Flatness ≥ 0.9 (ISO 13694)			
Strongest Side Order	Intensity ≤ 5% (Relative to Top-Hat Plateau)			
Stable z-Region (x Rayleigh Length of Unshaped Beam)	For M^2=1.0 1.2 x z_{RL}	M^2=1.1 1.0 x z_{RL}	M^2=1.2 0.6 x z_{RL}	M^2=1.3 0.3 x z_{RL}

INPUT BEAM REQUIREMENTS

Input Beam	Gaussian, TEM$_{00}$, M² ≤ 1.3, CW to ultrashort pulses down to 300 fs
Input Beam Diameter (1/e²)	Available for 2.5mm | 5.0mm | 8.0mm
Wavelengths	Available for 1030-1064nm | 515-532nm | 343-355 nm
System Requirements	Clear aperture ≥2x beam diameter (1/e²), Integrate into collimated beam with a focusing lens. Lateral alignment required
Angle of Incidence	45.0°

ELEMENT PARAMETERS

Element	Micro-structured Mirror (Continuous Reflective DOE)
Coating	>99.9% at 45.0° Dielectric HR Coating on flat fused silica substrate
Dimensions	Diameter: Ø25.0mm (+0.0mm -0.1mm) Thickness: 6.35mm (+- 0.10mm)

Performance values are specified for a TEM$_{00}$ Gaussian input with diffraction-limited wavefront quality at the DOE plane (λ/10 RMS or better) and sufficient clear aperture.

FIND YOUR CONFIGURATION AND GET STARTED
Use our online tool to check performance for your laser parameters

https://midel-photonics.de/3d-top-hat-tool

ABOUT MIDEL PHOTONICS

Founded in 2022, Midel Photonics GmbH is revolutionizing the photonic industry through innovative beam shaping. Our award-winning high-tech company sets new standards for precision and efficiency. With over 100 individually developed optical solutions, our team of experienced specialists provides customers with decisive competitive advantages.

Midel Photonics GmbH
Maarstr. 96, 53227 Bonn, Germany
www.midel-photonics.de
Phone: +49 228 28679710

Laser Beam Shaper