



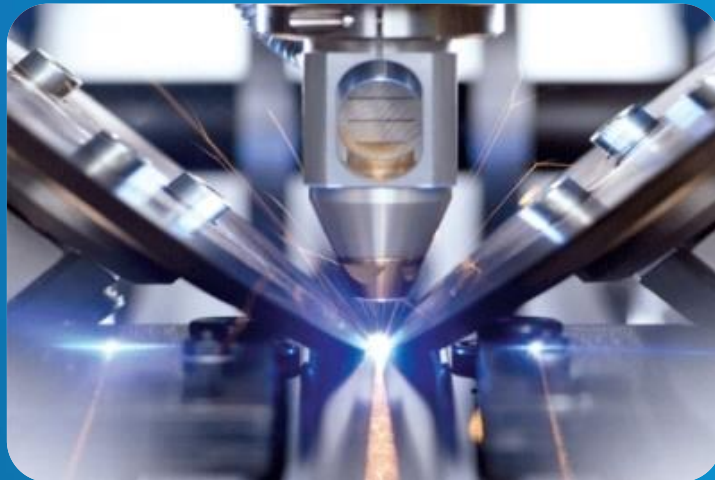
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# Laser beam shaping for material micro-processing

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EPIC, Vilnius

2024





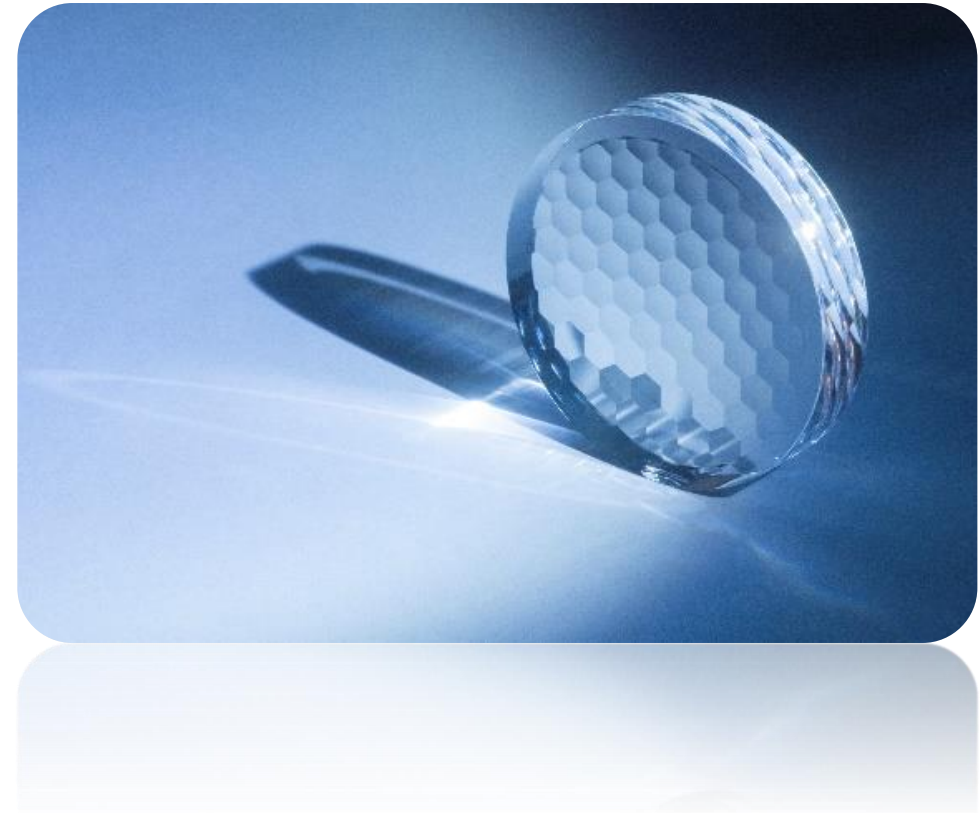
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# Refractive monolithic beamshapers for lasers

- **Efficient**
- **Compact**
- **Passive**
- **Lightweight**
- **SM and MM options**

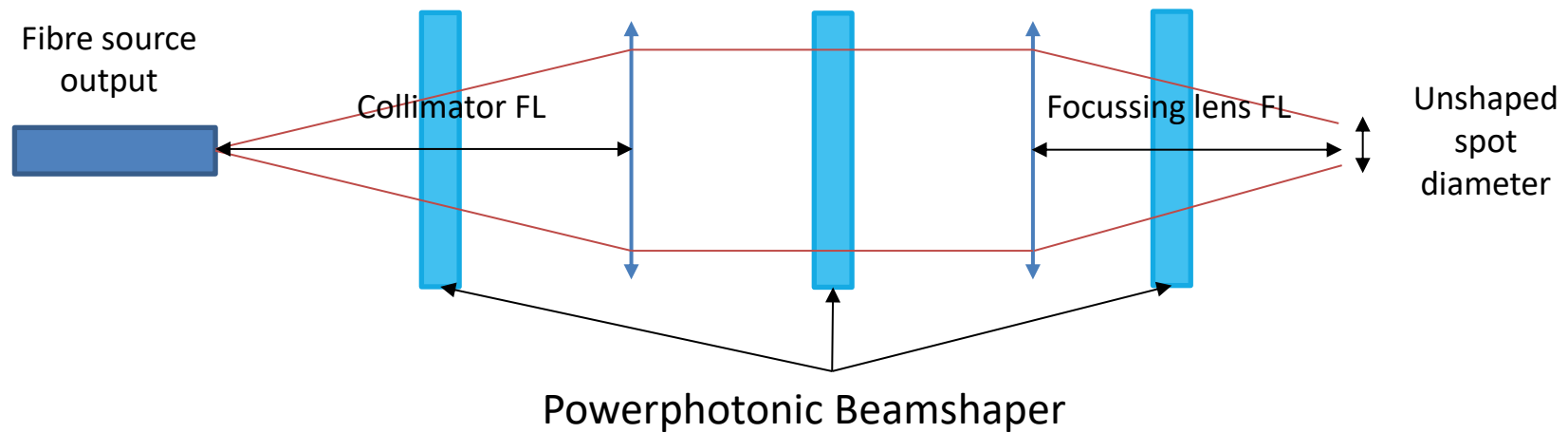
**PowerPhotonic** optics are also

- **Freeform**
- **High transmission efficiency**
- **Designed for easy addition to existing assemblies**





# Optic placement options

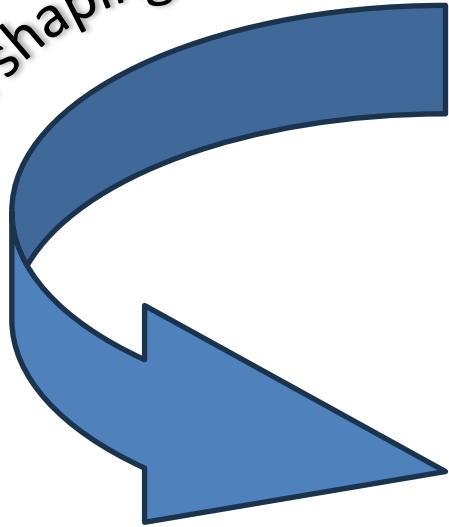




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# Our *freeform* optics manufacturing process

...Freeform  
beam shaping

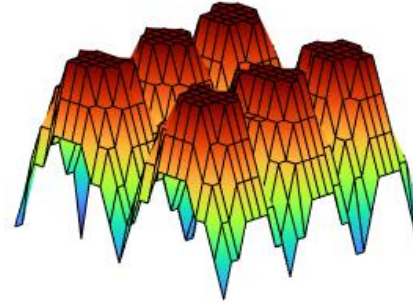


For example...

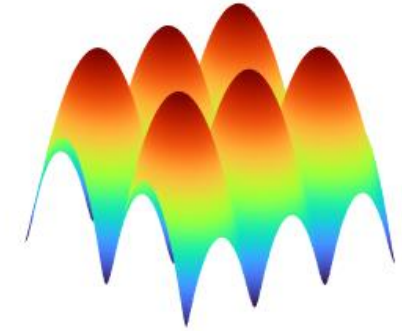
Pre-processing



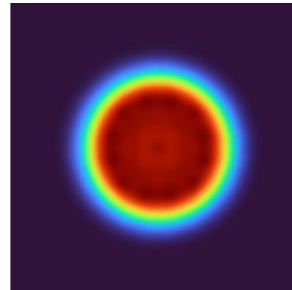
Ablate net shape (point-by-point)



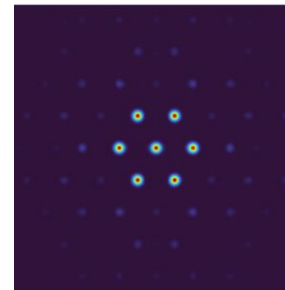
Re-flow surface



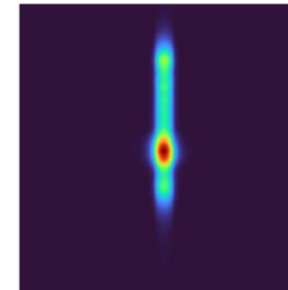
Flat top



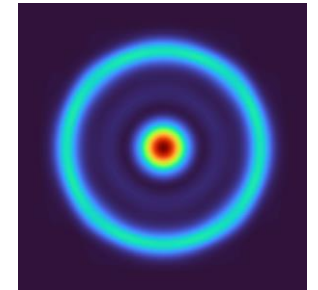
Multi spot



Tail shape

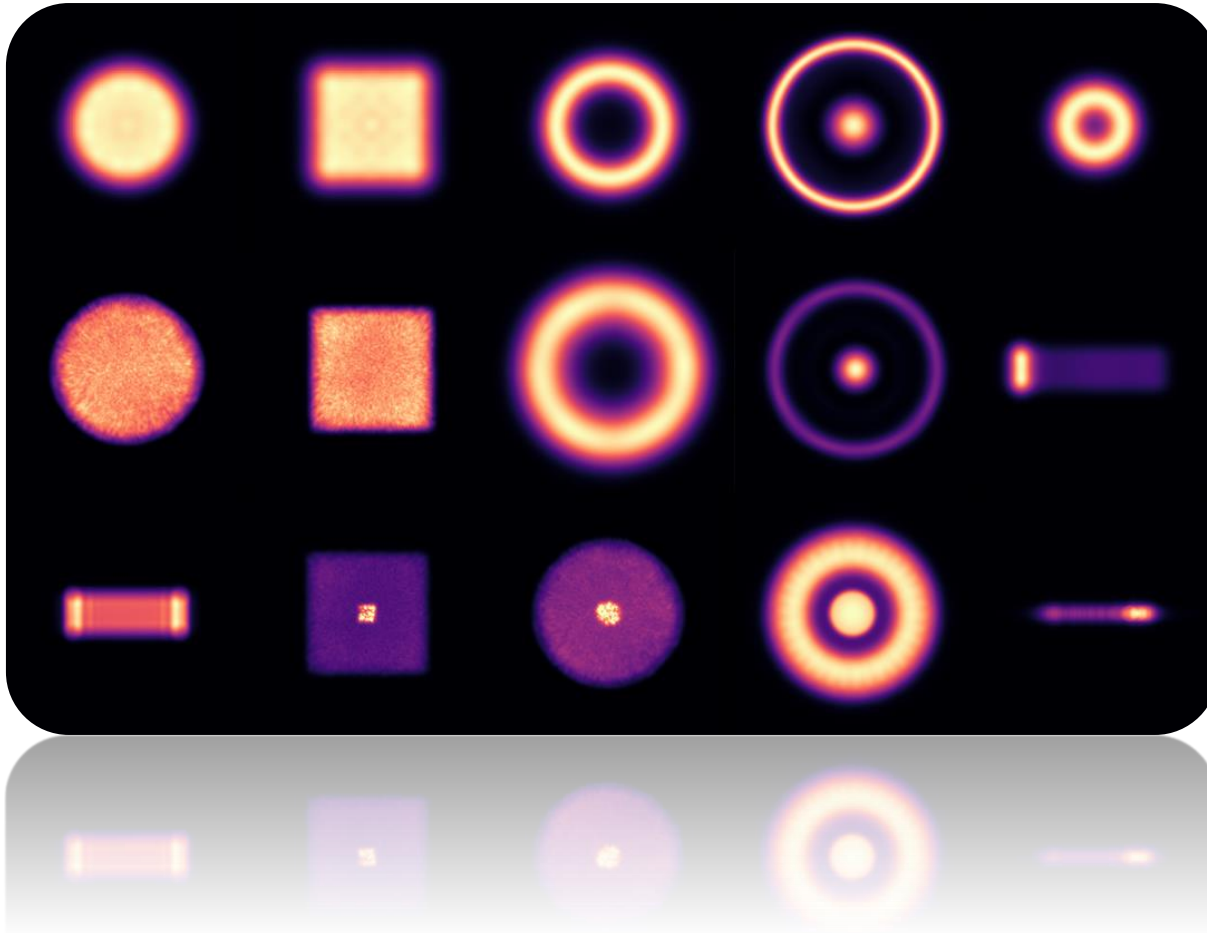


Core & ring





# Why do we need beam shaping?

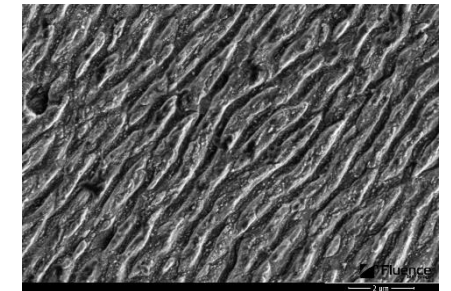
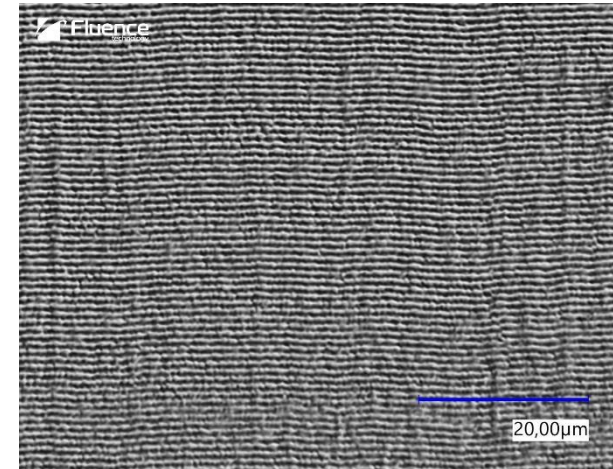
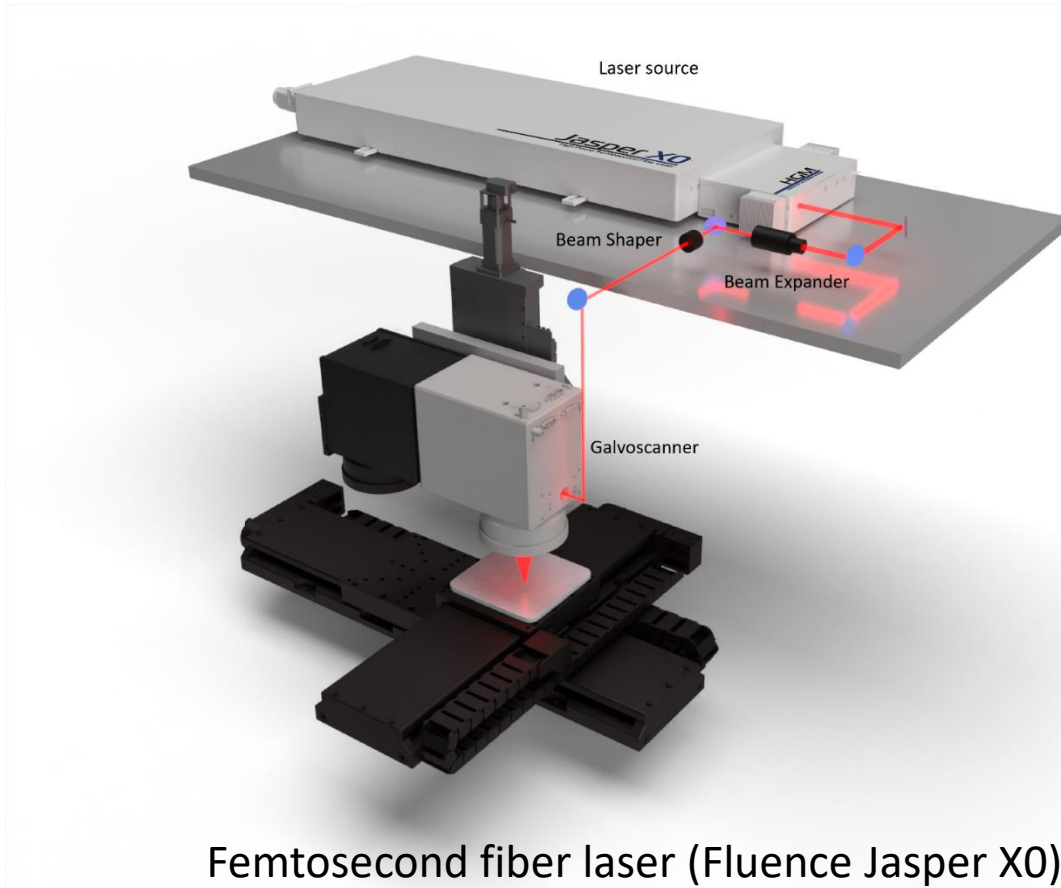


- **Efficiency is everything**
- **Photon conservation**
  - Right number
  - Right place
  - Right time



# Application 1: surface patterning with LIPSS

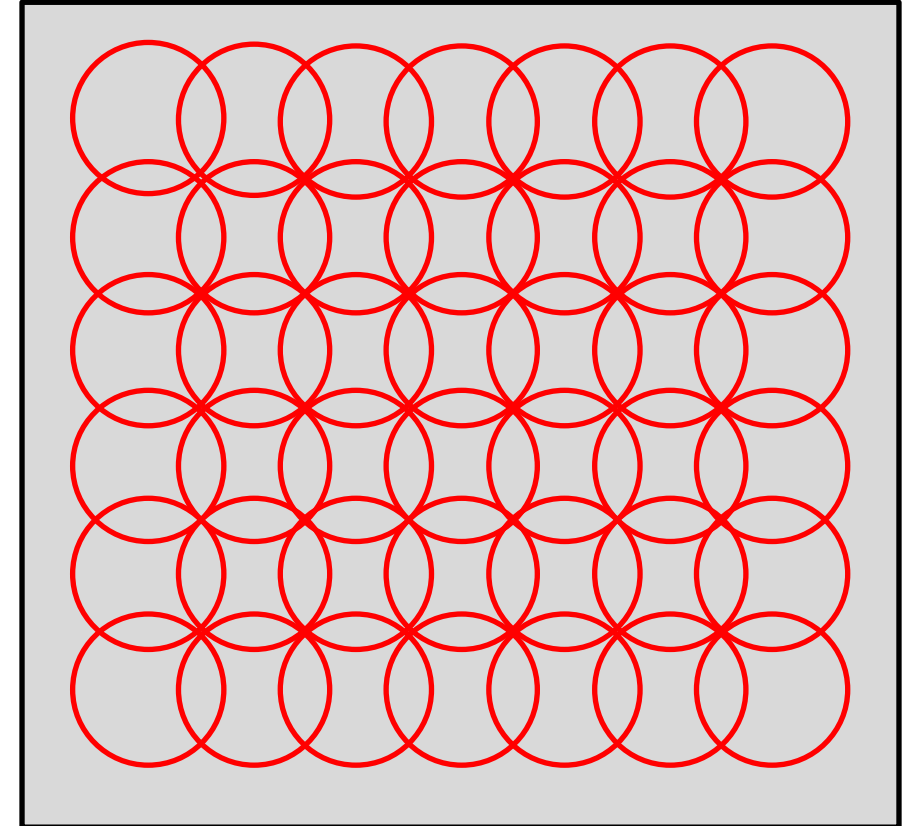
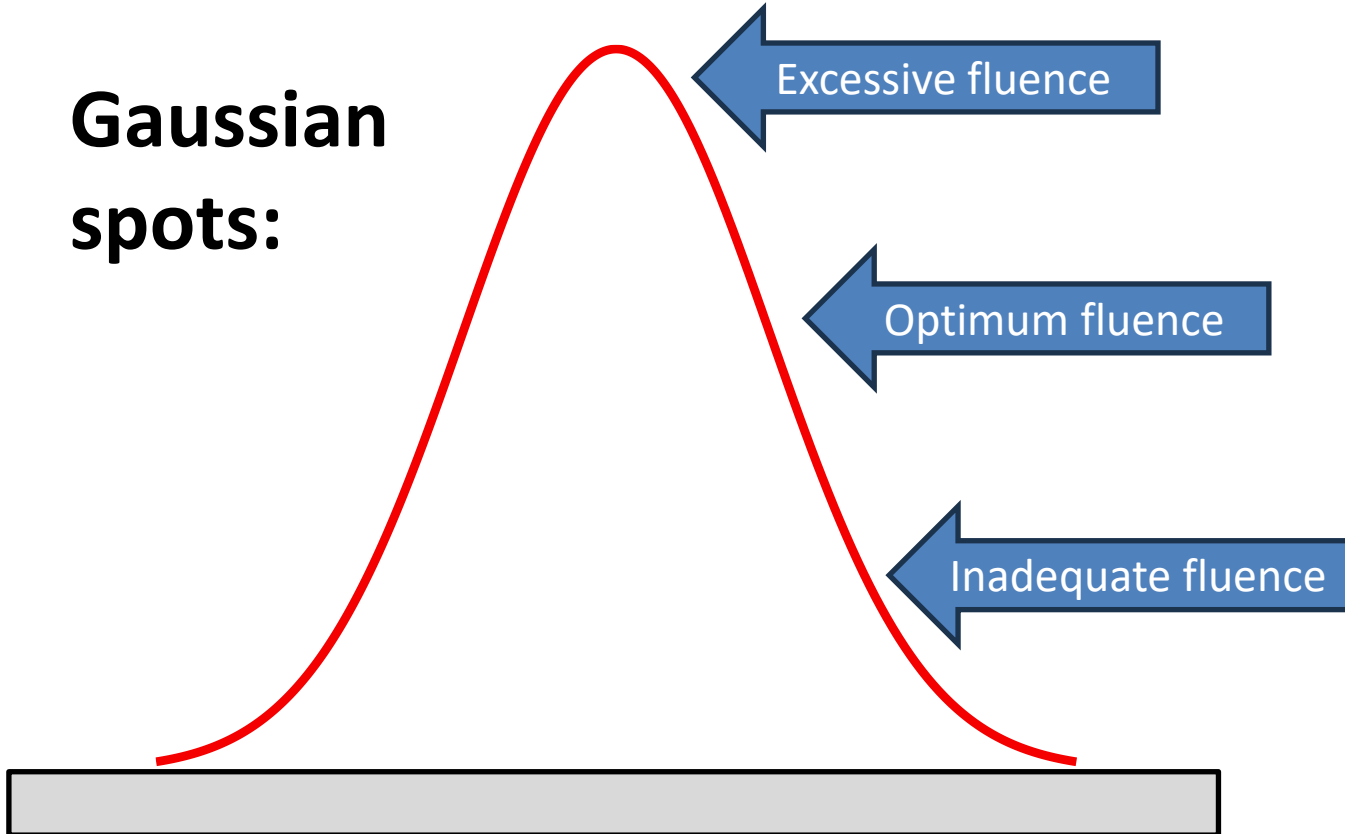
- We partnered with Fluence to trial a flat top beam shaper for LIPSS (laser induced periodic surface structures)





# Application 1: surface patterning with LIPSS

**Gaussian spots:**



1. **Inefficient**
2. **Non-uniform**

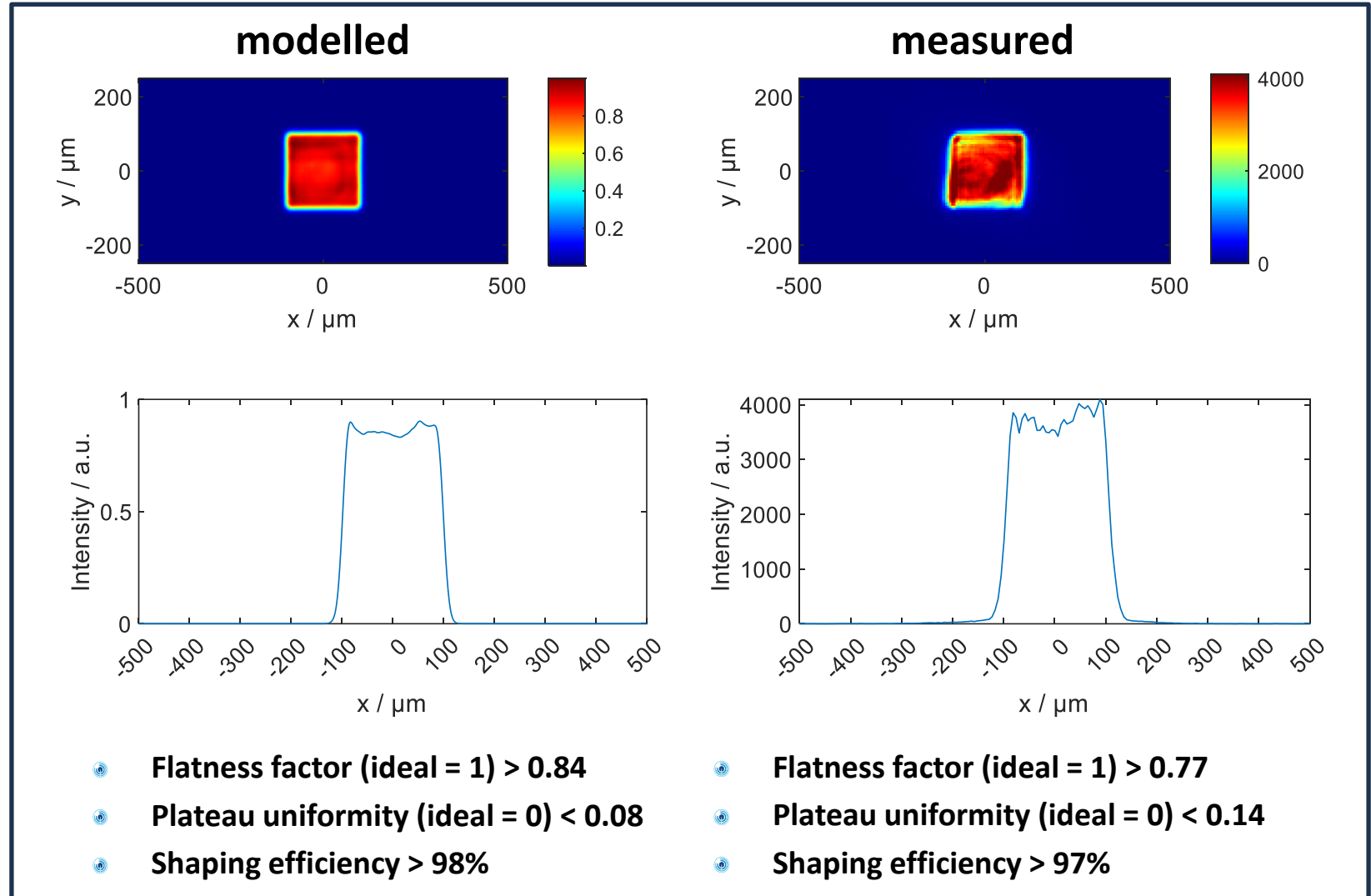


# Application 1: LIPSS – with beam shaping

## Parameters

- Beam shapes designed to attain  $> 0.2 \text{ J/cm}^2$  with  $100 \mu\text{J}$  pulses
- $\lambda$ : 1030nm
- $M^2$ : 1.1
- $90 \mu\text{J}$  @ 200kHz
- 250fs
- $P_{\text{avg}}$ : 18W

**Line and rectangular shape variants are also available**



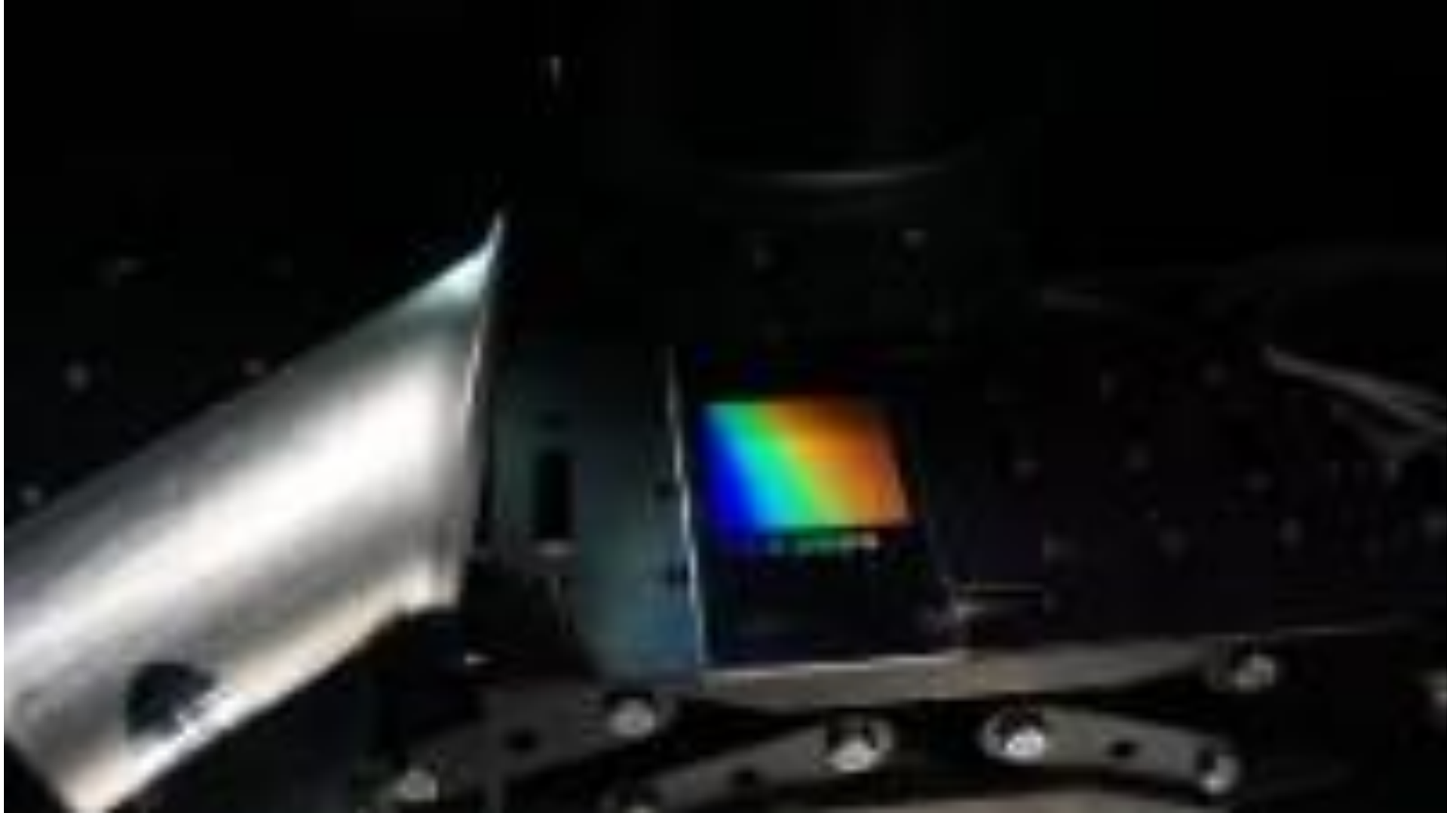




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# Application 1: LIPSS - Generation

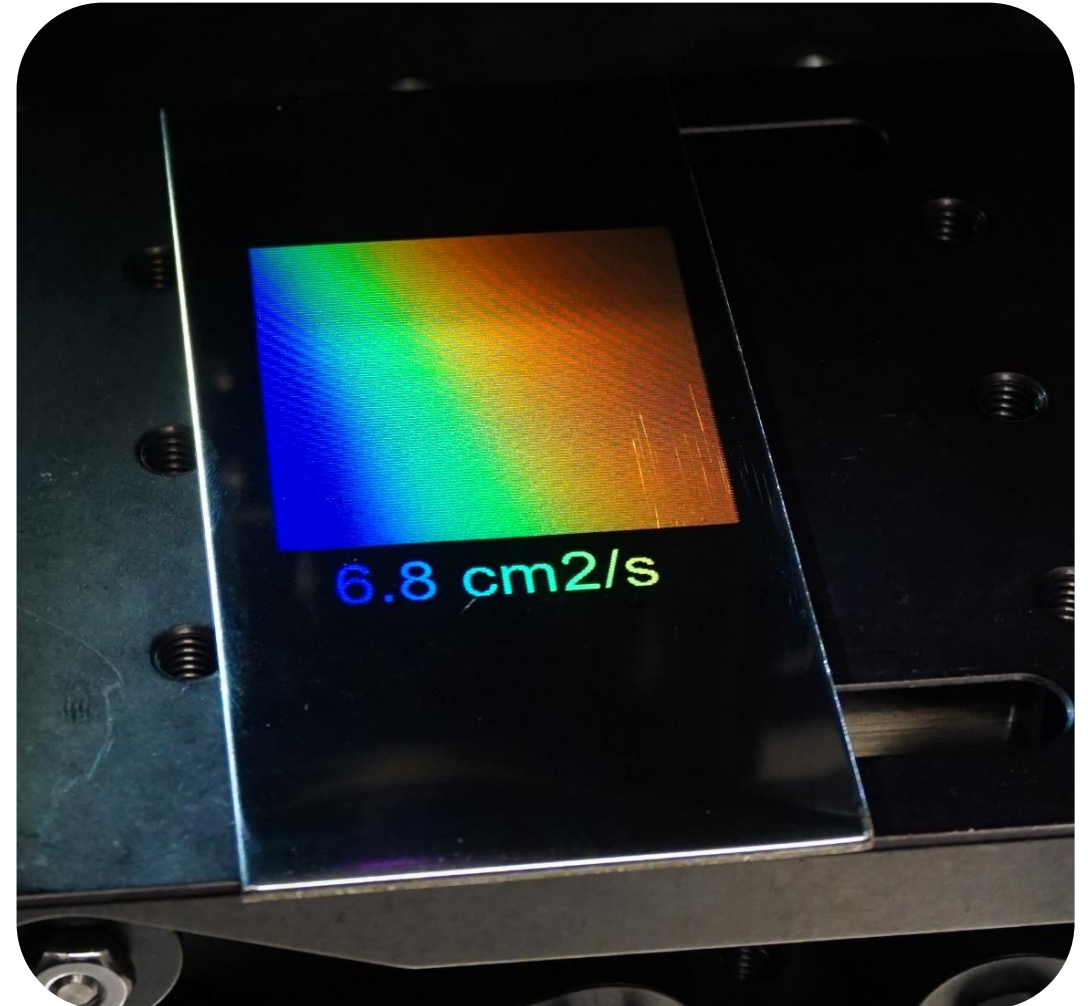
LIPSS over a  
40 x 40 mm  
area





# Application 1: LIPSS - Generation

- Square flat top beam shape
- LIPSS generated at a rate of 6.8 cm<sup>2</sup>/s at 18 W
- Efficiency of 0.38 cm<sup>2</sup>.s<sup>-1</sup>.W<sup>-1</sup> -> A4 sheet in < 1 minute at 30 W
- Optimised spot shape & low-loss shaping enables fast & efficient processing
- Shaper helps to utilize full available laser power at a reduced pulse repetition rate (reduced heat accumulation)
- Rectangular or line shapes enables a reduction of scanning speed at high repetition rates.

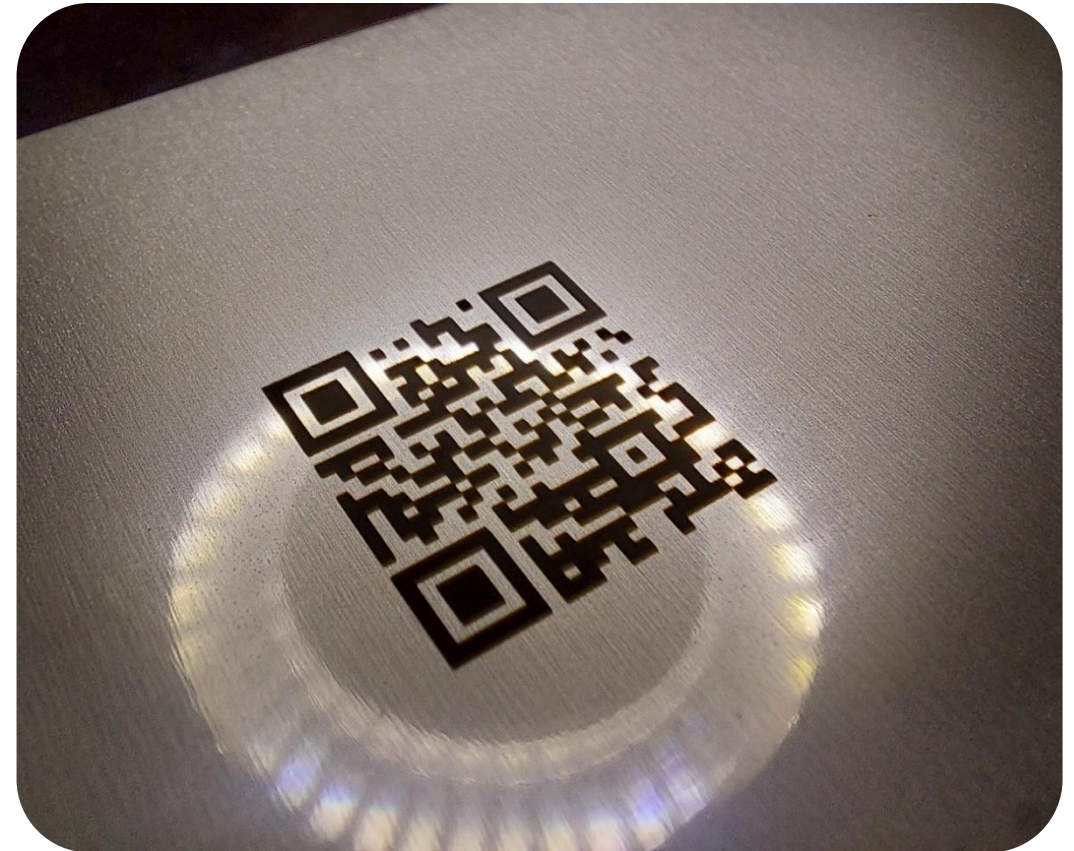
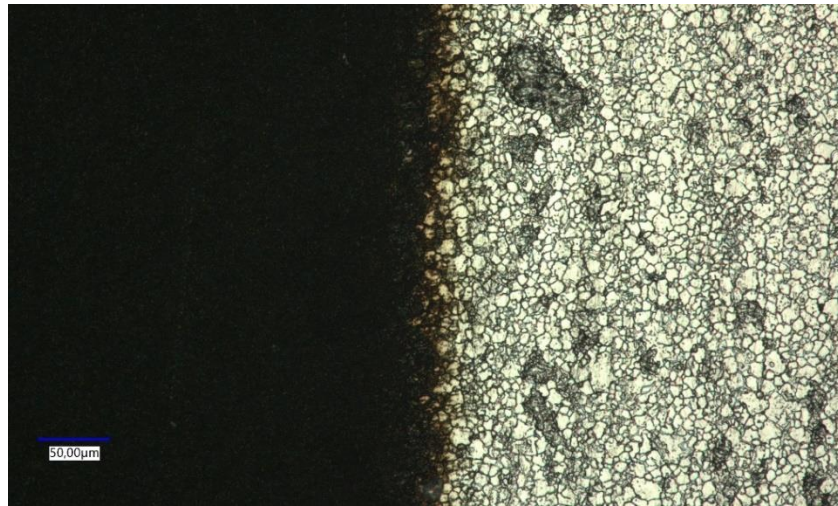




# Application 2: Black marking of stainless steel

	Processing speed (cm <sup>2</sup> /min)
Unshaped Gaussian spot	2.4
Flat top square	22.4

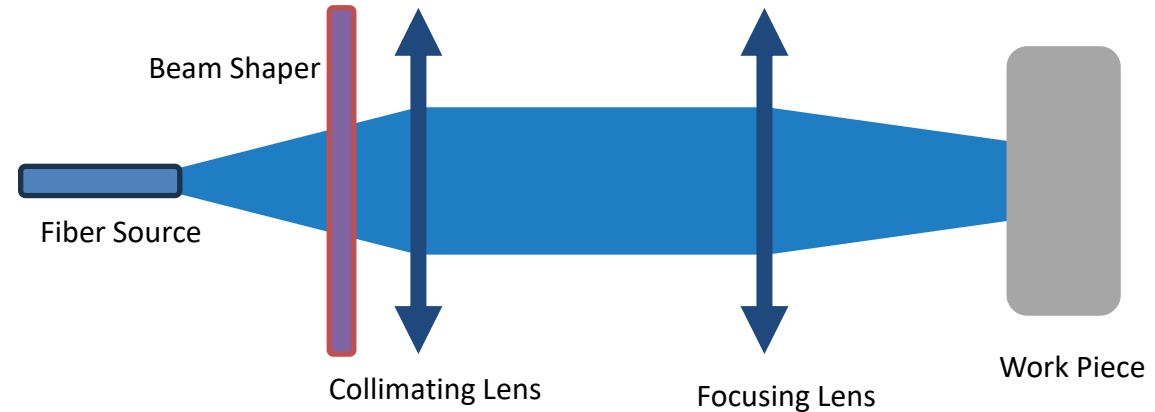
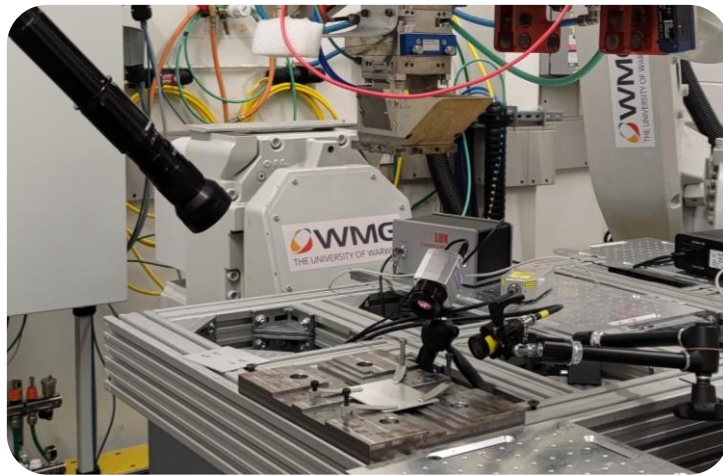
A square/rectangular beam shape is an ideal choice for right-angled corner marking





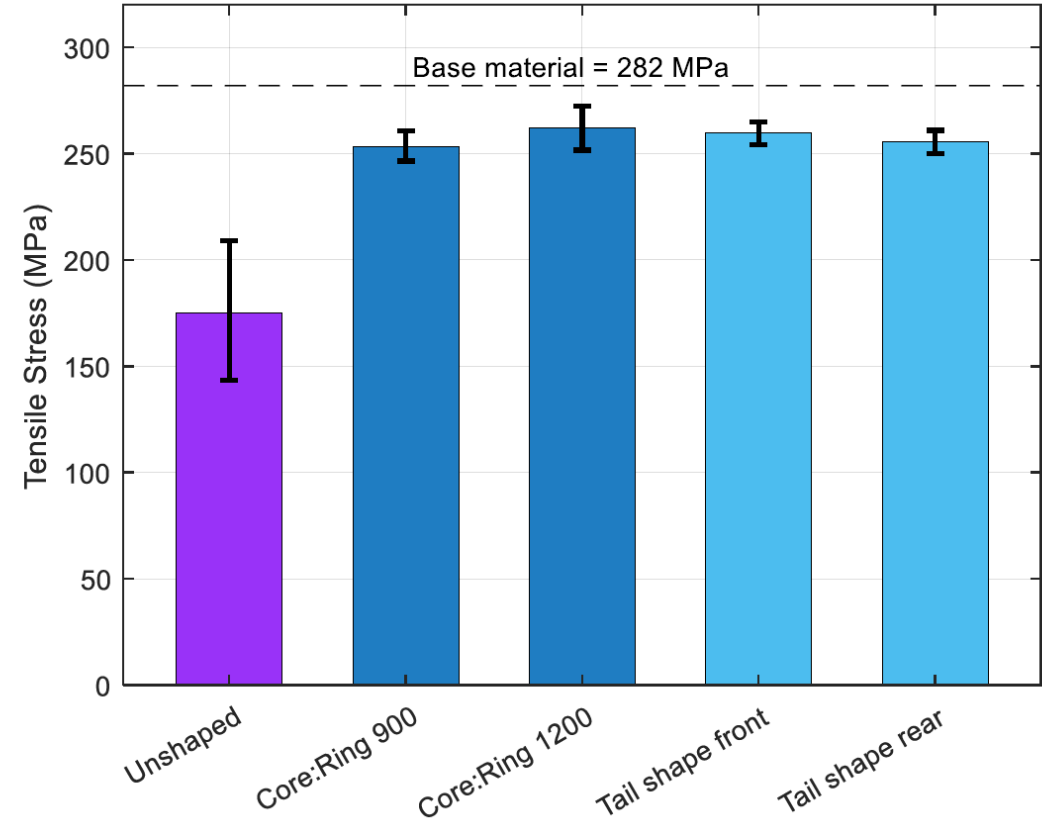
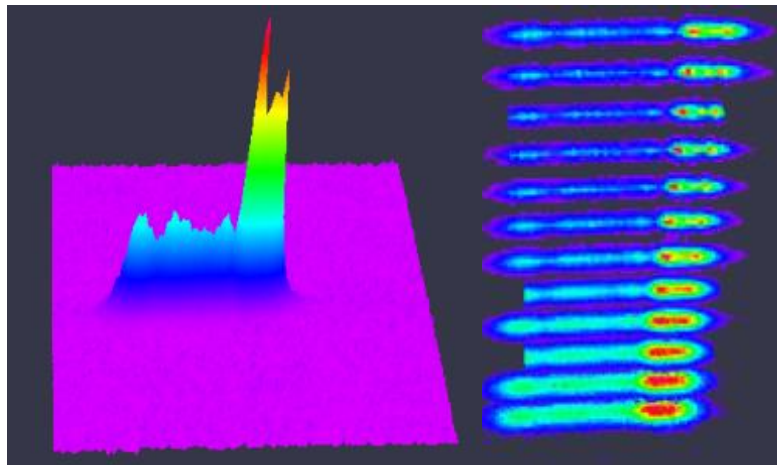
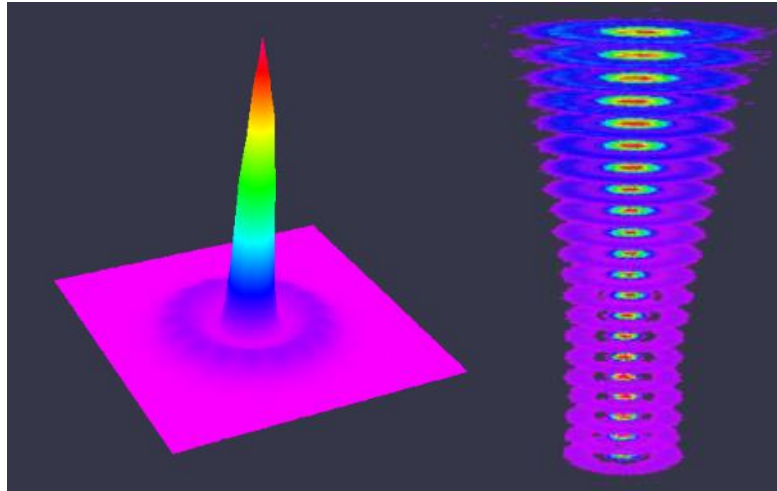
# Application 3: (macro) welding of Aluminium 6082

- Collaborating with WMG, we trialled ring and core beam shapers and tail shapers in comparison to the same setup with no beam shaping (MM system)
- Tensile stress improved in all 4 shaped beam trials
- Spatter was reduced
- Fewer cracks, particularly using a tail shaped beam





# Application 3: Welding of Aluminium 6082





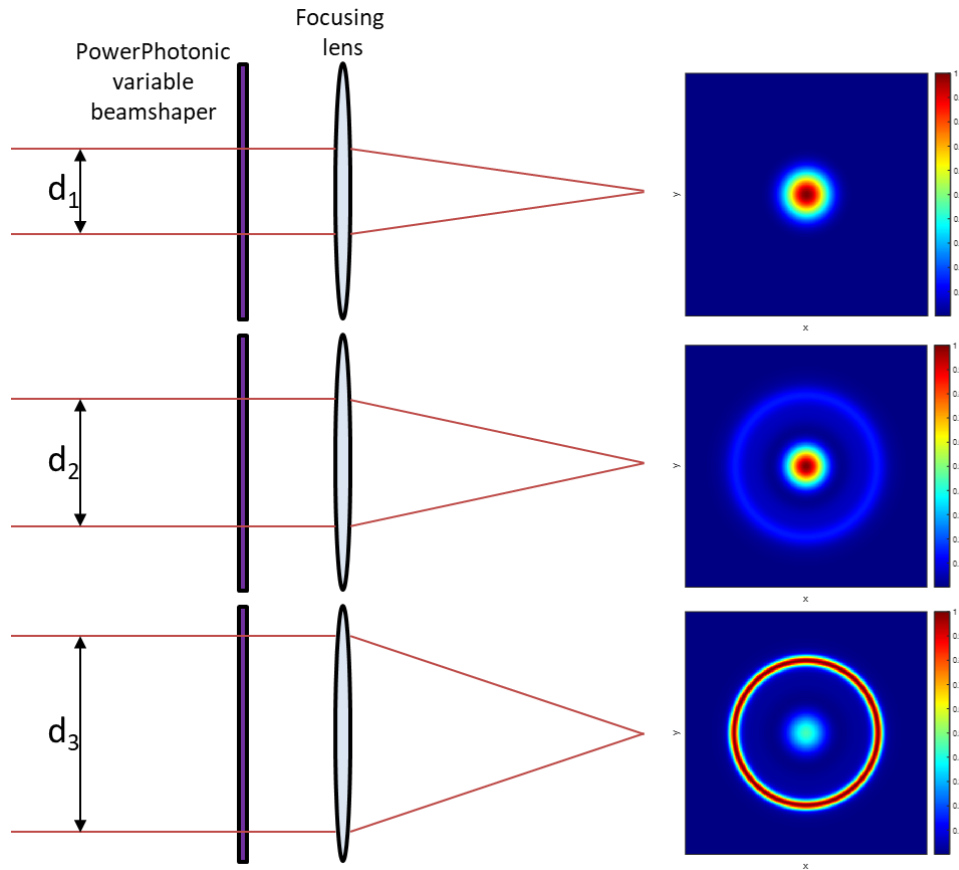
# Application 3: Welding of Aluminium 6082

- **Macro welding results with static beam shapes:**
  - Core and ring
  - Ring
  - Tail shapes
- **We have similar beam shapers for micro-welding applications**
  - Collaborative trials are welcomed

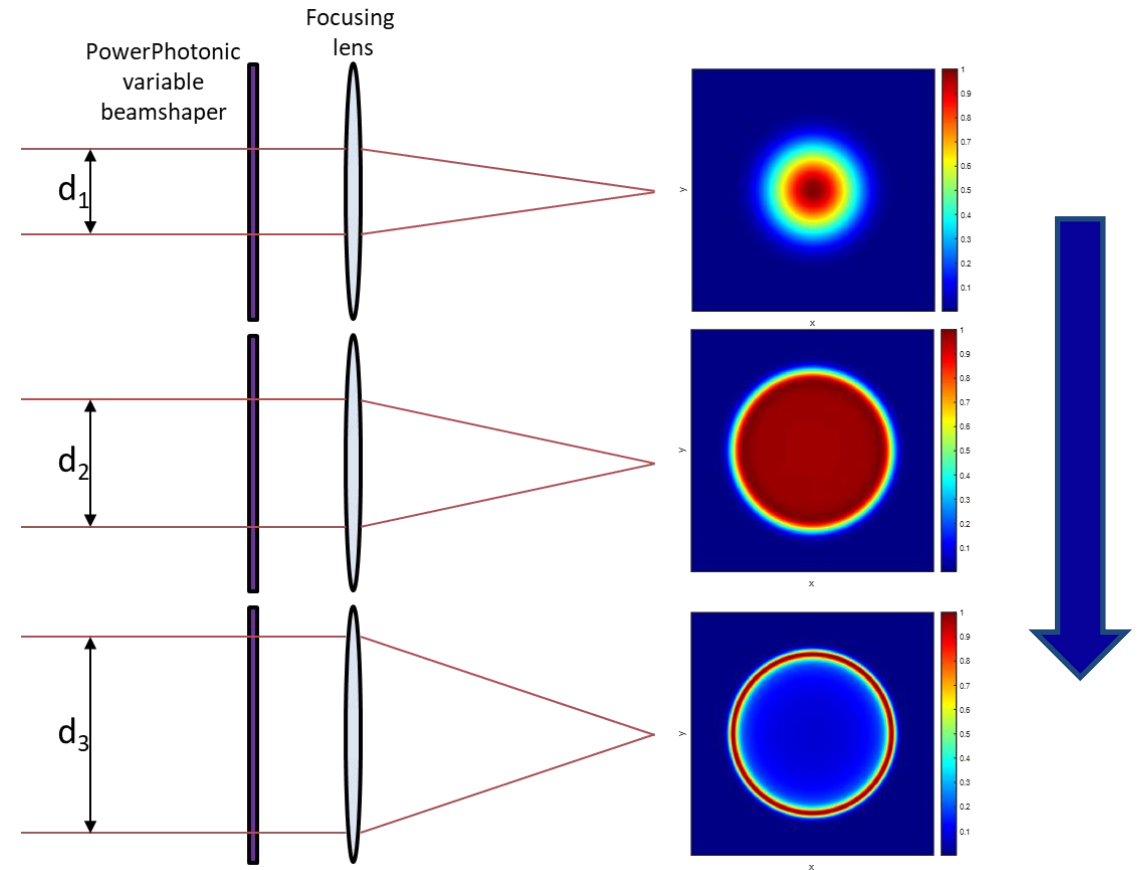


# (Continuously) variable beam shapers

Gauss (unshaped) -> varying ring: core intensity



Gauss (unshaped) -> top hat -> ring





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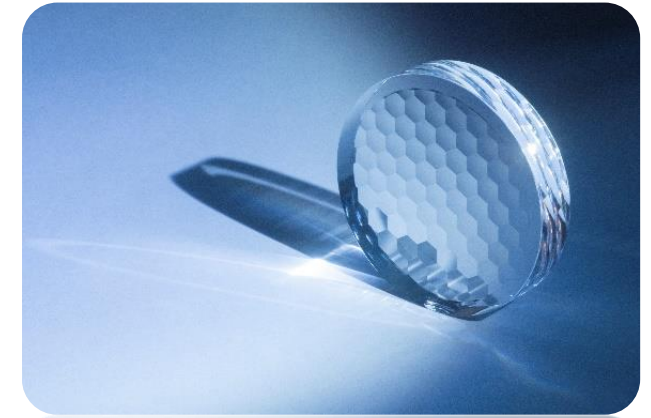
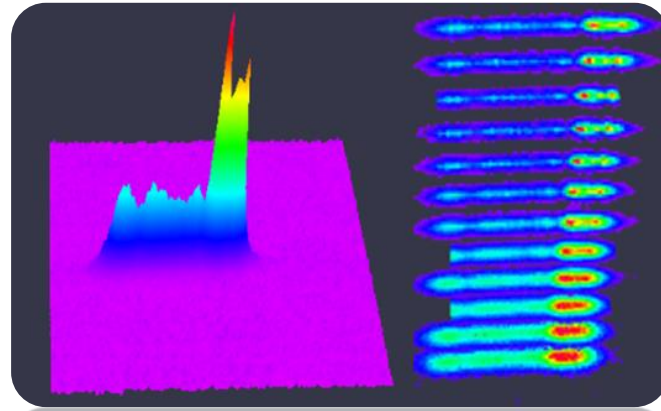
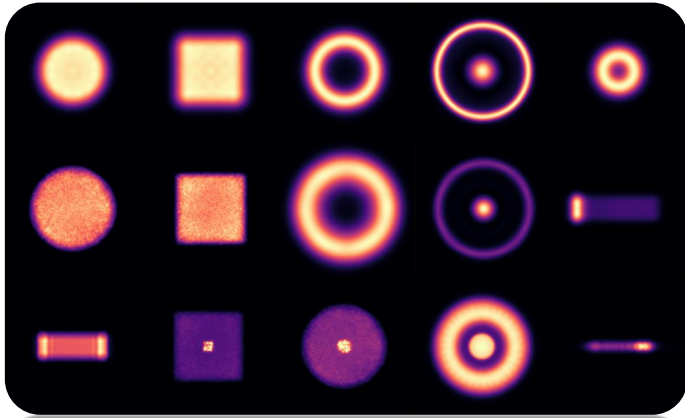
# Useful links

- ① <https://www.powerphotonic.com/>
- ① <https://www.powerphotonic.com/products/lightforge/>
- ① <https://www.powerphotonic.com/powerphotonic-tailshaper/>

For more details please contact: [sales@powerphotonic.com](mailto:sales@powerphotonic.com)

**We are always happy to hear from you!**





Thank you for your attention

