

Beam shaping for enhanced laser polymer welding

Dr. Daniel Vogler

LASER World of **PHOTONICS** 

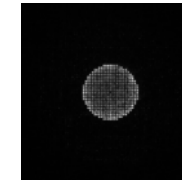
Laser Polymer Welding – Recent results and future prospects
for industrial applications in a European research project

Munich, Germany

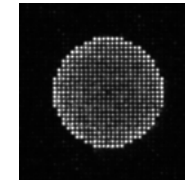
May 14, 2013

WHY BEAM SHAPING ?

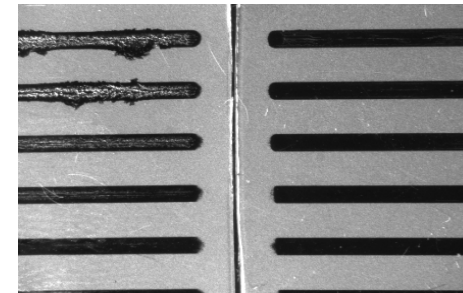
- Easy modification of laser spot diameters
- Optimization of intensity profiles for improved weld seams
- Customer-specific contour shaping for one-shot welding



1 mm



2 mm



without / with beam shaping technique at different power levels



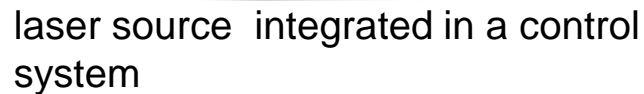
customer-specific beam shaping

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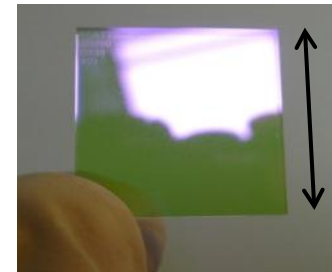
- Motivation
- Diffractive Optical Element (DOE)
- Application of DOEs in laser polymer welding
 - Modification of spot diameters
 - Optimization of intensity profiles: M-shaped spot
 - Simultaneous welding
- Advantages and disadvantages of diffractive beam shaping

Diagram illustrating the setup for measuring the diffraction pattern of a diffractive optical element (DOE):

- A laser source (NOVOLAS) is connected to a fiber.
- The light from the fiber passes through a collimation lens.
- The collimated beam then passes through the diffractive optical element (DOE).
- The light emerging from the DOE passes through a focus lens.
- The resulting diffraction pattern is observed in the focal plane.



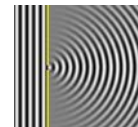
diffractive structure on glass substrate



20mm

analogue to slit diffraction

incident planar wave



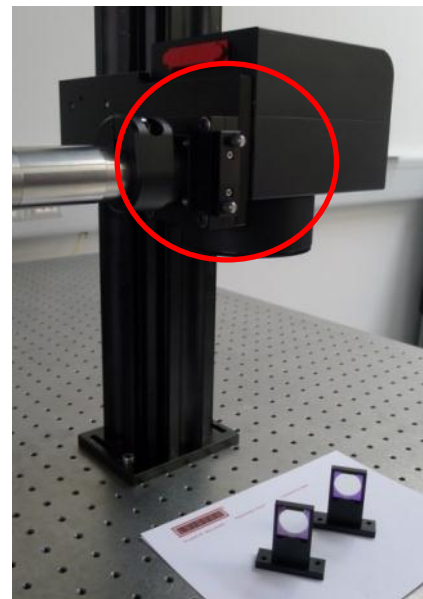
diffracted wave

IMPLEMENTATION OF DOEs IN OPTICAL SETUP

- Fixed implementation (e.g. in a spot optic)
- Exchangeable implementation (e.g. scanner optic)

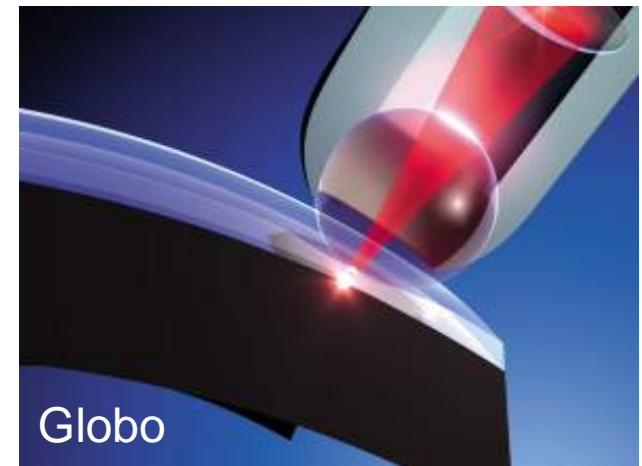
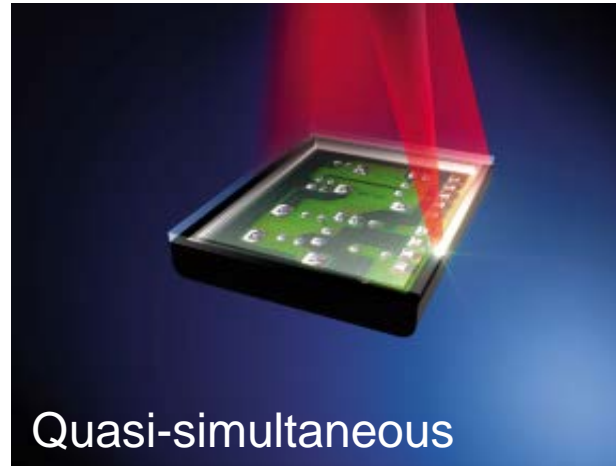
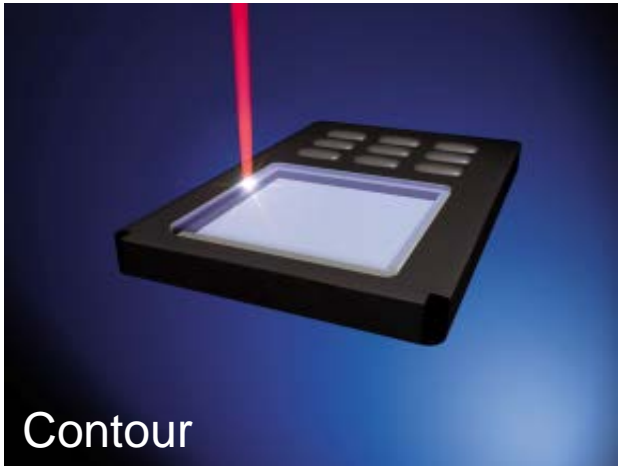


with open slot for DOE

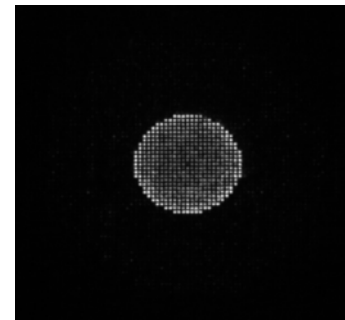


equipped with DOE

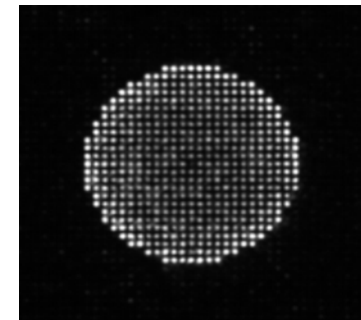
MODIFICATION OF SPOT DIAMETERS



Diffractive shaping of spot diameter without changing fiber, lenses and working distance.



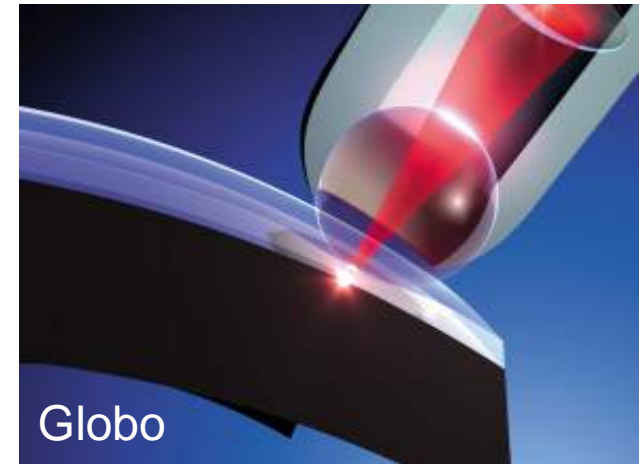
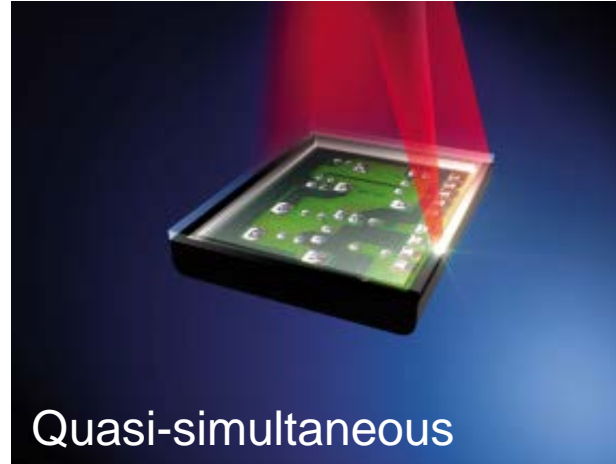
1 mm spot



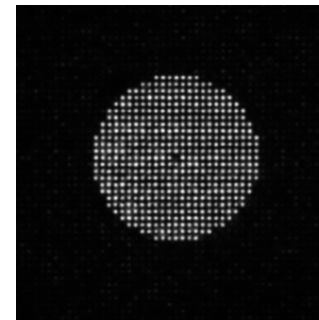
2 mm spot

measured intensity profiles of diffractive-shaped laser spots

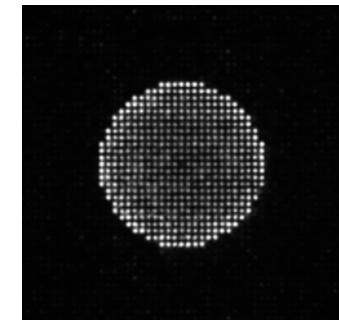
OPTIMIZATION OF INTENSITY PROFILE: M-SHAPE



Diffractive shaping of intensity profiles without changing laser, fiber cable and/or optic head.



top-hat profile



m-shaped profile

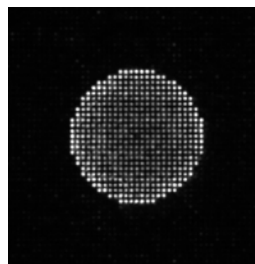
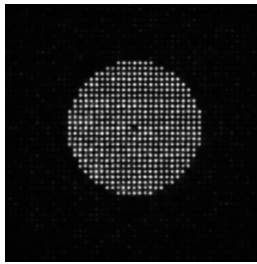
measured intensity profiles of diffractives-haped laser spots

OPTIMIZATION OF INTENSITY PROFILE: M-SHAPE

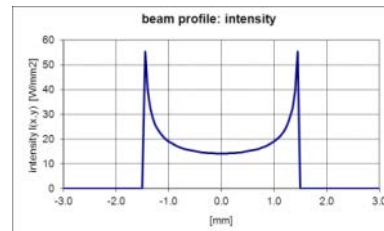
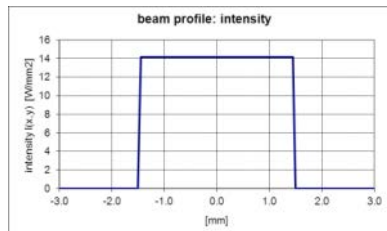
top-hat profile

M-shaped profile

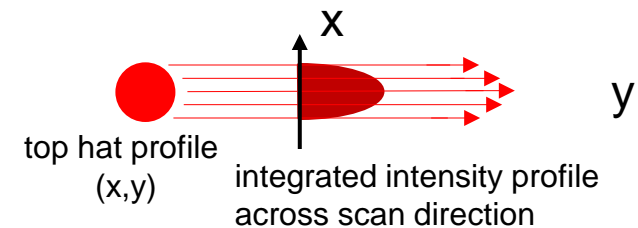
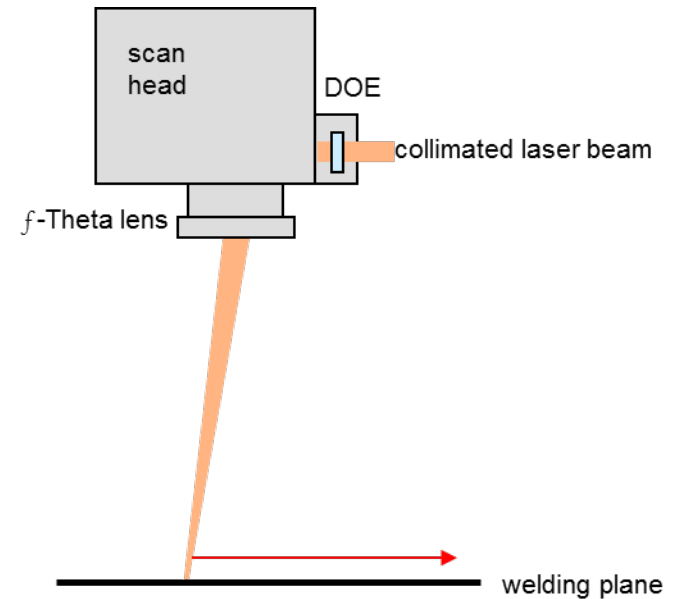
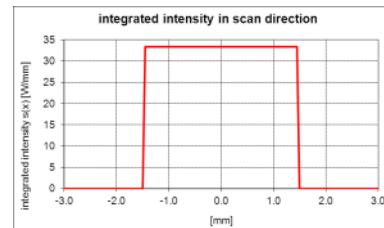
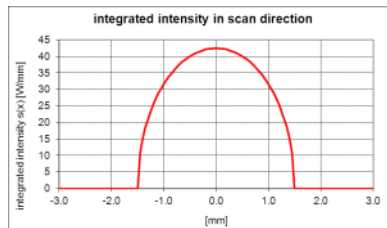
measured profile



intensity profile



integrated intensity profile of laser spot

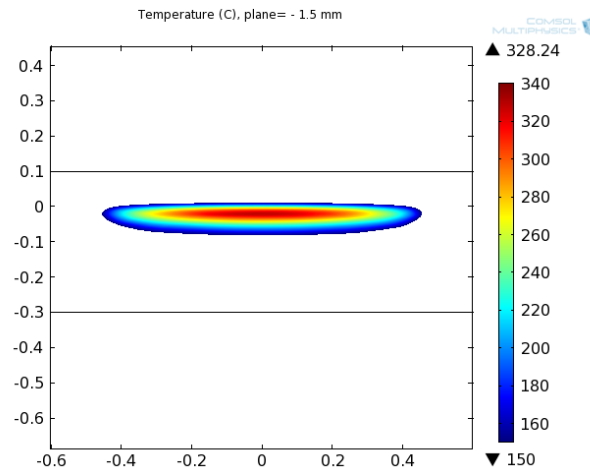


OPTIMIZATION OF INTENSITY PROFILE: M-SHAPE

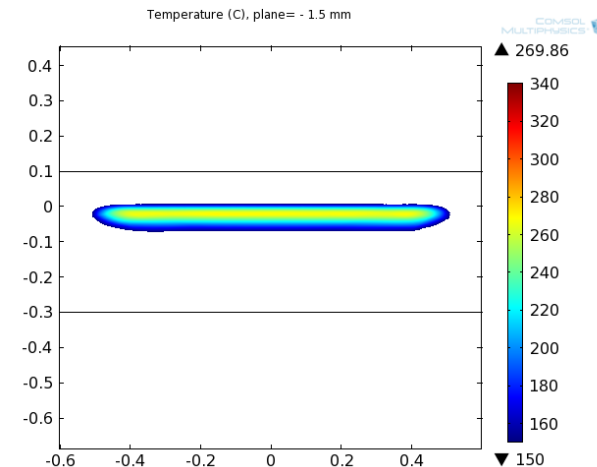
simulated heat
distribution after
laser absorption in
polymer across
scan direction

PC (0.4% carbon black)
power = 50W; v = 1m/s

top-hat profile

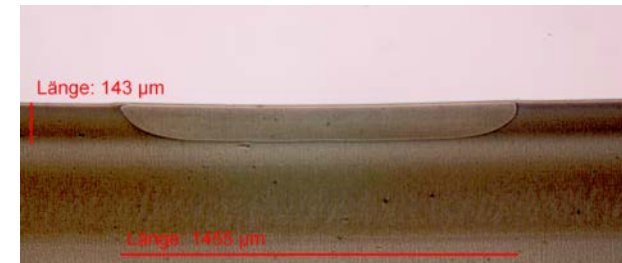
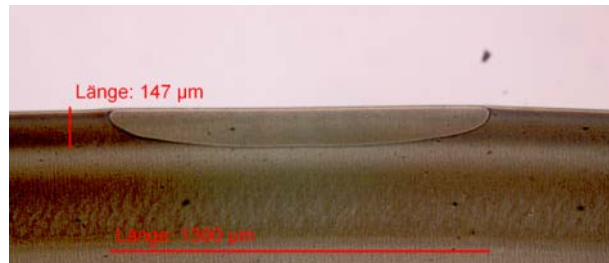


M-shaped profile



heat affected
zone in polymer

PP (0.5% carbon black)

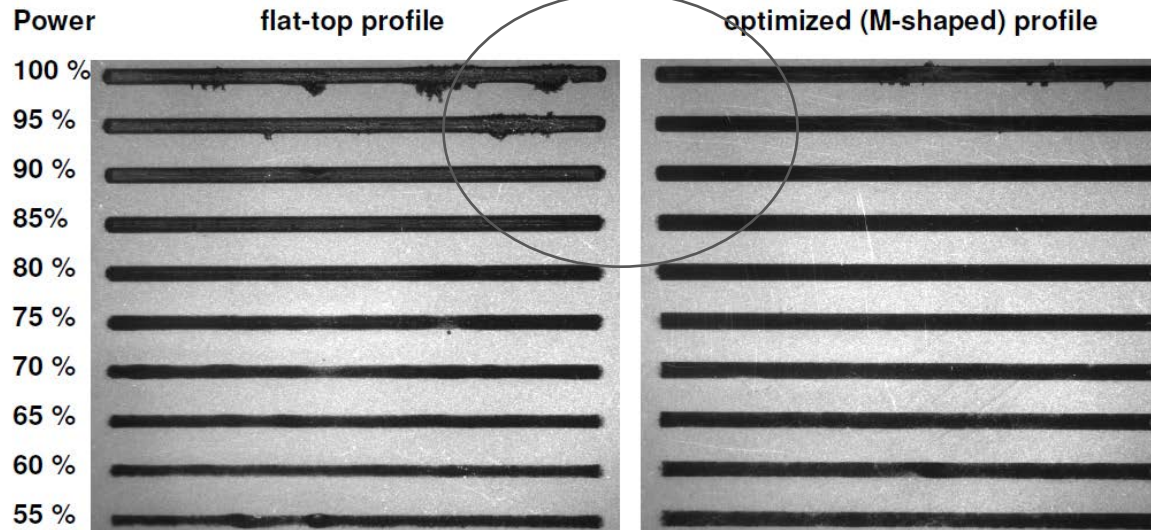


[Simulation and microtones by ILT]

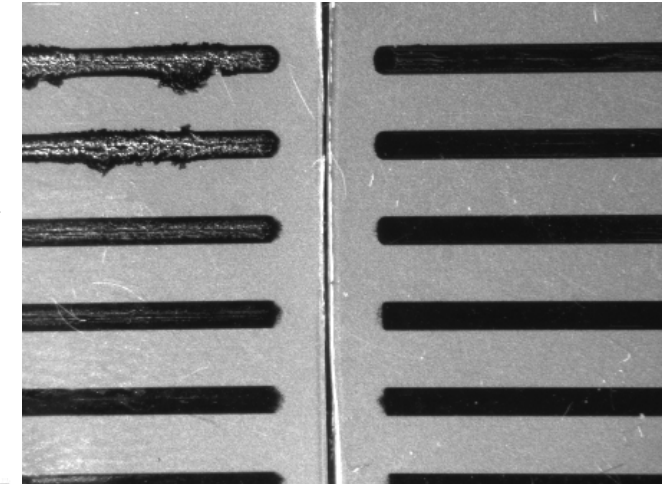
Intensity profile influences the heat distribution during weld process.

OPTIMIZATION OF INTENSITY PROFILE: M-SHAPE

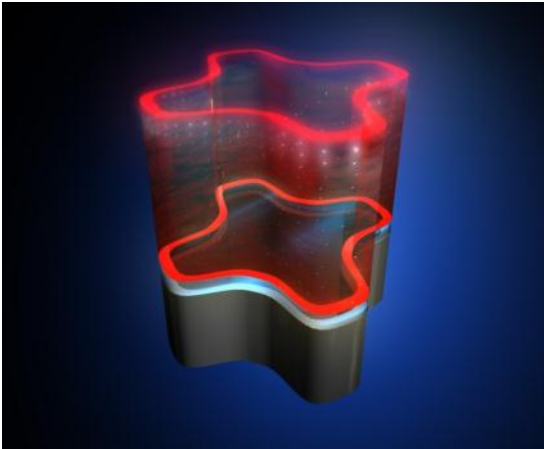
M-shaped intensity profile yields larger process window and ensures a defined edge of weld seams.



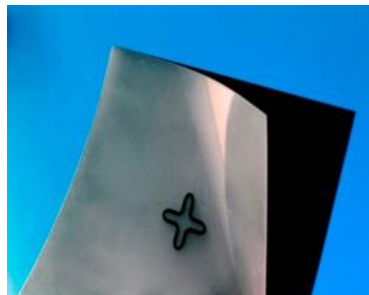
Contour welding: 100% Power = 53 Watt (fiber laser @ 1070nm)



SIMULTANEOUS (ONE-SHOT) WELDING



- any 2D contours, preferably centrosymmetric
- short welding time
- no moving parts
- suited for mass production



polycarbonate foil samples

ADVANTAGES AND DISADVANTAGES OF DOEs

Advantages

- any 2D contours
- no alignment required between DOE and laser beam \Rightarrow easy and quick exchange of DOE

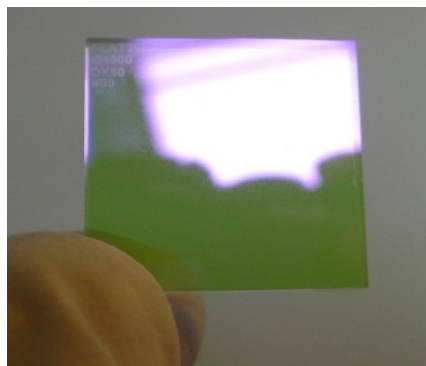
Disadvantages

- efficiency
Two phase level DOE: 70 - 80 % efficiency, higher efficiency on multi-level DOE
- price – high tooling costs, affordable

Characteristics of diffractive beam splitting technique

- DOE is designed for one wavelength (highest efficiency)
- size of the diffraction pattern depends on wavelength and focus lens

PRESENTATION OF DOE_s AT HALL 2, BOOTH 430

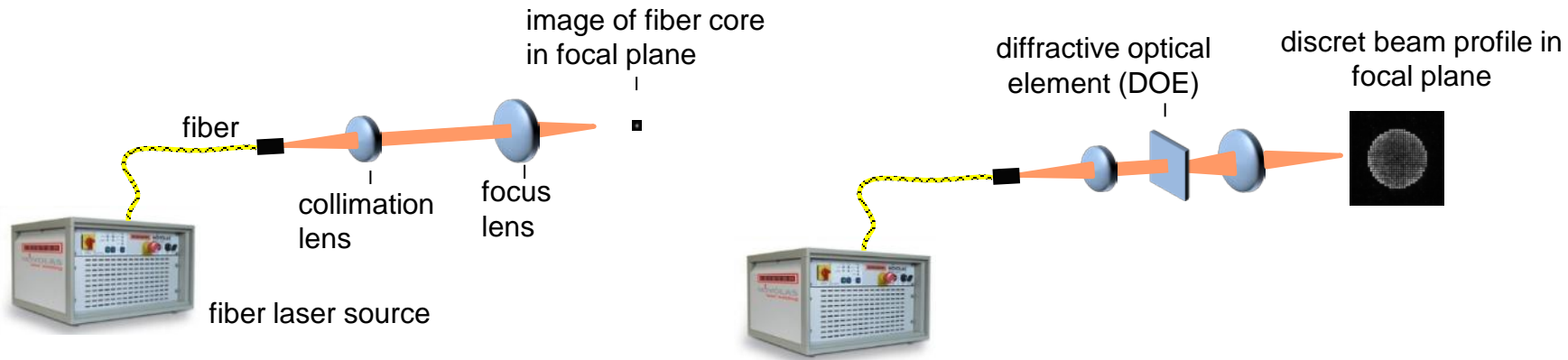


We are pleased to welcome you at BOOTH 430 in HALL 2

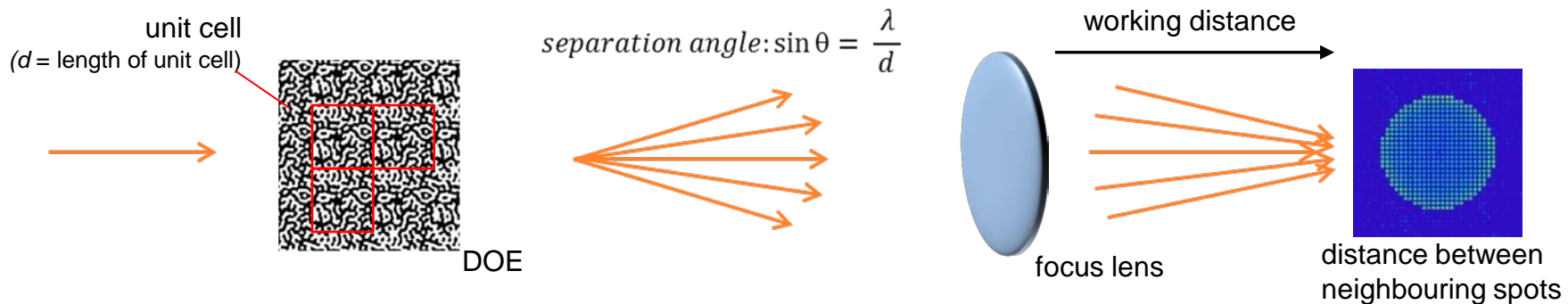
Thank you for your attention!

BACK UP SLIDES

DIFFRACTIVE BEAM SPLITTING TECHNIQUE

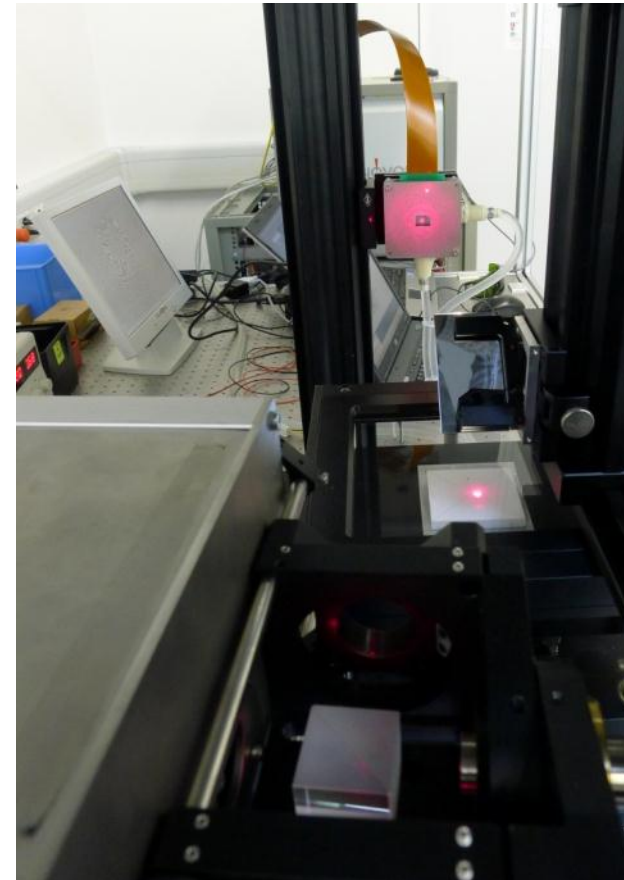
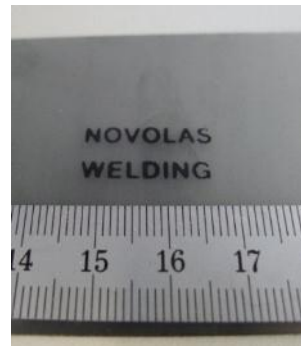
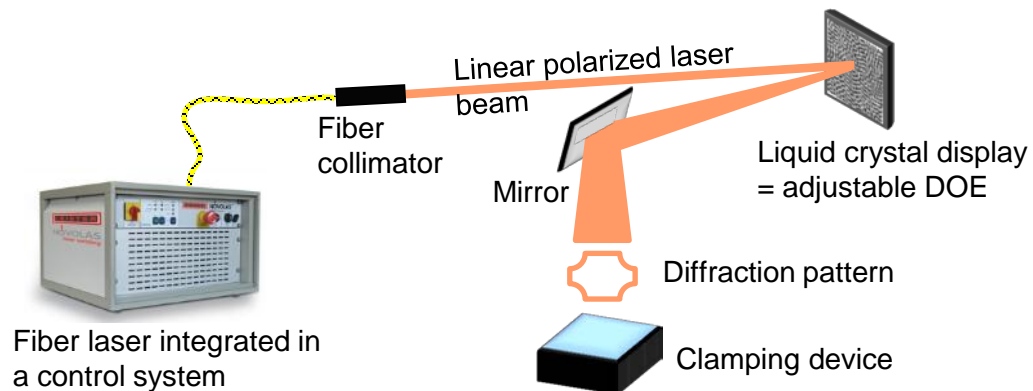


DOE acts as a diffraction grating, i.e. as a beam-splitter imaging original laser spot in an array. Each of the imaged laser spots is weighted with a DOE-defined factor.

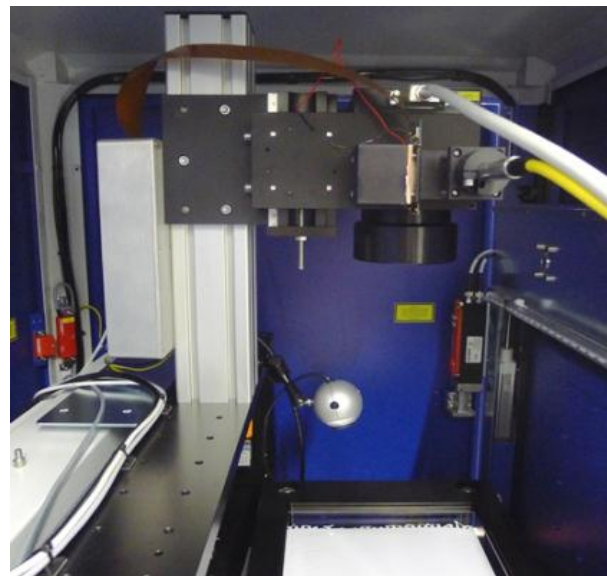


ADJUSTABLE DOEs / SPATIAL LIGHT MODULATOR (LCoS)

Spatial light modulators for polymer laser welding



PROTOTYPE MACHINE WITH ADJUSTABLE DOES



WELD SAMPLES ACHIEVED BY LCoS COMBINED WITH SCANNER



Simultaneous (cup) and contour welding with different weld seams



Simultaneous welding of a single cow arranged in an 3x3 array realized by scanner head