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M-shaping of Diode Laser Radiation as a Process Optimization for Polymer Welding Techniques

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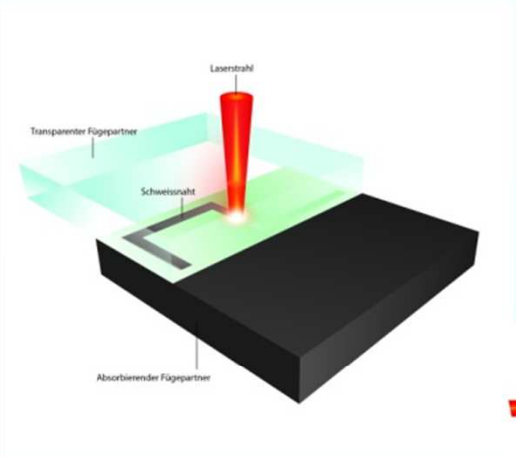
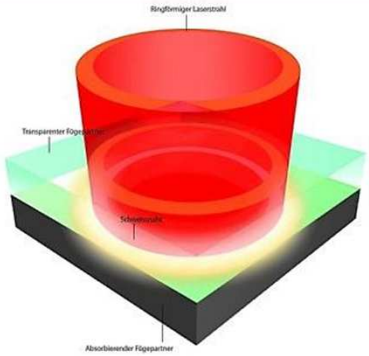
POLY BRIGHT

State of the Art

For joining thermoplastic parts the laser transmission welding with High Power Diode Laser (HPDL) is more and more the first choice

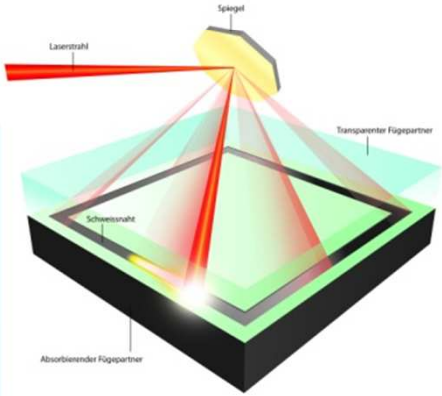
Adapted to the part geometries four joining technologies are available

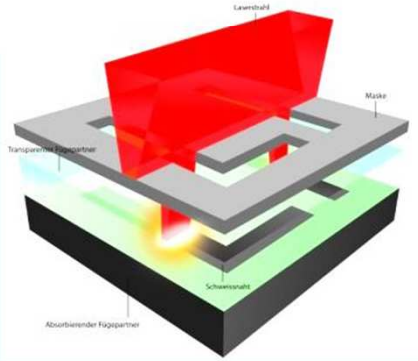




Simultaneous welding

The mainly used systems are the **Contour welding** and the **Quasi-simultaneous welding** with fiber coupled diode lasers



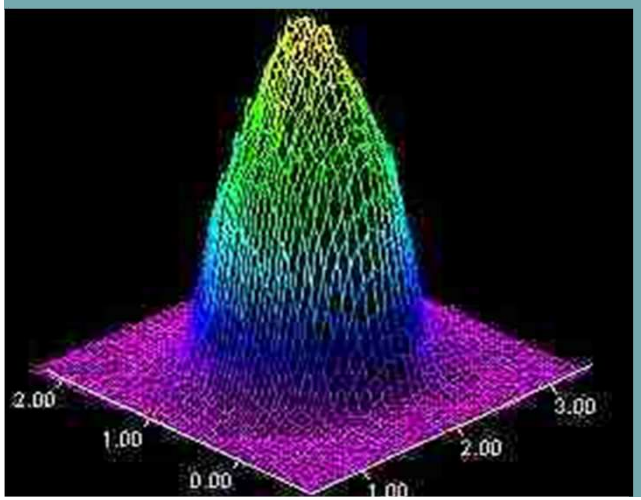


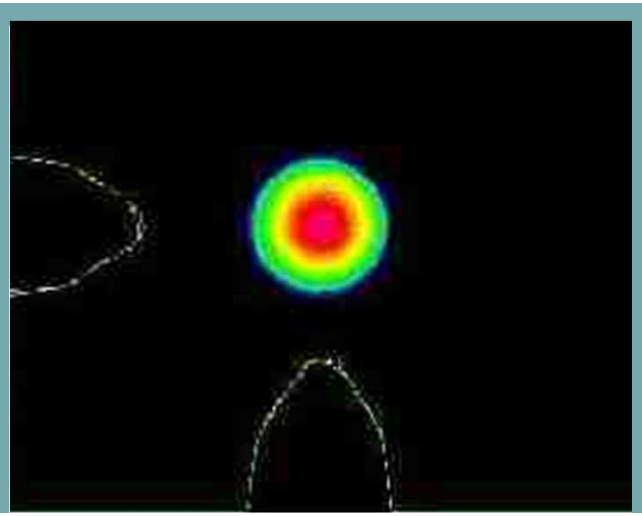
Mask welding

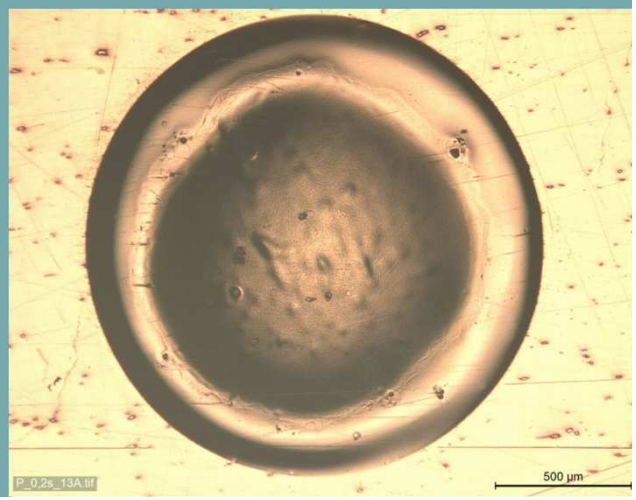
Motivation through the Use of Fiber-Coupled HPDL for Transmission Welding of Thermoplastics

- Intensity distribution nearly like a Gaussian profile
- Intensity concentration in the center of the spot
- Maximum heating in the center of the welding seam
- Maximum thickness of melted material in the center of the seam

Small process window OR: ???





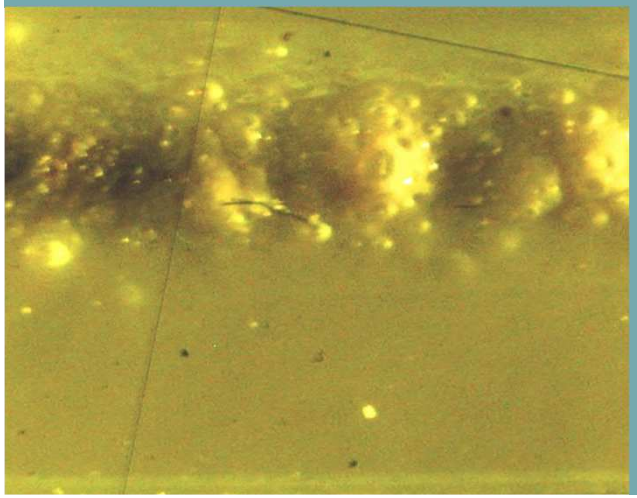


Failures caused by the existing Intensity Profile of Fiber-Coupled HPDL

- Overheating
- Bubble formation
- Material destruction
- Loss of contact and/or adhesion

CRITICAL PARTS

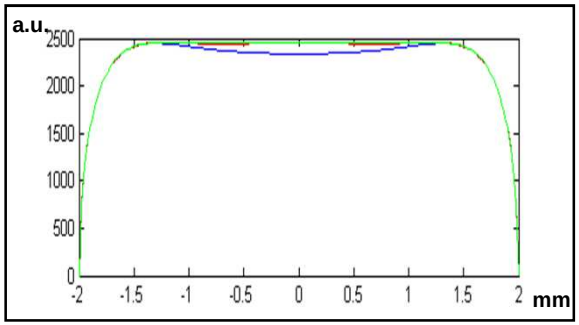
- Thin foils or small parts because of the about 1:1 aspect ratio between melting zone and material thickness
- Materials with a small temperature range for the melted state of aggregation
- Materials with a high coefficient of thermal expansion



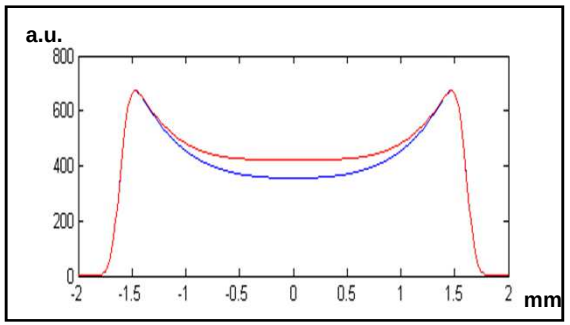
Optimization of the Heat Input

What is necessary to avoid the failures ?

A homogenous temperature distribution in the cross section of the welding seam…

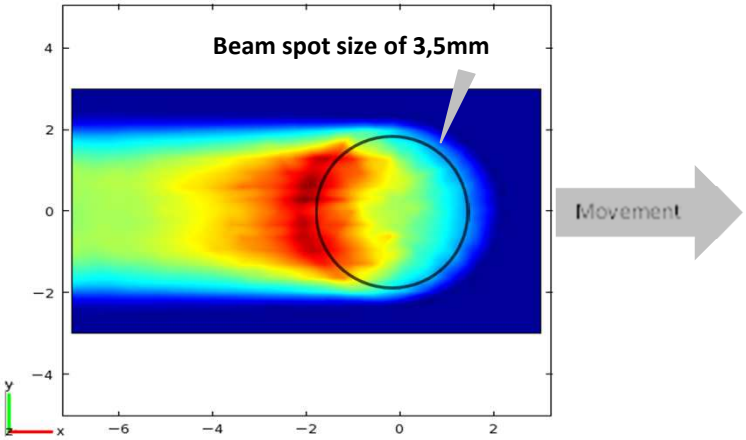


Thermal interaction with polymer



Radial intensity distribution

Simulation (PP)



…leads to a uniform melting in the welding seam!

Why LIMO is convinced that there is an Optical Solution

- ✓ 20 years experience in beam shaping
- ✓ More than 100 customized beam shapes with high precision free-form lenses
- ✓ Best fitted manufactory to produce freeform optical parts

LIMO's Freeform Micro Lenses Technology

$$z = \frac{cv \cdot p^2}{1 + \sqrt{1 - cv^2 (cc + 1) p^2}} + \sum_{i=1}^{\infty} AS_i p^i .$$

Optical Solution of M-shaped Intensity Distribution

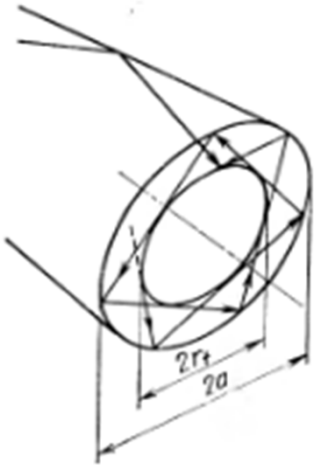
Idea: Generation of mainly non-meridial beams – avoiding beamlets through the center of the fiber

Approach:

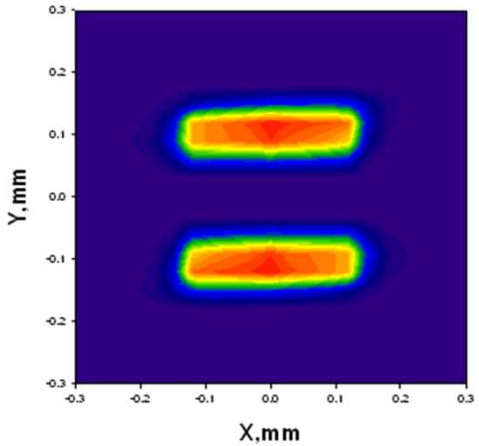
- non meridial beams passing the fiber
- angular distribution is maintained by the fiber
- fiber acts as rotational homogenizer

Ray tracing

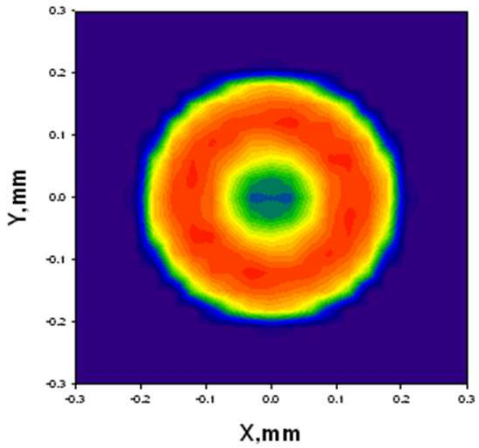
Non meridial rays



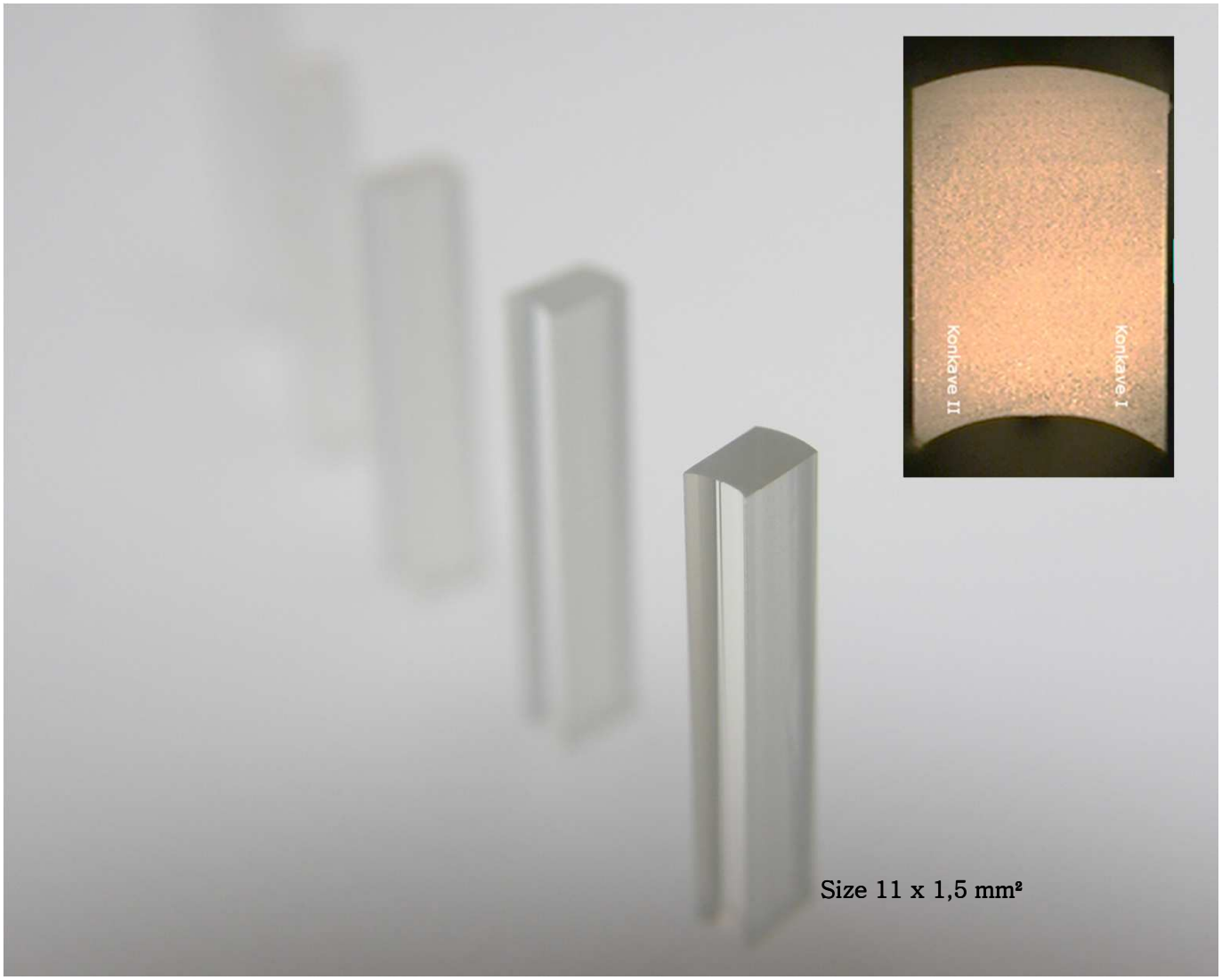
Near field at fiber input



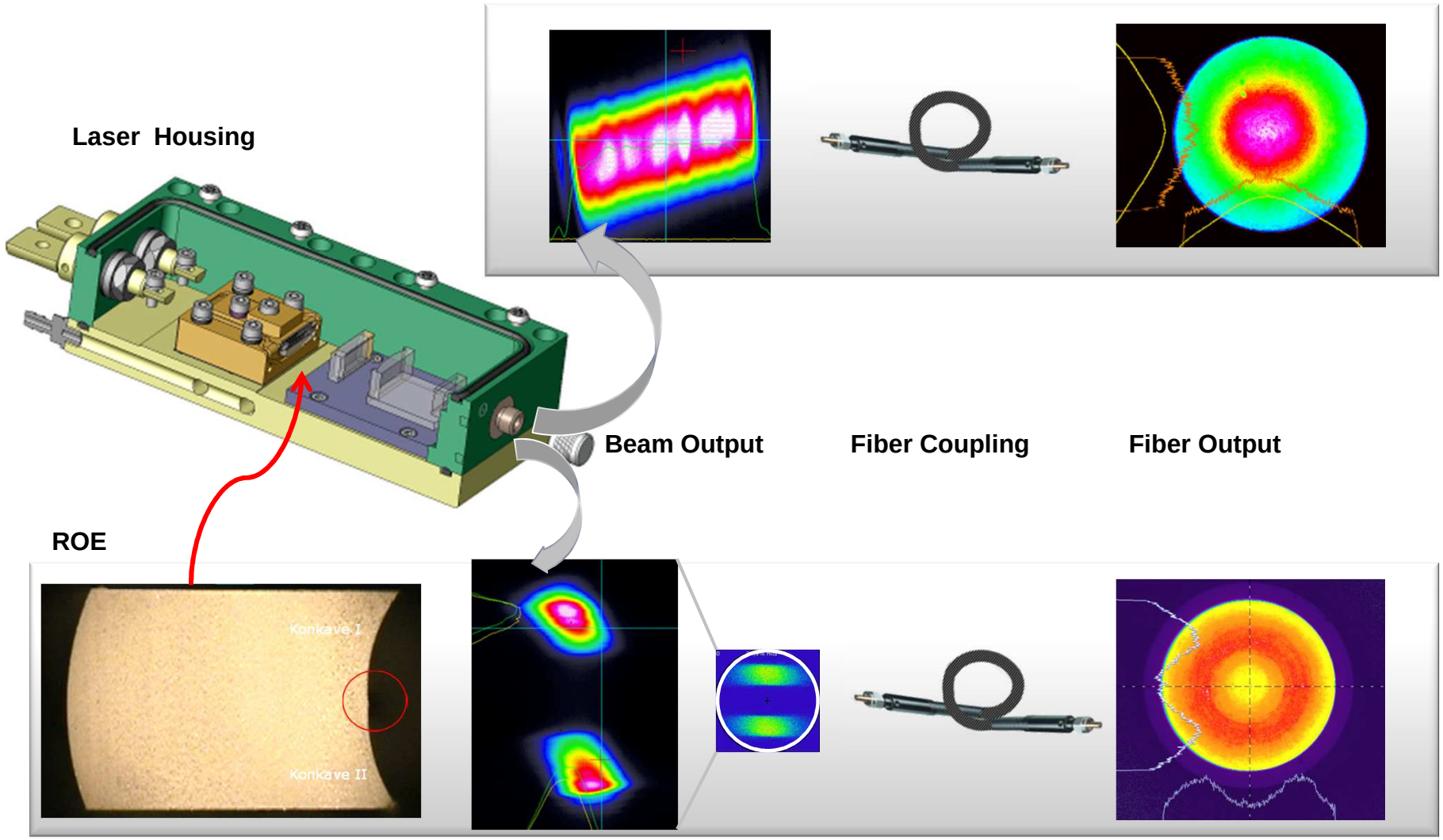
Near field at fiber output



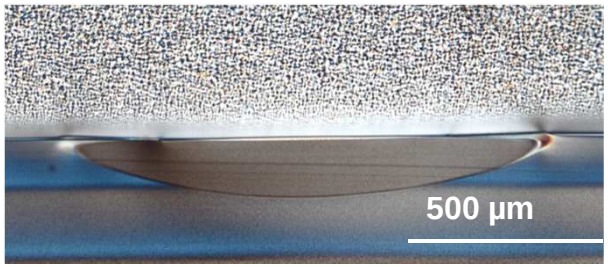
Design and Manufacturing of Refractive Micro Optic



Transfer of Setup to Laser



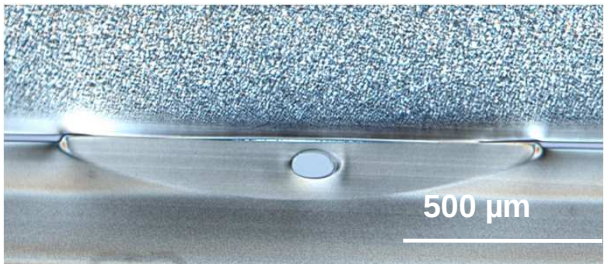
M-Shape Welding Results - Microtome Cuts

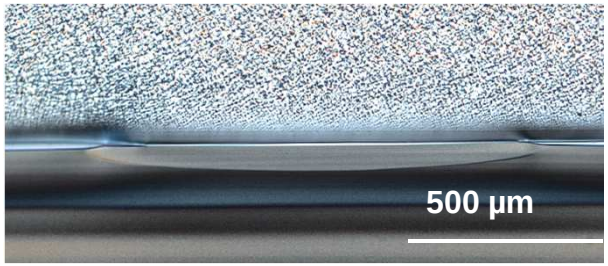


Optimal parameters
Good weld

Gaussian

High power
Decomposition

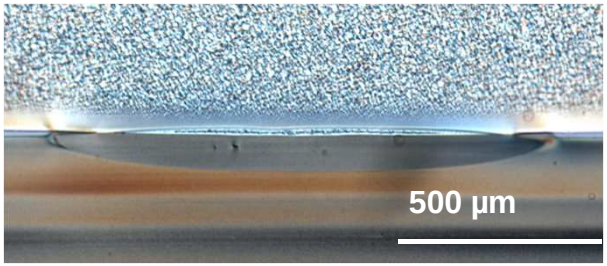


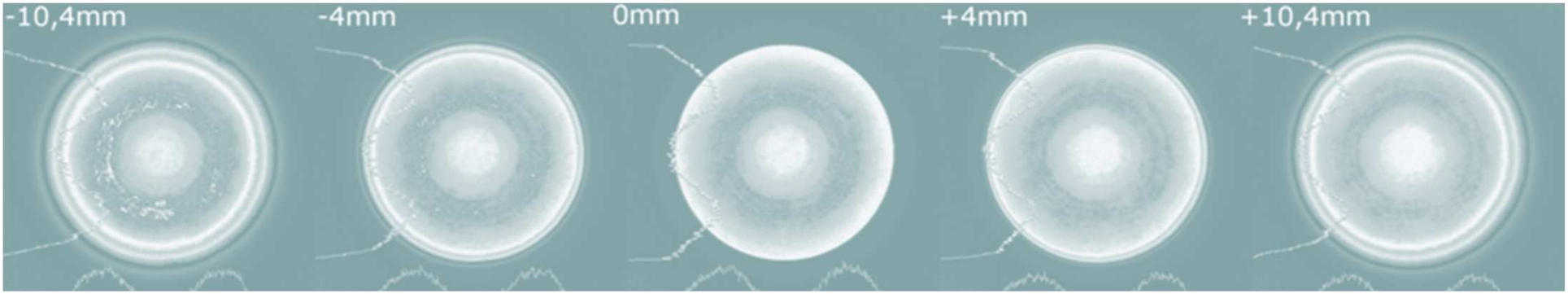


Optimal parameters
Very good weld

M-Shape

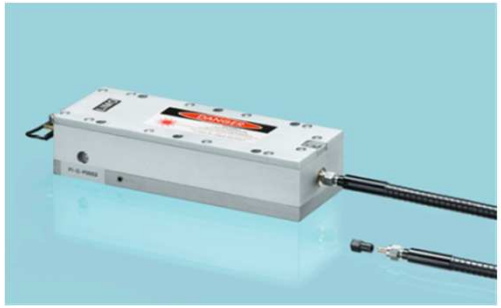
High power
Good weld





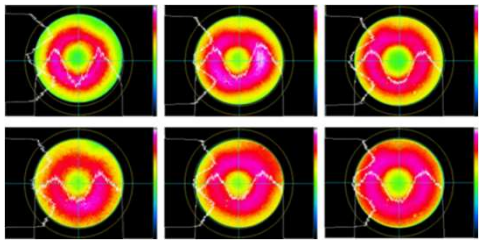
Optimized welding Results and increased Process Yield by using M-shaped Beam Profile

LIMO M-Shape Laser module



Power: **60 W**
Fiber core : **400 µm**
NA: **0,22**

wavelength: **980 nm**

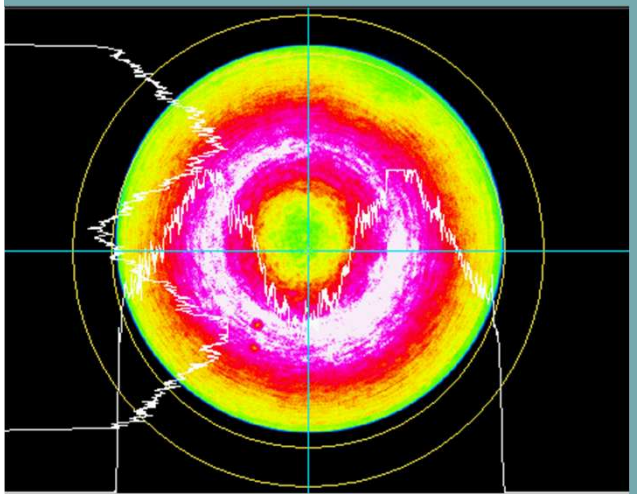


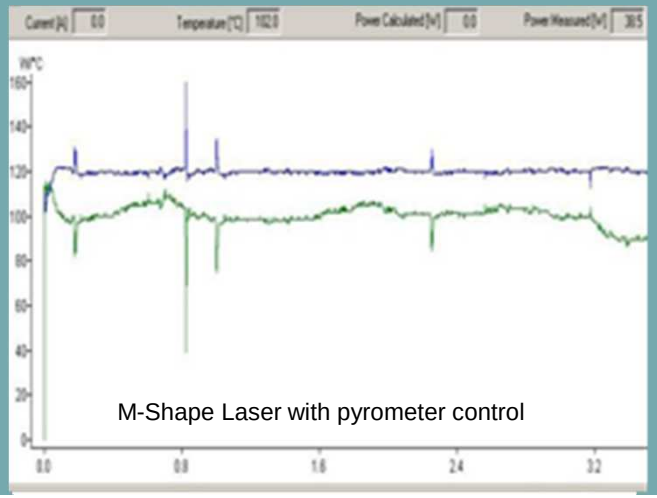
Intensity distribution
Fiber straight
1 to 10 m

Intensity distribution
Fiber twisted
1 to 10 m

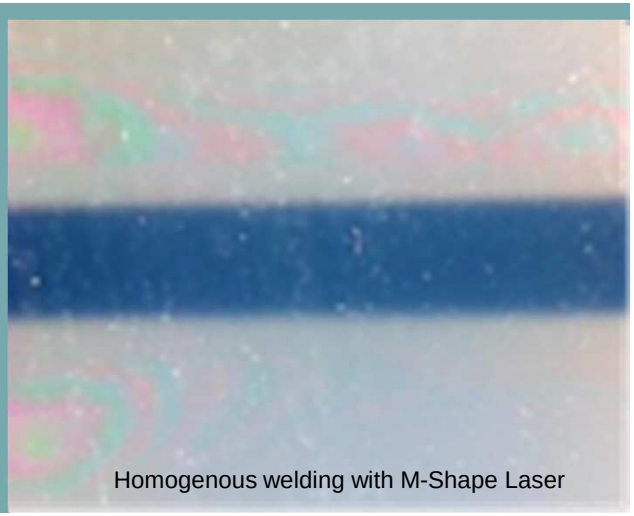
Benefits

- Laser intensity-profile adapted to the thermal material properties
- Flat and homogeneous welding seam
- Larger error-free process window
- Higher welding speed through optimized melting process
- M-Shape keep in form by twisted fiber



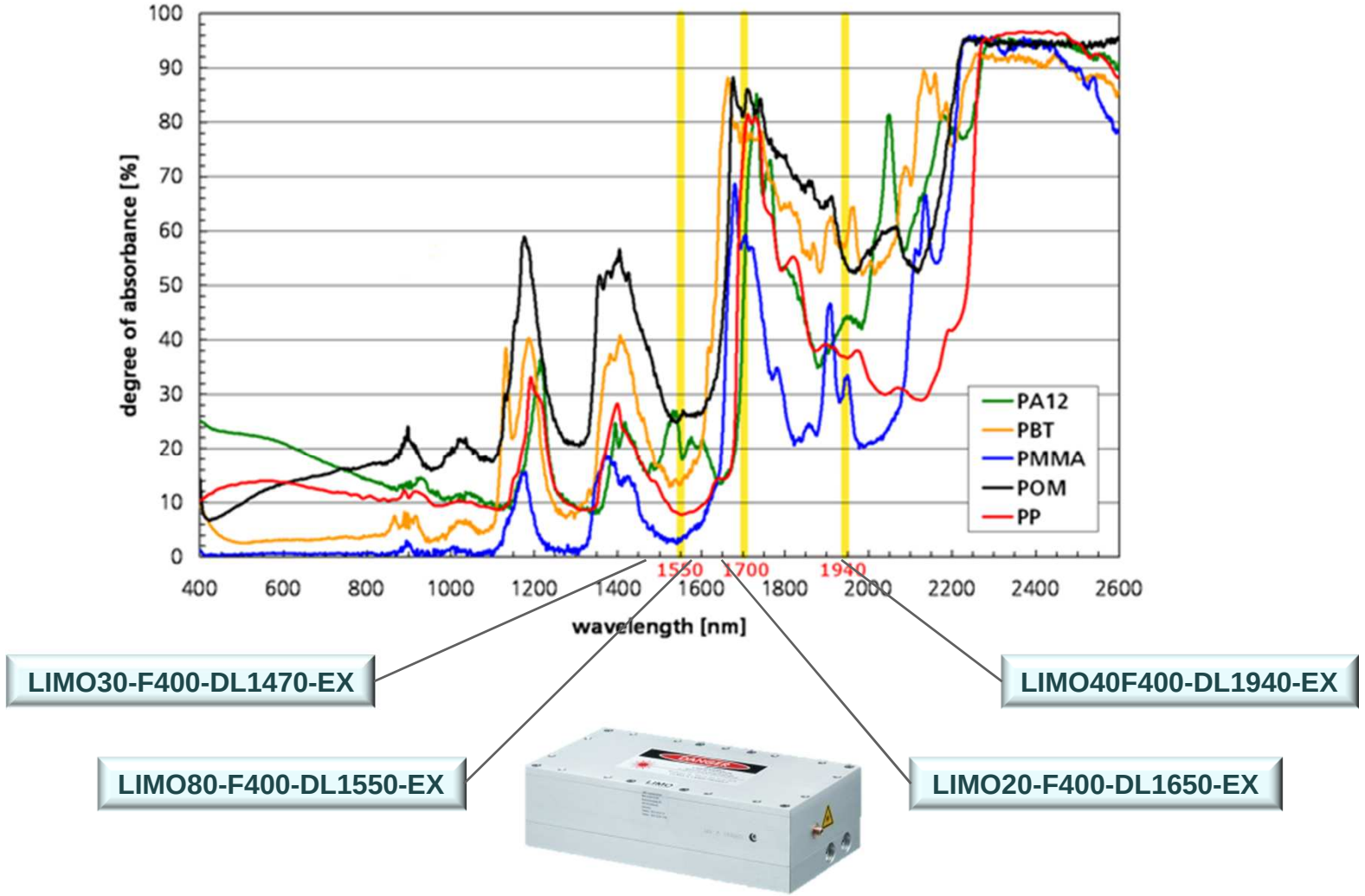


M-Shape Laser with pyrometer control



Homogenous welding with M-Shape Laser

Next Generation of LIMO Lasers Perfectly Adapted to the Absorption of many Polymers



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