

High Power Fiber Lasers – Adapted power sources for industrial applications



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Köping, 10th of Mai 2007



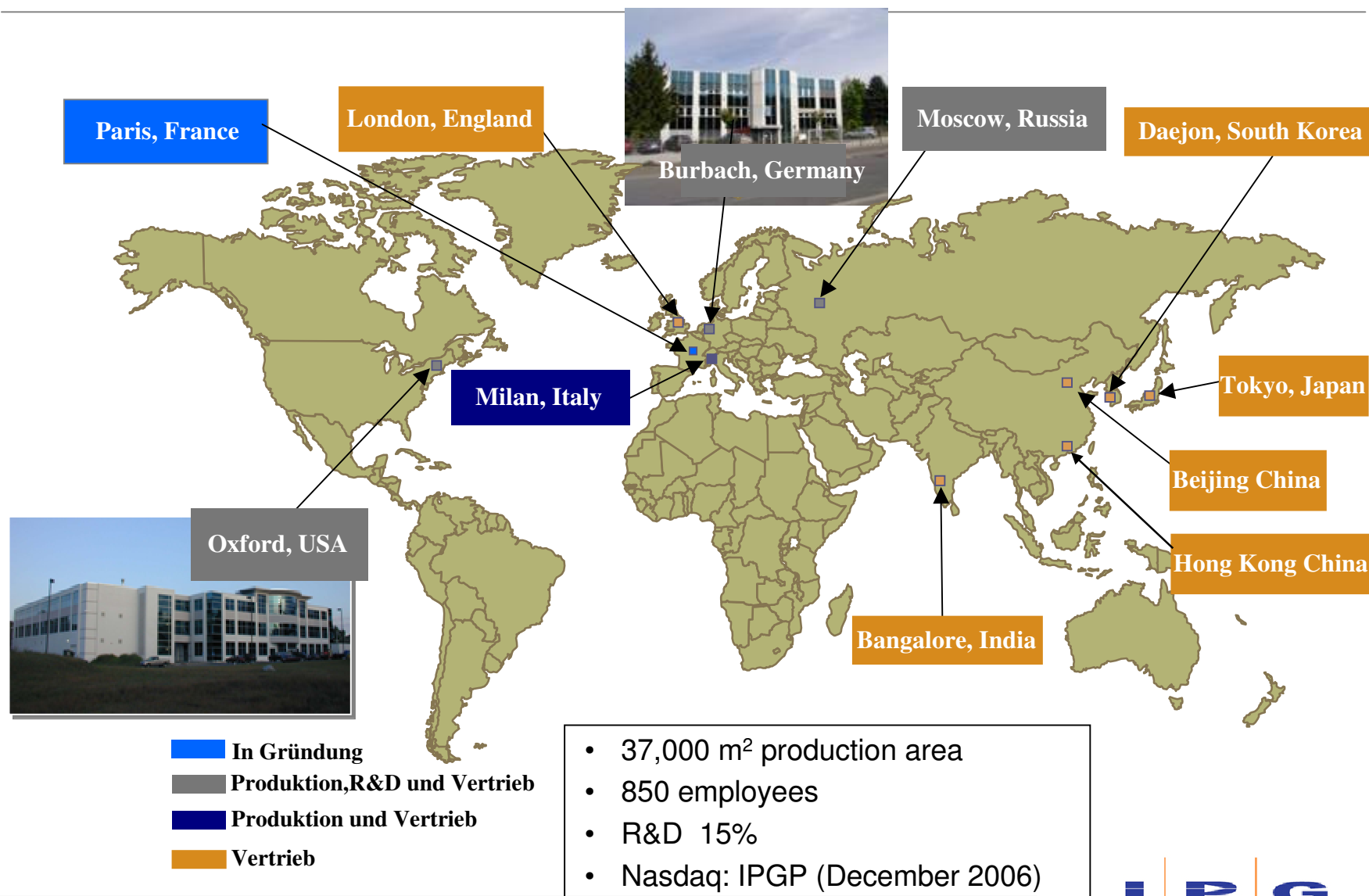
Content

- **Fiber Laser market**
Situation and development
- **IPG – Fiber Laser**
Technology and benefits
- **Application Single Mode**
- **Application Multi Mode**
- **Summary**



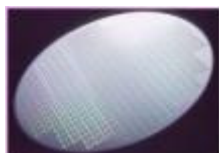


IPG Photonics Corporation





Vertical Integration



Fab Operations

Semiconductor Wafer Growth
Diode Processing
Chip Mounting
Burn-In



Laser diode Packaging

PLDs 5-25



Optical Preform

Silica based glass
MCVD method
Dope with rare earth ions



Final Assembly

Coupling
Final burn in
Shipment

Deep in technology
Deep in experience



Fiber Draw

3 Draw towers
Active fibers only
>200 different fibers



Modules

Up to 800-1000 Watts



Fiber Block

Podding active fibers



Components

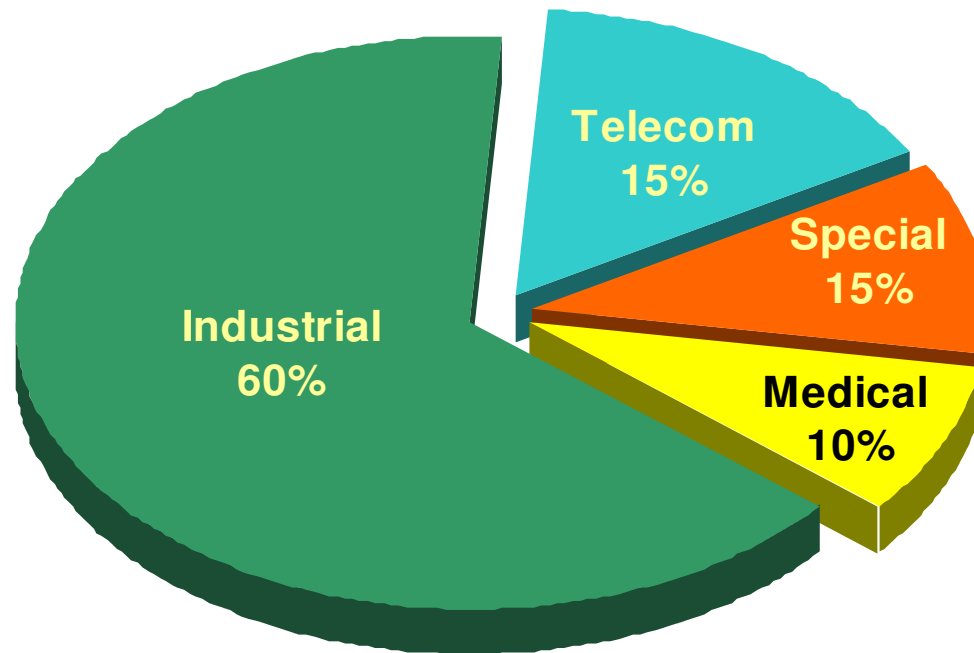
Bragg Gratings
Isolators
Couplers





Application Diversity

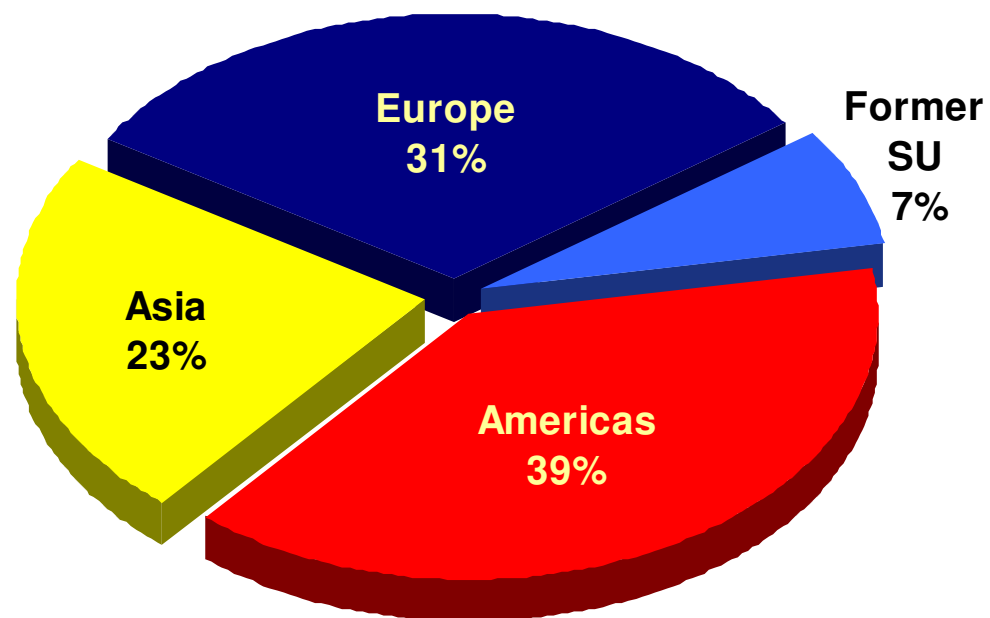
Jan-Aug` 2006





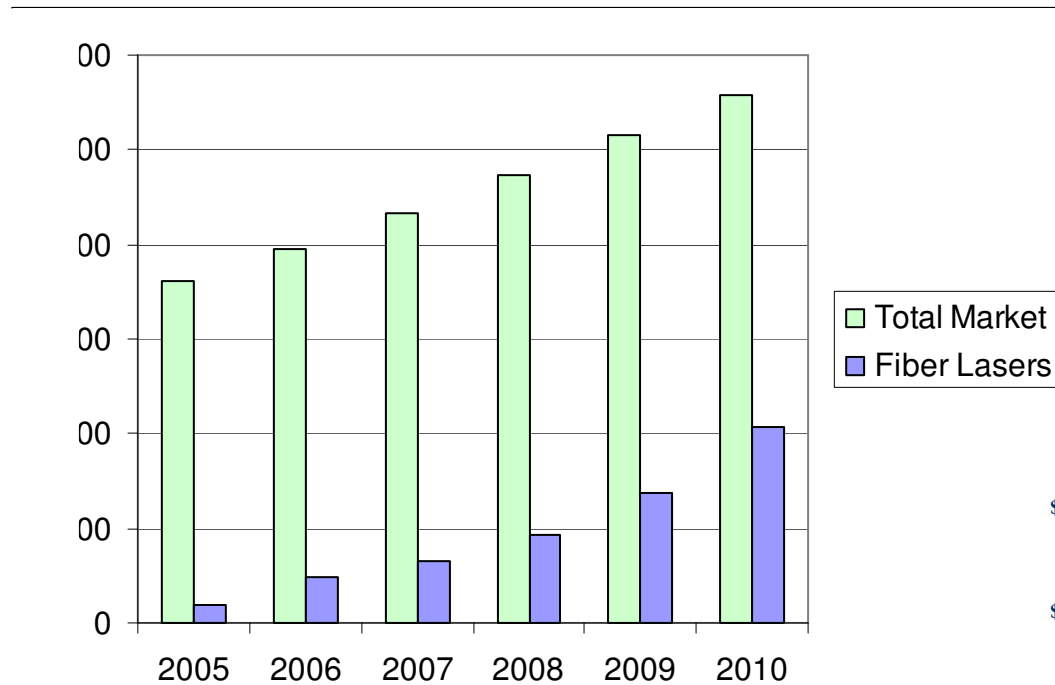
Geographic Diversification

Jan-Aug` 2006

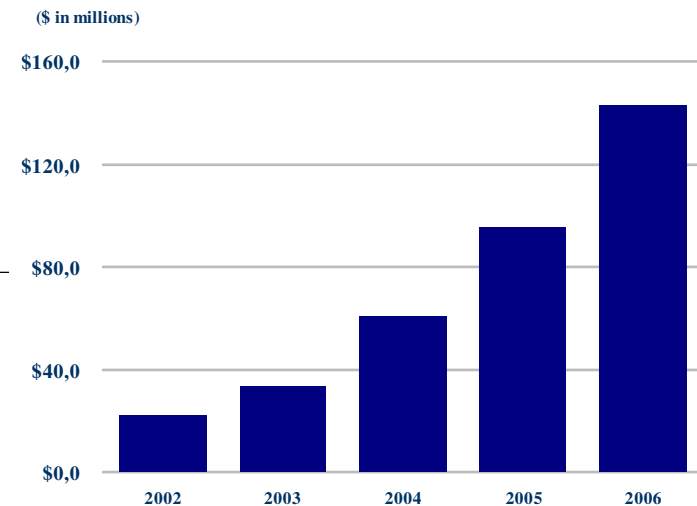




Dual Driver of Growth



- Total Laser market
9% per anno
- Fiber Laser
39% per anno
- IPG
50% per anno



Source: Fiber Laser Market
Review and Forecast 2006,
Strategies Unlimited





Competitive Laser Technologies

	<u>Power</u>	<u>Beam Quality</u>	<u>Wave length</u>	<u>Mainten- ance</u>	<u>Footprint</u>	<u>Ownership Costs</u>
Fiber Laser						
CO ₂ (Gas)						
Lamp Pumped Nd: YAG (Solid State)						
Diode Pumped Nd: YAG (Solid State)						
Disk Lasers Yb: YAG (Solid State)						

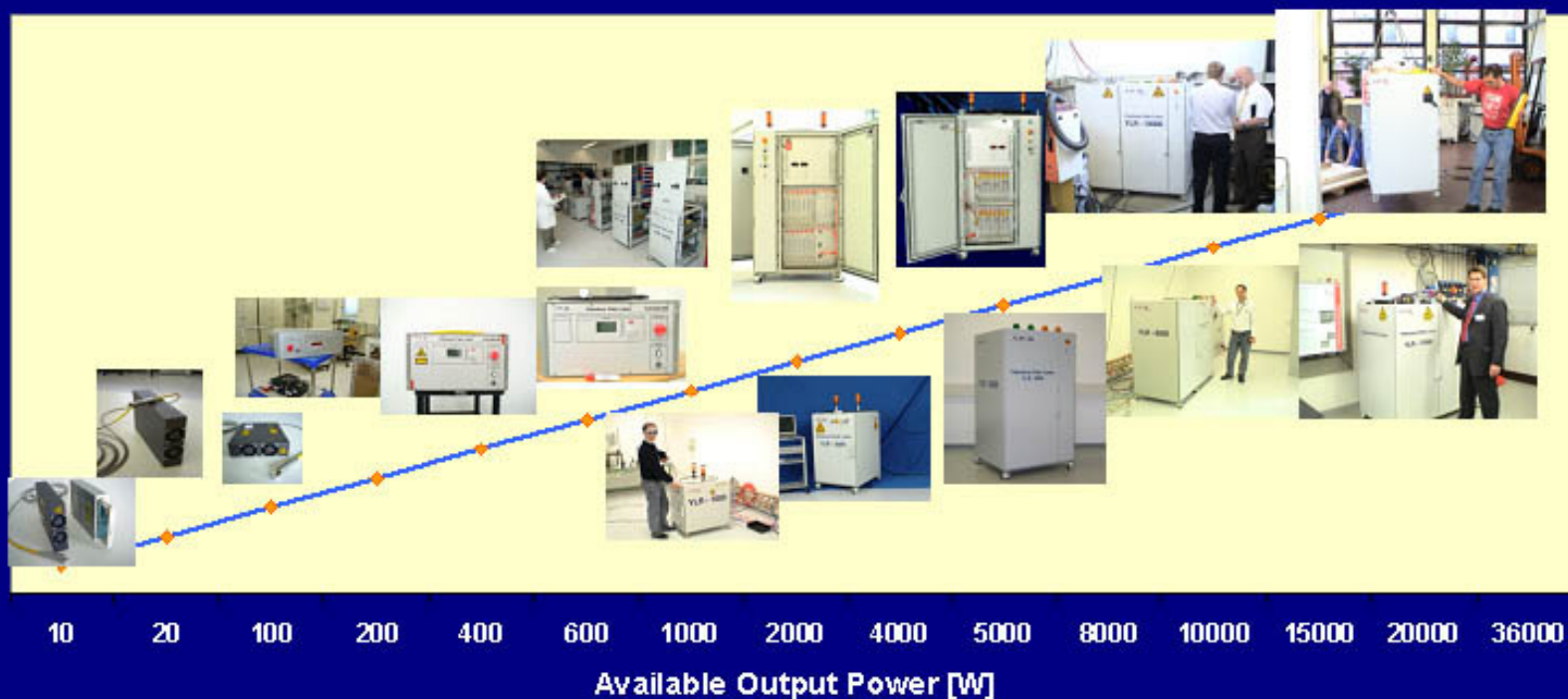
Best





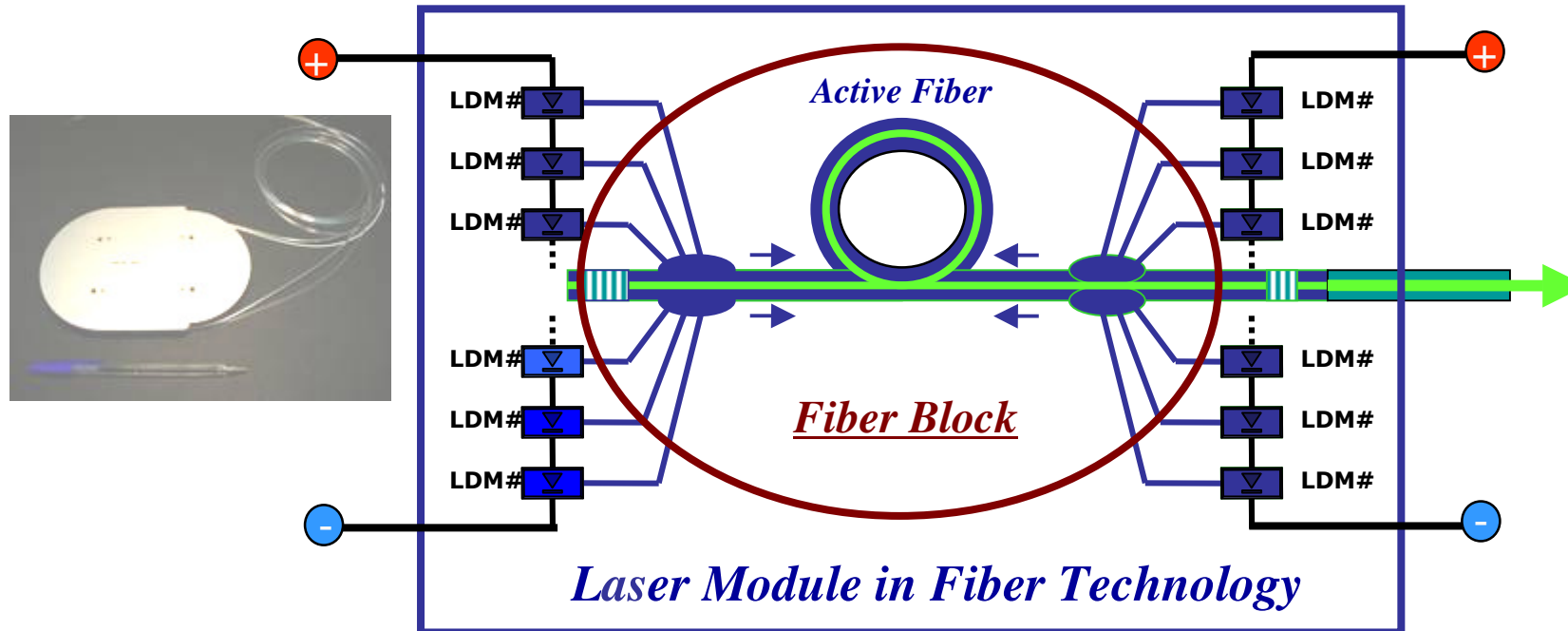
IPGs Commercial Products

IPG produces more than 400 different types of fiber lasers





IPG Fiber Laser

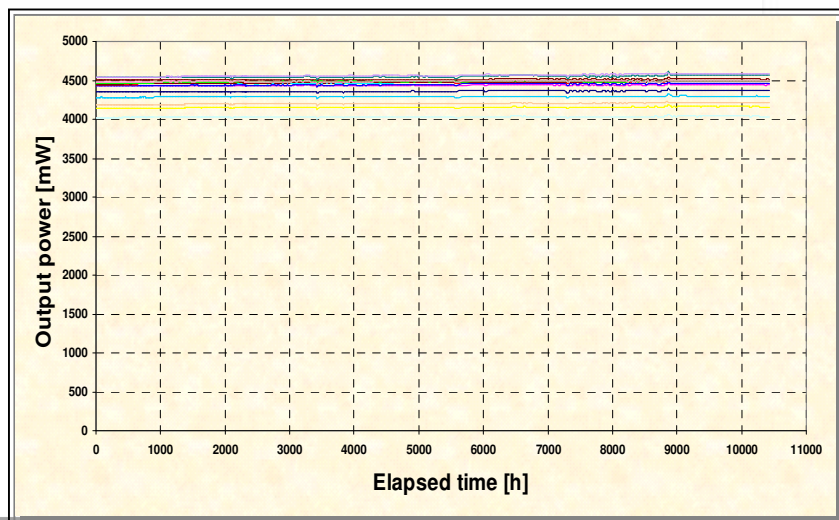
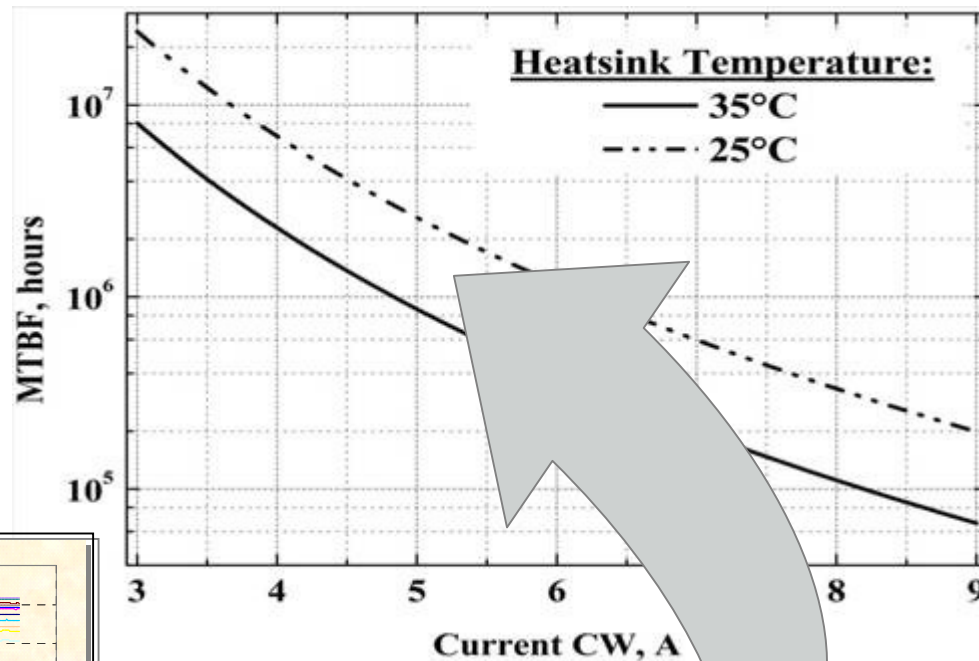
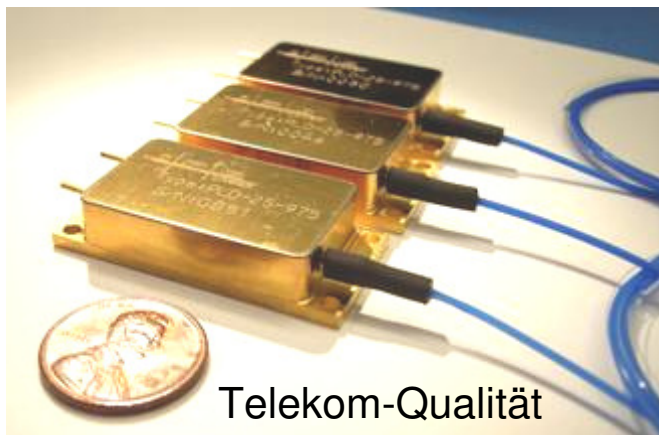


- compact integrated optical design
- single emitter diodes
- side pumped active fiber
- mechanically robust
- thermally stable





IPG Multi-Mode-Broadband Diodes



Fiber Laser Module

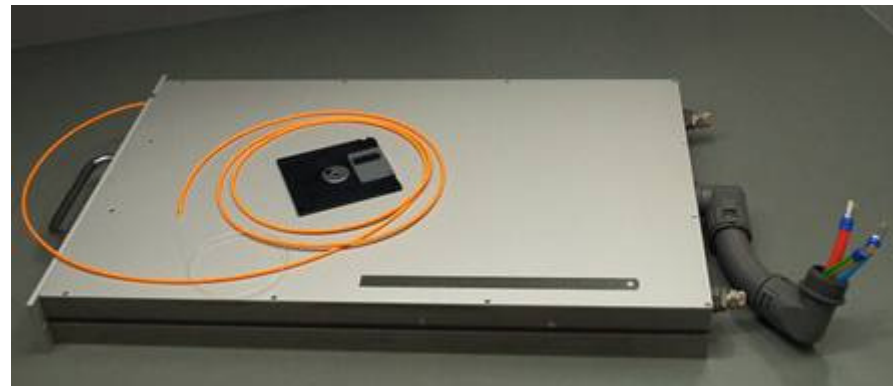


Typical $P=400\text{W}$
($P_{\text{max}} = 1400\text{ W}$)
 $\lambda = 1070\text{ nm}$

$\text{BPP} = 0.34\text{ mm} \times \text{mrad}$
($M2 < 1.05$)

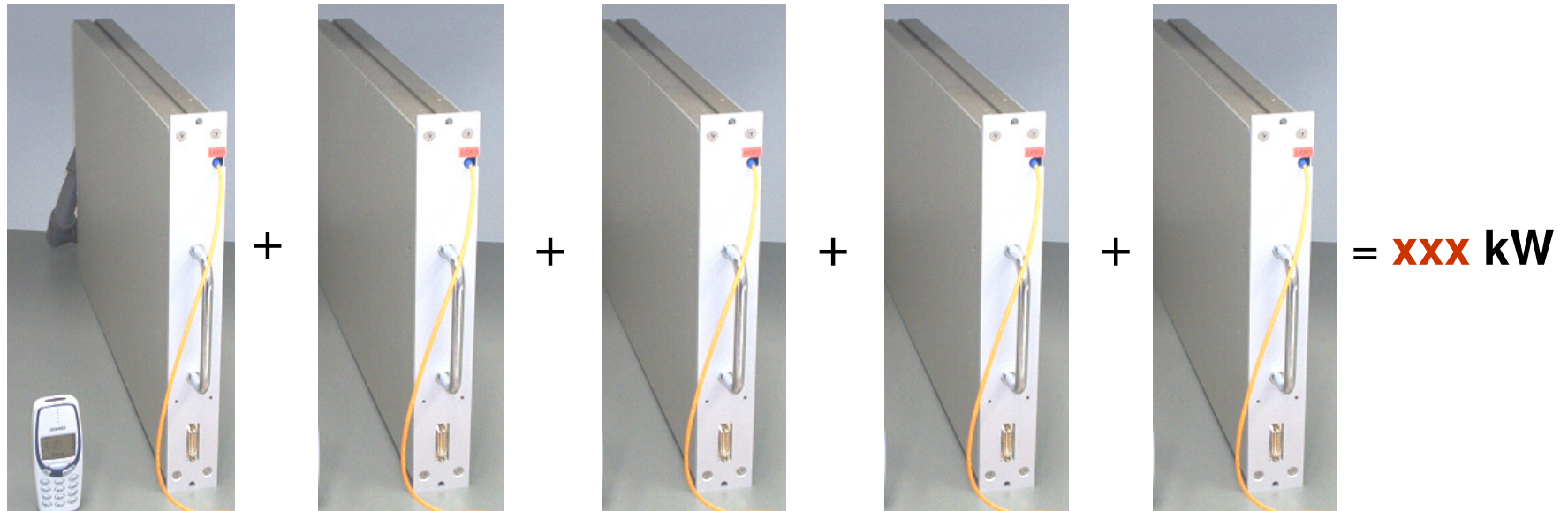
$\text{TxHxD} = 60 \times 33 \times 4.7\text{cm}$

Efficiency(DC) $> 35\%$





High Power Multimode Fiber Lasers



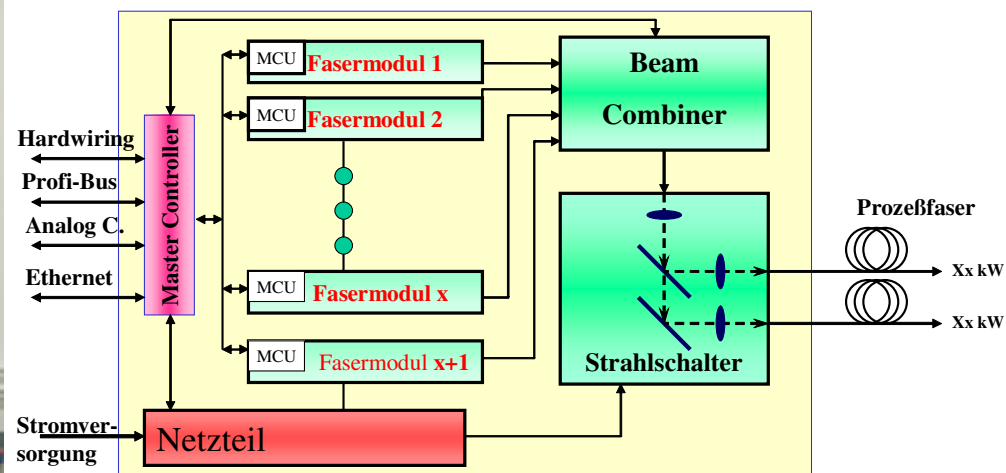
Modular Multi-KW Fiber Laser
Very High Beam Quality



High Power Fiber Laser



HPFL Layout



Power 1 – 50 kW

Advantage: Size, Weight, Mobility



2kW



5kW



10kW

- ☐ low weight
- ☐ mobil
- ☐ foot print < 1m²
- ☐ integrated beam switch*
- ☐ integrated heat exchanger or chiller*

*option



Size: CO₂ & Fiber Lasers

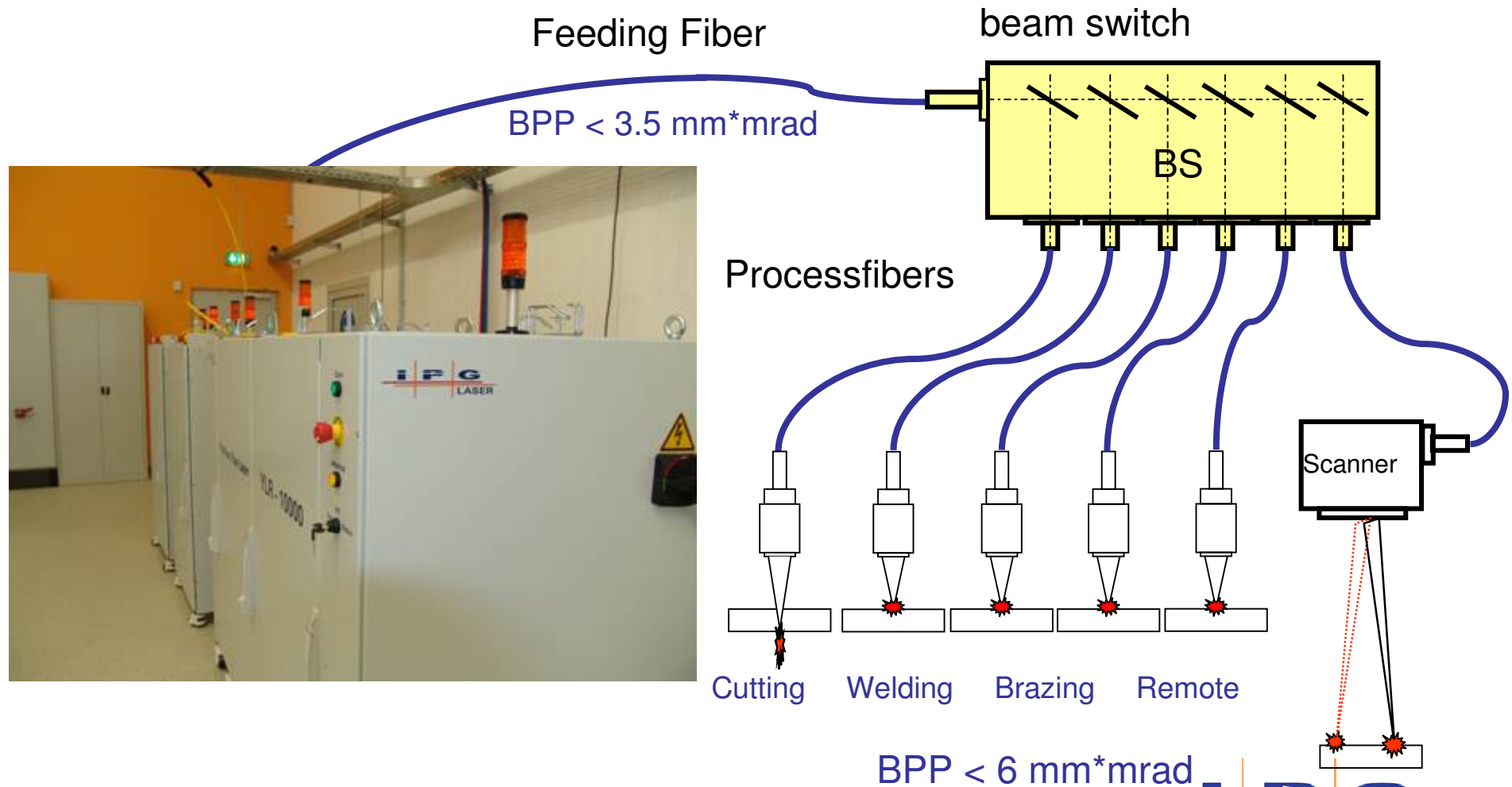
15 kW CO₂-Laser



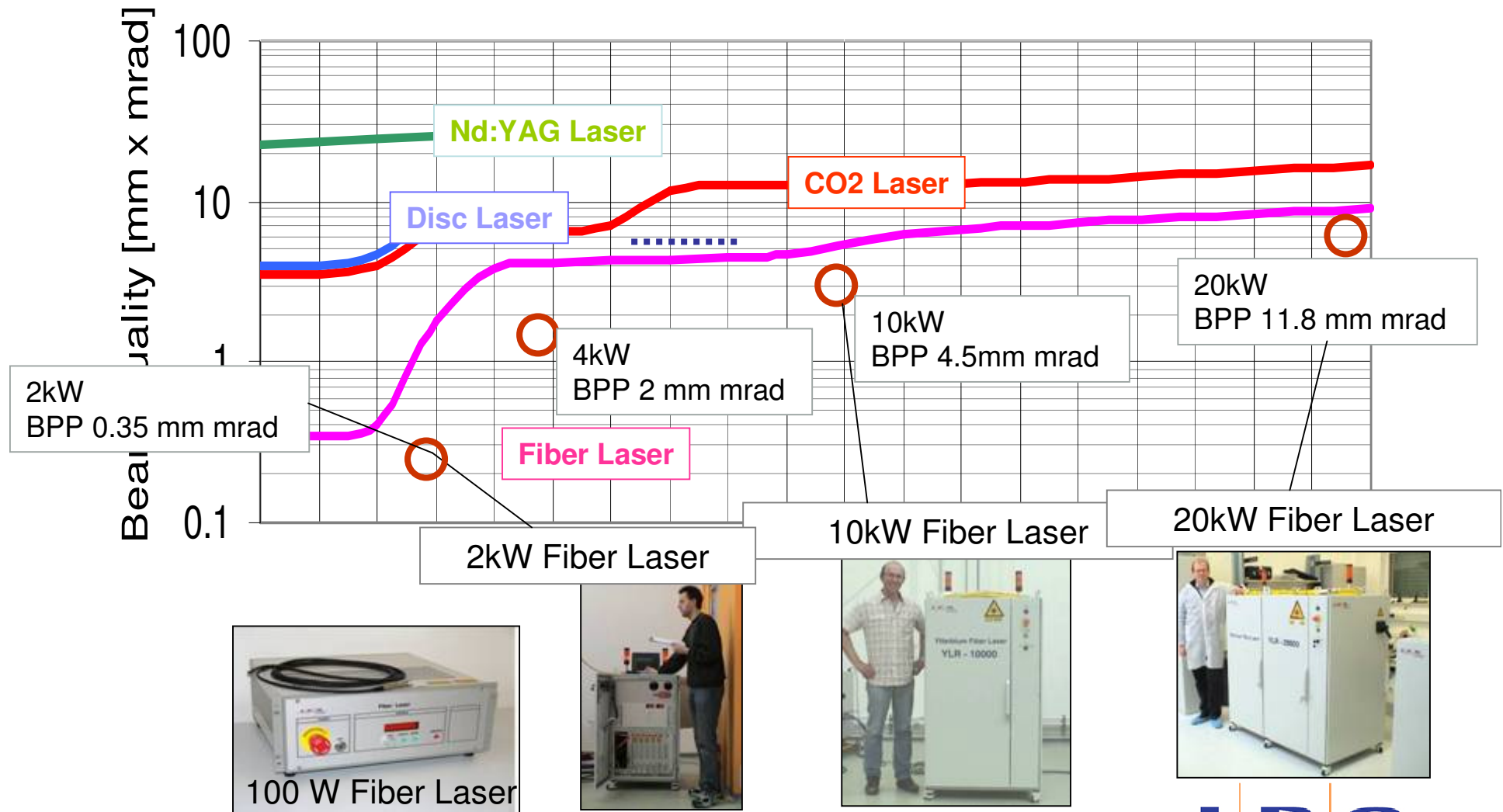
YLR-17000



Advantage: Flexibility & Productivity



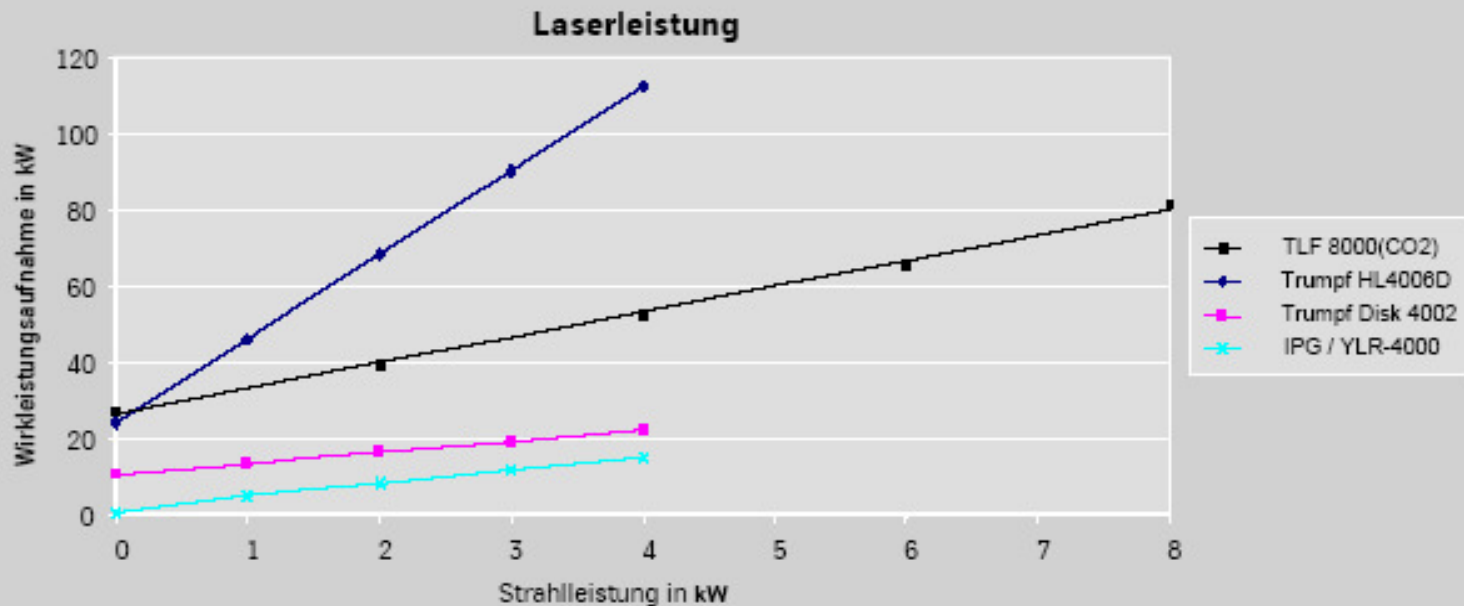
Advantage: Beam Quality



Advantage: Energy Consumption

Laserleistungsaufnahme

Erweiterung der Ergebnisse Laservermessung



ThyssenKrupp Steel





Technical and Economic Benefits

- **Modular and redundant**
- **Compact, low weight and mobile**
- **Easy integration**
- **High Beam Quality and Power**

- **Low Energy consumption**
- **Robust**
- **Varity of applications**
- **Easy to operate**
- **No wear parts**



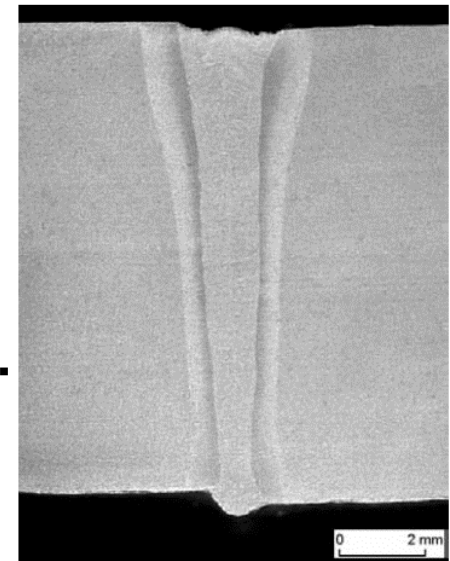


Fiber Laser Applications

- Singlemode applications
- Multimode applications

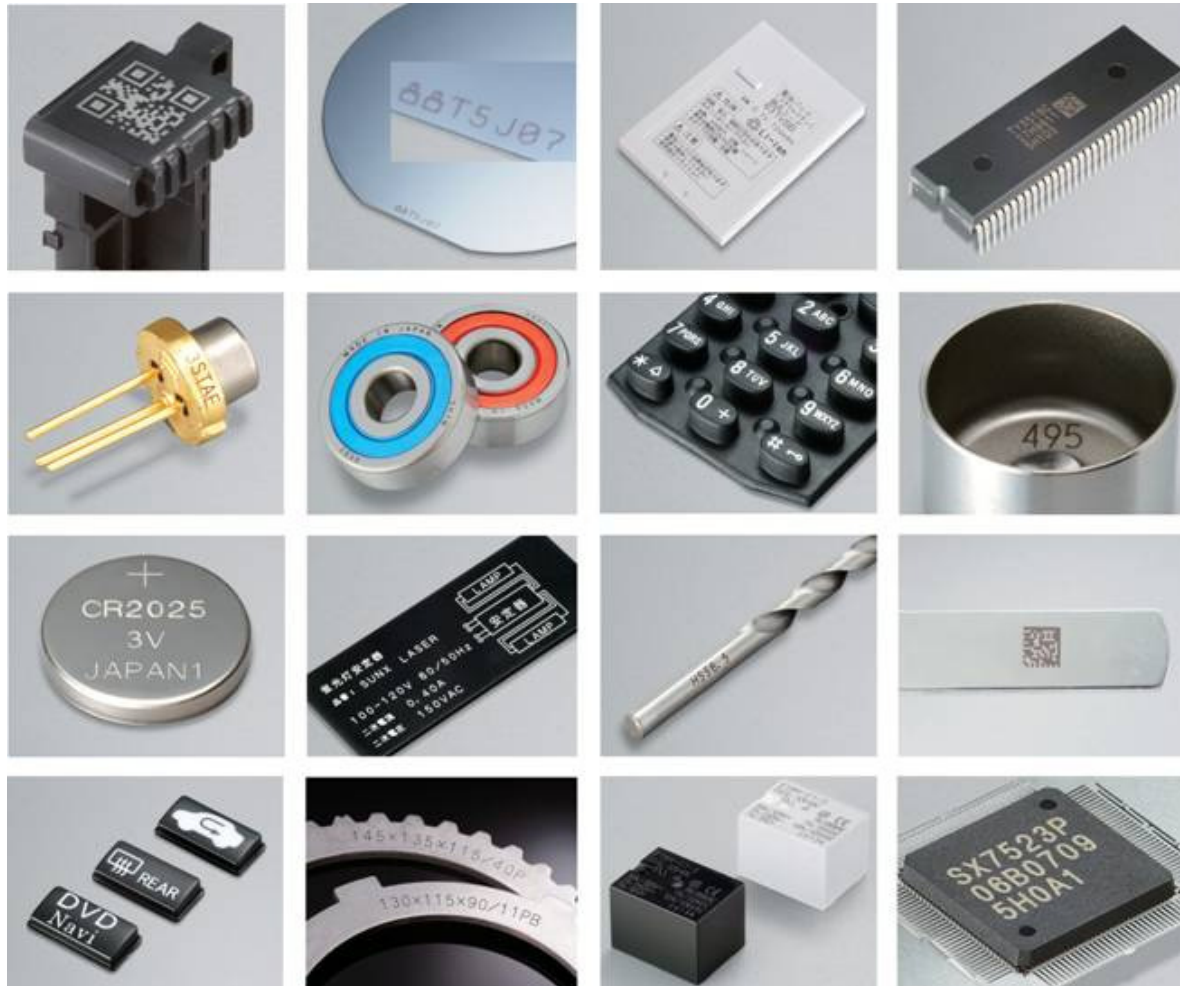


...from micro to macro ...





SM-Laser: Marking (qs&cw)

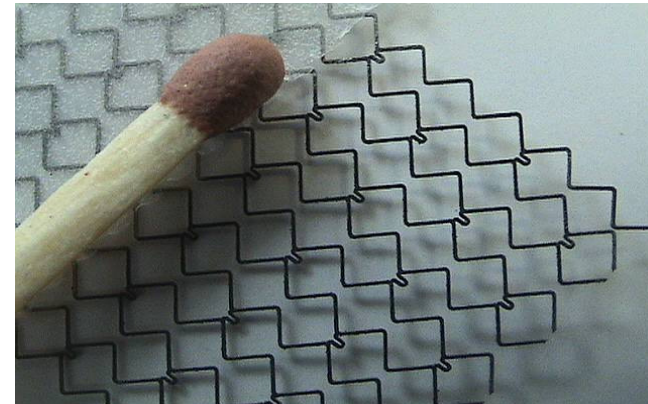


Source: Panasonic Electric Works

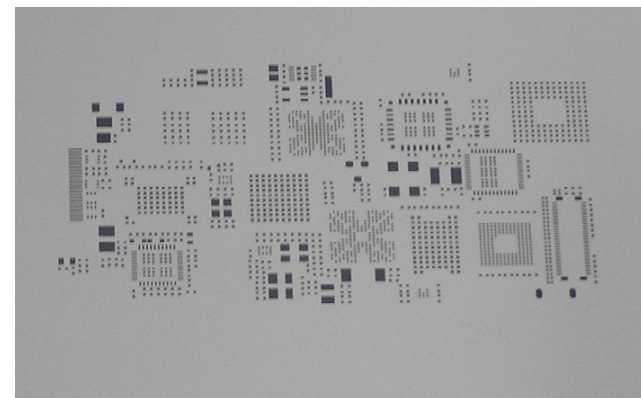




Cutting with SM-Fiber Lasers

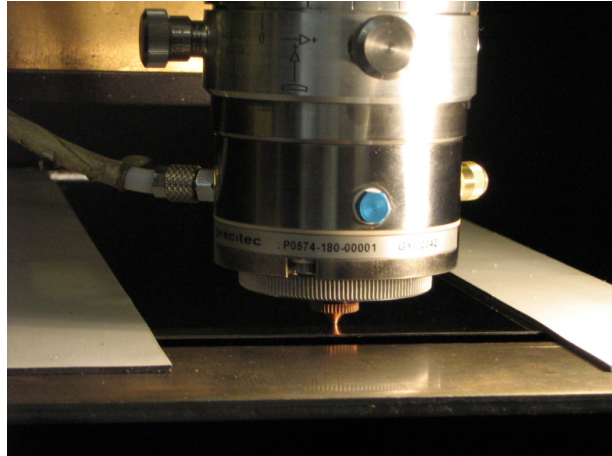


High precision, high speed, low heat input

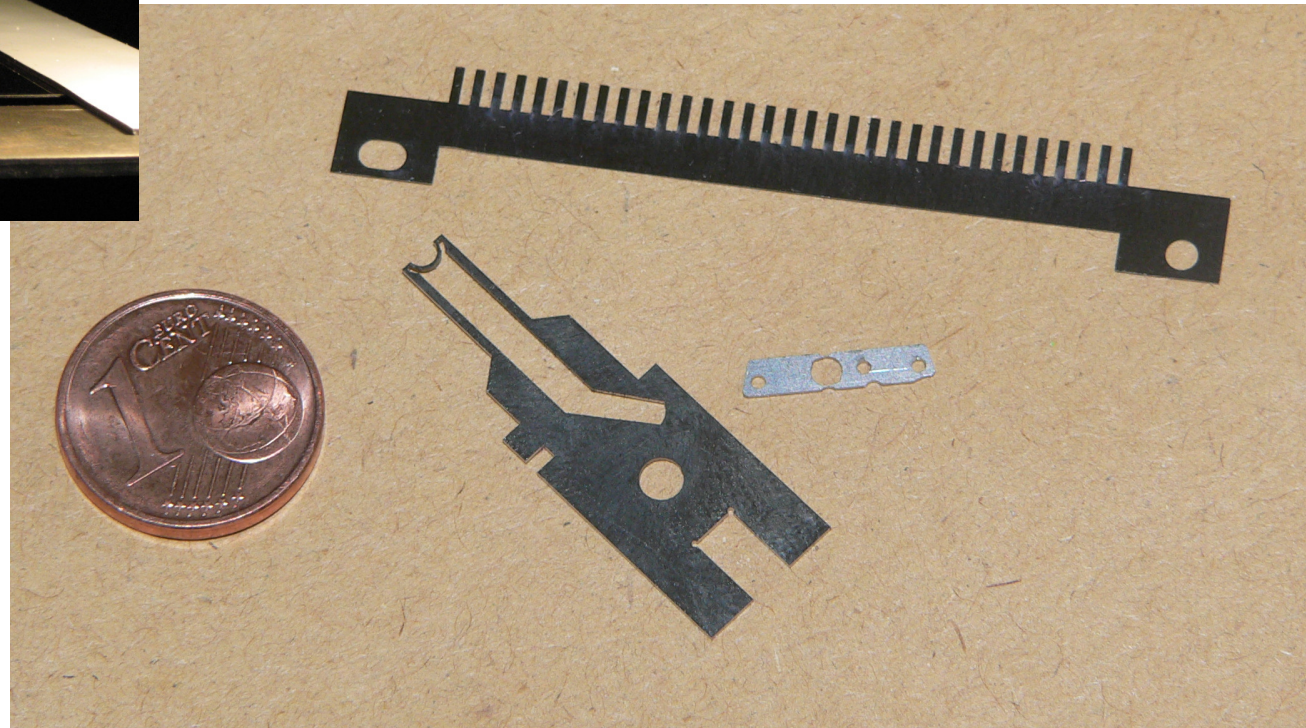




Cutting of Micro Parts



P= 100 – 200 W
Duty cycle 5 – 20 %

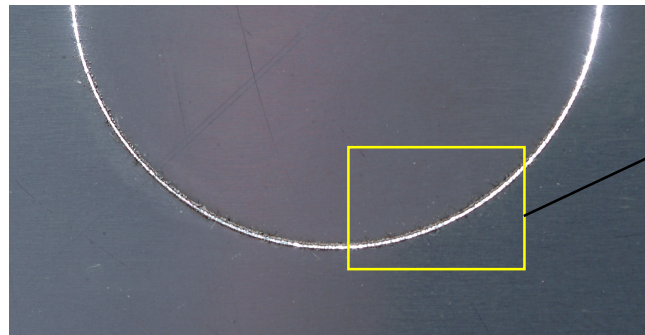


Remote Cutting- Future Application?

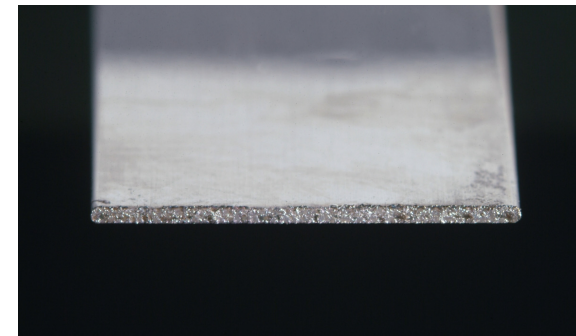
Setup



Results



- Laser Power: 1500 W
- Working Distance Scanner 200mm
- Material: Steel 1.4301
- Thickness 0,5 mm

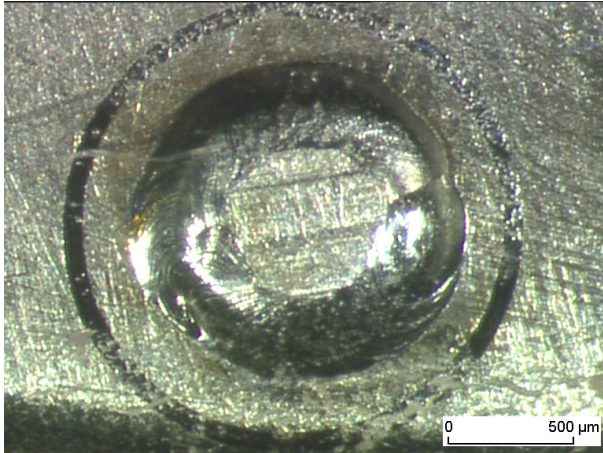


Courtesy of Fraunhofer Institute ILT, Aachen, Germany



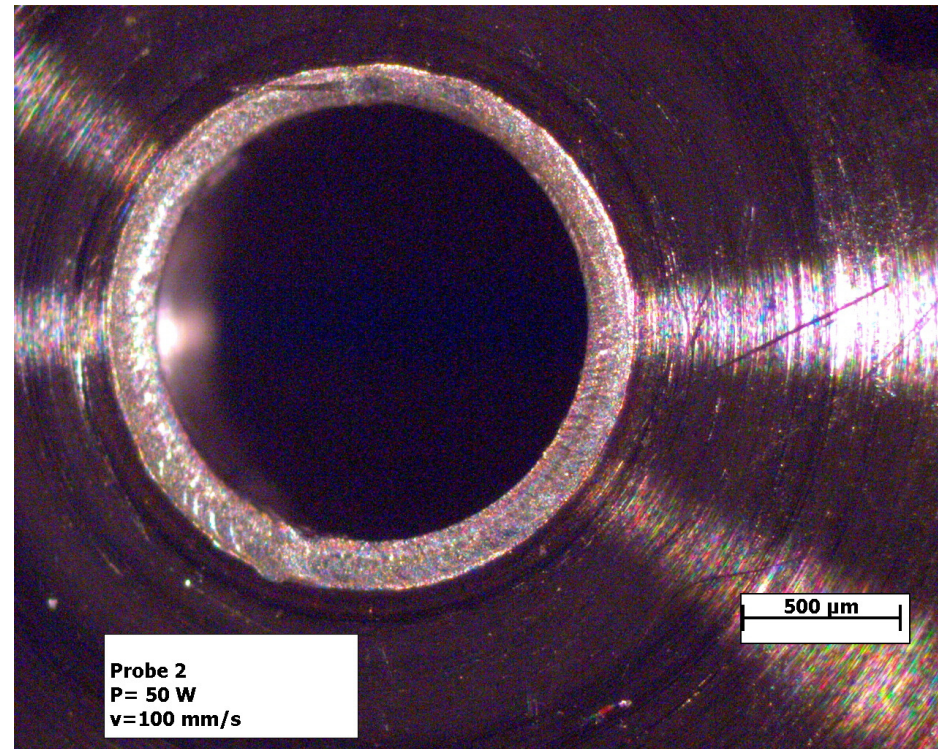


Mikro-Welding with Scanners

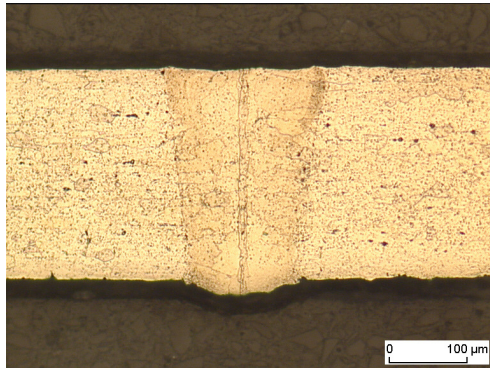


YLR 100SM
Scanner $f=100\text{ mm}$
 $P=50\text{ W}$
 $v=100\text{ mm/s}$

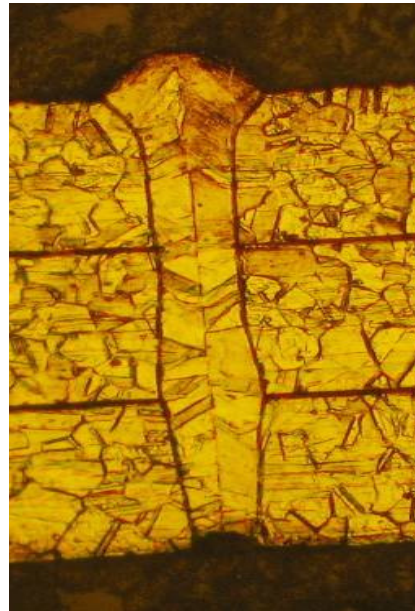
Tube-to-plate joint



Welding with Singlemode-Fiber Lasers

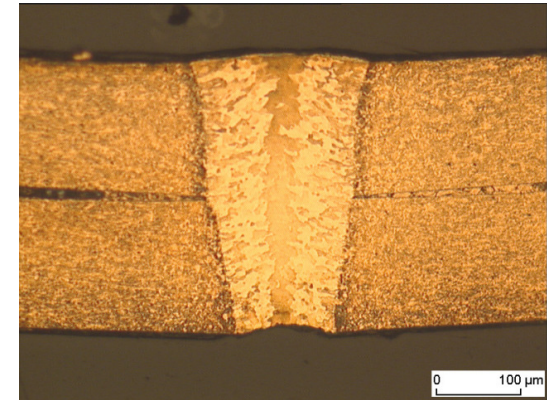


Aluminium

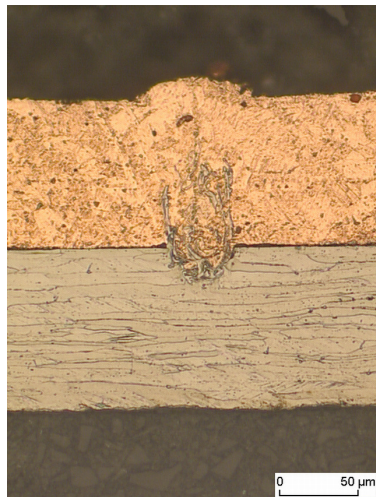


*Stainless steel
200W 80m/min*

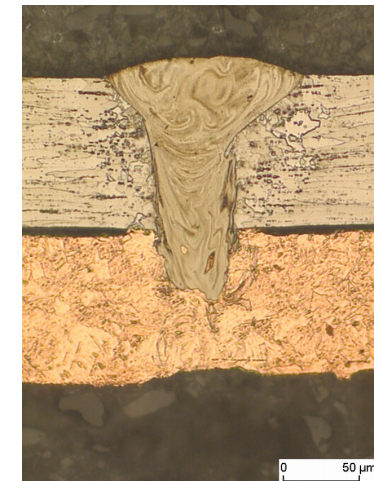
*Fe-Cu-
Joint*



Copper

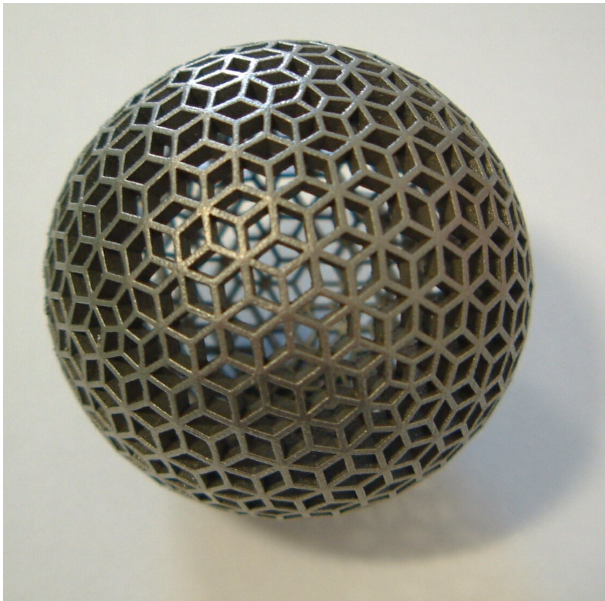


Quelle: BIAS

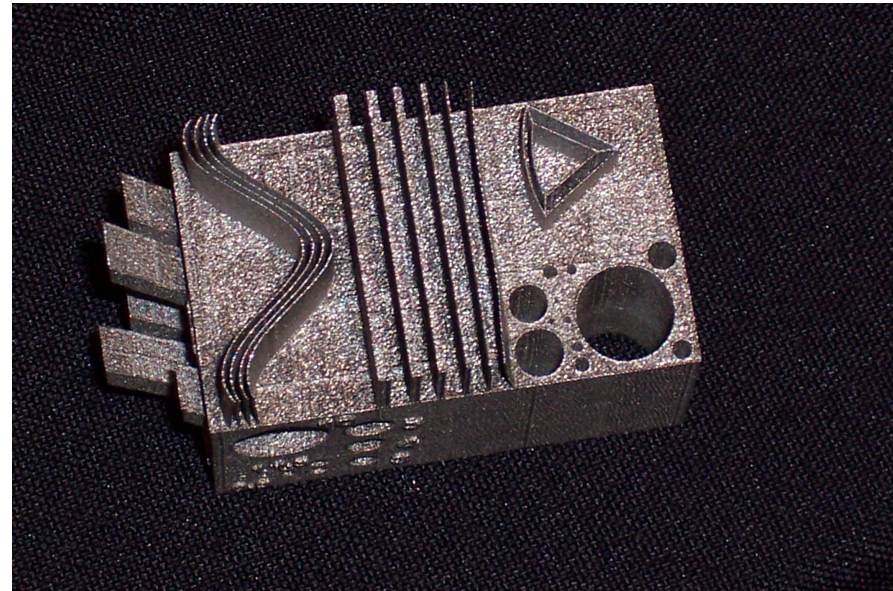




Laser Sintering – 200W Single Mode



Source: EOS

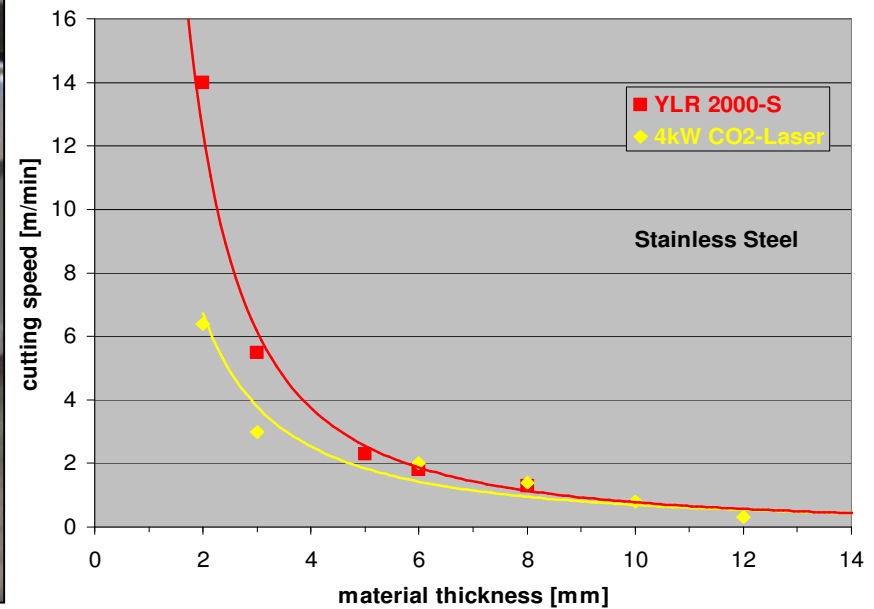


Metals, ceramics





Multi Mode Laser: 2D-Cutting

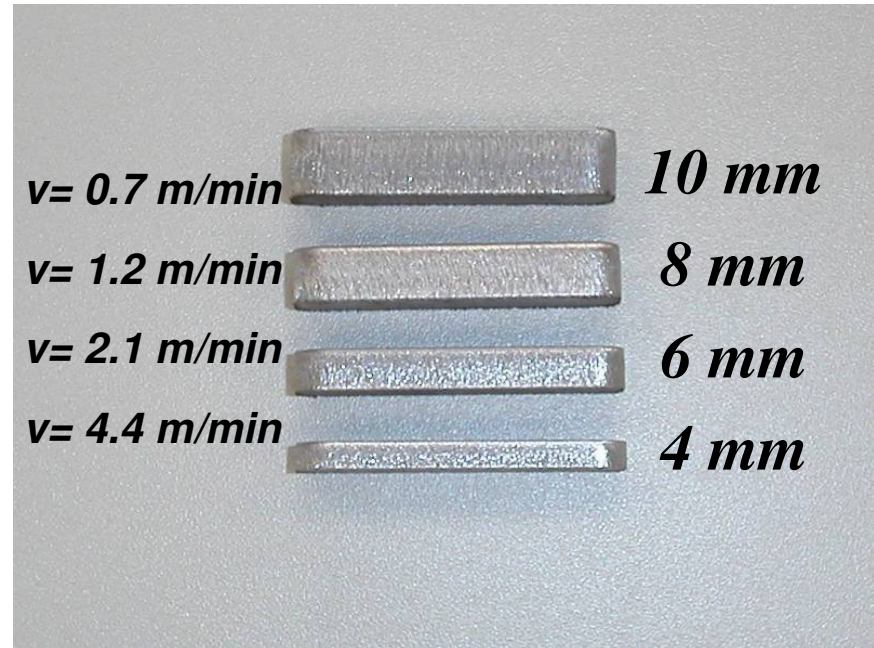
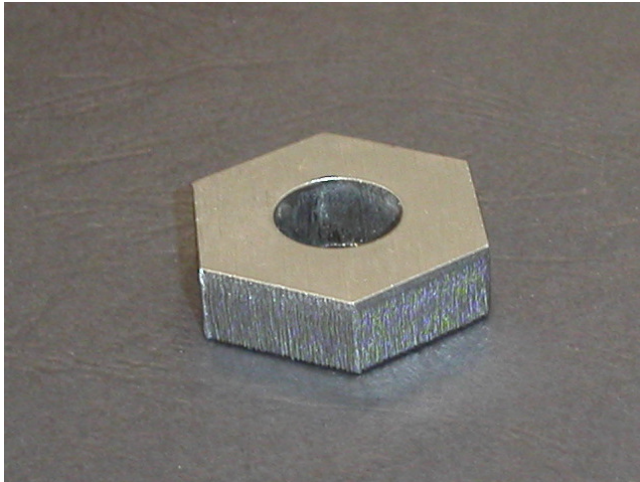


2D-flatbed cutting machine with 2kW fiber laser





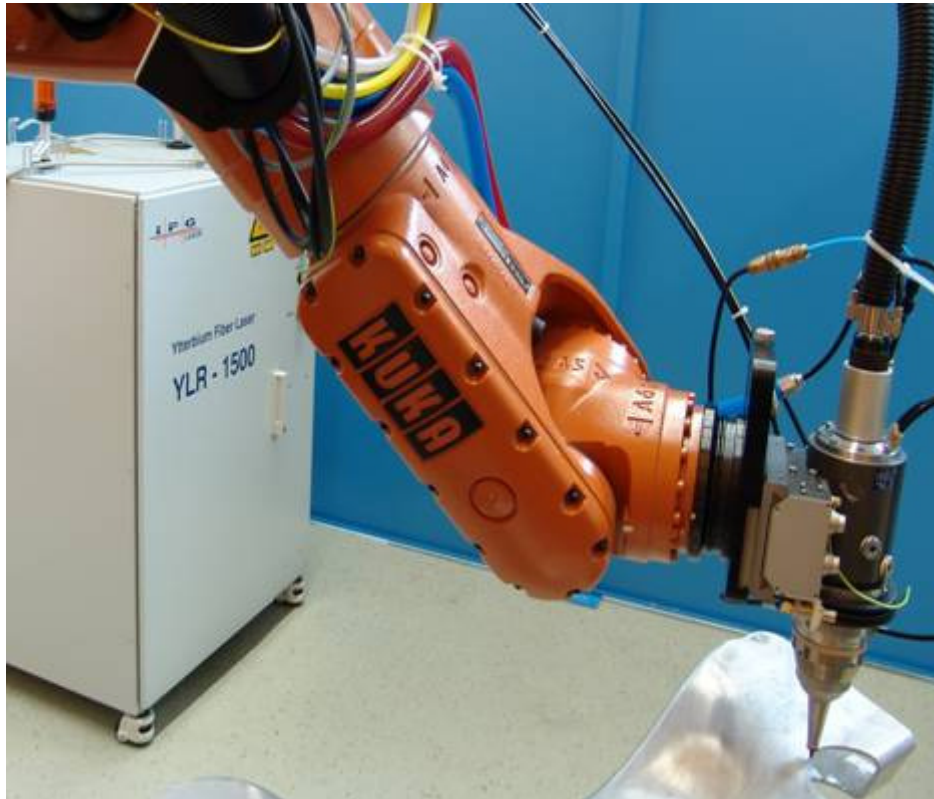
Cutting with 2 kW Fiber Laser



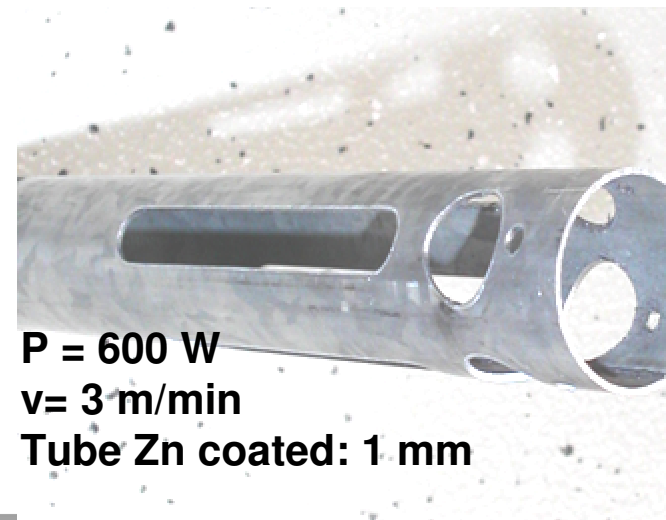
20 mm mild steel



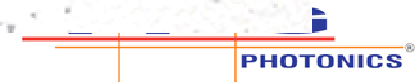
Multi Mode Laser: 3D-Cutting



Flexible Beam Guiding with fiber cable



**$P = 600 \text{ W}$
 $v = 3 \text{ m/min}$
Tube Zn coated: 1 mm**





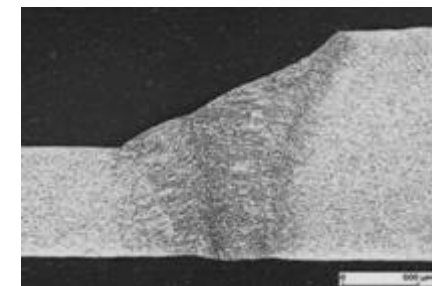
Fiber Laser in production



3D-Cutting cell with 4 Lasers



Multi Mode Laser: Welding

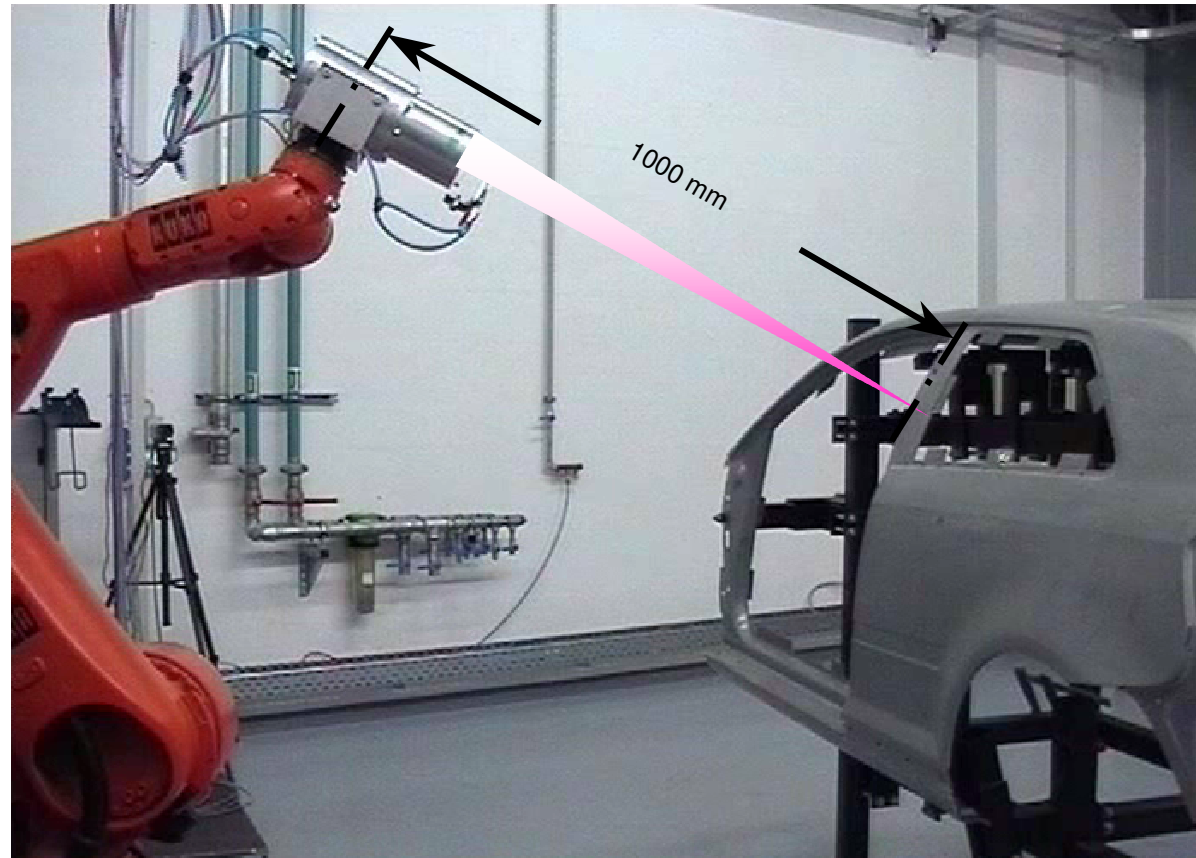


Tailored Blank Welding System
 $P=5\text{kW}$, $v=12\text{m/min}$, $s=0,8-1,4\text{mm}$





Remote Welding of Body in White (BIW)

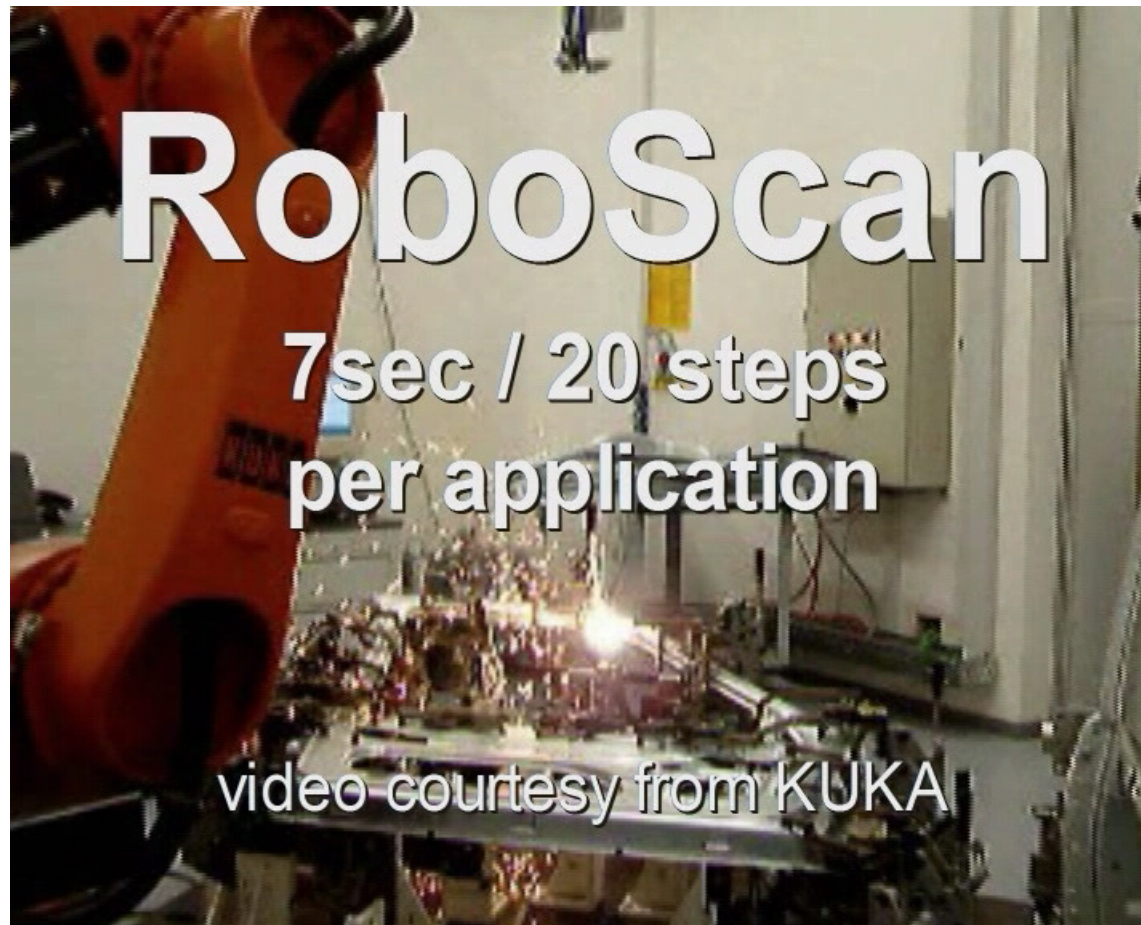


Better access with longer focal length





Remote Welding of Body in White (BIW)



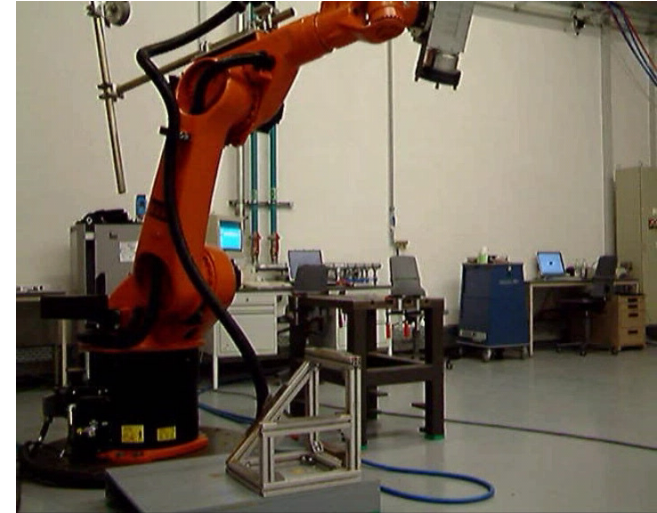
Highly productive stitch welding for body in white



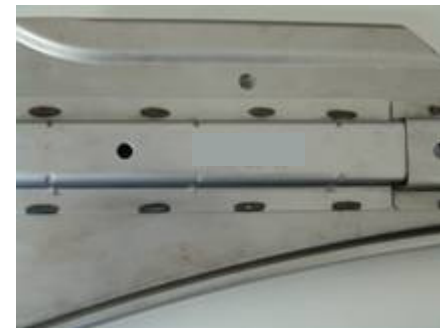
3D-Remote Welding without Scanner



Distance: 500 – 1500mm
Spot diameter: 0.6mm

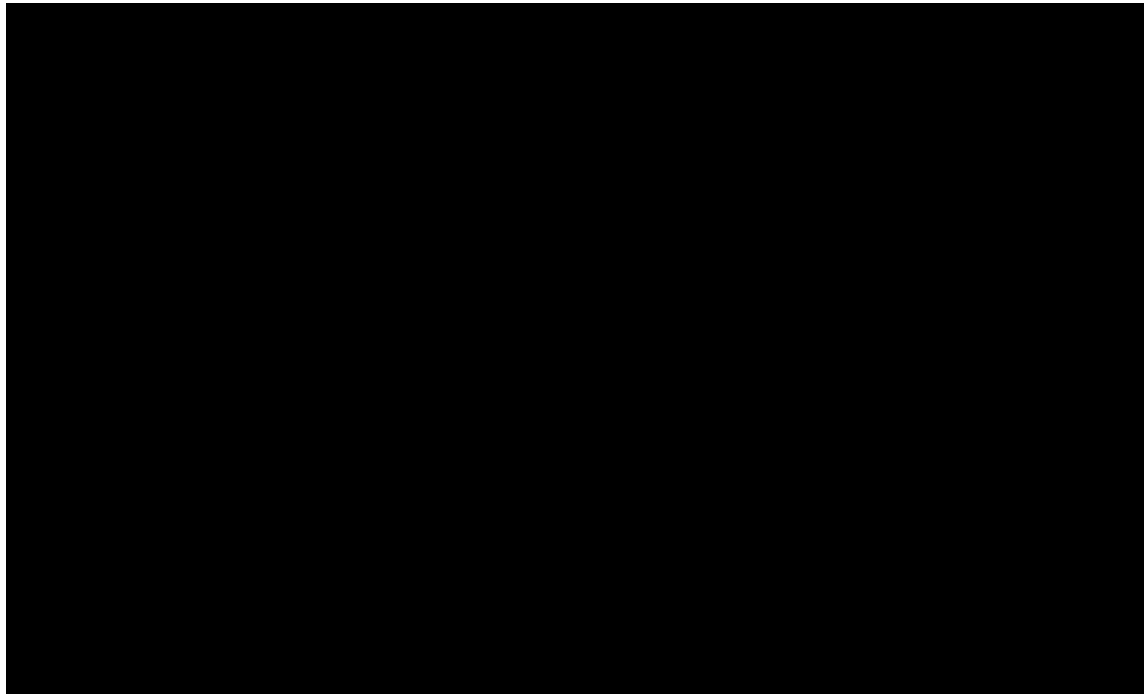


Video: Kuka Schweißanlagen





3D-Remote Welding with Scanner





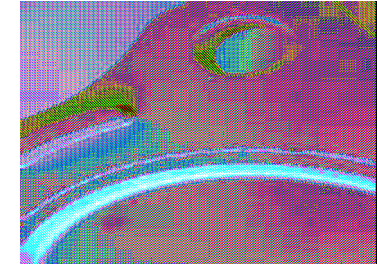
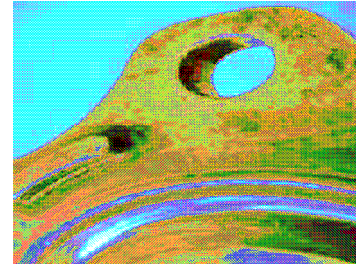
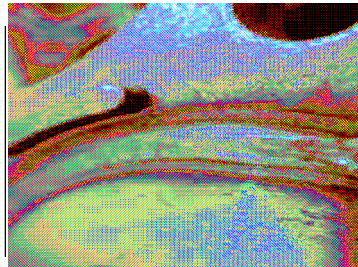
Welding of Gear Box Parts

CO₂-Laser

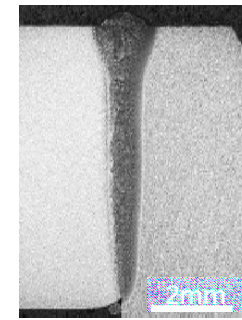
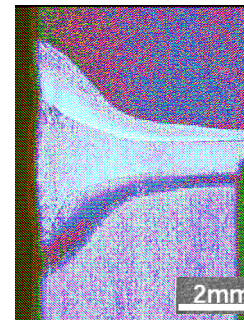
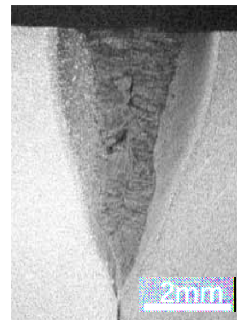
Electron beam

Fiber Laser

Fraunhofer
IWS
Institut
Werkstoff- und
Strahltechnik



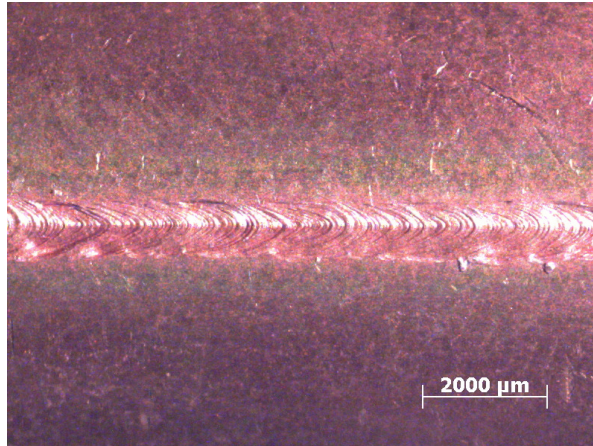
YLR4000-S
BPP 1,8 mm*mrad



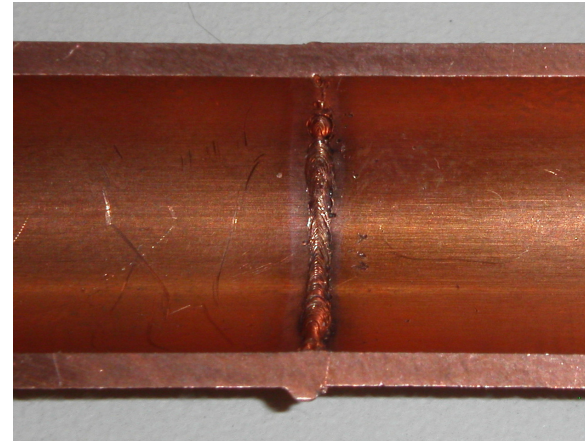
- Low heat input → Low distortion
- Reduced crack risk



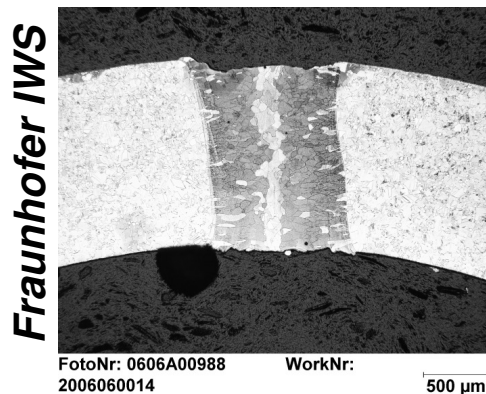
Welding of Copper



Longitudinal
($t = 1,4 \text{ mm}$)



circumference
($t = 1,4 \text{ mm}$)



Laser YLR5000

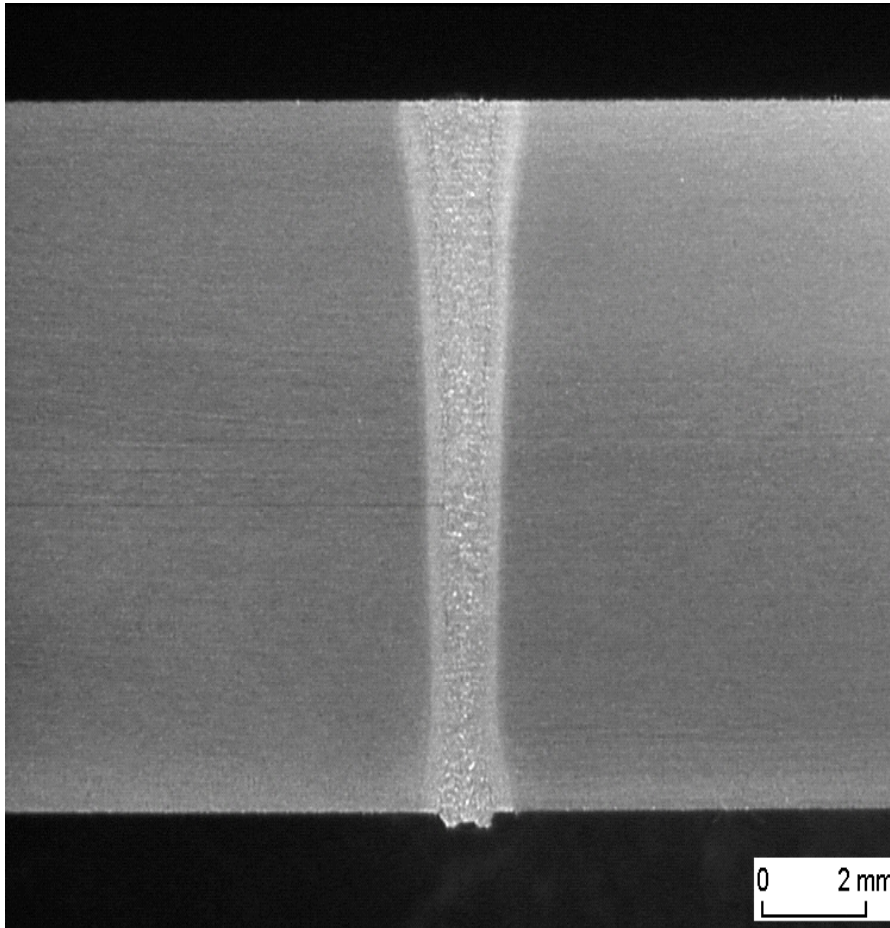
Fiber diameter $d_F = 100 \mu\text{m}$

Focal length $f = 300 \text{ mm}$

$P = 3 - 5 \text{ kW}$



10kW CW Ytterbium Fiber Laser

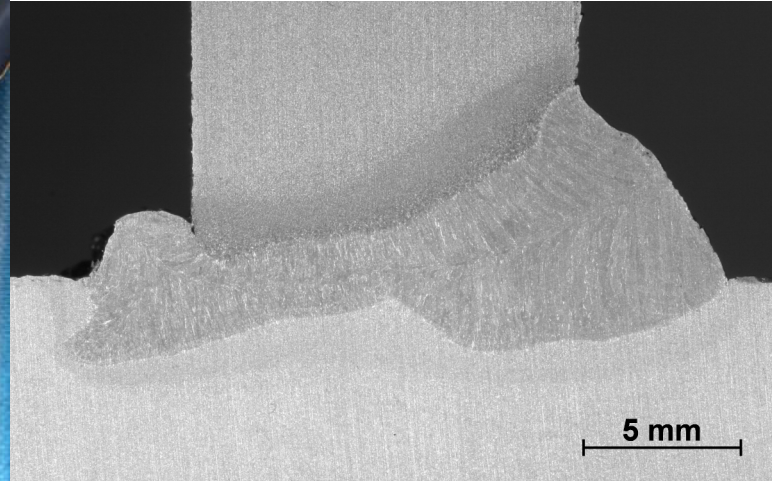


Pipeline Steel X70, 12 mm

Laser Power: 10.2 kW
Fiber Core: 200 μm
BPP: 11.5 mm x mrad
Welding Speed: 2.2 m/min



Hybrid Welding: Offshore



Offshore Application

$P=10\text{kW}$

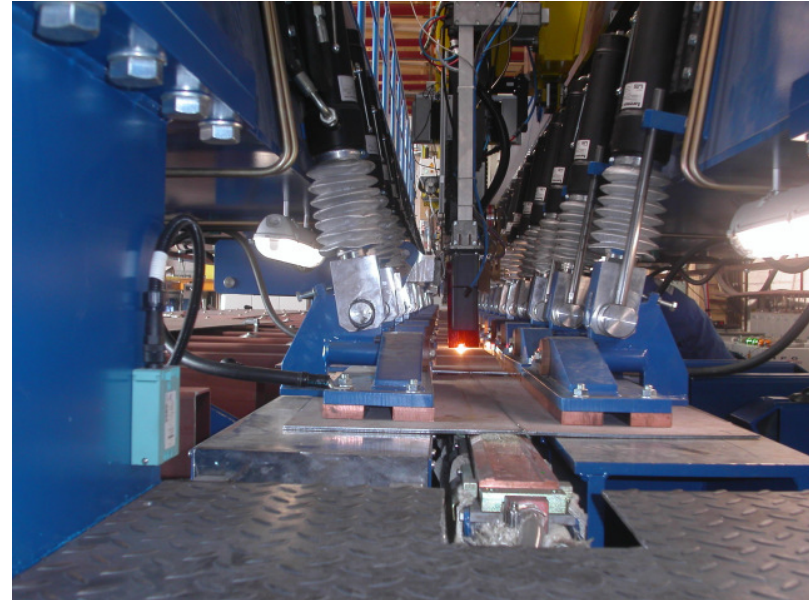
$v=1,5\text{m/min}$

Flange thickness: 15mm

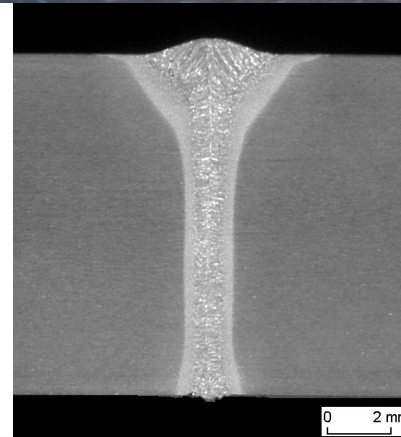




Hybrid Welding: Ship Yard



Quelle: BIAS



***Laser-Hybrid
X70***

$t = 12 \text{ mm}$

$P_L = 10.5 \text{ kW}$

$v_S = 2.2 \text{ m/min}$





Hybrid Welding Panel Line



Aker Finyards, Turku, Finland





Conclusion

- Fiber lasers have made major impact in the global material processing market
- The reliability has been proven on multiple material industrial applications at all power levels
- The performance of fiber lasers exceeds previous laser technologies while offering substantial cost benefit to users
- Fiber lasers have expanded the market for laser material processing
- 20kW and 36 kW are realized
- 50kW and more is possible, looking for application





IPG Application Lab in Burbach



- **Mikro/Makro Cutting**
- **Mikro/Makro Welding**
- **Hybrid Welding**
- **Remote Welding**
- **Marking**

Heartly Welcome and thanks for Your attention !

