

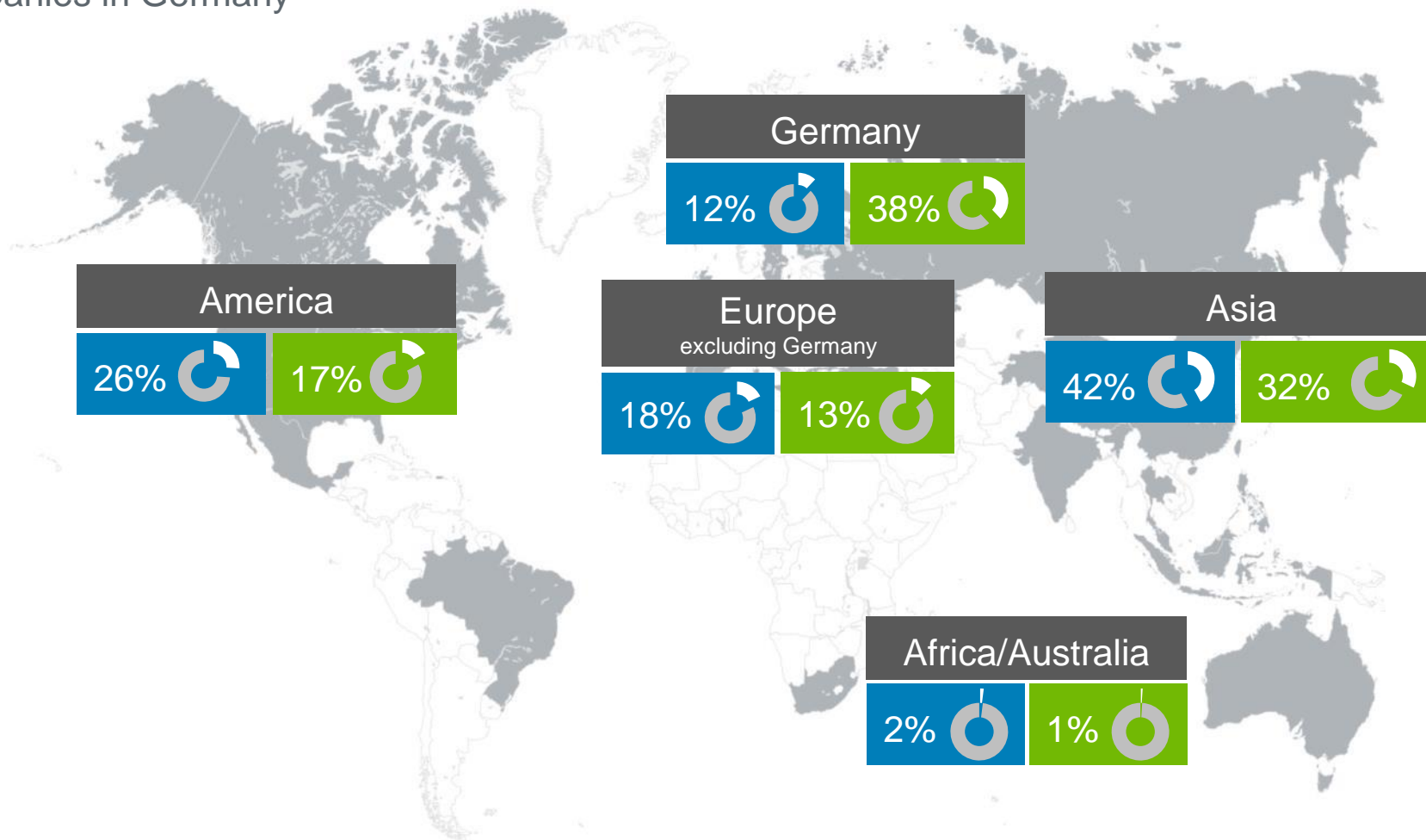
FIBER LASER ACTIVITIES AT HERAEUS QUARZGLAS

COST meeting Jena, 19.09.2017, [Gerhard Schötz](#), Andreas Langner



HERAEUS – A GLOBAL COMPANY

- › One of the biggest family owned companies in Germany
- › More than 100 sites in 38 countries
- › The shareholder's group contains approx. 240 persons
- ›  Total revenues of €12,9 billion in 2015
- ›  More than 12,500 employees



COMPANY STRUCTURE

Global Business Units (GBU)

Heraeus Precious Metals – HPM

Heraeus Electronics – HET

Heraeus Photovoltaics – HPT

Heraeus Medical Components – HMC

Heraeus Medical – HME

Heraeus Electro-Nite – HEN

Heraeus Quarzglas – HQS

Heraeus Noblelight – HNG

Heraeus Emerging Businesses – HEB

Incubator New Businesses – INB

Group Functions

Communications & Marketing

M & A

Human Resources

Environment, Health & Safety

IT & Digital Agenda

Global Procurement

Legal &
Responsibility Management

Operations Excellence

Accounting

Heraeus Site Operations

Controlling

Regional Center
East Asia (Singapore)

Treasury

Regional Center (USA)

Tax, Customs & Export Control

Regional HQ China

Auditing

HERAEUS QUARZGLAS: FUSED SILICA PRODUCTS AND SOLUTIONS



Base Materials

- › Pre- and semi-finished quartz products (tubes, plates, ingots opaque quartz products)



Lamp Materials

- › Doped / un-doped fused silica tubes and sleeves for specialty lamps and in UV and Excimer Laser applications



Fabrication

- › Quartz glass components for the production of microchips and solar cells
- › Repair and refurbishment services



Telecom Fiber

- › High purity fused silica tubes for core rod manufacturing
- › Large RIC© Cylinders as cladding for telecom fibers



Specialty Fiber

- › Specialty fiber preforms and tubes for medical, industrial and sensing applications
- › Fiber laser fibers and preforms

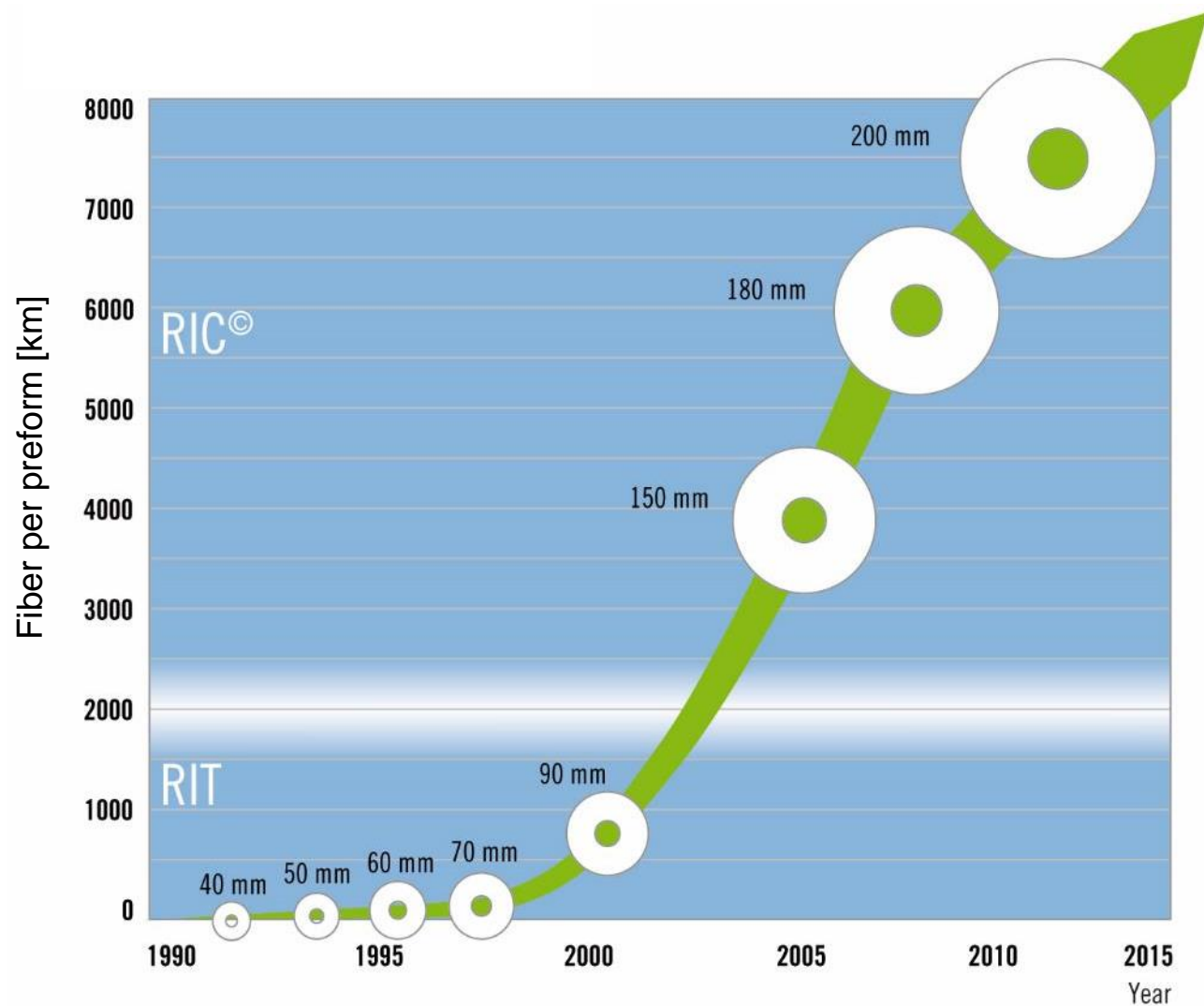


Optics

- › Synthetic fused silica lens blanks for microlithography
- › Optics for high energy laser projects and applications
- › High purity fused silica products for commercial optics applications

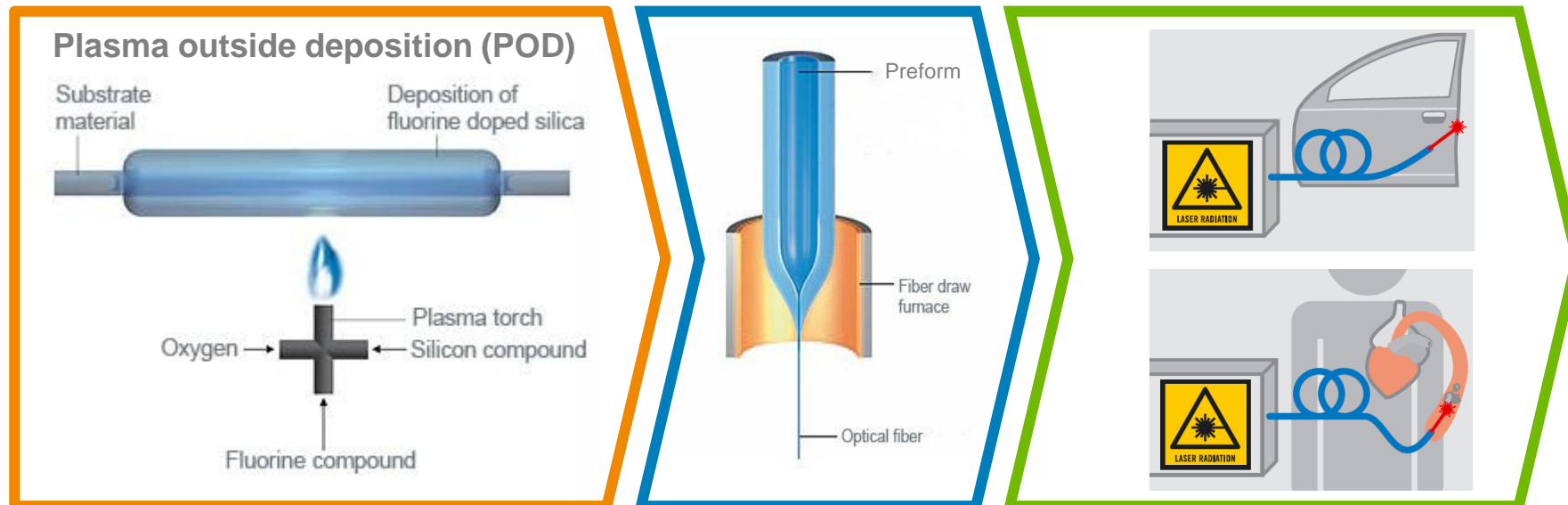
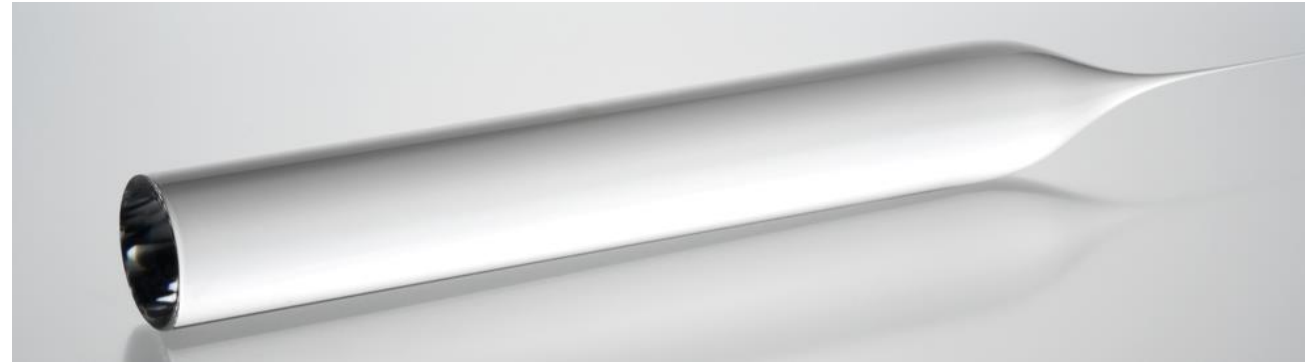
We give value to our customers by providing products and solutions that offer unique technical performance and lower cost of ownership.

PREFORM SIZE EVOLUTION FOR TELECOM PREFORMS

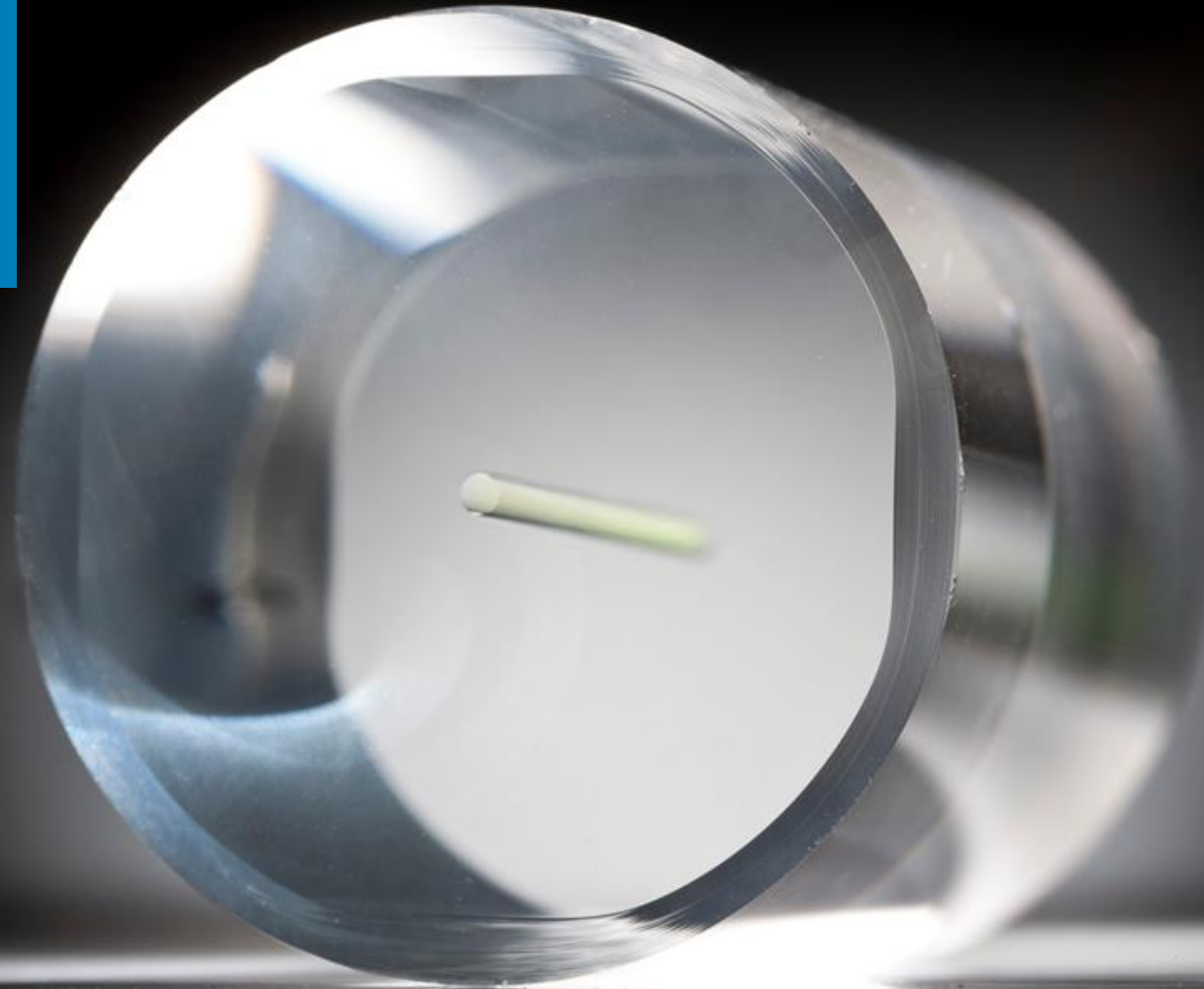


Economy of size

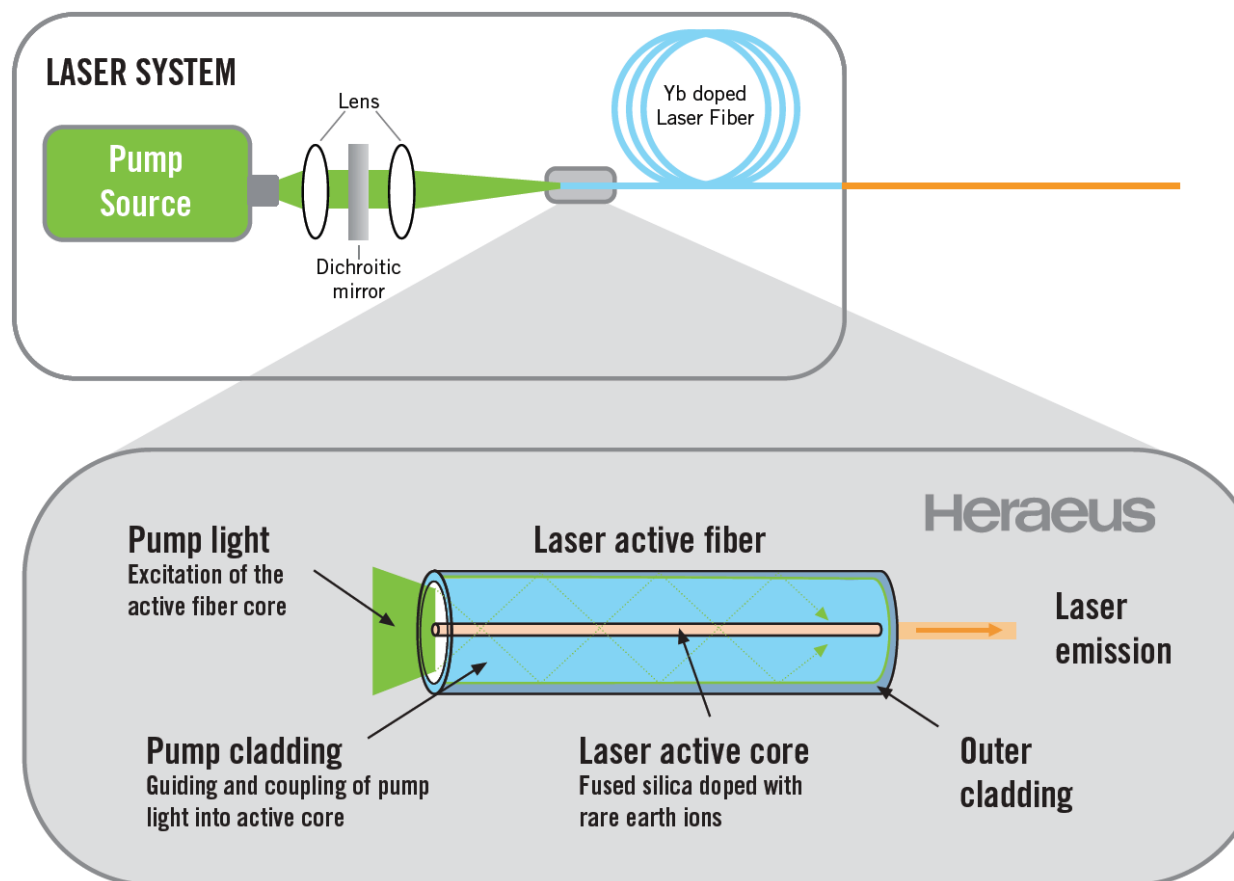
FLUOSIL® PREFORMS



FIBERLASER
PRODUCTS



FIBER LASER PRINCIPLE



Substrate tubes for fiber laser preform production

Product

Substrate tubes



Types

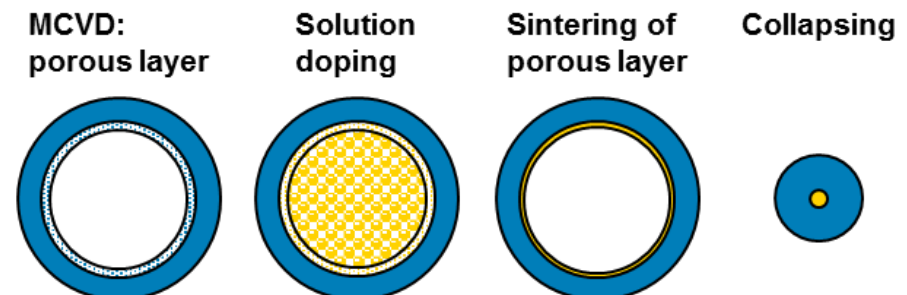
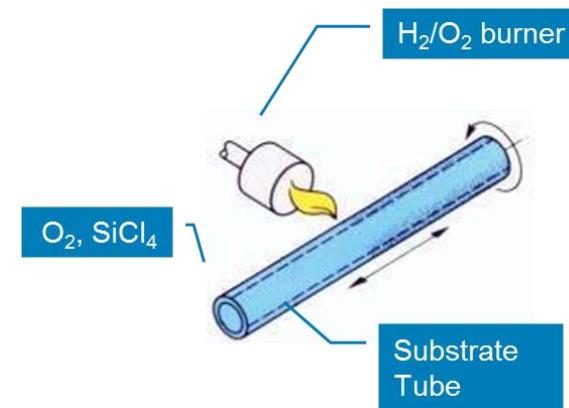
F300/F500: undoped, Cl \leq 2500 ppm

F300HP: improved ovality and siding

F320-xx / F520-xx: F doped

Application

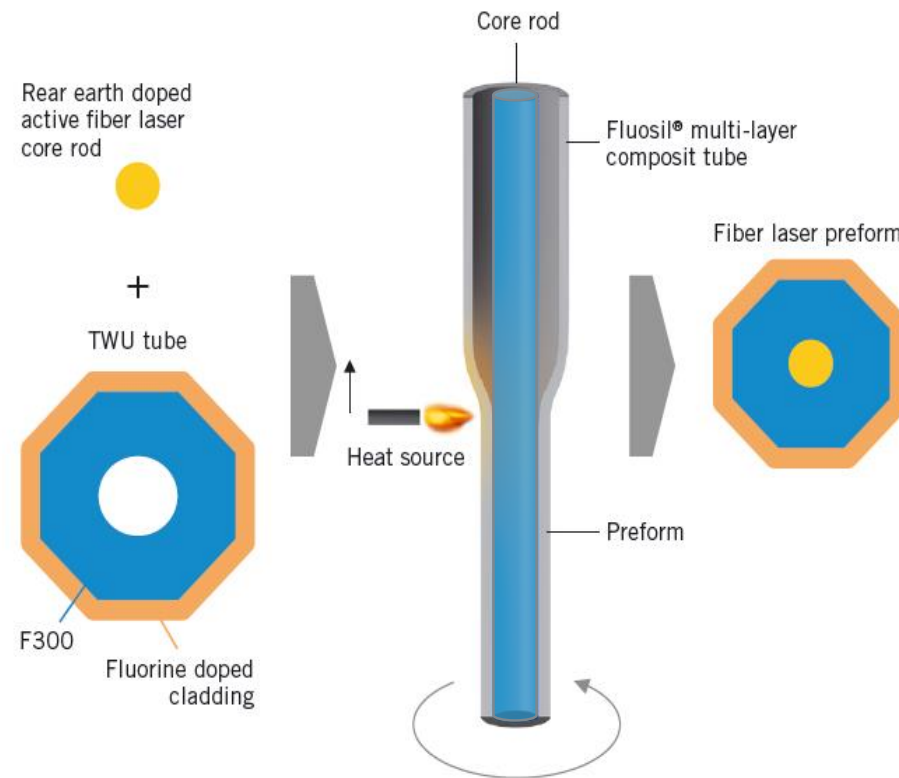
MCVD solution doping



STRUCTURED SANDWICH JACKETING TUBES FOR FIBER LASER CORE RODS

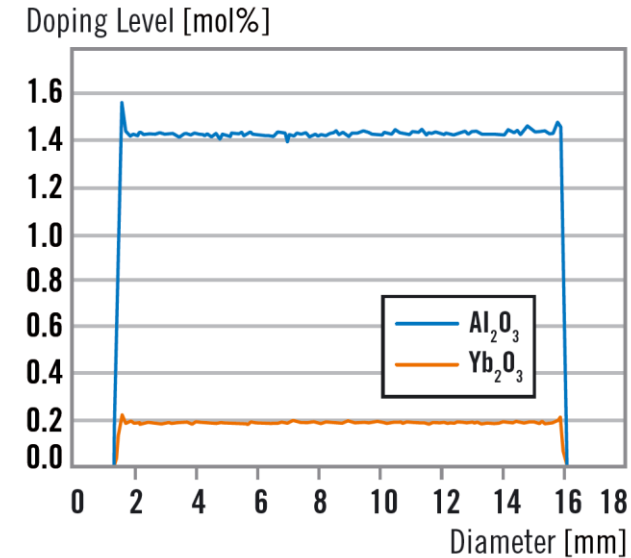
- Complex jacketing tube designs realized by Heraeus „toolbox“ (POD, machining, polishing,...)
- Sandwich tube:
F300 silica inside and highly F-doped silica (Fluosil®) outside
- Complex inner interface designs (e.g. D-shaped, 4D, octagonal, hexagonal)
- Tubes well suited to overclad rare earth doped core rods

Overcladding Process

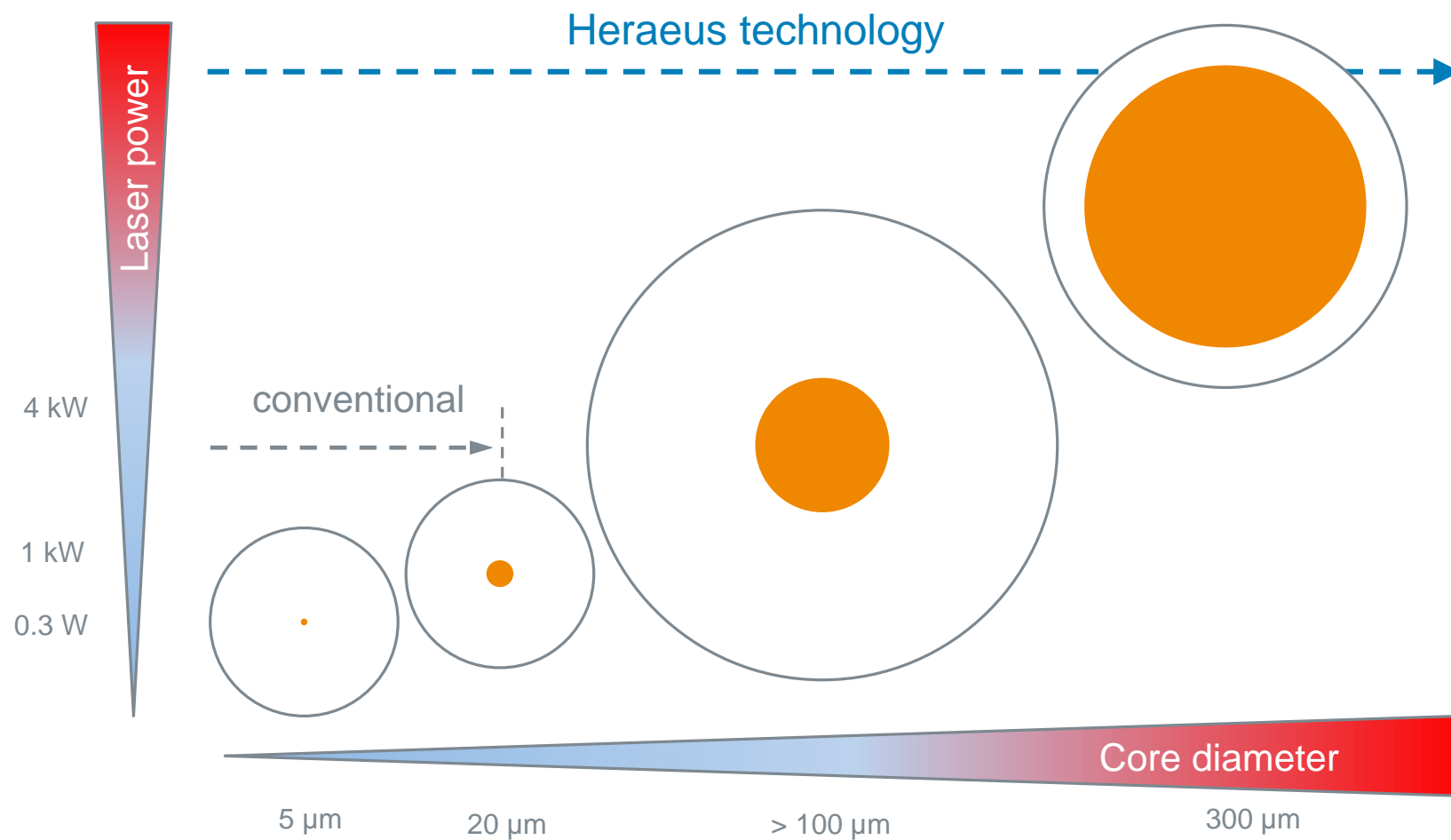


YB DOPED FUSED BULK SILICA („REPUSIL“ PROZESS)

- High doping levels
(up to 0.25 mol % Yb_2O_3)
- High purity synthetic silica
- High batch-to-batch reproducibility
- **Excellent homogeneity**
- Radial and axial uniform doping level
- Excellent doping level predictability
- **Large rod size**
($\varnothing_{\text{typ.}} \sim 15 \text{ mm}$, $L_{\text{typ.}} \sim 150 \text{ mm}$)
- Very well suited for high power fiber lasers
- Enables novel laser designs (e.g. XLMA)



TREND: POWER SCALING OF LASER FIBERS

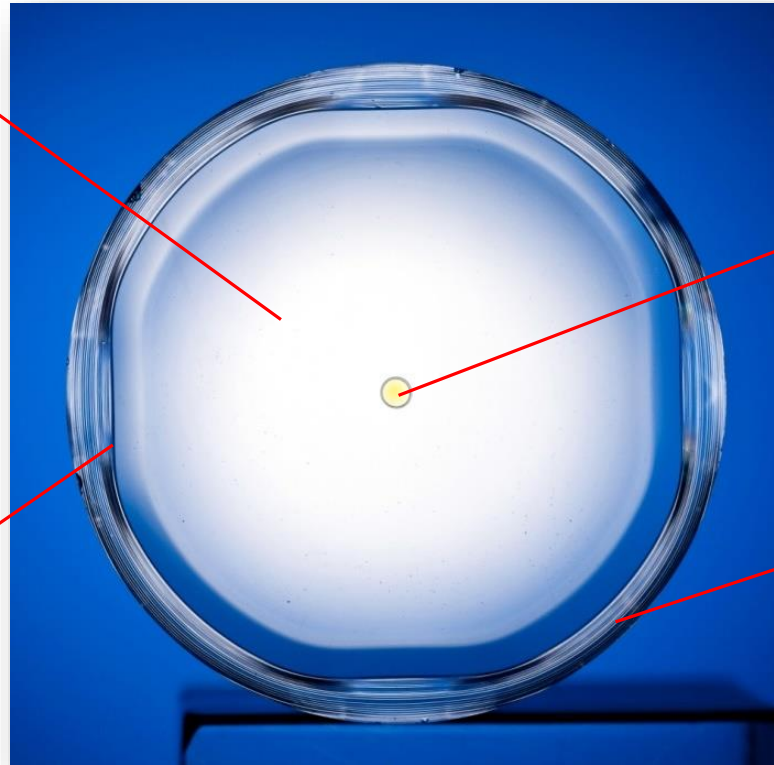


EXTRA LARGE MODE AREA (XLMA) LASER FIBER

Un-doped silica

Jacketing process

Precise machining



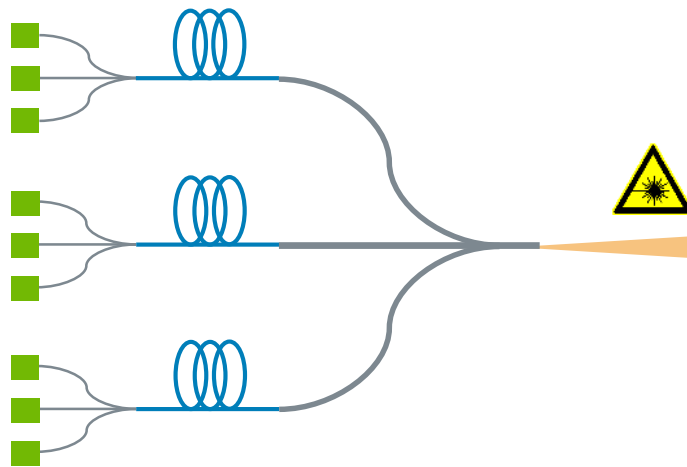
Laser core
(\varnothing 50 ... 100 μm)

F-doped silica
(POD)

Heraeus has all technologies in house!

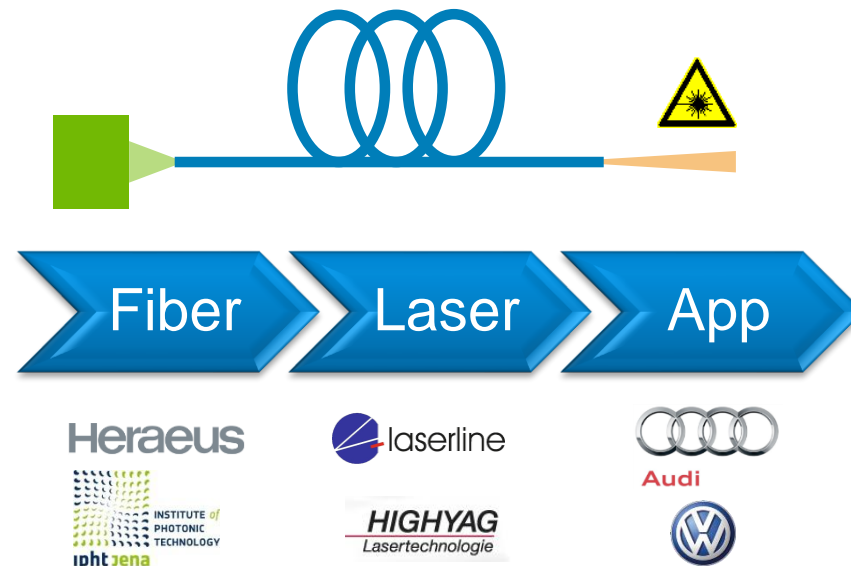
Multi kW Fiber Laser Concepts

Conventional concept



- Complex
- Susceptible (back reflections)
- Expensive

New concept (XLMA fiber)



- Simple design
- Robust
- Economic



Marketing of special XLMA fibers with Nufern: NUXLMA-Fiber

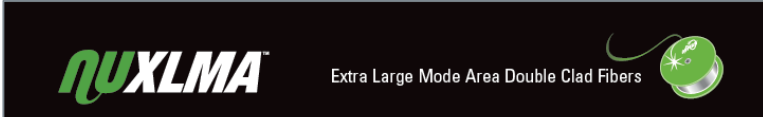


**Extra Large Mode Area
Double Clad Fibers**

The New Frontier In Fibers for Lasers
Nufern is expanding its broad range of double clad fibers with Extra Large Mode Area (XLMA) fibers using Heraeus' proprietary process for making large core doped glass. The XLMA ytterbium doped fibers provide users with high absorption and large core areas for multi-kW, multimode lasers and high pulse energy amplifiers. These fibers are also extremely well suited for making amplified spontaneous emission (ASE) sources with low spatial and temporal coherence which makes them ideal sources for full-field imaging and ranging applications. The fibers are offered with a triple clad geometry enabling multi-kW average powers and multi-MW peak powers. This new class of XLMA fibers is expected to expand the frontiers of fiber lasers, amplifiers and ASE sources in materials processing, imaging and ranging applications.

NUFERN
www.nufern.com

OPTICAL FIBERS — FIBER GYRO COILS — DEFENSE TECHNOLOGY — FIBER LASERS & AMPLIFIERS

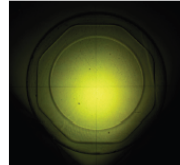
Optical Attributes

- Extra large mode areas — 60 to 200 μm
- High absorption — reduced effective lengths, low non-linearities
- High damage threshold for high pulse energies & peak powers
- Low spatial coherence — ASE sources for speckle free imaging
- Low temporal coherence & high bandwidth for ranging applications
- High brightness for high speed and long distance imaging

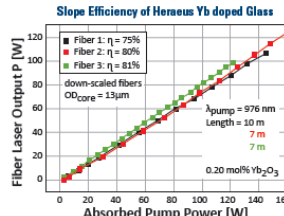
Mechanical Attributes

- Excellent dimensional control for splicing into all fiber devices
- Triple clad geometry allows for enhanced power handling
- High proof strength for long term mechanical reliability
- Excellent damp heat resistance


XLMA-YDF-300/400/480 Fiber Cross-Section



Slope Efficiency of Heraeus Yb doped Glass



Comparison of Speckle Contrast



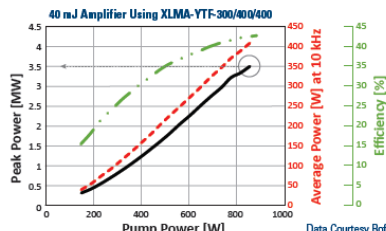
Features & Benefits

- High absorption & very large mode areas — Enables short fiber lengths & low non-linear effects
- High damage threshold — For high pulse energies and peak powers
- Highly multimoded fiber — Ideal candidate for speckle free sources
- High power per mode with low coherence — For ranging applications
- NuCOAT_{TM} fluoropolymer coating — Excellent damp & dry heat performance for extended life

Applications

- Multi-kW multimode lasers
- High pulse energy amplifiers
- ASE sources for spectroscopy and fiber sensors
- ASE sources for full-field imaging
- Sources for optical coherence tomography and frequency resolved LIDAR's

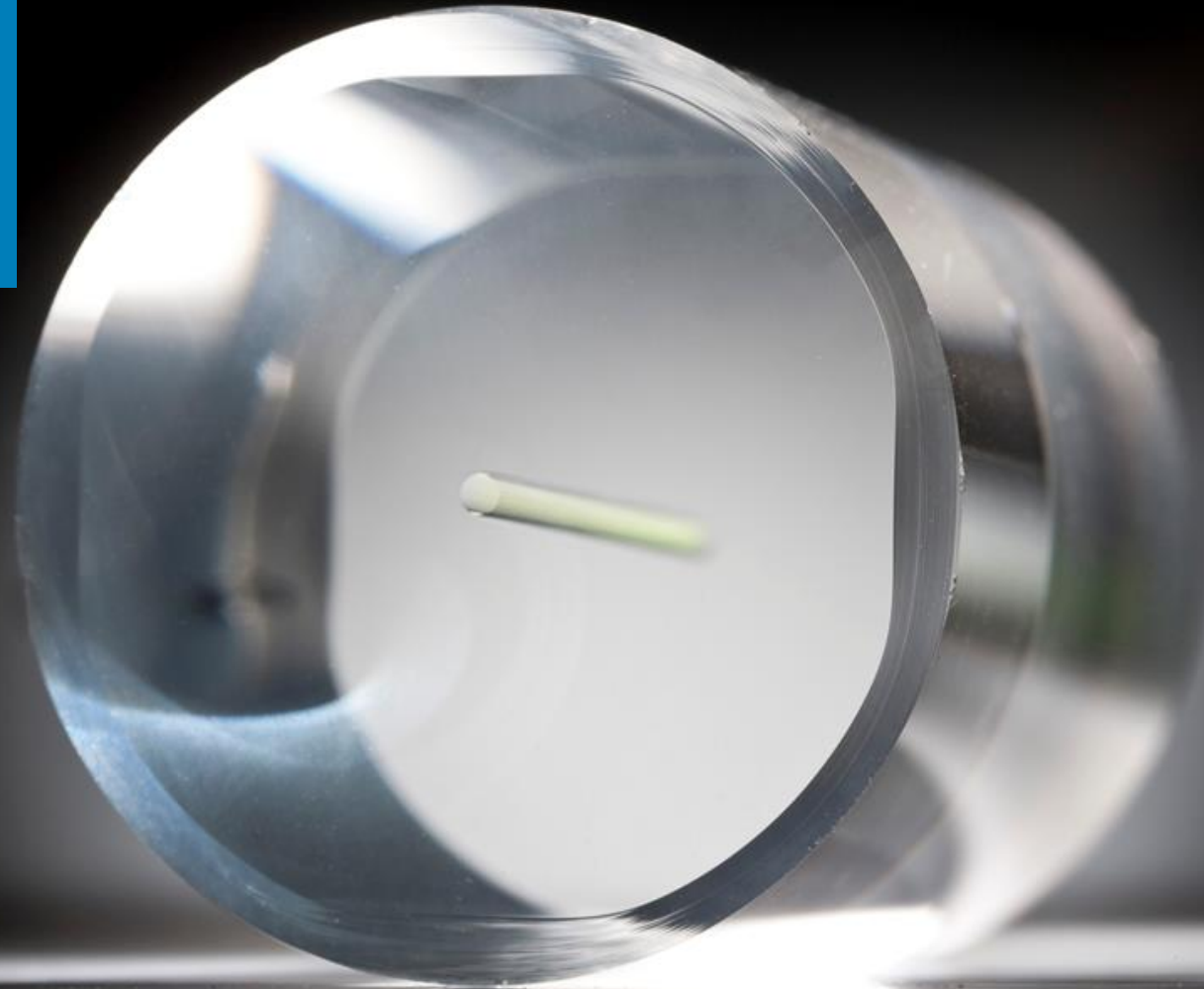
40 mJ Amplifier Using XLMA-YTF-300/400/400



7 Airport Park Road, East Granby, CT 06026
Toll Free: 866.456.0214 | Tel: 860.408.5000 | Fax: 860.844.0210 | www.nufern.com
Capabilities and typical design parameters are described above. Various standard and OEM designs are available.

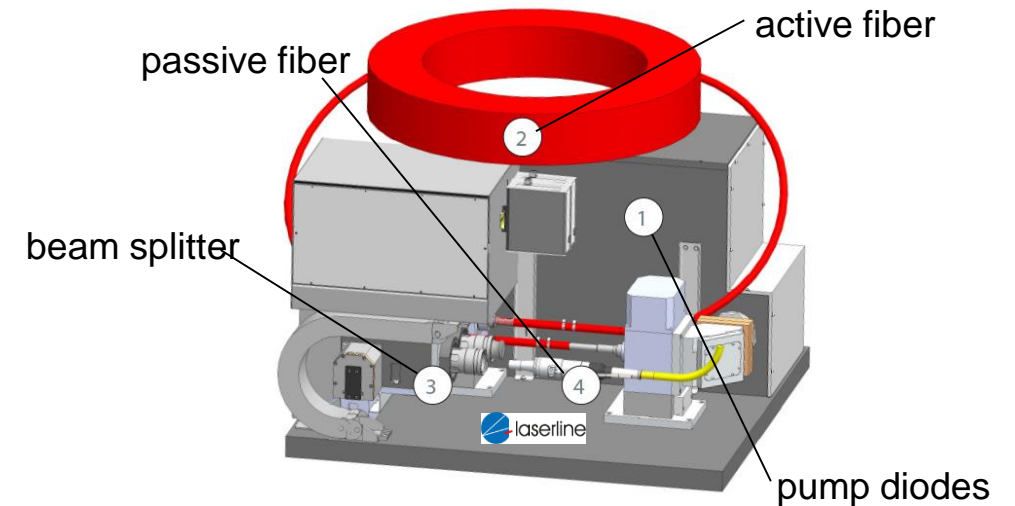
NUFERN
NU27-1/16

FIBERLASER
COOPERATION
PROJECTS



ReMiLas Project (Remote Welding with XLMA Converter Lasers)

- Fiber: Extra large mode area (XLMA)
- Target: **Modulated output power**
8 kW, modulation ~ kHz, 5 mm x mrad
- Application: Remote welding of dissimilar metal sheets
e.g., Al/steel, Cu/Al
- Process control with ultra-fast pyrometers and
an X-ray ultra-fast imaging system
- Partners:



Source: Laserline

<https://www.laserline.de/de/diodenlaser/ldf-serie-mit-strahlkonverter.html>



Wieland



scansonic
mechatronic innovation

» laser technology
Dr. Mergenthaler GmbH & Co. KG

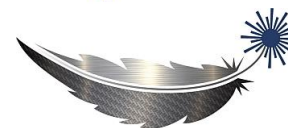


Heraeus

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of Education
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Photonischer Leichtbau



SURLAS Project (Surface Functionalization with Ultra Short Pulsed Lasers)

Target:

- Ultra short pulsed single mode fiber amplifier for surface functionalization
- pulse duration < 100 ps, peak power up to MW range

Our tasks:

- Development of preforms with adjusted design
- Accurate refractive index measurement and control
- Refractive index adjustment by F co-doping

Partners:



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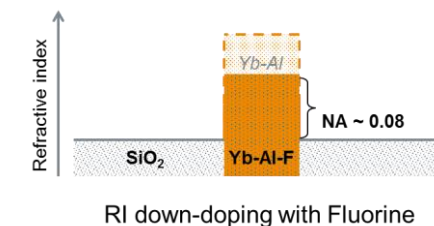


Federal Ministry
of Education
and Research



CIGS-Thin-film solar module. Source: LPKF

http://www.photonikforschung.de/fileadmin/Verbundsteckbriefe/17._ERA-NET%2B%20OLAE%2B/SurLas_Projektsteckbrief_M-ERA-NET_bf.pdf



EKOLAS Project (High Efficient Converter Laser)

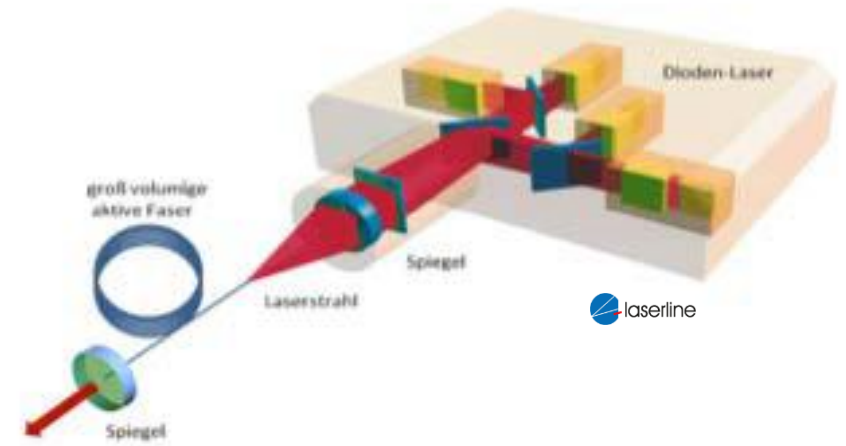
Target:

- High efficient converter laser based on XLMA fibers
- wall-plug efficiency 45 %, 6 kW cw, beam quality 4 mm x mrad

Our tasks:

- Reduction of background loss to ≤ 10 dB/km in REPUSIL material
- Development of design adjusted passive fibers
- Improved material and fiber diagnostics

Partners:



Source: Laserline

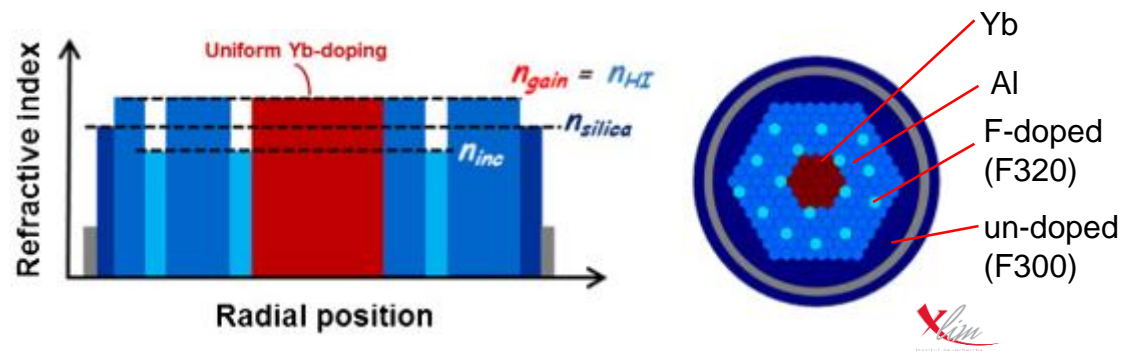
http://www.photonikforschung.de/fileadmin/Verbundsteckbriefe/3._Laser/barrierefreie_Steckbriefe/EKOLAS_Projektsteckbrief_EffiLAS_bf_C1.pdf

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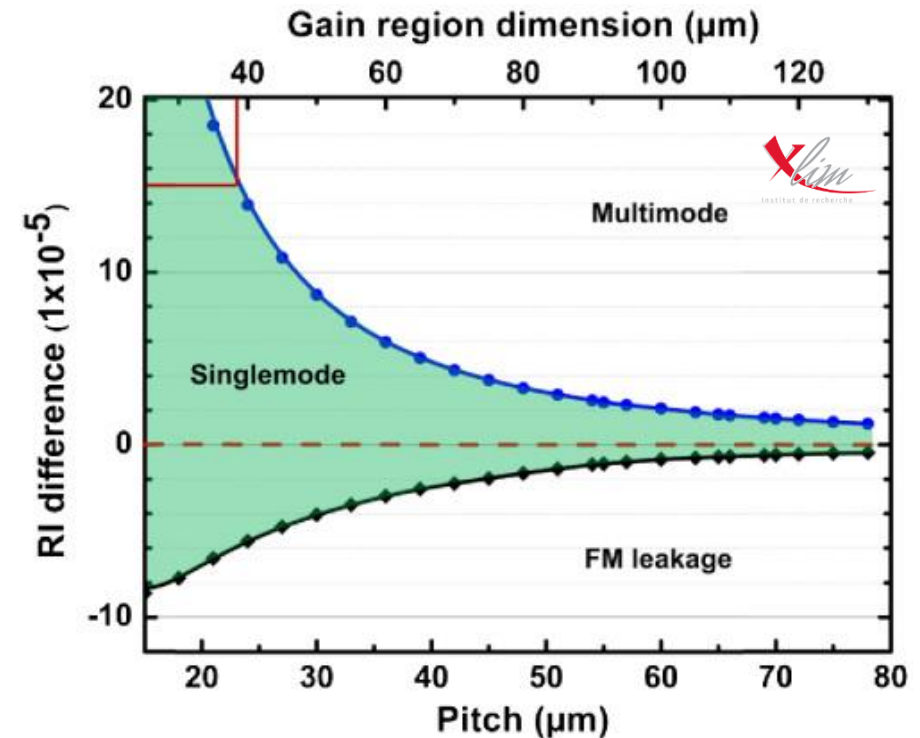
EATLase Project

Fully-Aperiodic Large-Pitch Fibers (FA-LPF) for Single Mode Laser Emission



Precise refractive index control ($\leq 1 \times 10^{-4}$) to allow single-mode operation in FA-LPF with large cores

Partners:

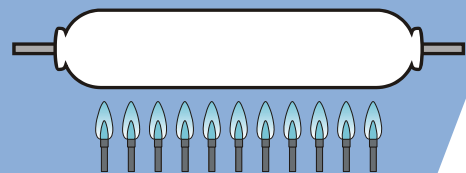
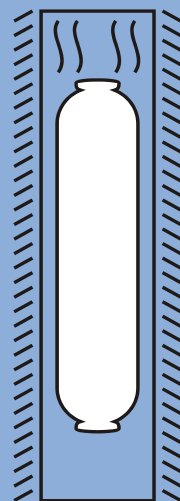
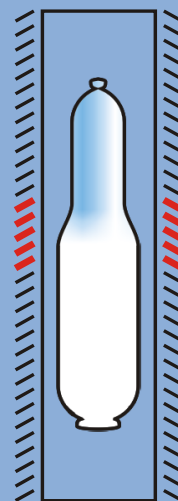
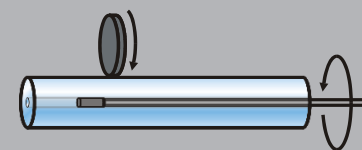
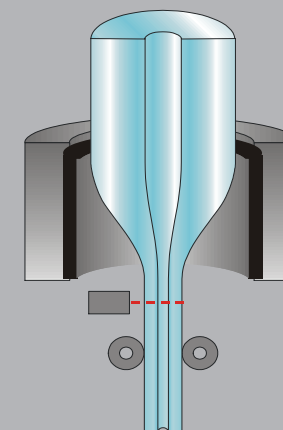


[Lit.: R. Dauliat et al., Applied Optics, Vol. 55, Issue 23, pp. 6229-6235 (2016)]



Thank you for your attention!

PRODUCTION OF SYNTHETIC FUSED SILICA

Soot Deposition**Dehydration****Vitrification****Machining of SQ-Cylinder****Tube or preform draw**

Clean Room