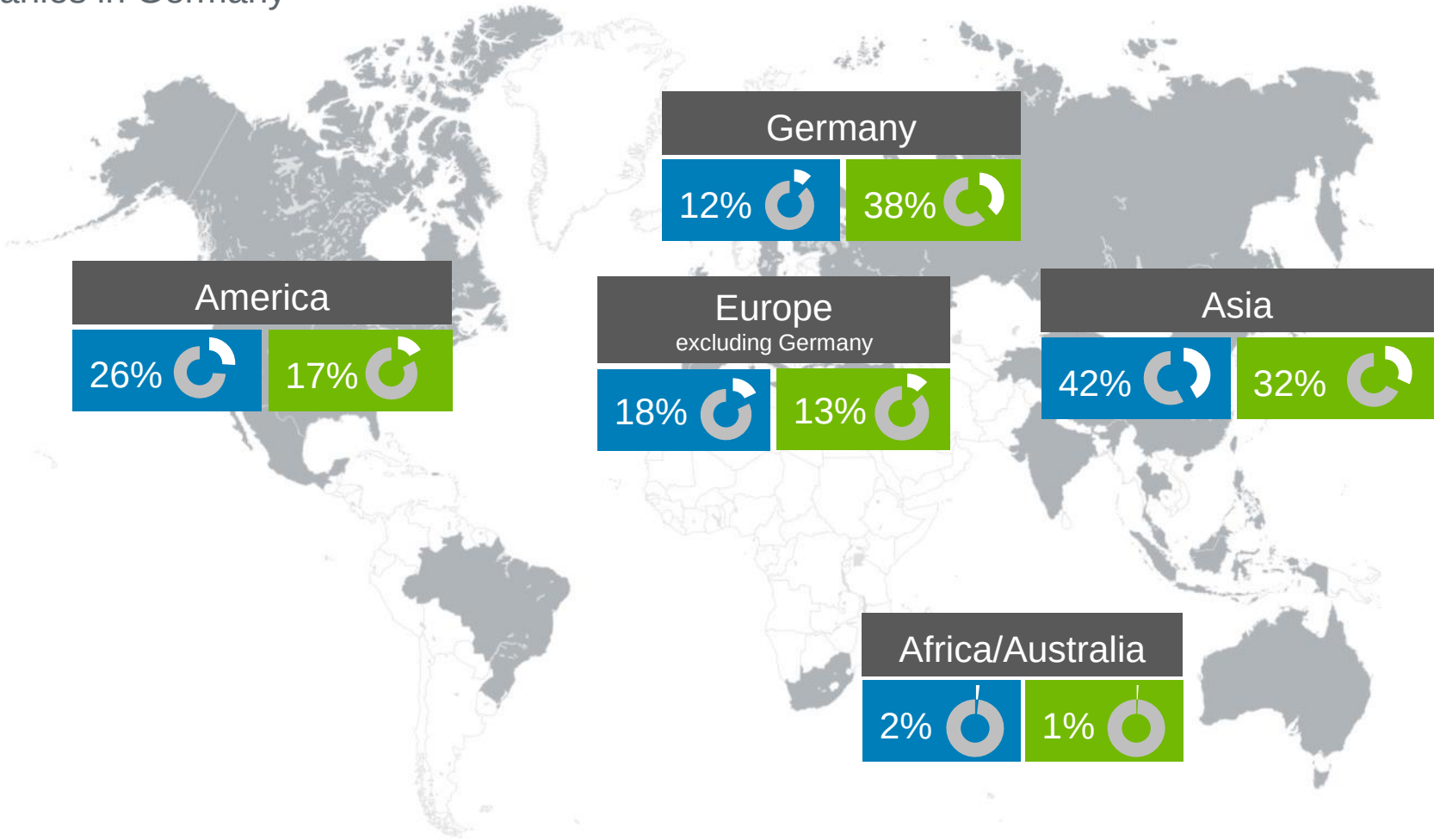
FIBER LASER ACTIVITES AT HERAEUS QUARZGLAS

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

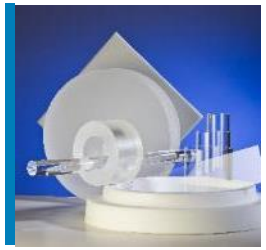
Global Business Units (GBU)

- 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

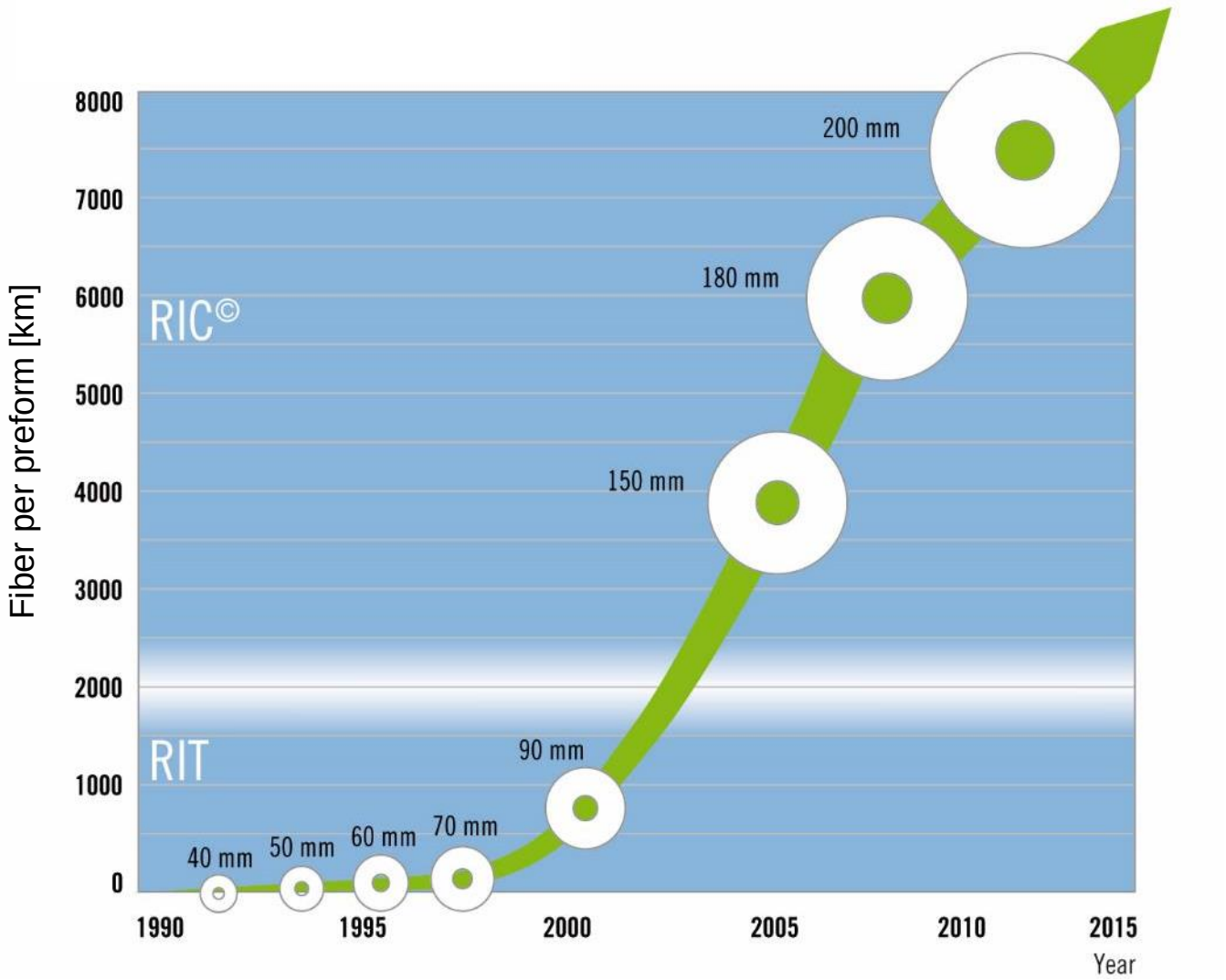
› Synthetic fused silica lens blanks for microlithography

› Optics for high energy laser projects and applications

› High purity fused silica products for commercial optics applications

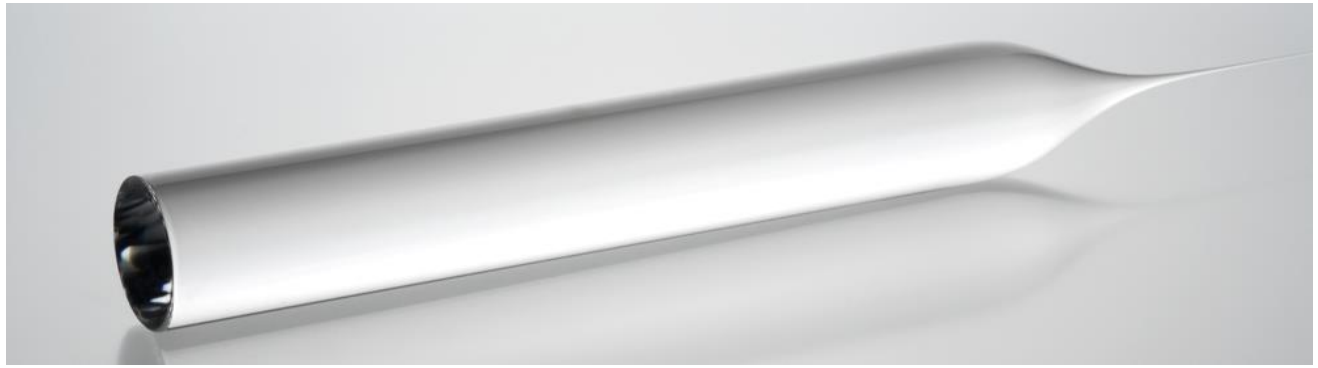
We give value to our customers by providing products and solutions that offer unique technical performance and lower cost of ownership.

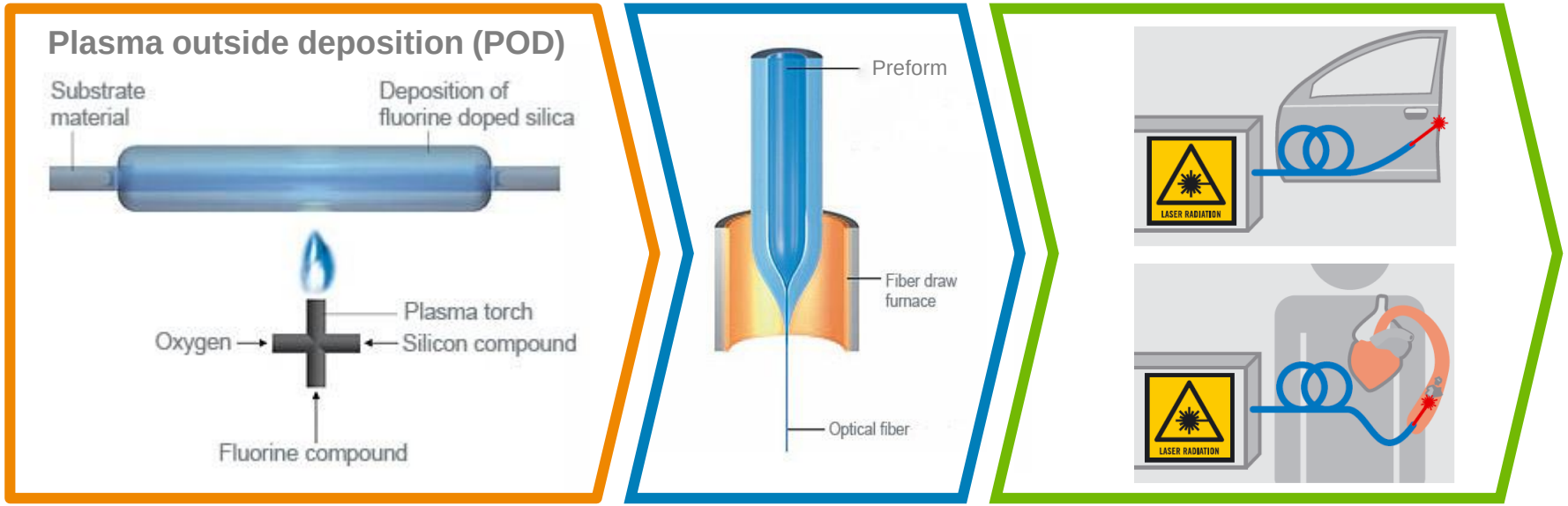
PREFORM SIZE EVOLUTION FOR TELECOM PREFORMS



Economy of size

FLUOSIL® PREFORMS





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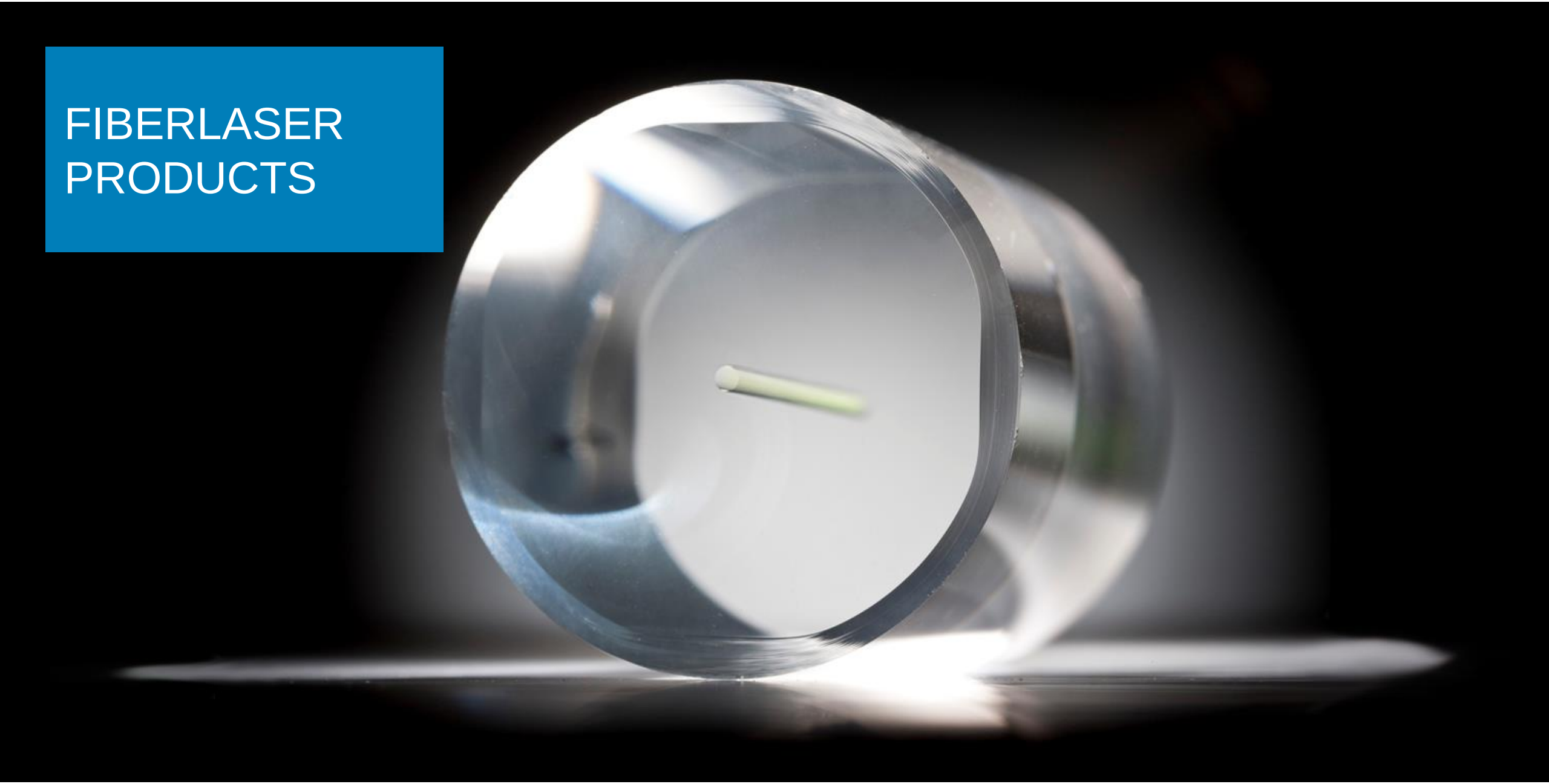
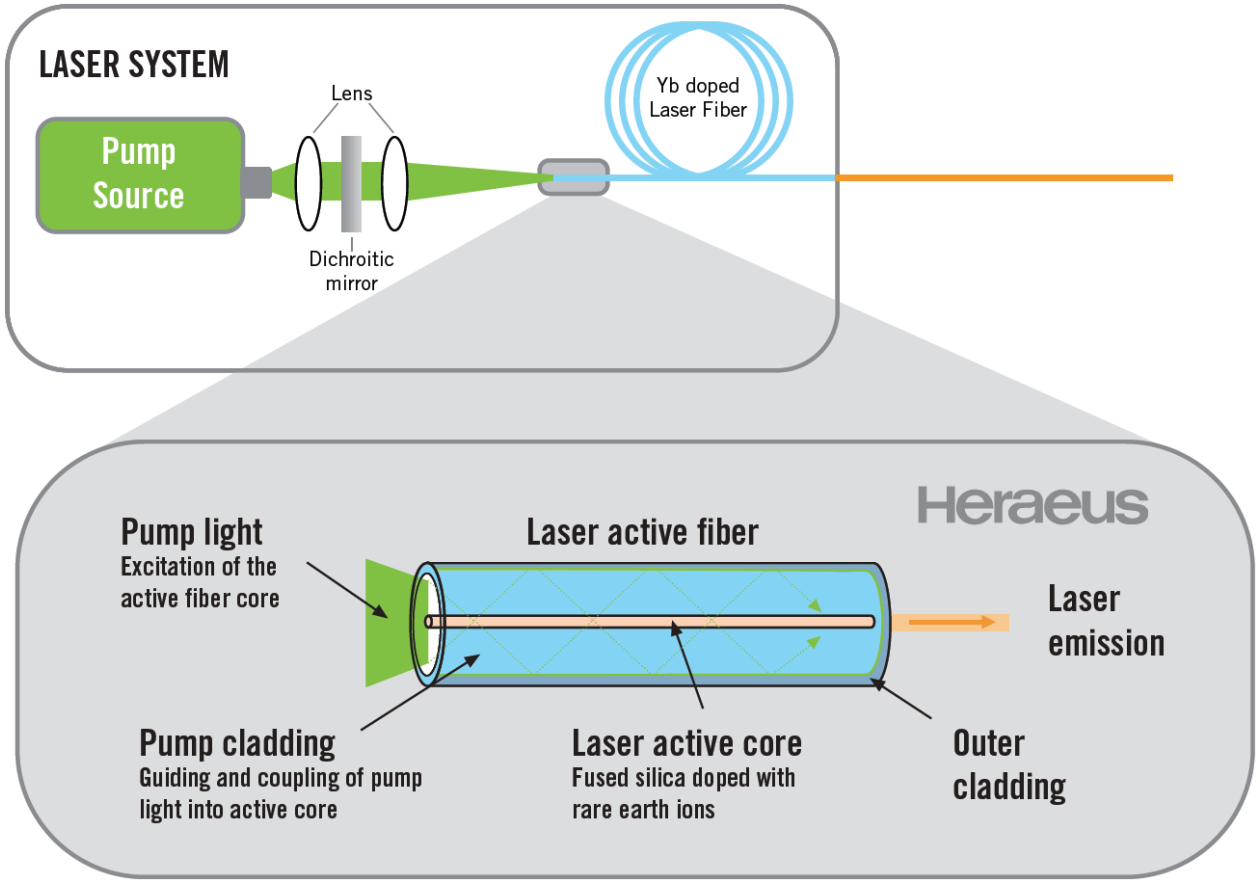
FIBERLASER PRODUCTS



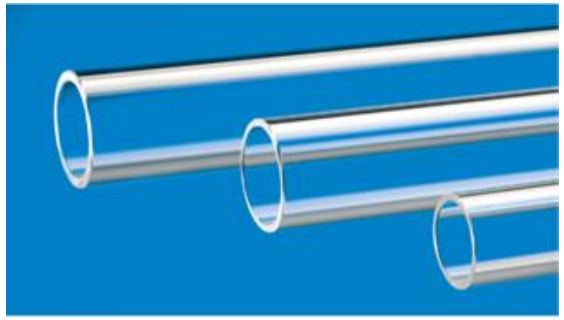
FIBER LASER PRINCIPLE



Substrate tubes for fiber laser preform production

Product

Substrate tubes



Types

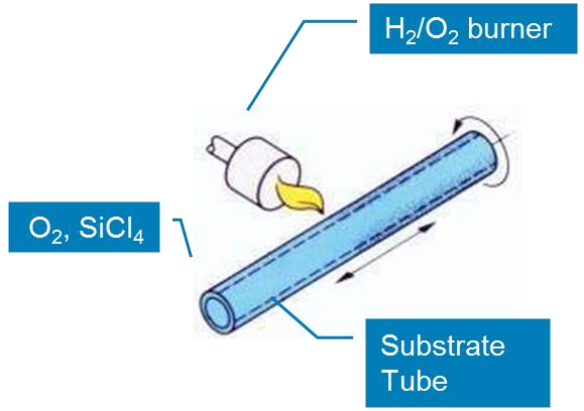
F300/F500: undoped, Cl <= 2500 ppm

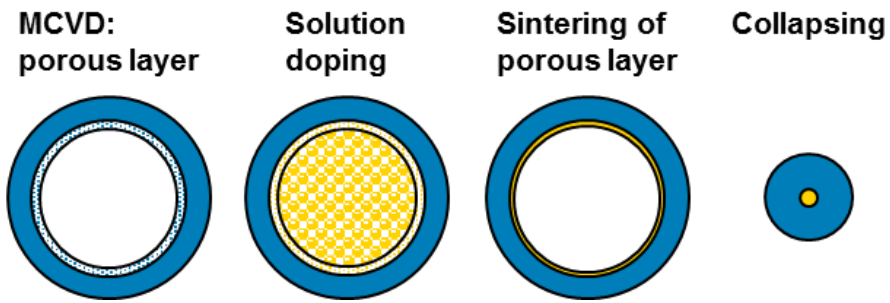
F300HP: improved ovality and siding

F320-xx / F520-xx: F doped

Application

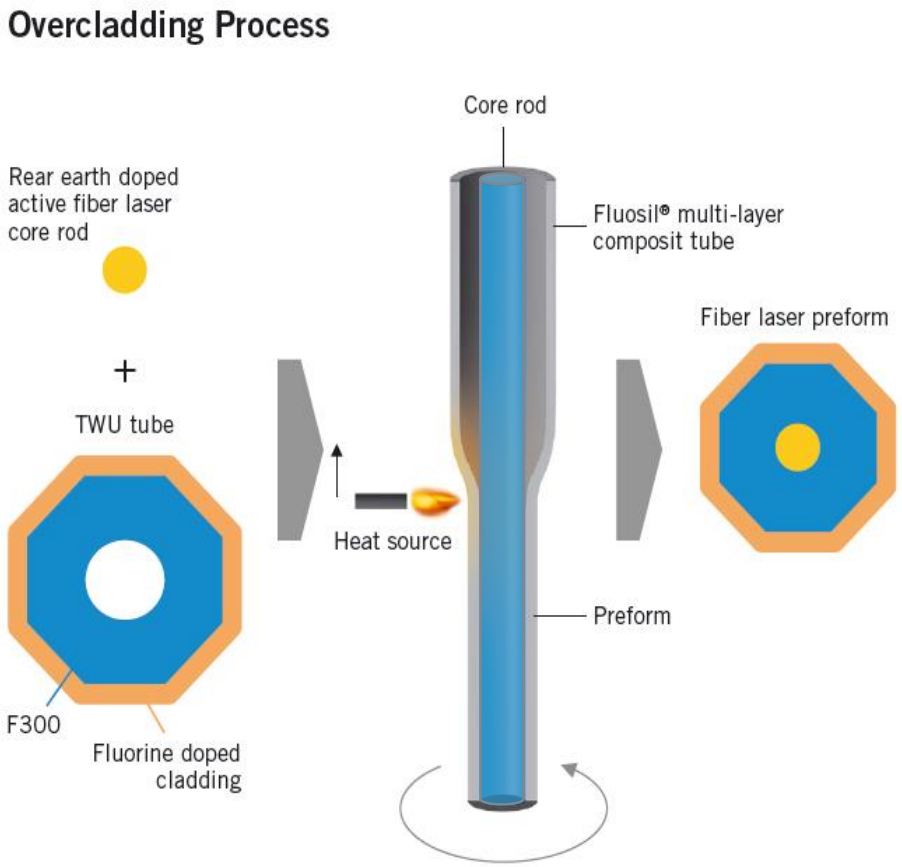
MCVD solution doping





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

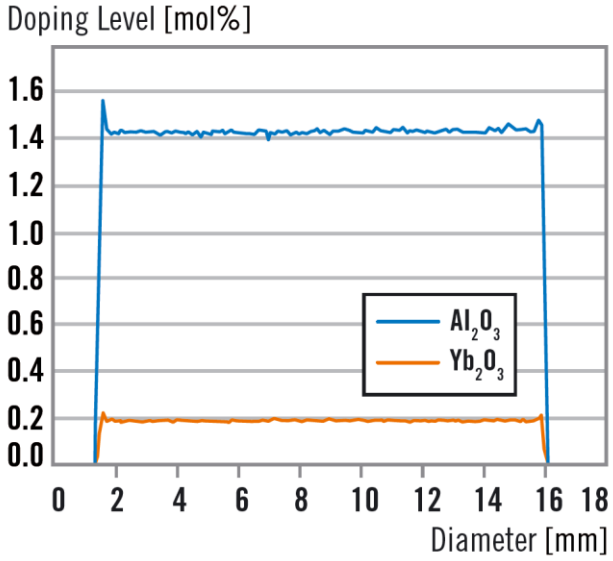


YB DOPED FUSED BULK SILICA („REPUSIL“ PROZESS)

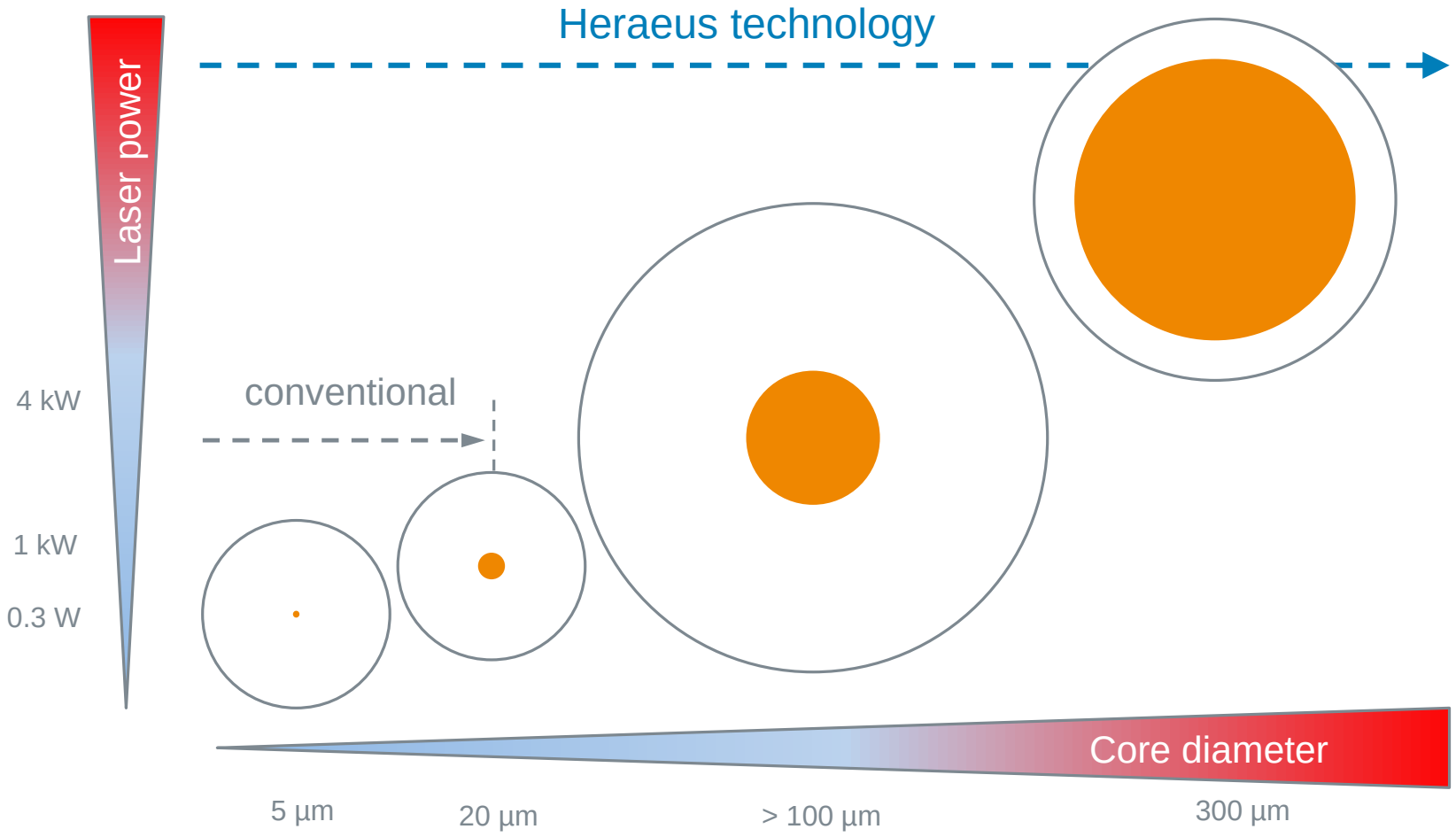
- High doping levels

  (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**

  ($\varnothing_{typ.}$ ~ 15 mm, $L_{typ.}$ ~ 150 mm)
- Very well suited for high power fiber lasers
- Enables novel laser designs (e.g. XLMA)



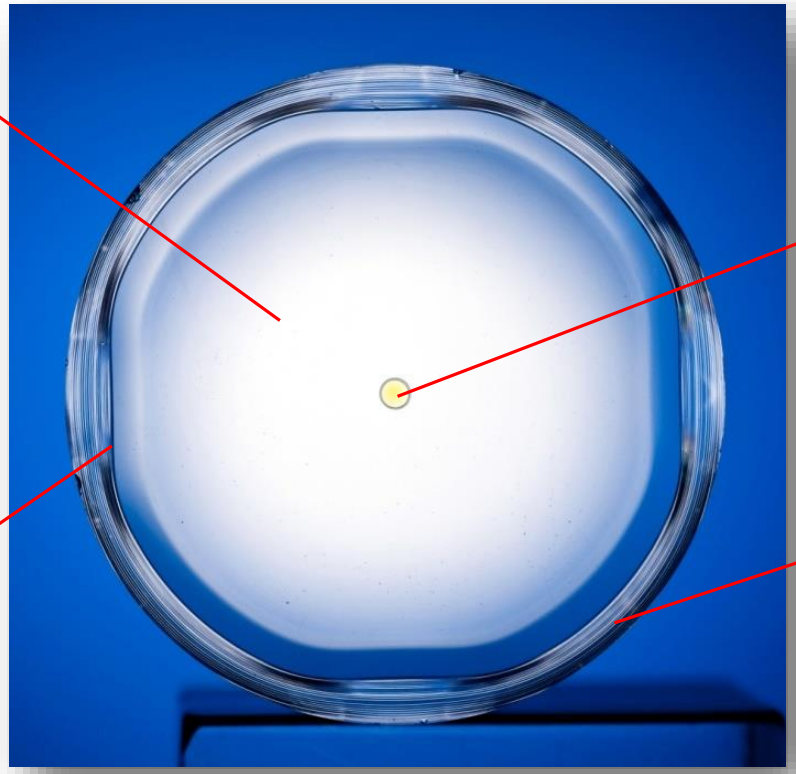
TREND: POWER SCALING OF LASER FIBERS



EXTRA LARGE MODE AREA (XLMA) LASER FIBER

Un-doped silica

Jacketing process



Laser core
(∅ 50 … 100 µm)

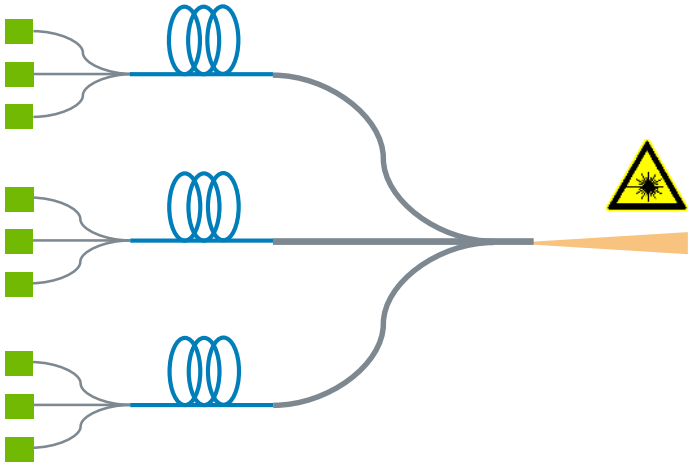
F-doped silica
(POD)

Precise machining

Heraeus has all technologies in house!

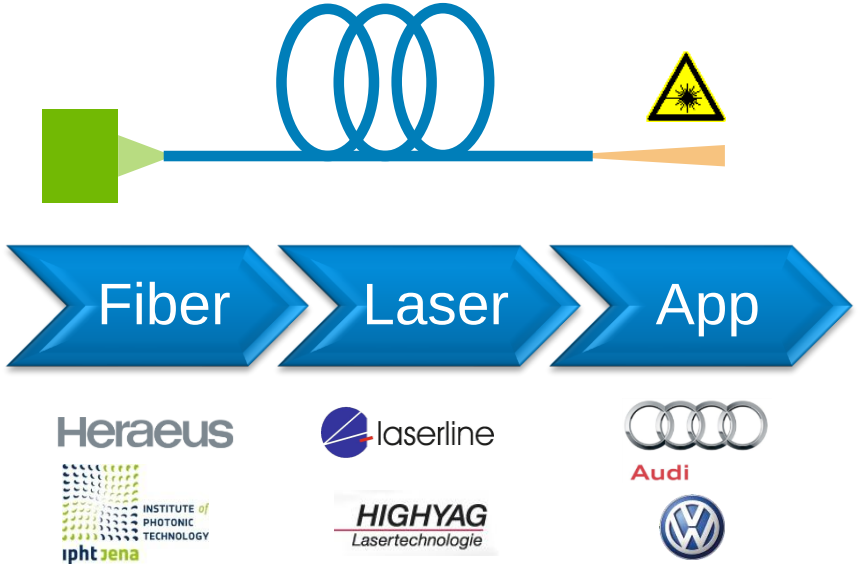
Multi kW Fiber Laser Concepts

Conventional concept



- Complex
- Susceptible (back reflections)
- Expensive

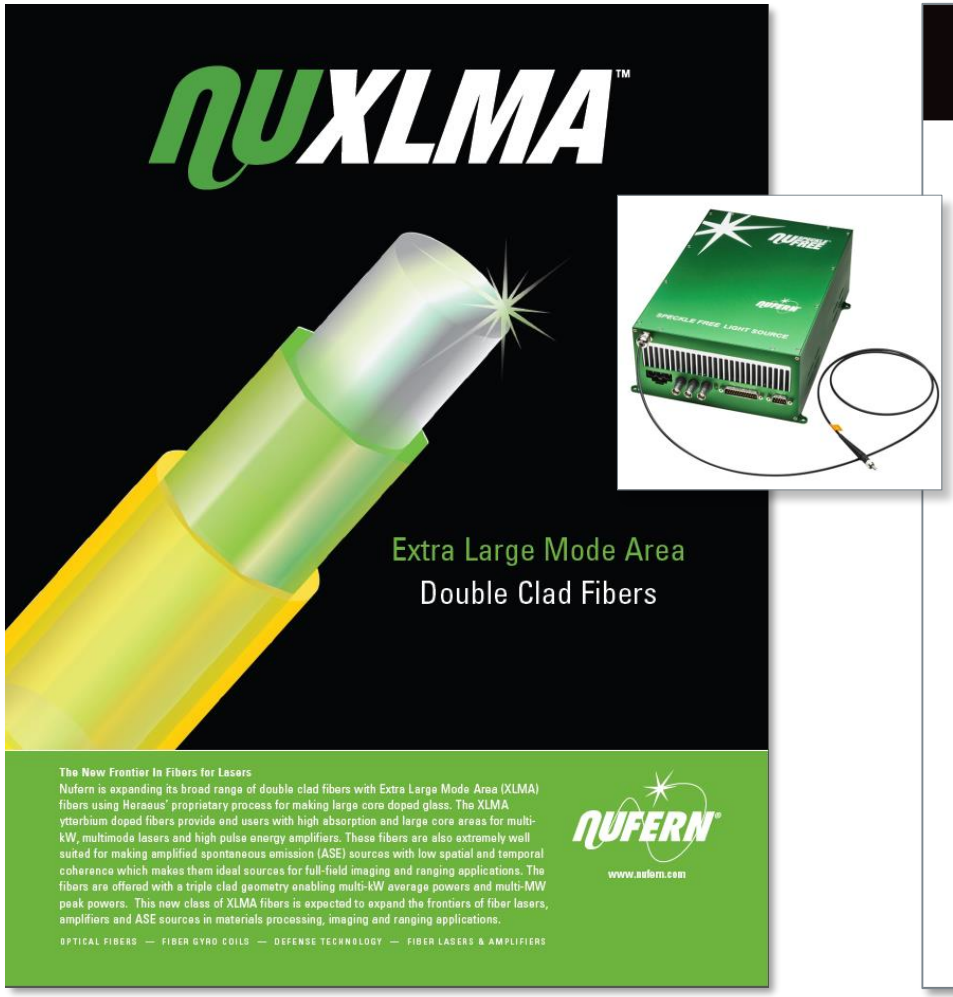
New concept (XLMA fiber)

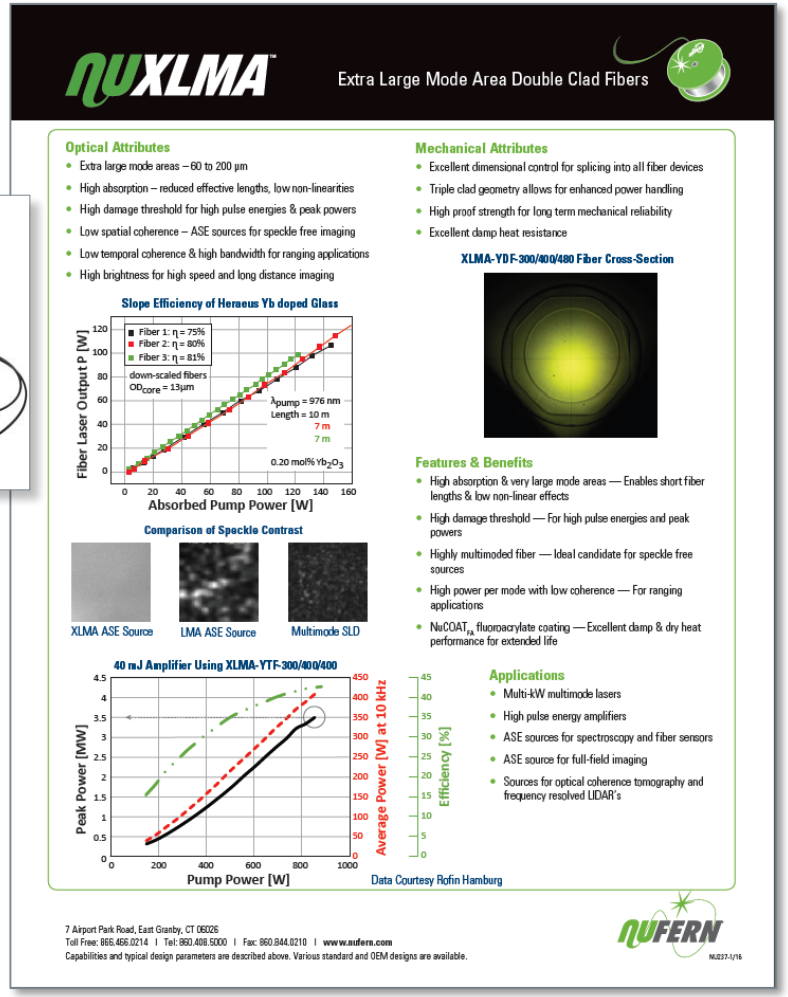


- Simple design
- Robust
- Economic

Federal Ministry of Education and Research

Marketing of special XLMA fibers with Nufern: NUXLMA-Fiber





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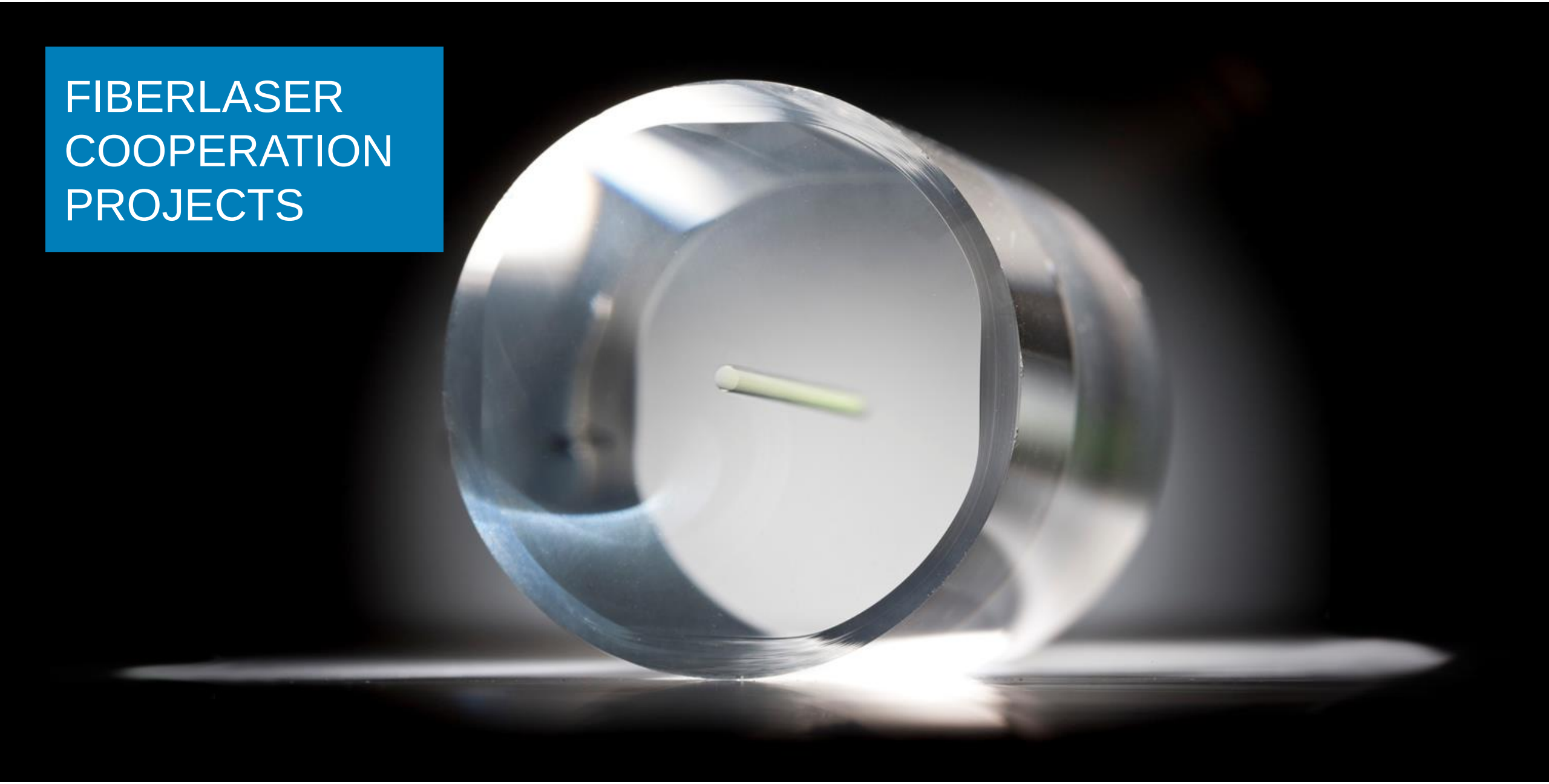
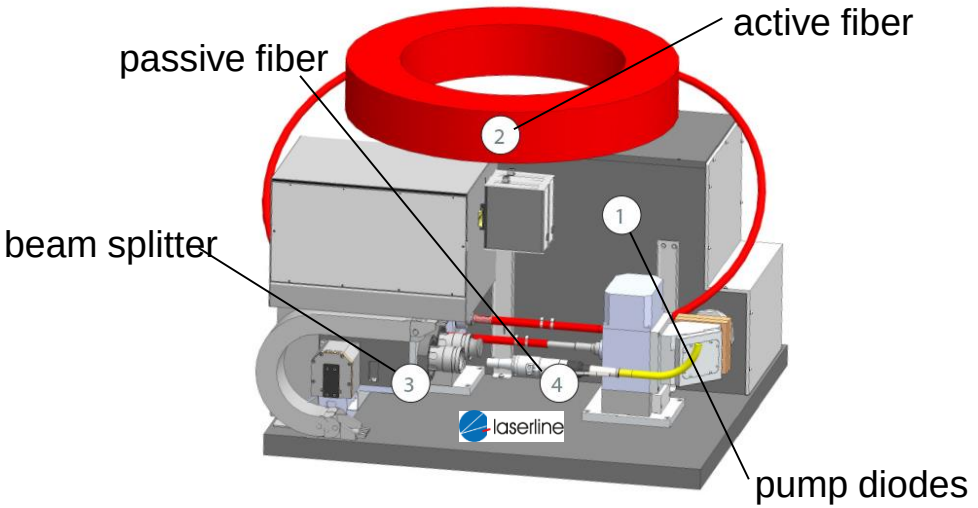
FIBERLASER COOPERATION PROJECTS



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

Photonischer Leichtbau

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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:

LPKF Laser & Electronics

MAN Diesel

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INSTITUT für PHOTONISCHE TECHNOLOGIEN ipht jena

SPI Lasers

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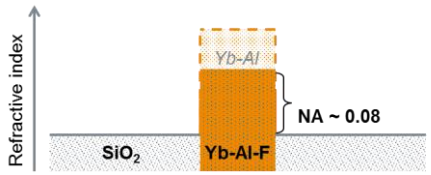
M-era.Net

CIGS-Thin-film solar module. Source: LPKF

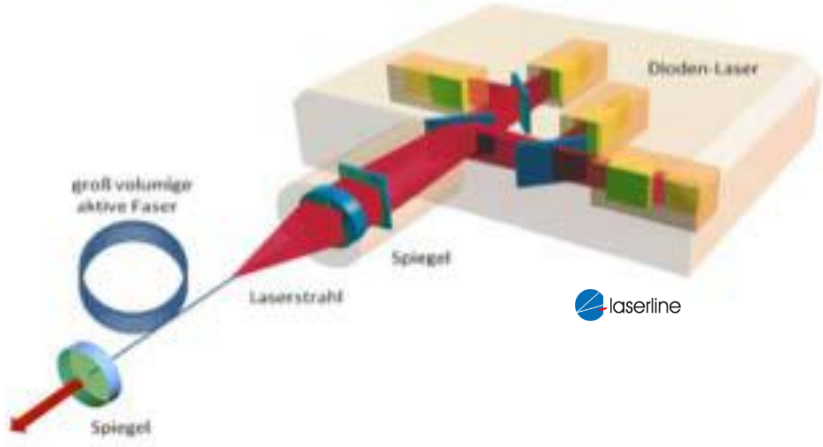
http://www.photonikforschung.de/fileadmin/Verbundsteckbriefe/17._ERA-NET%2B%20OLAE%2B/SurLas_Projektsteckbrief_M-ERA-NET_bf.pdf



RI down-doping with Fluorine

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



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

- Partners:

welser profile · laserline · OSRAM Opto Semiconductors · Fraunhofer ILT · fiberware · Heraeus

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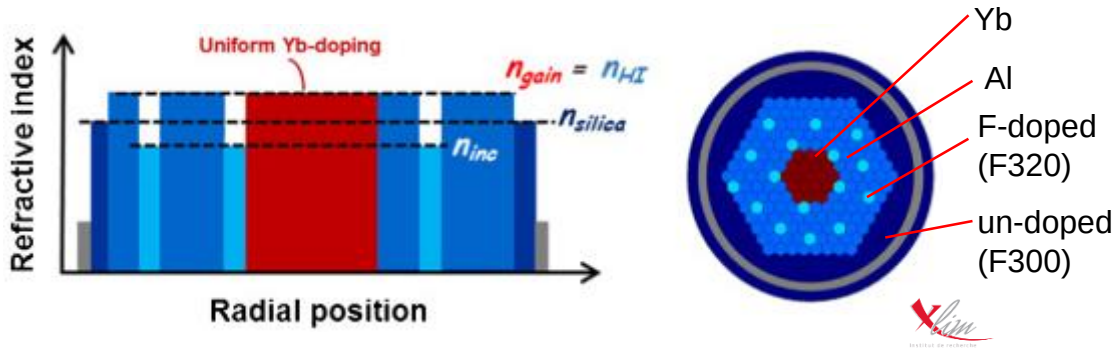
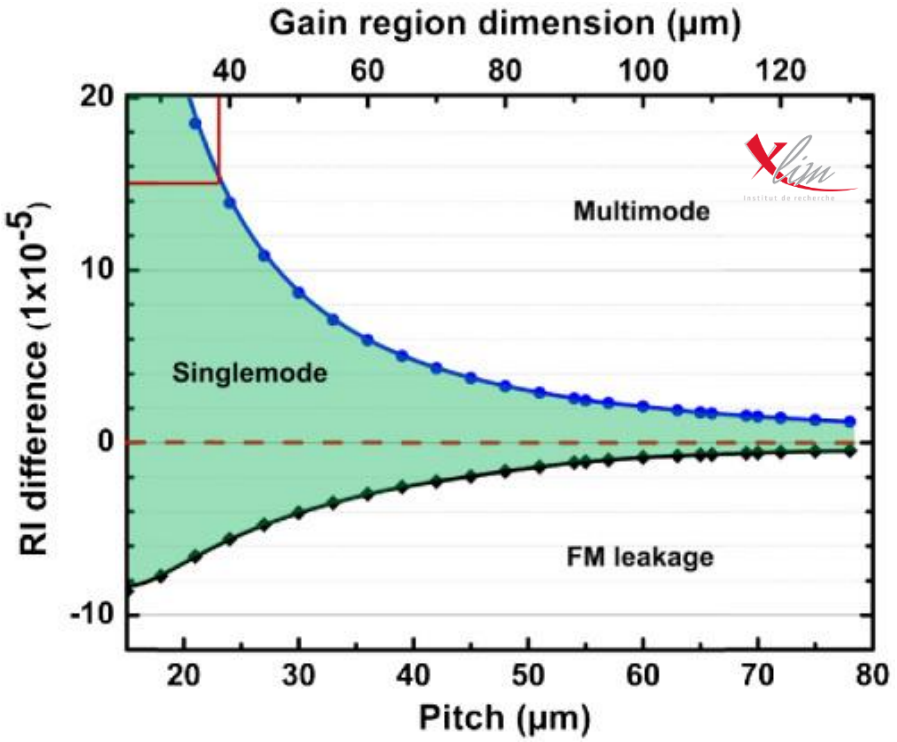
EFFILAS++

EATLase Project

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





- Precise refractive index control (≤ 1 x 10^{-4}) to allow single-mode operation in FA-LPF with large cores
- Partners:

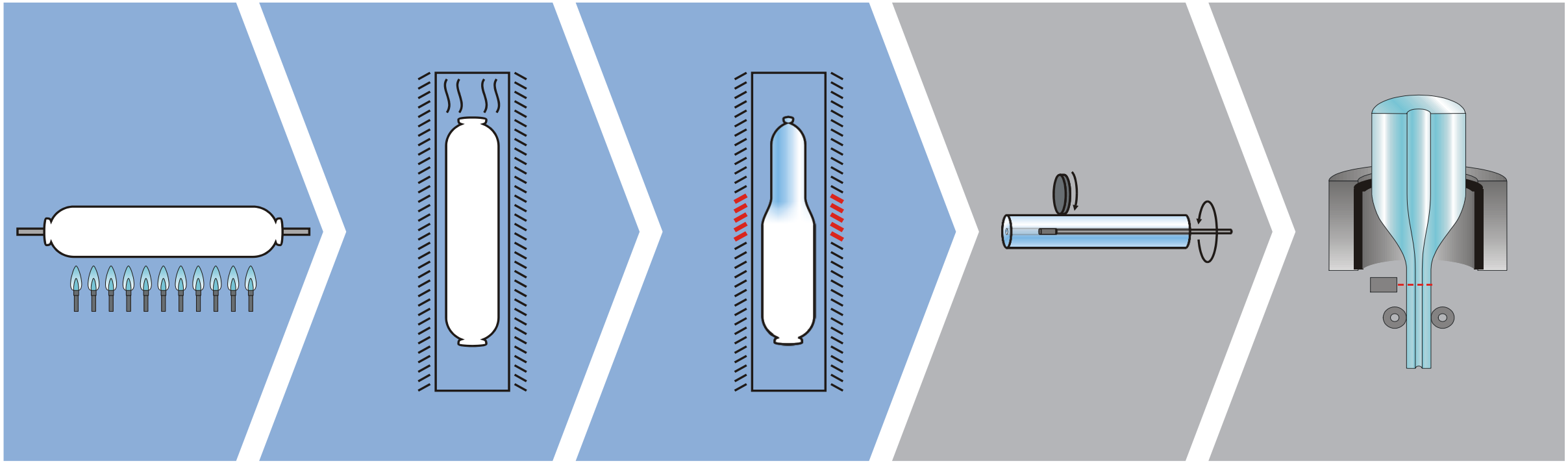
[Lit.: R. Dauliat et al., Applied Optics, Vol. 55, Issue 23, pp. 6229-6235 (2016)]

Heraeus

Thank you for your attention!

PRODUCTION OF SYNTHETIC FUSED SILICA

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



Clean Room