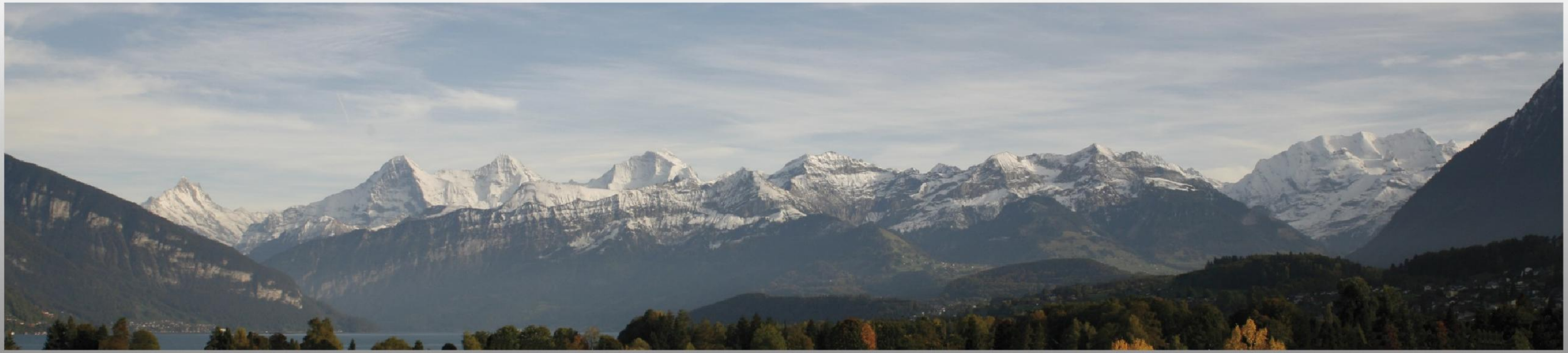
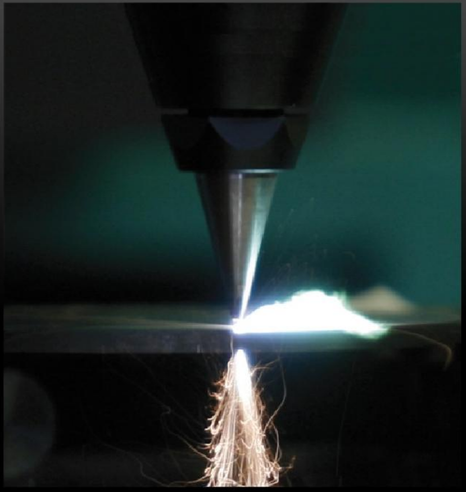


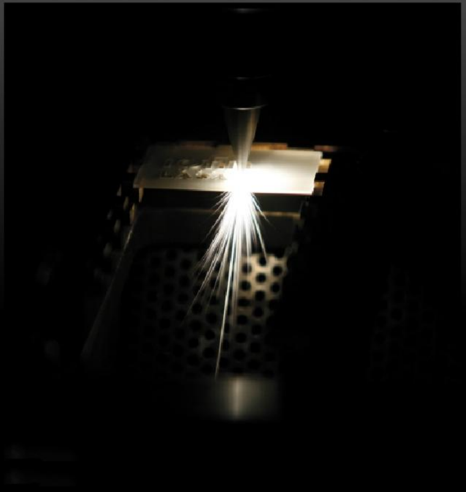
All in Fiber Systems

for Material Processing

LASAG SWISS PRECISION

U. Dürr / Rofin-Lasag





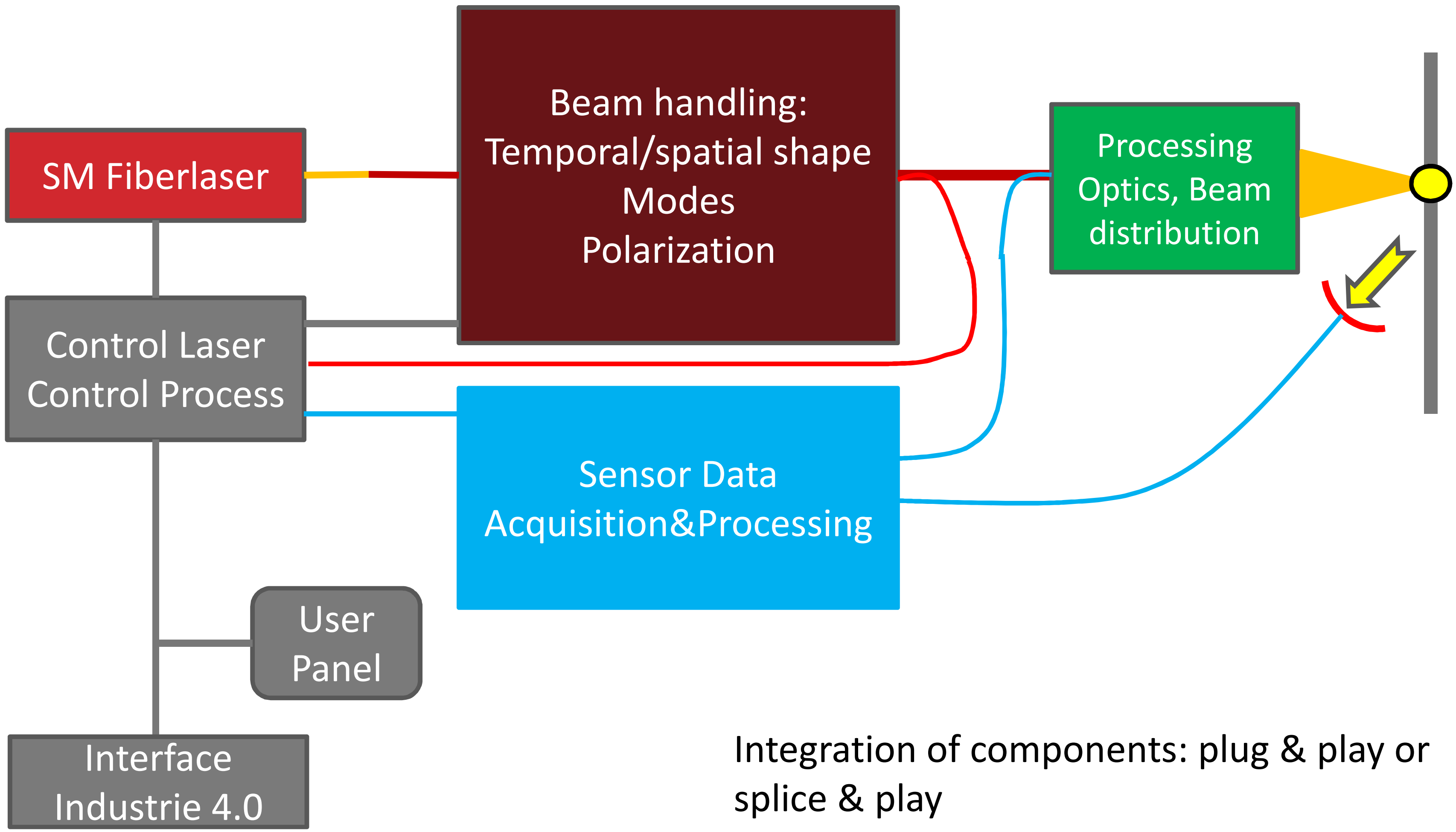
SWISS TRADITION FOR WORLDWIDE PRECISION

All In Fiber Systems

U.Dürr / Rofin-Lasag

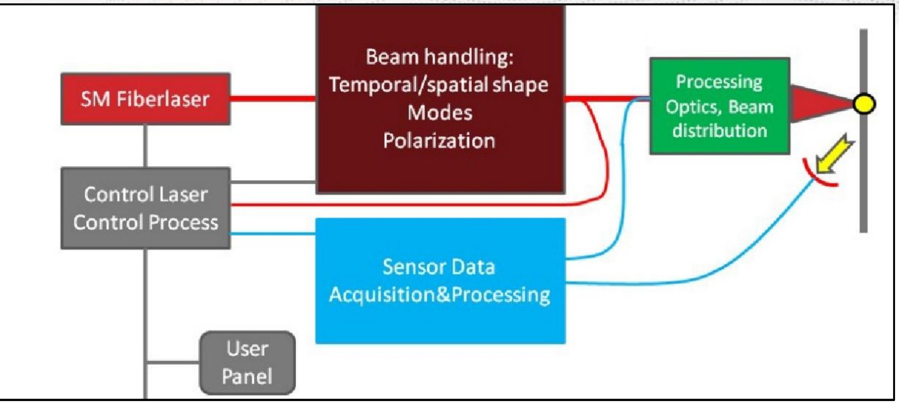
LASAG SWISS PRECISION

All in Fiber Systems for (industrial/medical) Material Processing



Integration of components: plug & play or splice & play

All in Fiber Systems



Fiberlaser + Transport Fiber + beam Control

cw /cw-modulated / qcw /pulse shape /pulsed (not UFL)

SM because of mode stability and beam quality

Advantages:

SM high power /average power/stable

wavelength flexibility

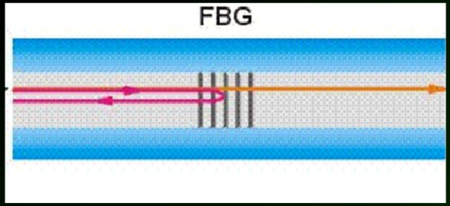
Fundamental Problems:

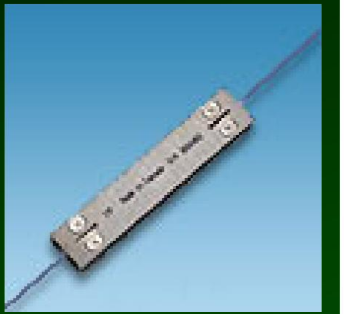
Backreflection / fiber damage

Raman (power loss/ damage fiber laser)

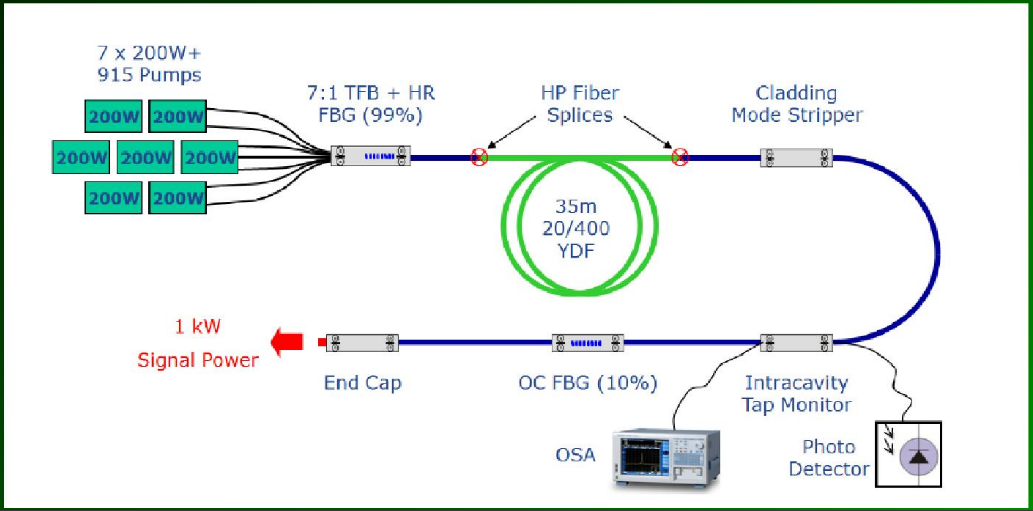
Linewidth (limits in efficiency of nl effects)

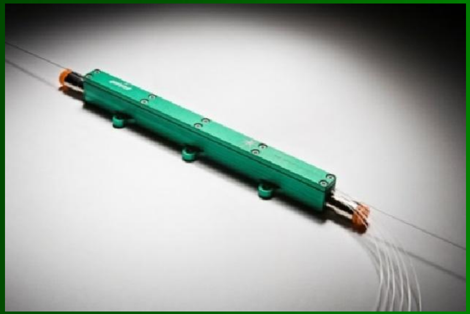
Coupling losses (heat damage)


FBG

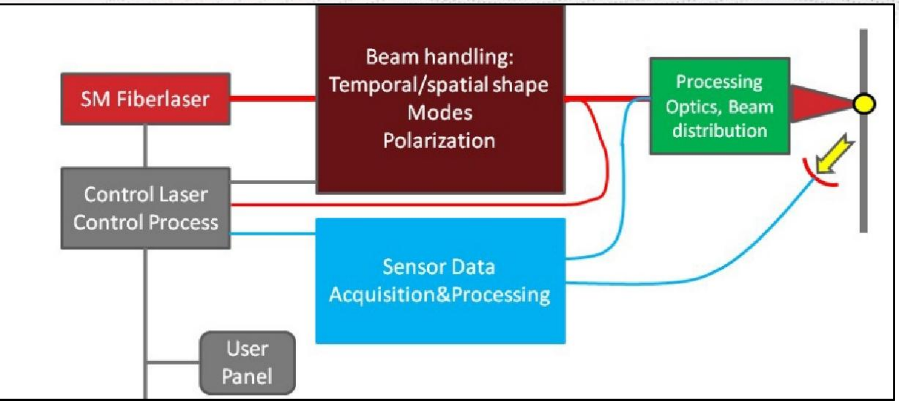



NUMATCH™
Connecting High Performance
Fiber Laser & Amplifer Components


7 x 200W+
915 Pumps
200W
7:1 TFB + HR
FBG (99%)
HP Fiber
Splices
Cladding
Mode Stripper
35m
20/400
YDF
1 kW
Signal Power
End Cap
OC FBG (10%)
Intracavity
Tap Monitor
OSA
Photo
Detector



All in Fiber Systems



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cw /cw-modulated / qcw /pulse shape /pulsed (not UFL)
SM because of mode stability and beam quality

Advantages:
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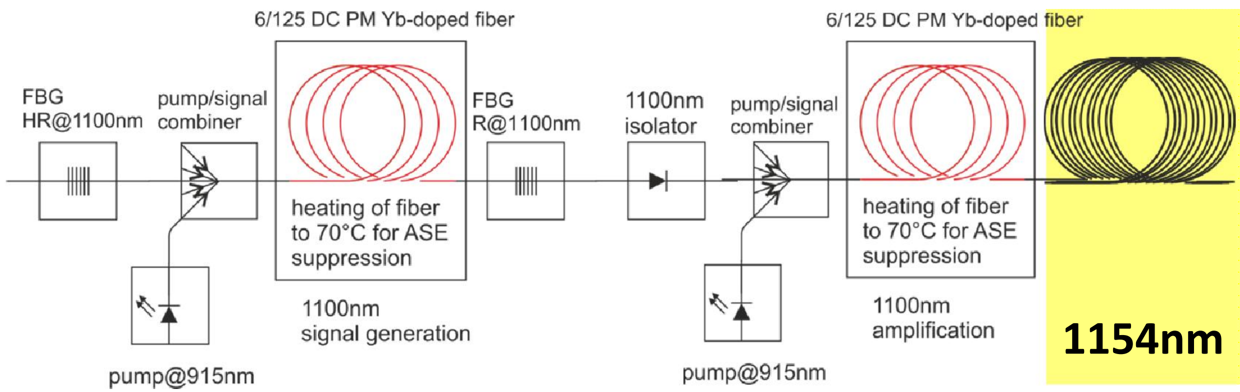
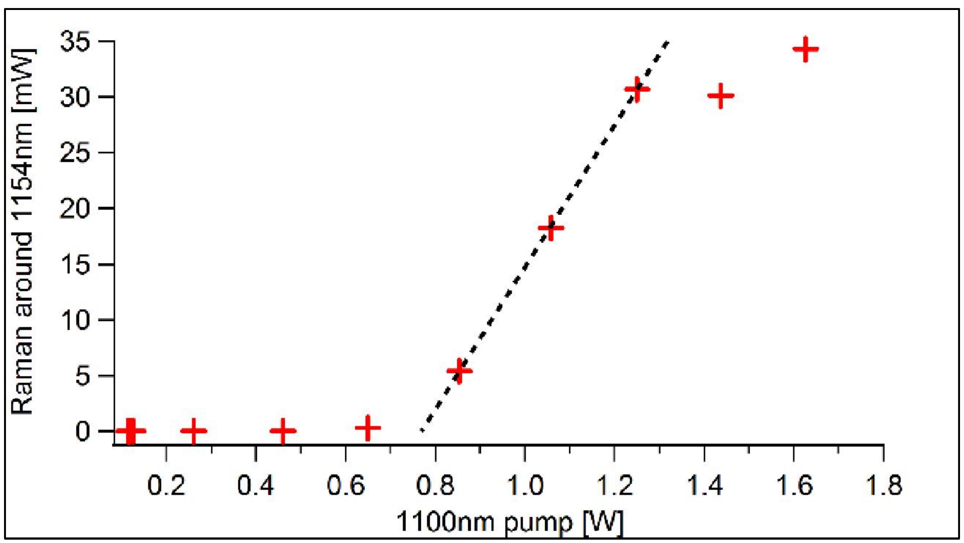
wavelength flexibility

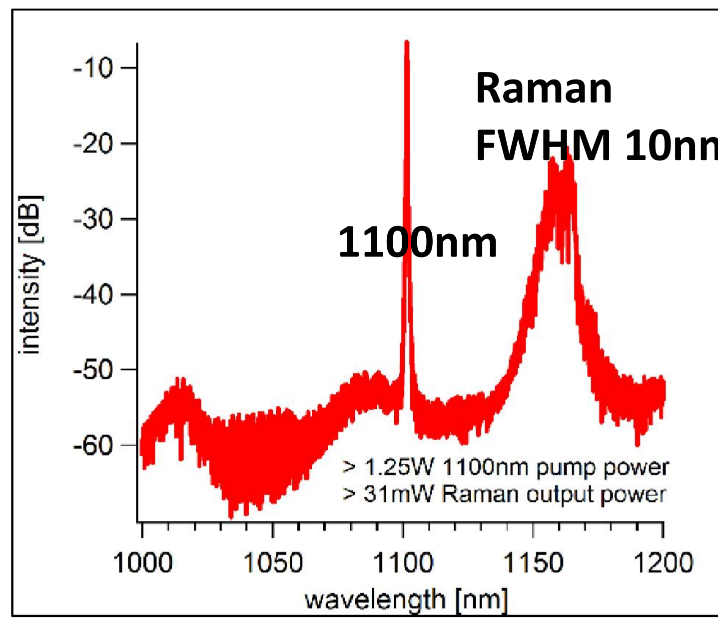
Experiment 1: Raman shifter

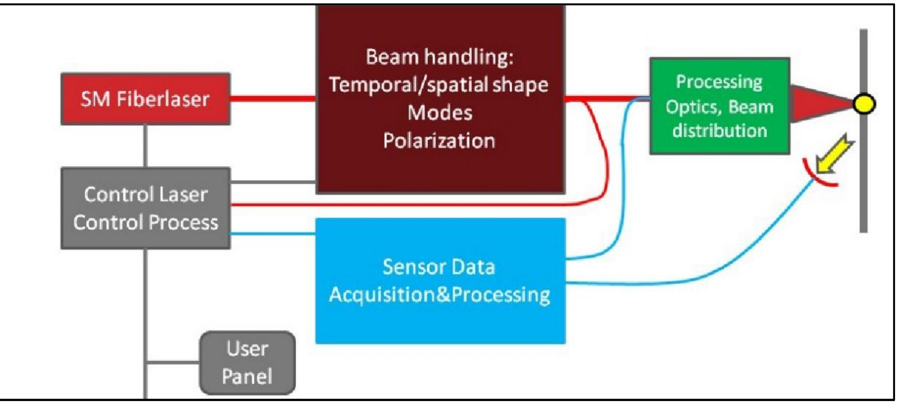
UNIVERSITÄT BERN



> slope efficiency 6%
> max. output power 35mW
> FWHM 10nm







Fiberlaser + Transport Fiber + beam Control

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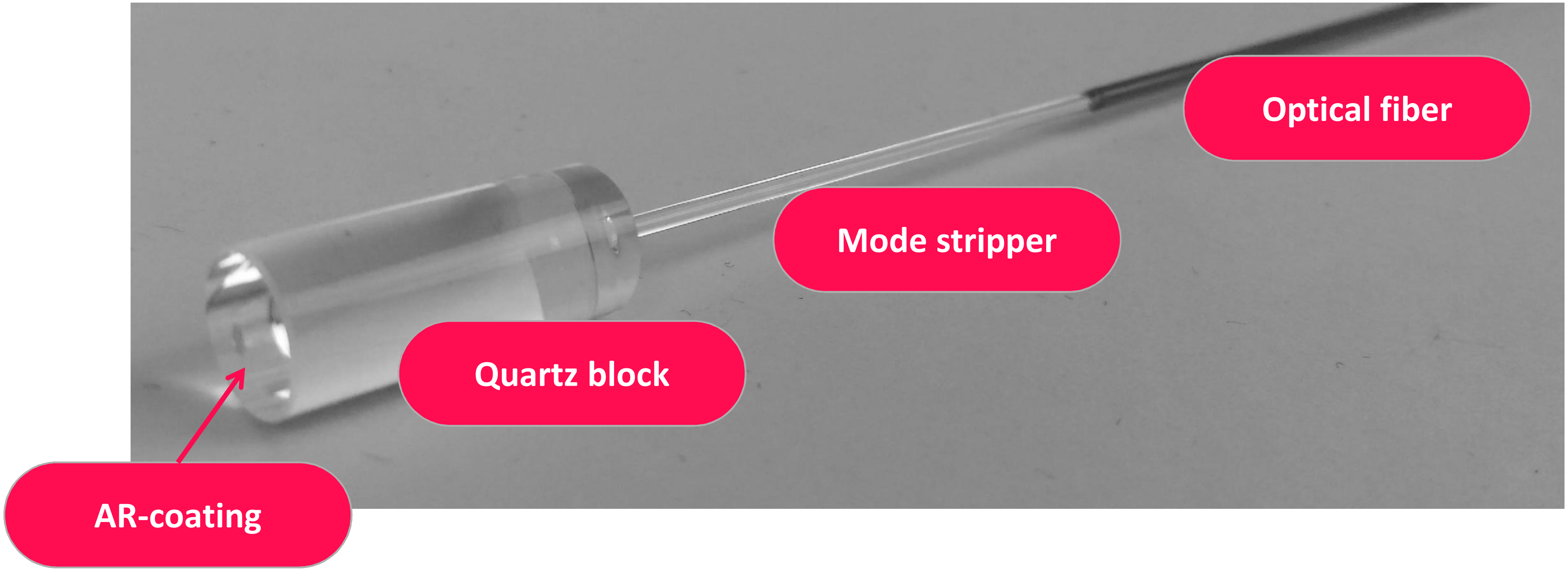
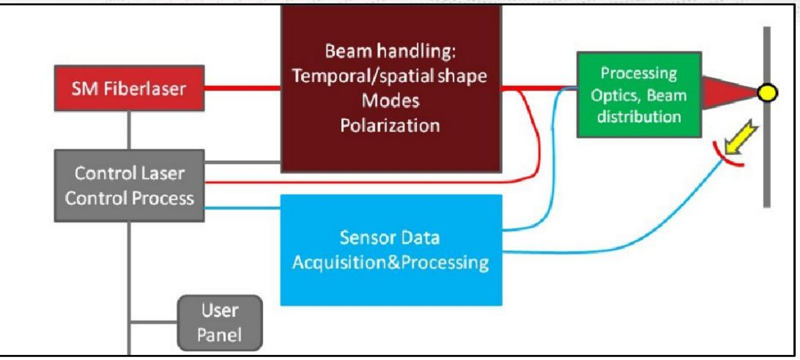
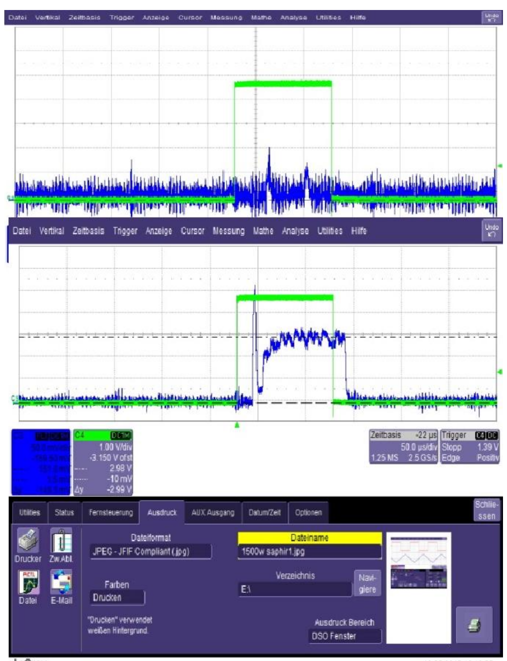
Optoskand fundamental fiber technology

- **Mode stripper** – Surface treatment that remove all cladding modes.
- **Quartz block** – Bonded fused silica end cap. Decrease surface power density.
- **AR-coating** – Remove Fresnel losses.



All in Fiber Systems





500W

1.4kW

Thermal cutting of Sapphire

Fiberlaser(SM) + Transport Fiber

cw /cw-modulated / qcw /pulse shape /pulsed (not UKP)

SM because of mode stability and beam quality

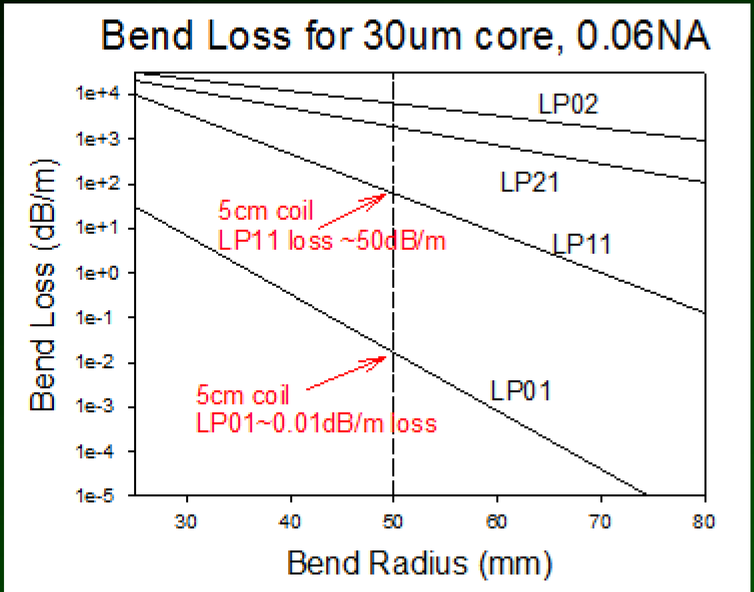
Fundamental Problems:

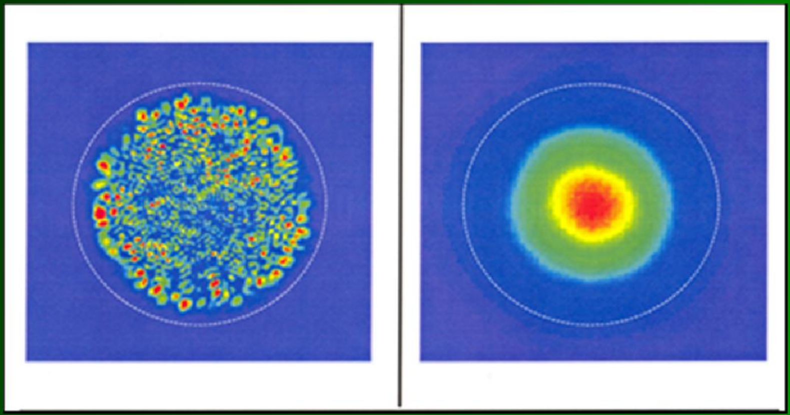
Influence of optical components and application on Fiberlaser

Backreflection */ fiber damage/Laser damage*

LMA Double Clad Fibers

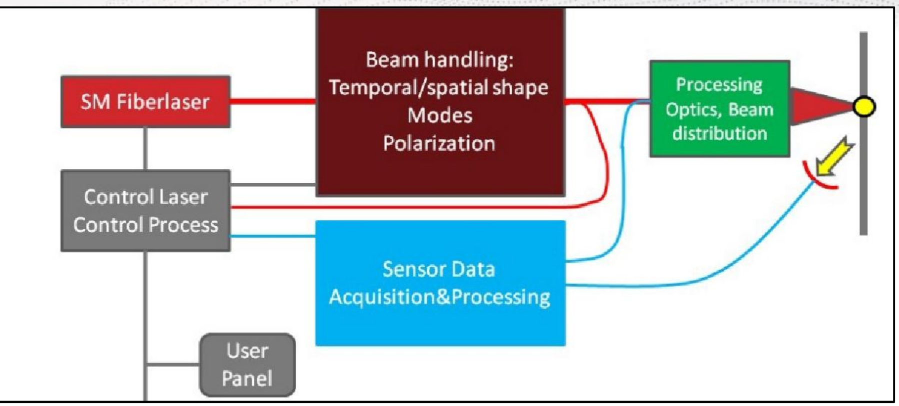
	Singlemode "SM"	Multimode "MM"	Large Mode Area "LMA"
# Signals	1	~ 1000	2 to 5
Core Size (microns)	3 – 10	50 – 150	15 - 50
NA	0.12 – 0.20	0.20 – 0.35	0.05 – 0.10

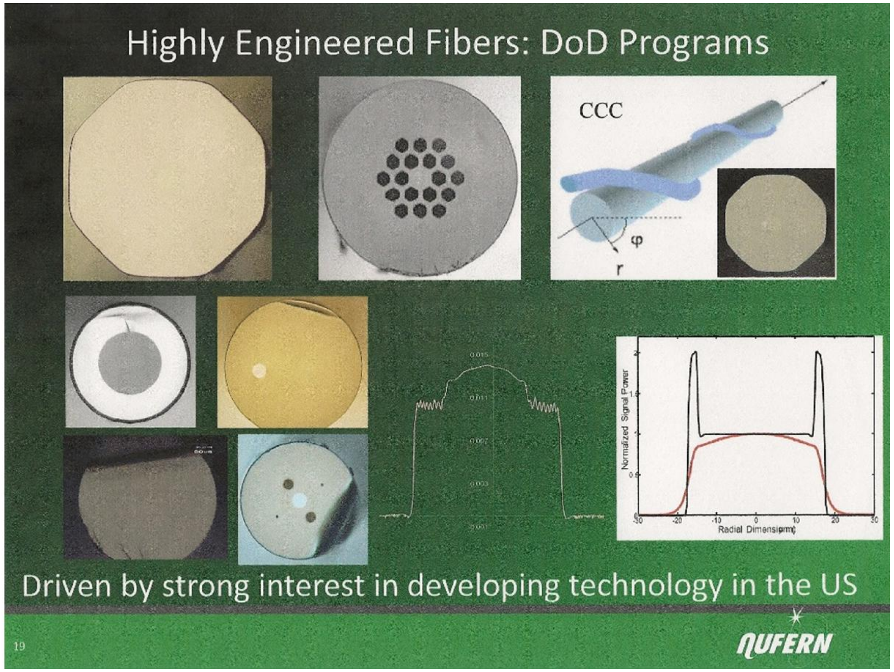




- Large, Low NA Cores offer large mode areas
- LMA fibers, while few moded, can be used for single fundamental mode operation.

All in Fiber Systems





Beam Control / manipulation by fibers or pigtailed components

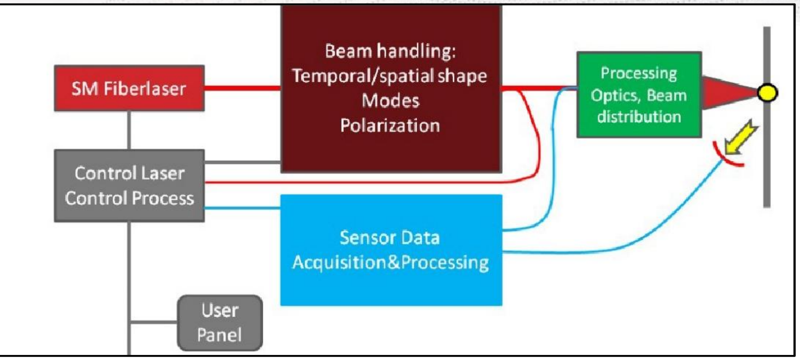
cw/cw-modulated / qcw /pulse shape /pulsed SM

Fibers or pigtailed optical components with low losses and high damage threshold?

Advantages:
No free optics/adjustment/contamination

Examples for existing fibers with beam shaping capabilities:
-GRIN (Refractive index)
-Square Shape (cross section)
-structured fiber

All in Fiber Systems



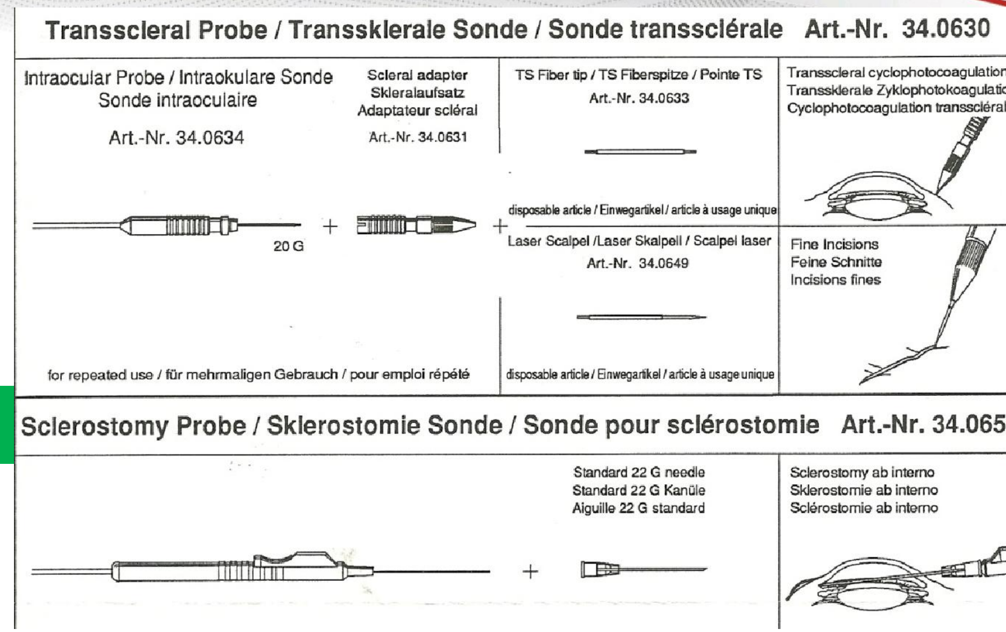
Processing head

-focussing optics/autofocus

-spatial beam distribution (time share(scan)/ energy share (DOE))

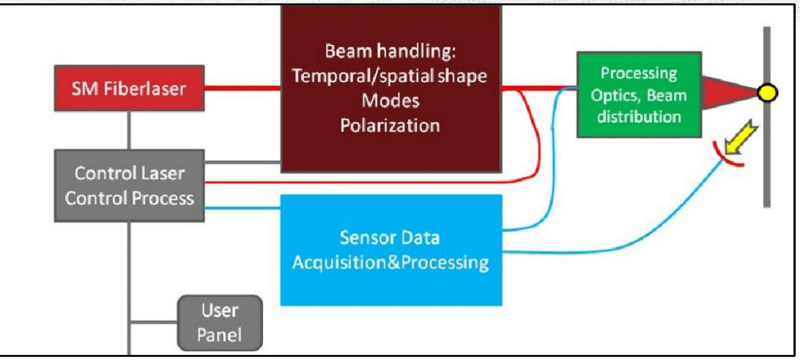
-Process measurements(on/offline) (backreflection(absorption/depth etc/ Temperature/imaging)

-Workpiece surface measurements (autofocus/ Structure/roughness etc)



Low power Medical Laser system with fiber probes or laser endoscopes already all in fiber systems

All in Fiber Systems

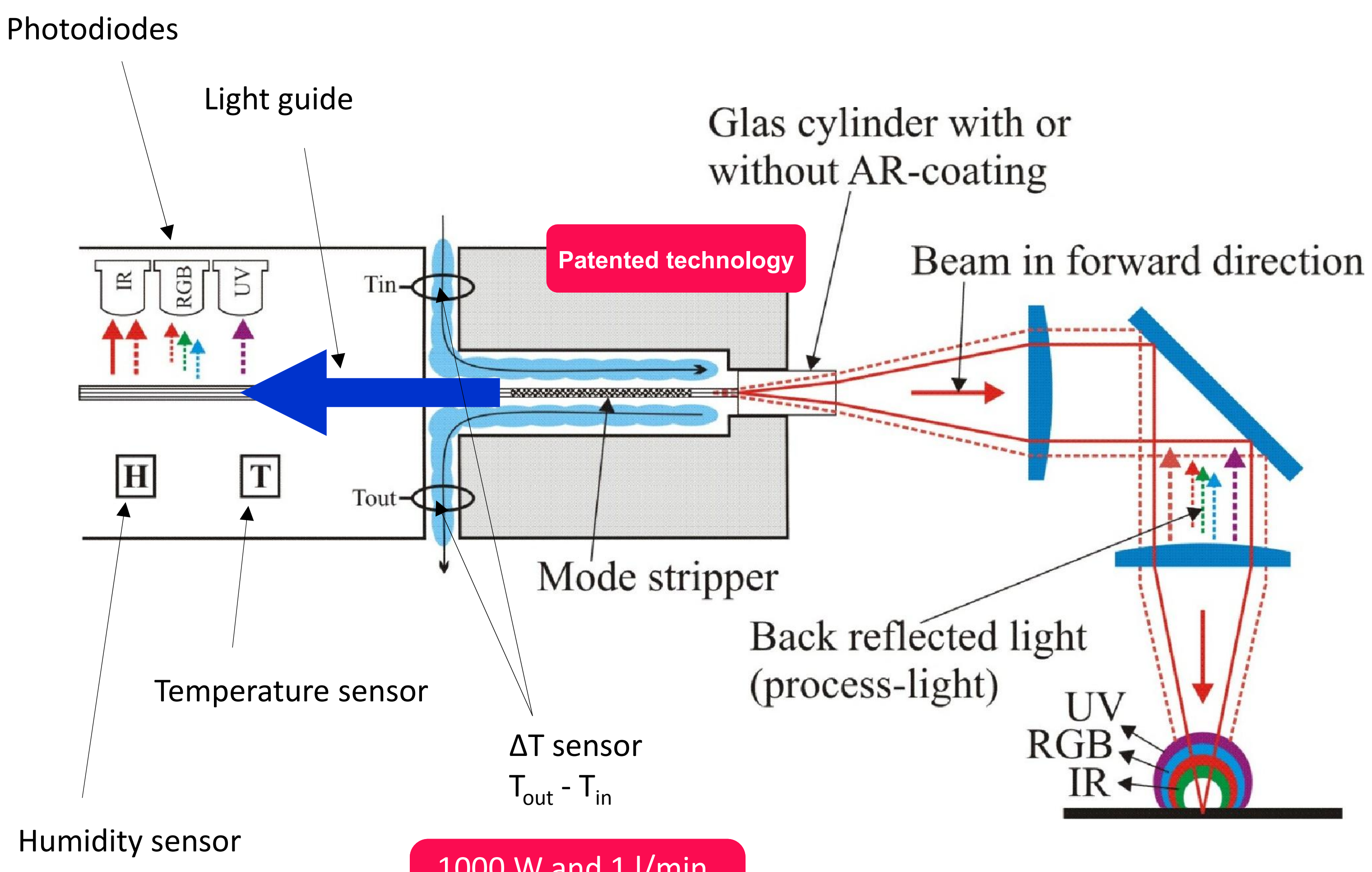


Sensor data acquisition & processing

Intelligent plug or fiberoptic signal capture and separation and processing in module

Or intelligent integration
Example: all in fiber OCT in combination with fs laser for cornea treatment

QD fiber – Sensor principle



1000 W and 1 l/min
=> ΔT = 14 °C

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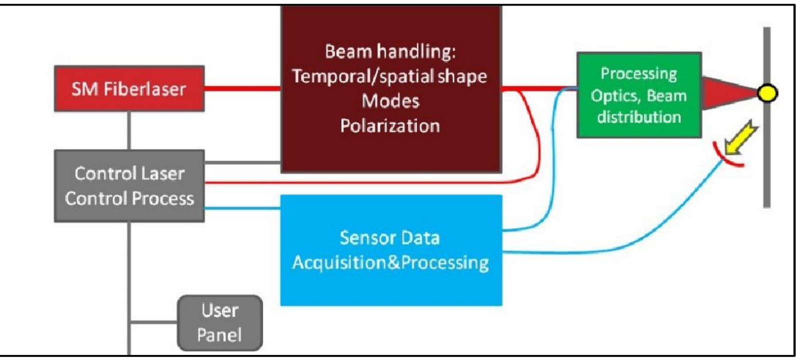
All in Fiber Systems



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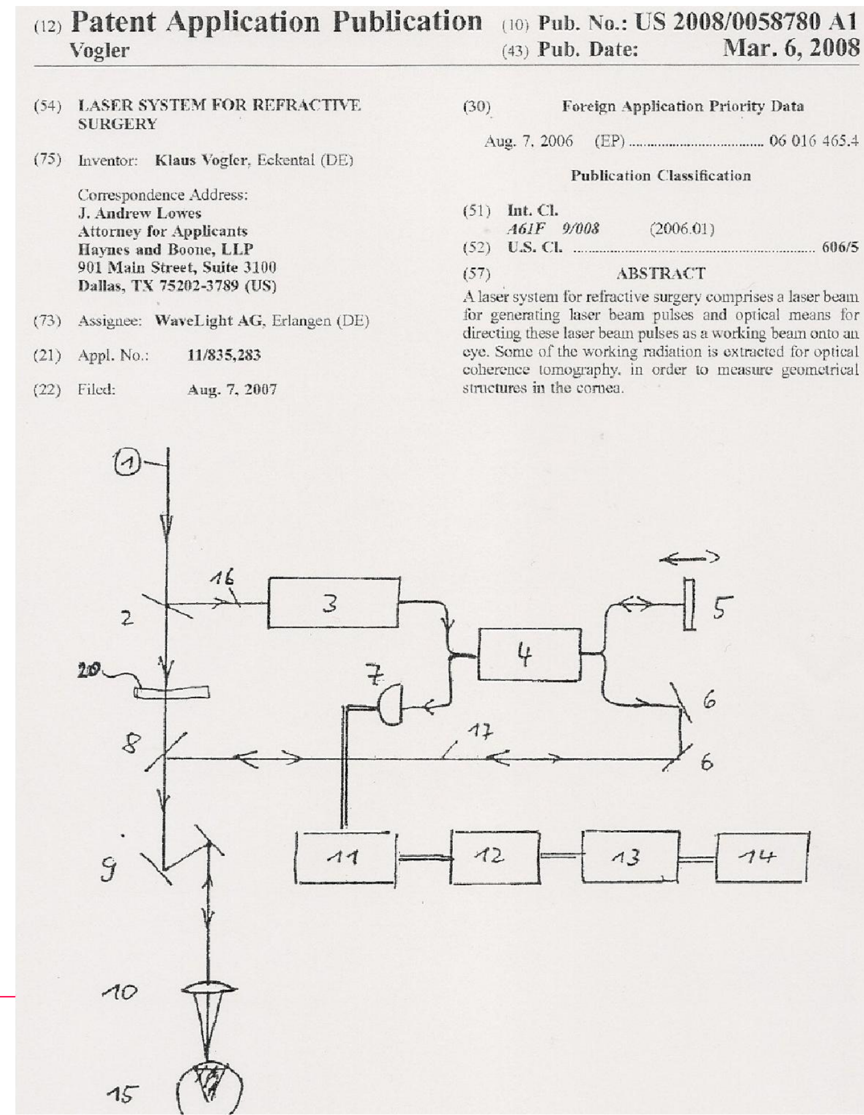
(12) **Patent Application Publication** (10) **Pub. No.: US 2008/0058780 A1**
Vogler (43) **Pub. Date: Mar. 6, 2008**

(54) **LASER SYSTEM FOR REFRACTIVE SURGERY**

(75) Inventor: **Klaus Vogler**, Eckental (DE)

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(73) Assignee: **WaveLight AG**, Erlangen (DE)

(21) Appl. No.: **11/835,283**

(22) Filed: **Aug. 7, 2007**

(30) **Foreign Application Priority Data**

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Publication Classification

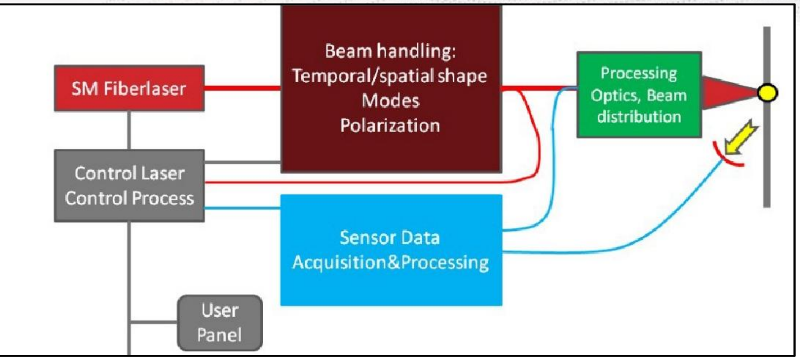
(51) **Int. Cl.**
A61F 9/008 (2006.01)

(52) **U.S. Cl.** 606/5

(57) **ABSTRACT**

A laser system for refractive surgery comprises a laser beam for generating laser beam pulses and optical means for directing these laser beam pulses as a working beam onto an eye. Some of the working radiation is extracted for optical coherence tomography, in order to measure geometrical structures in the cornea.

All in Fiber Systems



Summary

All in fiber systems for medical applications (low power) already available

All in fiber systems for (high power) material processing need improvement on component level to
-Manage thermal and nonlinear effects of the components
-Manage interaction of components
-integrate new multiplexing methods (see IT fiber technology)
-splice and play on proper fiber package (customized application system)

Vielen Dank für Ihre Aufmerksamkeit

Thank you for your attention

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Optoskand fundamental fiber technology

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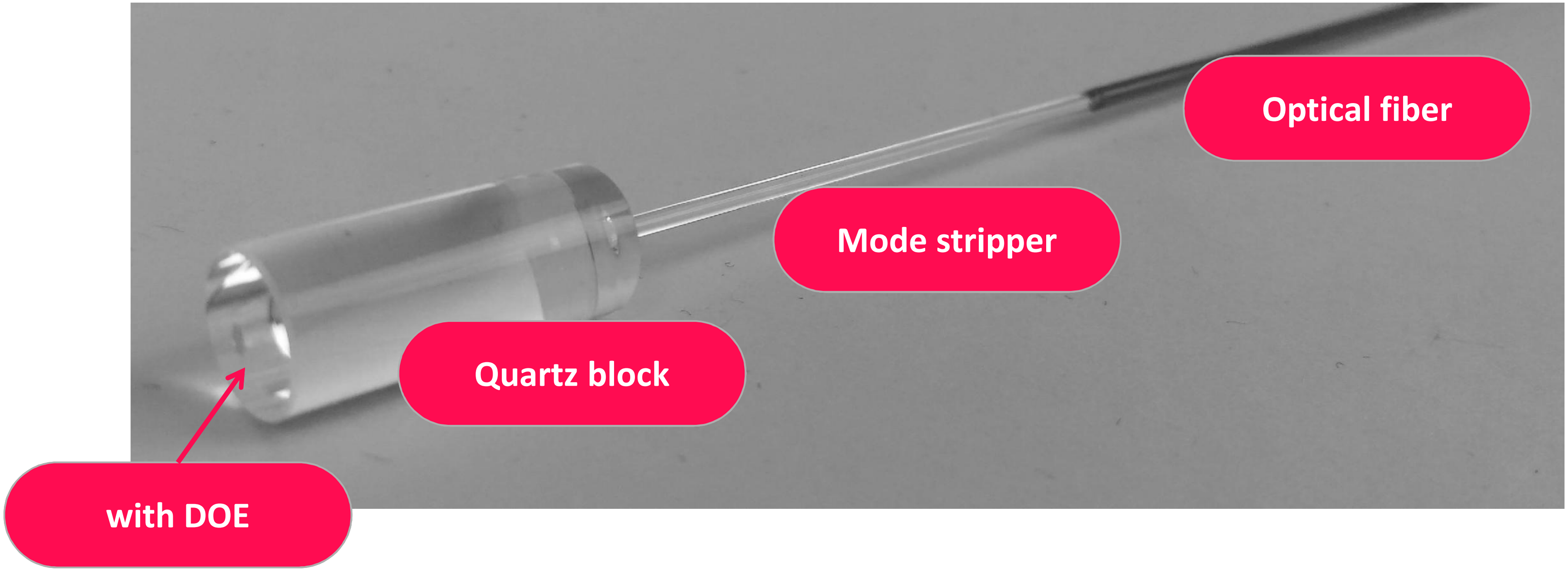
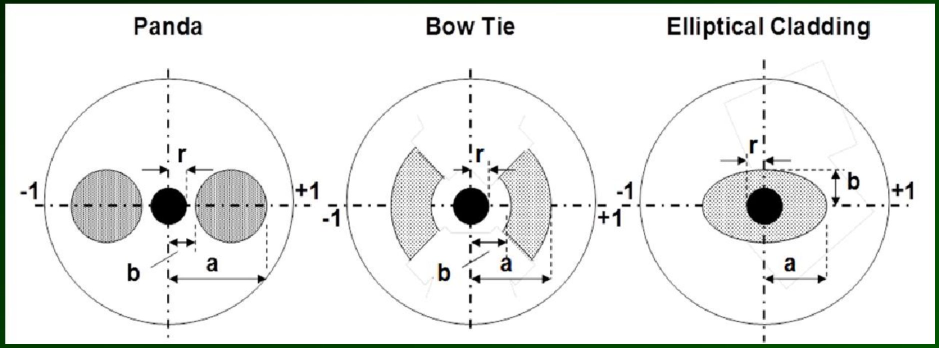
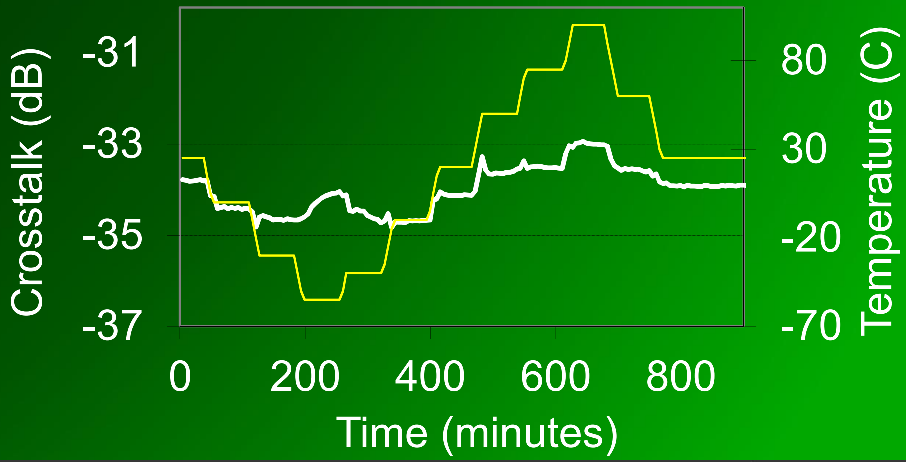


Polarization Maintaining Fibers

- PM-RGB Fibers (400 – 850 nm)
  - Ge Doped and Pure Silica Core
  - Hytrel and Nylon Buffers
- PM Telcom Fibers (980 – 1550 nm)
  - Gratings, Couplers, Fiber Pigtails
  - 250 or 400 μm Acrylate Coating



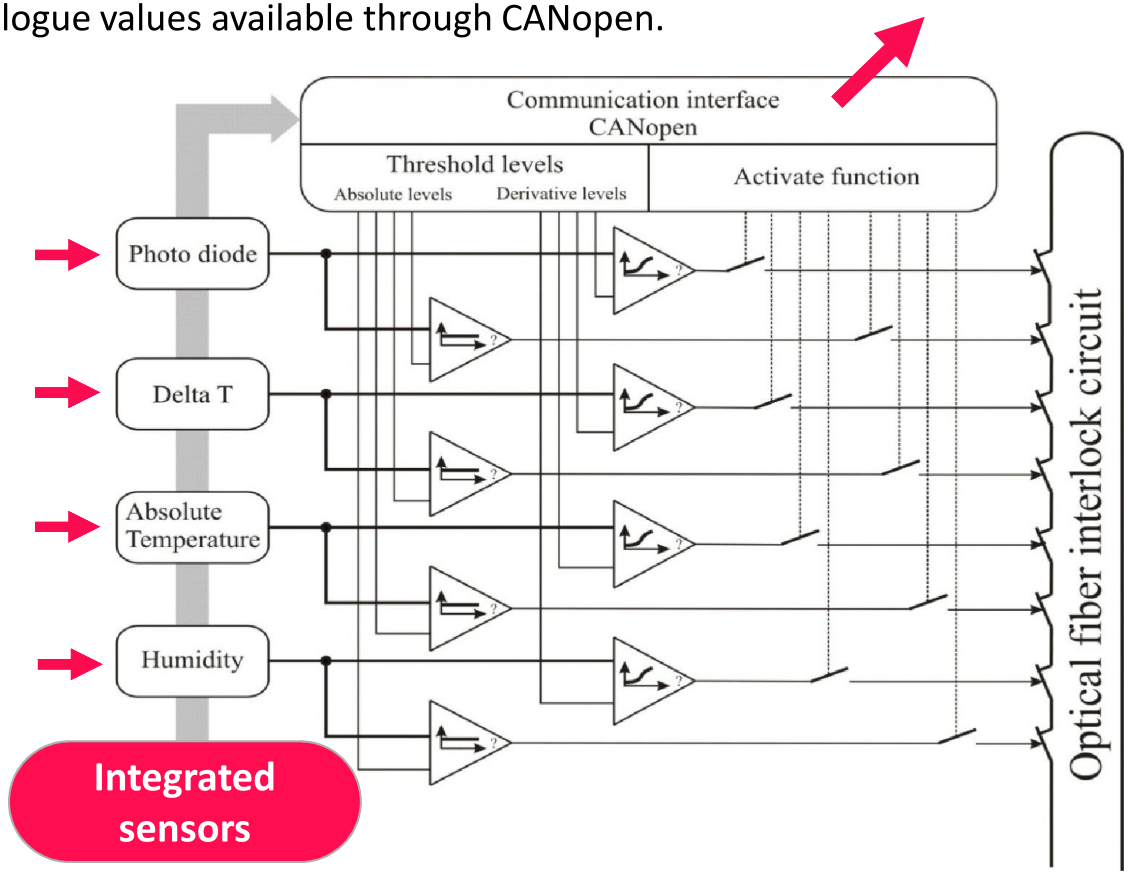
Temperature Cycling Results



NUFERN

QD fiber – Sensor communication

- Integrated sensor board for each QD connector.
- Switch off the fiber interlock in case of reaching the threashold level.
- Analogue values available through CANopen.



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Photosensitive Fibers

- Photosensitive Glass
  - Ge/B or Ge/F co-doped
- CMS or CMO designs
- FBGs for kW Class Lasers