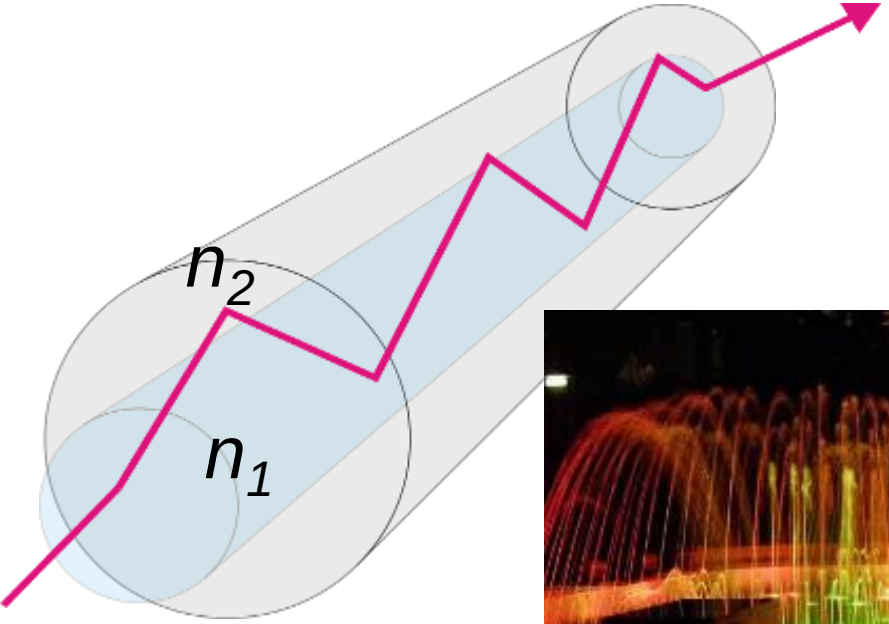
Technology of Optical Fibers

Academy of Sciences

Institute of Photonics and Electronics v.v.i.

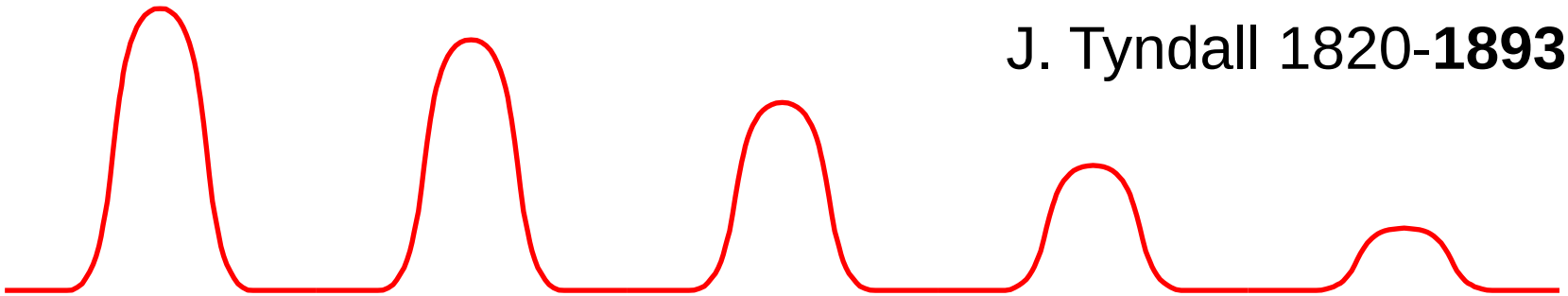
I.Kašík, www.ufe.cz

Optical fibers



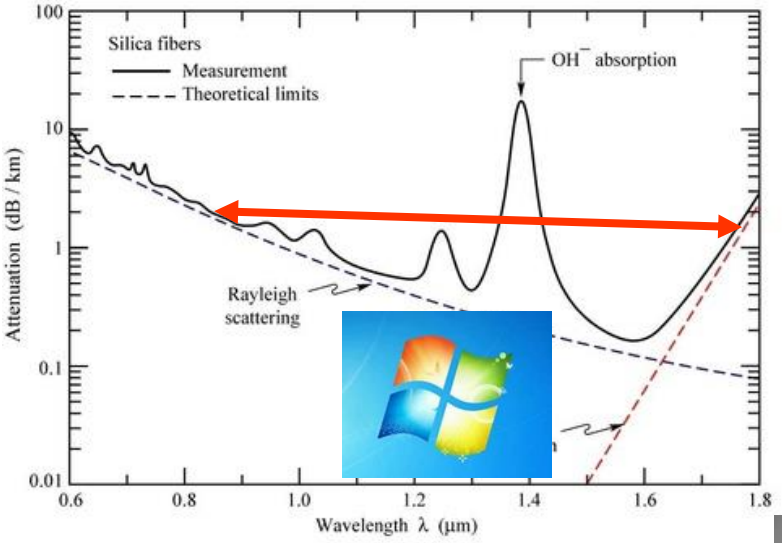
* dielectric
* mostly circular
* d >> L
* ***$n_1 > n_2$***
* ***total reflection***

W. Snell 1580-**1626**
J. Tyndall 1820-**1893**



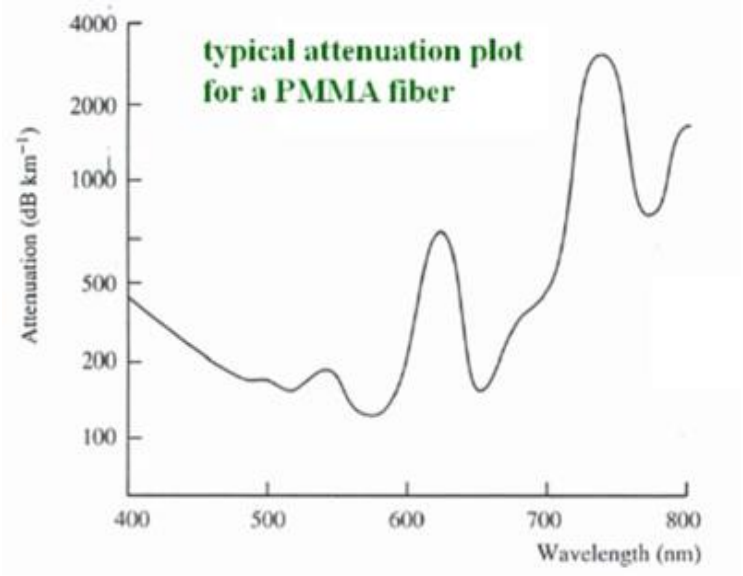
Optical fibers

Optical losses in optical fibers (intrinsic, extrinsic)



[Wiki]

20 dB/km
1% transmited



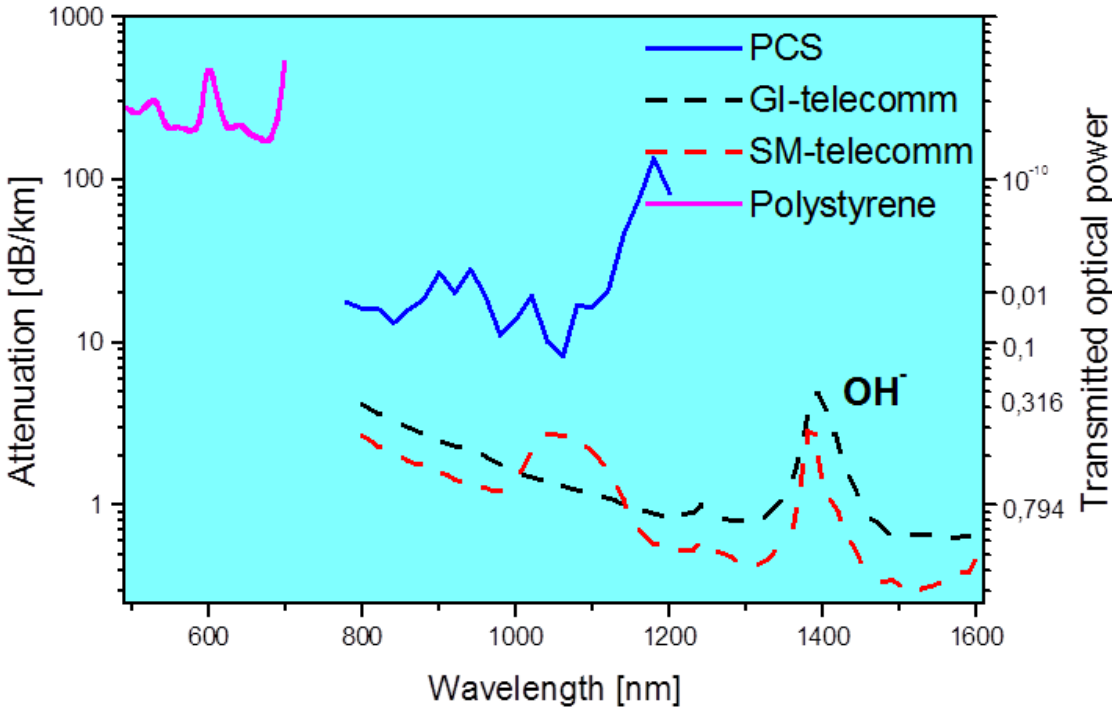
[Profimedia]

Nobel prize 2009 Ch.K.Kao

Optical fibers

Optical losses in optical fibers (intrinsic, extrinsic)

- high-purity
- silica based materials, max. impurities acceptable in ppb (10^{-9})



Conventional glassmaking =>

ULTRA-PURE TECHNOLOGIES

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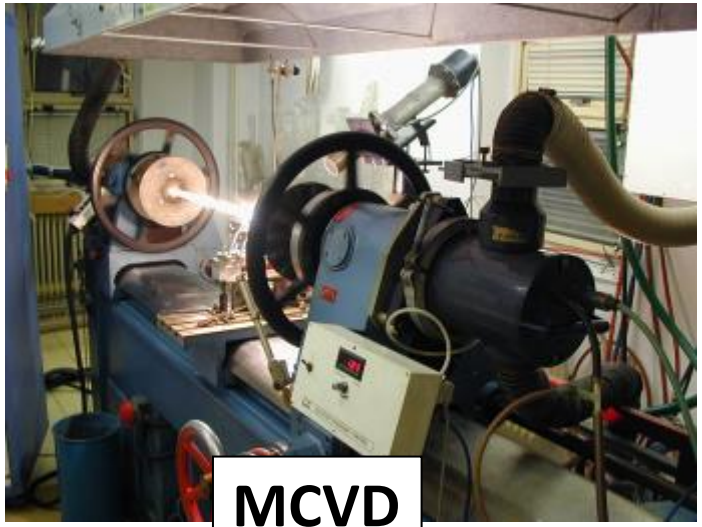
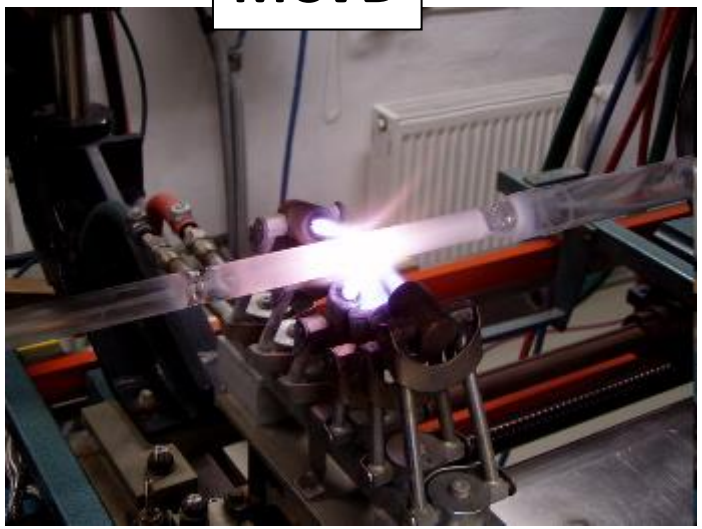
Optical fiber preparation - technology

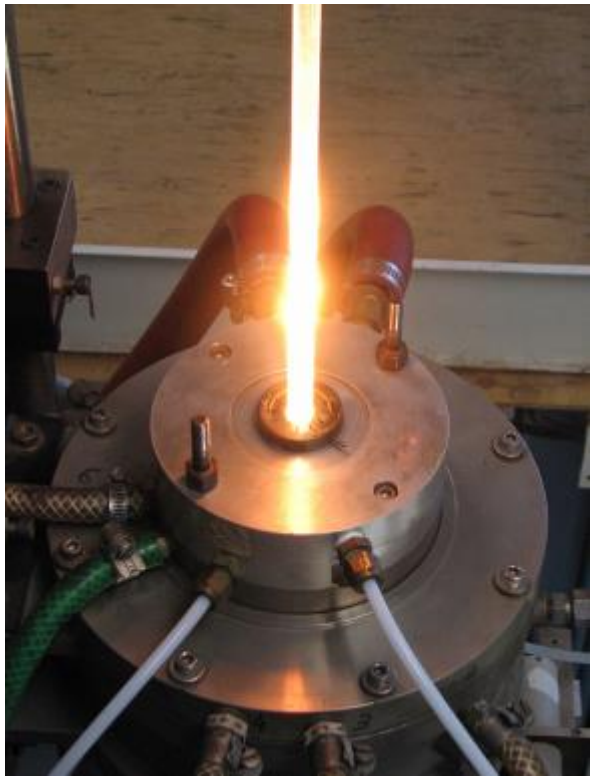


MCVD



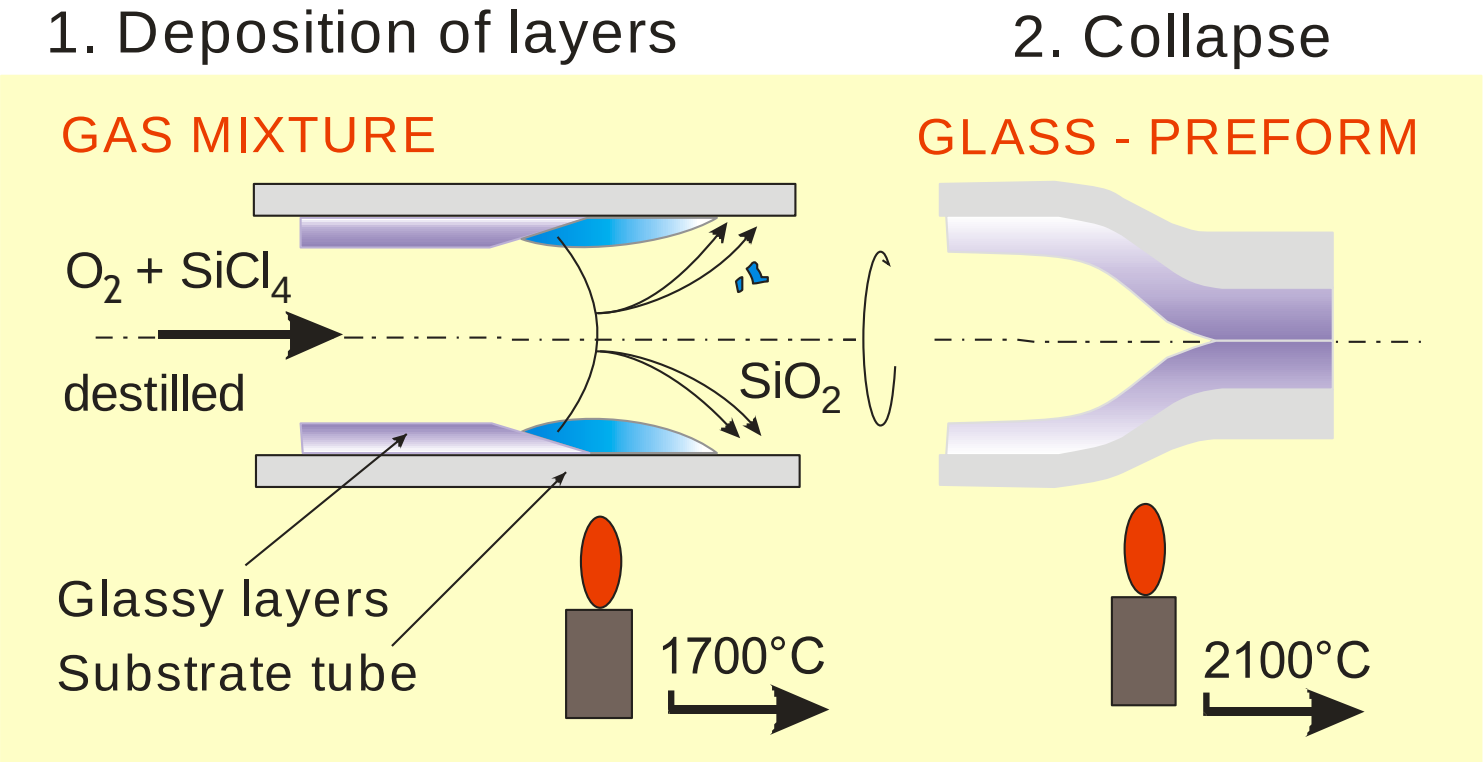
1. Preform

2. Fiber drawing



PREFORM PREPARATION - MCVD

MCVD – (Modified) Chemical Vapor Deposition



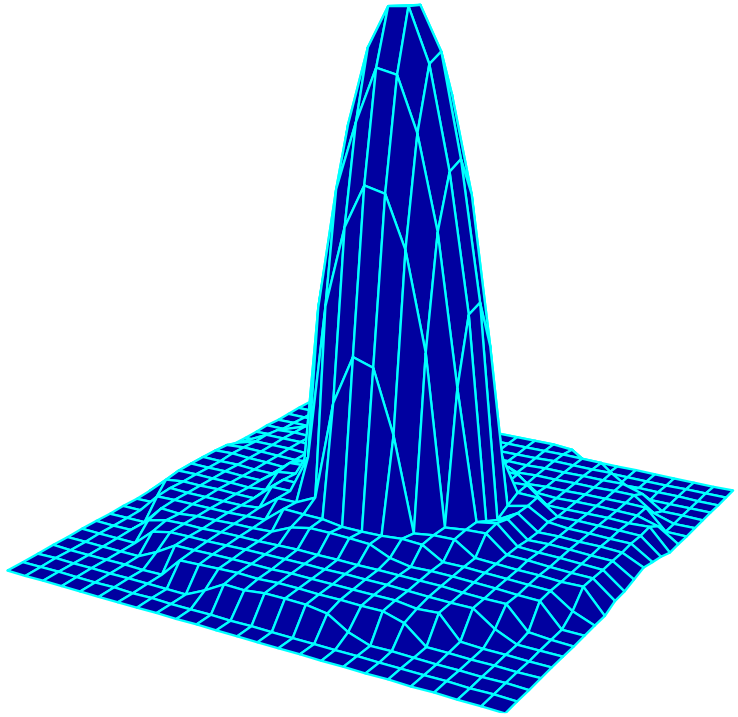
Sequential sintering of **thin glassy layers** (of thickness 1-20 μm) onto inner wall of silica substrate **resulting in bulk material – preform**.

A (g) + B(g) = AB (s)

high purity (~ 10^1 ppb) **high precision** (better than 1 %)

MCVD

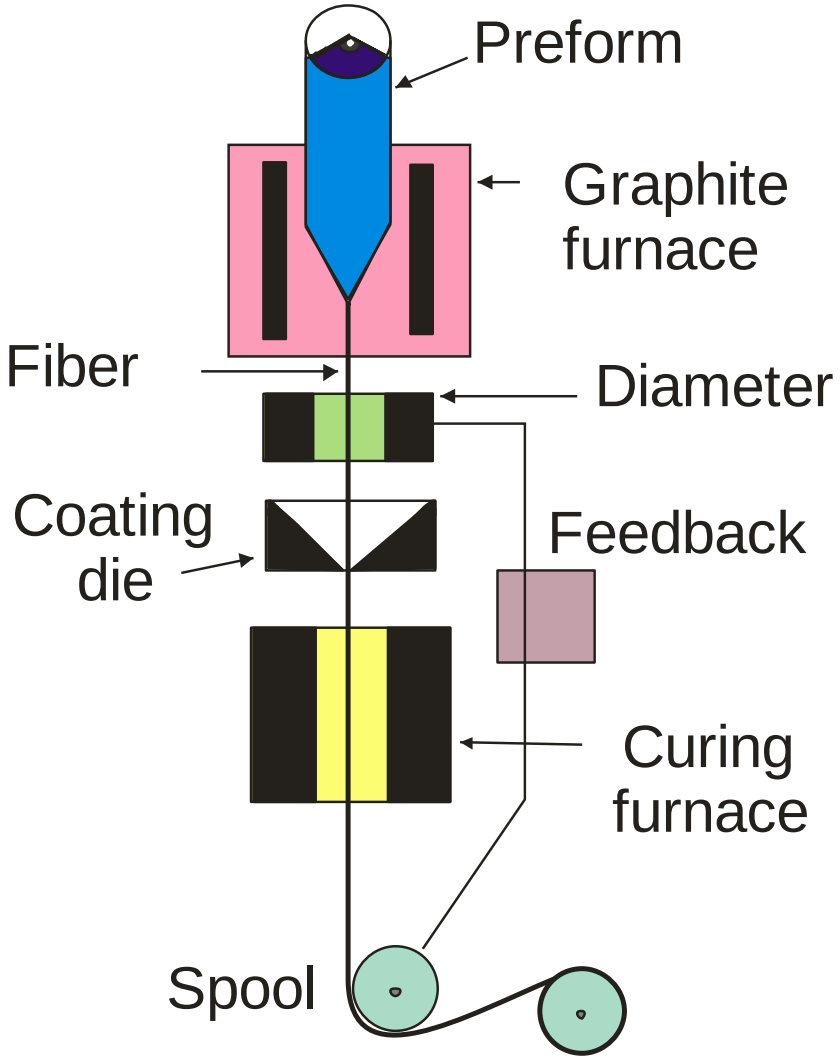
Microphoto of cross section of produced preform



Tomography of the refractive-index profile of preform

High purity material due to FO-Optipur purity starting materials.
High quenching rate ranging from 10^2 to 10^3 °C/s !
Dopants = change of refractive index

Drawing of optical fiber from preforms



Diameter
80-1000 µm

Temperature
1800-2100°C

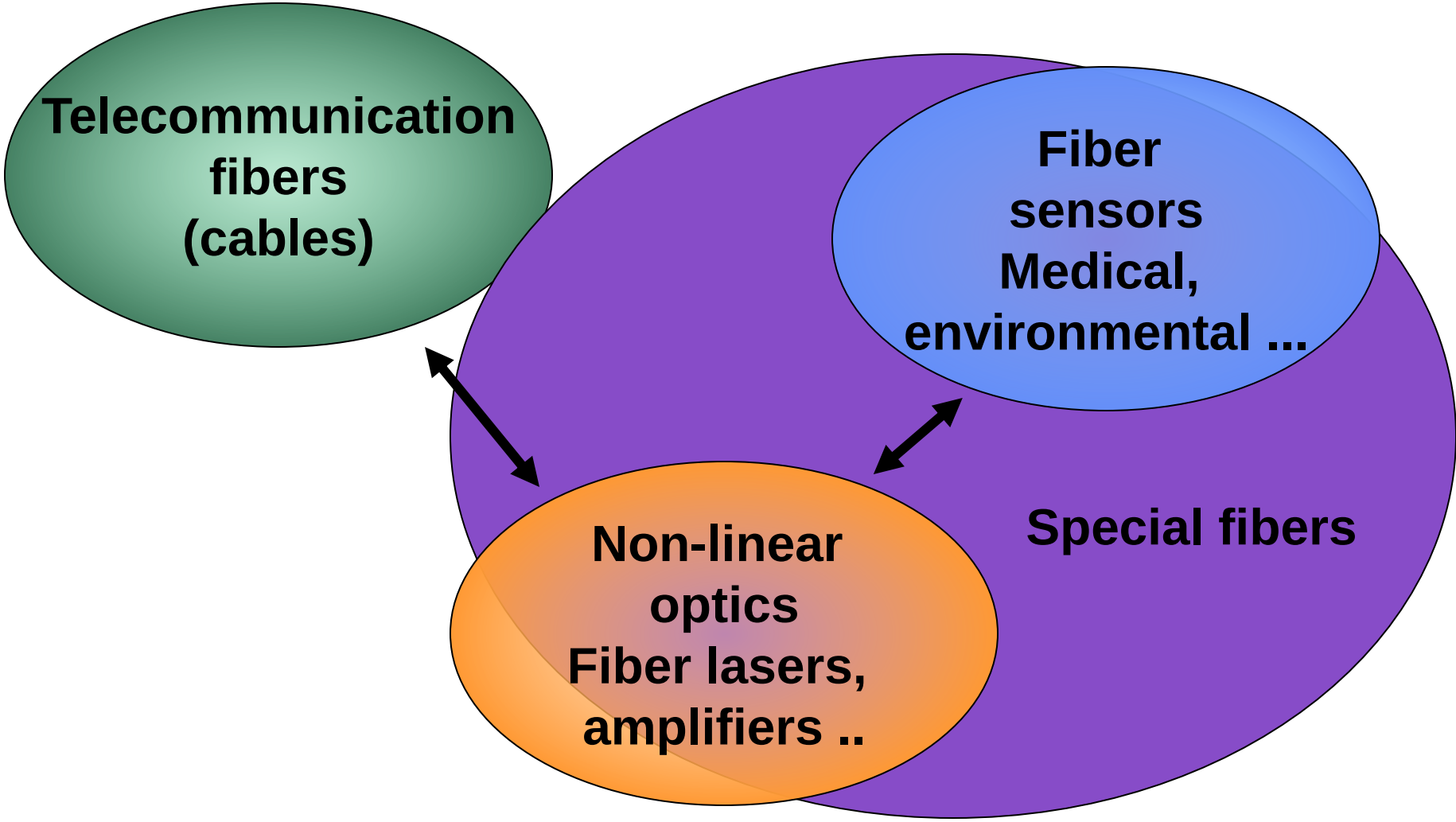
Diameter
80-1000 µm

Temperature
1800-2100°C

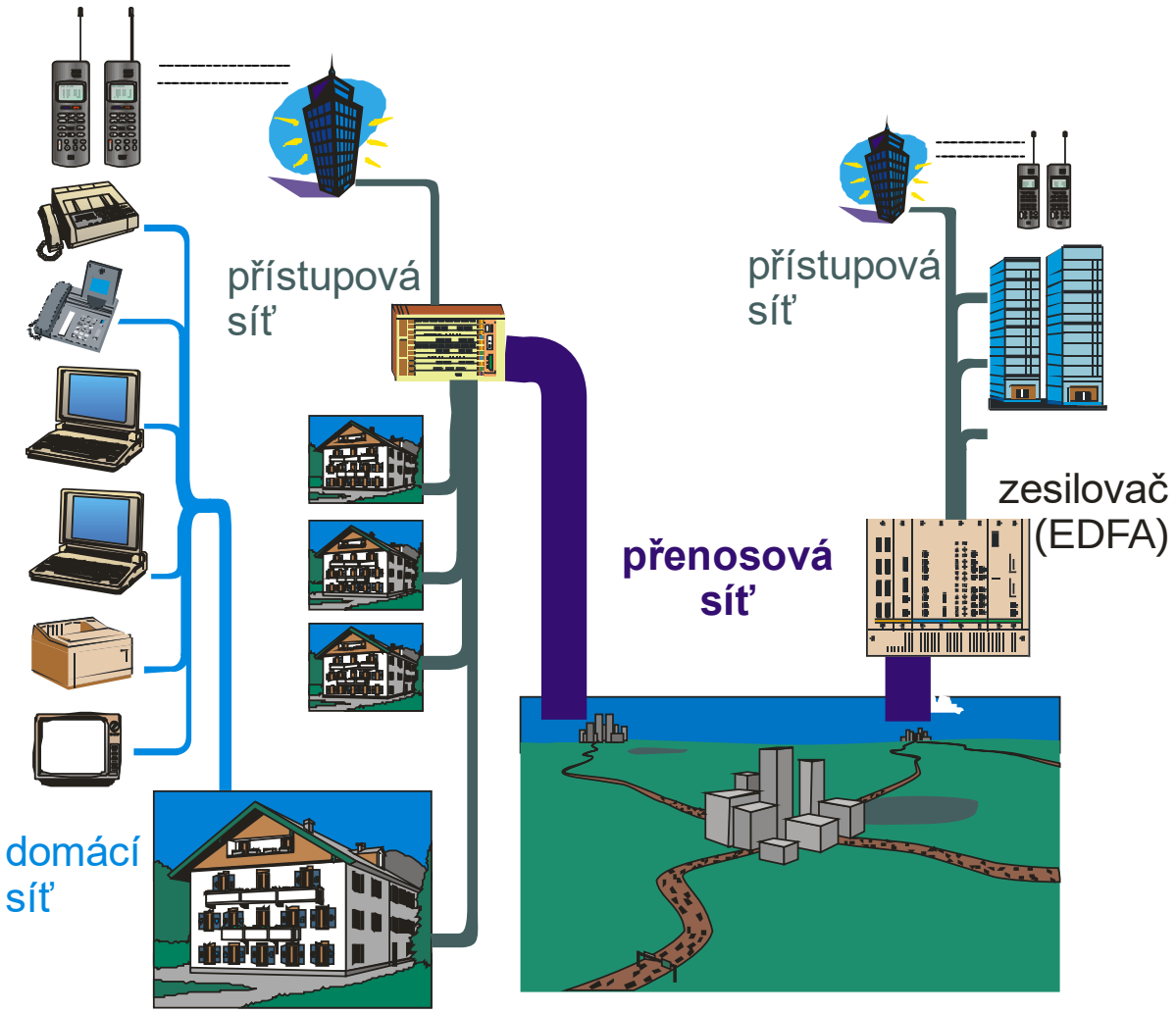
- No textile
- No thermo-insulation

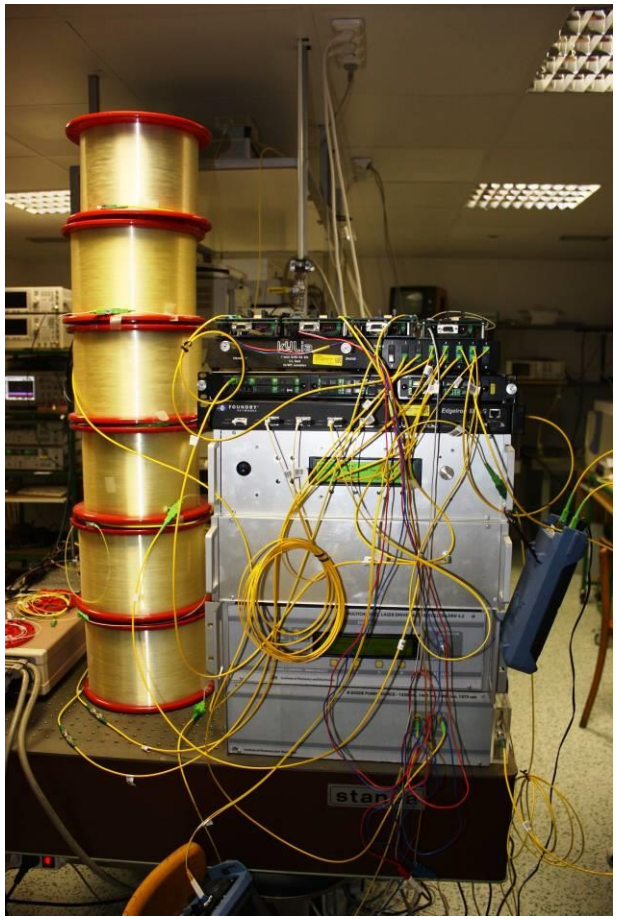
Technology

Application



Optical fibers - telecommunications





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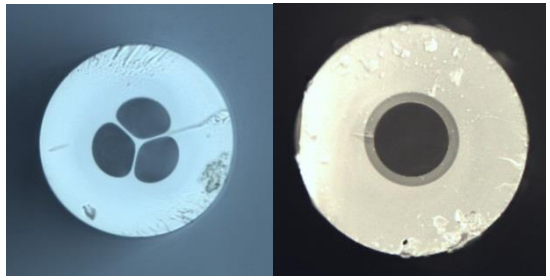
Praha - Brno

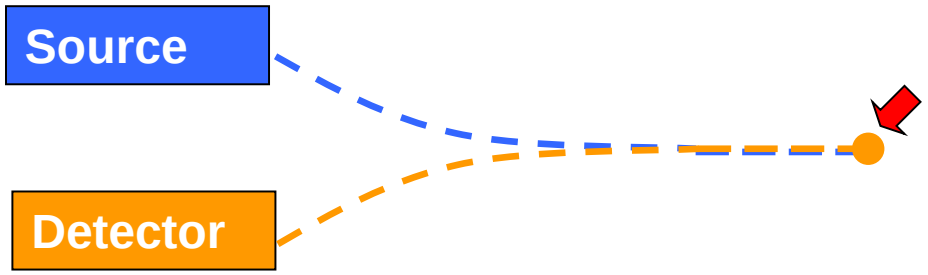
Optical fiber sensors



Source

Detector

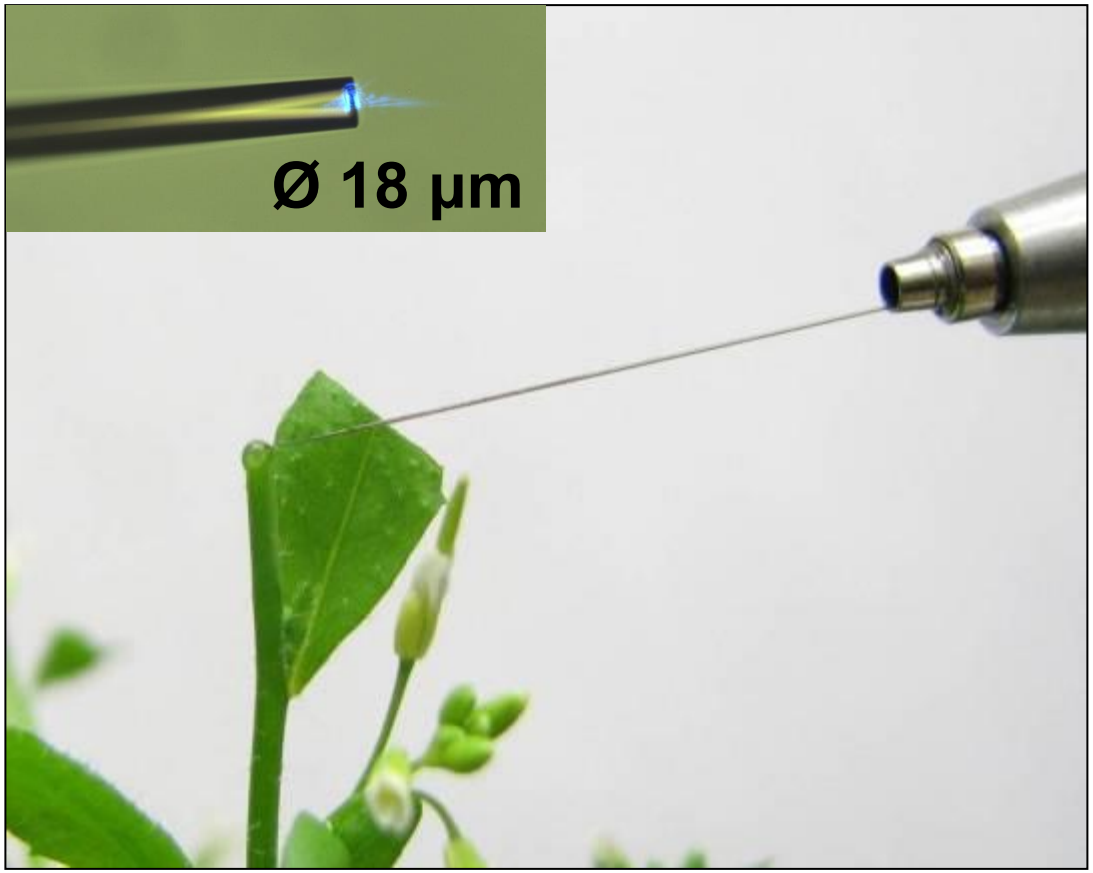
Continuous monitoring of (bio)chemicals and their concentration.



Suitable for :
remote sensing
distributed sensing
flammable or explosives
in high-voltage areas
human body

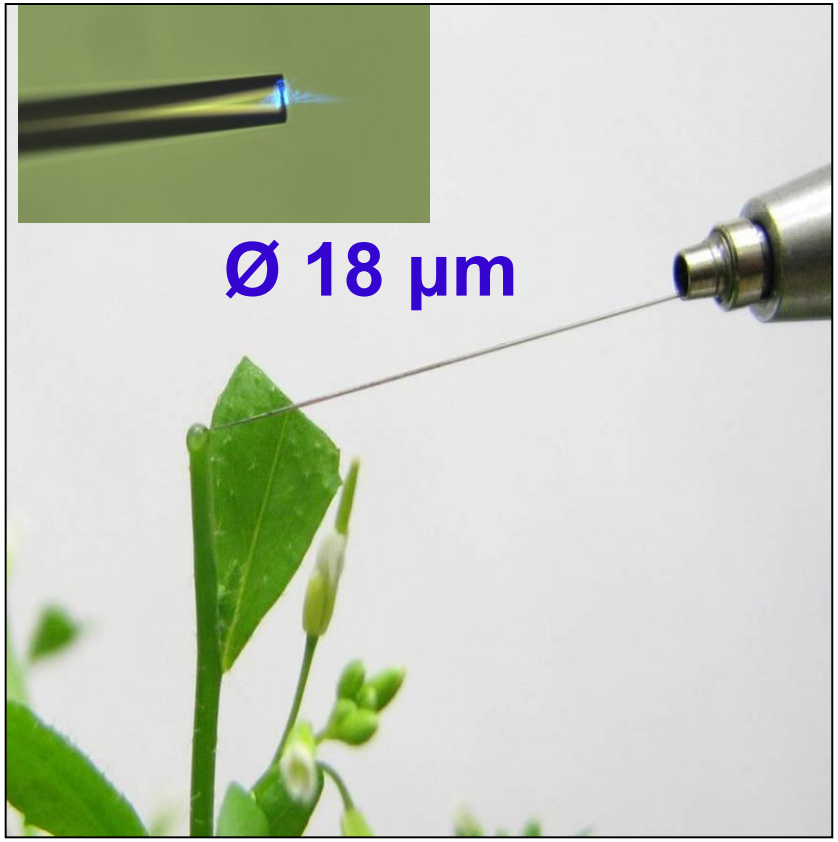
Optical fiber sensors

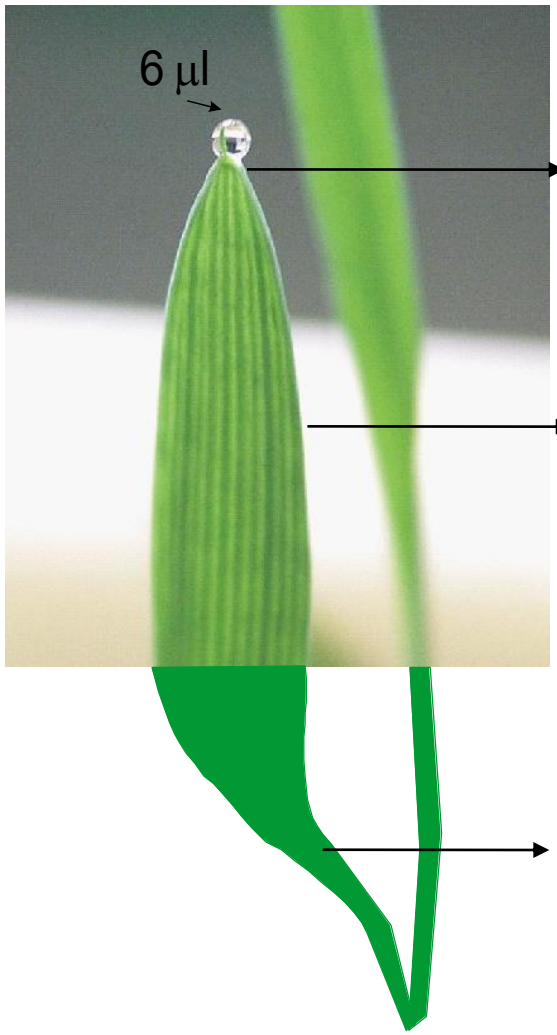
In vivo detection of pH in small samples (droplets, cells)



Sterilizable !!
Long-term operation

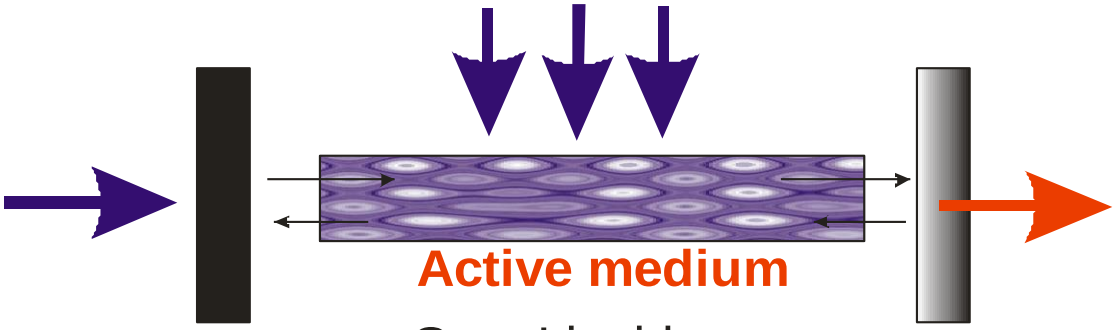
Optical fiber detection of pH





pH		
	kapky	objem
	5.0	5.4
	5.6	5.4
	5.5	6.0

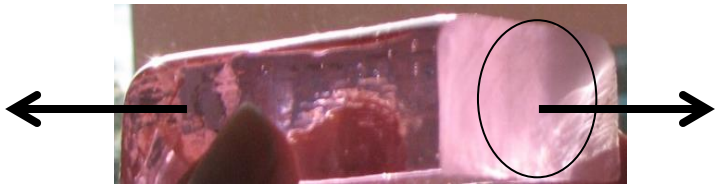
Silica specialty optical fibers for fiber lasers and amplifiers

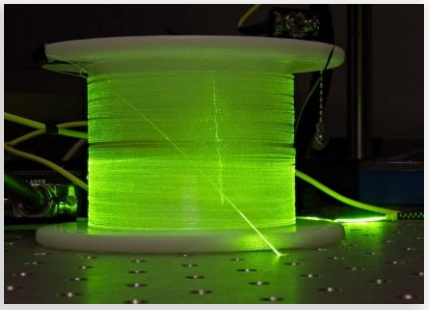


Mirror
100%

Gas, Liquid
Solid state :
* semidonductor
* glass
* OPTICAL FIBER

Mirror
8-99%



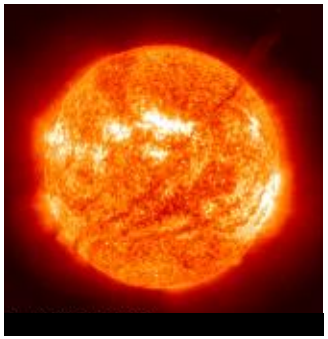


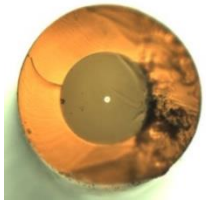
Er^{3+}

[C.J. Koester, E. Snitzer, Appl.Opt. (3) 1964, 1182] , [S.B. Poole, J.Lightwave Tech. LT-4 (**1986**), 870], [E.Desurvire, J.Lightwave Tech. LT-7 (1987), 835]

Fiber lasers mW → kW

* high conversion efficiency (fiber lasers ~70-90%) - savings
* high quality beam (nearly Gaussian, low divergency)
* **high brightness** (high concentration of power)
* good thermal management (cooling)
* effective pumping
* tunability
* compactness
* size (long resonator in small space)

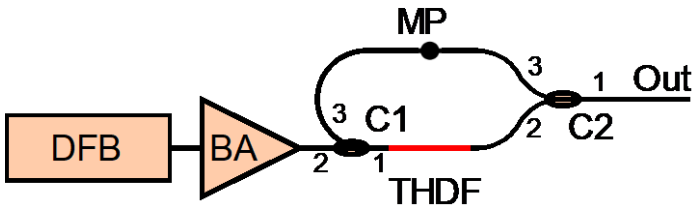


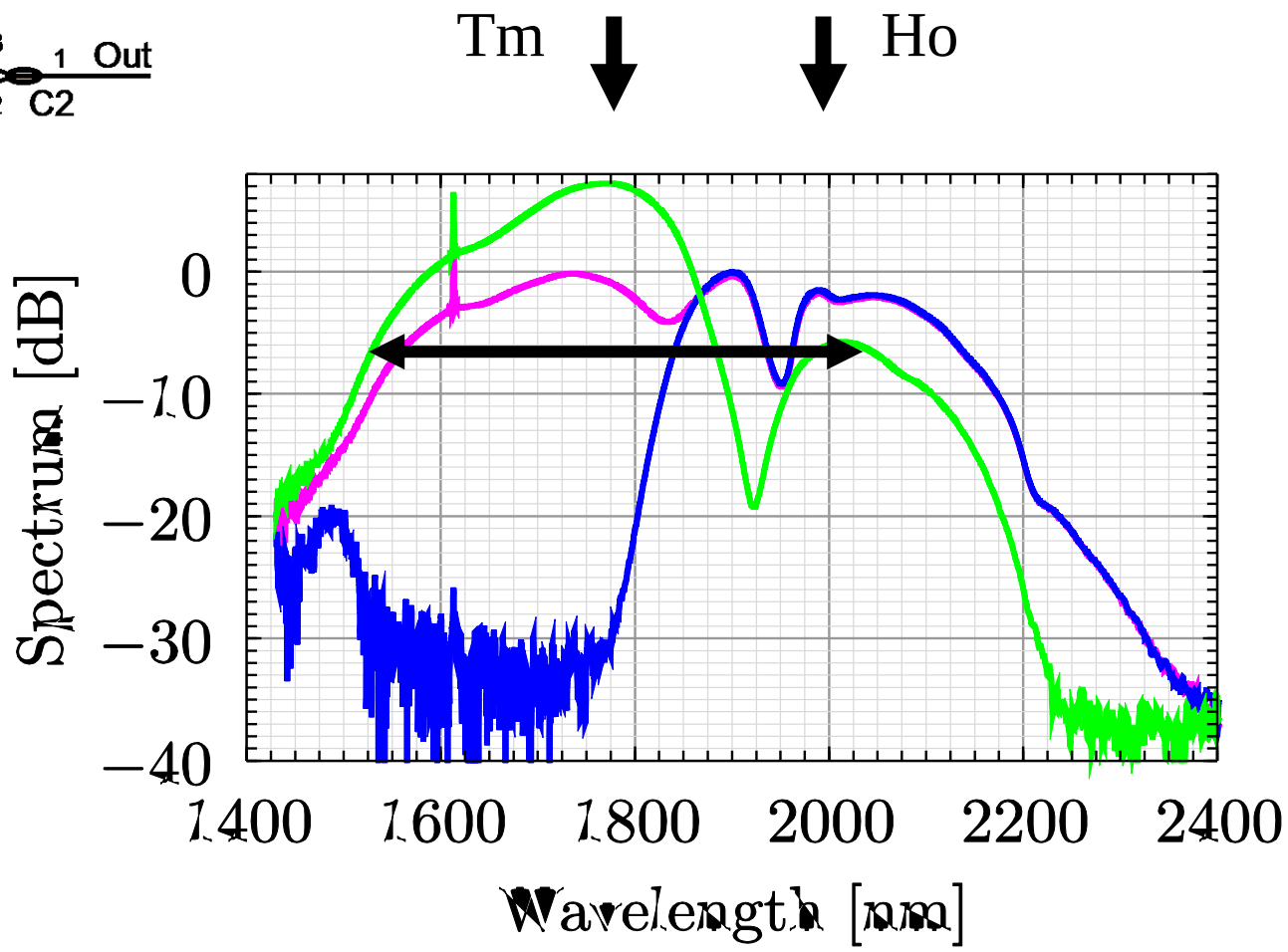


sun	63 MW/m^2
fiber laser	12.7 GW/m^2

[IPG]

Tm/Ho fiber for ASE (1550-2050 nm) stable source





1800 ppm Tm^{3+} / 360 ppm Ho^{3+}

[P.Honzatko, Optics letters 39 (2014) 3650-3653]

SUMMARY

1. Fiber technology : preparation of structures of high precision from materials of ultra-high purity (impurities in ppbs only). Difference between CVD and PVD.
2. Fiber preparation in two steps : preform preparation and fiber drawing. (M)CVD technique (preform) makes possible to prepare multilayered tailored structures of suitable level of purity.
3. Fibers conventional (passive) and special (active).
4. Research of optical fibers (CR) :

References

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- A. Mendez, F.T. Morse : Specialty optical fibers handbook, Elsevier Science & Technol, USA, 2006.
- Saaleh, Fotonika (1 - 4), Matfyzpres
- J. Schrofel, K. Novotný : Optické vlnovody, SNTL, 1986

- S. R. Nagel, J. B. McChesney, K. L. Walker : An overview of the MCVD process and performance, IEEE J. Quantum Electron. QE-18 (1982) 459-477

Peterka - Vláknové lasery
ČT-D Lovci záhad: Srdce superlaseru, 1/6/2014
Československý časopis pro fyziku 1/2010, 4-5/2010, 1/2011
Jemná mechanika a optika (5-6/2015)
Panorama 21. století 3/2012
ČT2 – PORT : Co dokážou lasery - 29/9/2010
ČT2 – Věda a vědci : Zkrocené světlo - 6/10/2010

Be UFE !

- **STUDY** (diploma, thesis)

Czech Technical University

Charles University

Institute of Chemical Technology

- **PROJECTS** - partners CZ

- **INTERNATIONAL** - collaboration

Be carefull !

EXCURSION

1. Preform preparation (MCVD)
2. Fiber drawing
3. Preform (fiber) characterization

Thank you for attention