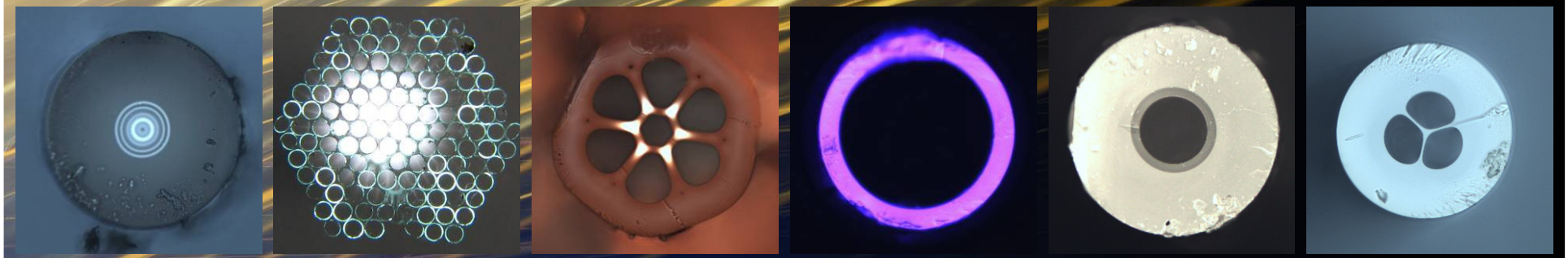
Optical fibers

Laboratory of optical fibers

Institute of Photonics and Electronics AS CR, v.v.i.

www.ufe.cz/dpt240



Institute of Photonics and Electronics AS CR, v.v.i.

Assoc. Prof. Jiří Homola

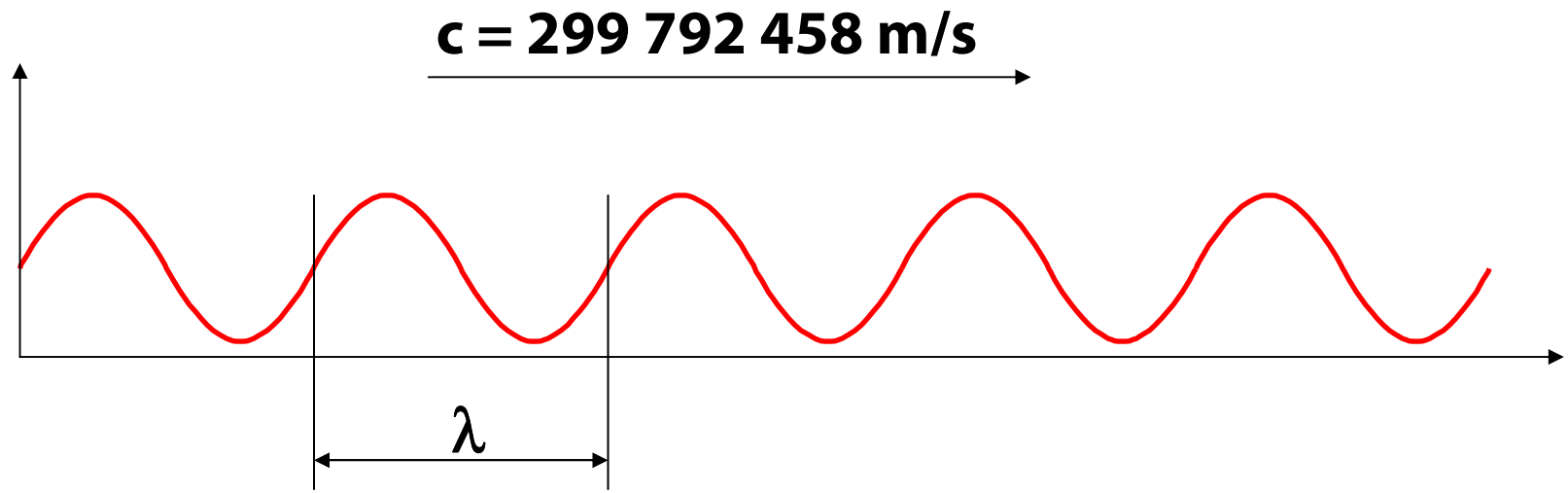
- **Optical Biosensors**
- **Fiber Lasers And Non-linear Optics**
- **Bioelectrodynamics**
- **Nanomaterials**

Photonics

Optics -science dealing with light (rays, quantum)

Foton -elementary particle of EMG rays-light

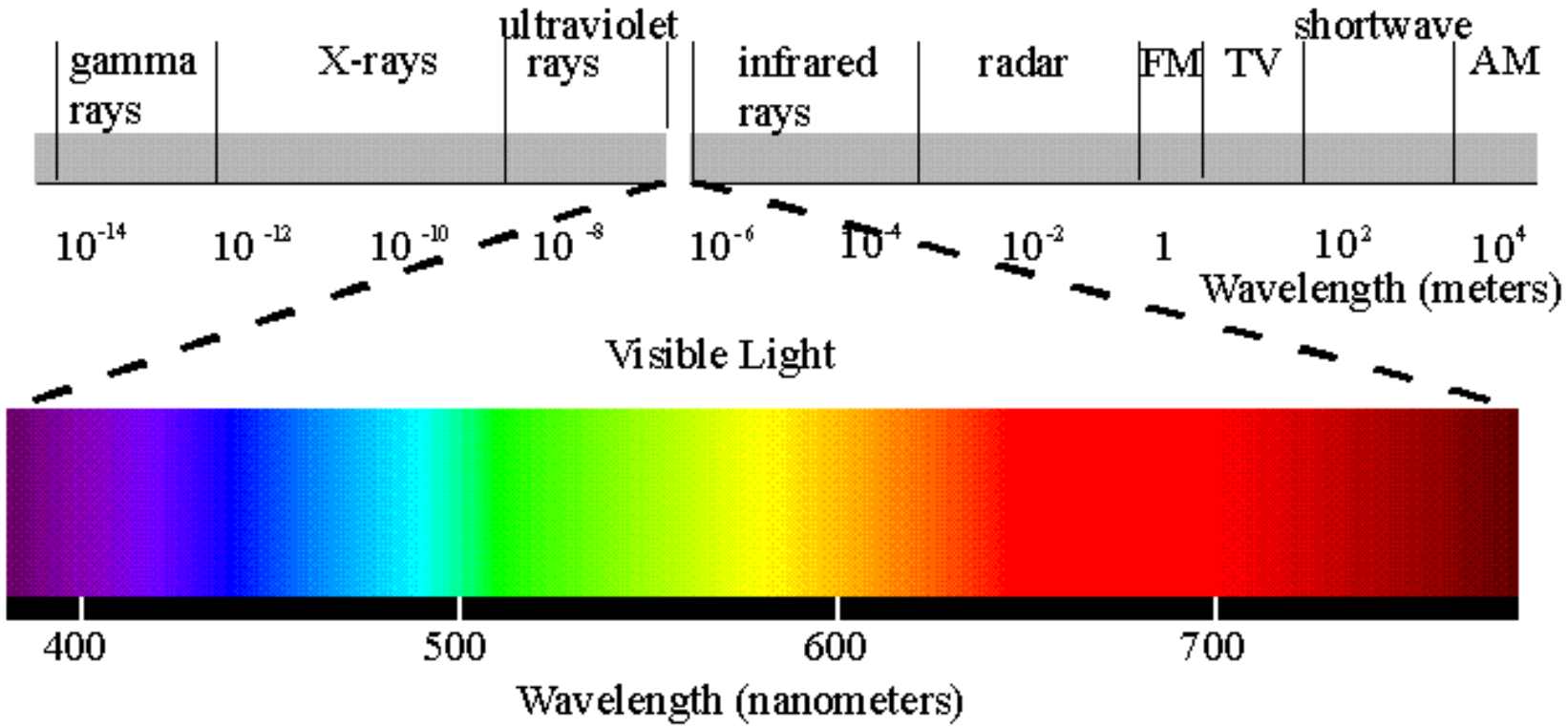
Photonics –science -properties and application of photons



$$f = c / \lambda$$

c	speed of the light
λ	wavelength
f	frequency

EMG spektrum



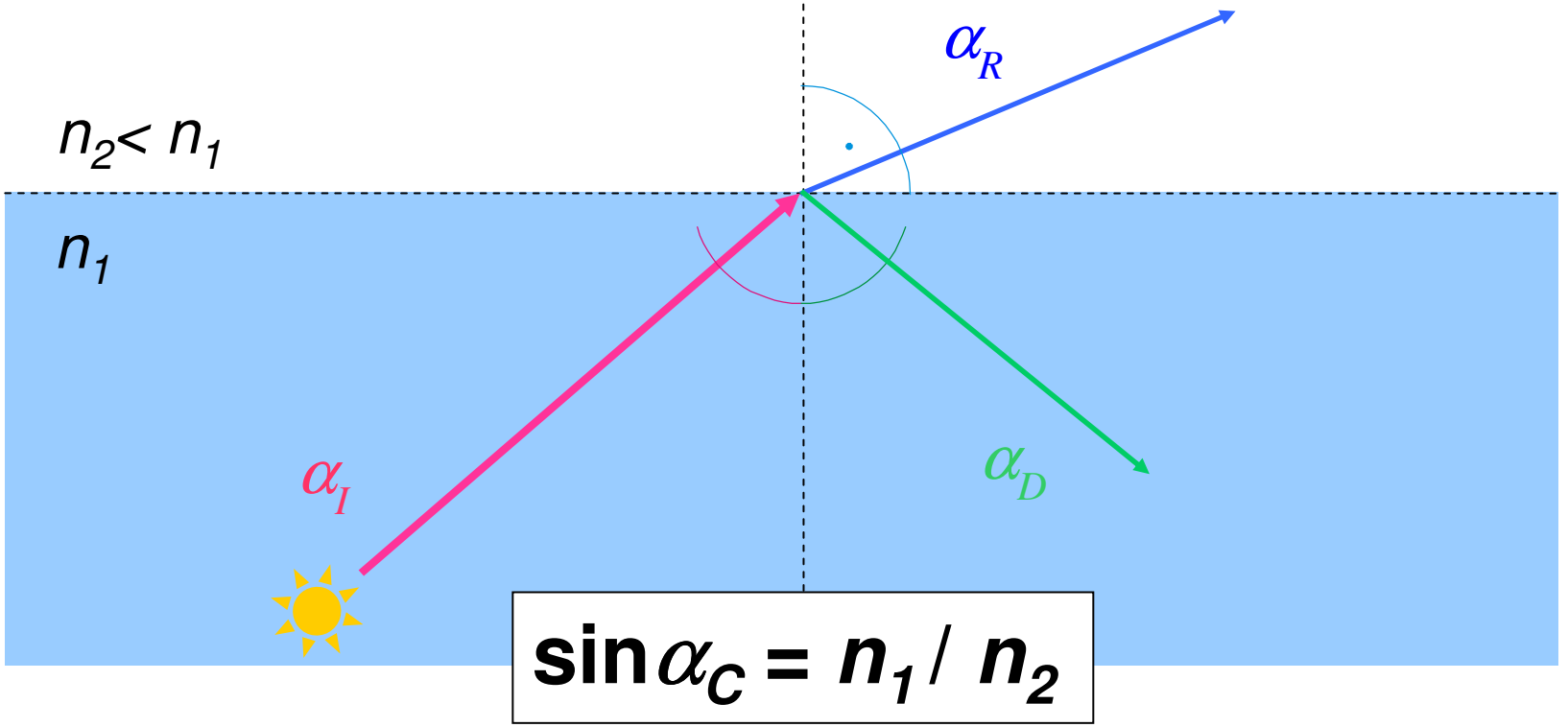
$$f = c / \lambda$$

Total reflection

α_R=90° => $\alpha_I = \alpha_C$~ Critical angle

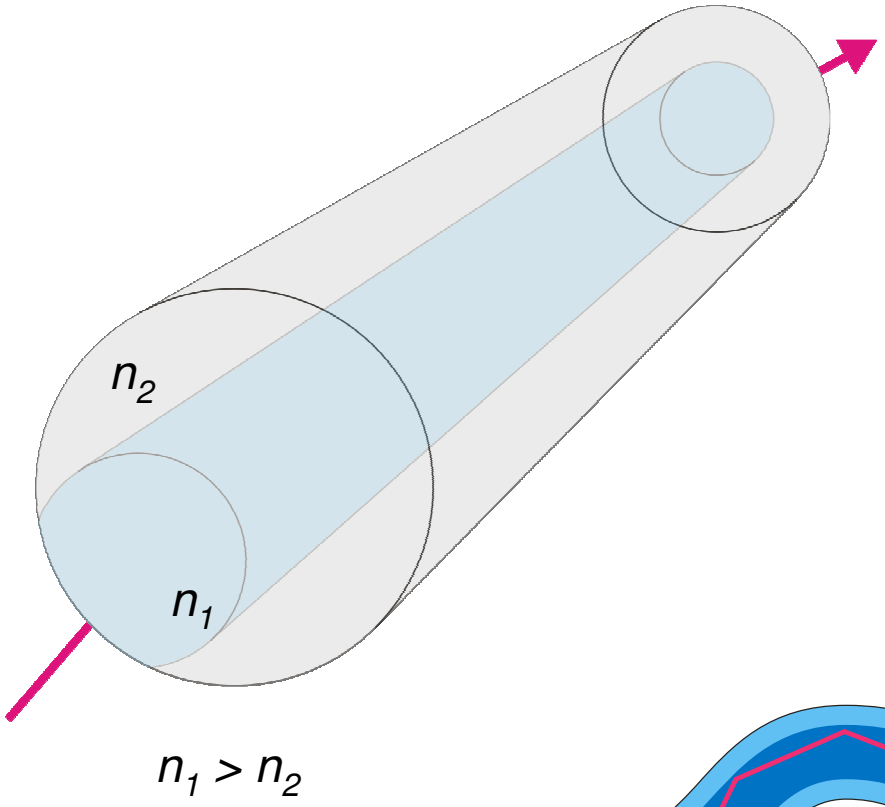
α_R>=90° => Total reflection

$$\frac{\sin \alpha_I}{\sin \alpha_R} = \frac{n_1}{n_2}$$

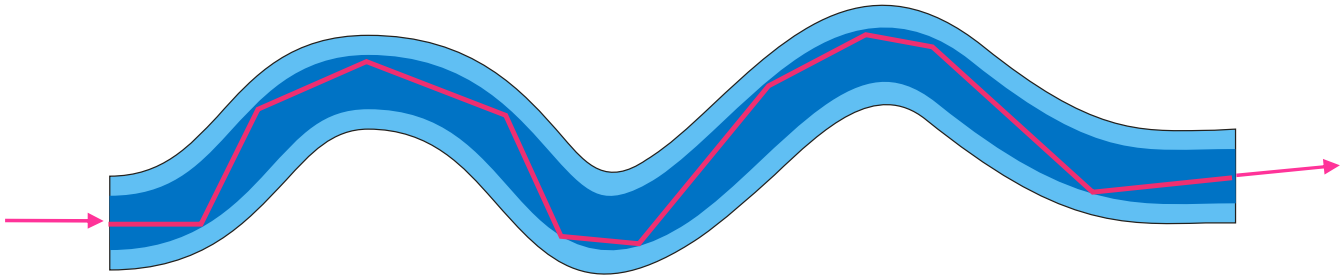


$$\sin \alpha_C = n_1 / n_2$$

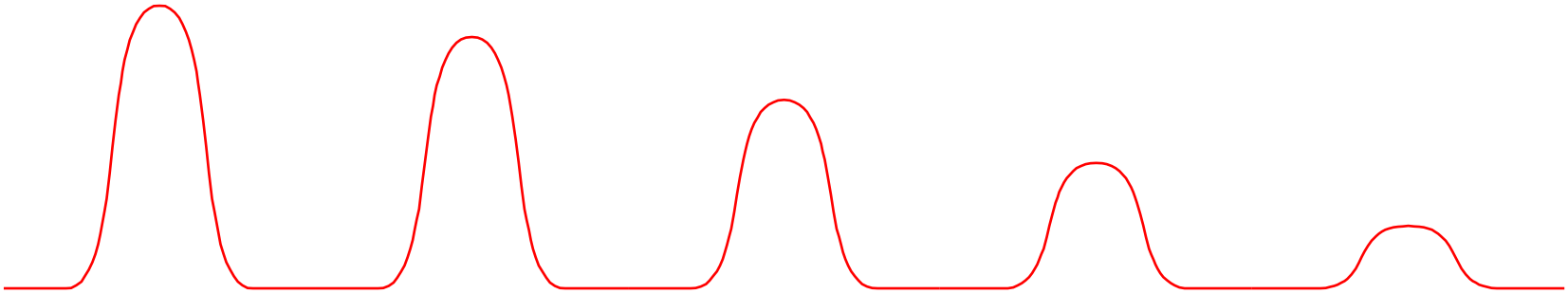
Principle of the waveguide



Refractive index (n=c/v)	
Vacuum	1
Air	1,0003
Water	1,330
Silica glass	1,457
Window glass	1,535



Condition : purity of the materials (↓Attenuation)



Attenuation of optical fibers

- Best fibers 0.2 dB/km ~ 5 % of optical power is lost after 1 km
- 3 mm of window glass correspond to 2 km of optical fiber

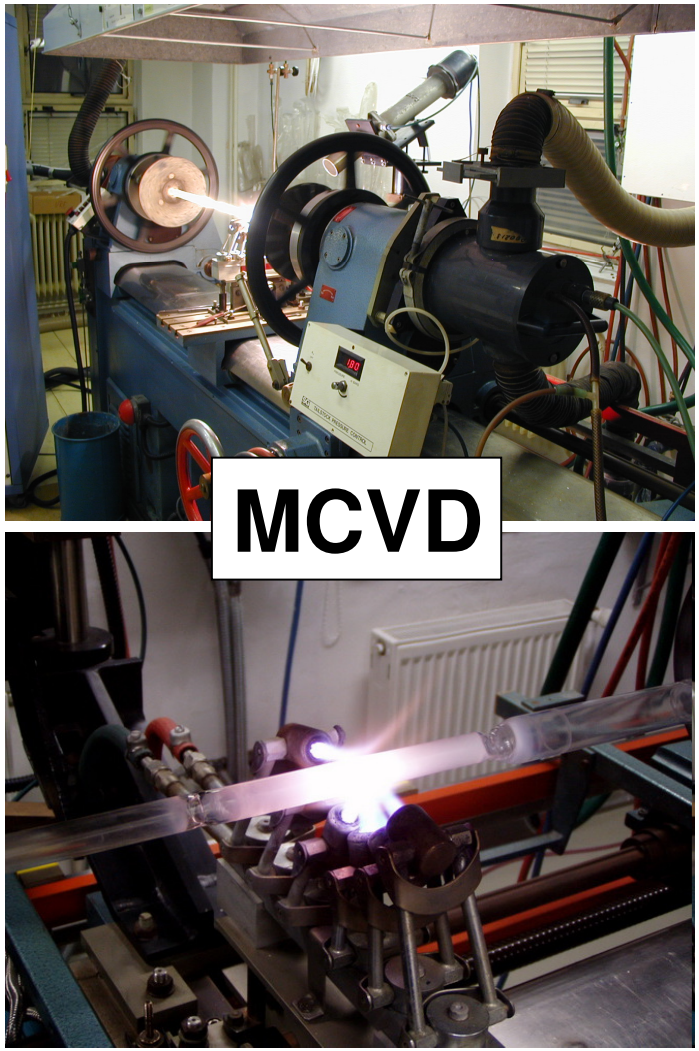
Charles K. Kao

½ Nobelovy ceny 2009

Very pure materials
FO Optipur
impurities on the level of several ppb = 10^{-9}

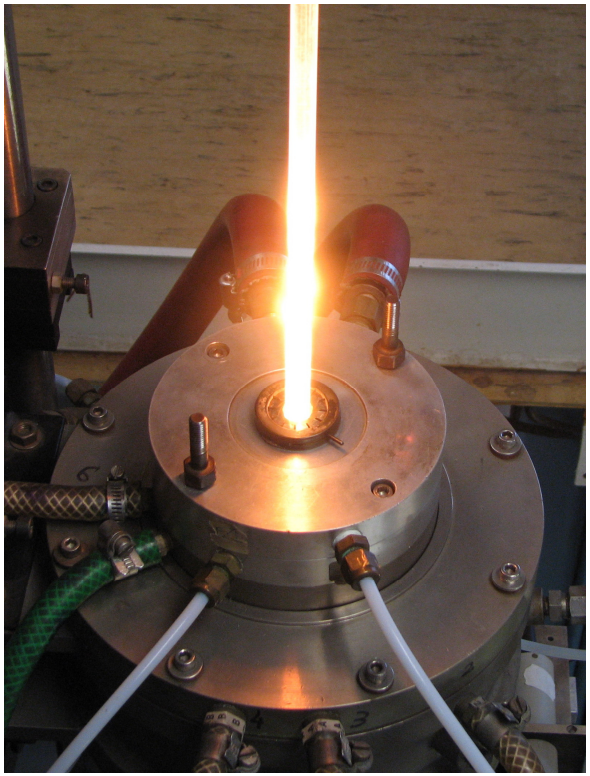
ULTRA PURE TECHNOLOGIES

Preparation of Optical Fibers

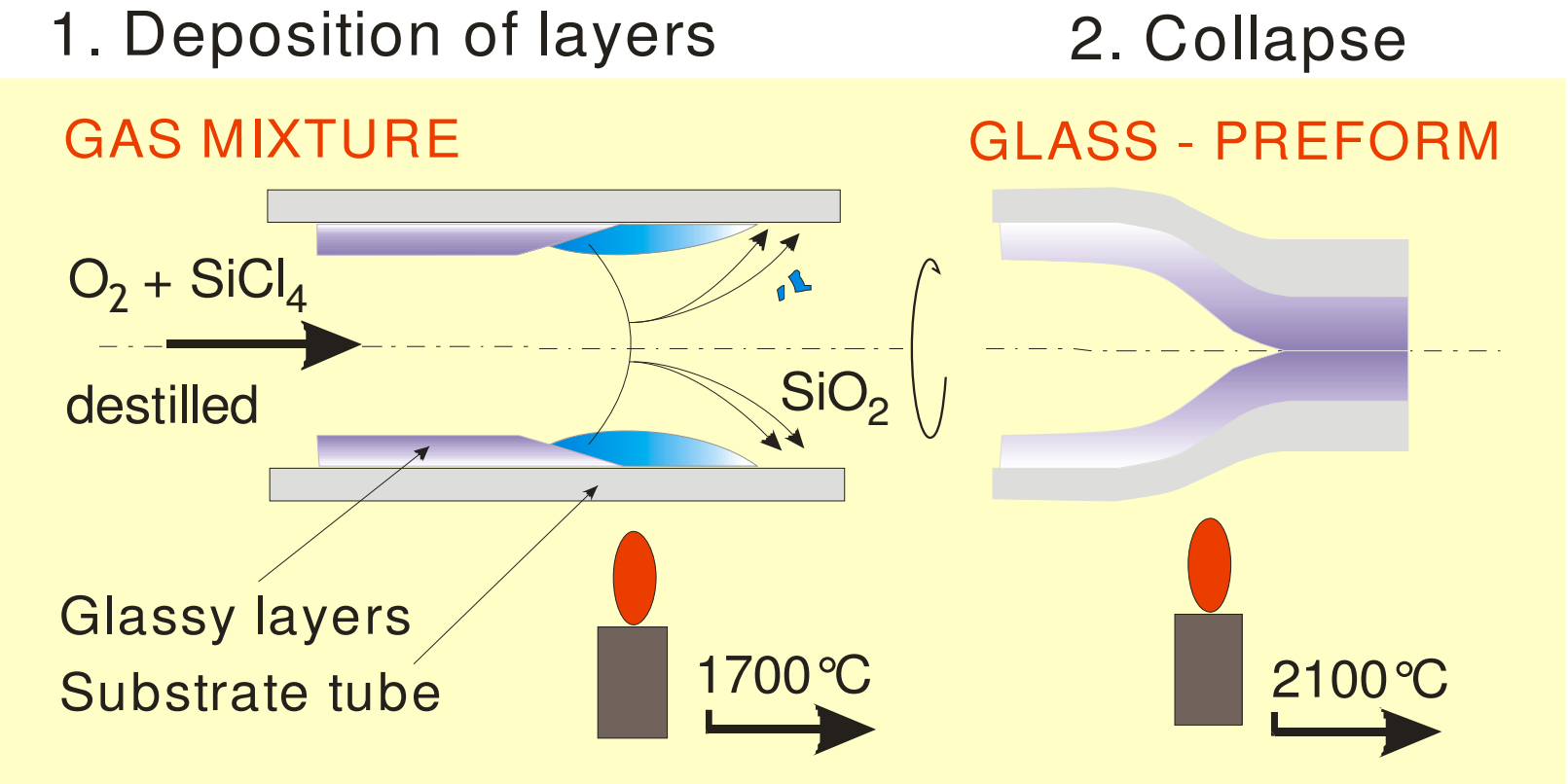


preform

Drawing



1) MCVD → Preforma

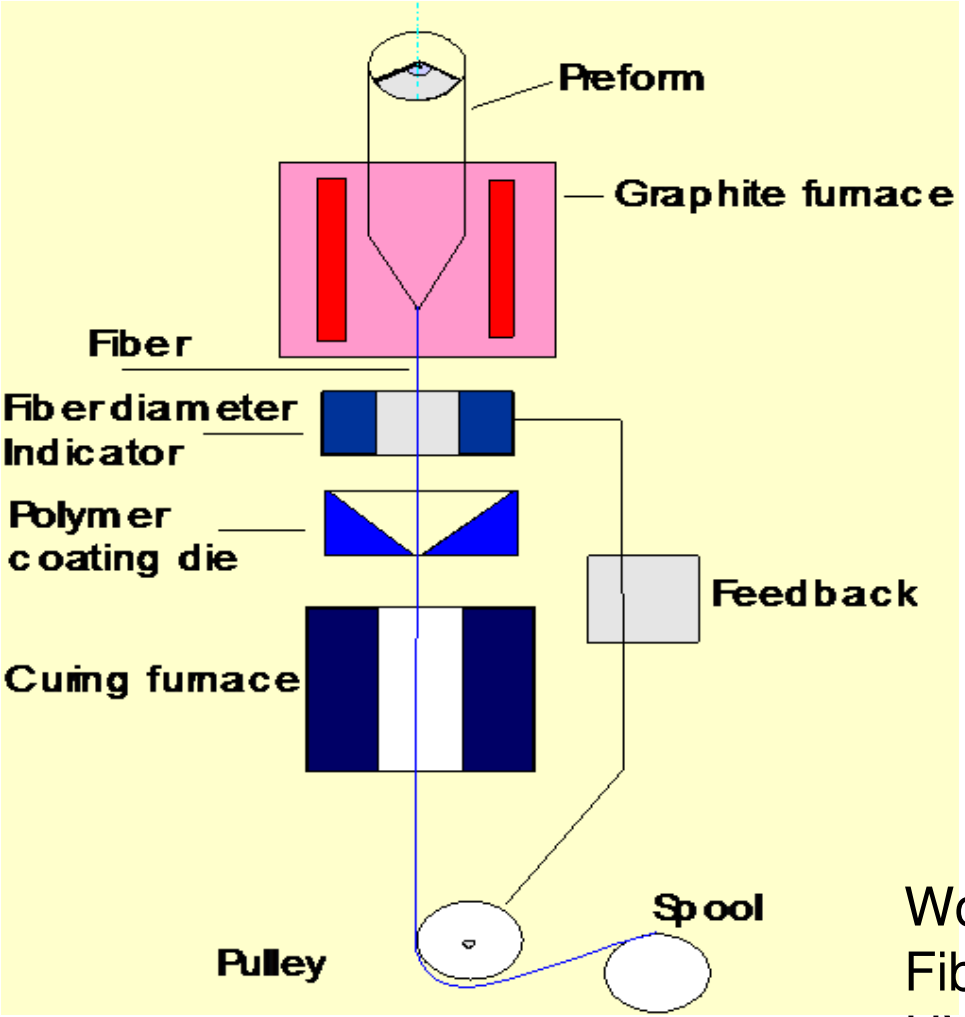


Sequential sintering of **thin glassy layers** (of thickness 1-20 µm) onto inner wall of silica substrate

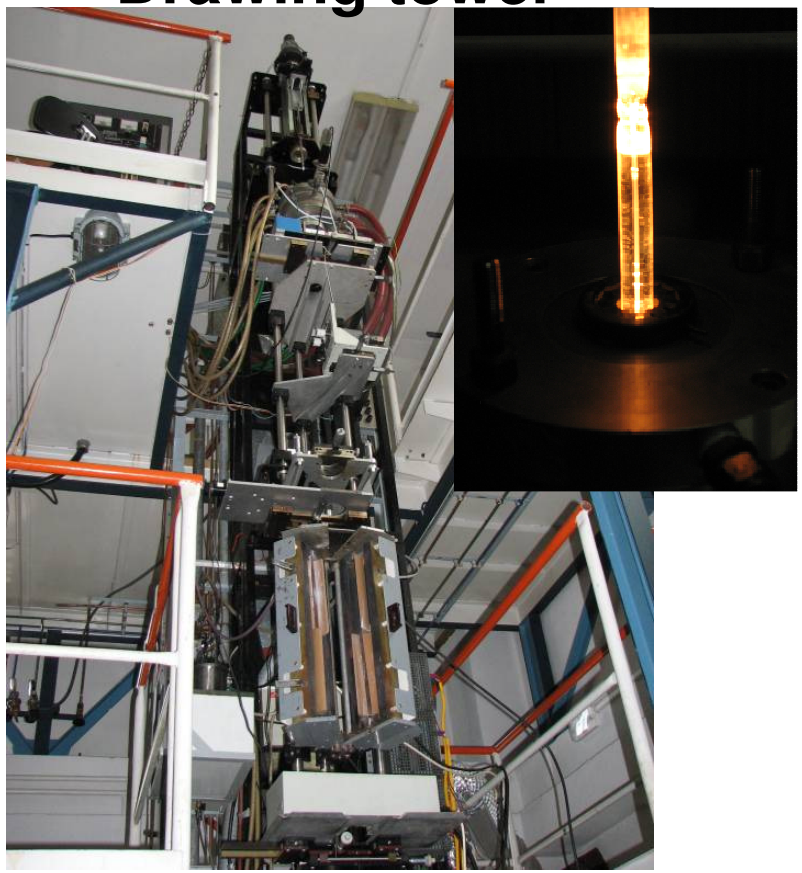
resulting in bulk material = **preform** [Nagel & McChesney 1982]

2) Fiber drawing

Process chart

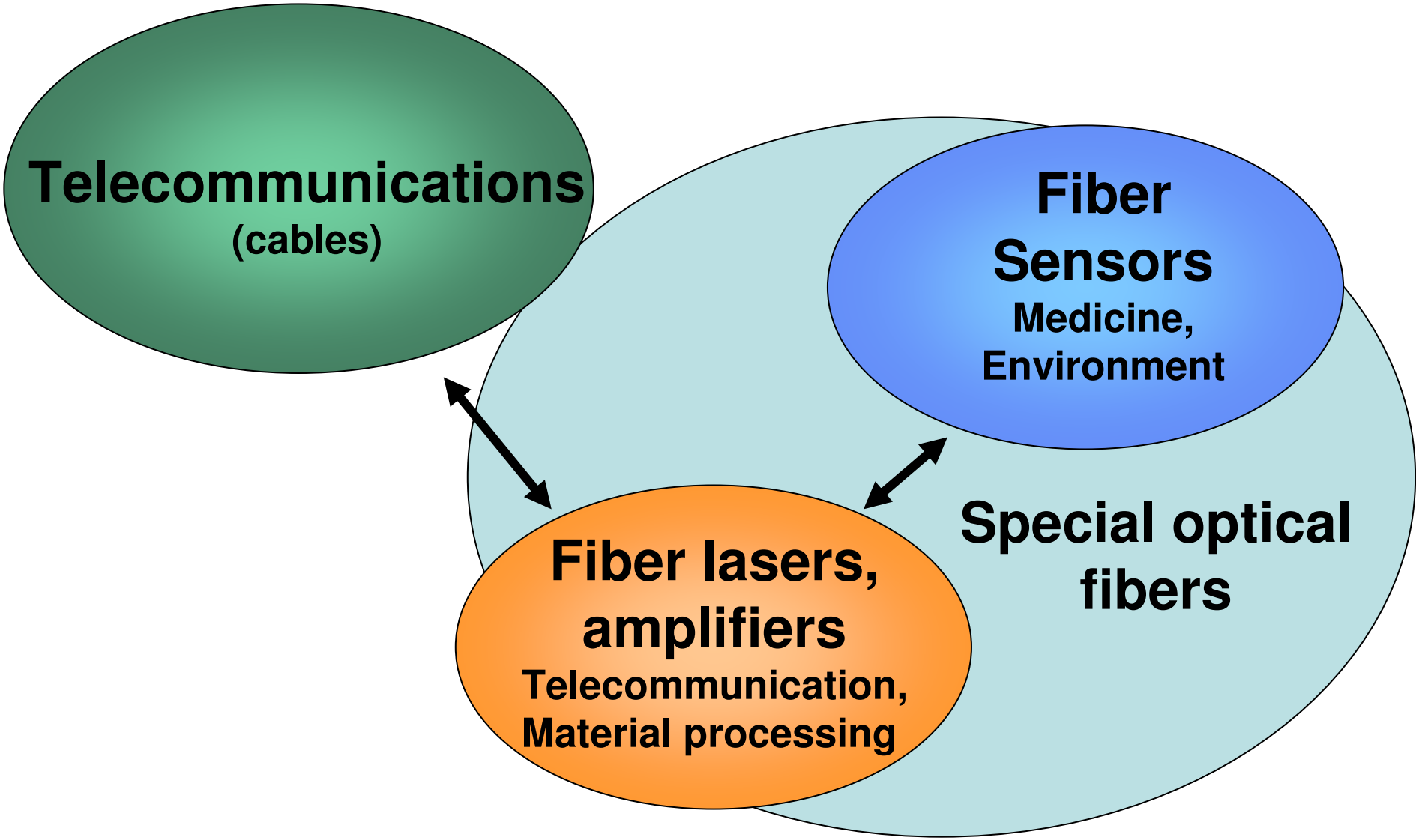


Drawing tower

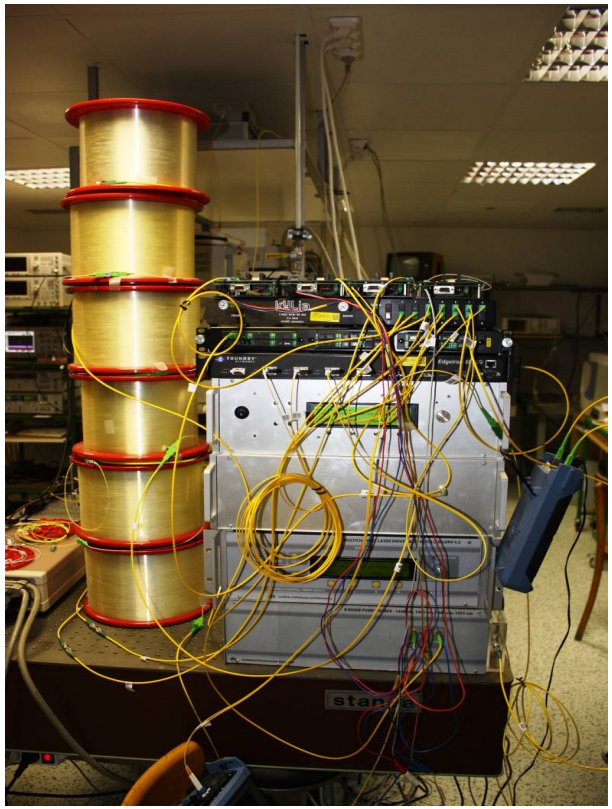


Working temperature: 1900-2100 °C
Fiber diameter 30 µm-1mm
UV/Thermally cured coatings (3-100 µm)

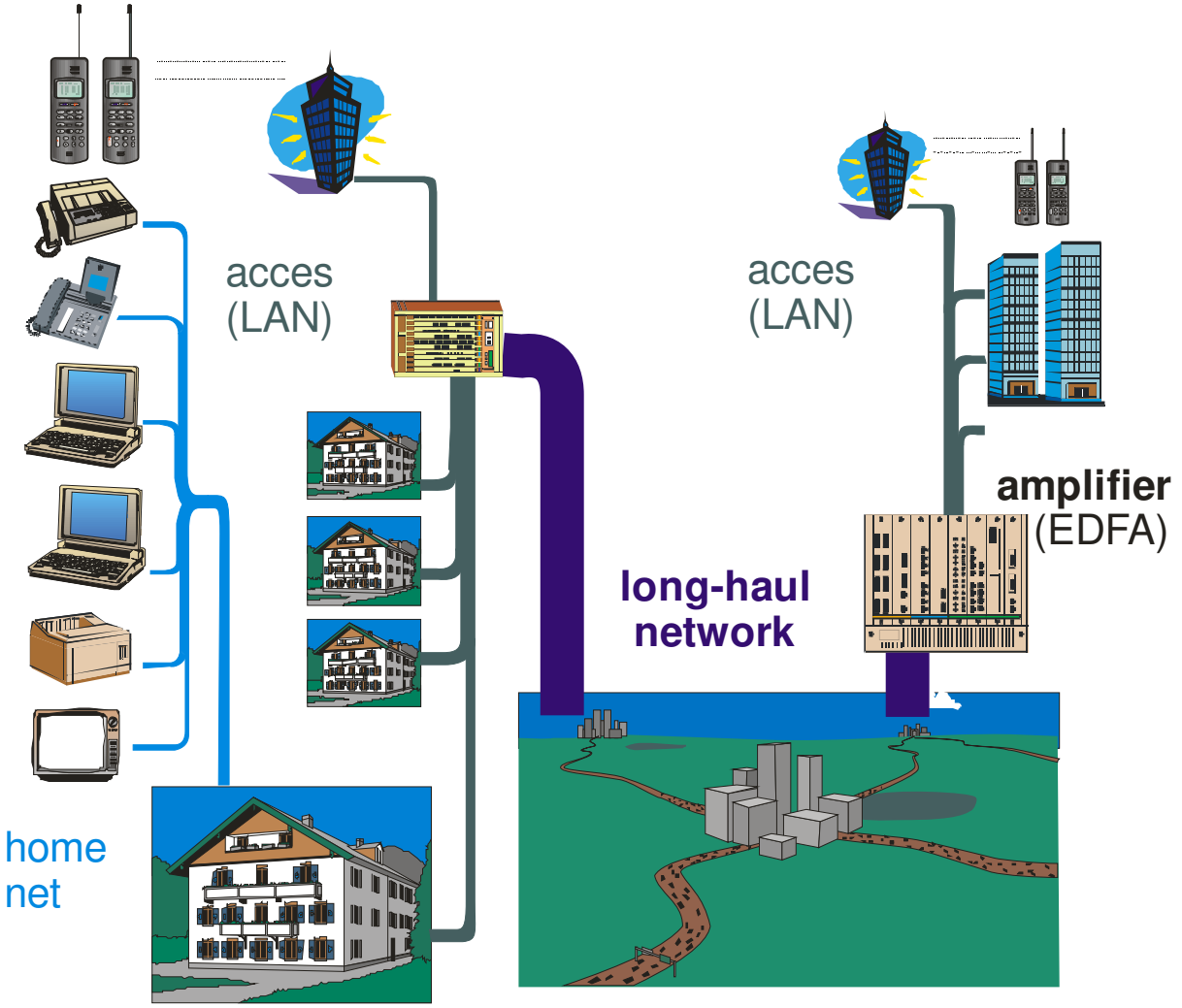
Application of optical fibers



Telecommunications

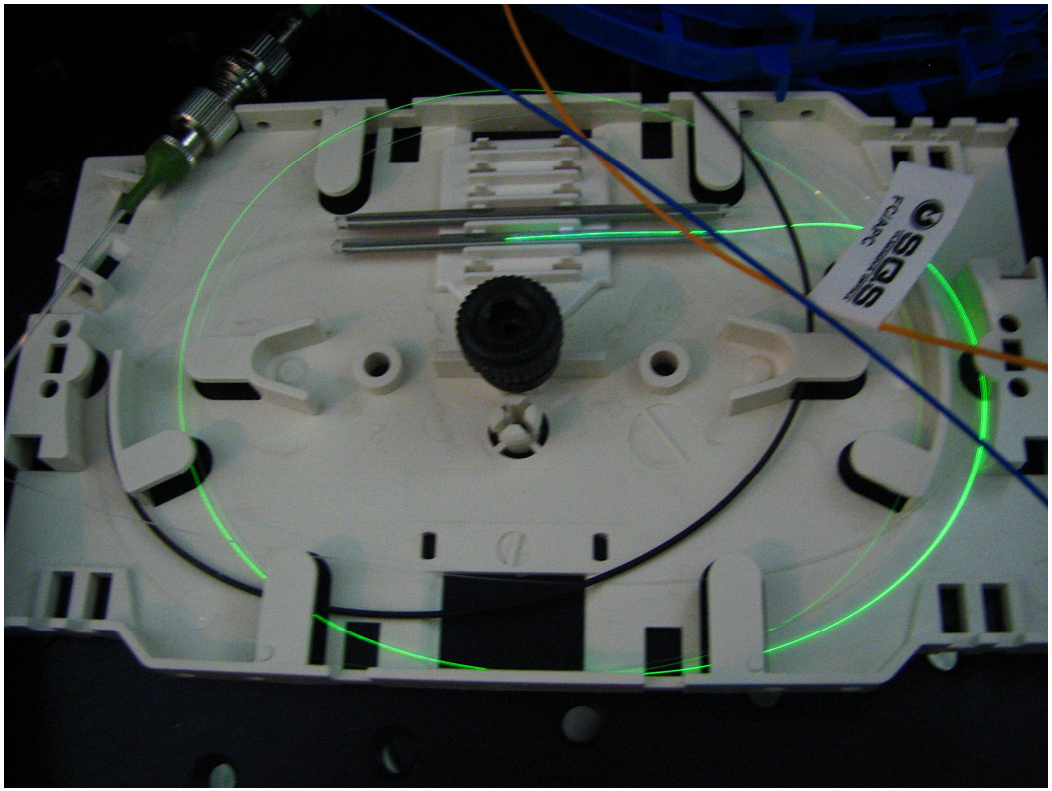


200 km testing datalink



Fiber lasers

-Telecomunications

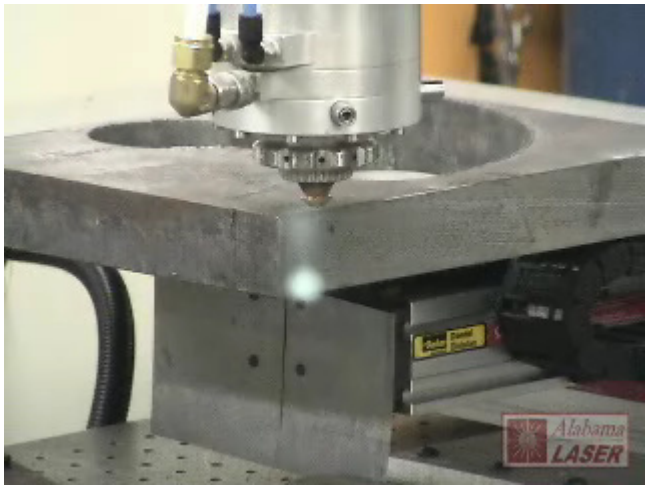


Er- fiber laser, 5m resonator, Liekki

–high power

Light intensities

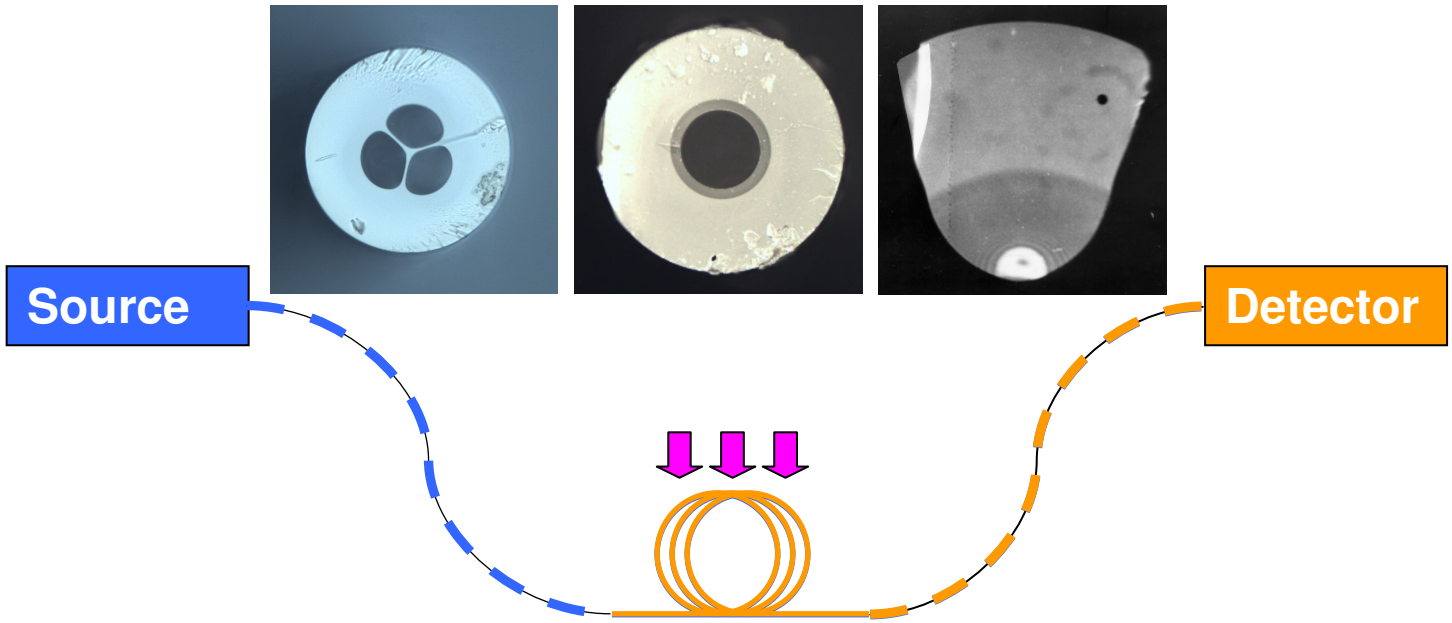
Sol	63 MW/m2
Fiber	12.7 GW/m2



Cutting and welding < 2kW

Fiber-optic SENSORS

Continual reversible monitoring of (bio)chemical species and their concentration



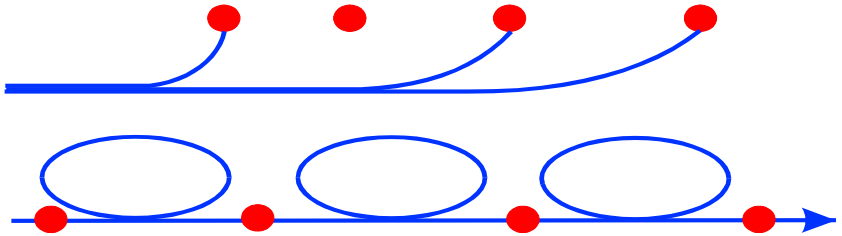
Change of light properties of fiber or deposed transducer
e.g. absorption, luminescence, polarization etc.

Advantages of fibre-sensors

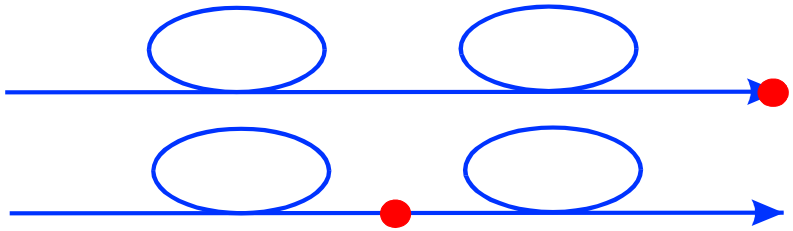
+ Flexibility
+ Remote sensing
+ **Distributed or micro-sensors**
+ **Explosive, high-voltage areas**, human body

Solution : fiber-optic sensors

Multipoint (distributed) detection

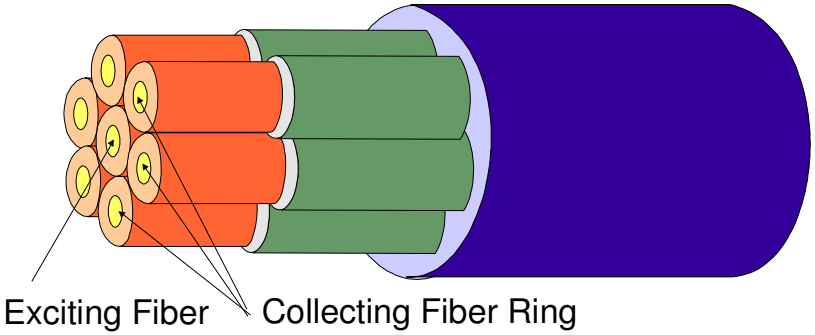


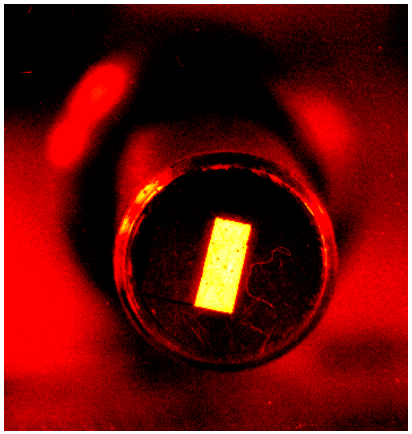
Point detection



Special optical fibers

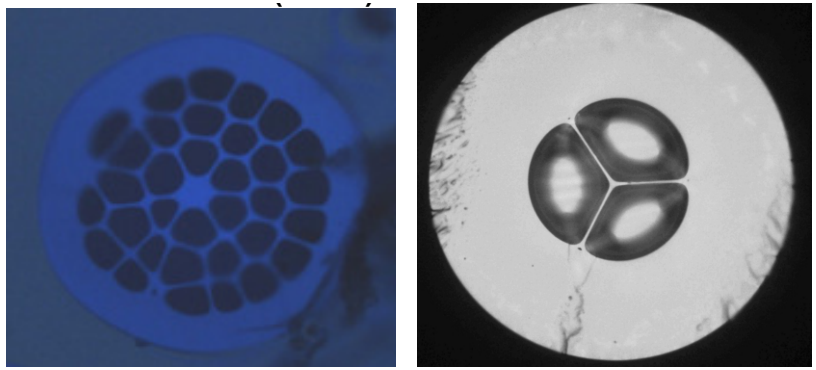
Fibre bundles

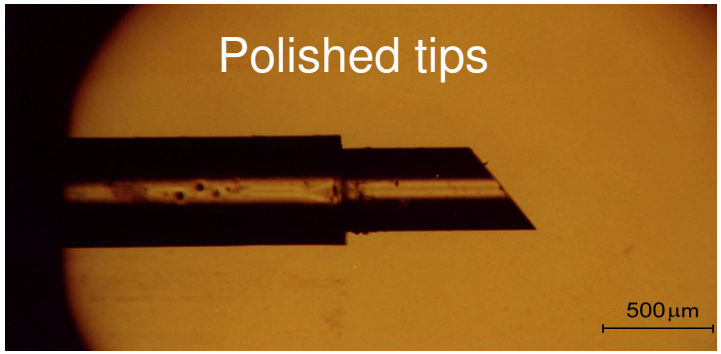




40 x 120 fibers 125 µm

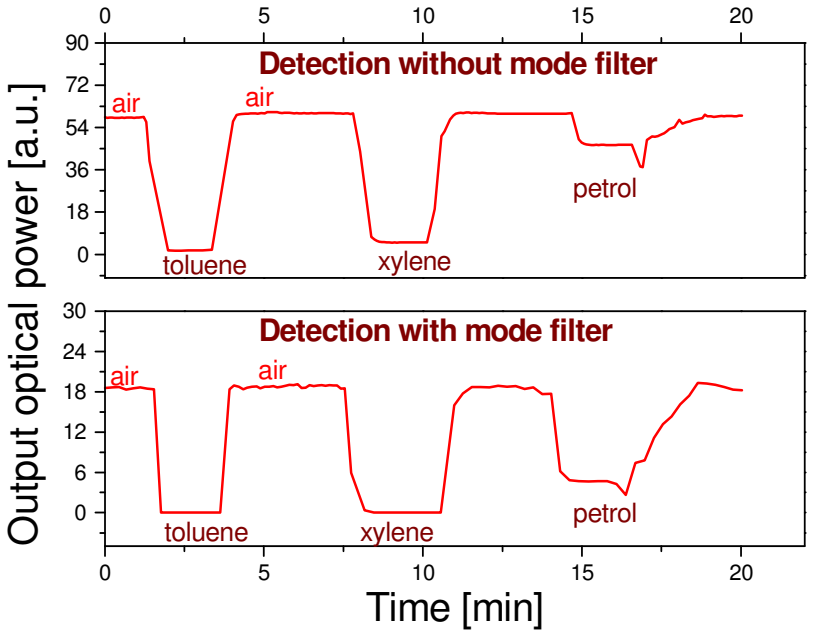
Tailored structures





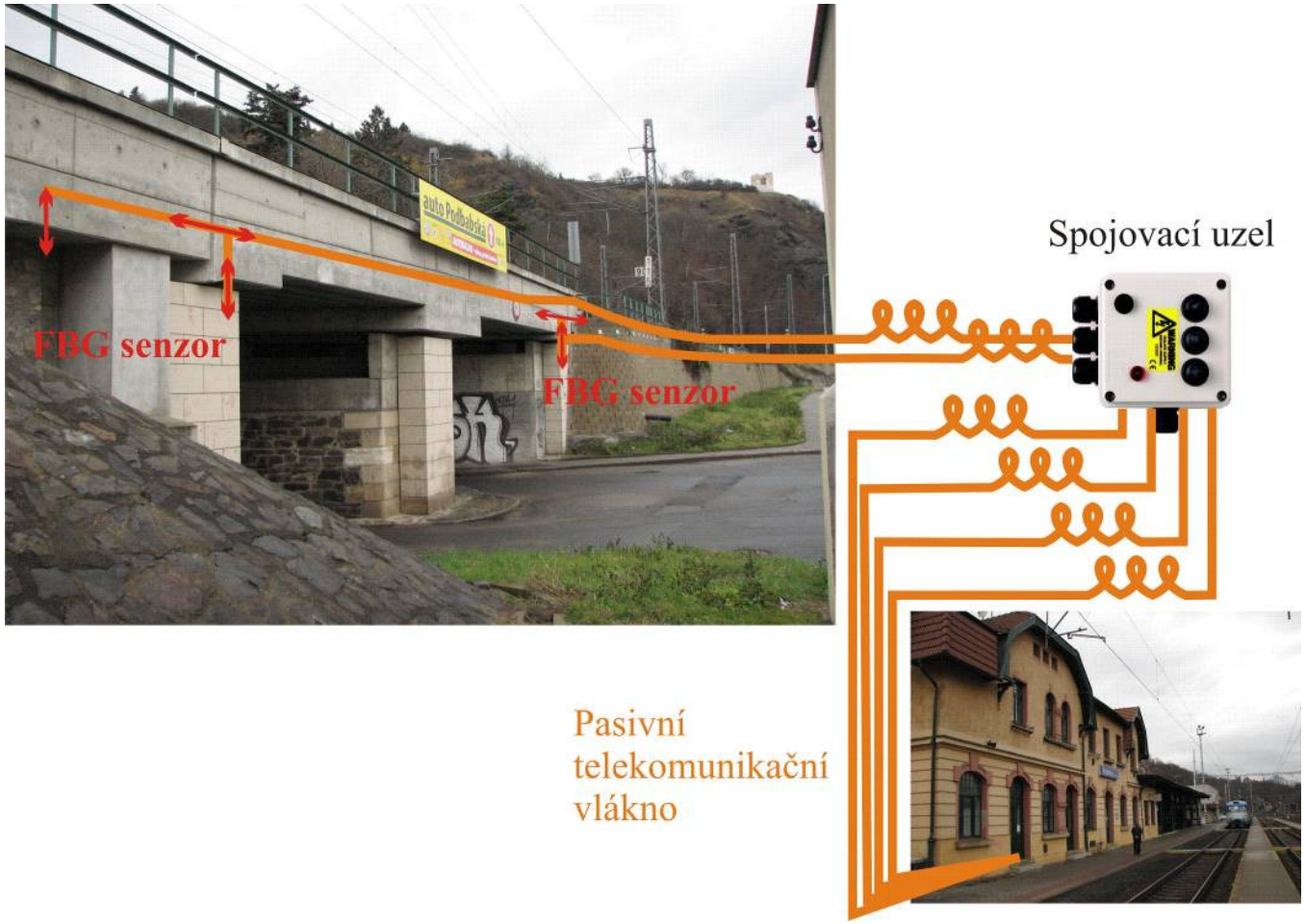
Refractometric detection of hydrocarbons

Gas or petrol leakages



Limit of the detection ~ 3-5 mg/l

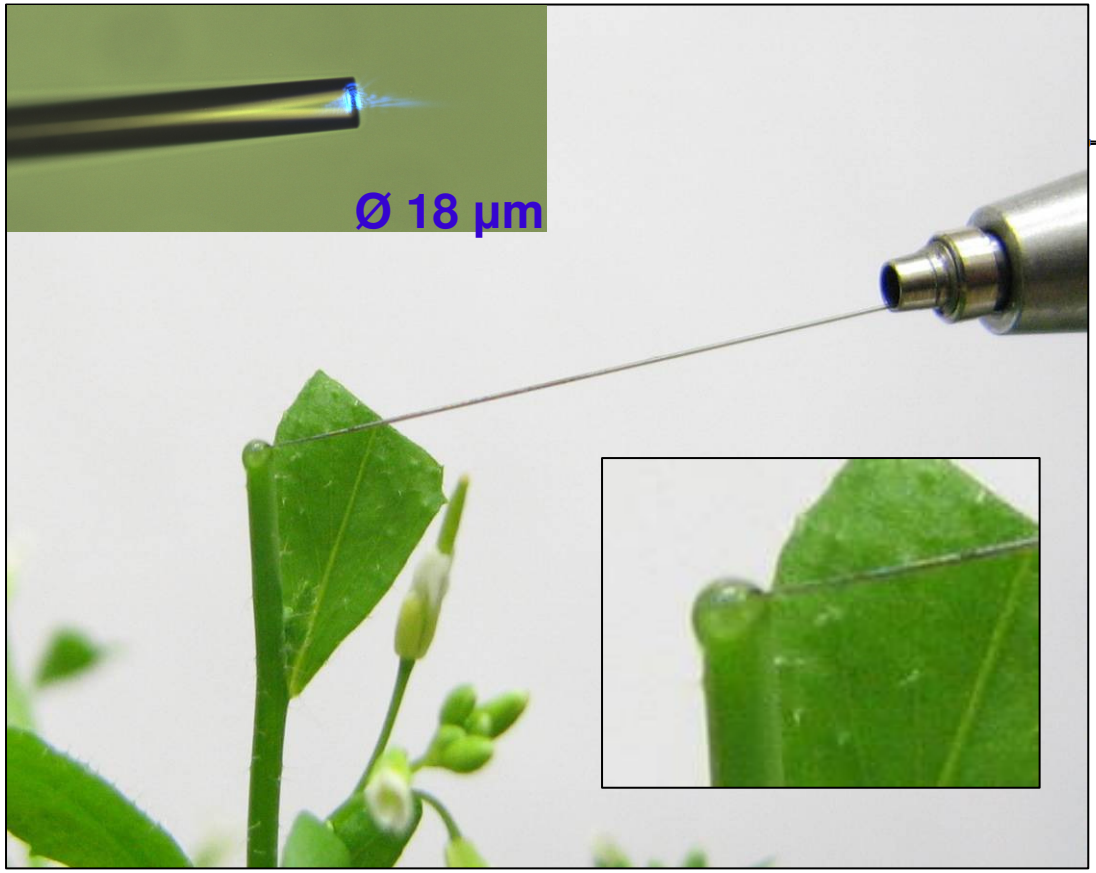
Sensor of tension



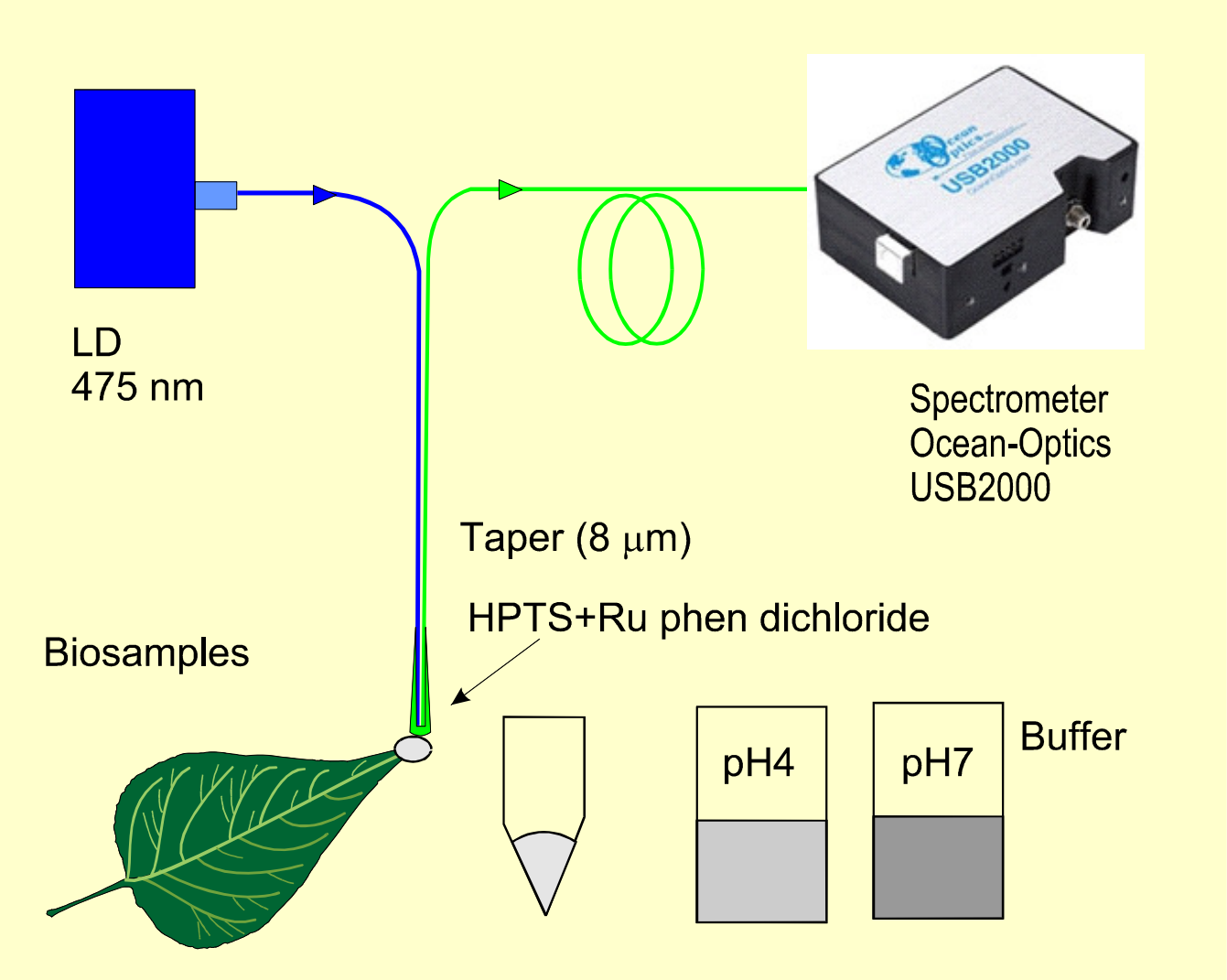
* Panorama 21. století 3/2012

Fiber-optic sensors

Detection of pH in mikrosamples (drops, living cells)



Local pH detection in microsamples



- **Fluorescence ratiomeric**
- **HPTS + int.standard Ru-phen**
- **Laser diode**
- **taper Ø 8 μm (GI 125/50)**

Thank You !

References

- Fused silica substrates
  Heraeus Quarzglas GmbH & Co. KG http://heraeus-quarzglas.com/
- Polymer coatings
  SSCP Corp. http://eng.sscpcorp.co.kr/
  DSM Functional Materials
  http://www.dsm.com/en_US/supercoatings/public/home/pages/homepage.jsp
- Technology
  Heathway http://www.heathway.com/
  Special Gas Controls Limited
  Nextrom http://www.nextrom.com
  Optacore http://www.optacore.si/