

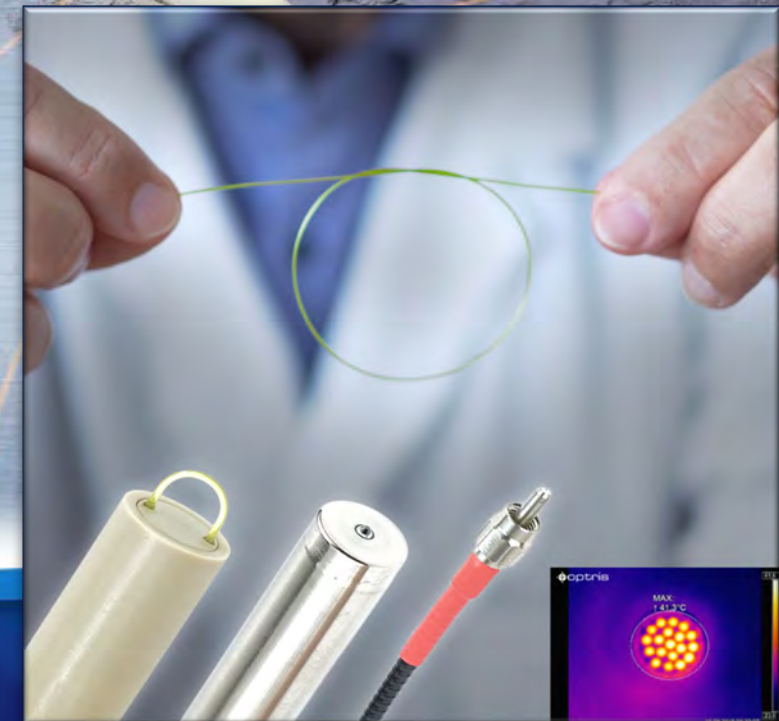
Fiber Photonics – from Fibers to System Solutions in 0.3-16 μ m Range



Slava Artyushenko

EPIC
European Photonics Industry Consortium

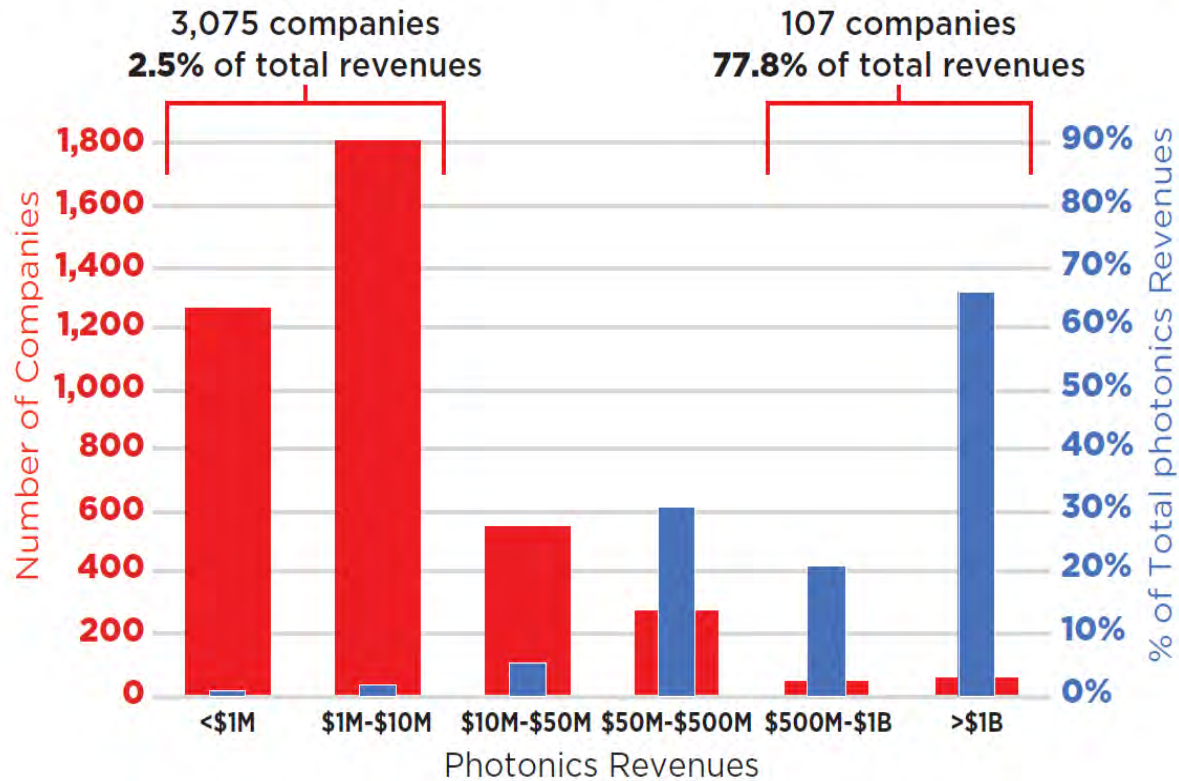
07 - 08 April 2022
Vilnius, Lithuania
EPIC Annual General Meeting 2022

The image shows a promotional banner for the EPIC Annual General Meeting 2022. It features the EPIC logo (three colored spheres) and the text "European Photonics Industry Consortium". The background is a scenic view of Vilnius, Lithuania, with several hot air balloons floating in the sky over a city with red-tiled roofs and a church spire. A red banner at the bottom contains the event details.

Global Leaders in Mid-IR Fibre Optics
2020 in the German Business Award

Who is Who in Photonics Industry – from Components to B2C

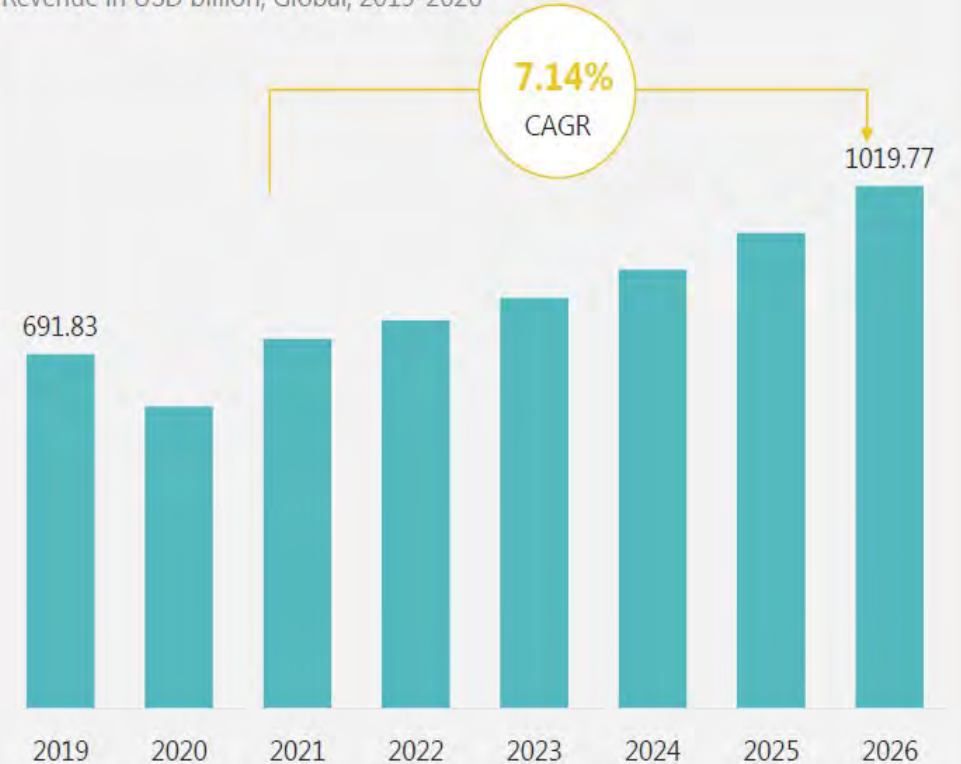
Producers Grouped by 2018 Revenues and Percent Share of Revenues



Optics & Photonics 2020 Industry Report

PHOTONICS MARKET

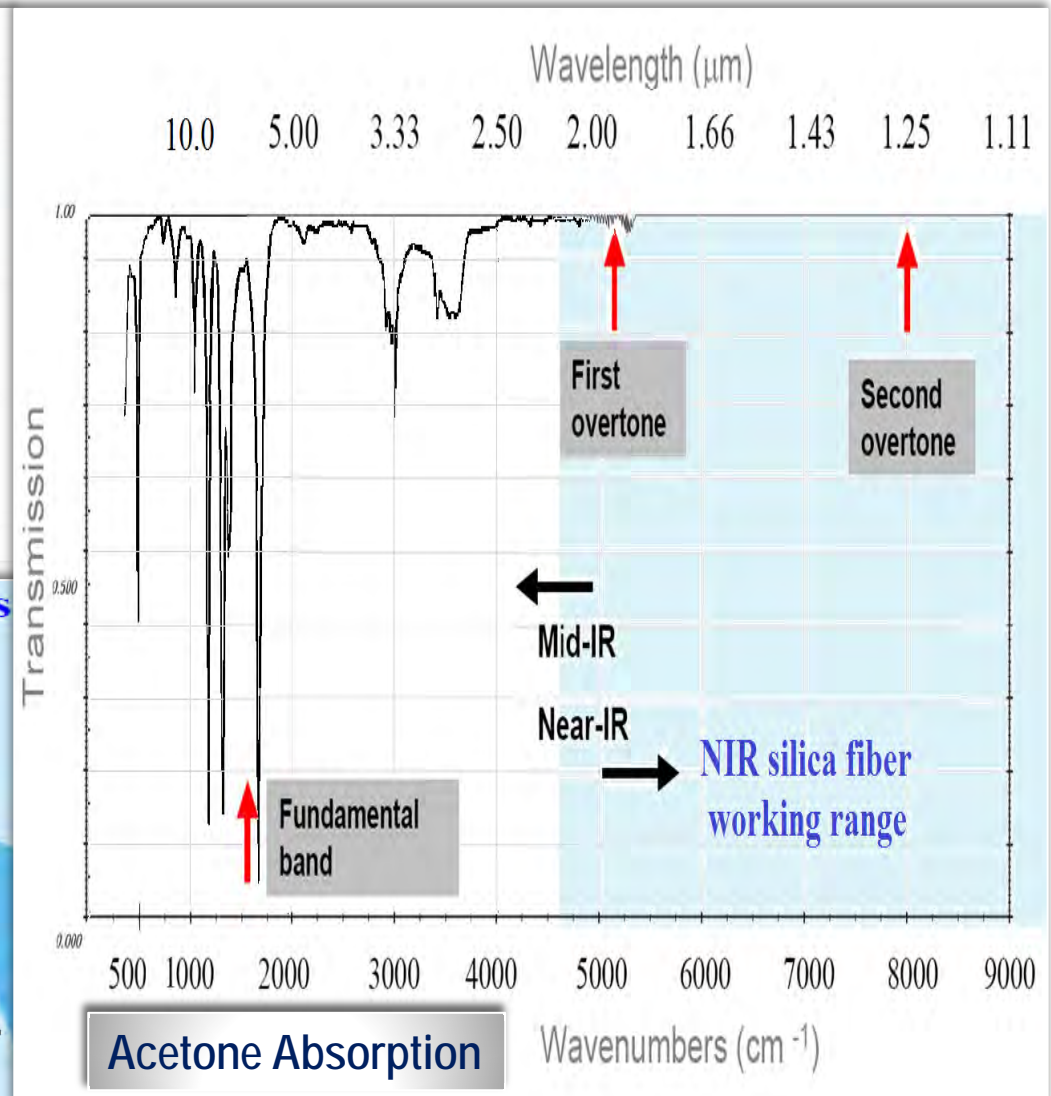
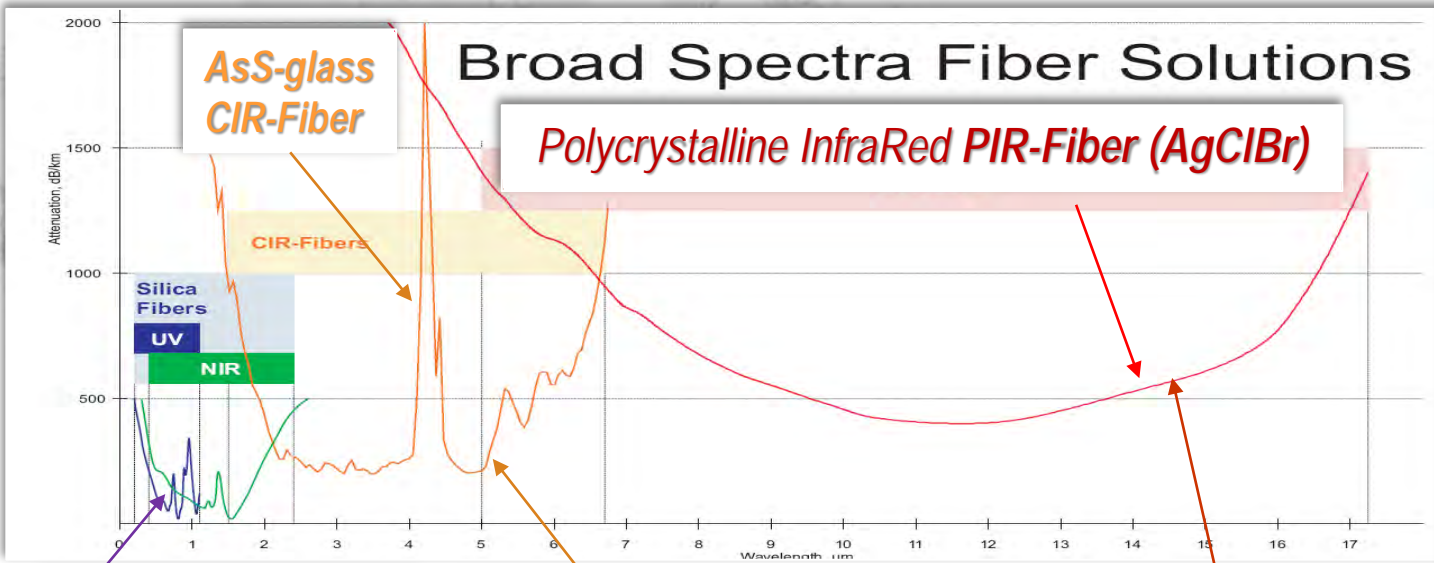
Revenue in USD billion, Global, 2019-2026



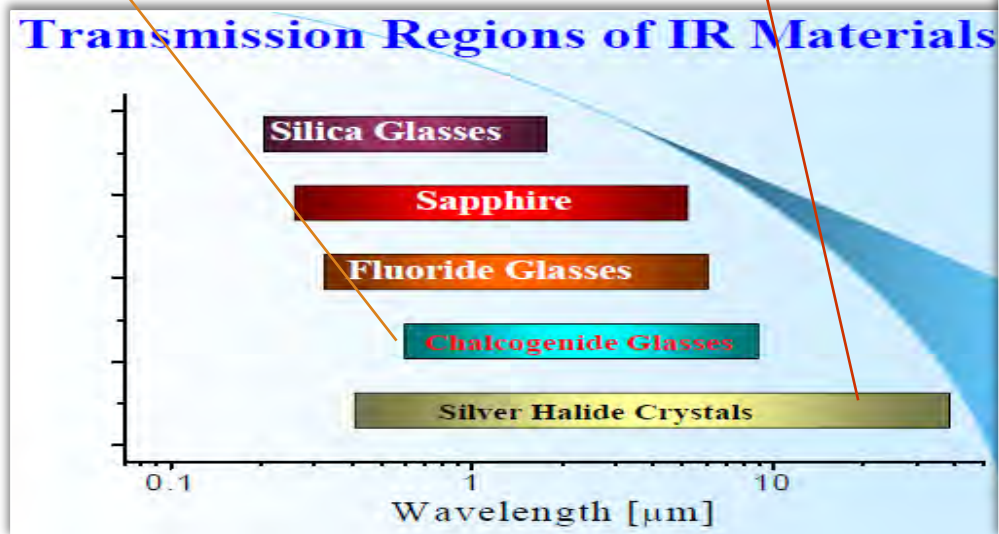
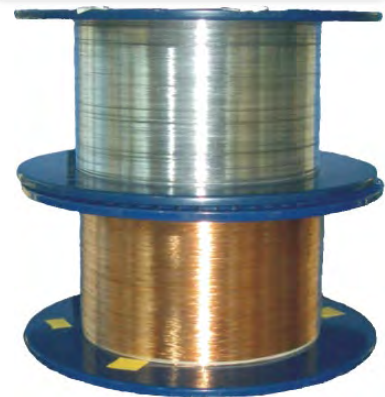
SOURCE: Mordor Intelligence

The Global Photonics Market was valued at USD 589.82 billion in 2020, and it is expected to reach USD 1019.77 billion by 2026, registering a CAGR of approximately 7.14% during the period of 2021-2026.

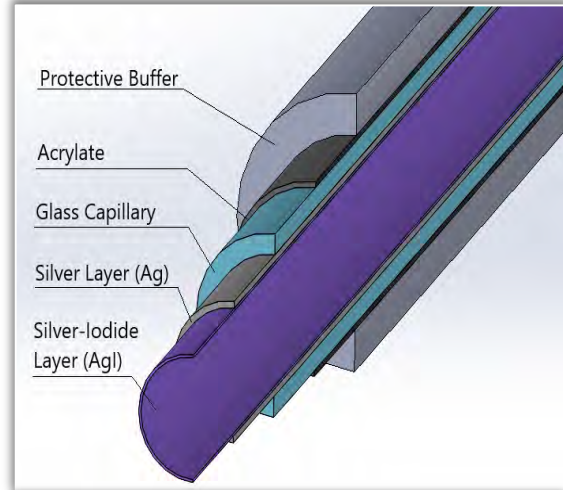
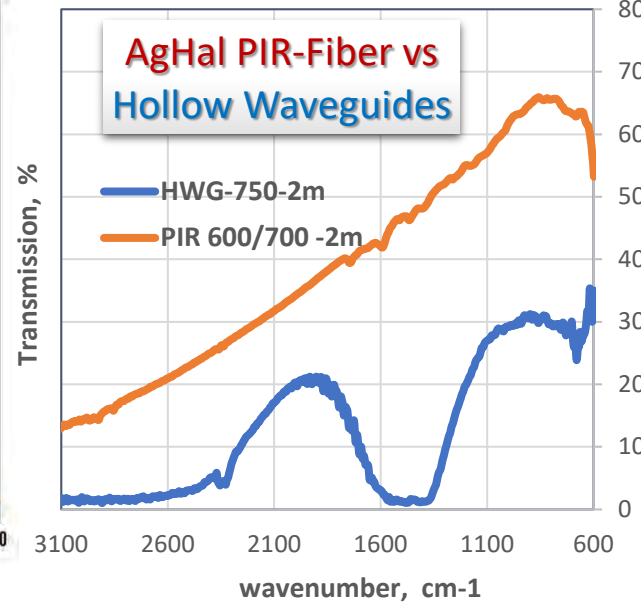
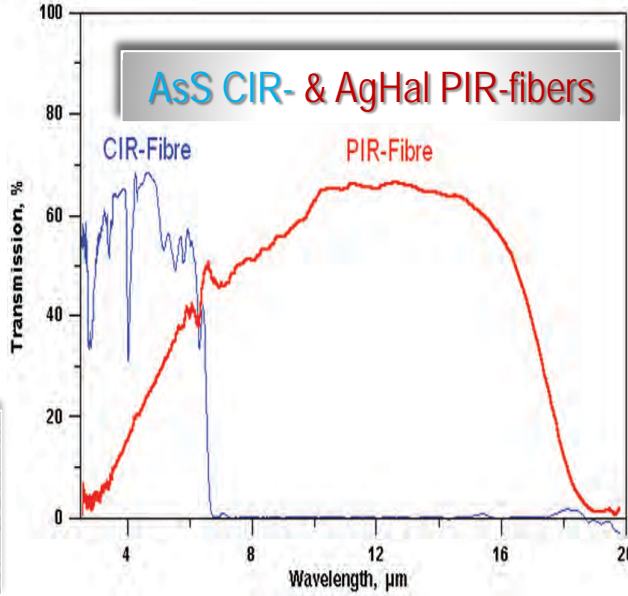
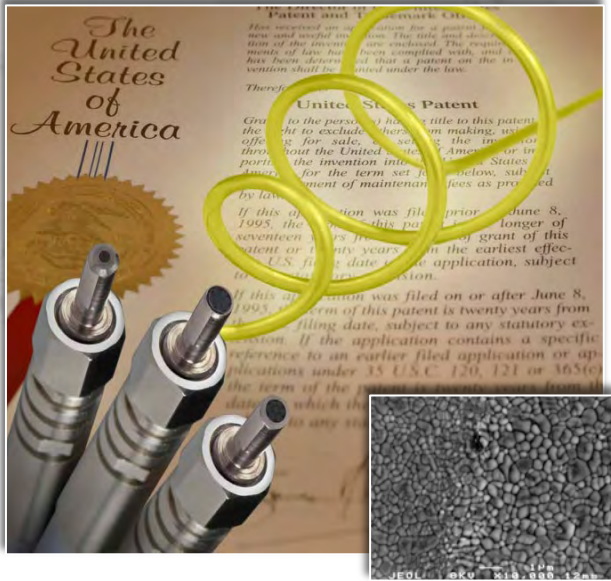
Silica & AsS-glass + PIR-Fibers & Hollow WaveGuides for 0.3-16 μm



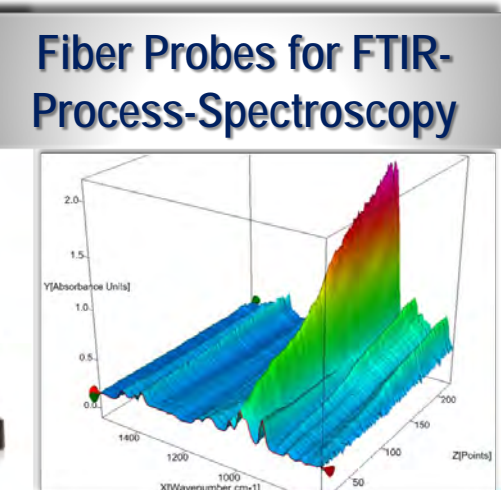
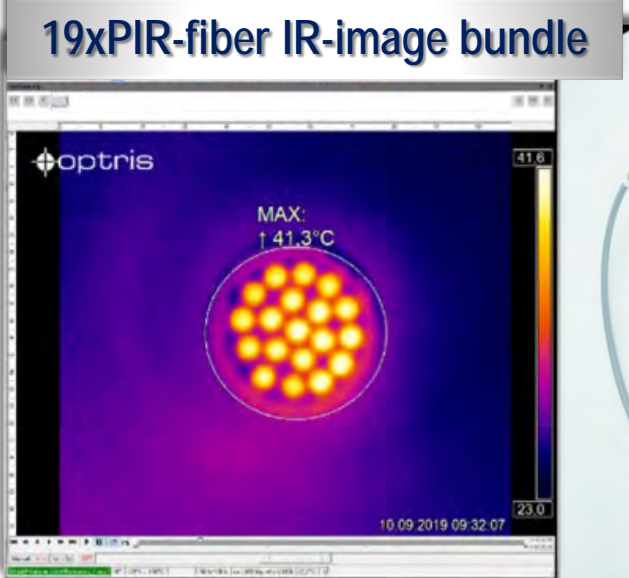
Silica Fibers
UV-Vis & Vis-NIR



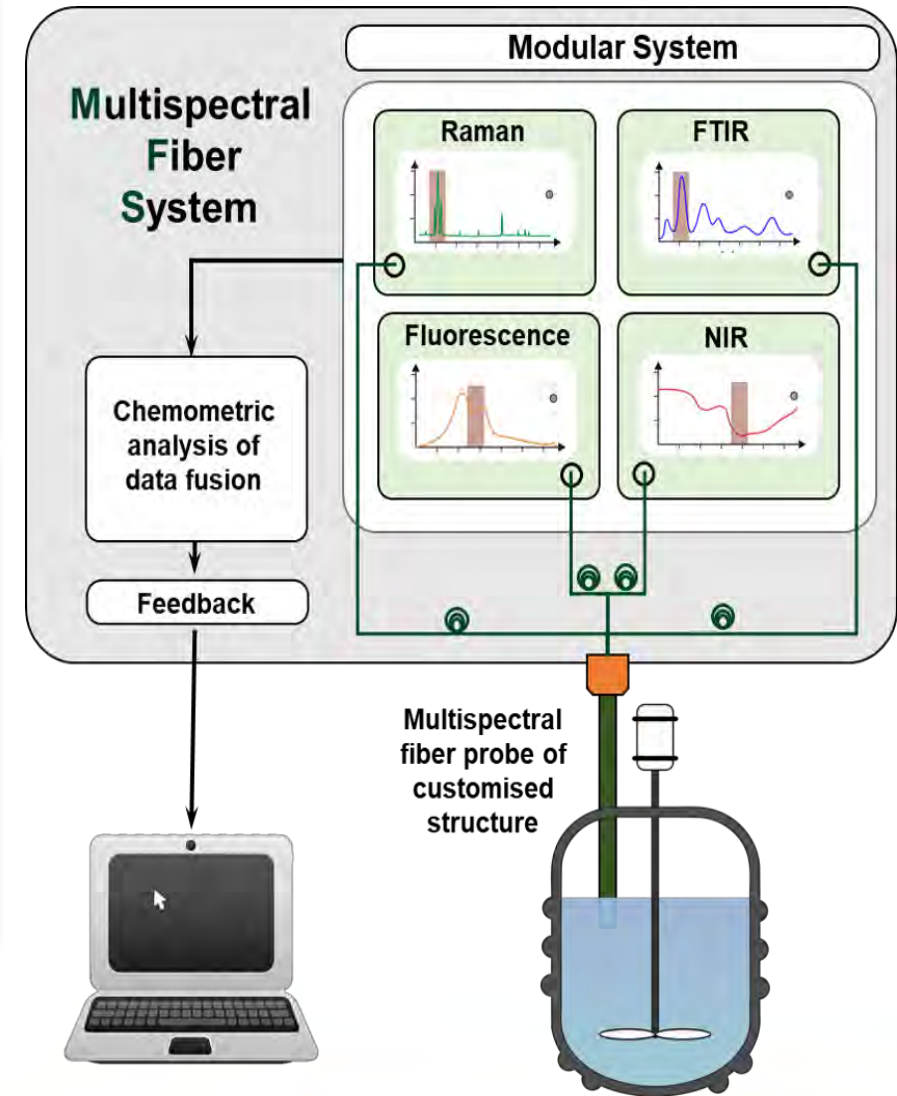
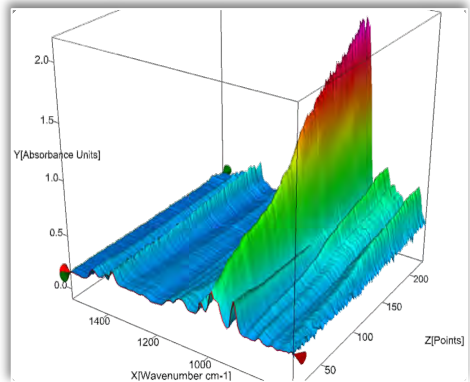
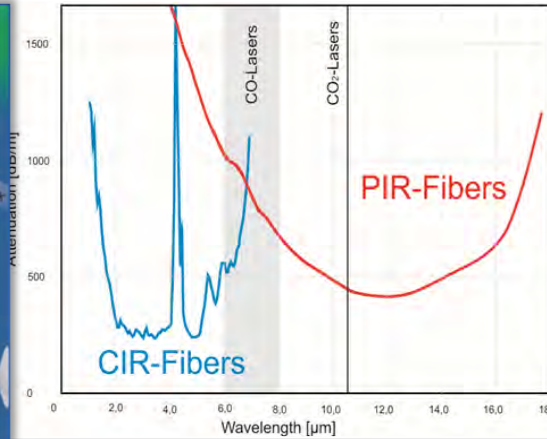
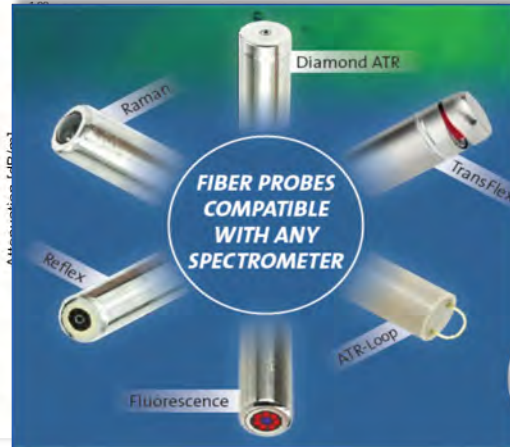
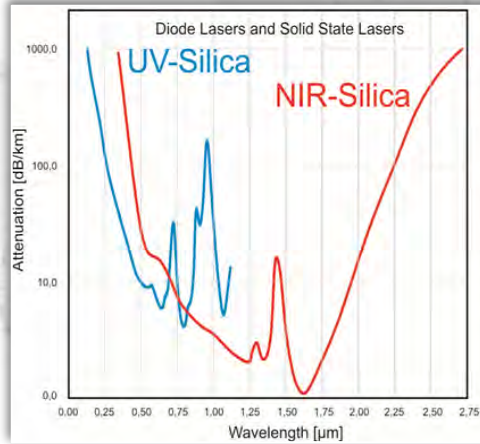
CIR- & PIR-Fibers vs Hollow Glass Waveguides for Mid IR-Photonics



**PIR-Fiber & HGW
Cables for ICL, QCL, OPO,
CO- & CO2-Lasers**



Multi-Spectral Fiber Systems to select the Best Process Control Method



Fiber Probes to upgrade Bench FTIR to Process-FTIR-Spectrometers



Why to choose Fiber coupled FTIR?

- Easy & Safe spectroscopy with no sample preparation
- Remote sensing for "hard to get to" Samples
- Identify Transient Intermediates; etc.
- Reaction End-Point Determination
- Hazardous (high temp, pressure, pH, vibration, etc.) Samples
- Air / Moisture Sensitive Samples
- Reaction Initiation
- Kinetics Determination
- In-situ Reaction Monitoring
- No delay with results

IR-Fiber Probes can be coupled with FTIR-spectrometer with & without sample chambers. Mirror couplers enable to use bench spectrometer when installed in sample chamber.



ATR-PIR-Fiber Probes for High Temperature PAT in Petrochemistry, SiS-ATR-Probes for Bio-Reactors and for Harsh Environment

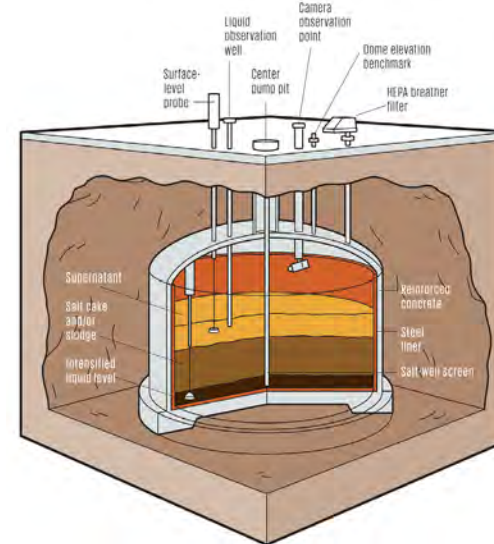
HT-ATR-Probe
(gas cooled) for
<250°C



Shaft-in-Shaft ATR-Probe
enables to sterilize Bioreactor
with detachable Shaft



Double-Shell Tank for
Nuclear Waste deactivation

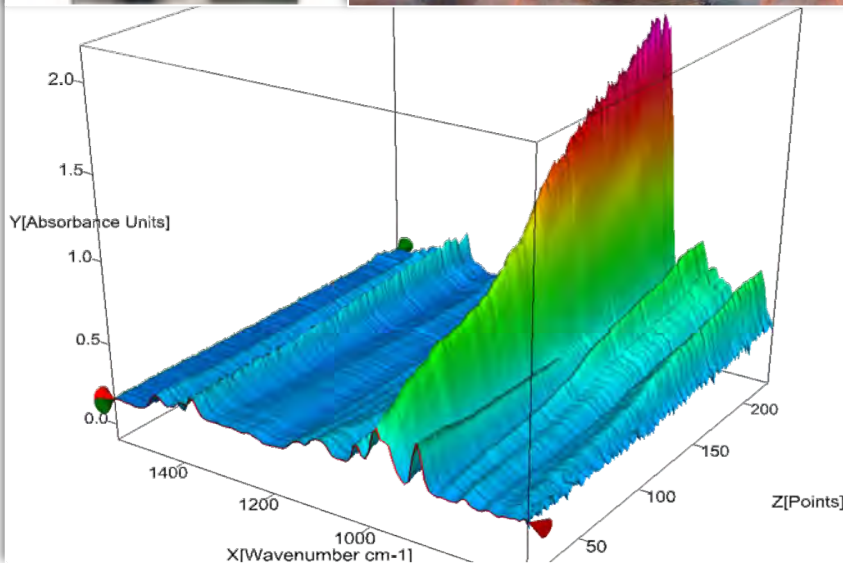
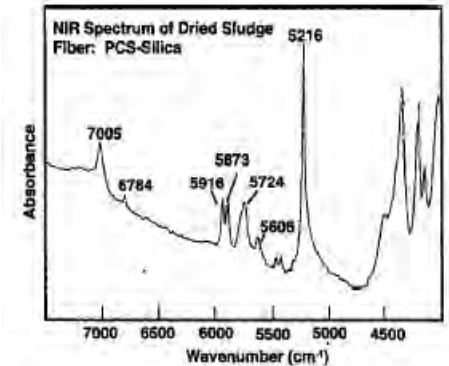
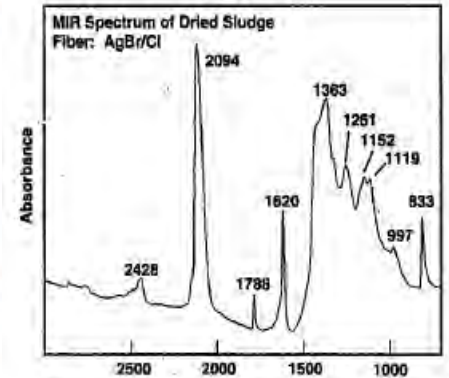


Constituent	Concentration, M
Na ₂ SO ₄	0.23
Na ₃ PO ₄	0.27
NaNO ₂	1.5
NaNO ₃	4.5
CsNO ₃	0.00013

Note: No radionuclides



Sludge Spectra



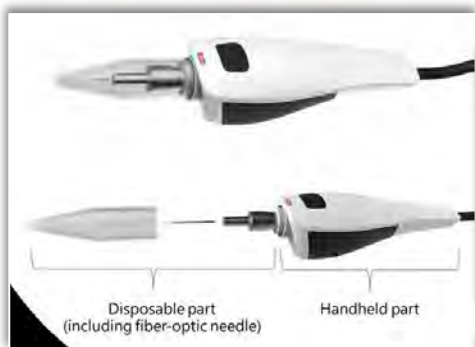
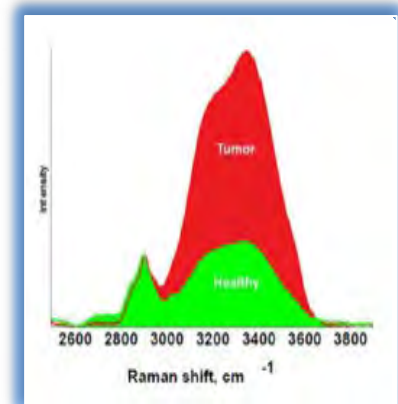
Needle Fiber Probe for HW-Raman Spectroscopy Guided Cancer Surgery

Eurostars-project: Ra-Sure (ESTAR18101)

300.000 new oral cancer patients/year
Surgery to remove tumour successful in only 15% of cases
Technology needed to support surgeon



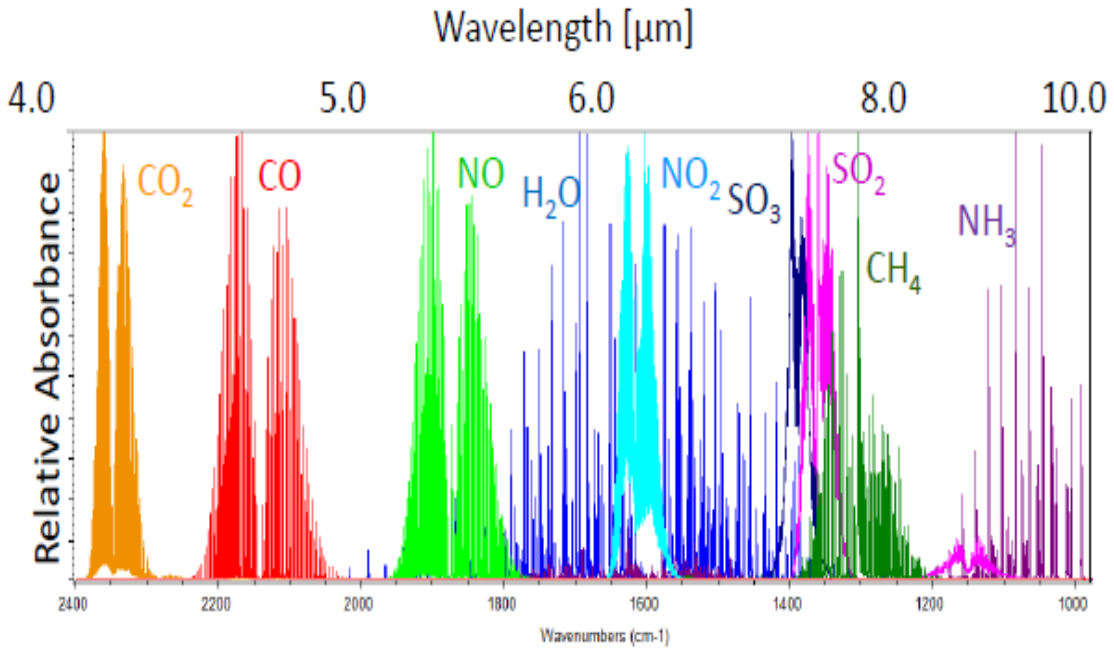
Single fiber Raman Needle Probe (OD=160µm)
penetrates in resected tissue for 1cm to detect *ex-vivo* oral cancer (SCC) margins in 1s – providing HW-Raman spectrum each 100ms (i.e. with 1mm accuracy)



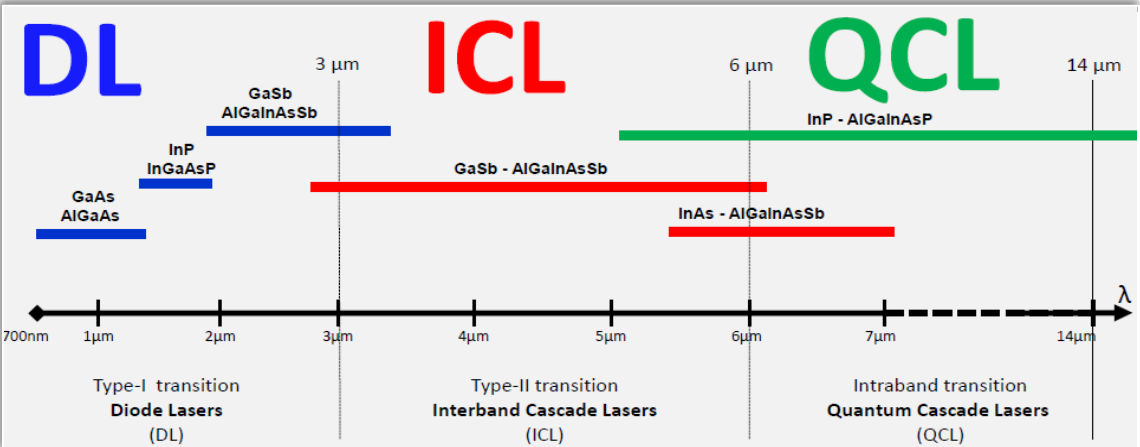
Water content is higher in Oral cancer - compared to the surrounding healthy tissue, and can be used as spectral biomarker to detect tumor margins



Sensors based on IR-Fiber or HGW-coupled Quantum Cascade Lasers



Opto Precision



PIR-fiber bundle enable to combine radiation from 7 QC-Lasers in one PIR-fiber Probe (see EU MIRACLE-project at www.miracleproject.eu)

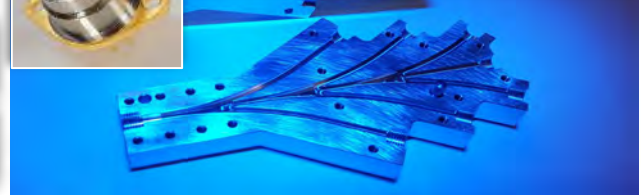
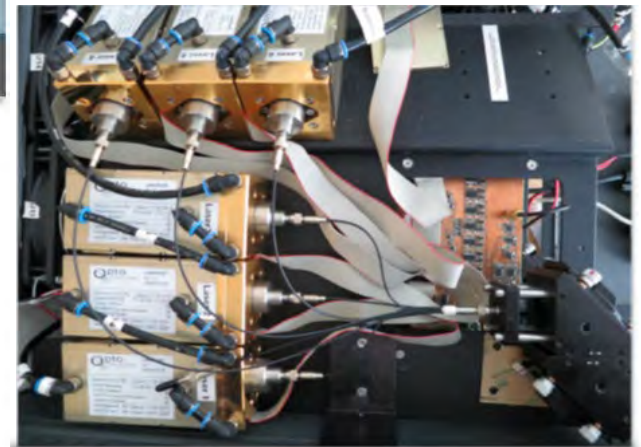
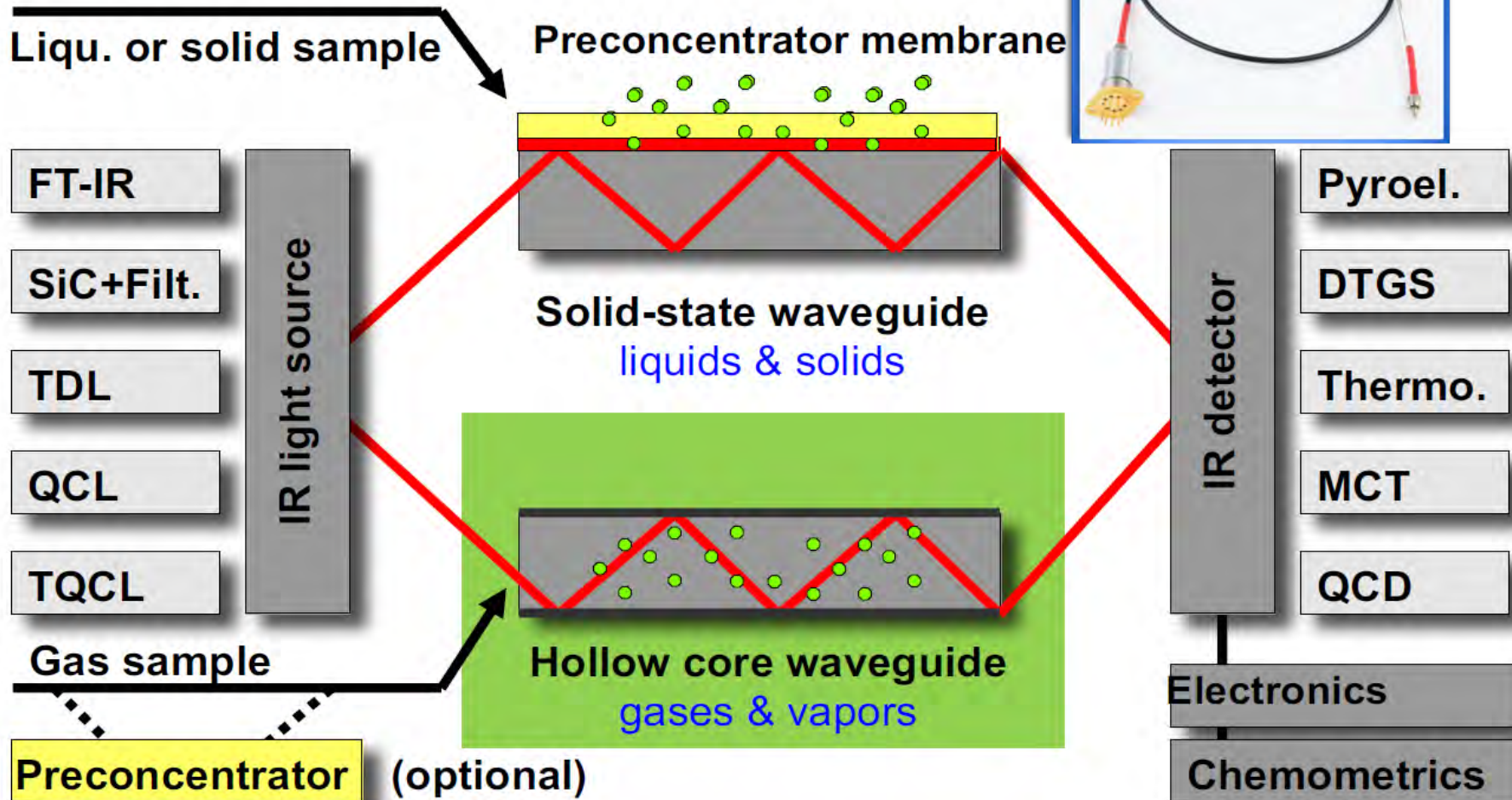


Nanosystems and Technologies GmbH
nanoplus

Coupling of Mid IR-components by Mid IR-fibers & Hollow Waveguides

Infrared Sensor Technology

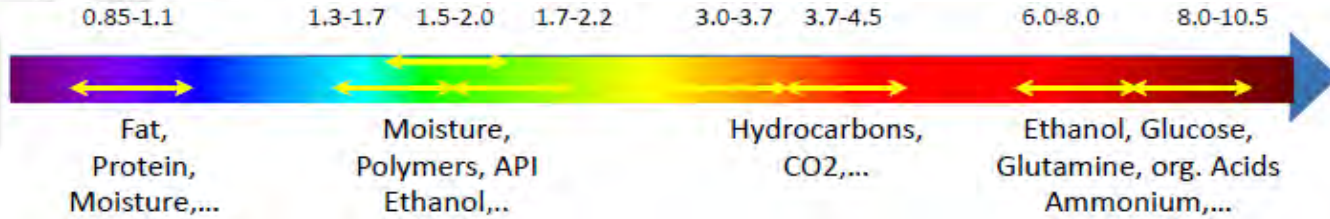
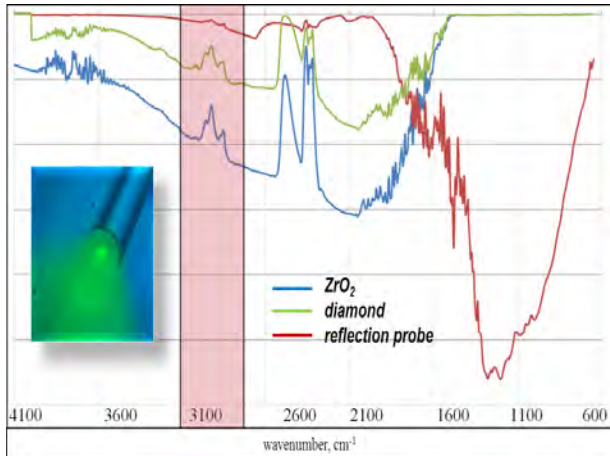
IR devices developed at IABC



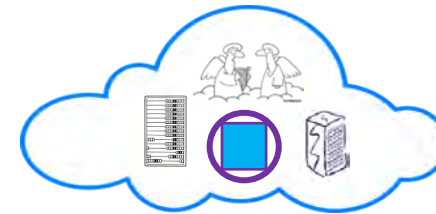
B. Mizaitkoff, Chem. Soc. Rev., 42, 85

Monitoring of biofermentos & polutions with spectral fiber sensors

Monitoring of petrochemical pollutions in soil



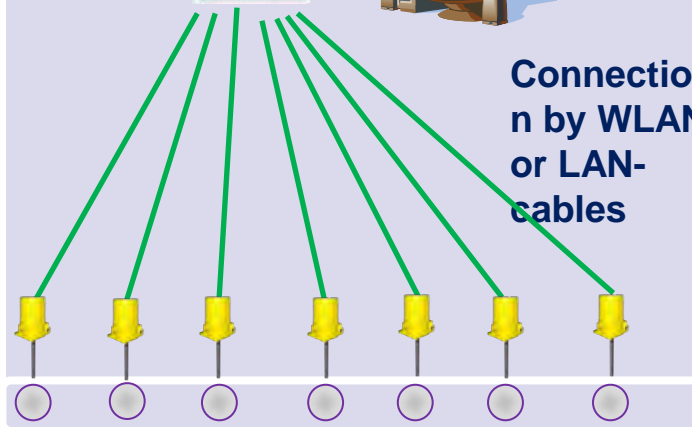
Sensors installed in measuring points and send results via wires, Ethernet, Wi-Fi, etc.



Control System

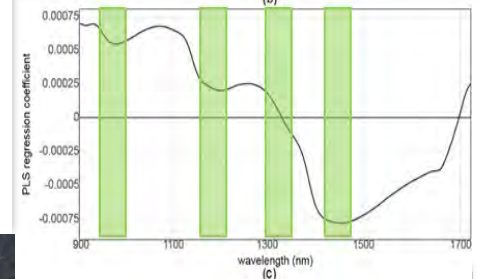
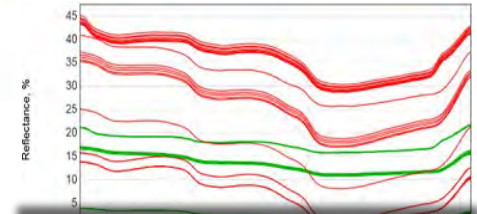


Connection by WLAN or LAN-cables



Various process points to monitor

Innovative IR-LED, QCL and Fabry-Perot tunable filters enable to develop compact spectral fiber sensors of customized design with data send to iCloud as in IoT - to enable **remote process control in customized applications**

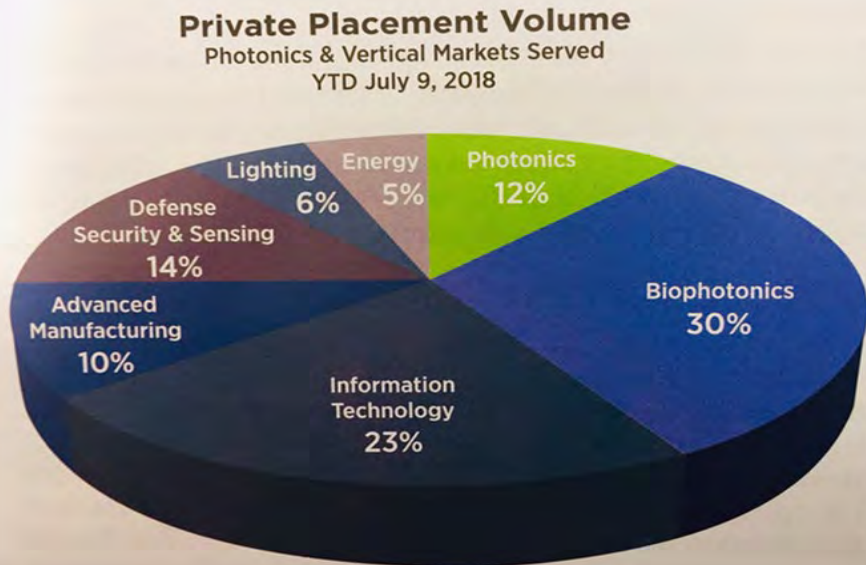


Multi-Wavelength IR LED & QCL-Spectral Fiber Sensors

Market Segments for Photonics vs Private Investments

Market trends (\$B)	2016	2021
Process Spec-py	13,01	22,04
Medical Sensors	8,49	15,01
Endoscopy	23,8	33,6
POC Diagnostics	21,1	37
Healthcare IT	107,5	228,8
IoT	157,05	661,74
Life Science	43,5	64,52
TOTAL	374,45	1062,71

Application Type	2015	2016	2021	CAGR% 2016-2021
Military	2,709	3,051	5,694	13.3
Homeland security	980	1,126	2,279	15.1
Industrial process	739	861	1,868	16.8
Factory automation	623	730	1,635	17.5
Civil structure	645	740	1,498	15.1
Transportation	566	661	1,510	18
Biomedical	462	540	1,183	17
Microfluidics	412	483	1,084	17.5
Bio-environmental	260	309	737	19
Wind-energy turbines	226	269	648	19.2
Oil and gas	254	295	619	16
Others	174	204	445	16.9
TOTAL	8,050	9,269	19,200	15.7



Fiber Photonics for broad spectra applications



www.artphotonics.com

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