

25 Years
of Fiber Magic

QCL +

IR Endo

Medicine

Laser Technologies

Process Spectroscopy

Probes · Bundles · Cables

Polycrystalline Infra-Red Fiber

Chalcogenide Mid-IR Fiber

Al / Cu Coated Silica Fibers

Hollow Waveguides

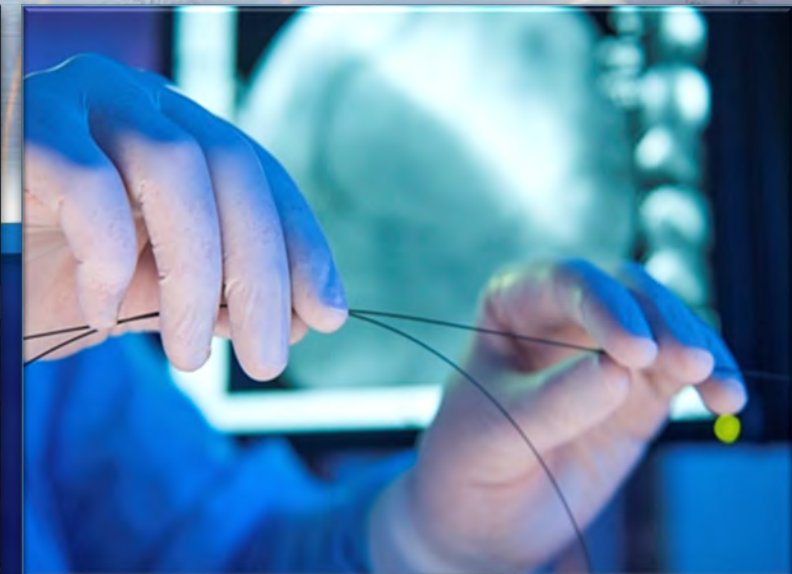
26-27 September 2023, Baden, Switzerland

EPIC Technology Meeting on Photonics for
Bio and Life Science Applications at PARK INNOVAARE

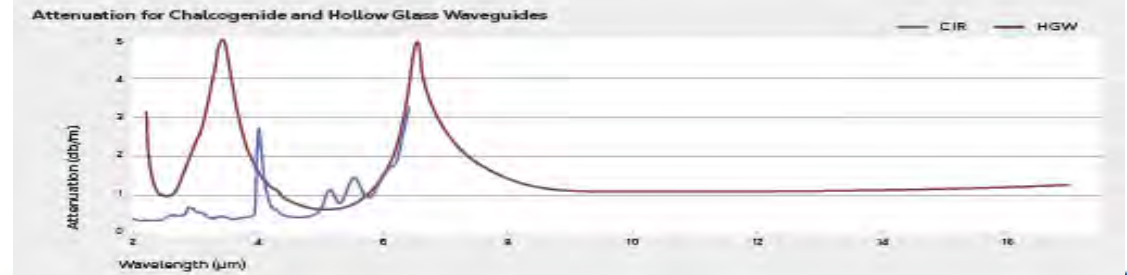
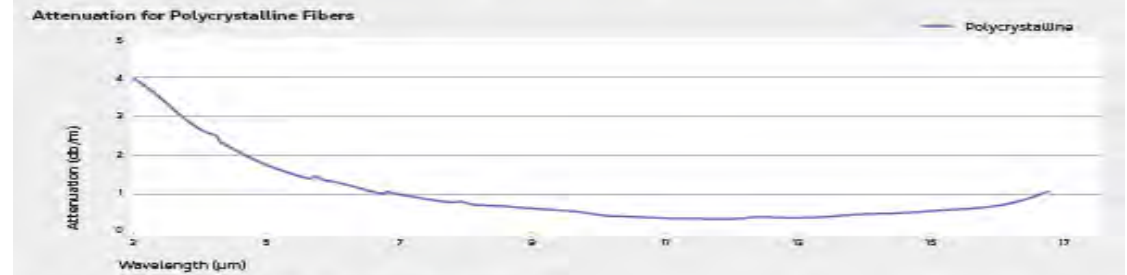
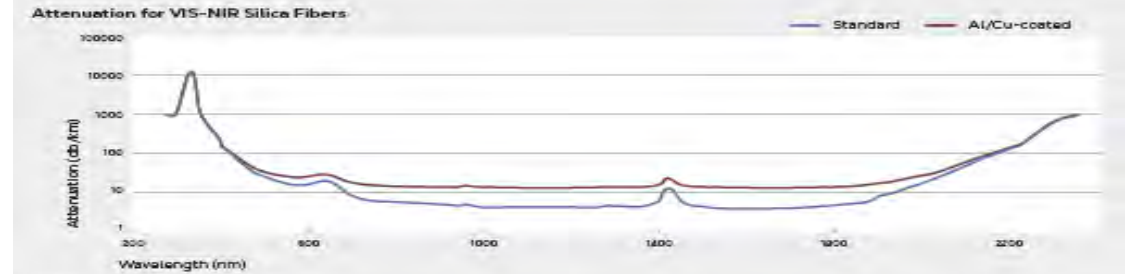
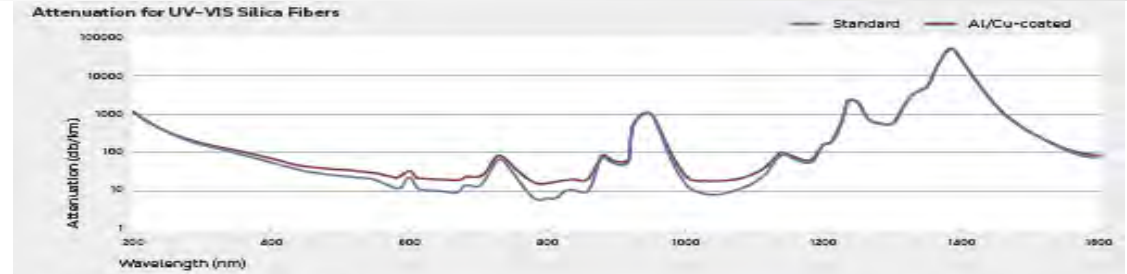
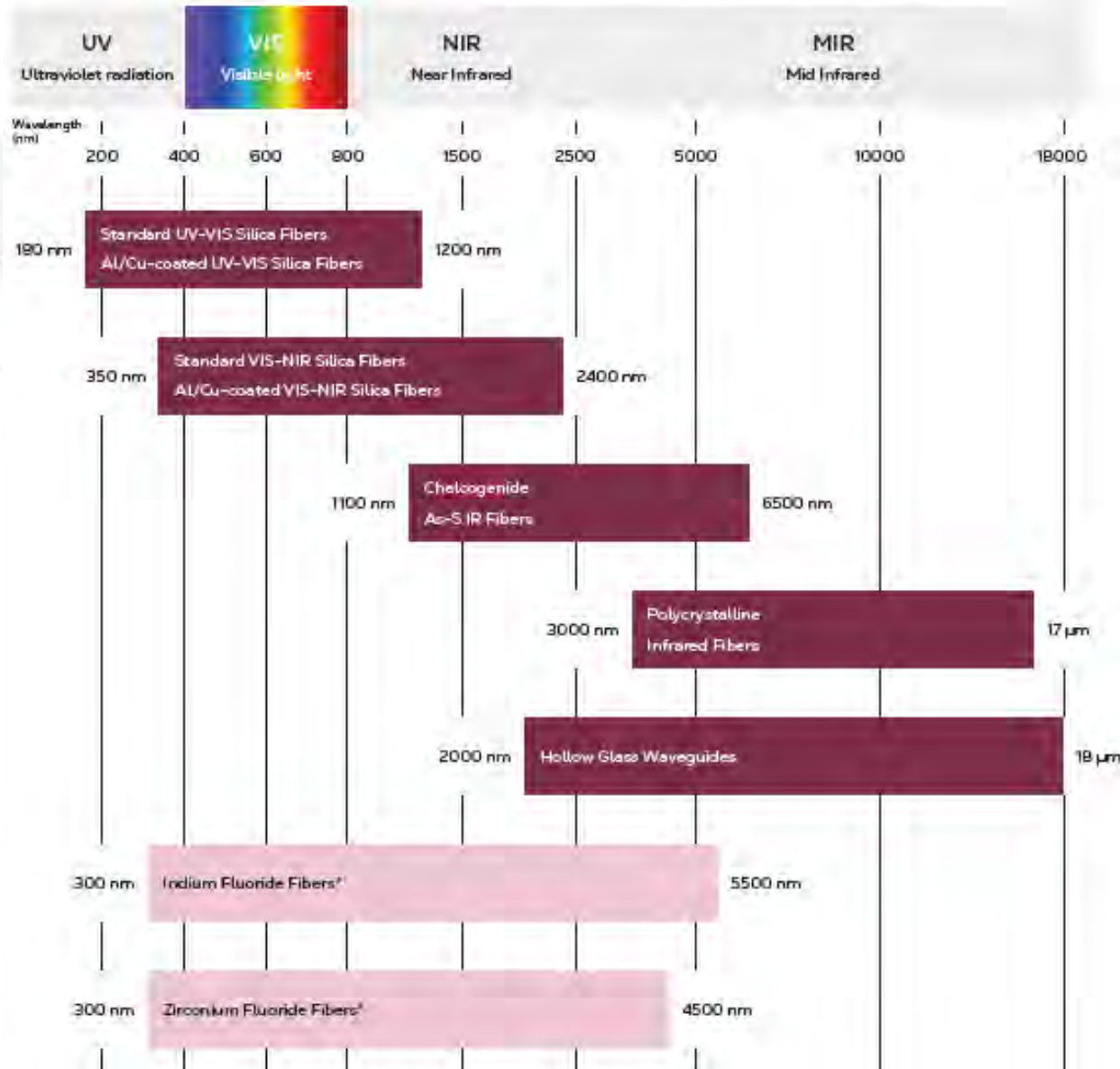


Fiber spectroscopy solutions *in-line* for biophotonics application in 0.3-16 μ m range

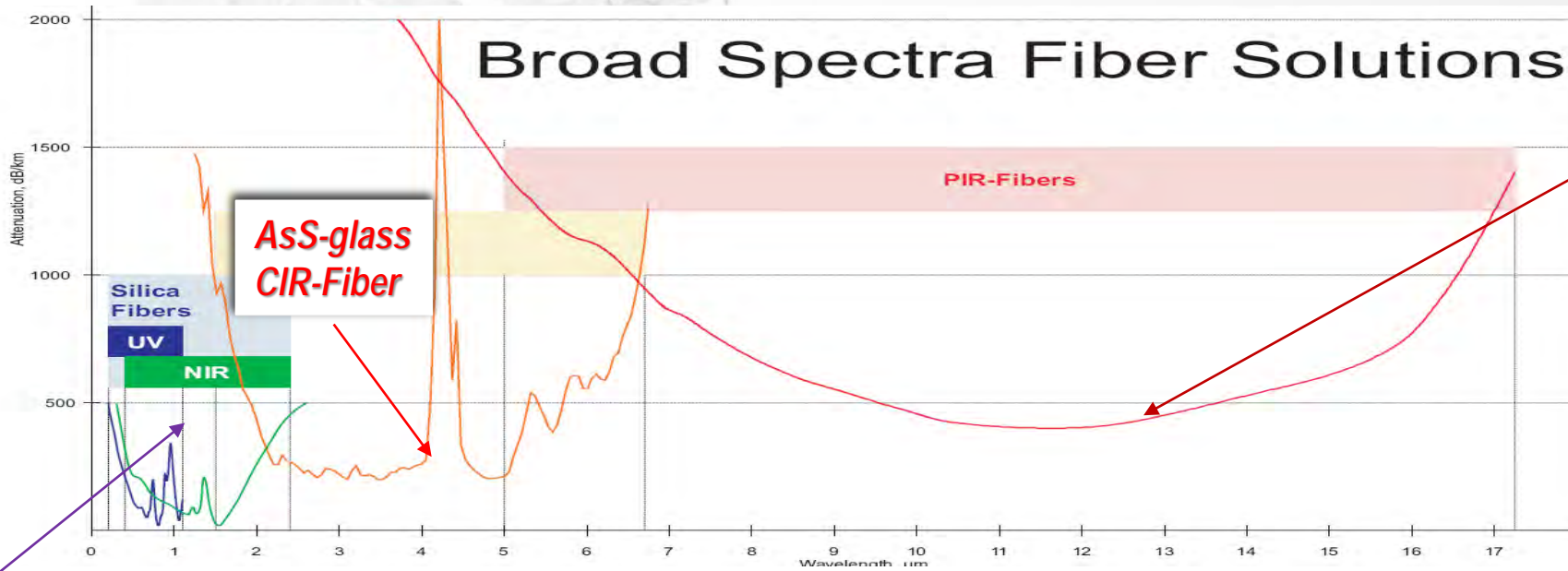
Viacheslav (Slava) Artyushenko



Overview of Transmission/ Attenuation for Different Fiber types



Silica, CIR & PIR-Fibers + Hollow WaveGuides for 0.3-16 μm



Polycrystalline InfraRed PIR-Fiber



Silica Fibers
UV-Vis & Vis-NIR



Tiny fiber probes enables spectral analysis of tissue inside human body *in-vivo* – vs common biopsy.

Single fiber Raman probe with $OD < 160 \mu\text{m}$ enables to detect tumor margin $< 0,1\text{s}$

RIVERD
INTERNATIONAL BV



Flexible Cables for Medical Lasers – from 308nm to 10,6μm

CO-laser

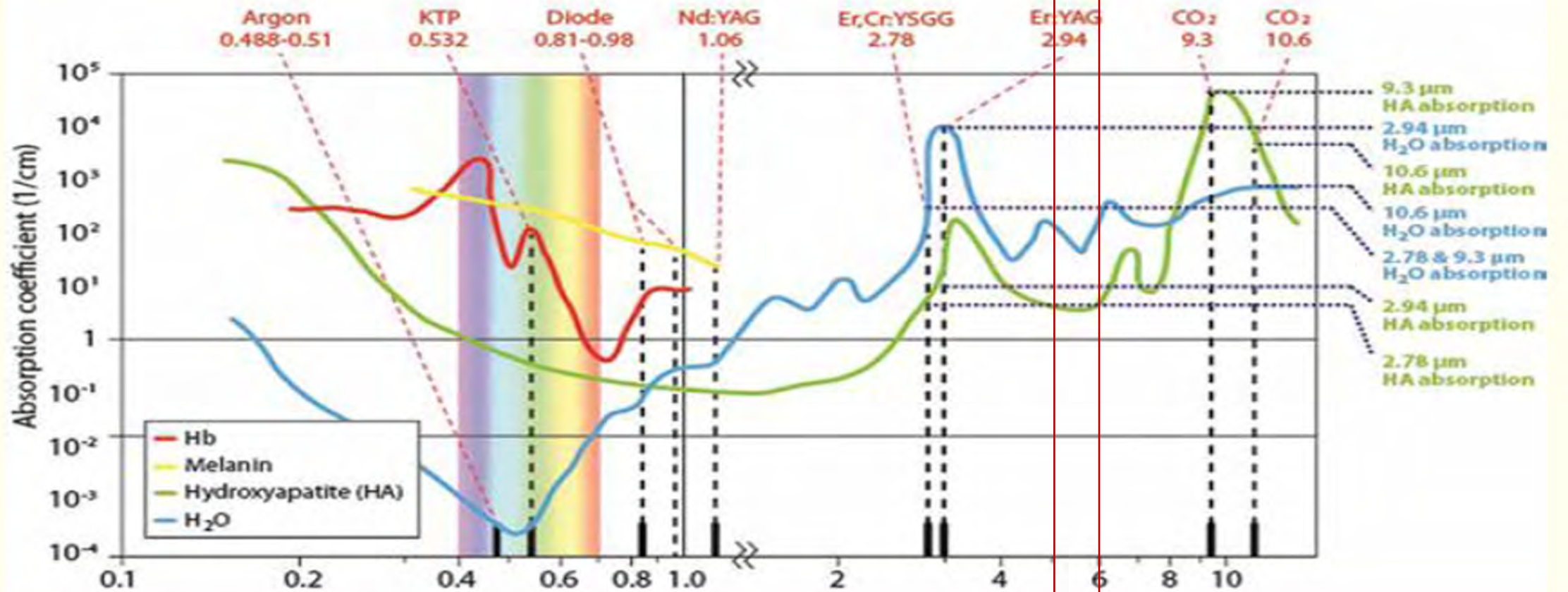


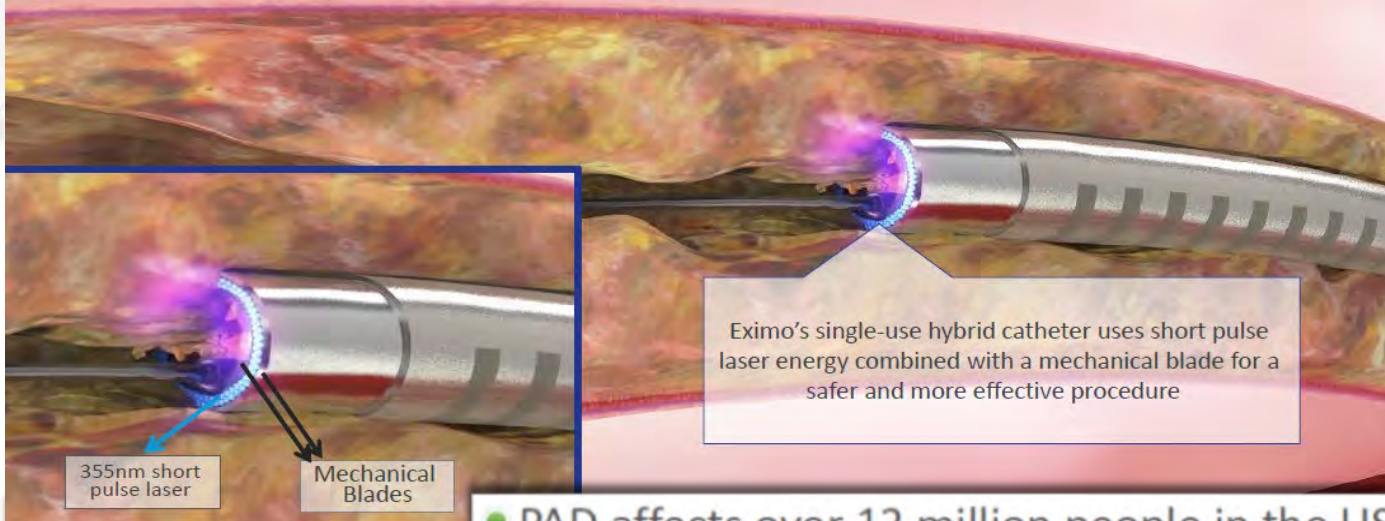
Figure 2: Absorption curves of various tissue components. Absorption of water is depicted by the blue line, and hydroxyapatite by the green line. Adapted from Featherstone and Fried³⁰ and Vogel and Venugopalan³¹

Laser Angioplasty with Atherocatheters at 308nm and 355nm

EXIMO
Hybrid Medical Technologies

B-Laser Hybrid Catheter™ - Smart Duo Work

EXIMO's novel combination of a transformational laser technology and a mechanical blade on a single catheter is poised to disrupt the PAD market



- PAD affects over 12 million people in the US
- Annual hospital costs associated with PAD amputations \$5.5B
- Approximately 185,000 amputations occur yearly, 122,000 (66%) caused by PAD

Atherectomy with 355nm Laser

Journal of

10/17

BIOPHOTONICS

www.biophotonics-journal.org

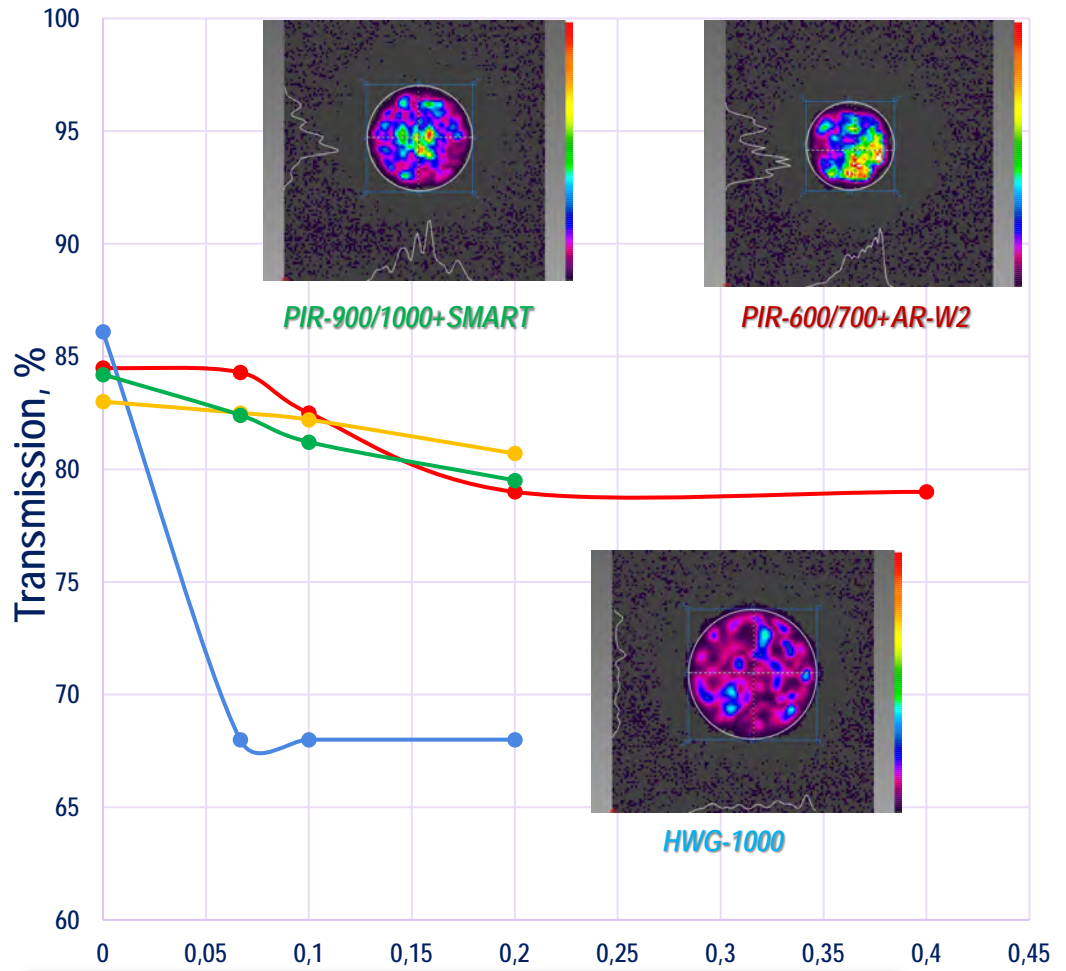


EXIMO™
EXIMO MEDICAL LTD.

- was acquired in 2019
by AngioDynamics

Использование эксимерного лазера для удаления атеросклеротической бляшки / В.Г.Артюшенко, В.С.Букреев, С.К.Вартапетов // Грудная Хирургия, 1986, № 5, с.16-20

PIR-Fiber vs Hollow Waveguide Cables for CO- or CO2-Lasers



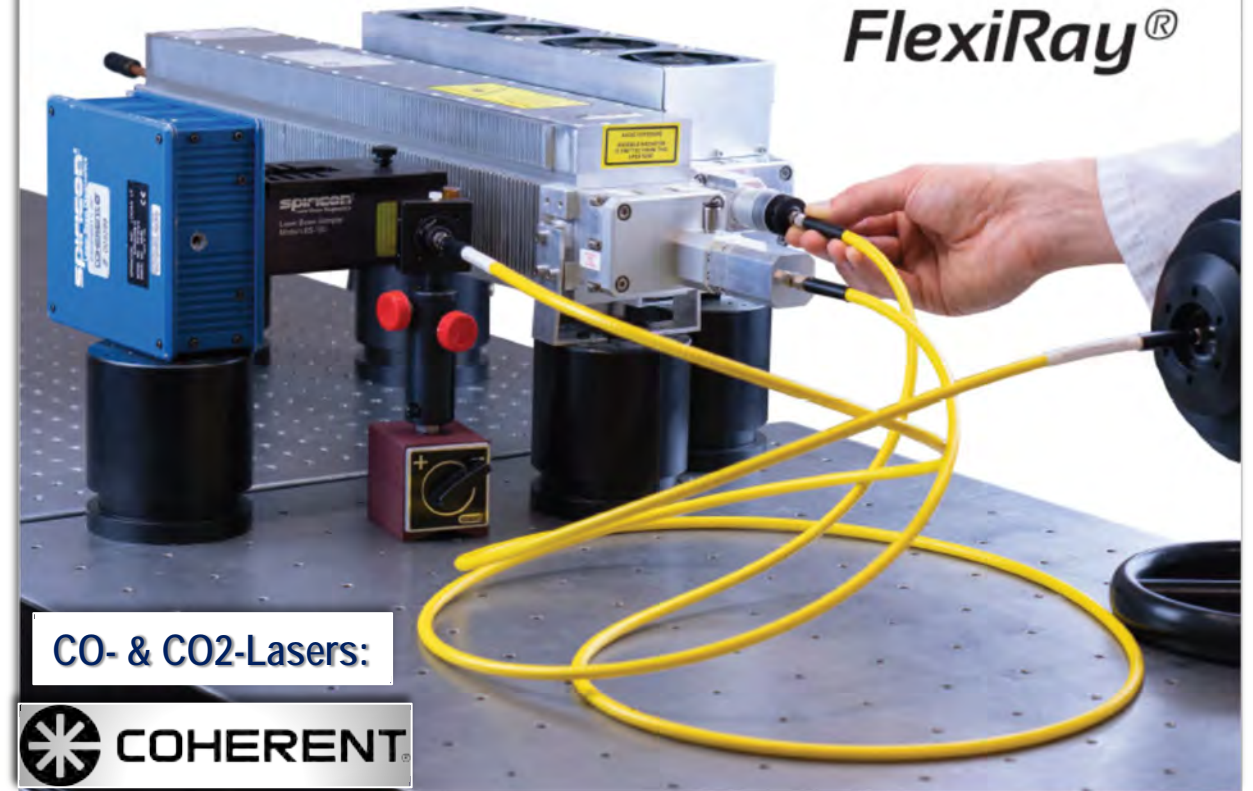
Cable Transmission vs Bending Radius

1/R, cm⁻¹

● PIR-AR-Windows ● HWG ● PIR600-SMART ● PIR900-SMART

- The most flexible cables for CO- & CO₂-laser power delivery
- SMART-technology to suppress Fresnel reflection losses
- Stable transmission under small bending radius

FlexiRay[®]

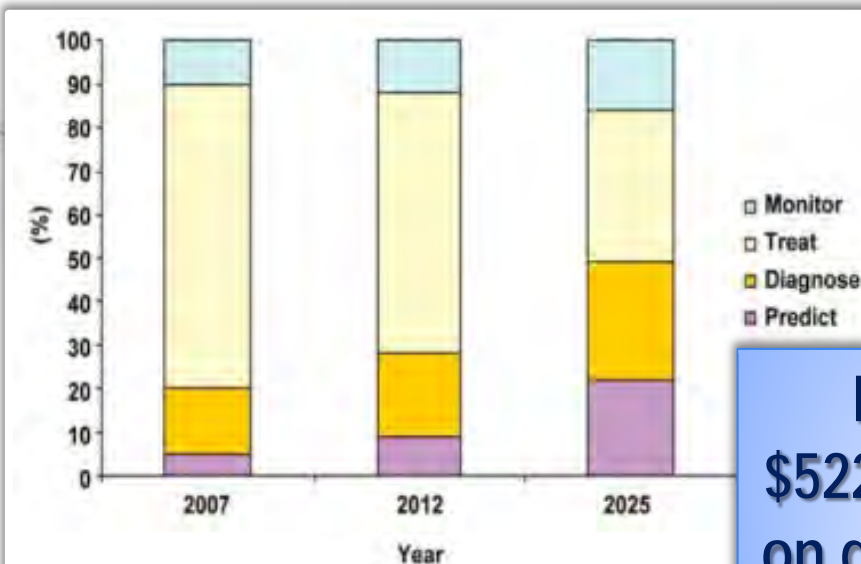


CO- & CO₂-Lasers:

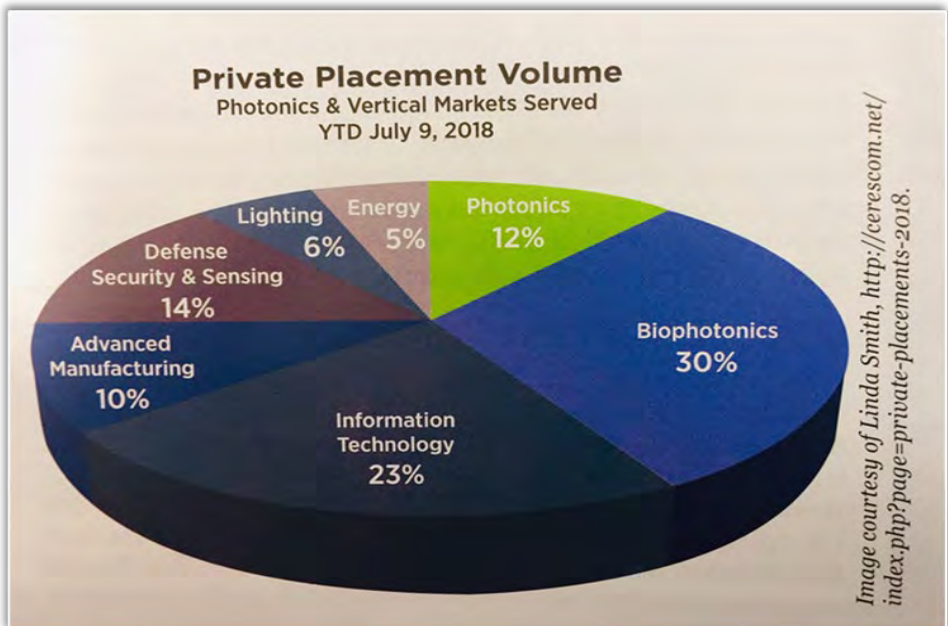


Recent Trends of Medical / Biophotonics Market

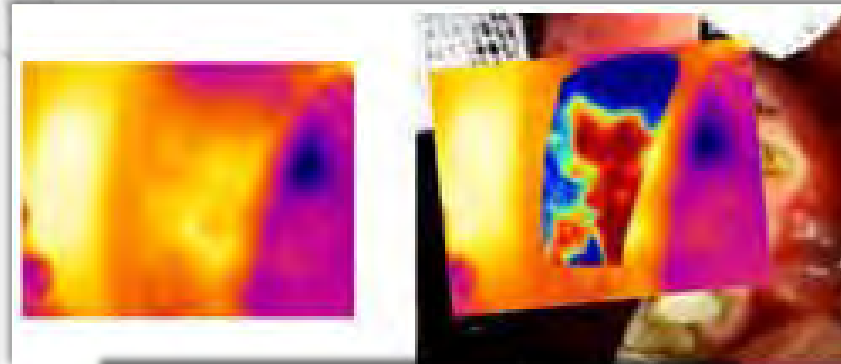
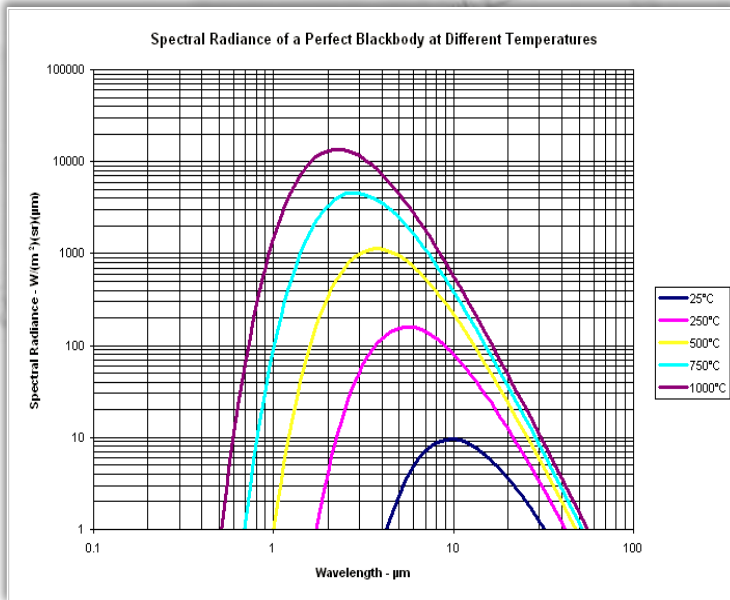
Market trends (\$B)	2016	2021
Process Spec-py	13,01	22,04
Medical Sensors	8,49	15,01
Endoscopy	23,8	33,6
POC Diagnostics	21,1	37
Healthcare IT	107,5	228,8
IoT	157,05	661,74
Life Science	43,5	64,52
TOTAL	374,45	1062,71



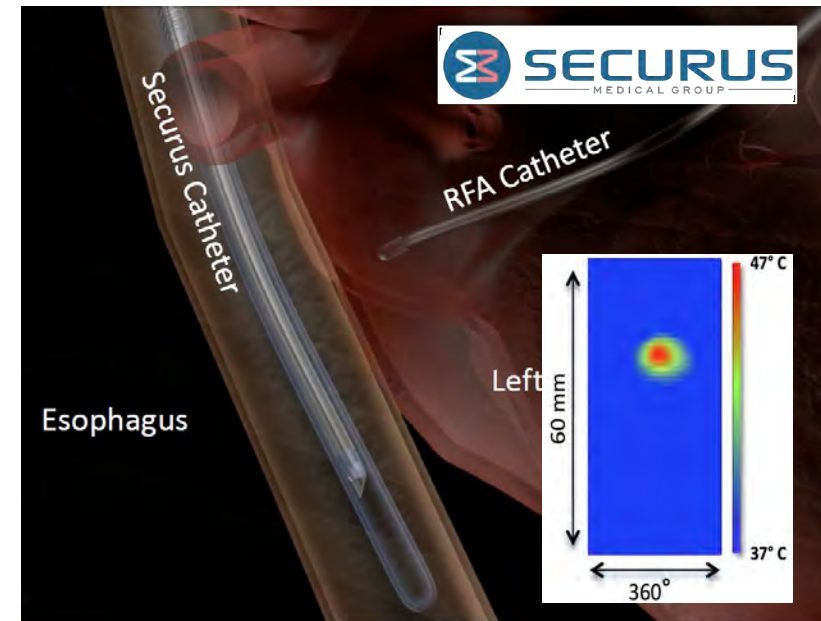
Medtech sales up to \$522bn in 2022 - with focus on diagnostics & screening



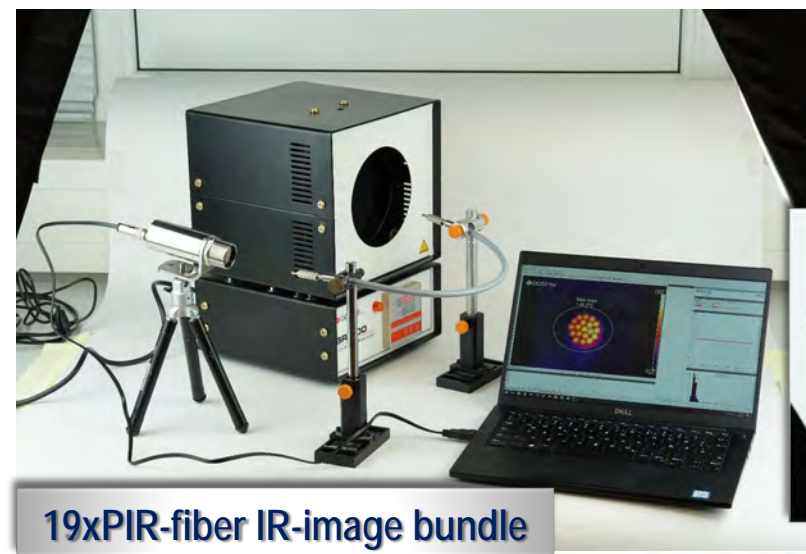
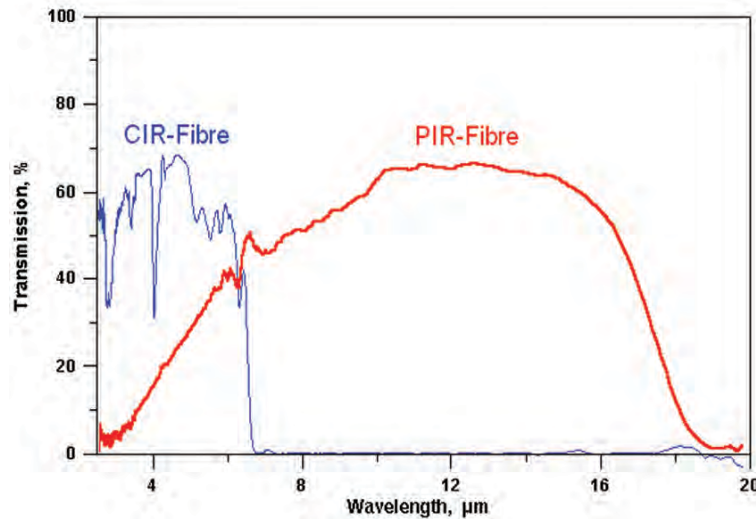
PIR-Fibers for IR-Imaging Endoscopy in Mid IR-Range



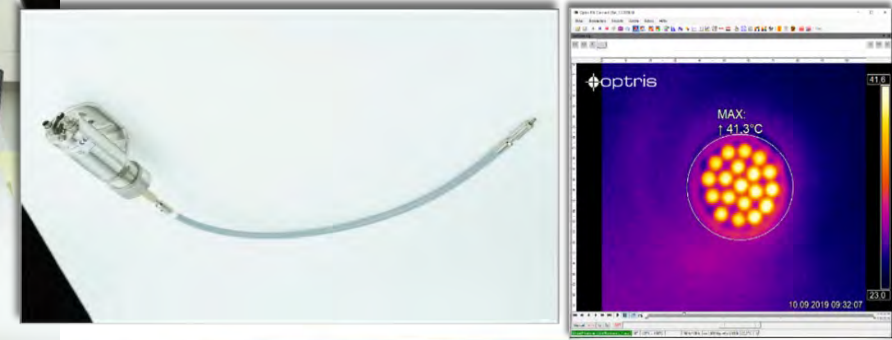
Classic thermography (left) vs HTB's HDI used in HDIntra (right)
www.htbioimaging.com



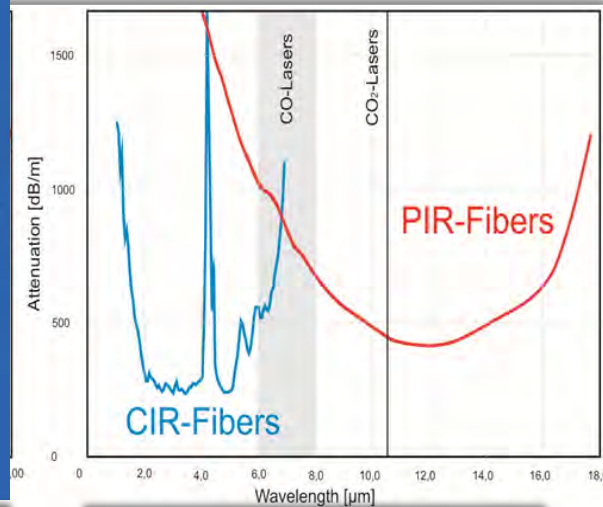
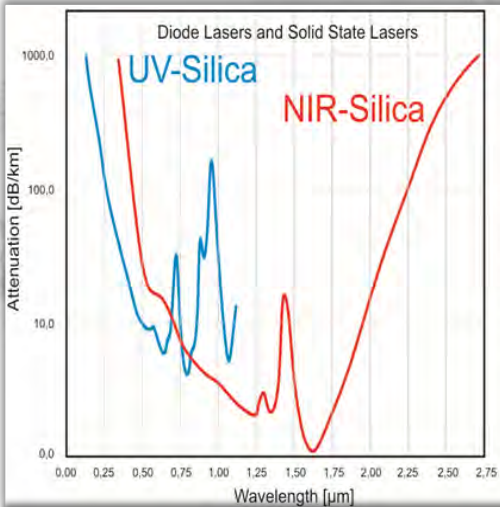
PIR-Fiber IR-imaging Endoscope



19xPIR-fiber IR-image bundle



Silica, CIR & PIR-Fiber Spectroscopy Probes for 0.3-16 μ m



Multi-Spectral Diagnostics with Fiber coupled FTIR, Raman, Fluo & Vis-NIR Spectrometers

FTIR-spectrometer with ATR-PIR-fiber probe

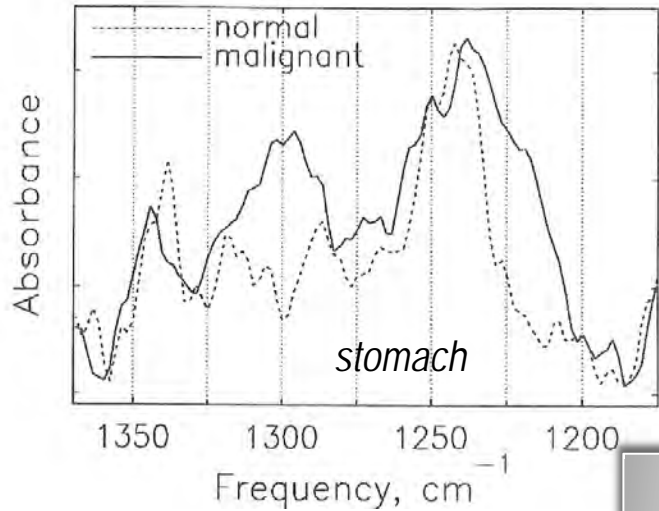
10m ATR-fiber Probe for IRis-F1 QCL Dual-comb spectrometer from IRsweep



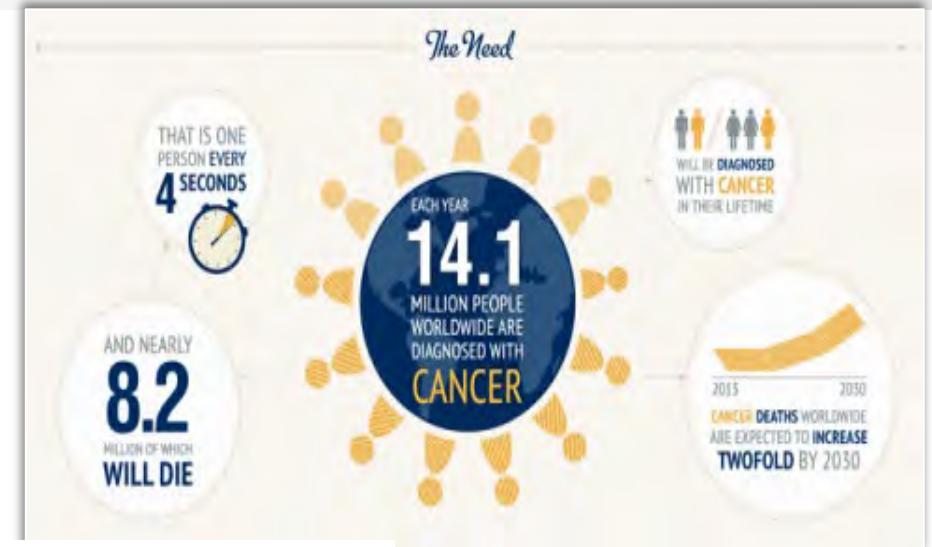
www.irsweep.com

www.artphotonics.com

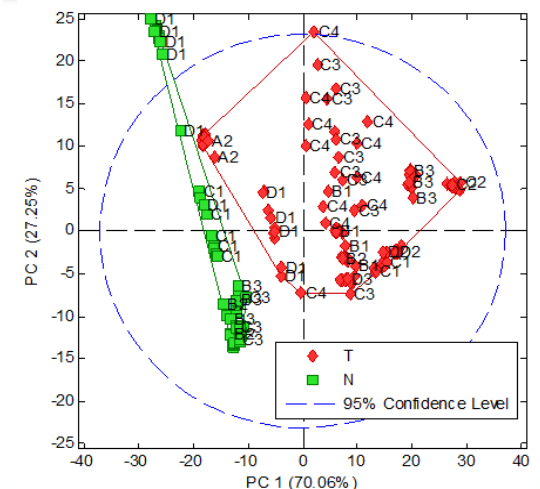
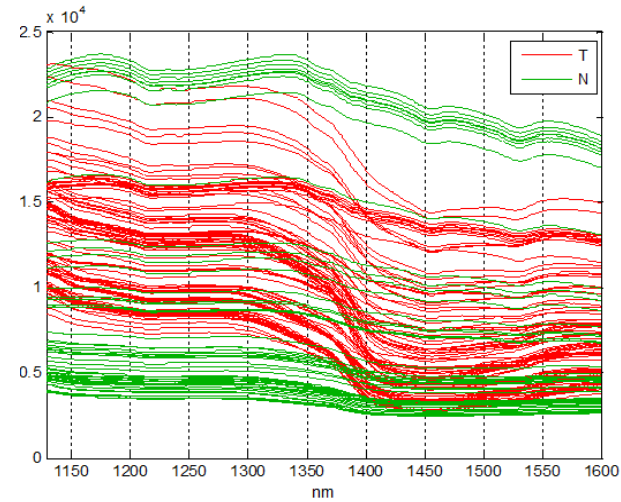
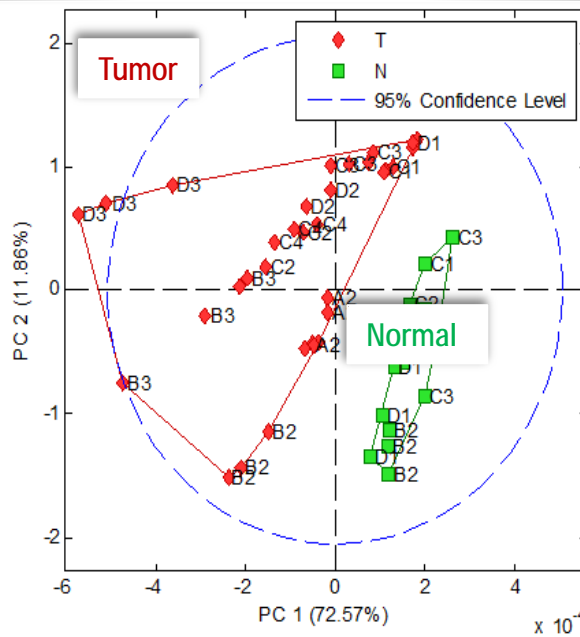
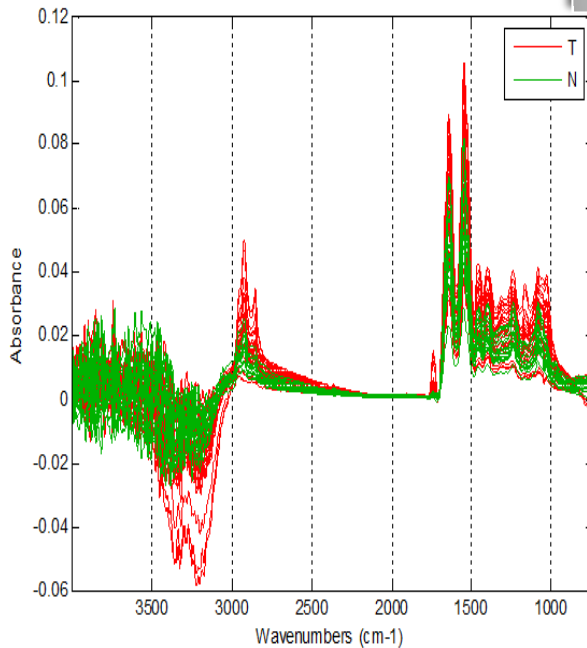
Cancer Diagnostics with ATR-MIR & DRS-NIR fiber-probes



Our ATR-probes coupled to FTIR-spectrometer enable to detect stomach cancer *ex-vivo* 30 years ago (see spectra at the left) - with the 1st data published in Proc. SPIE v.2328, 76-81, v.2631, 1994. Our tests in Berlin made on 2015-2016 for kidney RC-carcinoma have confirmed glucose role as this tumor biomarker together with the lipid/ water ratio



Mid IR-absorption Spectra of *normal* & *tumor* kidney with PCA spectra analysis

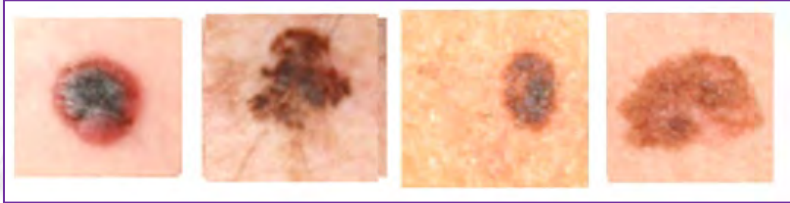


NIR-Spectra for normal and tumor of kidney (1129-1600nm) with PCA

Skin Cancer Detection with ATR-IR-Fiber probes at Tel Aviv University

Melanoma

This is a malignant skin cancer that is responsible for almost ~10000 deaths, out of 100000 new cases in the US, annually.



Basal Cell Carcinoma (BCC) & Squamous Cell Carcinoma (SCC)

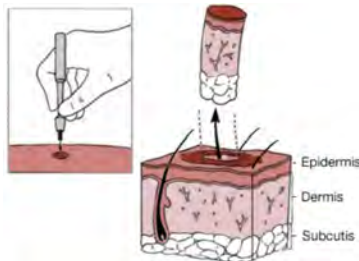
Much more common than melanoma.

Much less malignant than melanoma. Rarely metastasizes beyond the original tumor site.

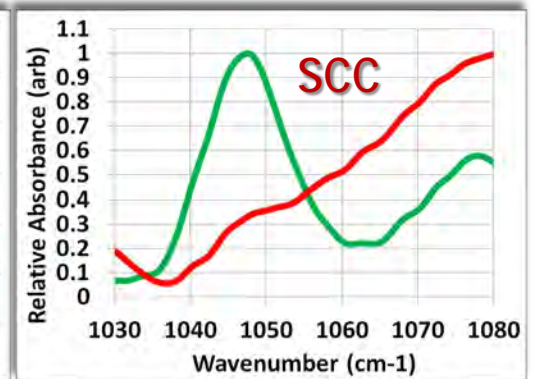
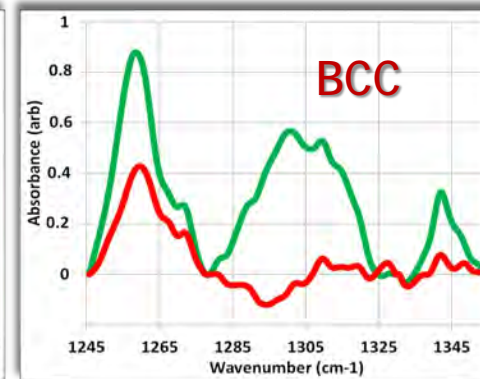
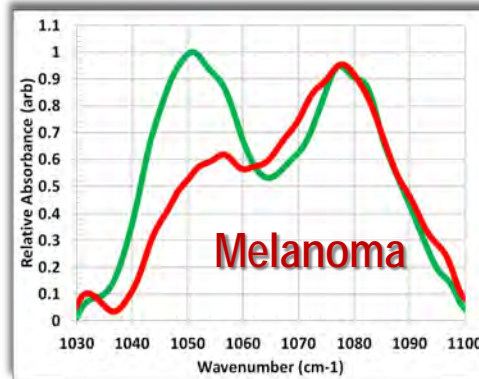


Dermoscopes:

Biopsy:

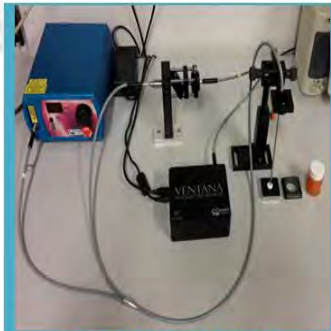
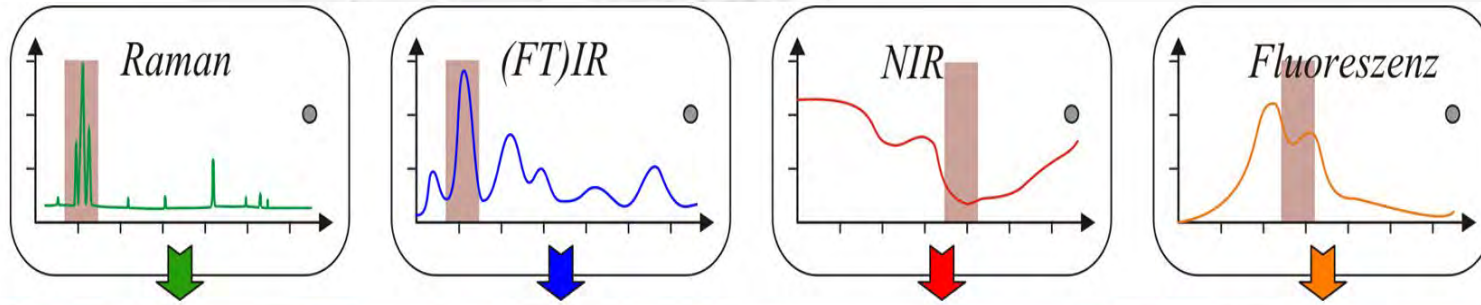


Prof. Abraham Katzir doing the tests of skin lesion with AgHal-fiber probe coupled to FTIR-spectrometer with one of 90 patients used for clinical studies. This non-invasive test enables to detect 5 melanoma, 7 BCC & 3 SCC (with a special algorithm)

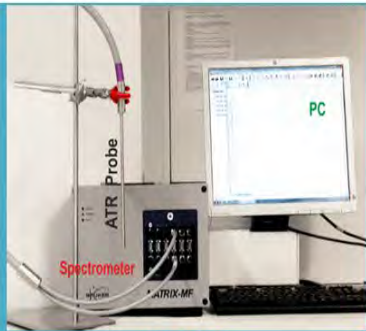


ATR-fiber spectroscopy may provide non-invasive, rapid, and easy to apply, diagnostic tool to enable fast detection of melanoma – with its differentiation from BCC or SCC

Tumor Detection with 4 Label Free Spectroscopy Methods



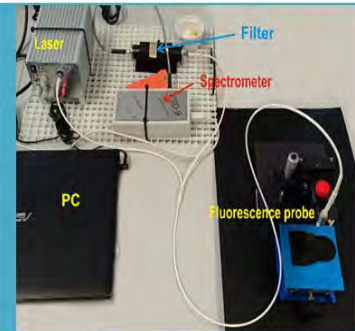
Raman @690nm & @785nm



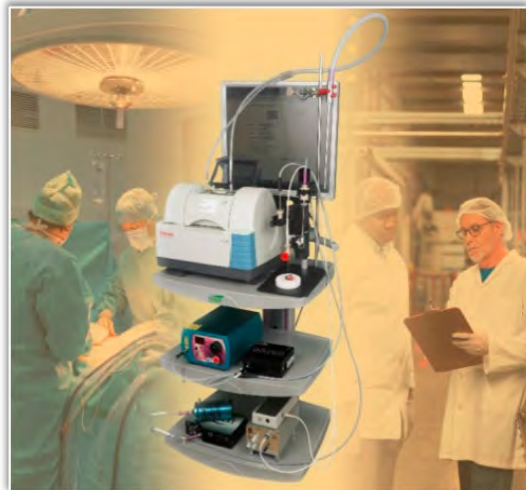
FTIR (MIR)



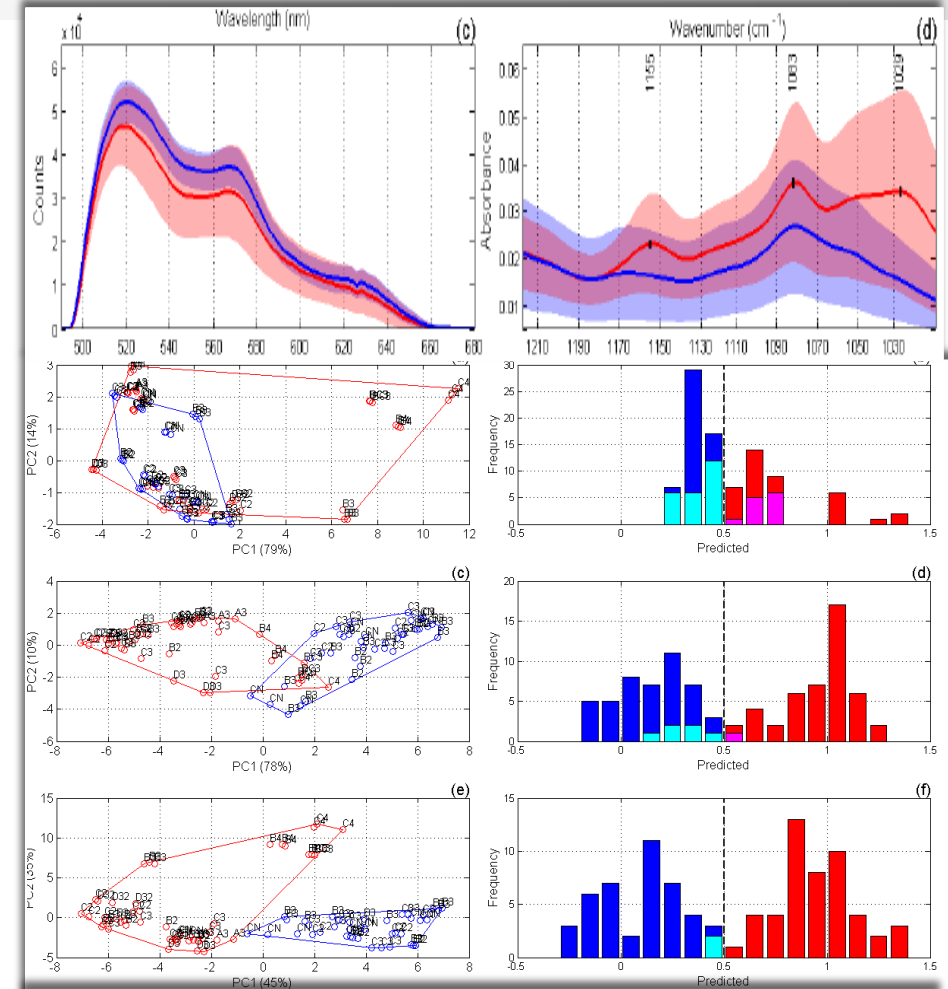
DRS NIR



Fluoreszenz @ 473nm



Comparison of all 4 key spectroscopy methods made for the same tissue spots enables to select the best one (or their best combination) for the most sensitive, specific and accurate detection of tumor margins. This selection depends on organ & type of cancer, while spectra fusion from different methods leads to much higher accuracy in real time tumor detection



PCA for Fluorescence, Mid IR absorption and their spectra fusion to detect kidney cancer

Synergy from Spectral Data Fusion from Different Methods

Mid-IR + Fluorescence

Better distinguish kidney RC-carcinoma tumor

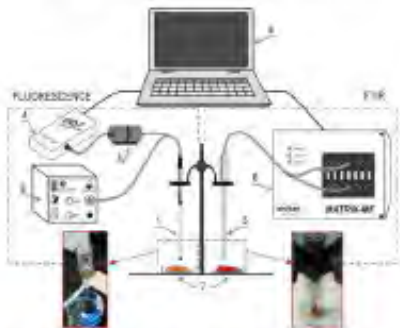
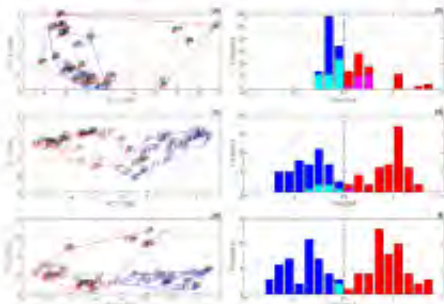


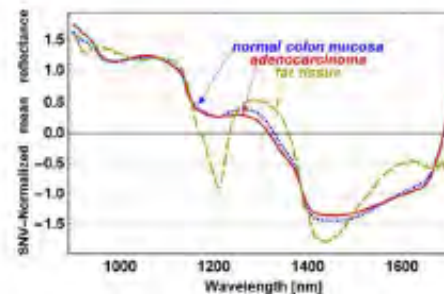
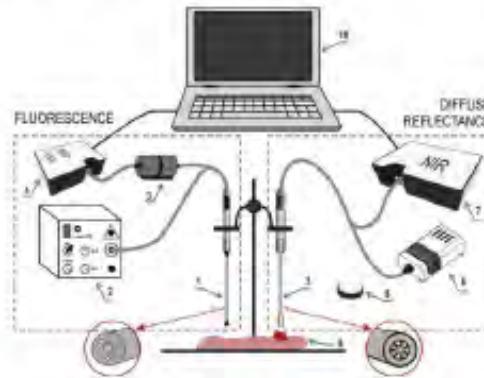
Figure 1. Experimental setup for fluorescence (left) and mid infrared (MIR) (right) spectral data fusion. 1—Fluorescence probe, 2—blue light source, 3—MIR transmitter fiber, 4—fluorescence spectrometer, 5—transmitted and reflected MIR probe, 6—MIR spectrometer, 7—optical analyzer.



Bogomolov, A., Belikova, V., Zabarylo, U. J., Bibikova, O., Usenov, I., Sakharova, T., ... & Artyushenko, V. (2017). Synergy effect of combining fluorescence and mid infrared fiber spectroscopy for kidney tumor diagnostics. *Sensors*, 17(11), 2548. <https://doi.org/10.3390/s17112548>

Near-IR + Fluorescence

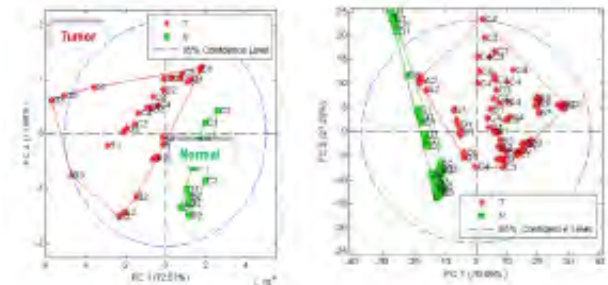
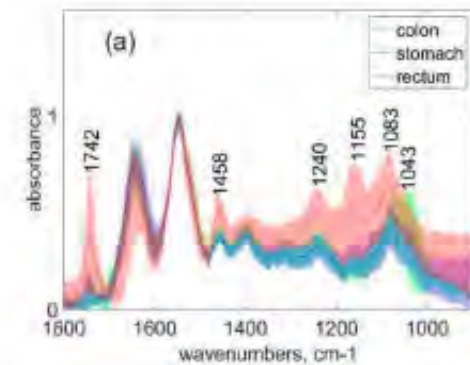
Higher sensitivity in discrimination between malignant and benign colorectal tissue



Ehlen, L., Zabarylo, U. J., Speichinger, F., Bogomolov, A., Belikova, V., Bibikova, O., ... & Kamphues, C. (2019). Synergy of fluorescence and near-infrared spectroscopy in detection of colorectal cancer. *Journal of surgical research*, 242, 349-356. <https://doi.org/10.1016/j.jss.2019.05.011>

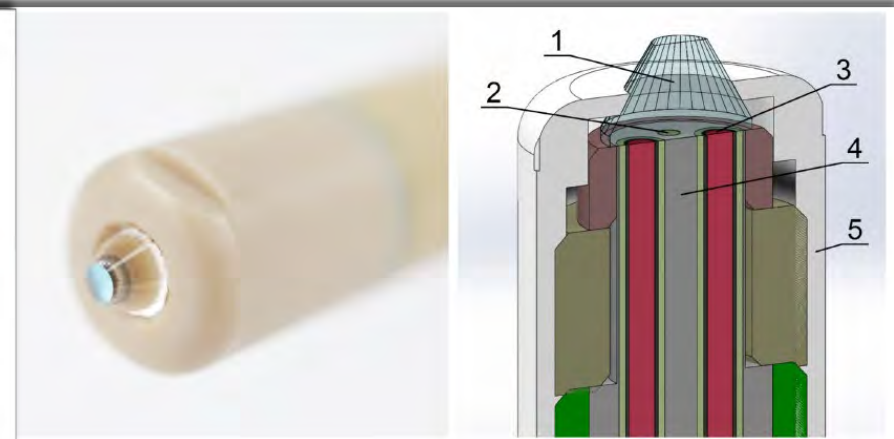
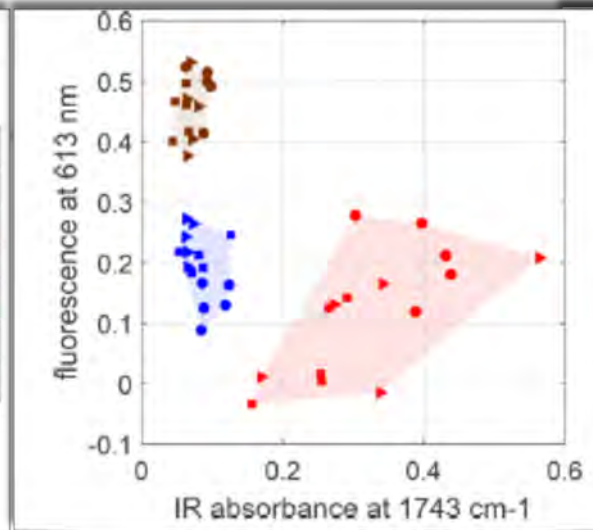
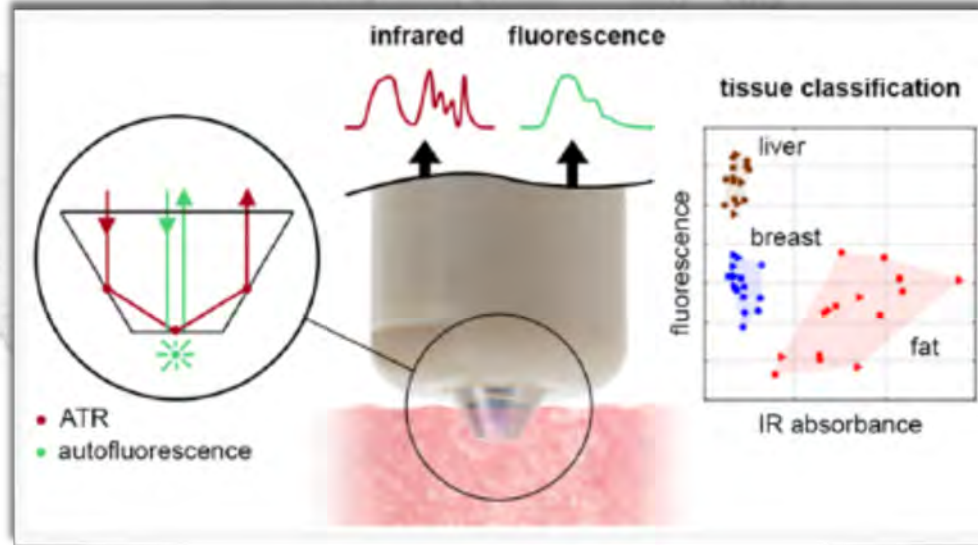
Near-IR + Mid-IR

Increasing the accuracy of abdominal cancer detection



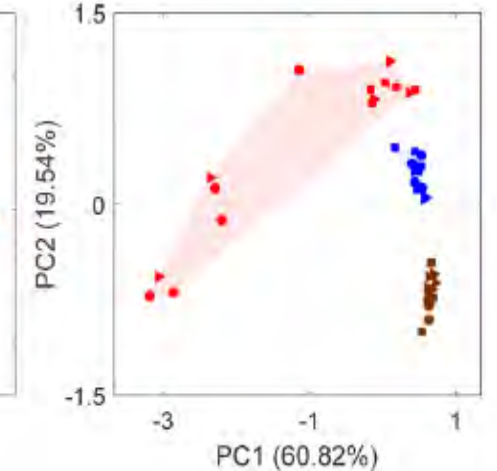
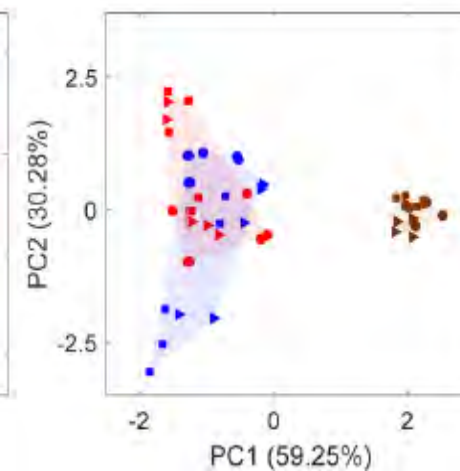
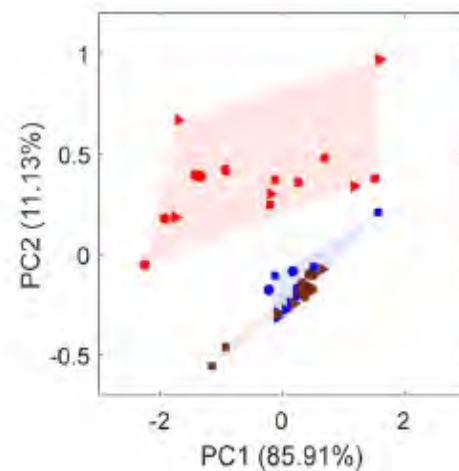
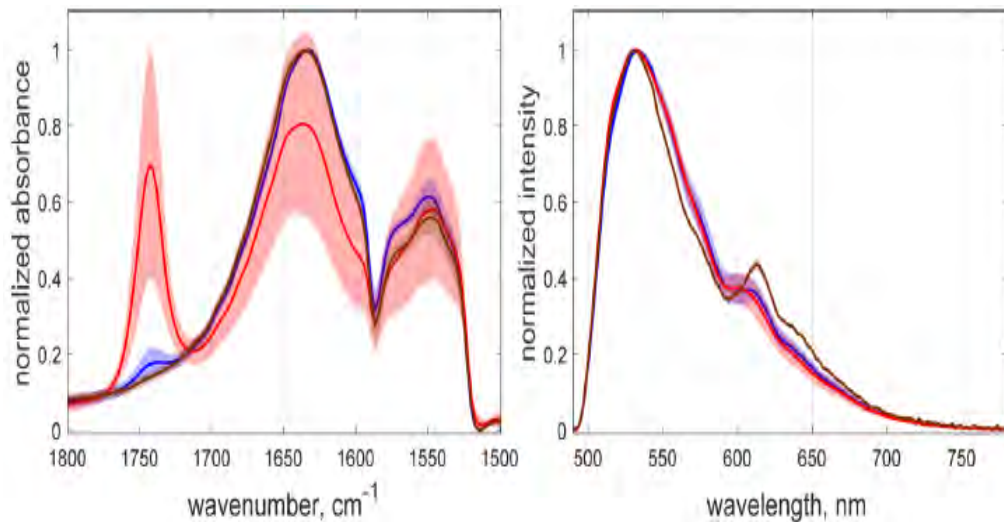
Hocotz, T., Bibikova, O., Belikova, V., Bogomolov, A., Usenov, I., Pieszczyk, L., ... & Zabarylo, U. (2020). Synergy effect of combined near and mid-infrared fiber spectroscopy for diagnostics of abdominal cancer. *Sensors*, 20(22), 6706. <https://doi.org/10.3390/s20226706>

Combi-Fiber Probe for Mid-IR/Fluo-Spectra Fusion Sensors



<https://doi.org/10.1021/acs.analchem.1c00080>

**analytical
chemistry**



Needle Fiber Probe for HW-Raman Spectroscopy Guided Cancer Surgery

Eurostars-project: Ra-Sure (ESTAR18101)

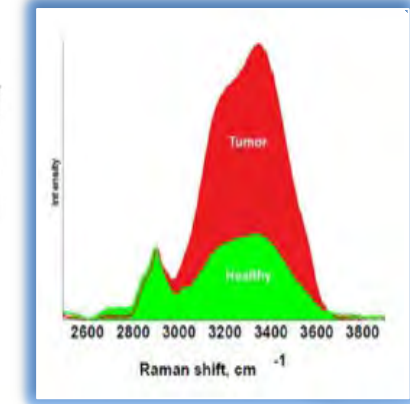
300.000 new oral cancer patients/year

Surgery to remove tumour successful in only 15% of cases

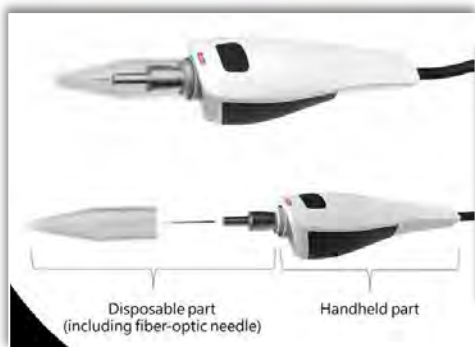
Technology needed to support surgeon



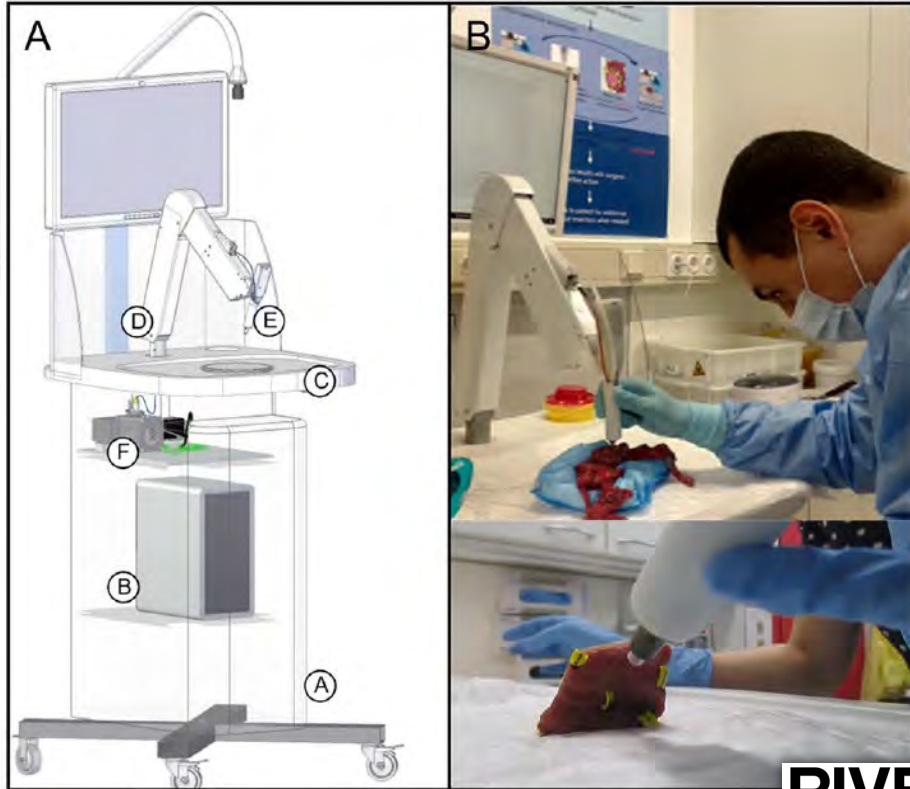
Single fiber Raman Needle Probe (OD<180 μ m)
penetrates in resected tissue for 1cm to detect *ex-vivo* oral cancer (SCC) margins in 1s – providing HW-Raman spectrum each 100ms (i.e. with 1mm accuracy)



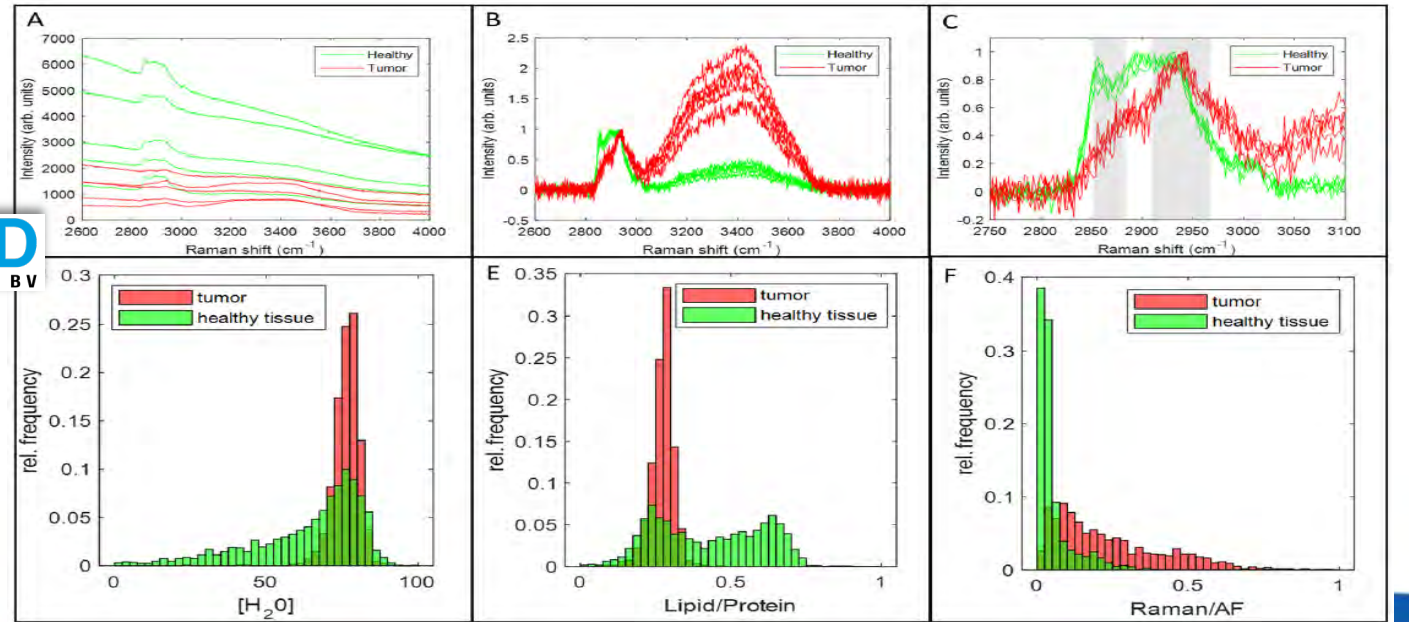
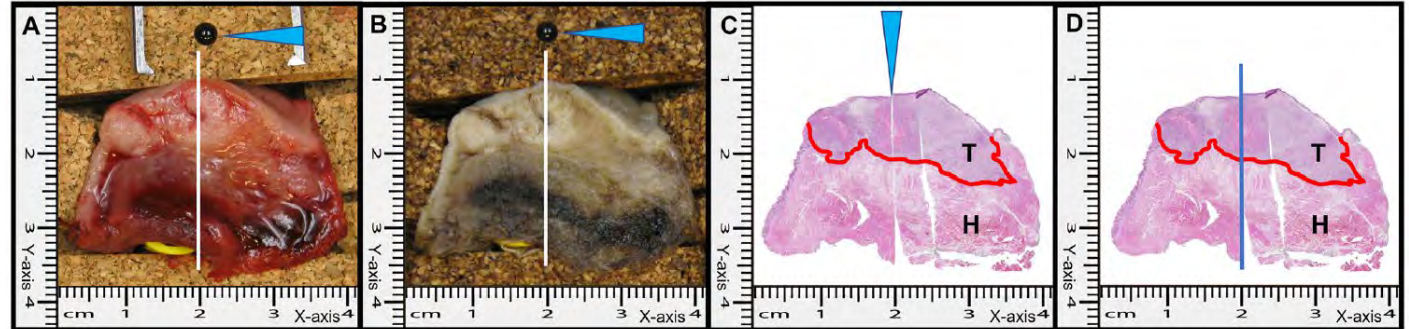
Water content is higher in Oral cancer - compared to the surrounding healthy tissue, and can be used as spectral biomarker to detect tumor margins



RIOARM-device from RiverD for detection of tumor margin *ex-vivo*

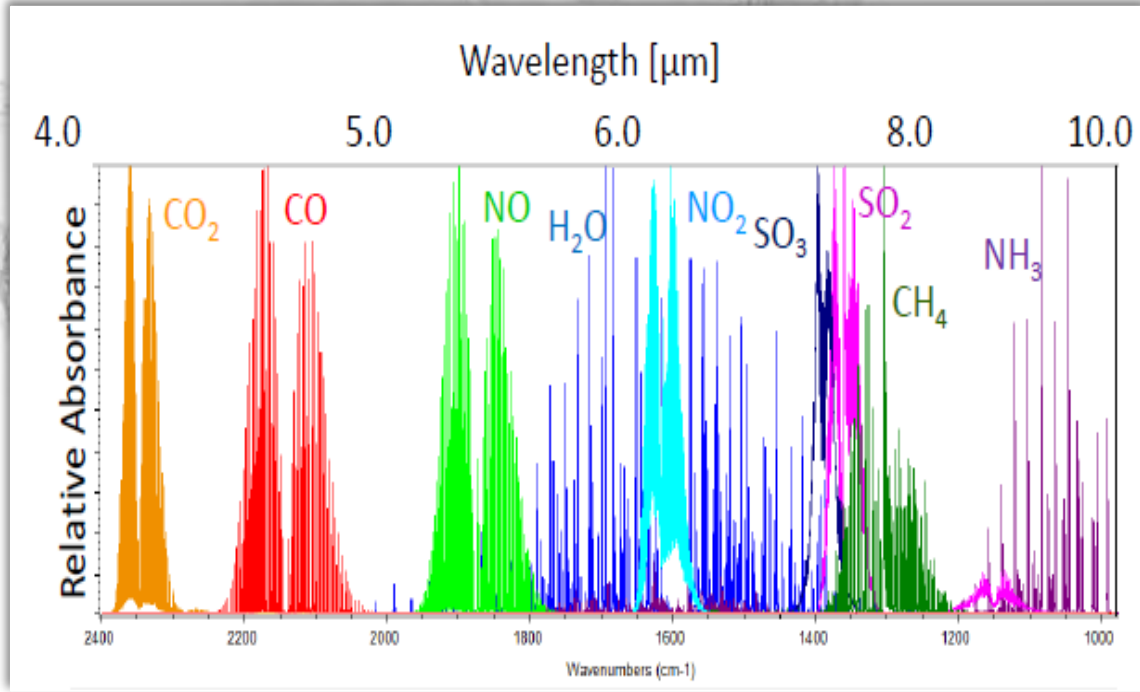


Disposable HWVN single fiber-optic needle probe of 150 μ m OD is used to deliver laser light at 671nm to tissue and collect back scattered light to Raman spectrometer for HW- spectra in 2600-4000 cm^{-1} range

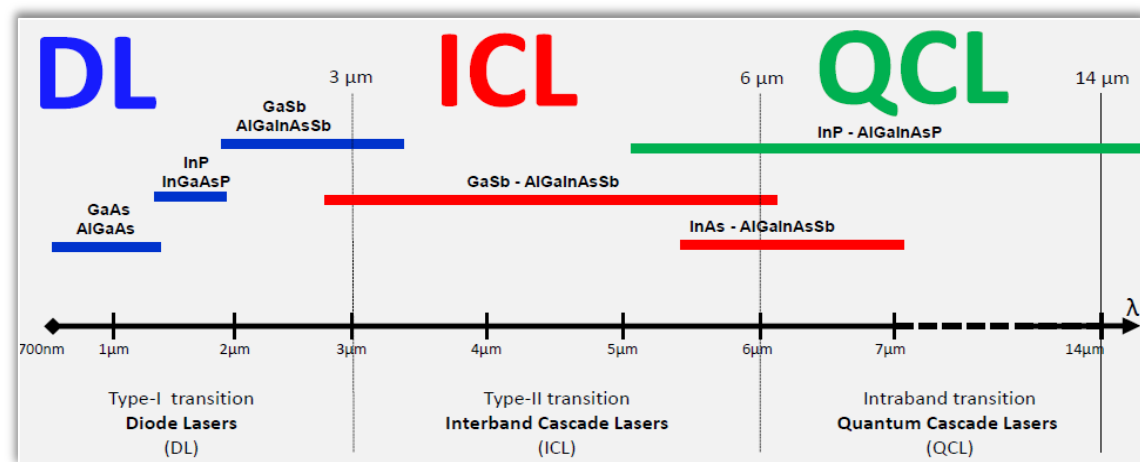
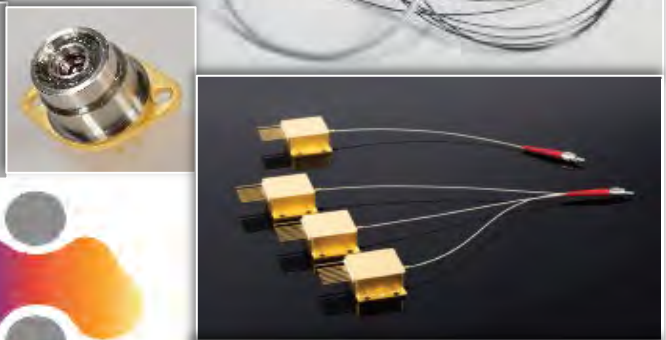


RIVERD
INTERNATIONAL BV

IR-Fiber coupled Quantum Cascade Lasers for Biomed

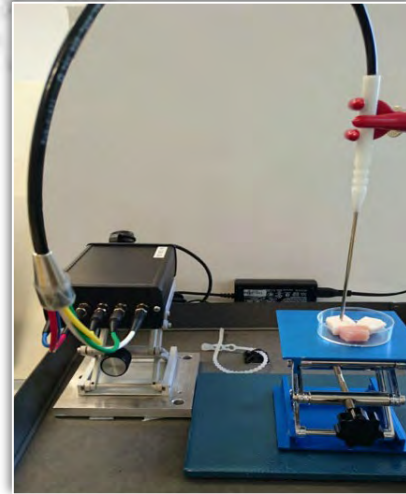


PIR-fiber spider bundle combines radiation of 7 QC-Lasers into one PIR-fiber Arthro-Probe



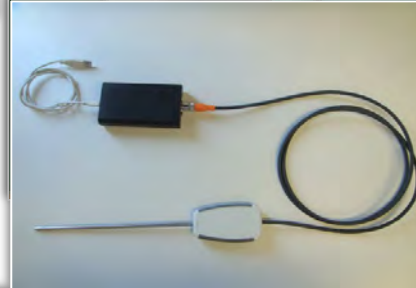
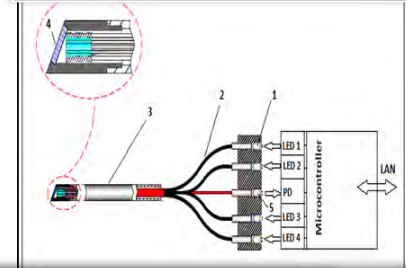
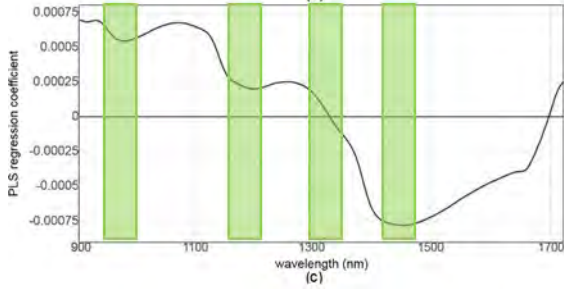
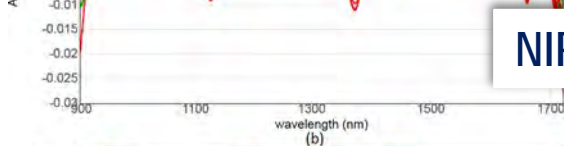
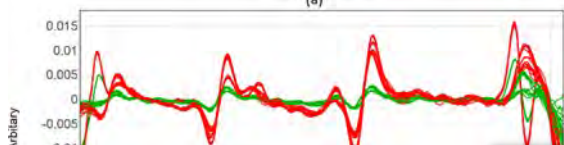
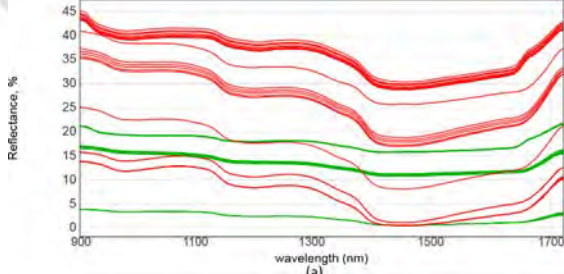
IR-fiber bundles allow to combine radiation from many QCL into one fiber - to make customized multi-spectral systems.

Spectral Fiber NIR-LED-Margin Sensor for Onco-Surgery

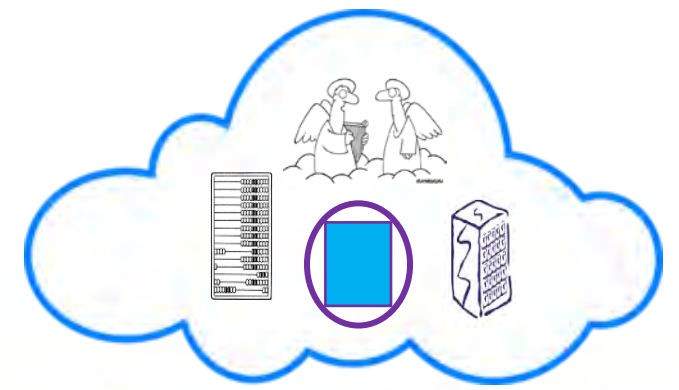
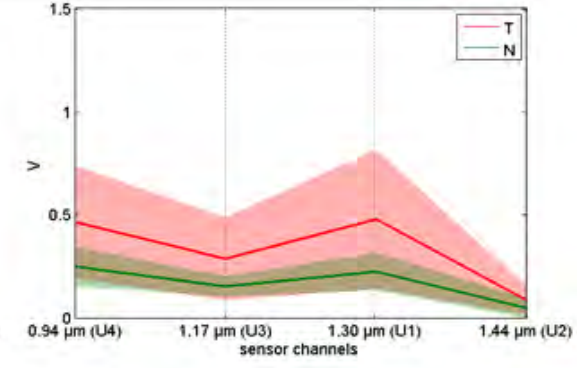
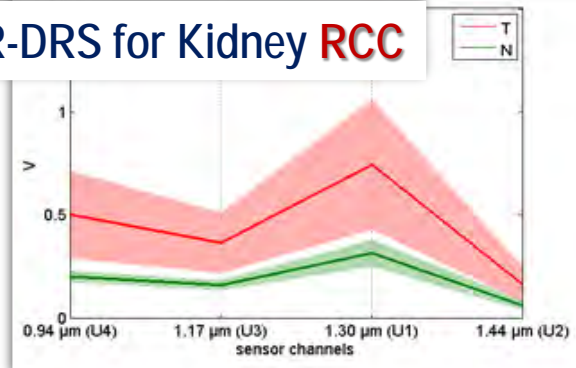


The global market for IoT networking solutions will grow from \$392.1 billion in 2017 to \$1.0 trillion by 2022 with a CAGR of 21.6% for this period

Medical Fiber Sensors – should be developed as a big part for this Dream Future!



NIR-DRS for Kidney RCC



art photonics proposal to EPIC partners:

- ➔ ***Development and production of fiber cables/ probes in the broad spectral range 0.3-16 μ m – as fiber bridge between any spectrometer and bioreactor (including animals and human) to enable remote molecular analysis for any media: tissue, liquid, gas mixture, - in-citu & in real time, including medical diagnostics *in-vivo* – for point of care & telemedicine***

Looking for partners:

- ➔ ***To develop not only new biomedical and biotechnology applications with complicated multi-spectral systems, but to design a variety of customized fiber sensors – with small size, low cost, friendly software, compatible with smart-phones and upgradable via iCloud to the enhanced databanks. Spectral fiber sensors will help to detect tumor margins *in-vivo* and make diagnostics of various diseases by tissues & bioliquids analysis using***

QCL +

IR Endo

Medicine

Laser Technologies

Process Spectroscopy

Probes · Bundles · Cables

Polycrystalline Infra-Red Fiber

Chalcogenide Mid-IR Fiber

Al / Cu Coated Silica Fibers

Hollow Waveguides



Let's develop joint fiber photonics solutions!

Thanks to our great partners:
RiverD, MantiSpectra,
OptoPrecision, Nanoplus,
Securus, Uni.Ulm, +++!



Welcome to contact at
Slava@artphotonics.com

www.artphotonics.com