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# 21 Year in Fiber Photonics for Broad Spectral Range 0.3-16µm

# Viacheslav Artyushenko



# **Metal coated Silica and CIR- & PIR-fibres**



# broad spectra fiber solutions

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# **High Power Silica Fiber Cables**





### Free fiber end connectors



| Specification           |   |                           |                           |  |  |
|-------------------------|---|---------------------------|---------------------------|--|--|
| Laser Cable Type        | SMA   | P-SMA                     | P+SMA                     | HP-SMA   | HP-D80   |
| Max Laser Beam Power, W | 5   | 30                        | 150                       | 300  | 900  |
| Connector Type*         | SMA 905   | SMA 905 free<br>fiber end | SMA 905 free<br>fiber end | SMA, free fiber<br>end, epoxy free,<br>long coupling nut | D80 free fiber<br>end, epoxy free,<br>metal radiator |
| Ferrule Material        | ARCAP   | ARCAP                     | ARCAP;<br>Copper-Alloy    | ARCAP;<br>Copper-Alloy                                   | Copper-Alloy   |
| Fiber Centricity, µm    | <6  | <6                        | <6                        | <10  | <10  |
| Fiber Core Material     | Pure fused silica: High OH <sup>-</sup> ( $\lambda$ = 0.25 – 1.2 µm); Low OH <sup>-</sup> ( $\lambda$ = 0.4 – 2.3 µm) |                           |                           |  |  |
| Core Diameter*, µm      | 200, 400, 600, 800 *(opt.: other diameter and core shape)   |                           |                           |  |  |
| Fiber Cladding Material | Fluorine doped fused silica   |                           |                           |  |  |
| Numerical Aperture*     | 0.22 ± 0.02 (Full Acceptance Angle 25°), *(opt.: NA=0.12)   |                           |                           |  |  |







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# **5kW Diode Laser with Ring Fiber Bundle**







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# Fiber Optics Drive Innovation in the Operating Room



Article | November 12, 2018

Source: SCHOTT North America, Inc. - Lighting and Imaging By Nilesh Samant, Sales Manager, SCHOTT North America Inc.



With their unique ability to transmit light and images while remaining flexible, optical fibers have been an enabling technology in the operating room for decades. They are the key technology in endoscopes, which revolutionized medicine by providing surgeons a view into the body that allows them to operate through natural openings or tiny slits in the body, greatly reducing recovery time. Endoscopes also provide critical visual access to internal organs and tissues, allowing doctors to look for cancer and damaged tissue.

# **FDA-approved atherocatheters for PAD**





# B-Laser Hybrid Catheter<sup>™</sup> - 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

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



# **Atherectomy Clinical Results**



# Patient #2 (20 cm CTO)

# Patient#3 (6 cm calcified CTO) Journal of 10/17 BIOPHOTONICS



**Treated vessel** 

After

**Before** 

# Polycrystalline IR-fibers only transmit up to 16µm

- Sweet dream to suppress optical losses in PIR-fibers below the level reached for Silica fibers has failed – as the several additional mechanisms of optical losses contribute too much and limit attenuation at 0.1-0,5 dB/m.
- Advantages of Silver Halide PIR-fibers vs KRS-5 fibers have proved that they are the best in IR-fiber optics to use up to 16µm

### **Transmission Regions of IR Materials**



### Estimation of optical loss minimum

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The crystals with the low intrinsic optical loss level allowing plastic deformation, thallium and silver halides for example (Figure 1), are of particular interest for PC fibers fabrication. The region of the intrinsic optical loss minimum of these crystals is limited by the Mandelstam-Brillouin scattering  $\gamma^{\circ}{}_{MB}$  from the short-wave side and by the multiphonon absorption  $\beta_{mp}$  from the long-wave side. Absorption by free carriers  $\beta_p$  can also play an essential role.

# PIR- & CIR-fibers for 1-18µm





Polycrystalline IR-fibers (PIR-fibers) extruded from AgCI:AgBr crystals with sub-micron structure are the best for 3-17µm. They are non-toxic, non-hygroscopic, and very flexible

# **PIR-Fiber Cables for CO- & CO2-Lasers**



High Power PIR-fiber Cables can deliver power of CO-lasers at 5.2-6.2 $\mu$ m & CO<sub>2</sub>-lasers at 9-11 $\mu$ m. Special design of HP-connectors includes the special SMART-treatment of fiber ends - to suppress Fresnel reflection for >2 times



"New CO Laser Technology offers processing benefits" by Andrew Held, Coherent Inc.
Photonics Spectra, p.34, September 2015







 The most flexible cables for CO- & CO<sub>2</sub>-laser power delivery

 Stable transmission under small bending radius SMART-technology to suppress
 Fresnel reflection losses



# Attenuation Spectra of PIR-fibers vs Hollow Waveguides (from Uni. Rutgers & Polymicro)



FX80 - 🗆 × \_ 8 × Ab POLYMI Meter PolyMicro hollow fiber lnn ID Ab POLYM2 G 8R7 PolyMicro fiber with ~6" radius U bend 3,0000 Hollow Glass Waveguides 2.6587 Silver iodide film **CO-**Silver film 2.3229 laser 1.9927 Glass substrate 1.6569 **Polymer coating** 1.3266 CO2-Hollow Waveguides 0.9908 laser 0.6606 **PIR-fiber** 0.3333-0.0000 2500.00 2275.84 2053.86 1831.88 1609.90 1387.92 1165.94 943.96 721.98 500.00 ASE 5/10  $\odot$ FX> DISP Analyze Collect File I/O Convert Modify User Help Command

# **Transmission of HWG vs PIR-fibers under Bending**



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# Mid IR-Fiber Pyrometry in 3-16µm Range

m







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# **PIR-fiber Endoscopic IR-imaging**



Boston<br/>ScientificThermographic Imaging System to use<br/>during RF-ablation for arrythmia patientsMonitor:Continuous, high-resolution thermal imageProbe:Esophageal infrared thermal mapping catheter



# **PIR-fiber Endoscopic Pyrometry**



# **PIR-Fiber IR-imaging Endoscope** FDA clearance from February 2018



# ATR-fiber probes for FTIR-spectrometers art photonics



# ATR-Probes of different design









# **Cancer Diagnostics with ATR-fiber Coupled FTIR**



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# Label Free 4 Fiber Spectroscopy Methods art photonics





Comparison of all 4 key spectroscopy methods done for the same tissue spots enables to select the best one (or the best combination) for the most sensitive, specific and accurate detection of tumor margins. It'll define design of organ specific spectral fiber sensor – to make it portable, fast, cheap and easy to use.



# **Multi-Spectral Fiber System for Research**



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# **HW-Raman Guided Oral 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







uma

# SurGuide

Improving Surgical Oncology

Product: MarginGuide - device & disposables Worldwide market (oral cancer): 1500 hospitals \* 100 procedures/yr Introduction: 2021 (Europe)

# Do you need unique fiber solution?



# **Think positive!** We Can Do It!



# This presentation was presented at EPIC World Photonics Technology Summit 2019

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