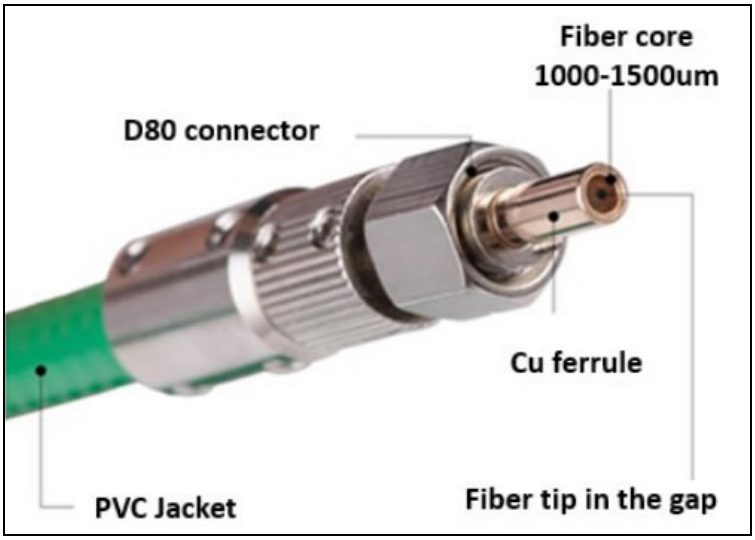
Sintec Optronics

STA Series Fiber Optic Cables for Laser Hair Removal



Recently, laser hair removal, a cosmetic procedure that uses lasers with radiation in the near infrared range (700 - 1063nm), has gained great popularity. The radiation of this range of light is well absorbed by melanin, which results in hair follicle destruction without subsequent restoration.

Today, there are many different types of hair removal lasers in the market. Despite their differences they all share one common feature, fiber optic cable. All hair removal lasers use fiber optic cable to transport the powerful laser beam to the target.

Fiber cables for hair removal, require large core diameter fibers to guide the light from the laser source to the tissue, from 1000 μm to 2000 μm, and high-quality fiber tip polishing is critical for the application. Failure can result in fiber burnt and malfunction of the laser application.

Fiber Cables for Hair Removal (specification)

Cable type	STA-NIR1000-D80	STA-NIR1200-D80	STA-NIR1500-D80
Fiber specifications	Core: 1000um ± 2% primary coating: 1100um ± 2% secondary coating: 1180um ± 3% protective coating: 1400um ± 5%	core: 1200um ± 2% primary coating: 1320um ± 2% secondary coating: 1400um ± 3% protective coating: 1600um ± 5%	core: 1500um ± 2% primary coating: 1650um ± 2% secondary coating: 1840um ± 3% protective coating: 2000um ± 5%
Numerical aperture (NA)	0.22±0.02	0.22±0.02	0.22±0.02
Spectral range	0.4 – 2.4um	0.4 – 2.4um	0.4 – 2.4um
Connectors	D80	D80	D80
Ferrule material	Cu	Cu	Cu
Fiber centratton in the ferrule	<10um	<10um	<10um
Cable length	Up to 5m	Up to 5m	Up to 5m
Protective tubing	PVC metal coated	PVC metal coated	PVC metal coated

There are two very critical elements in the design of a fiber cable for hair removal laser, centricity of the

fiber at the connector ends and fixation of the fiber at the connectors. Uncentered fiber may result in fiber tip damage, burnt, and can also harm the operator or patience. Inadequate fixation of the fiber at the connectors can lead to fiber protrusion or pull inside the connector. As a result, the laser focusing disrupts and the cable fails to perform.

Correct fiber positton:
The end of the fiber is located in the crater of the ferrule.

Incorrect fiber positton:
Fiber protruded of the ferrule

Incorrect fiber positton:
Fiber pulled inside the ferrule

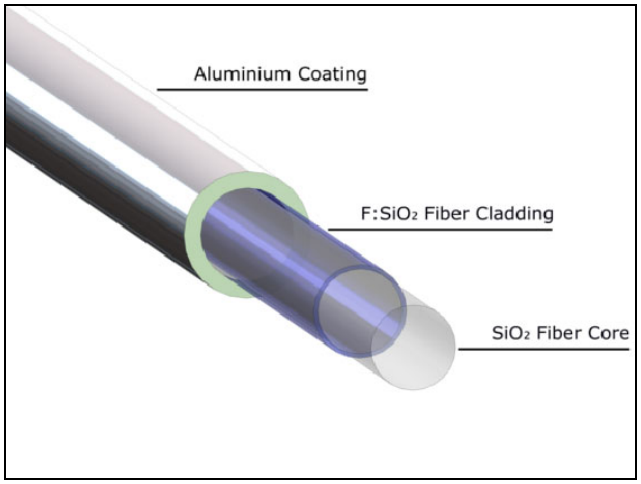
Optical Fibers

1.1 STA Series Al-Coated Silica Fibers

Aluminum coated silica fibers are the optimal solution for applications in high temperature, vacuum and harsh environment conditions.

Al-coated fibers have all benefits of silica-silica fibers. Additional significant advantages include a superior mechanical strength and better fatigue resistance compared to polymer coated fibers.

The transmission range spans 220 to 2400nm depending on UV or NIR silica fiber core choice. The working temperature range is from -270°C to 400°C; humidity – up to 100%.



Main features:

- Working temperatures up to 400°C
- Excellent mechanical strength and flexibility
- No outgassing under high vacuum conditions
- Solderable into connectors (epoxy-free option)
- Effective heat rejection along metal coating
- Steaming, ETO, steam, e-beam or gamma sterilizable

Applications:

- High temperature environment
- Harsh Chemical environment
- Nuclear radiation resistant devices
- Down-hole sensing for oil and gas industry
- High Power Laser delivery
- Medical applications

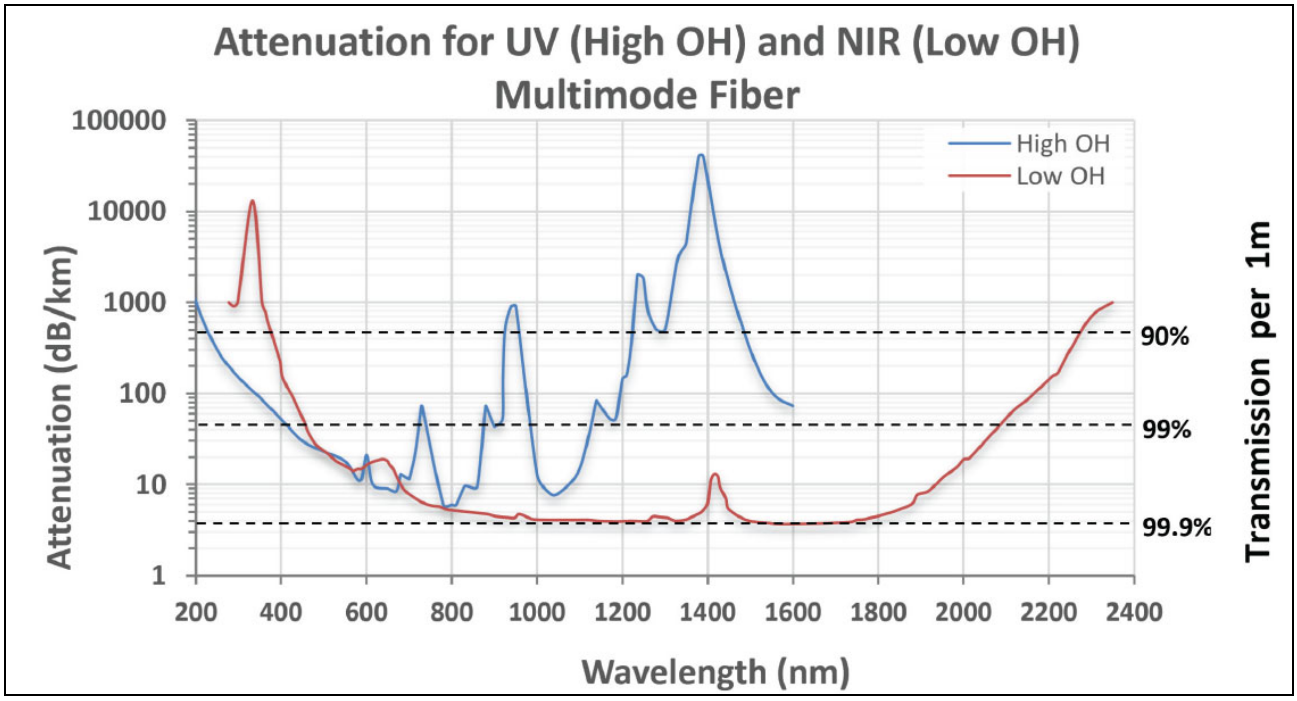
Parameters of Standard Al-coated Fibers

Code	Type	Core, μm	Cladding, μm	Coating Cu, μm	NA
STA-100/110 Al	Step Index Multimode	100 ± 2%	110 ± 2%	145 ± 5%	0.22
STA-200/220 Al	Step Index Multimode	200 ± 2%	220 ± 2%	270 ± 5%	0.22
STA-400/440 Al	Step Index Multimode	400 ± 2%	440 ± 2%	535 ± 5%	0.22
STA-600/660 Al	Step Index Multimode	600 ± 2%	660 ± 2%	745 ± 5%	0.22
STA-50/125 Al	Graded Index Multimode	50 ± 2%	125 ± 2%	165 ± 2%	0.22
STA-9/125 Al	Graded Index Multimode	9 ± 5%	125 ± 5%	165 ± 2%	0.13

Specifications

Core/ Cladding material Step Index	Pure Fused Silica Core / Fluorine Doped Silica Cladding
Graded Index	Germanium Doped Fused Silica Core / Pure Fused Silica
Fiber core diameters, μm	9; 50; 62.5; 100; 200; 400; 600
Al coating thickness, μm	15 – 150 (depending on fiber diameter)
Standard Numerical Aperture (NA)	0.22 ± 0.02

Available Numerical Aperture (NA)	0.12 ± 0.02 / 0.26 ± 0.02
Min operating temperature, °C	-270
Max operating temperature, °C	+400
Humidity Range	Up to 100%
Minimal bending radius (long term)	200 x fiber outer diameter
Minimal bending radius (short term)	100 x fiber outer diameter
Tensile strength (short gauge), GPa	3.5 – 6
Two point bending strength, GPa	>10
Static fatigue parameter	>100

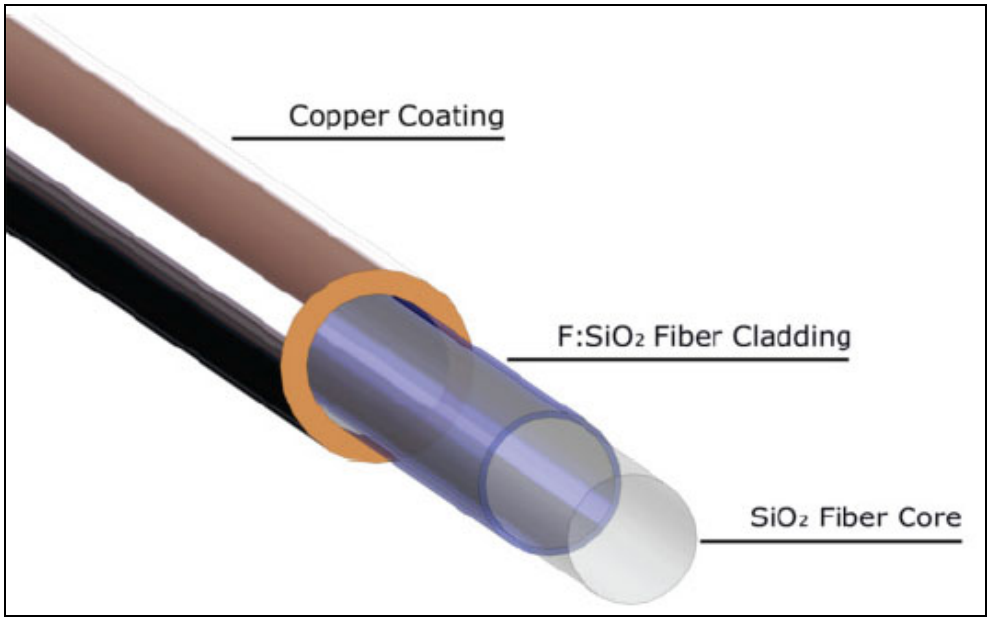


1.2 STA Series Cu-alloy Coated Silica Fibers

Our copper-alloy coated silica fibers are the optimal solution for applications in high temperature, vacuum and harsh environment conditions.

Cu-alloy coated fibers have all benefits of silica-silica fibers. Additional significant advantages include a superior mechanical strength and better fatigue resistance compared to polymer coated fibers.

The transmission range spans 220 to 2400nm depending on UV or NIR silica fiber core choice. The working temperature range is from -270°C to 600°C; humidity – up to 100%.



Main features

- Working temperatures up to 600°C
- Excellent mechanical strength and flexibility
- No outgassing under high vacuum conditions
- Solderable into connectors (epoxy-free option)
- Effective heat rejection along metal coating
- Steaming, ETO, steam, e-beam or gamma sterilizable

Applications

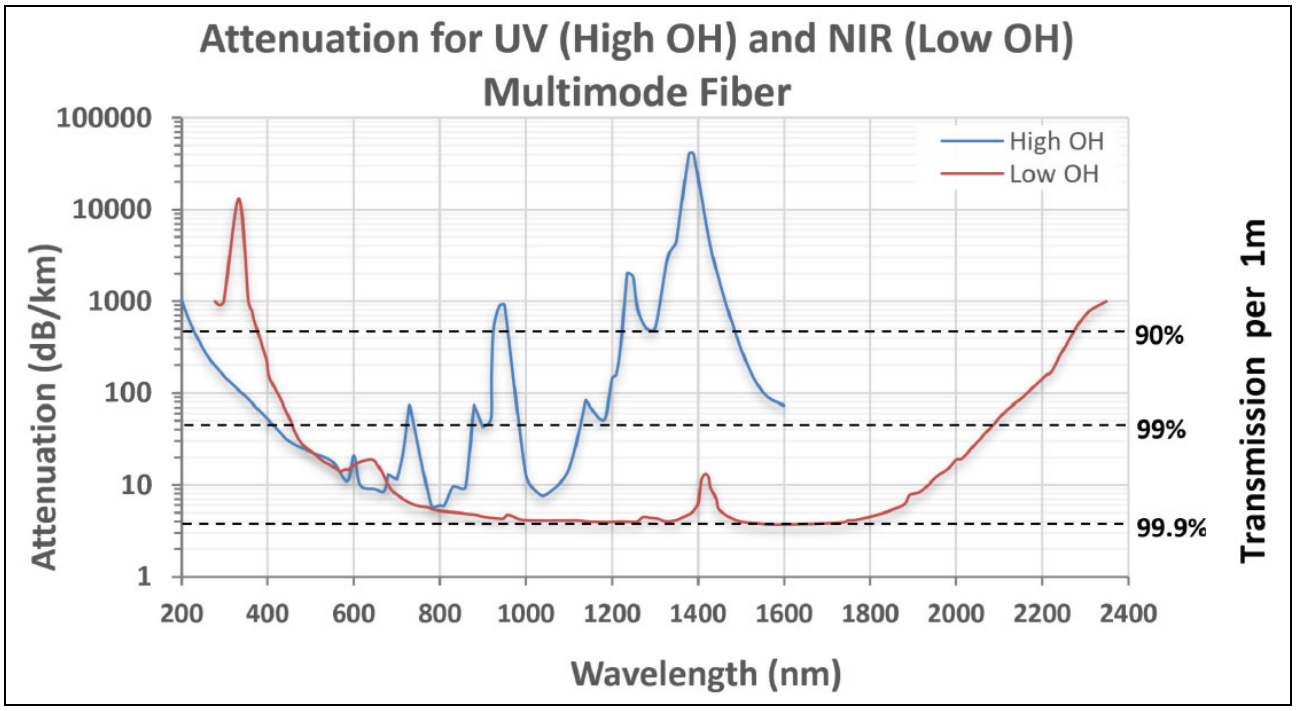
- High temperature environments
- Harsh chemical environments
- Nuclear radiation resistant devices
- Down-hole sensing for oil and gas industry
- High power laser delivery
- Medical applications
- Soldered fiber bundles

Specification of Cu-alloy coated Fibers

Core/ Cladding material Step Index	Pure Fused Silica Core / Fluorine Doped Silica Cladding
Graded Index	Germanium Doped Fused Silica Core / Pure Fused Silica
Fiber core diameters, µm	9; 50; 62.5; 100; 200; 400; 600
Cu-alloy coating thickness, µm	15 – 50 (depending on fiber diameter)
Standard Numerical Aperture (NA)	0.22 ± 0.02
Available Numerical Aperture (NA)	0.12 ± 0.02 / 0.26 ± 0.02
Min operating temperature, °C	-270
Max operating temperature, °C	+600
Humidity Range	Up to 100%
Minimal bending radius (long term)	200 x fiber outer diameter
Minimal bending radius (short term)	100 x fiber outer diameter
Tensile strength (short gauge), GPa	3.5 – 6
Two point bending strength, GPa	>10
Static fatigue parameter	>100

Parameters of Standard Cu-alloy Coated Fibers

Code	Type	Core, µm	Cladding, µm	Coating Cu, µm	NA
100/110 Cu	Step Index Multimode	100 ± 2%	110 ± 2%	145 ± 5%	0.22
200/220 Cu	Step Index Multimode	200 ± 2%	220 ± 2%	270 ± 5%	0.22
400/440 Cu	Step Index Multimode	400 ± 2%	440 ± 2%	535 ± 5%	0.22
600/660 Cu	Step Index Multimode	600 ± 2%	660 ± 2%	745 ± 5%	0.22
50/125 Cu	Graded Index Multimode	50 ± 2%	125 ± 2%	165 ± 2%	0.22
9/125 Cu	Graded Index Multimode	9 ± 5%	235 ± 5%	165 ± 2%	0.13

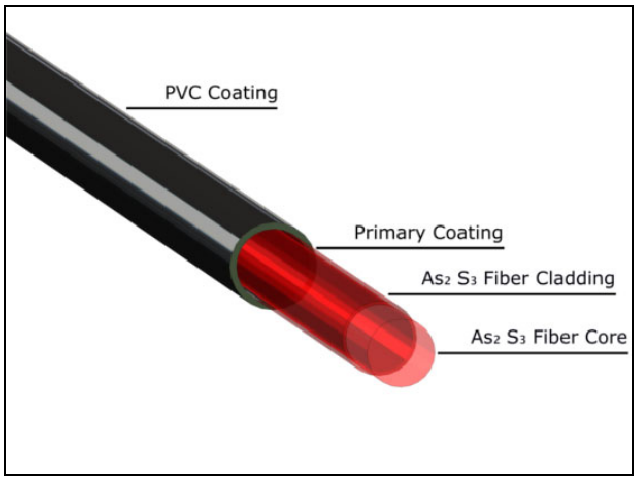


1.3 STA Series Chalcogenide IR-Glass Fiber (CIR Fiber)

Chalcogenide As-S glass fiber transmits IR-radiation in the spectral range of 1.1–6.5µm. High performance CIR core/clad fiber are drawn with core diameters span from 8µm to 500µm.

Advanced drawing process with double polymer jacket provides a superior mechanical strength and high flexibility of CIR- fibers.

Low optical losses and small absorption peaks over the mentioned spectral range ensure a successful use of CIR-fiber for a wide range of applications.



Features

- High transmittance in the range 1.1 – 6.5µm
- Low optical losses of about 0.2 – 0.3 dB/m at 2.5 – 4µm and 4.5 – 5µm
- Core/Clad structure with core diameters span from 8 to 500µm
- Double polymer coating for high flexibility

Applications

- Mid IR spectroscopy
- Flexible IR pyrometry
- Flexible IR-imaging Systems
- Power delivery for quantum cascade lasers

Fiber specification

Transmission Range	1.5 - 6μm
Core/Clad Structure	As2S3/As-S
Core/Clad Diameter	200-500/300-600μm
Core Refractive Index	2.4
Effective NA	0.28
Protective Coating	Double Polymer Jacket
Ambient Temperature Range	270 - 370 K

CIR Infrared Optical Fiber Standard Cables

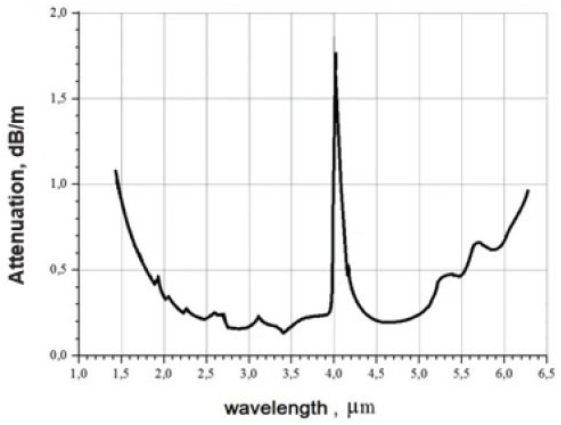
Chalcogenide Infra Red (CIR) (1.5 - 6μm) fiber is drawn in core/clad structure with double polymer coating and characterized by a low optical losses and high flexibility. Delivery is from stock or within few weeks ARO. All standard cables include PEEK-polymer protective jacket and SMA termination.

Parameters of standard Chalcogenide fibers

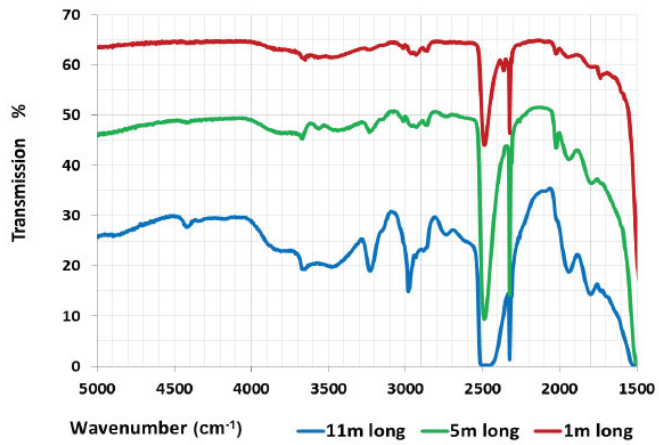
Part Number	STA-CIR8/300	STA-CIR 50/250	STA-CIR 250/300	STA-CIR 340/400	STA-CIR 500/550
Type	Step Index Single-mode	Step Index Few-mode	Step Index Multimode	Step Index Multimode	Step Index Multimode
Core Dia., μm	8±1	50±3	250±10	340±10	500±10
Cladding Dia., μm	300±15	250±10	300±15	400±15	550±15
Protective Jacket Dia., μm	400±20	410 ± 20	400 ±30	510 ± 30	700 ± 30
NA	0.25 ± 0.02	0.13 ± 0.02	0.30 ± 0.03	0.30 ± 0.03	0.30 ± 0.03
Min Bending Radius, mm	60	50	60	80	100

Specifications

Core/cladding composition	As_2S_3
Spectral Range	1.1 – 6.5μm
Core Refractive Index	2.42
Fresnel Reflection Losses	31%
Attenuation at 3 – 4μm & 4.5μm – 5μm	0.2 – 0.4dB/m
Effective Numerical Aperture NA	see Parameters of standard Chalcogenide fibers
Glass Transition Temperature, Tg	185 °C
Operating Temperature	–273°C to +90°C
Core/Clad Diameter (standard)	see Parameters of standard Chalcogenide fibers
Protective Jacket	Fluoro polymer + PVC
Tensile Strength	>70 MPa
Minimum Bending Radius (fixed)	100x [Fiber Diameter]
Minimum Elastic Bending Radius	200x [Fiber Diameter]



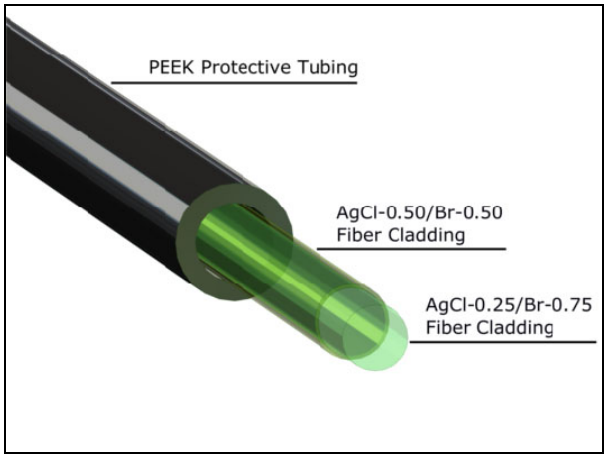
Attenuation vs wavelength in CIR-fibers



Transmission vs Wavenumber in As-S CIR fiber of different length

1.4 STA Series Polycrystalline Infra Red Fibers (PIR – Fibers)

The development of specialty fibers for the Mid-Infrared region has resulted in a unique product - Core / Clad Polycrystalline Infra-Red (PIR-) fibers. The PIR-fibers are non-toxic, very flexible, transparent across a broad spectral region 4 -18µm and capable of operating over the wide temperature range of 4K up to 420K. They are manufactured in a core/clad structure of superior quality from pure AgCl: AgBr solid solution crystals using an innovative vacuum extrusion method. They possess by no aging effect compared to an alternative bare core fiber. The range of PIR-fiber cables are available with a durable PEEK polymer jacket and terminations using either an SMA - type connector with a Ti or polymer ferrule or special one, manufactured on customer request. A wide variety of different optical coupling units can also be designed & fabricated for specialized customer requirements.



Fiber Features:

- High transmittance in the range 3 – 18µm
- Low optical losses of about 0.2 – 0.3 dB/m in the range 9 – 13µm
- Core/Clad structure with core diameters span from 240 to 860µm
- Minimal aging effect
- Non-hydroscopic and non-toxic

Applications

- Mid IR spectroscopy
- Flexible IR pyrometry
- Flexible IR-Imaging systems
- Power delivery for quantum cascade Lasers
- Power delivery for CO and CO2 Lasers

Parameters of Standard Polycrystalline fibers

Part Number	STA-PIR240/300	STA-PIR400/500	STA-PIR600/700	STA-PIR900/1000
Type	Step Index Multimode	Step Index Multimode	Step Index Multimode	Step Index Multimode
Core Dia., µm	240±10	400±10	600±10	860±20
Cladding Dia., µm	300+0/-10	500+0/-15	700+0/-15	1000+0/-20
Protective Jacket Dia., µm	no	no	no	no
NA	0.35±0.05	0.35±0.05	0.35±0.05	0.35±0.05
Min. bending Radius, mm	45	75	100	150

Specifications

Core/cladding composition	AgCl:AgBr
Spectral Range	3 – 18µm
Core Refractive Index	2.15
Fresnel Reflection Losses	25%
Attenuation at 10.6 µm	0.2 – 0.4dB/m
Effective Numerical Aperture NA	0.35 +/- 0.05
Melting Point	410 °C
Operating Temperature	–273 to +140°C
Core/Clad Diameter (standard)	see Parameters of standard Polycrystalline fibers

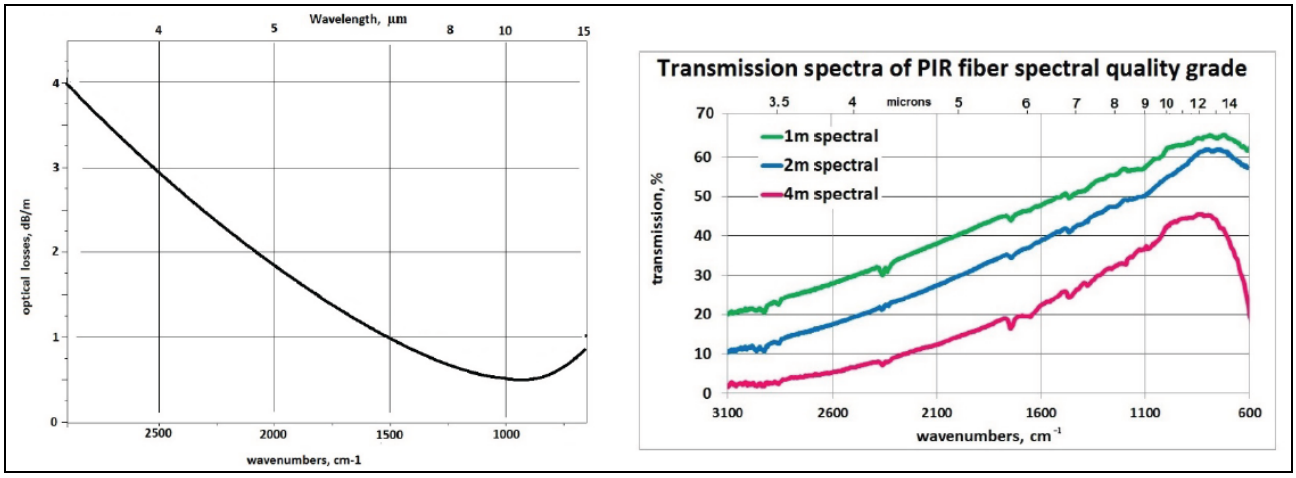
Laser Damage Threshold for CW CO2 laser	>12kW/cm²
Tensile Strength	> 70MPa
Minimum Bending Radius (fixed)	5 x [Fiber Diameter]
Minimum Elastic Bending Radius	150 x [Fiber Diameter]

PIR-fibers are protected by a loose PEEK-jacket (PolyEtherEtherKetone) to provide stiff, flexible and hermetic protection against mechanical, photoinduced and chemical damage over a wide temperature range up to 250°C.

Standard Cable termination with a special Ti-ferrule SMA-connector:
• for low power (spectroscopy & radiometry) applications;
• for high laser power delivery - free standing fiber end ;
• standard cable length - 1m & 2m.

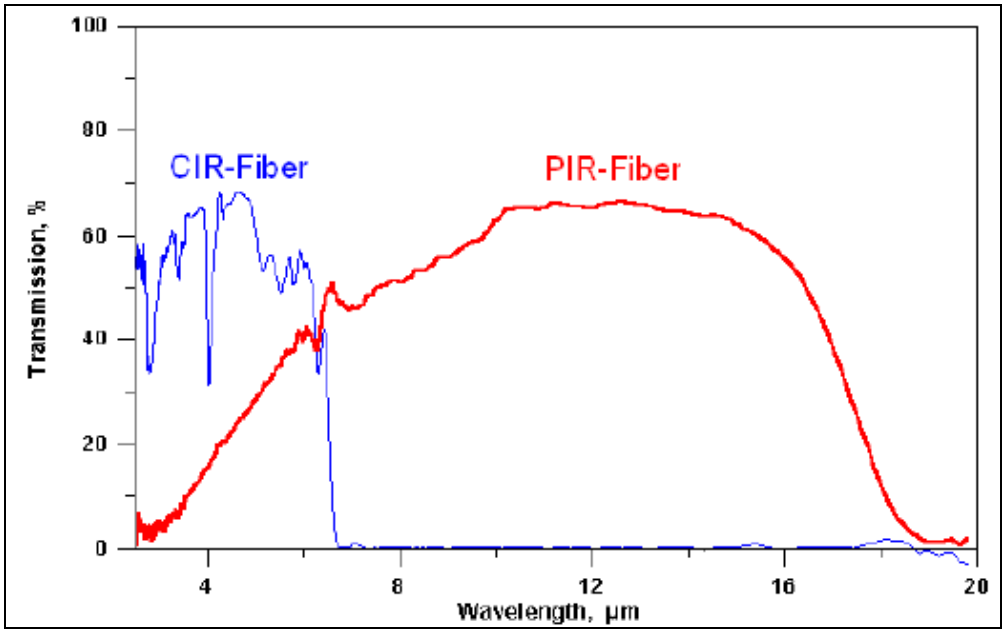
PIR-fiber end-surface treatment:
• Cutting low cost, high performance - standard;
• Polishing for special application, including AR-coating - on request;
• SMART for reduced reflection of high CO2-laser intensity - on request.

Options
• accessory kits for remote spectroscopy with FTIR, QCL and TDL-spectrometers;
• pig-tailing of IR-detectors: TE- & LN-cooled MCT, PbSe, thermopiles, etc.



1.5 Comparison of CIR- and PIR-Fibers

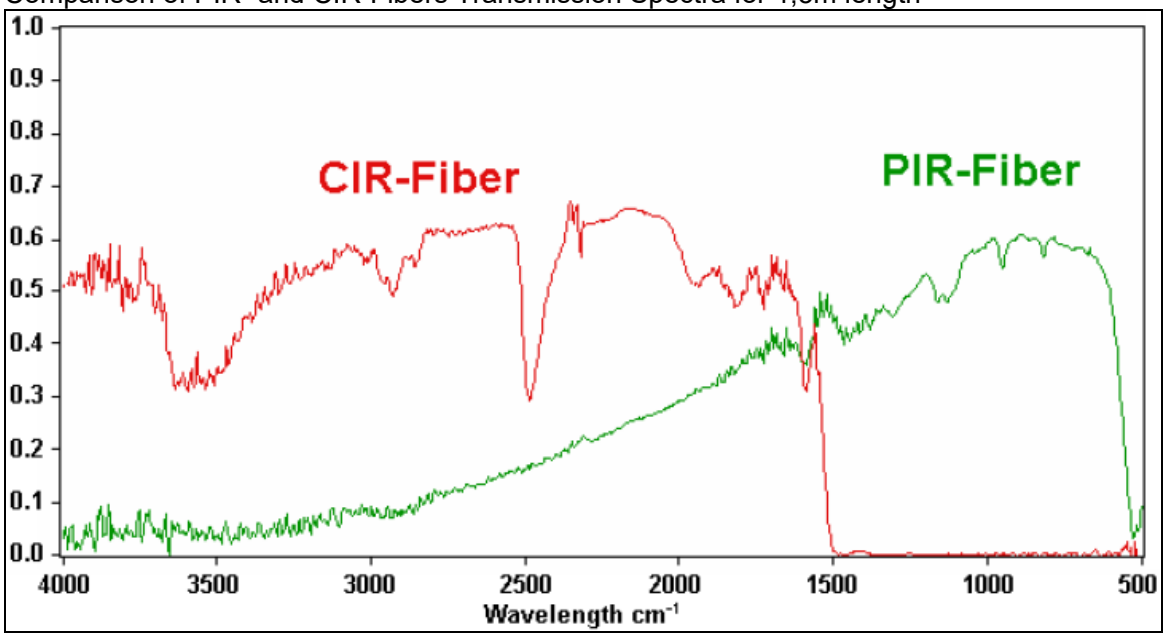
Typical transmission spectra of 1.5m long PIR-900/1000 fiber (red) versus CIR-750/850 fiber (blue) (includes reflection & coupling losses at fiber ends without AR coating and some absorption bands of atmospheric moisture, etc.)



Typical Specification of CIR- and PIR-fibers

No.	Parameter	CIR-Fiber	PIR-Fiber
1	Transmission range	1.5 to 6µm or 1600- 6500cm^{-1}	3 to 18µm or 550 - 3300cm^{-1}
2.	Core/Clad structure materials	Chalcogenide As-S glasses	AgCl:AgBr solid solution crystals
3.	Specific Features	Toxic & Fragile, Non-hygroscopic	Non-toxic, Non-hygroscopic, very flexible, slightly UV-sensitive
4.	Core/Clad diameter	200-500/300-600µm	400/500, 630/700, 700x700, 900/1000µm
5.	Core refractive index	2,4	2,2
6.	Effective NA	0,28	0,25
7.	Optical losses	Minimum of 0,2dB/m at wavelengths 2-4µm	Minimum of 0,2-0,3dB/m at wavelengths 10-12µm
8.	Operation temperature	From 270 to 370K	From 4 to 420K
9.	Max length of cable	Up to 50-100 meters	Up to 20-40 meters

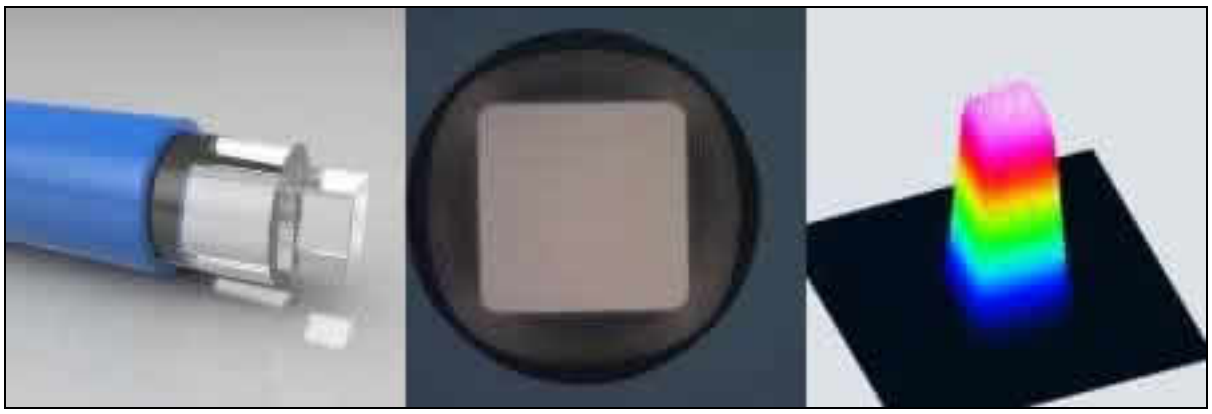
Comparison of PIR- and CIR-Fibers Transmission Spectra for 1,5m length



1.6 Square Core Fibers

Square core fibers excel in specific applications where traditional circular core fibers with Gaussian outputs are not ideal. The uniform “top hat” intensity profile these fibers provide are the desired output profile when performing tasks such as welding, photolithography, and spectroscopy. Square core fibers

with round claddings are also excellent candidates for use in the laser diode industry, where the square shape enables a more ideal coupling match with the diode source. We offer pure silica square core fibers with a fluorine doped cladding (0.22 NA) in a wide range of core diameters from 100 µm to 1000 µm.



Applications

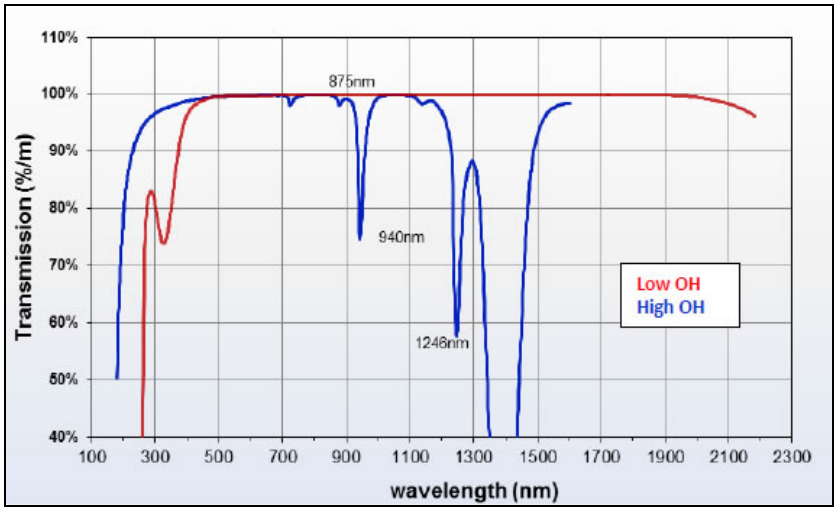
- Laser materials processing
- Astronomical spectroscopy
- Non-circular diode beam coupling
- Photolithography

Features

- Homogenized output distribution
- Top hat beam profile
- Greater capture area than round fibers for square inputs
- Broad application wavelengths: 190nm to 1250nm (High OH) and 300nm to 2400nm (Low OH)
- Various jacketing options: Acrylate, Nylon or Polyimide

Numerical Aperture	0.22 ±0.02
Core Sizes (Flat to Flat)	100 µm to 1000 µm
Typical Clad/Core Ratio (RD clad)	1.2 (diagonal to Clad OD)
Dimensional Tolerances -Core/ Clad/ Jacket -Corner Rounding in Core (R/L)	 ±2%/ ±2%/ ±5% ≤ 25%
Jacketing Options & Temp Range: -Acrylate -Nylon -Polyimide	 -40°C to +85 °C -40°C to +100 °C -190°C to +350°C
Proof Test Level (4 axis bend) -Acrylate/ Nylon -Polyimide	 100 kpsi 50 kpsi
Anti-Reflective Coating Option	Standard thin film coatings or RARe Motheye Nanosurfacing available upon request

Fiber Series	Core	Clad	OH Content
STASQR	Square	Round	Low
STSSQR	Square	Round	High


110%
100%
90%
80%
70%
60%
50%
40%
Transmission (%/m)
875nm
940nm
1246nm
Low OH
High OH
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
wavelength (nm)

2. Optical Fiber Cables

We offer high-performance, high-quality specialty optical fiber cables covering broad band spectral range, from UV (220nm) to Mid Infrared (18μm), for applications that include industrial manufacturing, military, environmental sensing, and space applications. In addition to the range of standard products, our fiber optic cables can be customized to meet the needs of the research & development environment, where the novel coupling and mixed bundles are often required.

UV/VIS/NIR (220 – 2500nm): Silica fiber cables, with a range of diameters and NAs are available with a variety of polymer and metal coatings. Innovative high power connectors can be selected for laser power delivery from diode laser modules and high power industrial lasers.

CIR (1.5 – 6.0μm): In the mid infrared, our chalcogenide infrared (CIR) fiber cables have optical transmission to match the output from LEDs and solid state infrared lasers including Quantum Cascade types.

PIR (4.0 – 18.0μm): In the mid infrared, our silver halide polycrystalline infrared (PIR) fiber cables are suitable for coupling to black body sources, LEDs, CO_2 lasers and solid state infrared lasers including quantum cascade types.

2.1 STA Series Laser Fiber Cables UV-VIS-NIR (High Power Silica Fiber Cables)

Our optic laser cables are the best for laser power delivery with high brightness and beam quality. Robust design of our laser cables secures long term use for industrial and medical applications.

Our specialty is to provide high temperature assemblies (up to 600°C) for high power and/or vacuum applications by using metal-coated silica fibers. Bundles of metal-coated fibers are able to combine power from many laser modules to reach output in multi kW power range.

Our manufacturing technologies assure precise fiber position inside the connector ferrule and a perfect surface quality of the fiber end. Our quality control procedures and special equipment such as digital fiber microscope, infrared vision camera, power meter, beam profiler and 100W diode laser are used to test each cable before shipment to the customer.

Main Features:

- Special laser fiber structures
- Cool high power connectors HP-SMA and D80
- Flexible and robust for high power & bright laser beams

Applications:

- Laser welding of metals & plastics
- Laser cutting & drilling
- Rapid surface processing
- Medical laser power delivery
- Laser target & rangefinder
- Laser spectroscopy

Spectral ranges	0.18–1.2μm (UV-VIS) or 0.35–2.4μm (VIS-NIR)
Pure silica fiber core diameter	100, 200, 300, 400, 600, 800, 1000, 1200, 1500μm
Numerical aperture	0.22 ± 0.02 (Full acceptance angle 25°) 0.12 ± 0.02 (Full acceptance angle 14°)
Protective fiber jacket	Nylon, Tefzel, Acrylate, Al, Cu
Cable protective tube	PVC coated stainless steel monocoil, bend protected silicon coated stainless steel bend protection
Connector type	HP-SMA (High Power SMA); D-80
Temperature range	-40°C to +600°C (Cu coated)
Cable length	1.5 & 3m (optional: from 5cm to 50m)

MCS-fibers in bundle	3, 7, 19, 37, 64

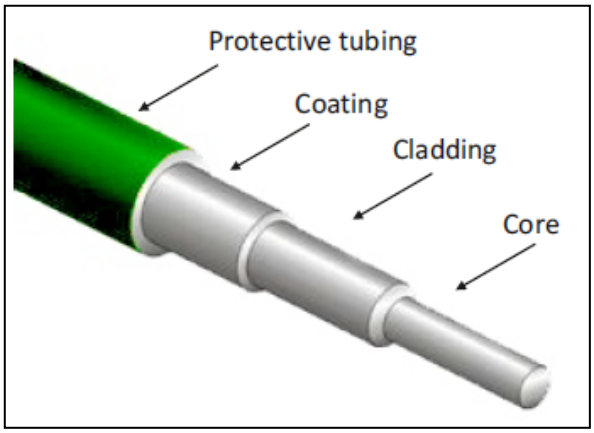
*customized dimensions available on request

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 fiber end	SMA 905 free fiber end	SMA, free fiber end, epoxy free, long coupling nut	D80 free fiber end, epoxy free, metal radiator
Ferrule Material	ARCAP	ARCAP	ARCAP; Copper-Alloy	ARCAP; Copper-Alloy	Copper-Alloy
Fiber Centricity, µm	<6	<6	<6	<10	<10
Protective Tubing*	Simplex	Polymer coated metal protection tube (optional PEEK)			
Protective Tubing OD*, mm	3.0 or 3.2	5.3; 6.4	5.3; 6.4	6.4	8.9
Fiber Core Material	Pure fused silica: High OH^- (λ= 0.25 – 1.2 µm); Low OH^- (λ= 0.4 – 2.3 µm)				
Core Diameter*, µm	200, 400, 600, 800 (optional: other diameter and core shape)				
Fiber Cladding Material	Fluorine doped fused silica				
Numerical Aperture*	0.22 ± 0.02 (Full Acceptance Angle 25°), (optional: NA= 0.12 ± 0.02)				
Fiber Cable Length*, m	1.5, 3.0, 5.0 (optional: from 5cm to 200m)				

* Others available on request.

Anatomy of an Assembly

For assembling Optical Cables the multimode fibers with core from pure fused silica and the cladding from fluoride doped silica are used. A buffer material is then applied. A buffer coats the core and cladding, strengthens the fiber. In most assemblies polyimide is used as the buffer; other assemblies use aluminum or acrylate. Then protective tubing is applied over the core, cladding and buffer to protect the fiber and provide strain relief. The standard jacketing is stainless steel silicone monocoil. Precision optical Connectors terminate the cable and are precisely aligned to ensure concentricity of the fiber. Finally, end caps protect the fiber tips against scratches and contaminants.



Choosing the Right Fiber Cable for Laser Power Delivery

The most critical issue in building laser power delivery system is choosing the right optical fiber cable. Three main parameters are important to make right selection:

1. Fiber type & core diameter
2. Coating and protective tube
3. Connector

One important consideration in ordering an optical fiber assembly is which fiber type you should specify for your application. Typically, the wavelength range needed for your application should match the wavelength range of the fiber type.

Low OH^- and High OH^- Optical Fiber: The optical attenuation characteristics are quite different for high OH^- and low OH^- optical fiber core material. For UV-VIS spectral range (λ = 0,18 - 1,2 µm) silica-silica fibers with High OH^- content should be used and for VIS-NIR range (λ =0,35 -2,5 µm) – silica-silica fibers with Low OH^- group concentration are more convenient.

The next significant parameter is the fiber core diameter. Smaller fiber cores are preferred in order to get the best beam quality and high flexibility. However optical fiber cables have several restrictions in their power transmitting capabilities, and there are important limitations to selecting the appropriate (smallest) fiber size. The laser itself imposes constraints on the smallest fiber that can be used.

Choosing Connectors

Selecting the right connector for your needs can be complicated by the many choices available today. Choosing the best fiber optic connector for any installation will have an impact on how efficient and cost-effective the job is completed.

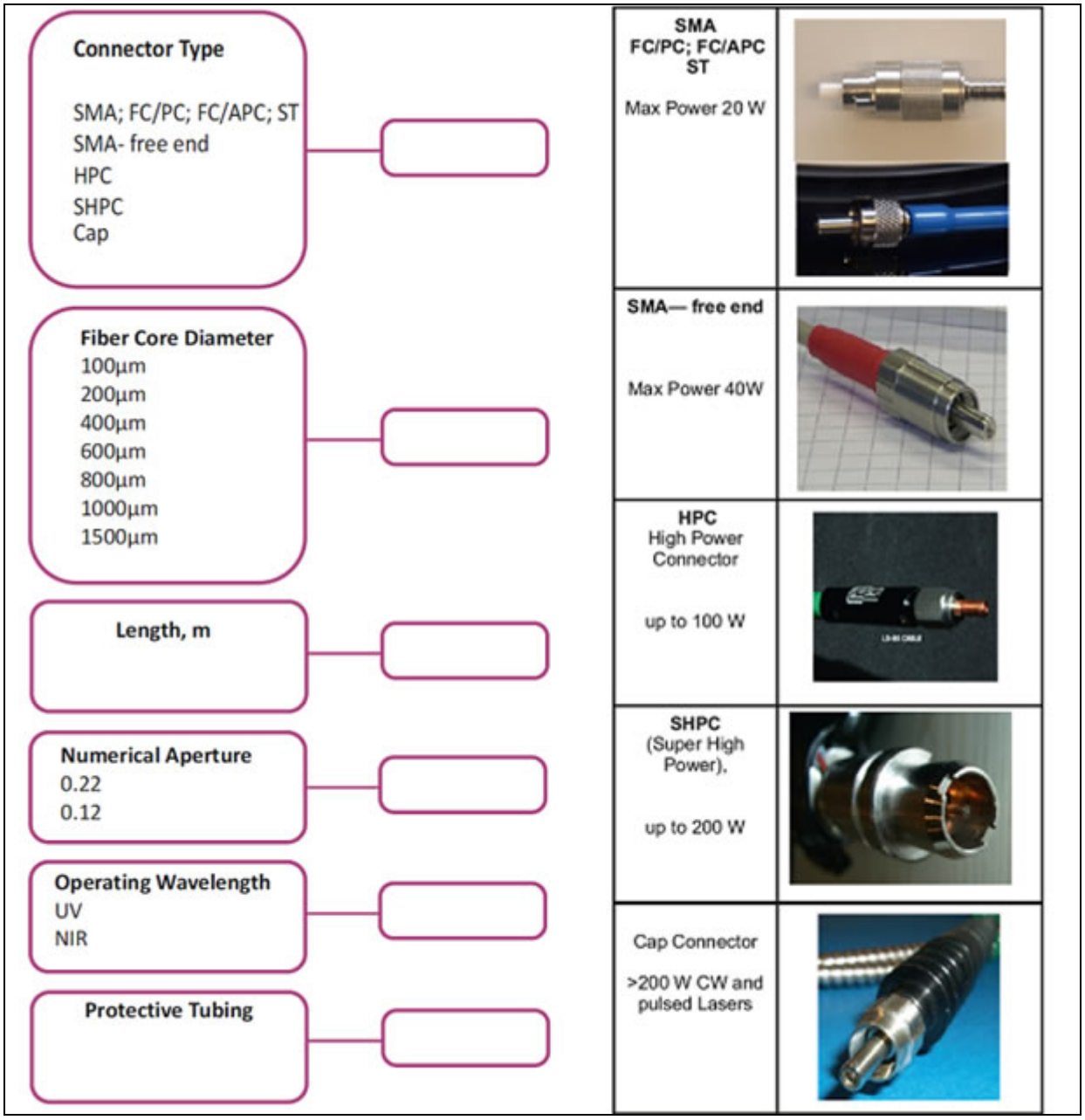
In today's laser power fiber delivery system, there are various optical fiber connector types: SMA, ST, FC/PC, FC/APC, DL80, D-200 connectors, cap-customized. Bespoken Mitsubishi connector design may include ferrule protection by sapphire ring to prevent metal evaporation by intensive laser beam.

High power connectors feature an air-gap design, where the fiber extends into free space between 1.1mm to 1.5mm, providing an epoxy-free region where thermal energy can be safely dissipated without burning the surrounding material. This is the key mechanism for failure in standard connectors.

In addition we utilize a number of unique methods of polishing fiber tip or fusing a glass end cap to the end of the fiber (cap connector) to maximize power handling.

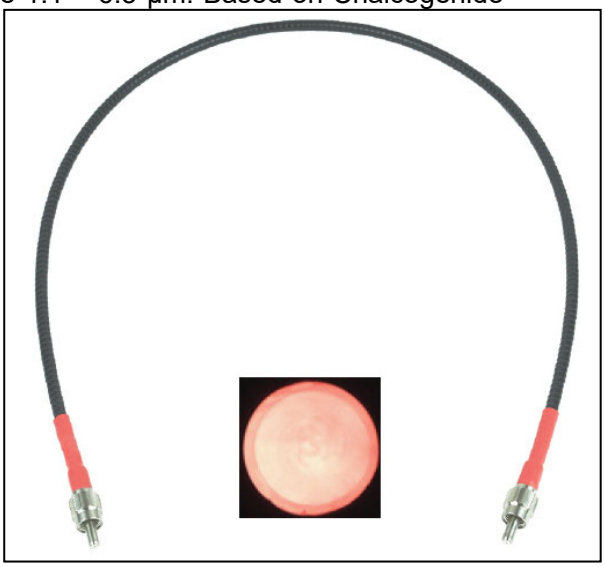
High power connectors compatible with SMA 905 and FC receptacles are offered.

Finally, each cable assembly goes through the tight quality control with several examinations during the fabrication process, including extensive inspection of fiber tip quality by fiber check technique. Data will help alleviate the confusion by reviewing the basic considerations prior to deciding on the best connector for an installation.



2.2 Chalcogenide IR-fiber Cables

We offer excellent fiber cables for a mid-Infrared spectral range 1.1 – 6.5 µm. Based on Chalcogenide Infra-Red (CIR-) fibers, the fiber cables are used in a wide range of applications including power delivery of QCL, spectroscopy, flexible IR-imaging systems, etc. CIR- fiber cables are available with a variety of standard fiber diameters, SMA-905, FC/PC, FC/APC connectors, and several types of protective tubing. Our manufacturing technologies assure precise fiber position inside the connector ferrule and a perfect surface quality of the fiber end. Before shipping, each fiber cable passes through detailed Quality Control procedure.



Main features:

- High transmittance in 1.1 – 6.5µm range
- Low optical losses 0.2–0.3dB/m at 2.5–4 µm and 4.5–5 µm
- Core/Clad structure with core diameters span from 8 to 500µm
- Temperature range -50°C + 90°C

Applications:
- Mid-IR spectroscopy
- Flexible IR-imaging systems
- Flexible IR pyrometry
- Power delivery for quantum cascade lasers

Optical fiber type	Chalcogenide step index multimode
Wavelengths range	1.1 – 6.5 µm
Fiber core/cladding sizes (µm)	see parameters of standard chalcogenide fibers
Effective numerical aperture (NA)	see parameters of standard chalcogenide fibers
Minimum bending radius depending on protective sheathing	PEEK tubing – 130mm metal PVC coated tubing – 80mm stainless steel tubing – 80mm stainless steel silicone-coated tubing – 130mm
Connectors	SMA-905; FC/PC or FC/APC
Temperature range	-50°C to + 90°C

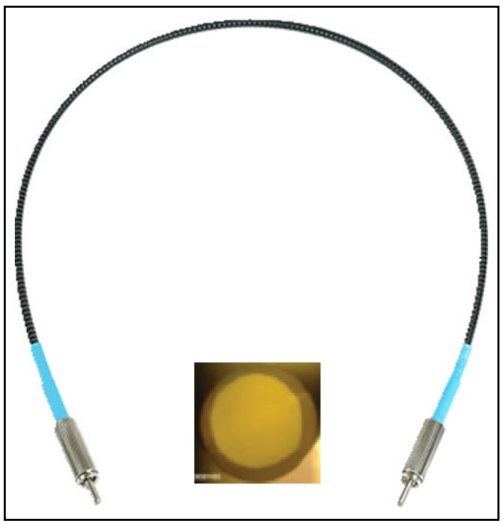
Parameters of Standard Chalcogenide Fibers

Part number	Type	Core, µm	Cladding, µm	Protective jacket, µm	NA	Min bending radius, mm
STA-CIR8/300	Step index single mode	8±1	300±15	400±20	0.25±0.02	60
STA-CIR50/250	Step index few mode	50±3	250±10	410±20	0.13±0.02	50
STA-CIR250/300	Step index multimode	250±10	300±15	400±30	0.30±0.03	60
STA-CIR340/400	Step index multimode	340±10	400±15	510±30	0.30±0.03	80
STA-CIR500/550	Step index multimode	500±10	550±15	700±30	0.30±0.03	100

2.3. Polycrystalline IR-fiber Cables

We offer excellent fiber cables for a broad Mid-Infrared spectral range 3–17µm. Based on Polycrystalline Infra-Red (PIR-) fibers, our fiber cables are used in a wide range of applications including Mid-IR light delivery, spectroscopy, remote temperature sensing, etc. PIR-fiber cables are available with a variety of standard fiber diameters, with different connectors (SMA-905, FC/PC, and FC/APC), and several types of protective sheathing. Our manufacturing technologies assure precise fiber position inside the connector ferrule and a perfect surface quality of the fiber end. Before shipping, each fiber cable passes through the detailed quality control procedure.

Main features:
- High transmittance in the range 3–18µm
- Low optical losses 0.2–0.3dB/m at 9–13µm
- Core/Clad structure with core diameters span from 240 to 860µm
- Minimal aging effect
- Non-hydroscopic and non-toxic
- Contact us for customized -50°C to 140°C option or vacuum proof option



Applications:
- Mid-IR spectroscopy
- Power delivery for quantum cascade lasers
- Power delivery for CO- and CO2-Lasers
- Flexible IR-imaging systems
- Flexible IR pyrometry

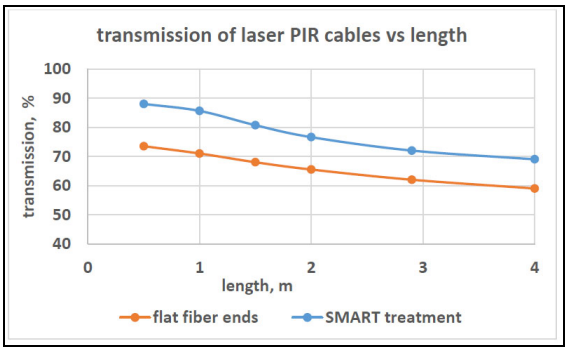
Optical fiber type	Polycrystalline step index multimode
Wavelengths range	3 - 17 m
Fiber core/cladding sizes (m)	see standard fiber parameters on the second page
Effective Numerical Aperture (NA)	0.30 +/- 0.05
Minimum bending radius depending on protective sheathing	PEEK tubing – 130mm metal PVC coated tubing – 80mm stainless steel tubing – 80mm stainless steel silicone coated tubing – 130mm

Connectors	SMA-905, FC-PC or FC-APC with titanium ferrule
Temperature range	-50°C to + 80°C

Part number	Type	Core, μm	Cladding, μm	Protective jacket, μm	NA	Min bending radius, mm
STA-PIR240/300	Step index few modes	240±10	300+0/-10	no	0.35±0.05	45
STA-PIR400/500	Step index multimode	400±10	500+0/-15	no	0.35±0.05	75
STA-PIR600/700	Step index multimode	600±15	700+0/-15	no	0.35±0.05	100
STA-PIR900/1000	Step index multimode	860±20	1000+0/-20	no	0.35±0.05	150

2.3 Flexible Fiber Power Delivery for CO_2 Laser

We offer high power fiber cables for flexible delivery of CO_2 aser radiation. Polycrystalline Infra-Red (PIR-) fiber cables provide stable power transmittance under the bending that is an important advantage as compared to hollow waveguides. Special SMART treatment of PIR-fiber ends suppresses Fresnel reflection to increase output power by 10-12%.



Main features:

- The most flexible cables for CO_2 laser power delivery
- Stable transmission under the bending
- SMART-technology to suppress Fresnel reflection losses
- Transmitted power up to 40W

Applications:

- Medical CO2 lasers
- Laser cut and laser treatment

Optical fiber type	Polycrystalline step index multimode
Wavelengths range	optimised for 9.2 μm and 10.6 μm
Fiber core/cladding sizes (μm)	see table below
Effective numerical aperture (NA)	0.10 - 0.20 depending of the cable length
Minimum bending radius depending on protective sheathing	- PEEK tubing 130mm - metal PVC coated tubing 80mm - stainless steel tubing 80mm - stainless steel silicone coated tubing 130mm
Connectors	- SMA-905 with titanium ferrule and free standing fiber end
Temperature range	-50°C to + 80°C
Length	≤ 5m

Customized design on request.

Standard Fiber Core/clad Diameters and Power Threshold

	Type	Core dia, um	Cladding dia, um	Coating	CO2 laser power threshold, W	Min elastic bending radius, mm
STA-PIR 400/500	Step index multimode	400±10	400+0/-15	no	10	70
STA-PIR 600/700	Step index multimode	600±15	700+0/-15	no	20	100
STA-PIR 900/1000	Step index multimode	860±20	1000+0/-20	no	35	130

2.4 STHPFC-9— Power Fiber Cables for Diode Lasers

Our Power Fiber Cables (PFC) with PC-SMA905 connector exploit the air-gap-ferrule design, where the fiber prolongs into free space securing an epoxy-free area, where thermal energy can be safely dissipated without burning the surrounding material, making them ideal for high-power applications.

A heat-sink is attached to the rear of the connector, which conducts extraneous heat away from the fiber, further reducing the possibility of breakdown.

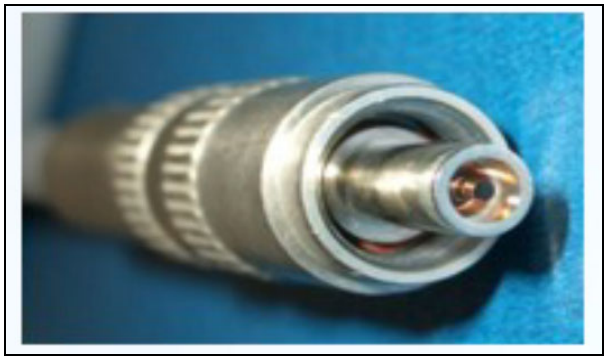
Each cable assembly goes through the tight Quality Control with several examinations during the fabrication process, including extensive inspection of fiber tip quality by FiberCheck® technique, leading , as a result, to a special product.

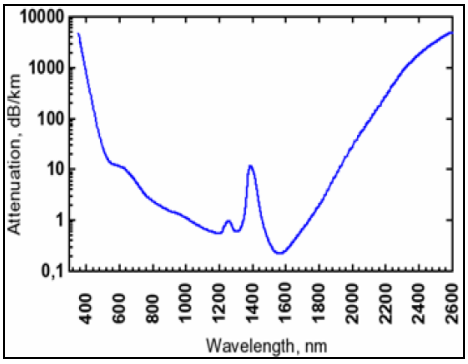
VIS-NIR—Low OH Fiber:

- Operating Wavelength Range: 350-2500 nm
- Damage Threshold: >5J/mm² (1ms pulse at 1060 nm, & > 1.3 kJ/mm² CW at 1060 nm)
- PC-SMA 905 connector
- Anodized aluminum heat sink
- Air-Gap-Ferrule Epoxy Free

STHPFC-9 General Specifications

Core	Pure fused silica (low OH-)
Core diameter (μm)	9
Cladding	Fluorine doped fused silica
Cladding diameter (μm)	135
Coating	Polyimide coating (-190°C to 385: C)
Protective tube	Silicon coated Stainless Steel
Numerical aperture	0.22
Fibre connector	PC-SMA905
Length	3 m
Max. laser power (W)	1 W
Short term bending radius (cm)	3.6
Long term bending radius (cm)	14.4





3. Optical/Laser Fiber Bundles

Special laser fiber structures
Cool high power connectors HP-SMA and D80
Flexible and robust for high power & bright laser beams

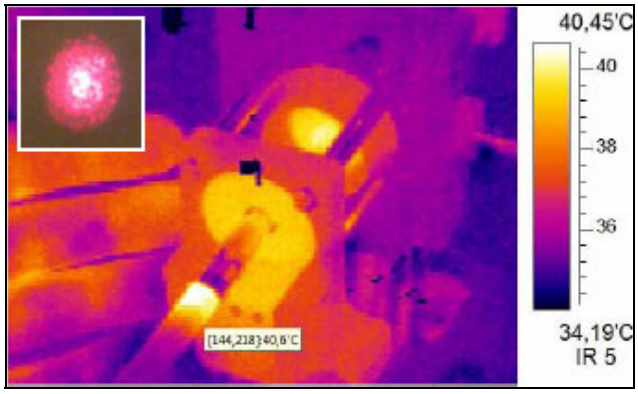
Our laser bundle products are the best for laser power delivery with high brightness and beam quality, while high power connectors of special design stay cool even when mode-stripping effect is provided.

Robust designed laser cables secure the long term industrial & medical applications. Bundles of unique metal coated fibers combines power from many lasers to reach output in multi kW range in any shape.

Applications:

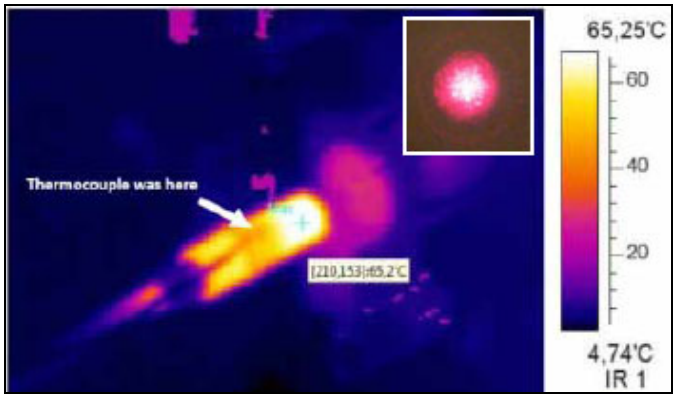
- Laser welding of metals & plastics
- Laser cutting & drilling
- Laser surface treatment
- Medical laser power delivery
- Laser target & rangefinder
- Laser spectroscopy

Comparison of Our Cables with a Common Laser Cable



IR-image of our fiber cable with special silica fiber structure & HP connector design without mode stripper & radiator

- Fiber core - 200µm; NA=0.22
- Connector – HP-SMA (High Power SMA)
- High transmission of fiber cable with 1.5m length provides 53W output of Diode Laser at λ = 1.47µm
- Temperature of connectors measured with thermopile after 15min of power transmission: for input end – 43°C, for output end – 36.6°C
- Insert: visualized profile of output beam for 53W

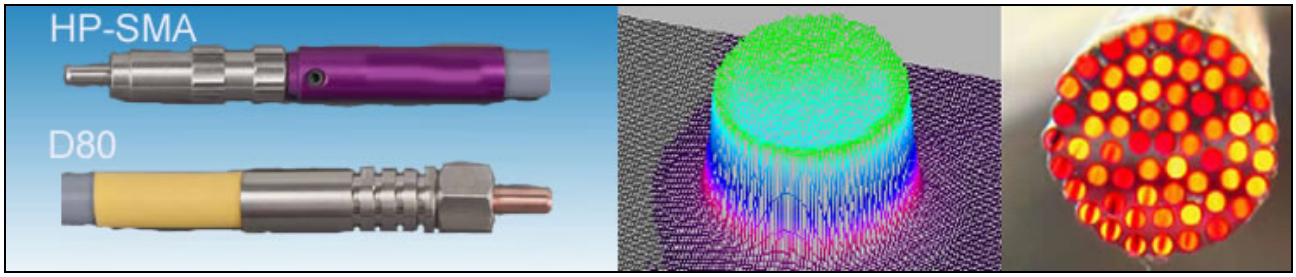


IR-image of common fiber cable assembled with mode stripper & radiator at the output end

- Fiber core - 200µm; NA=0.22
- Connector – HP-SMA with Mode stripper and radiator
- Mode stripper absorbs cladding modes, but cuts off transmission of 1.5m cable to 33W output for diode laser at 1.47µm – providing the same beam profile
- Temperature of connectors measured with thermopile after 3min for 33W of power output: input end – 44°C, output end – 78°C
- Insert: visualized profile of output beam for 33W

Standard Specifications:

Spectral ranges, μm	0.18–1.2μm (UV-VIS) or 0.35–2.4μm (Vis-NIR)
Pure silica fiber core	100; 200; 400; 600; 800; 1000; 1200; 1500μm
Numerical aperture	0.22 ± 0.02 (full acceptance angle 25°) 0.12 ± 0.02 (full acceptance angle 14°)
Protective fiber jacket	Nylon, tefzel, acrylate, Al, Cu
Cable protective tube	PVC coated stainless steel monocoil, bend protected silicon coated stainless steel bend protection
Connector type	HP-SMA (high power SMA); D-80
Temperature range	-40°C to +600°C (Cu coated)
Cable length, m	1.5 & 3 (optional: from 5cm to 50m)
MCS fibers in bundle	3, 7, 19, 37, 64,



3.1 Mid-IR Chalcogenide and Polycrystalline Fiber Optic Bundles

Our development of specialty fibers for the Mid-IR region has resulted in a unique product – chalcogenide infra-red (CIR-) fibers. Chalcogenide glasses (As_2 S_3) transmit IR radiation in the spectral range of 1.1–6μm. Our CIR fibers are drawn in core/clad structure with double polymer coating and characterized by low total optical losses and low absorption peaks over mentioned spectral range. High flexibility & high transmission of our Mid-IR fibers allowed producing commercial fiber bundles & convertors for mid-IR applications for spectral range from 1.5μm up to 18μm.

Main features:

- Multispectral fiber bundles in the broad spectral range: from 0.2 to 18μm
- Fiber bundles contain up to thousands of optical fibers
- Custom fiber arrangement
- High and low temperature special design
- Standard or custom connectors and ferrules
- Splitting light from light source into several channels
- Combining light from several sources
- Reshaping of light beam cross section

Applications:

- Spectroscopy
- Medical diagnostic
- Optical sensors
- Laser delivery
- Pyrometry
- Analytical instruments
- Chemical analysis

Spectral range, μm	1.5–6 μm (chalcogenide fibers)	6–18μm (polycrystalline fibers)
Fiber core dia., μm	200, 300, 400, 500	
Total length, m	Up to 10	
Protective tubing	Metal, PVC coated, flexible hard plastic polymer PEEK	
Numerical aperture	from 0.3	
Temperature range	-200°C +100°C	
Optical connectors	SMA; long SMA; FC/PC; ST	

3.2 UV-VIS-NIR Silica Fiber Optic Bundles

Round-to-round (R/R) and round-to-line (R/L) fiber bundles are probably the most popular and demanded, since they are used in the manufacture of a wide range of fiber optic sensors and probes. We offer optical fiber bundles in straight, bifurcated multi-furcated design. For spectroscopy fiber probes we are offering unique bundles with metal-coated fibers, which allow to block the cross-talk between the fibers, and in result signal/noise ratio is higher than in similar bundles with fiber polymer coatings. Our silica fiber bundles are terminated with SMA905, FC/PC, ST or custom connectors and for spectral range from 0.2μm up to 2.2μm.

Main features:

- Silica fiber bundles in UV-VIS-NIR spectral range from 0.2 to 2.2 μm
- Fiber bundles contain up to thousands of optical fibers
- Custom fiber arrangement
- High and low temperature special design
- Standard or custom connectors and ferrules
- Splitting light from light source into several channels
- Combining light from several sources
- Reshaping of light beam cross section

Applications:

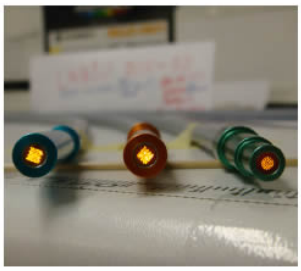
- Spectroscopy
- Medical diagnostic
- Optical sensors
- Photolithography
- Laser welding / soldering / marking
- Laser delivery
- Pyrometry
- Analytical instruments
- Chemical analysis

Common Parameters of Silica Fiber Optic Bundles and Converters

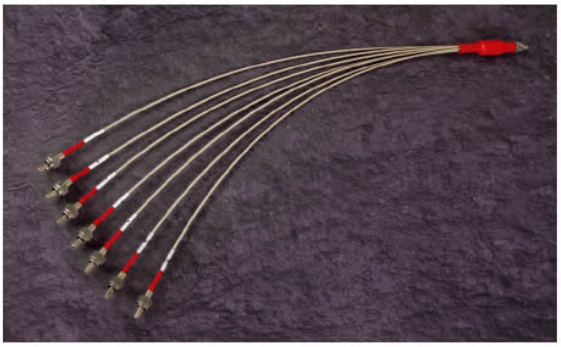
Spectral range, μm	200 – 1200 nm (Low OH silica)	400 – 2200 nm (High OH silica)
Fiber core dia., μm	10, 50, 100, 200, 300, 400, 600	
Total length, m	Up to 100	
Protective tubing	Stainless steel; metal, PVC coated; flexible hard plastic polymer PEEK; flexible Ni or Cr plated metal tube	
Numerical aperture	from 0.12 to 0.55	
Temperature range	-40°C +120°C up to 600°C – on request	
Optical connectors	SMA; long SMA; FC/PC; ST	


Coherent and randomized silica fiber bundle

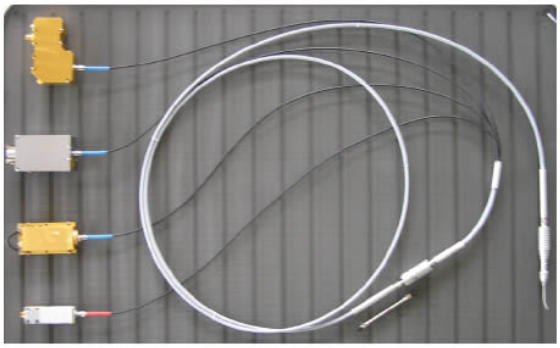
Sintec Optronics Pte Ltd
E-mail: sales@sintec.sg
URL: http://www.sintec.sg



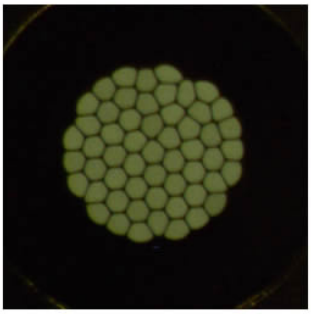

Mixed fiber bundle consisting of UV silica, VIS-NIR silica and CIR fibers to enable remote spectroscopy in 0.2 µm to 6µm spectral range



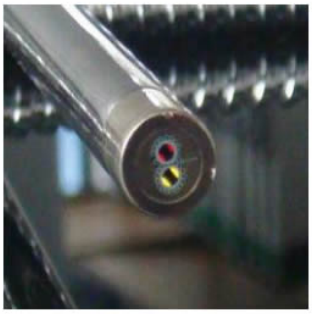
CIR Fiber Splitter: 1 x7

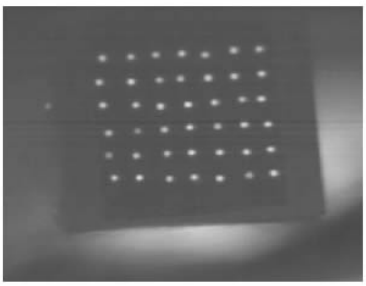


Silica Fiber Combiner

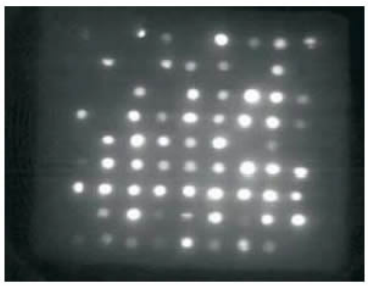


UV/VIS/NIR (180 - 2500 nm) -from silica fibers
Mid Infrared (1.5 - 6.0 µm) - from CIR fibers
Mid Infrared (4.0 - 18.µm) - from PIR fibers
UV/VIS/NIR/MIR (180 nm - 18 µm) -
mixed fiber bundle from Silica, CIR & PIR fibers in any combination






IR-Image Converter:
7x7 PIR - 300 µm fibers grid to 1x49 Line Bundle



Imaging bundle assembled
from 9x9 PIR - 200µm fibers

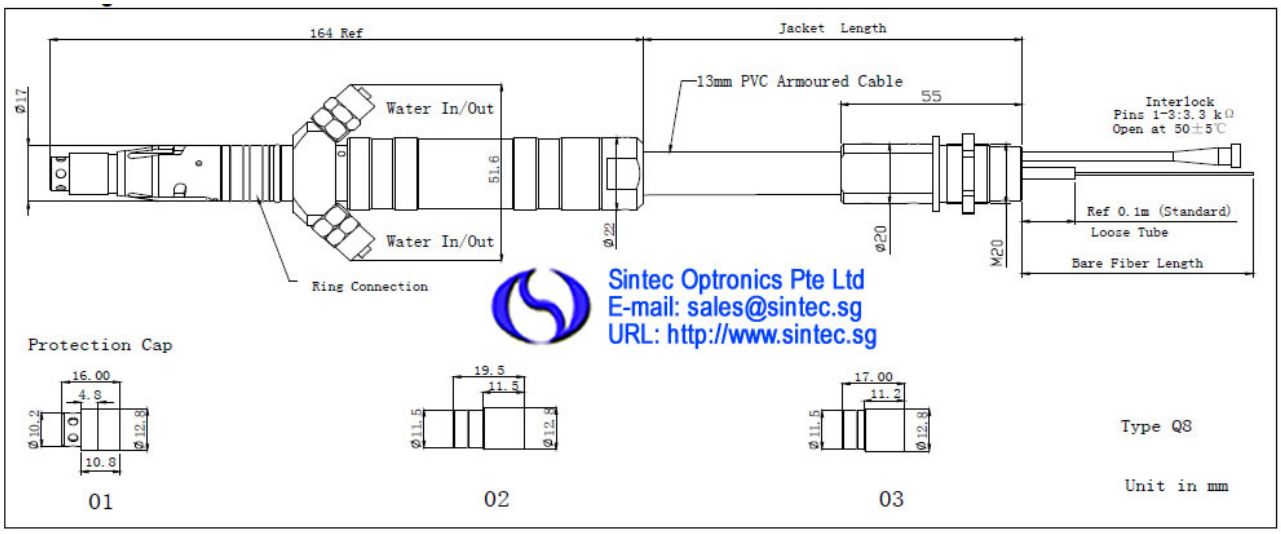
4. ST Series Fibers with Connectors

1. STO-Q8 Series Fiber Optical Cables (Indirect Water Cooling)

Features
High Handling Power
Water Cooling System & Compatible Design
Cladding Mode Stripper Integrated
Interlock System Integrated
Excellent Environmental Stability and Reliability

Applications
Fiber Lasers
Research & Design
Laser Cutting
Laser Cleaning
Laser Welding

	Unit	Parameter
Operating Wavelength	nm	900～1000（Nominal Center Wavelength 950nm） 1030～1090（Nominal Center Wavelength 1064 nm）
Typ. Transmission Ratio	-	99%
Min. Transmission Ratio	-	98%
Max. Handling Power (CW)	W	1000, 2000, 4000, 6000， 8000 or Specify
Pulse Power	-	Max. 10KW @10ms Max. 50KW @1ms Max. 1MW @50ns
Loss Power Handling Capability	-	1KW for 10 min 500W Continuously
Nominal Beam Pointing Accuracy	deg	1
Min. Beam Ellipticity	-	0.92
Max. Fiber Tensile Load	N	5
Package Material	-	Stainless Steel / Aluminum / Copper
Operating Temperature	℃	+10 to +50
Storage Temperature	℃	-10 to +75
Max. Water Pressure	Bar	4
Flow of Water	L/min	1.5-2.5
Fiber Length ≤15 m	-	The Fiber Length Tolerance is -10cm
15m＜Fiber Length ≤30m	-	The Fiber Length Tolerance is -20cm
Jacket Length≤15m	-	The Jacket Length Tolerance is +0.2/-0.1m
15m＜Jacket Length ≤30m	-	The Jacket Length Tolerance is +0.4/-0.2m

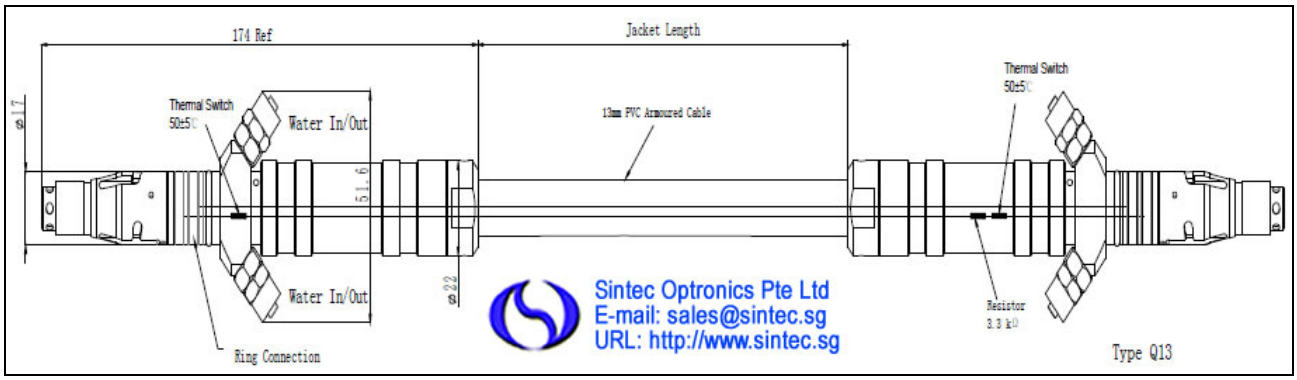


STO -①①-②②-③-④④-⑤⑤-⑥⑥-⑦-⑧⑧-⑨⑨

①①: Wavelength	④④: Fiber Type	⑥⑥: Bare Fiber Length With Loose Tube
06 - 1064nm	01-Nufern GDF-20/400-M NA0.065	01 - 1 m
08 - 1080nm	03-Nufern BD-S100/120/360-STN NA0.22	1.5 - 1.5 m
SS - Specify	08-Nufern LMA-GDF 25/400-M NA0.065	02 - 2 m
	10-Nufern BD-S50/70/360-STN NA0.22	SS - Specify
②②: Connector Type	11-Coractive DCF-UN 50/400 NA0.12	
QB - QBH Compatible	20-Nufern LMA-GDF- 30/250-M NA0.06	⑦: Package Type
	SS - Specify	Q8 - Type Q8
③: Handling Power		
1000 - 1000W	⑤⑤: Jacket Length	⑧⑧: Protection Cap Type
1500 - 1500W	10 - 10m 13mm Armoured Cable	01 - Aluminum Without Window
2000 - 2000W	15 - 15m 13mm Armoured Cable	02 - Aluminum With Window For SM Fiber
3000 - 3000W	18 - 18m 13mm Armoured Cable	03 - Aluminum With Window For MM Fiber
3500 - 3500W	20 - 20m 13mm Armoured Cable	SS - Specify
4000 - 4000W	22 - 22m 13mm Armoured Cable	
4500 - 4500W	23 - 23m 13mm Armoured Cable	⑨⑨: Water Pipe Length
6000 - 6000W	SS - Specify	05 - 5×2m
8000 - 8000W		NN - None
S - Specify		SS - Specify

2. STO-Q13 Series Fiber Optical Cables (Indirect Water Cooling)

	Unit	Parameter
Operating Wavelength	nm	440～460（Nominal Center Wavelength 450nm）or specify
Typ. Transmission Ratio(By Design)	-	98%
Min. Transmission Ratio(By Design)	-	96%
Max. Handling Power (CW)	W	2000 or Specify
Pulse Power	-	Max. 10KW @10ms Max. 50KW @1ms Max. 1MW @50ns
Loss Power Handling Capability	-	1KW for 10 min 500W Continuously
Nominal Beam Pointing Accuracy	deg	≤1
Min. Beam Ellipticity	-	0.92
Max. Fiber Tensile Load	N	5
Fiber Cable Lengths Tolerance	M	±0.5
Package Material	-	Stainless Steel / Aluminum / Copper
Operating Temperature	℃	+10 to +50
Storage Temperature	℃	-10 to +75
Max. Water Pressure	Bar	8
Flow of Water	L/min	1.5-3



STO-①①-②②-③-④④-⑤⑤-⑥⑥-⑦-⑧⑧-⑨⑨

①①: Wavelength
45 - 450nm
SS - Specify

②②: Connector Type
QB - QBH Compatible

③: Handling Power
2000 - 2000W
S - Specify

④④: Fiber Type
44 - Coractive DCF-UN-50/250-22 NA0.22
45 - Coractive DCF-UN-50/70/200-22 NA0.22
SS - Specify

⑤⑤: Jacket Length
05 - 5m 13mm Armoured Cable
15 - 15m 13mm Armoured Cable
25 - 25m 13mm Armoured Cable
SS - Specify

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E-mail: sales@sintec.sg
URL: http://www.sintec.sg

⑥⑥: Bare Fiber Length With Loose Tube
NN - No Need

⑦: Package Type
Q13 - Type Q13

⑧⑧: Protection Cap Type
01 - Aluminum Without Window
SS - Specify

⑨⑨: Water Pipe Length
05 - 5×4m
NN - None
SS - Specify

3. STH Series Laser Fibers with Connectors

Used to deliver laser beam with high coupling efficiency and high damage shreshold.

- Fiber length: 2meter (other lengths available upon request)
- Wavelength: UV-IR (108nm to 2500nm)
- Connector: SMA905 at both ends (other connectors available upon request)
- Core diameter: 100/200/300/400/600/800
- N. A.: 0.22 (others available upon request)
- Diameter of protective tubing: 6mm
- Core material: crystal fiber

Ordering Information:
STH-xxxxx-Fyyy-z, where xxxx means connector (such as SMA905…), yyy means core diameter in um, z means fiber length in meter. For example, STH-SMA905-F400-2 is an optical fiber with SMA905 connectors, core 400um and 2m long.