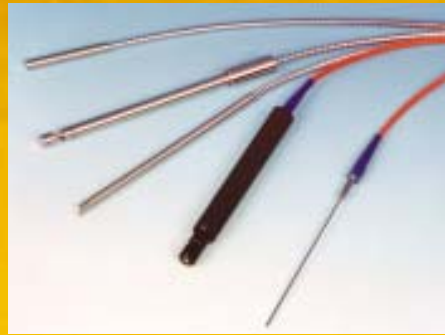


# Fiber Optics



## Introduction

The use of fiber optics as light guidance allows a great modularity and flexibility in the setup of an optical measurement system. Optical fibers can be made of many materials, such as plastic, glasses and silicates ( $\text{SiO}_2$ ). For high quality fiber optics, as used in spectroscopic applications, synthetic fused silica (amorphous silicon dioxide) is used, that can be intentionally doped with trace elements to adjust the optical properties of the glass.

The basic principle of light transport through an optical fiber is total internal reflection. This means that the light within the numerical aperture of a fiber ( $\text{NA} = \text{input acceptance cone}$ ) will be reflected and transported through the fiber. The size of the numerical aperture depends on the materials used for core and cladding.

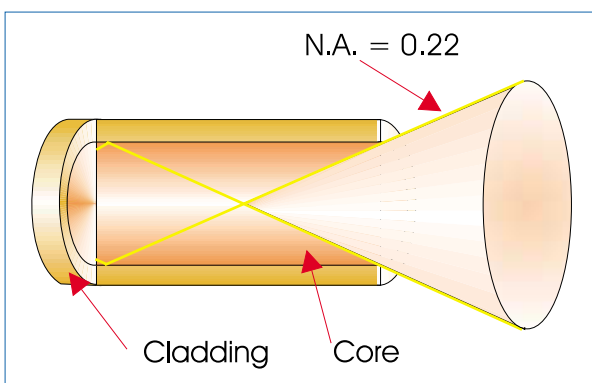
Two basic types of silica fibers can be distinguished; single-mode and multi-mode fibers, depending on the propagation state of the light, traveling down the fiber. For most spectro-

scopic applications multi-mode fibers are used. Multi-mode fibers can be divided into 2 subcategories, step-index and graded-index. A relatively large core and high NA allow light to be easily coupled into the fiber, which allows the use of relatively inexpensive termination techniques. Step-index fibers are mainly used in spectroscopic applications.

Graded-index multimode fibers have a refractive index gradually decreasing from the core out through the cladding. Since the light travels faster in material with lower refractive index, the modal dispersion (amount of pulse-spreading) will be less. These graded-index fibers are mainly used in telecommunication application, where bandwidth at long distance (2-15 km) plays an important role.

In the following paragraphs some basic fiber optic components and properties will be discussed.

## Fiber Optic Design



**Figure 16 Numerical Aperture**

### Core

For spectroscopic applications, generally, multi-mode step index silica fibers are used. These range in core thickness from 50 microns to 1 mm. The core is made out of pure silica. Other fiber cores with much higher absorption are made out of certain glass types or plastics. These are not offered in this catalog.

First a distinction is made between silica with high or low OH content. Silica fibers with high OH (600-1000 PPM) are used in the UV/VIS wavelength range because of the low absorption in the UV. They are referred to as UV/VIS fibers. For Deep-UV applications (below 230 nm) special solarization resistant fibers can be used.

The water content causes strong absorption peaks in the NIR wavelength range. In order to get appropriate fibers for the NIR range, the “water” is removed from the silica. This results in low OH fibers (<2 PPM) with low absorption in the NIR. They are referred to as VIS/NIR fibers.

### Cladding

In order to get the light guiding effect the core is cladded with a lower index of refraction material. For the highest quality fibers with the lowest absorption this is a fluorine-doped silica, the so-called silica-silica or all-silica fibers with a numerical aperture (NA) of 0.22.

### Buffers

Without further protection fibers would easily break, because of small scratches or other irregularities on the surface. Therefore a next layer, the buffer, is added. This buffer also determines under what circumstances the fiber can be used. Temperature range, radiation, vacuum, chemical environment and bending are factors to be considered.

Polyimide buffers offer a wide temperature range (-100 to 400°C) and superior solvent resistance. Also, this material is non-flammable. Drawbacks are sensitivity to micro bending and the difficulty to remove it.

For extreme temperatures (-190 to 750°C) a gold buffer is used. Gold-coated fibers are virtually inert to all environments and make hermetically sealed high pressure feed through's possible. (See: pressure feed through's). The same is true for aluminum buffers for temperatures from -190 up to about 500°C. Low outgassing makes them also excellent for use in vacuum.



Figure 17 Fiber optic design

### Technical Data

Fiber type	Step index
Core Numerical Aperture	0.22 ± 0.02
Buffer NA	Polyimide (1,78) strips cladding modes
Laser damage resistant core	1,3 kW/mm <sup>2</sup> CW at 1060 nm, up to 10 J, pulsed
Bend radius	Momentary 100 x clad radius
	Long term 600 x clad radius
Mechanical Stress	Standard proof test: 70 kpsi

Figure 18 Transmission UV/VIS Fibers

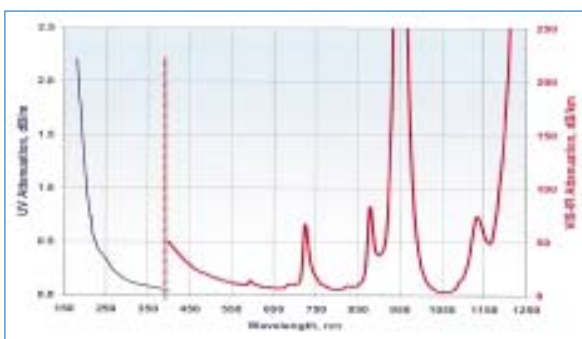
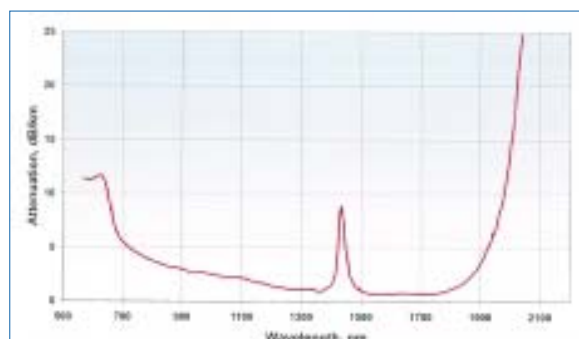


Figure 19 Transmission VIS/NIR Fibers



## Solarization Resistant Fibers for Deep UV applications

Most spectroscopic applications with fiber optics have been restricted to wavelength ranges above 230 nm, because standard silica fibers with an undoped core and fluorine doped cladding are frequently damaged by exposure to deep-UV light (below 230 nm). This solarization effect is induced by the formation of "color centers" with an absorbance band of 214 nm. These color centers are formed when impurities (like Cl) exist in the core fiber material and form unbound electron pairs on the Si atom, which are affected by the deep UV radiation.

Not long ago, solarization resistant fibers, which were hydrogen loaded, were developed (UVI). The disadvantage for

these fibers is the limitation on smaller fiber diameters and limited lifetime, caused by the H<sub>2</sub> outgassing from the fiber. Recently, with the availability of a modified core preform, a new fiber became available (UVM). This fiber provides long-term stability at 30-40 % transmission (for 215 nm).

All fiber optic probes, cables and bundles with core diameters of 100 μm, 200 μm, 400 μm, 600 μm and 800 μm can be delivered with solarization resistant fibers. All assemblies, made by Avantes, are pre-solarized for an 8-hrs period, to have a constant transmission of 30-40% @ 215 nm.

Figure 20 Solarization standard UV400 fiber

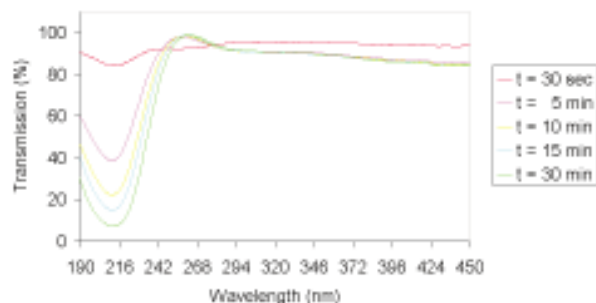


Figure 22 Solarization UV100-SR fiber

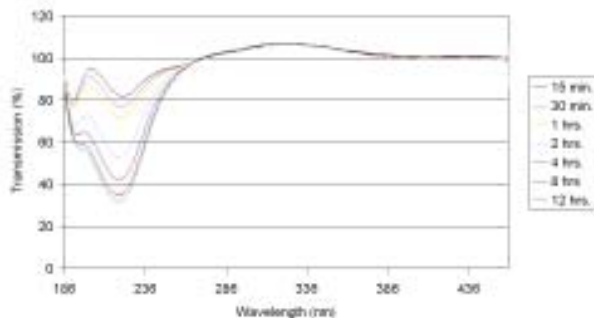
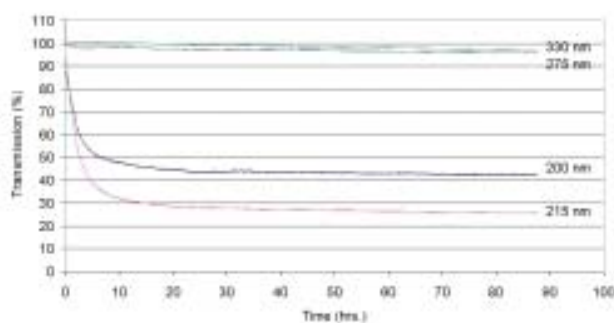


Figure 21 Solarization UV100-SR fiber



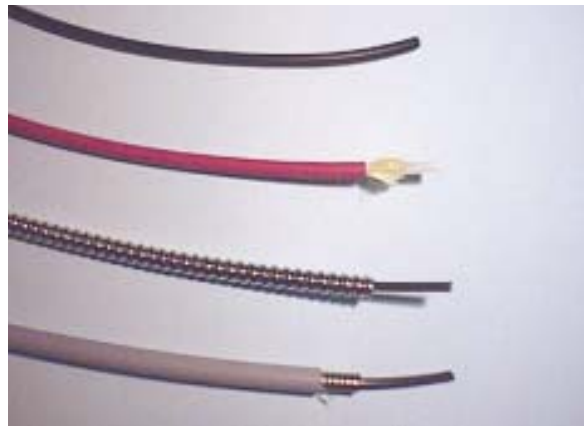
### ORDERING INFORMATION

-SR	solarization resistant fiber for DUV applications
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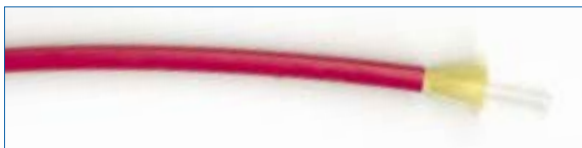
## Fiber Optic Sleeves

For different applications Avantes offers different sleeving material. Standard our fiber optic cables and bifurcated cables are protected by a Kevlar reinforced polypropylene inner tubing with PVC red outer jacket. All of our standard reflecti- on probes are protected by a flexible chrome-plated brass outer tube, with hooked profile for optimal strain relief with silicon or PTFE inner tubing. For waterproof and some medi- cal applications stainless steel spiral tubing with glassilk and gray outer silicon rubber coating can be provided. Inside this tubing silicon or PTFE inner tubing is used as well. Especially for small, flexible, endoscopic probes we use a PVC rubber sleeving. Some specifics on the sleeveings can be found in the following technical information. Contact us if you have any special conditions requirements.

### Fiber Optic sleeving material



#### Standard - Kevlar reinforced PVC



#### MS - Silicon coated stainless steel



#### ME - Chrome plated brass



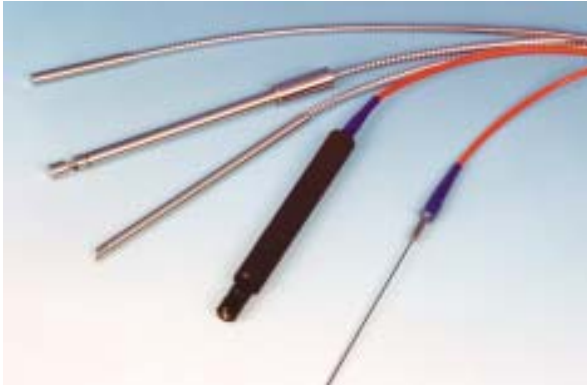
### Technical Data

Sleeve material	Kevlar reinforced PVC	Chrome plated brass	Silicon coated stainless steel	PVC
Inner Tubing	Polypropylene	Silicon/PTFE	Silicon/PTFE	n.a.
Outer dimensions	3,8 mm	5,0 mm	5,8 mm	2,0 mm
Temperature Range	-20 °C to +65 °C	-65 °C to +250 °C	-60 °C to +180 °C	-20 °C to +65 °C
Tensile Strength	150 N	350 N	70 N	n.a.
Application	Standard	Heavy Industrial	Waterproof IP67	Medical

### ORDERING INFORMATION

-ME	flexible chrome-plated brass outer tube, with hooked profile
-MS	stainless steel spiral tubing with glassilk and gray outer silicon rubber coating

## Fiber Optic Probe properties



All Avantes fiber optic cables and probes can be modified to customers request. Most materials we use in our fiber optic assemblies can be replaced with others to improve specific chemical or thermal resistance or to enhance vacuum or pressure properties.

**Please contact our fiber design engineers with your specific request.**

In the following paragraphs some of the most essential technical parameters are listed for our standard materials.

### Thermal resistance

The thermal resistance of a fiber optic assembly depends on the following components:

1. Fiber, the standard fiber design is a silica/silica fiber and has a polyimide buffer, covering a wide thermal range  $-190$  to  $400$  °C. For higher temperatures aluminum coated (to  $500$ °C) or gold coated (to  $750$ °C) fibers are recommended.
2. Sleeving, the standard sleeving is PVC based and has a small temperature range ( $-20$ °C to  $65$ °C), for higher temperatures a flexible metal sleeving (-ME) with silicone inner tubing is recommended (up to  $250$ °C) or stainless steel tubing (not flexible, to  $750$ °C).
3. Probe ends, connectors and ferrules are standard made of metal and have a wide temperature range. For special plastics, like PVC, PEEK and Teflon a limited temperature range is applicable.
4. Bonding epoxy, the standard epoxy used is a heat curing bonding epoxy with a temperature range of  $-60$ °C to  $175$ °C. The curing temperature is standard  $100$  °C, for high temperature ranges (order code -HT), the curing temperature is  $200$ °C. Sometimes UV-curing epoxies are used.

### Technical Data

Temperature range	Fiber	Sleeving	Probe end	Epoxy
$-20$ °C to $+65$ °C	Standard Polyimide	Standard PVC	Standard metal/ PVC/PEEK/PTFE	Standard
$-30$ °C to $+100$ °C	Standard Polyimide	Metal (-ME) or silicone (-MS)	Standard metal/ PEEK/PTFE	Standard
$-60$ °C to $200$ °C (HT)	Standard Polyimide	Metal (-ME) or silicone (-MS)	Standard metal/ PEEK/PTFE	High temperature curing epoxy
$-60$ °C to $400$ °C	Standard Polyimide	Metal (-ME) or SS-tubing	Metal	Special polyimide epoxy or ceramic
$-60$ °C to $500$ °C	Aluminum coated	SS-tubing or none	Metal	Direct bonding
$-60$ °C to $750$ °C	Gold coated	SS-tubing or none	Metal	Direct bonding

#### ORDERING INFORMATION

-HT	High temperature version
-----	--------------------------

## Chemical resistance

The chemical resistance of a fiber optic assembly depends on the following components:

1. Fiber, the standard fiber design is a silica/silica fiber and has a polyimide buffer, which normally will not be in contact with the sample; the quartz core provides good resistance against most solvents.
2. Sleeving, the standard sleeving is PVC based and has a relative good chemical resistance. The -ME chrome plated brass sleeving also has a good chemical resistance, but is not waterproof. The Silicone metal sleeving (-MS) is recommended for waterproof environment, biomedical applications, etc. The PEEK and PTFE sleeving have the best chemical resistance.

3. Probe ends, connectors and ferrules are standard made of stainless steel and are not very well suitable in corrosive environment. For most corrosive environments PEEK, PTFE or Hastelloy® are recommended.
4. Bonding epoxy, the standard epoxy is resistant to water, inorganic acids, salts, alkalis, many aggressive organic solvents, most petrochemical products and an extended range of organic and inorganic environments.

The table below gives a good summary for the chemical resistance for our standard materials.

The table has been drawn up on the basis of relevant sources in accordance with the state of the art; no claim to completeness. The data constitutes recommendations only, for which no liability can be accepted.

Please contact us if you have any doubt about the materials to use for your application.

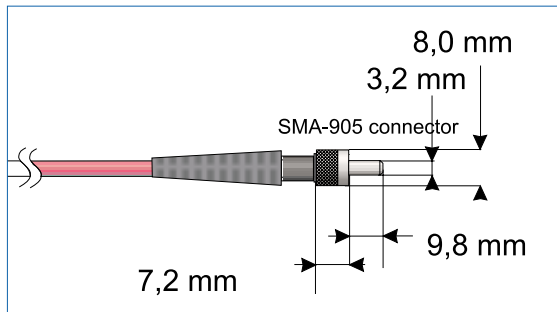
## Technical Data

Chemical environment	Fiber		Sleeving		Probe end		Epoxy
Acids weak	Silica/Silica	+	-ME -MS -PEEK -PVC	± + + +	St. steel PEEK PTFE Hastelloy®	- + + +	+
Acids strong	Silica/Silica	+	-ME -MS -PEEK -PVC	- ± + ±	St. steel PEEK PTFE Hastelloy®	- + + +	±
Bases weak	Silica/Silica	+	-ME -MS -PEEK -PVC	+ + + +	St. steel PEEK PTFE Hastelloy®	+ + + +	+
Bases strong	Silica/Silica	+	-ME -MS -PEEK -PVC	+ + + +	St. steel PEEK PTFE Hastelloy®	+ + + +	+
Aromatic carbons	Silica/Silica	+	-ME -MS -PEEK -PVC	+ + + +	St. steel PEEK PTFE Hastelloy®	+ + + +	+
Alcohols	Silica/Silica	+	-ME -MS -PEEK -PVC	+ ± + +	St. steel PEEK PTFE Hastelloy®	+ + + +	+
Ketons/Ethers	Silica/Silica	+	-ME -MS -PEEK -PVC	+ - + -	St. steel PEEK PTFE Hastelloy®	+ + + ±	±

+ = good resistance ± = conditional resistant - = not resistant

## Fiber Optic Connectors

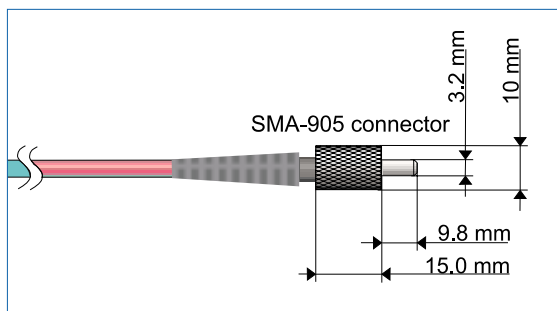
### Standard SMA



### SMA connectors

We supply all of our standard fiber optic cables, bundles and probes with SMA 905 connectors that easily fit into our complete range of spectrometers, light sources and accessories. The SMA 905 connectors are screw-fitted and can be rotated over 360 degrees. The typical insertion loss for the connectors is 0.5 dB. The maximum filling diameter for bundles is 2.46 mm.

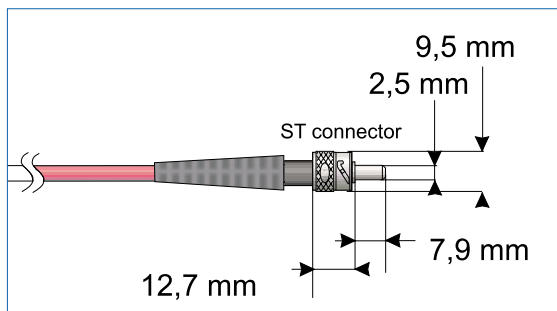
### SMA with extended ferrule



### Standard SMA connector



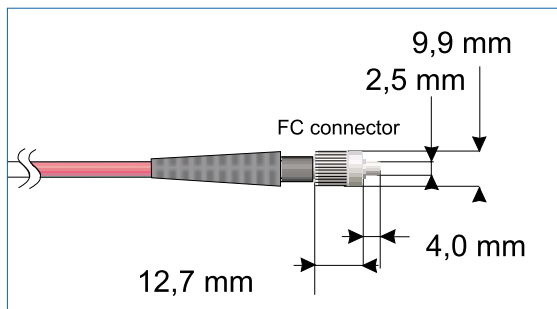
### ST connectors



### ST connectors

Optional ST-connectors can be mounted to our fiber optic products. ST-connectors easily mount with their bayonet type of fitting, and can therefore not rotate, i.e. they mount in a fixed position. The maximum filling diameter is 1.5 mm, typical insertion loss is 0.3 dB.

### FC/PC connectors



### FC/PC connectors

Optional FC/PC-connectors can be mounted to our fiber optic products. The multimode FC/PC connectors have an extremely low insertion loss of < 0.2 dB. The FC/PC connector cannot rotate, always mounts into the same fixed position and therefore has a high reproducibility.

### ORDERING INFORMATION

-ST	ST connector instead of standard SMA
-FC/PC	FC/PC connector instead of standard SMA



## Fiber Optic Cables

Fiber optic cables can be made in different lengths up to several hundreds meters. The standard length is 2 meters, contact us for specific requirements.

Different type of connectors, such as SMA905, ST or FC/PC connectors can be applied. The fibers are also available for different wavelength regions, like Deep UV solarization resistant fibers, UV/VIS fibers and VIS/NIR fibers.

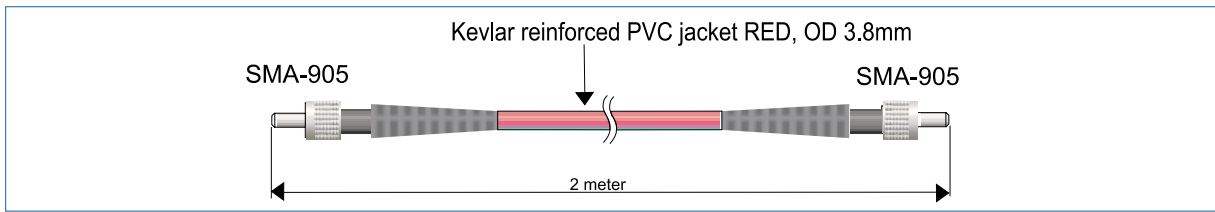
We offer different shielding, like Kevlar reinforced PVC sleeving with PTFE inner tubing (standard) or metal shielding with PVC-XY or PTFE inner tubing for higher temperature and more industrial applications.

Depending on the intended wavelength range a UV/VIS (200-800 nm) or a VIS/NIR (350-2000 nm) fiber is used. In the following table replace xx by respectively UV or IR. For deep UV use specify -SR (solarization resistant).

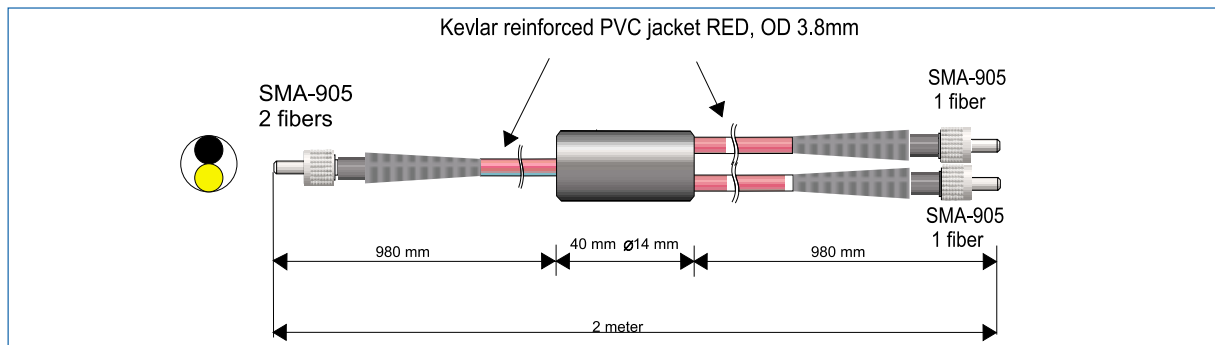
### Fiber Optic cable



### Patch cords



### Bifurcated cables



### ORDERING INFORMATION

FC-IR8-2	Cable with 8 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx50-2	Cable with 50 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx100-2	Cable with 100 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx200-2	Cable with 200 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx400-2	Cable with 400 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx600-2	Cable with 600 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx800-2*	Cable with 800 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FC-xx1000-2*	Cable with 1000 $\mu\text{m}$ Fiber, 2 m length, SMA terminations
FCB-xx50-2	Bifurcated cable 2x50 $\mu\text{m}$ , 2 m length, SMA terminations
FCB-xx100-2	Bifurcated cable 2x100 $\mu\text{m}$ , 2 m length, SMA terminations
FCB-xx200-2	Bifurcated cable 2x200 $\mu\text{m}$ , 2 m length, SMA terminations
FCB-xx400-2	Bifurcated cable 2x400 $\mu\text{m}$ , 2 m length, SMA terminations
FCB-xx600-2	Bifurcated cable 2x600 $\mu\text{m}$ , 2 m length, SMA terminations

Other lengths and fiber types are available. \* 800-1000 $\mu\text{m}$  with Acrylate buffer.

## Reflection Probes (Standard)

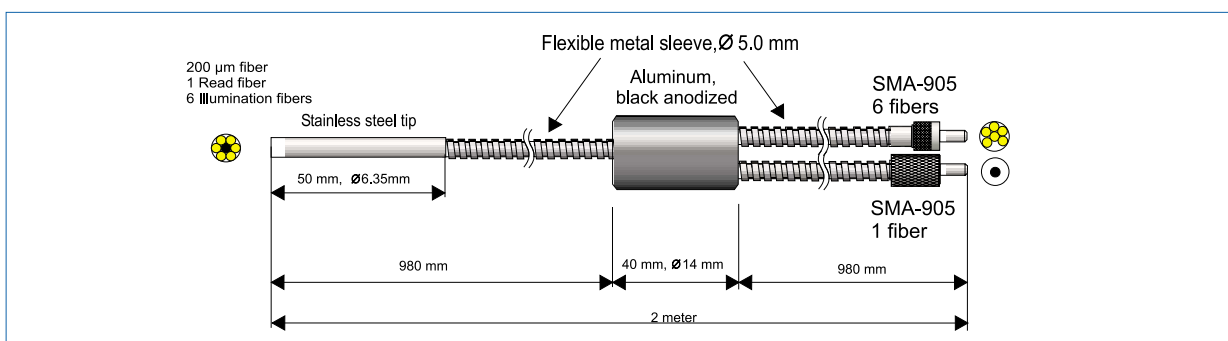
The FCR-7xx200-2 is a standard reflection probe to get spectral information of diffuse or directly reflecting or back-scattering materials.

Via a standard SMA905 connector light from a light source is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end. The surface will selectively reflect light back into a 7th fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or spectrum analyzer. A higher number of fibers are possible to couple more energy from the light source and to increase the signal level. For measurements under 90° the FCR-90-Option, a special adapter with a mirror under 45°, was developed, which can be easily mounted on the tip of the reflection probe. The FCR-COL is available to focus the measurement spot on an extended distance.



### Technical Data

<b>Fibers</b>	7 or 19 fibers 200 µm or 400 µm core, 6 or 17 light-fibers, 1 or 2 read fiber, N.A. = 0.22. Standard 2 m length, splitting point in the middle.
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Probe end</b>	Stainless steel cylinder, 50 mm long x 6,35 mm diameter.
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5.0 mm
<b>Temperature</b>	-30 °C to 100 °C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FCR-7UV200-2-ME</b>	Reflection probe UV/VIS, 7 x 200µm fibers, 2 m length, SMA term.
<b>FCR-7IR200-2-ME</b>	Reflection probe VIS/NIR, 7 x 200µm fibers, 2 m length, SMA term.
<b>FCR-7UV400-2-ME</b>	Reflection probe UV/VIS, 7 x 400µm fibers, 2 m length, SMA term.
<b>FCR-7IR400-2-ME</b>	Reflection probe VIS/NIR, 7 x 400µm fibers, 2 m length, SMA term.
<b>FCR-19UV200-2-ME-S1</b>	Reflection probe UV/VIS, 19 x 200µm fibers, 2 m length, SMA term.
<b>FCR-19IR200-2-ME-S1</b>	Reflection probe VIS/NIR, 19 x 200µm fibers, 2 m length, SMA term.
<b>FCR-90-Option</b>	90° Reflection add-on reflector for use with all 1/4" reflection probes
<b>FCR-COL</b>	Adjustable UV/VIS/NIR Collimating/focussing lens for FCR probes

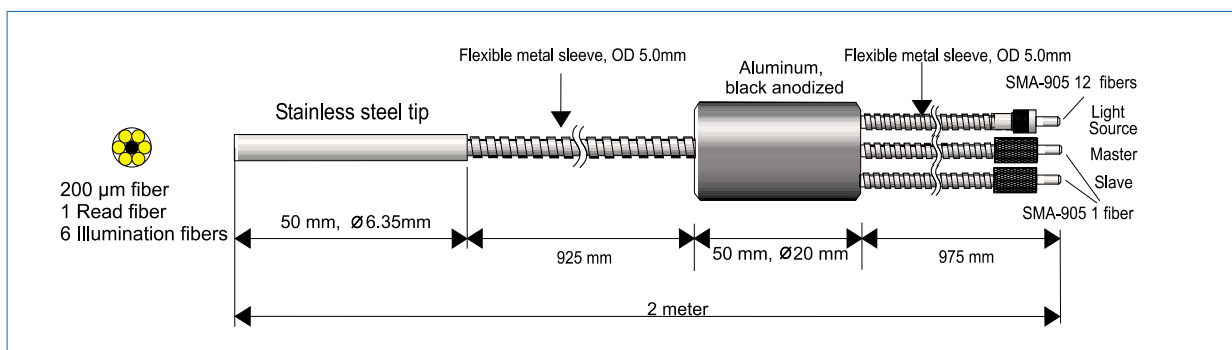


## Reflection Probes with Reference

The FCR-14x200-2-REF is a special reflection probe to get spectral information of diffuse or direct reflecting materials. The reference leg was added to be able to correct fluctuations of the lightsource by a second spectrometer channel. Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 12 fibers. These 12 fibers are split into 2x 6 fibers, 6 fibers carried to the probe end and 6 fibers reflecting on white diffuse material inside the coupler, then back reflecting into 1 fiber of the reference leg, connected through an SMA905 connector to the slave channel of the spectrometer. The probe end will selectively reflect light back into a 7th fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to the master channel of the spectrometer.

### Technical Data

<b>Fibers</b>	14 fibers 200 $\mu\text{m}$ core, 12 light-fibers, 2x1 read fiber, N.A. = 0.22. Standard 2 m length, splitting point in the middle.
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm(VIS/NIR)
<b>Connectors</b>	SMA905 connectors (3x)
<b>Probe end</b>	Stainless steel cylinder, 50 mm long x 6,35 mm diameter.
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5,0 mm
<b>Temperature</b>	-30 °C to 100 °C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FCR-14UV200-2-REF-ME</b>	Reflection probe with reference UV/VIS, 14 x 200 $\mu\text{m}$ fibers, 2 m length, SMA term.
<b>FCR-14IR200-2-REF-ME</b>	Reflection probe with reference VIS/NIR, 14 x 200 $\mu\text{m}$ fibers, 2 m length, SMA term.

## Reflection Probes with Small Tips

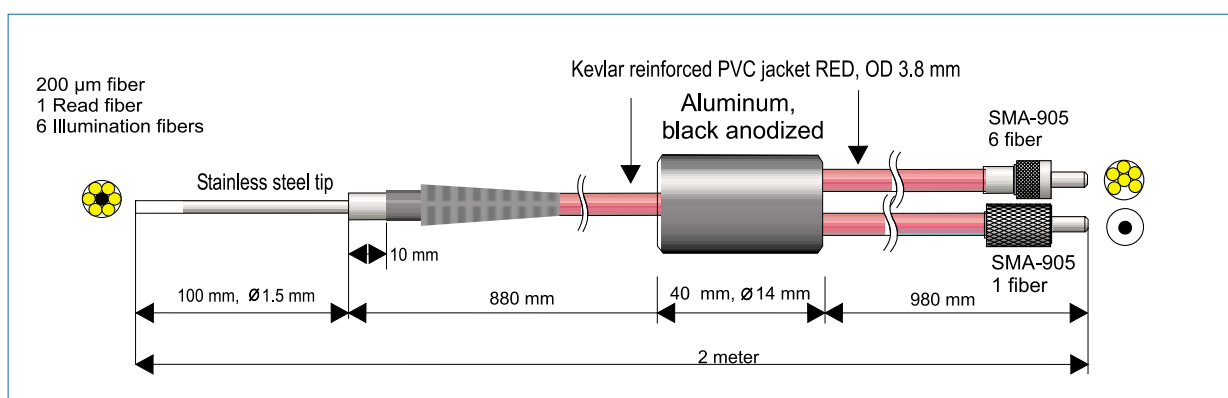
The FCR-7xx200-2-1,5/2,5x100 is a reflection probe with a small tip to get spectral information of diffuse or direct reflecting materials. This probe is implemented in many medical applications.

Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end. The surface will selectively reflect light back into a 7<sup>th</sup> fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or spectral analyzer. A special Angled Fiber Holder (AFH-15) is available for the 1,5 mm diameter reflection probe to enable reflection measurements under 15°, 30°, 45°, 60°, 75° and 90°, for more information see Reflection Probe Holders at the end of this section.



### Technical Data

<b>Fibers</b>	7 fibers 200 µm core, 6 light-fibers, 1 read fiber, N.A. = 0.22. Standard 2 m length, splitting point in the middle.
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Probe end</b>	Stainless steel cylinder, 100 mm long x 1.5 or 2.5 mm diameter.
<b>Tubing</b>	The optical fibers are protected by a Kevlar reinforced PTFE tubing with PVC sleeving. OD: 3.8 mm
<b>Temperature</b>	-20 °C to 65 °C.
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FCR-7UV200-2-1,5x100</b>	Reflection probe, 1,5 mm tip, UV/VIS, 7 x 200µm fibers, 100 mm long, 2 m length, SMA
<b>FCR-7IR200-2-1,5x100</b>	Reflection probe, 1,5 mm tip, VIS/NIR, 7 x 200µm fibers, 100 mm long, 2 m length, SMA
<b>FCR-7UV200-2-2,5x100</b>	Reflection probe, 2,5 mm tip, UV/VIS, 7 x 200µm fibers, 100 mm long, 2 m length, SMA
<b>FCR-7IR200-2-2,5x100</b>	Reflection probe, 2,5 mm tip, VIS/NIR, 7 x 200µm fibers, 100 mm long, 2 m length, SMA



## Reflection Probes for Powders and Thick Fluids

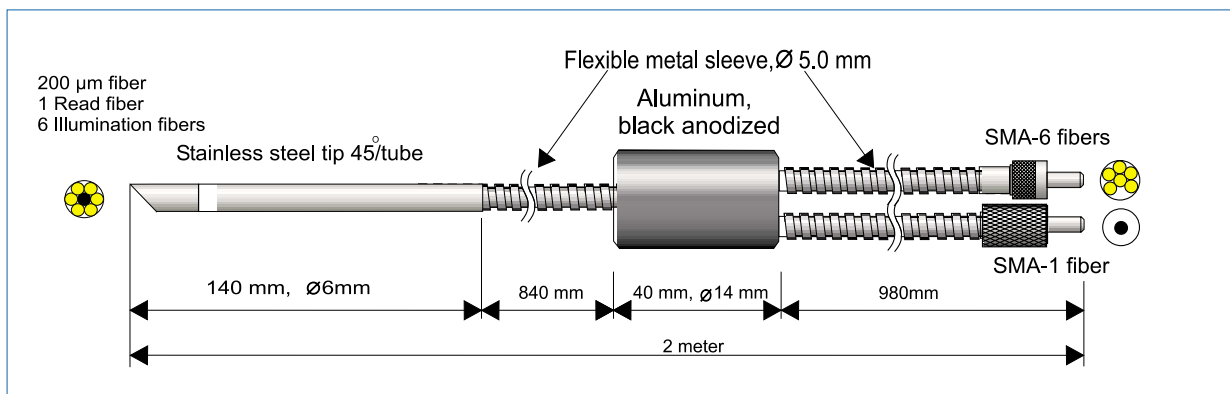
The FCR-7xx200-2-45 is a reflection probe to get spectral information about powders or highly absorbing fluids. The probe end is simply dipped into the powder or liquid to do the measurements.

Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end, where it lights up the material to be analyzed through a silica window under 45 degrees. This angle is necessary to avoid direct reflections from the window. The powder or fluid will selectively reflect light back into a 7<sup>th</sup> fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or a spectrum analyzer.



### Technical Data

<b>Fibers</b>	7 fibers 200 $\mu\text{m}$ core, 6 light-fibers, 1 read fiber, N.A. = 0.22, standard 2 meter length
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Probe end</b>	Stainless steel cylinder, 130 mm long x 6.0 mm diameter. The probe end contains a 5 mm diam. x 1 mm thick fused silica window. Waterproof
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5.0 mm
<b>Temperature</b>	-30°C to 100°C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FCR-7UV200-2-45-ME</b>	Reflection probe for powders and turbid fluids, UV/VIS range
<b>FCR-7IR200-2-45-ME</b>	Reflection probe for powders and turbid fluids, VIS/NIR range

## 1/2" Industrial Reflection Probes for Powders and Thick Fluids

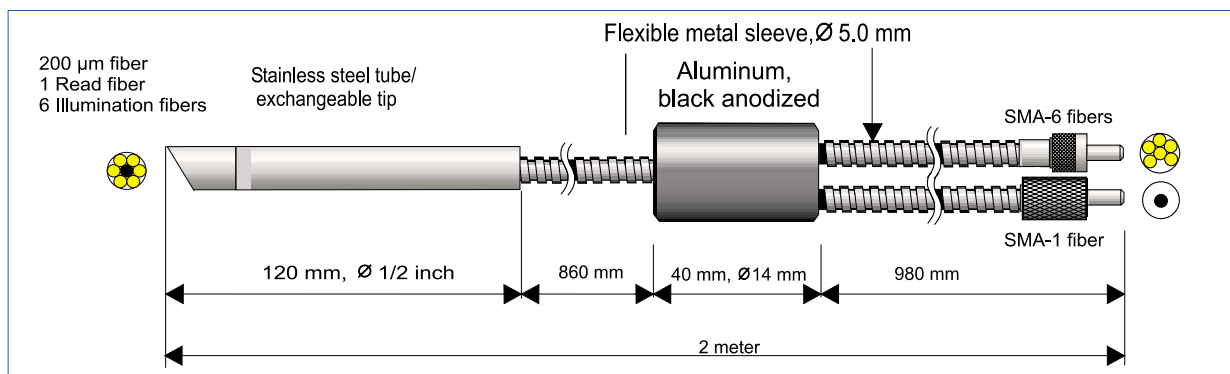


The FCR-7xx200-2-45-IND is a heavy-duty reflection probe with exchangeable tip to get spectral information about powders or thick fluids. The probe end is simply dipped into the powder or liquid to do the measurements.

Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end, where it lights up the material to be analyzed through a silica window under 45 degrees. This angle is necessary to avoid direct reflections from the window. The powder or fluid will selectively reflect light back into a 7<sup>th</sup> fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or a spectral analyzer.

### Technical Data

<b>Fibers</b>	7 fibers 200 µm core, 6 light-fibers, 1 read fiber, N.A. = 0.22, standard 2 meter length
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Probe end</b>	Stainless steel cylinder, 128 mm long x 12.7 mm (1/2") diameter. The probe end contains a ca. 10 mm diam. x 1 mm thick sapphire window. The probe tip is exchangeable and waterproof
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5.0 mm. Optionally a waterproof, steel reinforced, silicon tubing can be provided
<b>Temperature</b>	-30°C to 100°C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FCR-7UV200-2-45-IND</b>	1/2" Reflection probe for powders and turbid fluids, UV/VIS range
<b>FCR-7IR200-2-45-IND</b>	1/2" Reflection probe for powders and turbid fluids, VIS/NIR range
<b>FCR-TIP45</b>	1/2" Replacement tip with sapphire window for UV/VIS/NIR



## 1/2" Industrial Fluorescence Probe

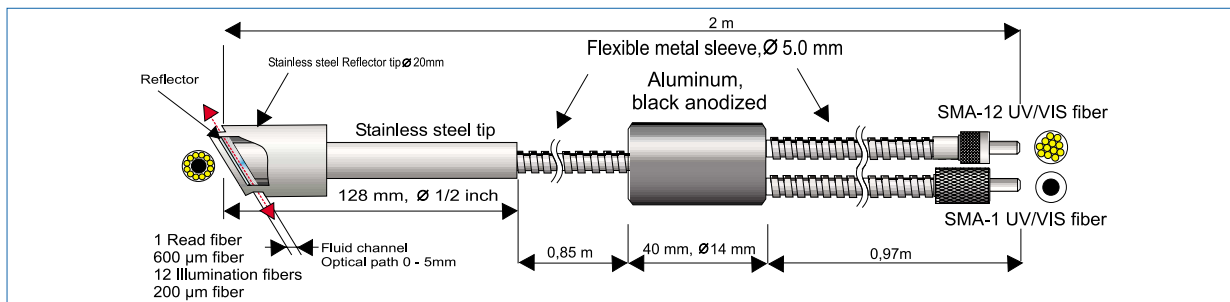
For fluorescence applications a special reflection probe was developed with 12 excitation fibers of 200µm around a 600µm read fiber, that takes the fluorescence signal back to the spectrometer.

A special reflector accessory FCR-FLTIP-IND is attached to the probe end to turn the 45° reflection probe into a fluorescence probe. The accessory prevents ambient light entering the probe and backscatters the excitation light to increase the fluorescence signal. The fluid channel path can be varied between 0 and 5 mm.



### Technical Data

<b>Fibers Illumination</b>	12 fibers of 200µm, UV/VIS
<b>Fibers Detection</b>	1 fiber 600µm
<b>Wavelength Range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connector</b>	2 x SMA 905
<b>Probe End</b>	Stainless steel cylinder, 128 mm long x 12,7 mm (1/2") diameter. The probe end contains a ca. 10 mm diam. x 1 mm thick sapphire window with anti-reflection coating. The probe tip is exchangeable and waterproof
<b>Fluorescence Accessory</b>	See drawing below
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5,0 mm Optionally a waterproof, steel reinforced, silicon tubing can be provided
<b>Temperature</b>	-30 °C to 100 °C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 60 mm, long term: 180 mm



### ORDERING INFORMATION

<b>FCR-UV200/600-2-IND</b>	1/2" Reflection Probe for fluorescence applications
<b>FCR-FLTIP-IND</b>	Fluorescence Reflector Accessory for 1/2" FCR-UV200/600-2-IND probes

## Micro Transmission Dip Probe

The Micro Transmission Dip Probe is a miniature transmission probe for micro-liter sampling.

The miniaturized tip of only 1,6 mm diameter enables sampling in all micro centrifuge tubes available on the market.

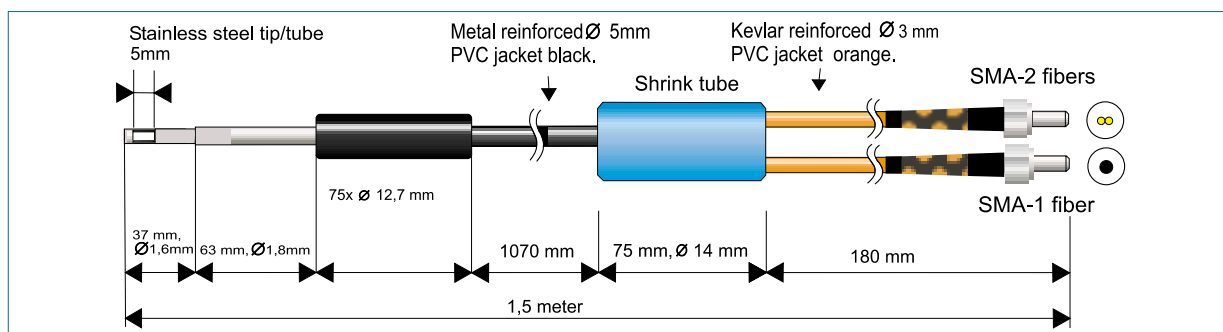
The micro Dip Probe can be supplied with a 2, 5 or 10 mm optical path length and can be used in a wavelength range from 230-1100 nm.

The distance for the optical path from the probe end is 7 mm, the probe has 2 SMA connectors to conveniently couple to the Avantes line of spectrometers and light sources. The probe has 3 UV/VIS fibers of 400 μm, 2 for illumination and 1 for detection.



### Technical Data

<b>Fibers</b>	2 illumination fibers, 1 detection fiber, all 400μm, UV/VIS, standard 1.5 meters
<b>Wavelength Range</b>	230-1100 nm
<b>Connectors</b>	2 x SMA 905
<b>Probe End</b>	Stainless steel cylinder, 37 mm long x 1.6 mm (1/16" ) diameter, then 63 x 1.8 mm. The probe end can be delivered with 3 different path lengths: 1 mm physical gap – 2 mm optical path, 2.5 mm physical gap– 5 mm optical path and 5 mm physical gap– 10 mm optical path
<b>Tubing</b>	The optical fibers are protected by a metal reinforced PVC outer tubing. The tubing also gives stress relieve. OD: 5,0 mm. Total probe length 1.5 m
<b>Temperature</b>	0 °C to 65 °C.
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 40 mm, long term: 120 mm



### ORDERING INFORMATION

<b>FDP-UV-MICRO-1</b>	1/16" Micro Dip Probe, UV/VIS, 1 mm gap (2 mm optical path), 1.5m
<b>FDP-UV-MICRO-2.5</b>	1/16" Micro Dip Probe, UV/VIS, 2.5 mm gap (5 mm optical path), 1.5m
<b>FDP-UV-MICRO-5</b>	1/16" Micro Dip Probe, UV/VIS, 5 mm gap (10 mm optical path), 1.5m





## Mini Transmission Dip Probe

The Mini Transmission Dip Probe is a miniature transmission probe for absorption measurements.

The miniaturized tip of only 3,2 mm (1/8") diameter enables sampling in most miniaturized centrifuge tubes available on the market.

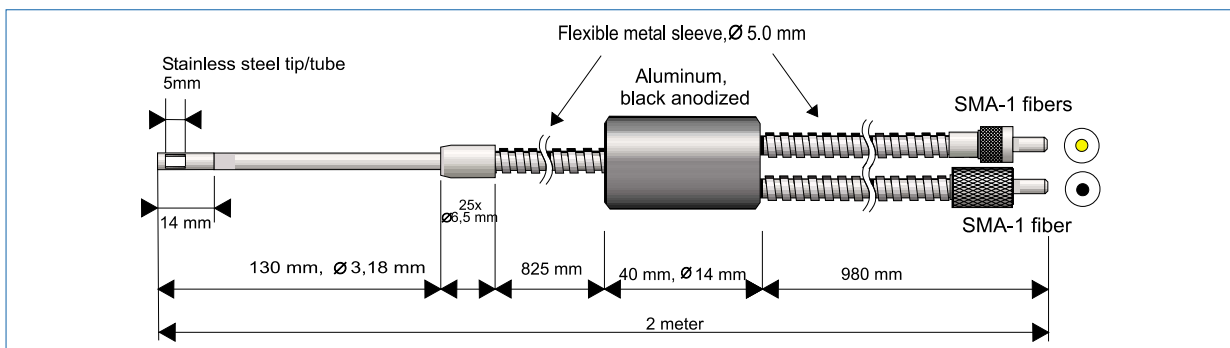
The mini Dip Probe has a 10 mm optical path length and can be used in the UV/VIS (200-800 nm) or VIS/NIR wavelength range (350-2000 nm).

The probe has 2 SMA connectors to conveniently couple to the Avantes line of spectrometers and light sources.



### Technical Data

<b>Fibers</b>	1 illumination and 1 detection fiber, both 200 $\mu\text{m}$ , standard 2 meters length
<b>Wavelength Range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	2 x SMA 905
<b>Probe End</b>	Stainless steel cylinder, 130 mm long x 3,2 mm (1/8") diameter. The probe end contains 5 mm physical, 10 mm optical path
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5,0 mm.
<b>Temperature</b>	-30 $^{\circ}\text{C}$ to 100 $^{\circ}\text{C}$ . (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FDP-2UV200-2-5-MINI</b>	1/8" Mini Dip Probe, 5 mm gap (optical path length 10mm), UV/VIS, 2m length
<b>FDP-2IR200-2-5-MINI</b>	1/8" Mini Dip Probe, 5 mm gap (optical path length 10mm), VIS/NIR, 2m length

## Transmission Dip Probe

The transmission dip probe is used to obtain online and in-line absorbance measurements in fluids. By dipping or permanently mounting the probe end into the fluid stream, the absorbance is measured.

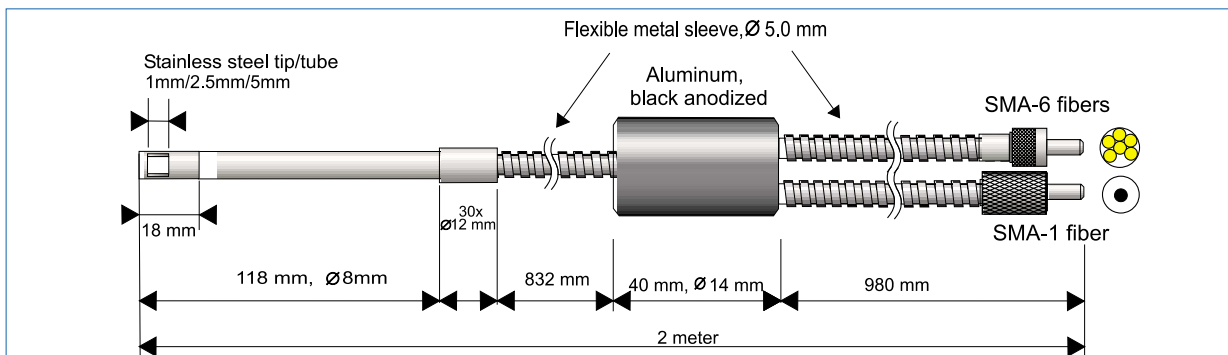
Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end, where it crosses a gap of 1, 2.5 or 5 mm and reflects against a diffuse white material. Back reflected light returns into a 7<sup>th</sup> fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or spectral analyzer.

At the probe end the read fiber is placed in the middle of the lighting fibers for best efficiency of the probe. Both bundles are led through one piece of flexible stainless steel tubing. In a ferrule they are split and run separated for one meter to reach the SMA905 connectors.



### Technical Data

<b>Fibers</b>	6 illumination fibers, 1 detection fiber, all 200µm, UV/VIS, standard 2 meters
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Tips</b>	Replacement tips are available with 1, 2.5 and 5mm spacing, i.e. an optical path of 2, 5 or 10 mm and contain a 5 mm diam. x 1 mm thick fused silica window
<b>Probe end</b>	Stainless steel cylinder, 100 mm long x 8,0 mm diameter. Waterproof
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5.0 mm
<b>Temperature</b>	-30°C to 100°C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FDP-7UV200-2-yy</b>	Transmission Dip Probe, UV/VIS, yy (1, 2.5, 5 mm) gap, 2 m length, SMA term.
<b>FDP-7IR200-2-yy</b>	Transmission Dip Probe, VIS/NIR, yy (1, 2.5, 5 mm) gap, 2 m length, SMA term.
<b>FDP-TIP-yy</b>	Replacement tips, 1 mm, 2.5 mm, 5 mm gap for probe (Fill in gap for yy, note optical path = 2*yy)



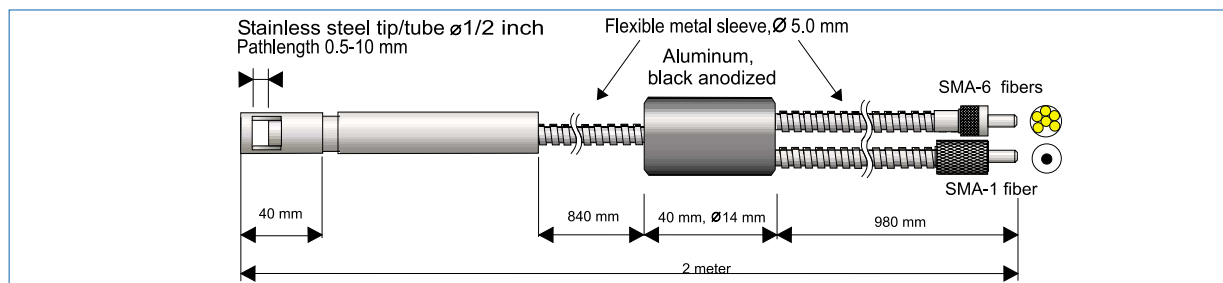
## Transmission Dip Probe with Variable Path Length

The transmission dip probe with variable path length can be used to obtain online and inline absorbance measurements in fluids. The 1/2" Probe has an optical path length, which can be set by the user in a range from 0.5 mm to 20 mm and is therefore extremely versatile for high- or low-absorption fluids. The probe end is simply dipped into the fluid to do the measurements. Via a standard SMA905 connector light is coupled into a fiber bundle, consisting of 6 fibers and carried to the probe end, where it crosses a user-defined physical gap of 0.25-10 mm and reflects against a diffuse white material. The back reflected light returns into a 7<sup>th</sup> fiber. This fiber transfers the data to the output SMA905 connector, which can be coupled to a spectrometer or spectral analyzer. At the probe end the read fiber is placed in the middle of the lighting fibers for best efficiency of the probe. Both bundles are led through one piece of flexible stainless steel tubing. In a ferrule they are split and run separated for one meter to reach the SMA905 connectors.



### Technical Data

<b>Fibers</b>	6 illumination fibers, 1 detection fiber, all 200µm, UV/VIS, standard 2 meters
<b>Wavelength range</b>	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
<b>Connectors</b>	SMA905 connectors (2x)
<b>Optical Path</b>	0.25 - 10 mm physical gap, i.e. an optical path of 0.5-20 mm
<b>Probe end</b>	Stainless steel or PEEK cylinder, 140-160 mm long x 12,7 mm (1/2") diameter. Waterproof
<b>Tubing</b>	The optical fibers are protected by a silicon inner tube and a flexible chrome plated brass outer tubing. The tubing also gives stress relieve. OD: 5,0 mm. Optionally a waterproof, steel reinforced, silicon tubing can be provided
<b>Temperature</b>	-30°C to 100°C. (High Temperature Probes available on request)
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 20 mm, long term: 60 mm



### ORDERING INFORMATION

<b>FDP-7UV200-2-VAR</b>	Transmission Dip Probe in SS with variable tip length, UV/VIS, 2 m length, SMA term
<b>FDP-7IR200-2-VAR</b>	Transmission Dip Probe in SS with variable tip length, VIS/NIR, 2 m length, SMA term
<b>FDP-7UV200-2-VAR-PK</b>	Transmission Dip Probe in PEEK for corrosive fluids with variable tip length, UV/VIS, 2 m, SMA term
<b>FDP-7IR200-2-VAR-PK</b>	Transmission Dip Probe in PEEK for corrosive fluids with variable tip length, VIS/NIR, 2 m, SMA term
<b>FDP-TIP-VAR</b>	Replacement Stainless Steel tip for Transmission dip probe with variable tip length
<b>FDP-TIP-VAR-PEEK</b>	Replacement PEEK tip for Transmission dip probe with variable tip length

## Transmission Dip Probe with Disposable Tip

FDP-VERSA

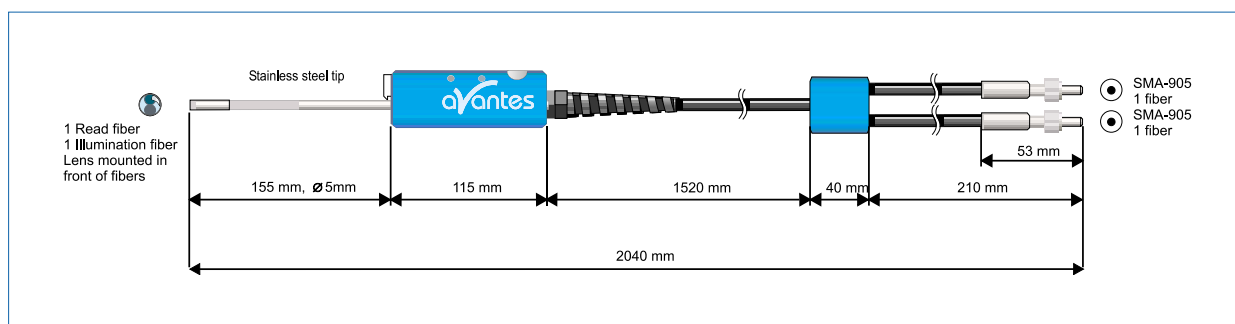


For absorption measurements in fluids a special dip probe is available with disposable tip.

The low-cost disposable tip contains a mirror coating on a quartz tube and can be easily replaced by just a click on the side of the probe. The advantages of the disposable tips are that no cleaning between measurements is necessary anymore and there is no carryover from one sample to the other. The disposable tips are available in different pathlengths and can be delivered with custom specific coatings

### Technical Data

<b>Fibers Illumination</b>	1 fiber 600µm UV/VIS, standard 2 meters length
<b>Fibers Detection</b>	1 fiber 600µm UV/VIS, standard 2 meters length
<b>Wavelength Range</b>	200-1100 nm (UV/VIS)
<b>Connector</b>	2 x SMA 905
<b>Probe End</b>	Stainless steel cylinder, 150 mm long x 8 mm diameter.
<b>Disposable tip</b>	Quartz, tip clearance 10.6 mm, available in path lengths of 2, 10 and 20 mm
<b>Tubing</b>	The optical fibers are protected by a PVC coated monocoil. OD: 5,0 mm Optionally a waterproof, steel reinforced, silicon tubing can be provided
<b>Temperature</b>	-40 °C to 125 °C
<b>Bending</b>	Minimum bend radius: Short term (few seconds) 120 mm, long term: 240 mm



### ORDERING INFORMATION

<b>FDP-UV600-2-VERSA</b>	Transmission Dip Probe, 2m long
<b>Versatip-2</b>	Quartz exchangeable Tip, 2mm optical path length
<b>Versatip-10</b>	Quartz exchangeable Tip, 10mm optical path length
<b>Versatip-20</b>	Quartz exchangeable Tip, 20mm optical path length

## Collimating Lens

COL-UV/VIS



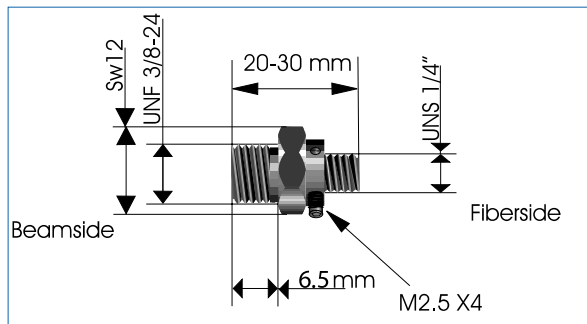
The collimating lenses convert divergent beams of light into a parallel beam. The lenses are optimized for the UV/VIS/NIR range, are SMA terminated for coupling to optical fiber assemblies and have anodized aluminum housings. The focal point can be adjusted.

COL-UV/VIS-90

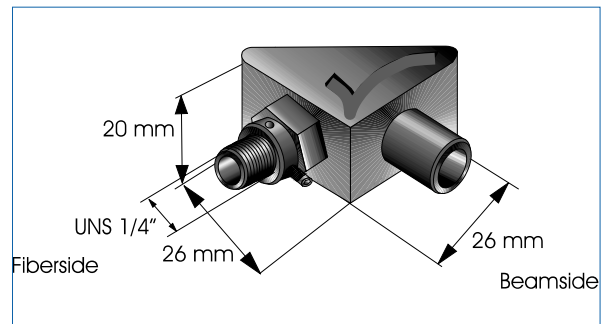


The COL-UV/VIS-90 is used to have the collimated light exit under a 90-degree angle. Optionally an FC/PC connector can be offered as well. The FCR-COL is available to mount on to a 1/4 " reflection probe to focus the measurement spot on an extended distance.

COL-UV/VIS



COL-UV/VIS-90



### Technical Data

Lens Diameter	6 mm
Lens confocal length	8.7 mm
Lens Material	Fused Silica
Wavelength range	200-2000nm
Fiber connection	SMA 905, UNS 1/4" (standard, FC/PC also possible)
Mirror reflectivity (for COL-UV-90)	>90% (200-1100nm)
Housing Material	Aluminum black anodized
Thread	UNF 3/8"-24
Temperature	-30 °C to 100 °C. (High Temperature assemblies available on request)

### ORDERING INFORMATION

COL-UV/VIS	Collimating lens for UV/VIS/NIR, incl. SMA adapter and adj. focus
COL-UV/VIS-FCPC	Collimating lens for UV/VIS/NIR, incl. FC/PC adapter, adj. focus
COL-UV/VIS-90	Collimating lens under 90 degrees for UV/VIS/NIR, incl. SMA adapter
FCR-COL	Adjustable UV/VIS/NIR Collimating/focussing lens for FCR probes

## Cosine corrector

### CC-UV/VIS

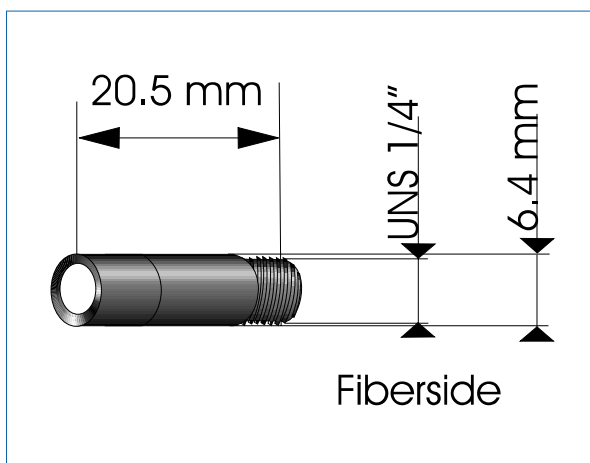


The CC-UV/VIS cosine corrector is a spectro radiometric sampling optic designed to collect radiation (light) over 180°, thus eliminating optical interface problems associated with the light collection sampling geometry inherent to other sampling devices.

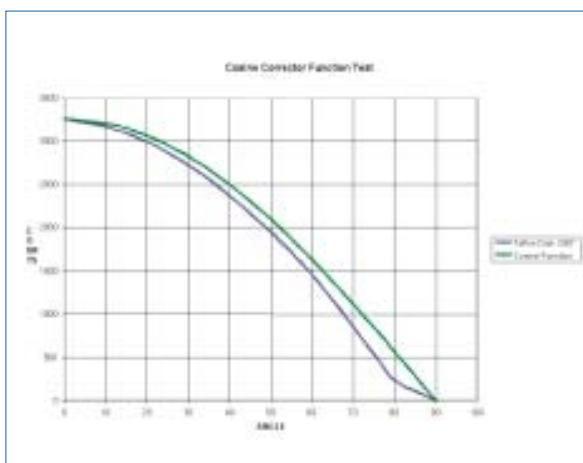
The CC-UV/VIS cosine corrector has teflon diffusing material and is optimized for applications from 200-1100 nm. The CC-UV/VIS cosine corrector screws onto the end of any SMA-terminated optical fiber. When coupled to a miniature fiber optic spectrometer, these cosine correctors can be used to measure UV-A and UV-B solar radiation, environmental light, lamps and other emission sources.

The CC-UV/VIS Cosine Corrector has a 0.25" O.D. barrel with a smooth yet rugged black oxide finish. The diffusing material is a thin disk that fits at the end of the barrel. The cosine corrector has an SMA 905 connector for convenient coupling to optical fibers.

### CC-UV/VIS



### CC-UV/VIS Angular response



### Technical Data

Diffusing material	Teflon (200-1100 nm), ca. 1mm thick
Barrel dimension	0.25" O.D.
Sampling geometry	accepts light at/from 180° FOV
Connector	SMA 905
Temperature	-60 °C to 200 °C

### ORDERING INFORMATION

CC-UV/VIS	Cosine corrector for UV/VIS/NIR, incl. SMA adapter
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## Vacuum Feedthrough

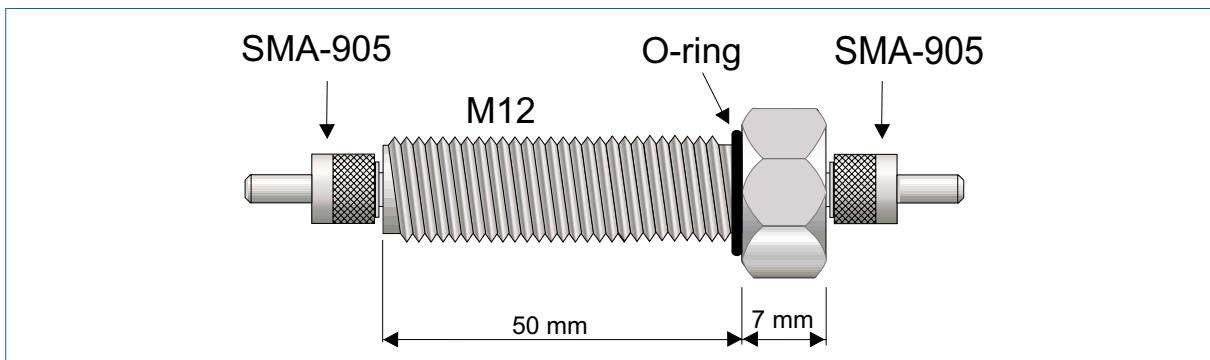
The FC-VFT vacuum feedthroughs are designed for use of fiber optics in vacuum chambers, such as for plasma monitoring. The vacuum feedthrough consists of an M12 housing with Viton® O-ring and 2 SMA fiber optic interconnects to allow easily coupling to fiber optic cables and probes. The vacuum feedthrough can be delivered for all fiber diameters, such as 50 µm up to 1000 µm for UV/VIS as well as for VIS/NIR.

### FC-VFT



### Technical Data

Fibers	1 fiber, diameter 50 µm/100 µm/200 µm/400 µm or 600 µm
Wavelength range	200-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
Connectors	Standard SMA905 connectors (2x)
Wall thickness of vacuum chamber	5-40 mm
Vacuum	Max. 10 <sup>-7</sup> mbar
Temperature	-40°C to 100°C. (High Temperatures available on request)



ORDERING INFORMATION (Specify xx = UV for UV/VIS, IR for VIS/NIR)	
FC-VFT-xx50	Vacuum feedthrough for 50 µm fibers, incl. SMA adapter
FC-VFT-xx100	Vacuum feedthrough for 100 µm fibers, incl. SMA adapter
FC-VFT-xx200	Vacuum feedthrough for 200 µm fibers, incl. SMA adapter
FC-VFT-xx400	Vacuum feedthrough for 400 µm fibers, incl. SMA adapter
FC-VFT-xx600	Vacuum feedthrough for 600 µm fibers, incl. SMA adapter
FC-VFT-xx800	Vacuum feedthrough for 800 µm fibers, incl. SMA adapter
FC-VFT-xx1000	Vacuum feedthrough for 1000 µm fibers, incl. SMA adapter

## Fiber Optic Mode Mixer

### MM-UV/VIS-SMA Mode mixer



The compact MM-UV/VIS-SMA Modemixer is made of stainless steel and anodized aluminum and allows the connection of two optical fibers with Standard-SMA-Connectors on the two ends of the product.

Key component is a high transmitting Suprasil-Rod with diameter of 3 mm. This part transmits the light from one to the other fiber. Afterwards the modes are perfectly mixed. The mode-mixer also works as a mode stripper. Typical applications are found when light from fiber (bundles) must be mixed and coupled into other fiber(bundles). Different types and fiber diameters are possible.

### Technical Data

Wavelength Range	180-2000nm
Optical Rod Diameter	3mm or 1 mm
Rod Material	Suprasil 1
Housing Material	Aluminum anodized / Stainless Steel
Fiber Connection	SMA 905, UNS 1/4"
Dimensions	Length 45mm, Diameter 9.5mm

### ORDERING INFORMATION

<b>MMA1-UV/VIS-SMA</b>	Modemixer / Modestripper 1mm UV/VIS diameter for SMA Connectors
<b>MMA3-UV/VIS-SMA</b>	Modemixer / Modestripper 3mm UV/VIS diameter for SMA Connectors



## Reflection Probe Holders

The RPH-1 Reflection probe holder is useful to fix an FCR standard reflection probe under an angle of 90 or 45 degrees, as mostly used for color measurements.

The 45 degrees angle is used for diffuse reflection measurements. The 90 degrees angle is used to measure specular reflection.

The holes have a 6,5 mm diameter and contain a setscrew to fix the probe in its position. The RPH measures 60 x 30 x 30 mm and is made of black anodized aluminum.

### RPH-1 Reflection Probe Holder



### AFH-15 Angled Fiber Holder



The AFH Angled Fiber Holder holder is useful to fix 1,5 mm diameter ferrule terminated fibers or reflection probes under 15°, 30°, 45°, 60°, 75° and 90° angles. In this way different reflection measurement setups can be made with multiple separate fibers for illumination and detection. A total of 11 holes have each a 1,6 mm diameter and contain a setscrew to fix the probe or fiber in its position. At the bottom is a 12 mm half round of space free to enable reflection in all directions. The AFH-15 is made of black anodized aluminum.

The AFH-Ocular was developed for reflection color measurements on small spot diameters (<0.5 mm). The ocular enables to precisely monitor the location of the measurement spot.

The holder is used for miniaturized reflection probes with 7 x 100 µm fibers and 1 mm outside diameter stainless steel tip. A black cover should be used during the measurement to cover the ocular from ambient light.

### AFH-Ocular



#### ORDERING INFORMATION

ORDERING INFORMATION	
<b>RPH-1</b>	Reflection probe holder for 45/90 degree mounting of 1/4" reflection probes
<b>AFH-15</b>	Angled fiber probe holder for measuring under different angles, needs 1,5 mm ferrule terminated fibers
<b>AFH-Ocular</b>	Angled fiber probe holder for precise measurements under 45 degrees incl. ocular

## Fiber Interconnects

SMA interconnect



ST interconnect



FC/PC interconnect



SMA Bulkhead



ST Bulkhead



FC/PC Bulkhead



The ME-FI-SM-MM SMA fiber interconnect and ME-SM-BC SMA Bulkhead are accessories for SMA-terminated optical fibers. Each connector consists of 1/4"-36 outside-thread female adapter for easy connection to any SMA-terminated optical fiber. For ST and FC/PC-connectors similar accessoi-

ries are available. The fiber interconnects may be useful for coupling patch cords to fiber optic probes and other devices, or for any multiple-fiber application where coupling of standard optical fibers and accessories is preferable to creating costly and complex fiber optic assemblies.

### ORDERING INFORMATION

ORDERING INFORMATION	
ME-FI-SM-MM	SMA Fiber interconnect, panel mountable
ME-FI-ST-MM	ST Fiber interconnect, panel mountable
ME-FI-FCPC-MM	FC/PC Fiber interconnect, panel mountable
ME-SM-BC	SMA bulkhead adapter to TO-18
ME-SM-BC-S	SMA bulkhead adapter to TO-5
ME-ST-BC	ST Bulkhead adapter
ME-FCPC-BC	FC/PC Bulkhead adapter