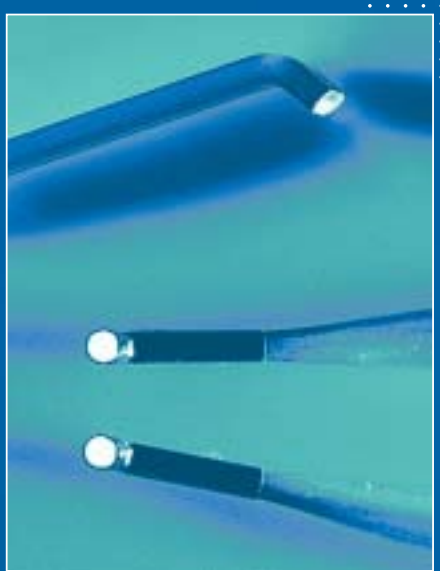


Medical fiber optic components

Hightech solutions for health

SCHOTT
glass made of ideas

Contents

Generations
of Know-how as Clear as Glass

With every one of our products you get more than 100 years of experience

More than 100 years ago Otto Schott realized the importance of glass as a raw material. In the course of his extensive research into optical glass, he discovered that the composition of this material could be influenced by chemical means. His first invention, lithium glass, has been followed up to the present day by more than 400 other types of optical and special glasses.

Applications for glass as a material are incredibly diverse with new ones being revealed all the time. Working closely with our customers, SCHOTT research workers and scientists are constantly seeking and finding new solutions for a variety of problems. There are approx. 600 people worldwide involved in Research and Development at SCHOTT.

Fiber Optics is a Business Segment of SCHOTT Glas and belongs to the Strategic Business Unit Opto-Electronics, one of five businesses of the SCHOTT Group. The Business Segment employs more than 800 people and has six locations in five countries:

- SCHOTT Glas, Fiber Optics Division (Mainz, Germany; Headquarter of the Business Segment)
- SCHOTT Fibre Optics UK (Doncaster/UK)
- SCHOTT Fostec (Auburn, NY, USA)
- SCHOTT Fiber Optics (Southbridge, MA, USA)
- Danseur s.r.o. (Valasské Mezirící, Czech Republik)
- SCHOTT Fiber Optics Nippon (Tokyo, Japan)

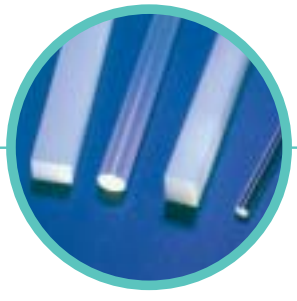
For more than 30 years, SCHOTT has developed fiber optic products for a diverse range of applications. Our name stands for high quality and innovative solutions in the field of fiber optic imaging and illumination.

The Fiber Optic Business Segment offers systems and components for medical and industrial applications as well as for automotive lighting, signage, architectural lighting and imaging applications.

Core Competencies

Our core competencies are in:

- **Glass melting** (own melting facilities, continuous improvement of existing and development of new glass types and innovative melting processes)
- **Fiber drawing** (production of 120,000 km glass fiber per day)
- **Assembly processes** (automated fiber harness production, epoxied and fused fiber assembling, optical finishing and inspection)
- **Imaging Fiber Optics** (flexible and fused high resolution coherent imaging components)



Our global business is divided into five product groups enabling a flexible and focused response to our customers.

Healthcare

Products: Special and standard fibers for illumination, flexible image bundles, imaging tapers and faceplates, light conducting tapers and rods, flexible light guides and laser delivery systems.
Applications: Endoscopy, surgical microscopy, surgical and diagnostic instruments, dental handpieces, dental filler curing, intraoral cameras, light therapy for infant jaundice treatment, clinical and laboratory diagnostics, ophthalmic lasers, X-ray imaging, photo-dynamic therapy (PDT) and light therapy.

Product Groups and Products

Industrial

Products: Customer specific linelights, hotformed light guides, light conducting rods, flexible image guides, multi-branch cable light guides, custom components, LED lighting components, cold light sources and accessories.
Applications: Stereo microscopy, machine vision, industrial illumination, thyristor control, sensors, etc.

Lighting

Products: Lighting systems and components, light sources, filters, fittings.
Applications: Architectural and decorative lighting, showcase lighting, road guidance systems, directional signs, alphanumerical signs.

Automotive

Products: Light guides for position lights and door lights. Glass fiber optic components for automotive data transmission systems.
Applications: Headlamps, illumination and design, databus applications.

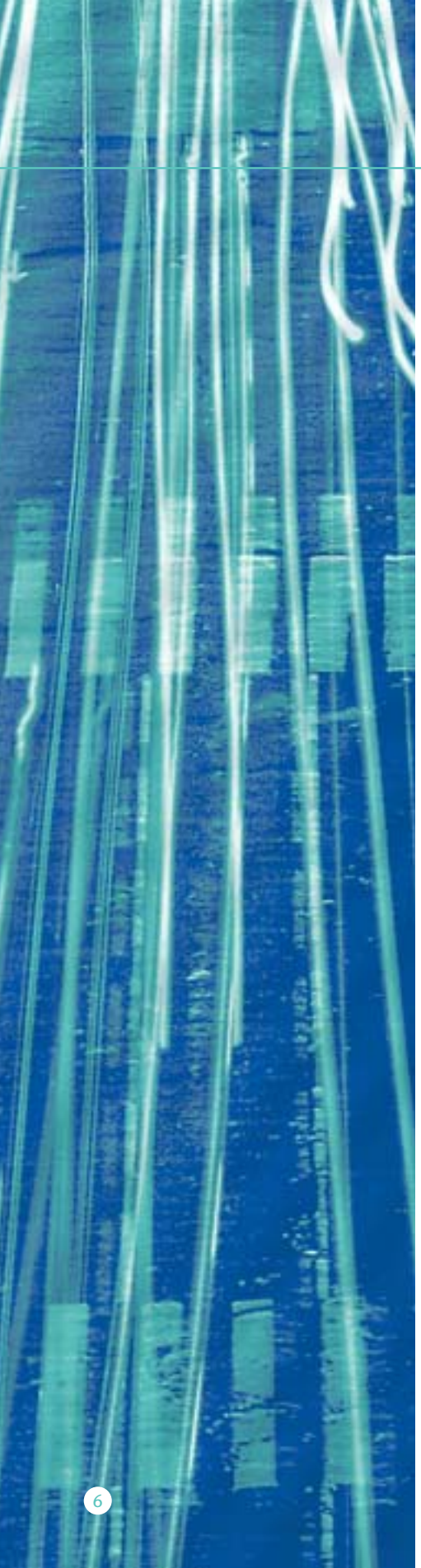
Imaging

Products: Fused fiber optic tapers and faceplates, flexible image bundles.
Applications: Night vision/Image intensification, medical and dental X-ray applications, endoscopy.

Customer ideas combined with SCHOTT's fiber optic expertise and creativity result in innovative new products that enable our customers' success

New fiber optic components for healthcare industry applications are the outcome of very close collaborations with our customers. Customer ideas based on knowledge of their industry, coupled with SCHOTT's fiber optic technology result in new products with clear benefits to the market.

Our ISO 9001 registration is a guarantee to you that the highest quality standards are maintained. We will continue to carry out further research and development in the future to constantly improve our products. We strive to be your single source fiber optics specialist to provide support during development stages from basic research and prototyping through mass production with competence, creativity and support.

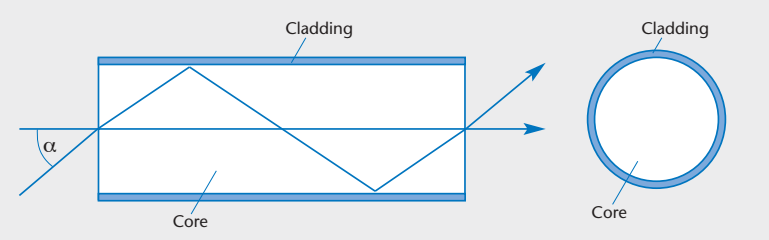


A Highway for Light

The physical principles and properties of fiber optic components

Optical fibers are the heart of all fiber optic components. Every optical fiber consists of a core with a high refractive index and a cladding with a low refractive index. Light rays which enter the fiber at one end are guided along the core by total internal reflection at the core/cladding interface. The light rays follow all the bends in the fiber and exit the fiber at its other end.
Bundles of optical fibers are combined with appropriate end terminations and protective sheathing to form light guides and image guides.
SCHOTT incorporates such fiber bundles into a multitude of engineered components by modifying their properties to suit the particular application.
The three most important characteristics of an individual fiber are its:

- Numerical aperture
- Spectral transmission
- Diameter



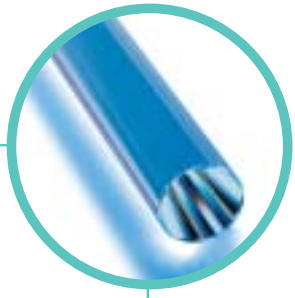
The principle of light transmission in an optical fiber

Numerical aperture

The numerical aperture of an optical fiber depends on the refractive indices of the two types of glass used for the core and the cladding.
The equation: $NA = n_0 \cdot \sin \alpha_0 = \sqrt{n_1^2 - n_2^2}$ applies to light rays which intersect the optical axis of a fiber. For simplicity it can be used for a light guide where:

n_0 = Refractive index of the surrounding medium
n_1 = Refractive index of the fiber core
n_2 = Refractive index of the fiber cladding
α_0 = Critical angle to the optical axis.

All light rays which strike the perpendicular polished end face of the light guide at an angle of $\alpha \leq \alpha_0$ are transmitted along the fiber.



Spectral transmission

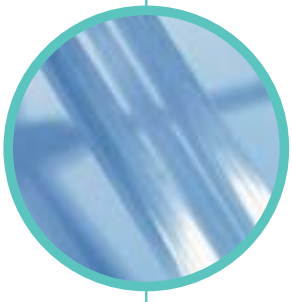
As light is transmitted through a fiber its intensity decreases. The relationship between the input intensity and the output intensity defines the spectral transmission $\tau(\lambda)$. The spectral transmission depends on three factors:

- Absorption losses in core glasses. These losses are mainly caused by unavoidable trace of elements metal oxides. Rayleigh light scattering results from a natural density fluctuation in the glass melt. These losses are proportionate to the length of the light guide.
- Losses resulting from less than ideal total reflection at the core/cladding interface depend greatly on the angle at which the light enters the fiber, also impacting the total number of reflections accumulated over the whole length of the fiber. The greater the number of reflections, the higher the loss.
- Fresnel reflection losses – at the input and output surfaces amount to approximately 11 % combined.

Fiber diameters

To ensure total internal reflection, the fiber cladding must have a minimum thickness of 2 µm for the visible range of the spectrum. An improvement in the optical efficiency can be achieved by increasing the diameter of the fiber without increasing the thickness of the cladding. This, however, results in a loss of flexibility. For the majority of applications an optimum relationship between transmission and flexibility is achieved with a fiber diameter of 70 µm.

The spectral transmission of fiber optic components is also influenced by an additional factor. As a result of round fibers being bundled together, interstitial gaps occur between the fibers, the gaps, like the glass cladding, do not transmit light.



Summary:
The spectral transmission of a light guide is essentially determined by the type and quality of glass used for the core and cladding, its absorption properties and the quality of the end terminations.

Medical Illumination

More scope for your creativity in product development

A fiber optic component fulfills the demands placed upon it if the characteristics of the light guide fibers are matched to the particular system requirement. SCHOTT fibers cover a broad spectral range; four fiber types for the visible range of the spectrum with different aperture angles, one for the UV range plus two special types to accommodate near IR and other conditions.

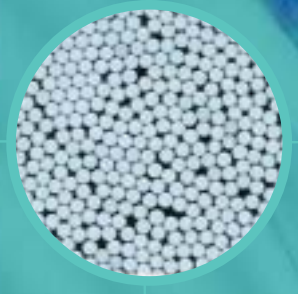
SCHOTT light guide fibers are available in three standard diameters:

- 30 µm
- 50 µm
- 70 µm

We will be happy to supply further information on special fibers and diameters on request.

Bonded ends

One method of end terminating a flexible fiber bundle is to bond the ends of the fibers within a ferrule with an adhesive. The required temperature for each application determines the choice of adhesive. For temperatures up to 200 °C a special bonding process is available. (See temperature resistance information.)

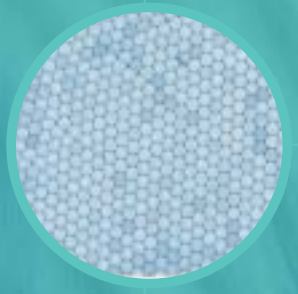


Bonded Fibers

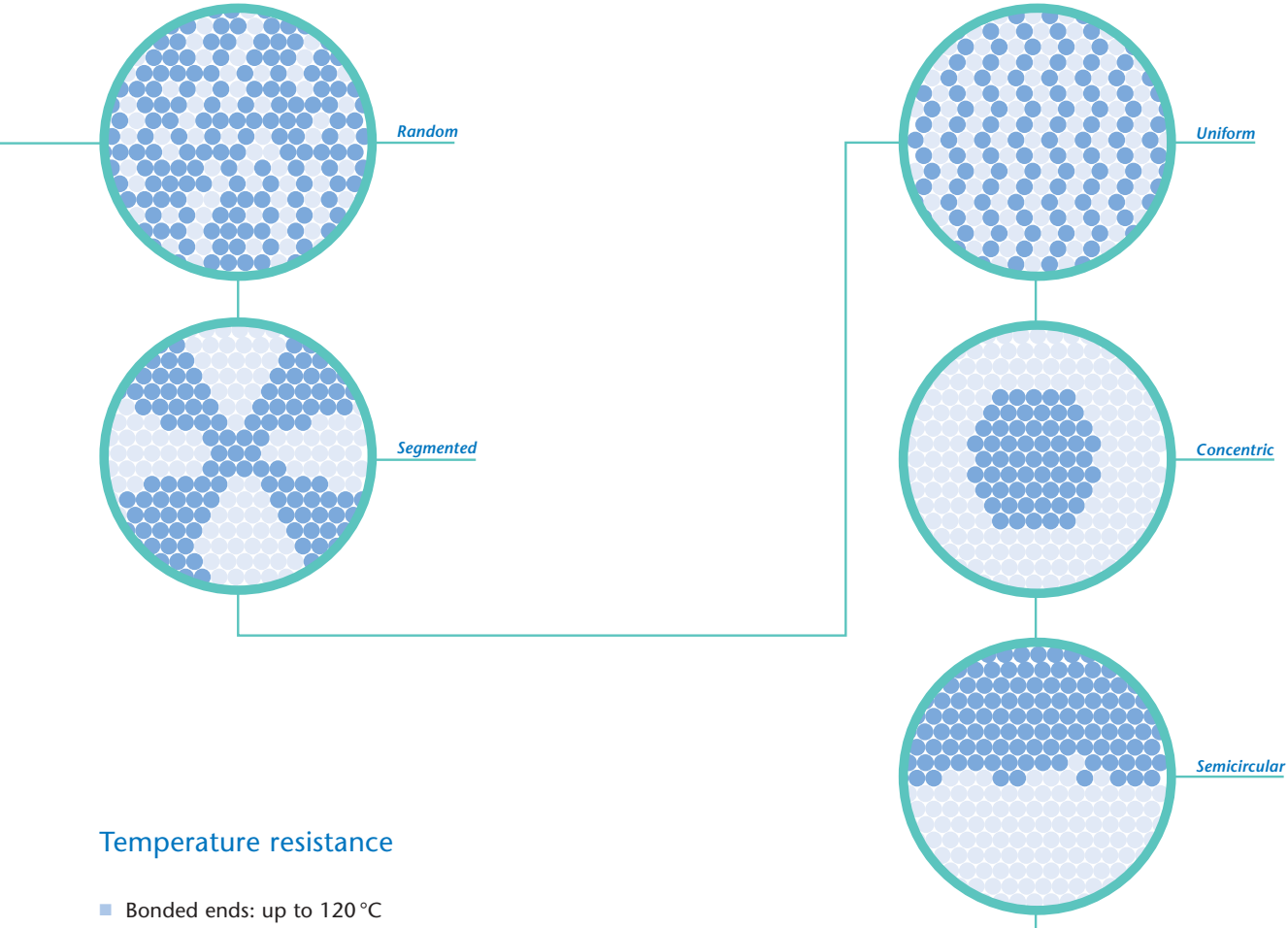
Fused ends

An end termination process developed by SCHOTT increases the long term operating safety of light guides in the upper temperature range to 350 °C. As a result of the fusing process the fibers change shape at the ends and become predominantly hexagonal so that gaps between the fibers are to a great extent eliminated. The same optical cross-section contains approximately 15 % more fibers compared to bonded ends thus resulting in a further benefit:

- The transmission is increased by approximately 15 %.



Fused Fibers

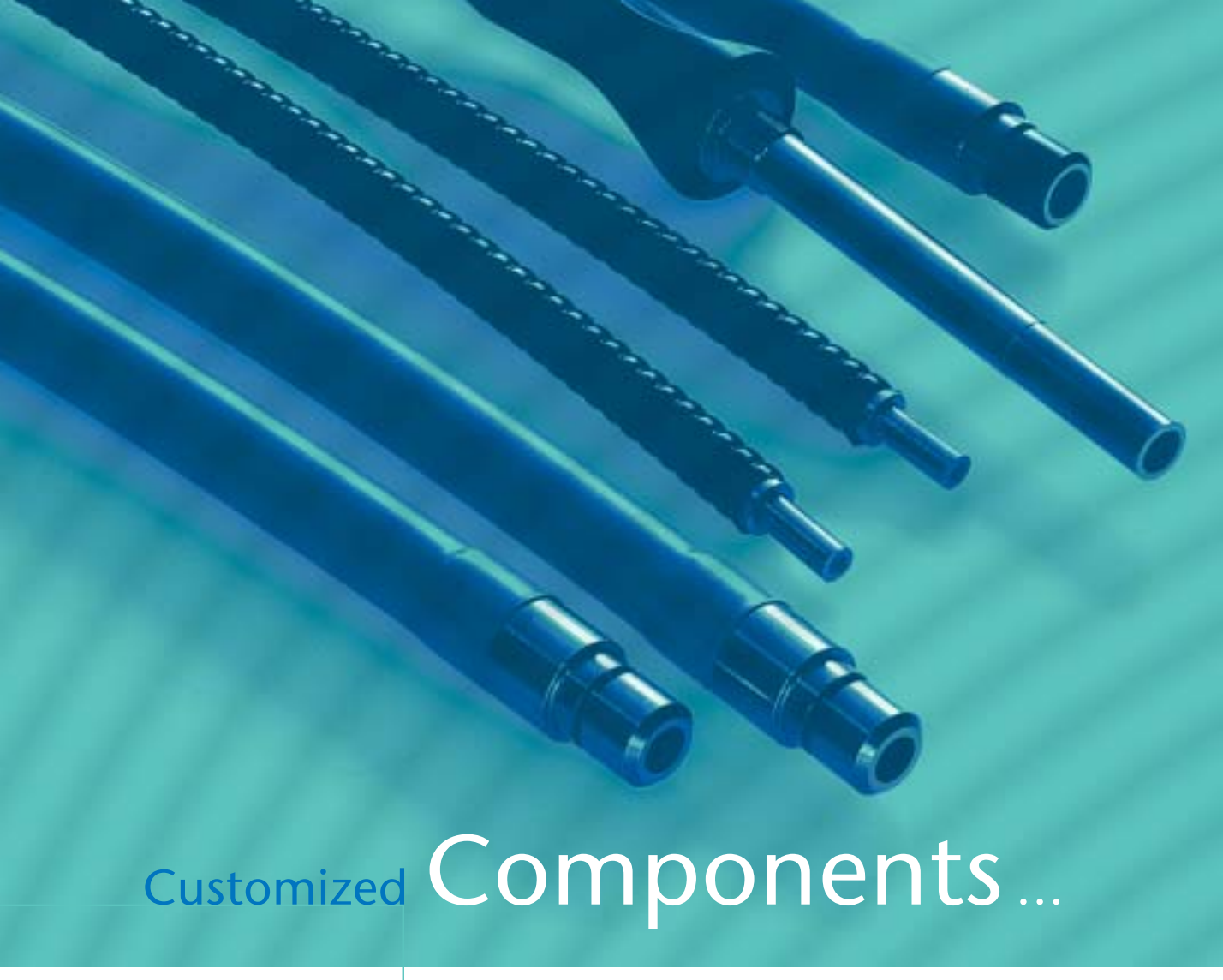


Temperature resistance

- Bonded ends: up to 120 °C
- Specially bonded ends: up to 200 °C
- Hot fused fibers made from multi-component glasses: up to 350 °C
- Hot fused fibers made from Quartz materials: up to 600 °C

The arrangement is the key

The arrangement of fibers within a light guide and/or end ferrule normally occurs arbitrarily during the manufacturing process. For certain applications, it can be useful to arrange the fibers in either a randomized or specific pattern. For example, in the case of multi-branch light guides, the fibers from the individual branches, which are brought together in a common end, can be mixed randomly so as to evenly distribute the energy from each location. The graphics on this page show several examples of these patterns. We would be pleased to recommend the most suitable for your application.



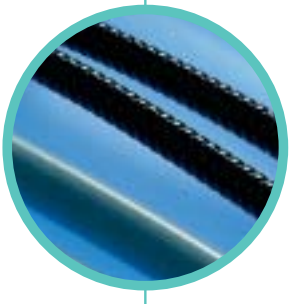
Customized Components ...

We manufacture custom components to meet your specifications

Our specialists will work together with you on the fiber optic design for your particular application. Beginning with your basic technical requirements, we can jointly draw up a plan of action addressing each stage leading to full production. During this process, we will provide you with complete assistance through the prototype and sample phases to ensure that everything is ready for a seamless transition into mass production.

Protective sheathing for long service life

Successful use and installation of components depends on the use of sheathing suitable for the particular application. The range of applications for fiber optic light guides is extremely wide and the requirements for the protection of the fiber optic components are equally varied. The two types of sheathing described here have proved to be highly suitable for many healthcare applications.



SZ Sheathing

- Smooth, easily cleaned surface
- Autoclavable with special bonding
- High mechanical load capability
- Material: stainless steel tube with braided fiberglass layer and silicone rubber outer covering
- Color: gray

End ferrules

End ferrules for bonded light guides are aluminum, brass, stainless steel, nickel silver or other specified to customer materials.

Stainless steel is used exclusively for end ferrules for hot fused components.

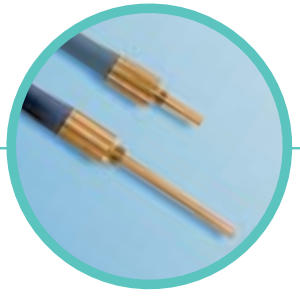
Metal/PVC Sheathing

- Flexible and waterproof
- Temperature range approximately –5 °C to 80 °C
- Colors: gray or black
- Material: PVC

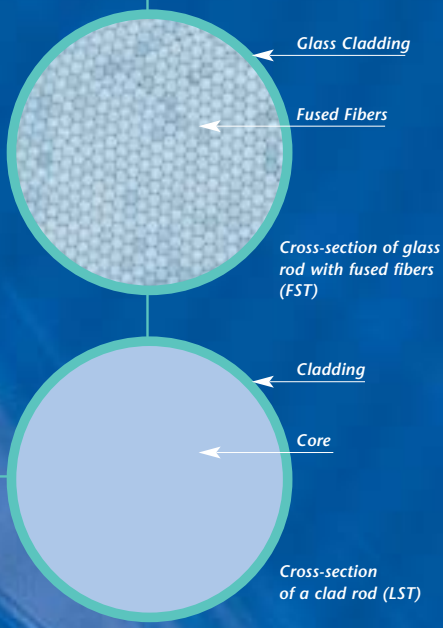
If you have special sheathing requirements we will be happy to advise you; we can also incorporate sheathing provided by you.

Housings

If requested we can manufacture housings to your specifications. Typical housing materials are: nickel, silver aluminum, stainless steel and various plastics.



Dental Illumination



More scope for your creativity in product development

New applications require our customers to continually demand more from their fiber optic components. These challenges have led to the development of various types of rigid light-conducting rods. SCHOTT currently manufactures straight, bent and cone type light-conducting rods with different diameters and different ranges of the spectrum. Light-conducting rods are ideal for the transmission of light over short distances if flexibility is not necessary or desirable. SCHOTT's specially selected glasses make these components more mechanically durable (reduced chipping) while being the most autoclavable in the market. Light conducting rods for dental curing applications have significant advantages:

- High transmission
- High temperature resistance
- Extremely suitable for autoclaving
- Reduction or enlargement of optically effective cross-sections and acceptance angles through cone shaped fiber rods (fiber cones).

SCHOTT has different types of clad rods (LST) and fiber rods (FST) in its product range.

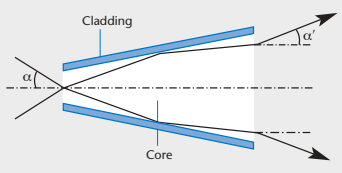
Type LST: The clad rod type LST is suitable for the visible and near infrared range and is characterized by its high light transmission. Both core and cladding are made of glass.

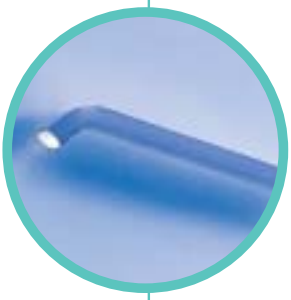
Type LST-IR: Type LST-IR is a glass/glass combination. This type is used for applications in the near IR up to wavelengths of approx. 2.5 µm.

Type FST: The difference between type LST and type FST light-conducting rods is that the FST type transmits the light with practically no change in its cross sectional energy distribution from its entry to its exit. This property is retained even in the case of bent or shaped fiber rods as used in dental handpieces. SCHOTT has developed special processes for bending fiber rods. Bent fiber rods are used in dentistry for hardening tooth-filling composites.

Customized Components ...

Type FSK: Type FSK light-conducting cones are fiber rods drawn out into a cone shape. This tapering effect causes the angles of acceptance at the input and output faces to be different (see graphic). Like fiber rods, fiber cones are used in dentistry for increasing light curing intensity, and in endoscopy for connecting light guides and/or components of different diameters.

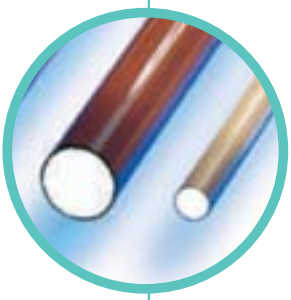




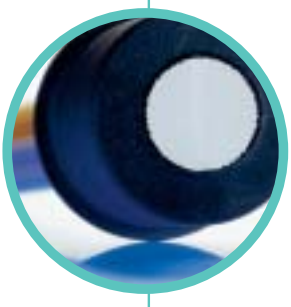
End finishing: The careful finishing of the end faces is an important stage in optimizing the performance of an optical component. Continuous inspection during the various manufacturing processes results in minimal process variation and a uniformly high level of quality. The grinding and polishing tools used are specifically designed for each particular component and are set up to ensure optimal processing.

Bending: SCHOTT has developed a semi-automated production process for the bending of fiber rods to comply with customer-specific design requirements. Such process controls ensure your products are the same every time.

Shaping: SCHOTT worked out a process to enable the geometry of fiber rods to be shaped precisely in accordance with customer requirements. Fiber rods shaped in this way are used in such components as high speed dental drills. SCHOTT has developed special glasses for these fiber rods in order to meet the ever more stringent hygiene requirements in sterilizing and autoclaving of equipment. SCHOTT light-conducting rods provide excellent transmission even after being subjected to thousands of cleaning and autoclaving cycles.



End ferrules: Fiber rods and cones are fitted with customer-specific coupling ferrules. SCHOTT uses own processes which guarantee a solid connection between the fiber rod and the ferrule that will withstand thousands of sterilizing and autoclaving cycles.

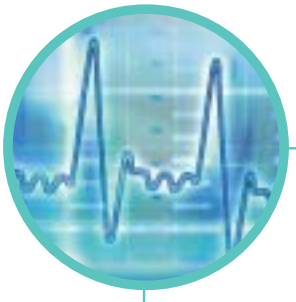


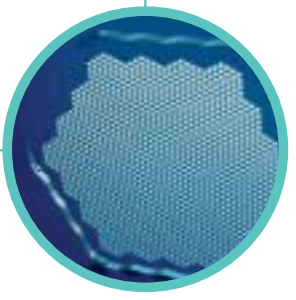
Sensor Components

SCHOTT's custom fibers and assemblies represent critical components in a myriad of sensor applications incorporating methods of spectroscopy and fluoroscopy. In today's healthcare industry, high throughput methods of molecular diagnostics are used in areas of clinical disease identification and drug discovery. SCHOTT's traditional fiber optics technologies as well as newly developed microarrays serve this area. In the expanding MRI environment, SCHOTT's custom components provide the conduit in monitoring patients' SPO2 and other vital signs. Other applications include systems which analyze blood coagulation to diagnose disorders and monitor post operative anticoagulant therapy.

In spectroscopy, single and multi-branched fiber optic components are used to transmit energy from a source to a specific medium, and translate the response from that medium to a detector for additional processing. SCHOTT's quality fibers and specialized construction materials and methods improve "signal to noise" and increase product sensitivity and performance for our OEM customers. Our flexible or rigid components are capable of transferring wavelengths UV through IR. Sturdy jacketing materials help protect the fibers even over distances of 30 feet.

Sophisticated hybrid assemblies further enhance the capabilities above by incorporating visual methods using SCHOTT's flexible image bundles. These next generation diagnostic and therapeutic devices will be used to detect and treat diseased tissue within the human body.





Medical Imaging

Leached Technology

SCHOTT's leached image bundles are utilized in a variety of fiber optic endoscopes found in today's medical, veterinary and industrial markets. Today's sophisticated ear, nose throat and urological procedures utilize high resolution flexible image bundles for image transfer.

Our wide range of sizes enable our bundles to be designed into larger diameter viewing scopes as well as smaller, multiple working channel instruments.

SCHOTT's high resolution, "zero broken" policy satisfies the stringent standards demanded by today's leading OEM's. Our solutions offer a "value" focused balance between quality, performance and cost.

Wound Technology

In addition to our "leached" image products, Schott also manufactures "wound" flexible image components. This alternative fiber ribbon stacking method produces larger rectangular image formats. Custom applications include vision systems found within the MRI.

SCHOTT is pleased to work with you to develop customized flexible fiber optic image bundles for your application.

Typical product range:

Leached Fiber Bundle outer diameter	Max. length	Effective imaging area	Fiber size	Fiber count
0.67 mm	1000 mm	0.60 mm	6.9 µm	~ 10000
1.00 mm	1000 mm	0.80 mm	8.2 µm	~ 13500
1.10 mm	1000 mm	0.90 mm	8.0 µm	~ 18000
1.20 mm	1000 mm	1.05 mm	8.4 µm	~ 18000

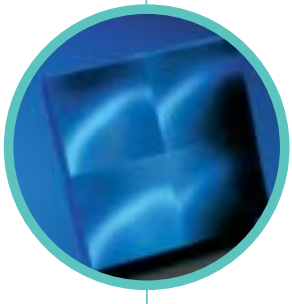
Faceplates

Faceplates

SCHOTT's fiber optic faceplates are used for high resolution, zero thickness image transfer in applications that include CCD coupling, CRT/LCD displays, image intensification, remote viewing, field flattening and X-ray imaging. Radiation attenuating faceplate materials are especially important for medical X-ray imaging applications.

All SCHOTT faceplates are designed to customer-specific requirements. Typical customized shapes range from round to rectangular and range in sizes up to 150 mm square; fiber sizes range from as small as 4.0 µm up to 25 µm or larger.

The standard numerical aperture is 1.0. Faceplates can be manufactured to meet vacuum tube requirements. They are also manufactured with various coefficients of thermal expansion to meet customer needs. SCHOTT's glass types are designed for use in the visible to near IR spectrum.



Tapers

Tapers

SCHOTT's fiber optic imaging tapers provide a reliable and efficient method of magnifying or minifying an image in image transfer applications. Fiber optic tapers are used in applications such as CCD coupling and X-ray imaging. Important features of SCHOTT's imaging tapers include high transmission efficiency, low image distortion, high resolution and small format.

All imaging tapers are fabricated to customer specific requirements and can be machined to your specific design requirements. Imaging taper sizes range up to 150 mm in diameter with typical magnification ratios up to 4:1. SCHOTT's imaging taper material provides for a numerical aperture of 1.0 on the small end.

Common fiber sizes range from 4 to 25 µm at the large end and are typically in the 3 to 6 µm range on the small end. SCHOTT's glass types are designed for use in the visible to near IR spectrum.

... and exactly what the customer wants

... to meet your requirements and specifications

There is a wide variety of applications in healthcare in which flexible and rigid fiber optic components by SCHOTT are used:

- Endoscopy
- Surgical microscopy
- Ophthalmology
- Dentistry
- Diagnosis and much more

The high level of requirements which healthcare imposes on the components used, such as the requirement for autoclavability, make fiber optic components the ideal solution. SCHOTT fiber optic components are the preferred choice of major OEMs. Our products are suited to autoclaving, ideal for transmitting light over long or short distances, and flexible to follow circuitous paths.

Our variety of fibers, ranging from narrow to wide angle, enable you to optimize your design to the illumination area desired. We can manufacture with either standard epoxy or specially developed fused end terminations for increased thermal resistance to better suit the variety of light source technologies available. If you would like to know more about SCHOTT fiber optic components, please use the enclosed fax form to request the appropriate leaflet and the relevant technical data sheets.

Wide variety of creative solutions

In cooperation with our partners, we are continually opening up new applications with fiber optical solutions. The starting point for these is our customers' ideas for new products or improvements to existing products.

Your ideas, our solutions

If you would like to know what fiber optics can do for your product area, please contact us. SCHOTT can provide competent advice and assistance in planning, in the development of product concept and design. Contacts Fax response:

for customers from Europe and Asia: please contact:

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SCHOTT
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