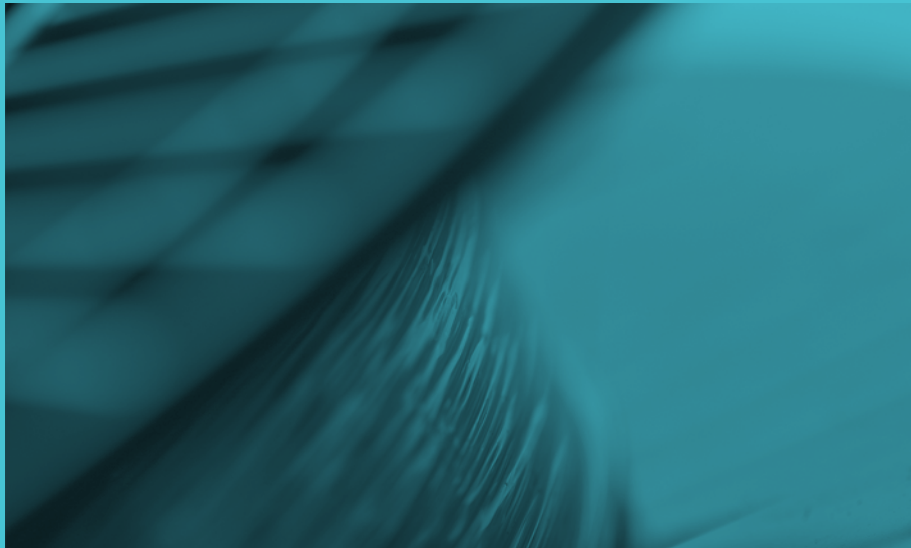


# Products & Services 2017



Insight | Innovation | Integrity

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# About Fibercore

**Fibercore has delivered over 30 years of innovation and excellence at the top of its profession, developing and manufacturing specialty optical fibers.**

The company continues to embody the spirit of innovation, technical excellence and quality, which has seen it flourish through the first three decades of monumental changes in both technology and its impact on society.

Established in 1982, Fibercore was formed as a spin-out from the world-renowned Optical Fiber Group of the University of Southampton, to offer the specialty optical fibers developed at the University, commercially.

Since 2003, Fibercore has increased its manufacturing capabilities ten-fold and introduced 'World-Class Manufacturing' philosophies to what was traditionally viewed as a scaled-up laboratory process. Our focus is firmly on the future, the recent expansion of the sales, marketing and development teams and the introduction of new photonics engineers into our skill base enables us to continue our commitment to the specialty fiber industry.

Fibercore products are used in an exceptionally broad and growing range of applications spread throughout more than 50 countries.

The applications include Oil & Gas, Fiber Optic Gyroscopes (FOGs), fiber optic hydrophones, fiber lasers, fiber amplifiers (EDFAs), current sensors, embedded sensors, medical devices, government and corporate research agencies and fibers for next generation telecommunications systems. The list just keeps on growing.

Fibercore's acquisition of Fibertronix places emphasis on an extended range of MM and SM fibers including graded index and pure silica core. In addition, the development of new double clad passive fibers extend our reach into the fiber laser and high power amplifier market. Continued advances in Fibercore's Multicore fiber technology have resulted in the availability of new Spun Multicore fiber for 3D shape sensing. Within FOG, further enhancements to birefringence and coating package design have kept our market-leading HB-G range at the top of the performance tree.

For more information about Fibercore, new products, career options [visit us at Fibercore.com](http://www.fibercore.com)

## SECTION 1



# Heritage

- |      |   |      |   |
|------|---|------|---|
| 1982 | Spun Low-Birefringence Fiber                                      | 2002 | 50µm, Low-Loss And Highly Bend-Insensitive Single-Mode Fiber  |
| 1983 | Bow-Tie Polarization Maintaining Fiber And Zing™ Polarizing Fiber | 2009 | Pure-Silica Core Single-Mode Fiber For Use In UV-Visible Applications   |
| 1987 | Neodymium Doped Fiber   | 2010 | Re-Introduction of Improved Zing™ Polarizing Fiber  |
| 1988 | Erbium Doped Fiber  | 2012 | Re-Introduction of Improved Spun Bow-Tie, Elliptically-Birefringent Fiber   |
| 1989 | Spun Bow-Tie, Elliptically-Birefringent Fiber                     | 2013 | High Temperature Coatings, Pure Silica Core Fiber, Portfolio for Oil & Gas Industry   |
| 1993 | Erbium-Ytterbium Co-Doped Fiber                                   | 2014 | Acquisition of Fibertronix. Multicore Fiber, Multimode Fiber, Through the Coating FBGs, Cables for Oil & Gas, Double Clad Passive Fiber |
| 1998 | Intrinsically Photosensitive Boron Co-Doped Fiber                 | 2016 | Completion Of Hydrogen Chamber  |
| 1999 | All-Silica, 'Cladding Pump' Rare-Earth Doped Fiber                |      |   |

# Technical Partnership

The success of your project is all that matters. Fibercore doesn't just sell specialty fibers - we'll work with you, putting everything that we have learned in the Industry at your disposal.

Fibercore has the depth and breadth of experience and engineering expertise in specialty fiber to make a real contribution to your project – from the very first contact, through supporting you in the selection of exactly the right fiber, all the way to on-time delivery and beyond. It is this exceptional level of intense, technical support that makes our customers return, year after year. We design the right solution for your need beyond the 100+ pages of this brochure. And if we cannot assist you with anything, then we will say so and do our utmost to use our unmatched knowledge to direct you towards someone who can.



1. Do you need specialty fiber?

- Have you got unanswered questions about fiber?
- Would you like more support from a fiber expert?
- Contact us

E: [info@fibercore.com](mailto:info@fibercore.com)  
 T: +44 (0)23 8076 9893  
[www.fibercore.com/ask](http://www.fibercore.com/ask)



2. Discuss with our fiber engineers

- Receive detailed feedback and analysis
- Research in the industry's online source of specialty fiber information - Fiberpaedia™

[www.fibercore.com/applications](http://www.fibercore.com/applications)  
[www.fibercore.com/fiberpaedia](http://www.fibercore.com/fiberpaedia)



3. Do you need a sample?

- Request a sample
- Request more in-depth data
- Request a solution

[www.fibercore.com/sample](http://www.fibercore.com/sample)



4. Finalize your fiber selection

- SM Fiber
- Photosensitive
- Multicore Fiber
- PM Fiber
- Spun Fiber
- Doped Fiber
- Passive Cladding Pumped
- Multimode Fiber
- Fiber Bragg Gratings
- Complementary

[www.fibercore.com/products](http://www.fibercore.com/products)



5. Is Fibercore the right partner?

- Over 30 years at the forefront of specialty fiber technology
- Purpose built state-of-the-art facilities
- ISO9001 quality
- ISO14001 environment
- OHSAS18001 health and safety
- ISO10012 test and measurement

[www.fibercore.com/facilities](http://www.fibercore.com/facilities)



6. What else do you need?

- Fiber qualification & reliability testing
- Fiber test & measurement
- Fusion splicing
- Hydrogen testing
- Custom preform & fiber development
- Custom & Multifiber
- Fiber calculator & EDF S/W
- Development projects

[www.fibercore.com/ask](http://www.fibercore.com/ask)  
[www.fibercore.com/calculator](http://www.fibercore.com/calculator)

# Harsh Environment

**The use of optical fiber sensors by the Oil & Gas, Nuclear, Chemical Processing, Civil Engineering and Space Vehicle industries has grown dramatically over the past decade. This growth can only accelerate and with it, the demand for optical fibers capable of delivering their performance reliably in these challenging environments.**

Typical telecommunications fiber is designed for benign environments in temperatures that range from -55°C to +85°C, degrading optically when used outside of this temperature range and when in certain environments with hydrogen, chemicals or radiation. Due to these factors, special coatings are available to address a greater temperature range and to handle certain chemical environments. In addition, the glass chemistry must be modified to address environments with hydrogen or radiation.

## Applications

### Radiation (Nuclear and Aerospace)

There are multiple applications where optical fiber is exposed to ionizing radiation such as nuclear power plants, nuclear storage facilities, space applications and some research facilities like CERN's Hadron collider or other high energy physics/particle accelerators. Fibercore has both single-mode and multimode fiber that has been designed specifically to be minimally impacted by ionizing radiation. These optical fibers are used for

communication links that go through such environments and are also used for a variety of sensing applications such as distributed temperature sensing (DTS) and strain sensing. Products ideal for a radiation environment include: pure silica core single-mode (pg. 35-36) and graded index pure core multimode (pg. 79).

### Oil and Gas

The Oil and Gas (O&G) industry has been using downhole optical fiber in wells where the temperatures can reach beyond 300°C and where hydrogen is present. These fibers are used for distributed temperature (DTS) and acoustic (DAS) sensing for frack monitoring and other process optimization, telemetry for downhole tools, pressure sensing and for strain monitoring. Fibercore offers coatings suitable for 150°C, 300°C and beyond, along with a carbon coating over the glass to prevent hydrogen ingress up to 150°C. Above 150°C, Fibercore offers pure silica core single-mode fiber (pg. 35-36) and a graded index pure core multimode fiber (pg. 79) that has been designed and manufactured in a proprietary way to minimize optical loss due to hydrogen exposure.

Products ideally suited to O&G environments, especially downhole, include single-mode and multimode fiber with carbon high temperature acrylate coating (pg. 34 & 79), pure silica core single-mode and graded index pure core multimode with polyimide or carbon polyimide (pg. 35 & 79), fiber Bragg gratings (FBGs) (pg.83) and fiber optic cables (pg. 87-93).

### Cryogenic

For applications where temperatures will be below -60°C, standard telecommunications fiber will not perform optically and a special polyimide coating is necessary. Liquid natural gas facilities and pipelines, where temperatures can drop to approximately -180°C, commonly use optical fiber for monitoring temperatures (DTS and/or DAS) to look for signs of leakage. These optical fibers are housed in fiber optic cables to allow for protection of the fiber during placement of the cable. Deployment of optical fiber in cryogenic applications is typically in cable (pg. 87-93) and uses polyimide coated single-mode and multimode fibers (pg.32 & 78-79).

### Acoustic/Seismic

In the O&G industry, fiber optic hydrophones and geophones are used to aid in the evaluation of existing reservoirs and to search for new reservoirs. In these devices, optical fiber is wound in a coil over a compliant mandrel at relatively small diameters, which is challenging if not impossible for standard telecommunications fiber to maintain guidance of the light. These sensors are either lowered downhole into the oil or gas well for vertical seismic profiling (VSP), laid on the subsea floor for ocean bottom seismic (OBS) or placed on the terrestrial surface for seismic profiling.

Fibercore offers a variety of smaller clad diameter fibers with reduced diameter coatings with higher numerical apertures to allow for superior performance in these challenging devices; 50µm and 80µm single-mode fibers (pg. 29-30 & 33).

### Chemical

In some applications, optical fiber is conveyed into the area where optical sensing is desired. The fluid to convey the fiber can be detrimental to the optical fiber coatings. Fibercore has suitable coatings to not only survive the conveyance of the fiber but also to withstand the residual chemical environment that remains after the operation. Pure silica core single-mode and graded index pure core multimode polyimide coated fiber (pg. 35-36 & 79) are ideally suited for harsh chemical environments. In addition, the single-mode fibers can have FBGs written into them as well and this area can be coated with chemically sensitive materials that will expand/contract in the presence of certain target chemicals. In this way, the fiber can become a distributed chemical sensor. FBGs (pg. 83) and our pure silica core single-mode polyimide coated fiber (pg. 35-36) provide the components for this type of sensing.

# Aerospace and Defence

**The fundamental benefits of lightweight, small size and immunity from EMI have enabled optical fiber technology to gain widespread acceptance in Aerospace and Defence. Today, an ever growing list of applications for specialty fiber is topped by Fiber Optic Gyroscopes (FOG), Avionics, LIDAR, Asset Monitoring, Sonar and Perimeter Security.**

The Aerospace and Defence (A&D) sectors were amongst the very first to embrace optical fiber technology. Originally this was for communications and now, increasingly for sensing.

A broad spectrum of A&D applications use specialty optical fibers to enhance performance and reliability from fiber optic gyroscopes (FOGs), through hydrophones, geophones, phased array radar, avionics, perimeter and asset security and LiDAR to inter-satellite communications.

## Applications

### Fiber Optic Gyroscope (FOG)

FOGs are interferometric sensors that make use of the Sagnac effect to detect and measure rotation. They are used in navigation, stabilization and positioning applications including ship and aircraft navigation, helicopter, missile and gun-sight stabilization, precision positioning of artillery and satellite receivers to name but a few.

The sensing element in a FOG is typically a precision coil of PM fiber of between 100m and 5,000m in length, depending on the degree of precision required. FOGs can equal the performance of the very best ring laser (RLGs) and iron ('spinning mass') gyros, used in submarine navigation. This offers reduced manufacturing costs, delivering true 'solid state' reliability of up to thirty times that of these competing technologies.

The entire optical circuit of a high precision FOG may be formed using a range of fibers that have been developed in unison to be fully compatible, delivering optimal performance with minimal effort.

FOG specific Fibercore products include:

- PM Gyro Fiber (pg. 54): Reduced diameter for sensing coils, delivering enhanced mechanical reliability and reduced package size
- Zing™ Polarizing Fiber (pg. 57): Single polarisation fiber to increase PER
- Erbium Doped Fiber IsoGain™ I-25H (pg. 64): High absorption EDF for ASE light sources
- Fiber coils (upon request): Ultra high precision, quadrupole-wound sensor coils

### Space Environments

Space qualified FOGs:

Radiation tolerant (RT) variants of both PM (pg. 54) and SM (pg. 26-36) fibers have been used in FOGs deployed by most of the World's space agencies for spacecraft and satellite use. The proprietary core and inner cladding formulation reduces radiation induced attenuation (RIA) by up to fifty times, when compared with conventional fibers. Fibercore products are delivering their performance in geostationary orbit, on the surface of Mars and to the furthest reaches of our Solar System.

Laser Communications:

Fiber lasers and amplifiers are now used increasingly in free-space inter-satellite and satellite-to-ground communications. Fiber based Laser Communications Terminals (LCTs) offer reduced weight, lower power requirements and 100X faster data rates than comparable RF systems and are therefore ideally suited for satellite and spacecraft deployment. Fibercore's Erbium Doped Fiber AstroGain™ active fiber range (pg. 66) has been developed specifically for this task.

### Embedded Sensors / Asset Monitoring

By embedding optical fibers into an airframe or other structure (with or without the inclusion of fiber Bragg gratings (FBGs) (pg. 83)) that structure becomes 'smart', capable of sensing its environment with respect to temperature, vibration, pressure, strain, shape etc. These techniques were pioneered in the 1980s, notably by McDonnell Douglas Aircraft Corporation and were also used by NASA in the development of adaptive wing aircraft. Fibercore's low and ultra-low profile fibers (pg. 26, 48 & 76) are ideally suited to embedded use, particularly when combined with specialized, harsh environment coatings.

### Light Detection and Ranging (LiDAR)

Primarily used for ultra-precise, 3-D distance measurement, LIDAR has many applications from atmospheric sensing, wind-shear detection, geological mapping, surveying in mines/quarries to obstacle detection in autonomous vehicles. Fibercore's EDF (pg. 64-67) and EYDF (pg. 68 & 70) active fiber products and matching passive fibers (pg. 72) are ideally suited to use in LIDAR.

### In-Flight Network and Entertainment Systems

Optical fiber has higher bandwidth and lower weight than copper cable and is ideally suited to avionics use, from flight systems through to in-flight entertainment. Relatively short distances tend to favour the use of multimode (MM) fiber (pg. 76), including radiation resistant and bend insensitive variants. These fibers are ideal for the tight bend-radii encountered in the increasingly dense fiber environment of a typical airframe.

### Acoustic and Seismic Sensors

Fiber based 'listening devices', hydrophones and geophones are being used increasingly in marine, submarine and terrestrial security. High strength (300+ kpsi), very highly bend insensitive fibers (pg. 28 & 41), often combined with FBGs (pg. 83) are ideally suited to this class of sensor.

### Perimeter and Border Security

Both distributed acoustic sensors (DAS) and 3-axis point sensing can deliver exceptional perimeter and border security. These are capable of detecting and analysing footfall and pinpointing tunnelling activity in real time. A number of police stations have already been equipped with these systems, with excellent results.

Fibercore has developed both cable (pg. 88) and fiber solutions that are now being deployed in these applications.



# Energy and Infrastructure

The entire World is critically dependent upon the security and integrity of its transport, data and energy infrastructures. Increasingly, it is fiber optic sensing technologies using specialty optical fibers that are responsible for monitoring these infrastructures to ensure their smooth running.

This applies equally to the supply of energy, distribution of internet data and the transportation of people and goods. Optical fibers are widely used throughout these industries with a growing use of fiber optic monitoring of electrical power distribution, structural health monitoring and intrusion sensing.

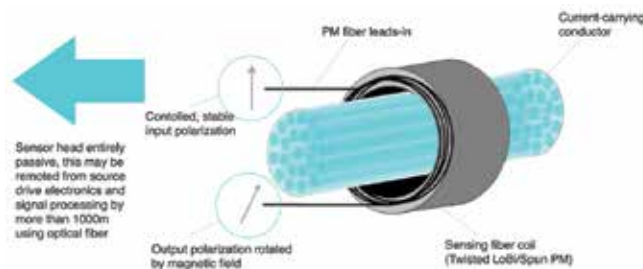
## Applications

### Energy (for Oil & Gas see pg. 10)

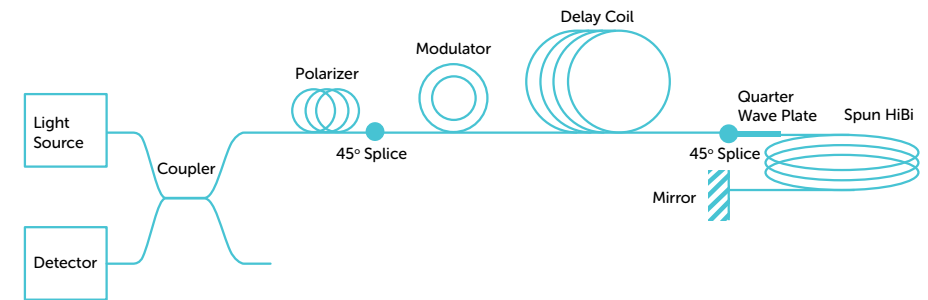
As the smart grid develops, accurate and instant information on the electrical power loading is required. Subsequently, fiber optic current sensors have been developed, which allow almost instant measurement of the electrical current at any

point within the network. These fiber optic current sensors (FOCS), also known as optical current transformers, are for optimizing the fiber optic Faraday effect to allow monitoring of current in high voltage power lines and transformers. Fibercore's spun fiber (pg. 58) is at the heart of products where high stability fiber design is critical to enable high accuracy current sensing. The fibers allow highly sensitive and accurate current sensing over a wide range of environmental conditions, including: temperature variation and vibration, suitable for the rigors of real life applications. In addition to the spun fiber within the product, Fibercore's PM fiber (pg. 48) for delay lines and Zing™ (pg. 57) for depolarizers are used in combination to result in world-class current sensors.

## Faraday Effect Current Sensor Schematic



## Details of Current Sensor Architecture



### Infrastructure

With optical fiber having the ability to be used as a sensor or have sensors written into the fiber directly, information can be gained on the health of a component or system remotely and over long lengths. Some examples are:

1. Embedding optical fiber into power cables to look for hot spots along the cable, which would indicate insulation breakdown or cable damage and to maximize the potential of the insulated power cable by allowing increased current flow up to the temperature rating of the cable.
2. Embedding fiber Bragg gratings (FBGs) (pg.83) into wind turbine blades to monitor strain and to count the number of flex cycles to evaluate component fatigue.
3. Using radiation resistant optical fiber (pg. 35, 54-56 & 79), for use in communication and sensing (distributed temperature and strain and point sensors) in nuclear storage and operations facilities.
4. Embedding optical fiber into dams to monitor leakage via distributed temperature sensing and monitoring strain either through FBGs or through Brillouin scattering for distributed strain.
5. Using optical fiber at critical junctures on bridges to monitor movement and strain through the use of FBGs (pg. 83) or Brillouin (pg. 29-30) scattering for distributed strain.
6. Small fiber optic cables can be embedded into concrete structures allowing for monitoring of the concrete curing process via temperature (DTS) (pg. 78) and strain (Brillouin (pg. 29-30) or FBG's (pg. 83)) allowing the user to optimize the process.
7. LIDAR, Light Detection and Ranging, uses specialty optical fiber for the transmission of the light. LIDAR is being used for driverless cars and aerial mapping (pg. 64-65).

# Biomedical

The use of optical fiber in the Biomedical industry has grown rapidly from simple light and image guides and power delivery for cutting and cauterizing through to next generation imaging, advanced diagnostics, 'smart' catheters and robotics. This increase in sophistication requires a greater need for more sophisticated specialty optical fibers.

With a full range of ultra violet (UV) (pg. 35), visible and near-IR single-mode (SM) fibers (pg. 28) in both polarization maintaining (PM) (pg. 50) and non-PM variants, multicore (MCF) fiber (pg. 42), fiber Bragg gratings (FBGs) (pg. 83), small clad, high numerical aperture (NA) (pg. 30), and side hole fiber (upon request), Fibercore's range of advanced optical fibers are suitable for a wide range of biomedical applications. These fibers find use within in vivo and in vitro applications, ranging from medical probes to advanced microscopy techniques. Fibercore can offer coatings suitable for both EtO (ethylene oxide), autoclave and other sterilization techniques.

The use of optical fiber in biomedical applications such as vascular intervention, ophthalmology, cosmetic procedures and dentistry is increasing with ever evolving, custom designed optical fibers. Fibercore's culture is to partner with our customers to find creative solutions to provide the optical performance desired in the most difficult of applications.

## Applications

### 3D Shape Sensing

Vascular and interventional radiology (VIR) requires imaging systems, such as X-rays or CT scanners, to assist with the guidance of angioplasty and catheter delivered stents. However, through the use of Fibercore's multicore fiber with FBGs inscribed along the length, the need for constant imaging using these techniques can be removed. The fiber is able to sense its own shape, enabling a 3D reconstruction of the path it is taking within the body in real time.

### Pressure Sensing

Twin hole (or side hole) fibers can be optimized to be sensitive to the hydrostatic pressures experienced within the body. This opens up various biomedical applications such as the precise location and measurement of pressure fluctuations within an artery, which can be an indicator of coronary artery disease (atherosclerosis).

### Haptic Sensing

Haptic sensing, or the ability to give touch feedback remotely, allows robotic surgery tools and non-directly mechanically coupled tools to be used with a greater dexterity. The use of Fibercore's reduced cladding diameter fibers with FBGs allows miniature strain sensors to be embedded within the tool, which enables a signal to be returned and converted into a mechanical feedback at the surgeon's hands. This gives surgeons a natural feel when using such tools.

### Optical Coherence Tomography (OCT)

OCT is an optical imaging acquisition technique that uses light waves to form images of translucent or opaque materials. Images appear as either 2D or 3D layered cross-section of an optical scattering media. One of the most well known areas of OCT imaging is for ophthalmology for retinal mapping. In ophthalmology, OCT measurements allow an ophthalmologist to thoroughly map and measure the thickness of the retina as well as aide in the early detection, diagnosis and treatment for retina disease and other conditions.

# Telecommunication

**The continual growth in bandwidth required to meet the increasing demands of an internet connected society drives technical developments at the device and component levels.**

These devices are required to become more efficient, smaller in size and have wider bandwidth, whilst still driving performance forward. Such requirements have driven specialty optical fibers into volume telecommunications markets.

## Erbium Doped Fiber Amplifiers (EDFAs)

Erbium doped fibers (pg. 64-67) are the standard choice for optical amplification. However, their demands vary depending upon the application of the amplifier. Low cost, C-band, low signal power, high efficiency amplifiers typically utilize erbium doped core pump fiber, such as the IsoGain™ I-4(980/125) and I-6(980/125) (pg. 64). As power level requirements increase, for example >400mW core pump power, high cut-off wavelength fibers provide better efficiency, such as I-4(980/125)HC.

With a growing demand to push the spectral bandwidth of amplifiers, L-band amplifiers are becoming more common. These would require very long lengths of standard erbium doped fibers to be used. To reduce the total length required, Fibercore offers highly doped fibers that allow much shorter lengths of fiber to be used, these fibers include: I-12(980/125)HC and I-15(980/125)HC (pg. 66).

Mini and micro EDFAs are popular for small package size C-band amplifiers. To achieve this, highly doped fibers such as the I-15(980/125)HC, can be used to dramatically reduce the coil lengths. Higher absorption and reduced cladding diameter fibers such as I-25H(1480/80) give improved mechanical reliability, short lengths and excellent bend loss.

To address the needs of satellite-to-satellite and satellite-to-ground communication, space grade erbium doped fibers have been developed, these are: AG980H and AG980L (pg. 66).

## High Power Amplifiers – Ytterbium Erbium Doped Fiber Amplifiers (YEDFAs)



High power amplifiers for telecoms and CATV require double or triple cladding fibers, which allow the pump light to be pumped directly into the cladding of the fiber, increasing the amount of pump light that can be used.

This in turn increases the signal power level, allowing signals in excess of 1W to be used. Unique to the industry, Fibercore manufacture an all-silica double clad fiber with a circular outer cladding and a petal structure inner cladding (pg. 68). The all-silica design means it can be stripped, cleaved, spliced and recoated like a standard optical fiber, without the need for low index recoat material. The circular cladding ensures the fiber sits within V-grooves centrally, avoiding problems associated with competitor octagonal cladding structures. For mode mixing, the petal structure gives efficient coupling of the pump light into the core of the fiber.

## OEM Amplifier GainBlock

As the splice recoating technology required for double and triple clad fibers is different to a standard core pump fiber, Fibercore offers a pre-assembled unit called an OEM Amplifier GainBlock (pg. 71). This unit incorporates a WDM, high power splices, cladding pumped gain fiber and heat sinking to allow easy upgrade of lower power amplifiers to higher power levels, without significant engineering investment.

## Multimode Large Core Fibers

Multimode pumps typically use fiber with a 105µm core diameter and a 125µm cladding diameter. Fibercore offers two variants (pg. 80) of this standard pump fiber: MM(105/125)0.15 with a 0.15 NA and MM(105/125)0.22 with a 0.22 NA. The 0.22 NA variant displays improved bend losses in comparison with the 0.15 NA version.

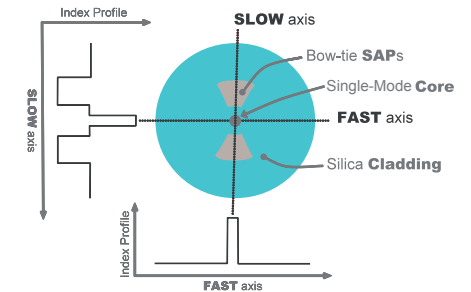
## Fused Taper Coupler Fibers

Fused taper coupler performance and manufacturing yields can be optimized by utilizing Fibercore's SM step index fibers, which do not have a fluorine ring. Typical telecoms fibers often have a fluorine ring, which can introduce

instabilities in the coupler manufacturing process. Fibercore's SM980(5.8/125) (pg. 28) dual window fiber and SM1500 (pg. 29) fiber range are ideally suited for coupler manufacturing.

## PM Fiber for Coherent Communications and Lyot Depolarizers

Typical 'Bow-Tie' HiBi Fiber Geometry



Polarization maintaining (PM) (pg. 48) fiber is used for coherent communications where the bandwidth of a fiber is increased 100% by utilizing the two polarization states of the fiber. Fibercore's Telecoms PM Fiber (pg. 52) is designed to offer outstanding core circularity and concentricity for excellent splice performance, whilst also ensuring low crosstalk between the polarization states. This range offers PM fibers for 1550nm, 14XXnm, 1310nm and 980nm.

Conversely, PM fibers are also used as Lyot depolarizers for depolarizing Raman amplifier pumps. By splicing two specific lengths of PM fibers together with the stress axis offset by 45°, an all-fiber depolarizer can be manufactured. The HB14XXT fiber has been specifically designed to offer the best-in-class birefringence, allowing short length depolarizers to be achieved.

# Industrial (Process Monitoring)

**Small size, lightweight, immunity from electromagnetic interference, high bandwidth and the ability to make truly distributed measurements make fiber optic sensing the optimum technology for many aspects of process monitoring. Specialty fibers simply increase sensor performance and enhance functionality still further.**

Existing technologies today suffer from electromagnetic interference (EMI), temperature limitations or size constraints, all of which limit the accuracy or usability of such sensors. By utilizing optical fibers, these challenges can be avoided, bringing additional sensing opportunities to industrial processes.

## Metrology



Image courtesy of Mahr

Polarization Maintaining (PM) fibers, for example Fibercore's HB range of highly birefringent fibers (pg. 48), are extremely useful for measuring small distances with high accuracy. The Bow-Tie stress applying parts (SAPs) ensure the input polarization state is kept stable under vibration and temperature changes, ensuring polarization dependant effects

do not degrade the accuracy of the measurement. PM fibers are available from visible to near infrared (IR) wavelengths, offering various options depending on whether the application is an interferometric, time of flight or other method.

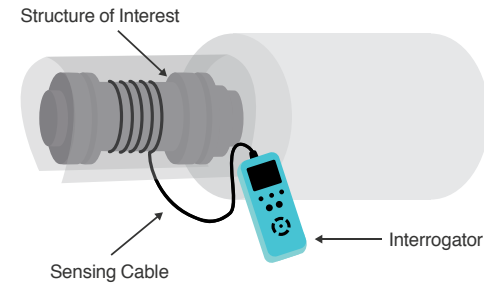
Visible wavelength PM fibers, for example HB450 and HB600 (pg. 50), are often used within interferometers where the distance measurement accuracy is better than the wavelength of the light used.

For ultra-small probes, 80 $\mu$ m and 60 $\mu$ m cladding diameter PM fibers are available in our PM Gyro Fiber range (pg. 54). These allow for smaller cross sections and improved mechanical lifetime when deployed with extremely tight bends.

## Condition Monitoring

Movable parts are prone to wear and tear, which can result in catastrophic failure if they are not repaired or replaced when damage is induced. Statistical distributions can be used to give a probabilistic approach to maintenance but this method would not avoid a catastrophic failure in the case of abnormal wear.

Fiber Bragg gratings (FBGs) (pg. 83) provide a method of monitoring vibrations on mechanical structures, which can be indicative of wear or even manufacturing error. These vibrations can be monitored live and automatic warnings triggered when an abnormal vibration occurs. For mass transportation devices, such as trains and aircrafts, this can save lives. For difficult to access industrial equipment, such as subsea pumps, this can ensure repairs are scheduled only when they are due, avoiding costly recovery processes.



Wind turbines provide an interesting example of using FBGs for not only condition monitoring of the rotating parts, but also strain sensing along the blades. This allows active feedback to correlate the blade pitch with the strain on the blades to enable optimized energy conversion in light or heavy wind.

## Temperature sensing

Multimode (MM) and single-mode (SM) optical fiber are used for continuous distributed temperature sensing (DTS) to provide constant thermal monitoring. Multimode based systems have a sensing reach of ~30km, while single-mode have a reach of ~100km. To help improve the temperature range of the sensing, high temperature acrylate coatings can offer continuous use up to 150°C and polyimide coatings offer use up to 300°C. For more extreme temperature ranges, metal coatings such as gold can be used to push beyond 300°C, for example in turbines. These coatings, with the exception of metal coatings, can also be used in conjunction with Fibercore's femtosecond laser written high temperature FBGs, which give extended thermal range beyond standard FBGs.

# Fiber Lasers and Amplifiers

**With the growing range of fiber lasers and high power amplifiers available today, there is a greater need for specialty fibers, ranging from high power double or triple cladding fibers through to highly complex polarizing, Zing™ fibers.**

These products require high quality manufacturing to ensure outstanding reliability when used at extreme optical power levels and reassurance that the manufacturing processes can scale to meet the global demand of the market. Fibercore's position as the highest volume specialty fiber manufacturer enables us to address the fiber laser and amplifier market with high quality technical products to enable the next generation of fiber lasers to ramp to high volumes.

## Passive Double Cladding Fibers

Passive double cladding fibers (pg. 72) are designed to transport the single-mode (SM) signal in the core and the pump light in the cladding from one location to another. These fibers are typically utilized in multimode pump combiners where the combined power of multiple multimode pumps are combined into the passive double cladding fiber and transported to the active double or triple cladding fiber.

For the fiber laser industry, Fibercore has developed the DC1060(10/125)0.08, which offers a 10µm core diameter and a low NA of 0.08 to enable compatibility to high power ytterbium

doped fibers. For the telecoms industry, the DC1500(11/125)0.12 and DC1500(6/125)0.21 enable compatibility to 11µm and 6µm MFD erbium/ytterbium doped active fibers.

To enable successful integration into components, the passive double clad fibers have been designed to be compatible with pump combiner manufacturing technology and have a germanium doped core, making the fibers photosensitive for fiber Bragg grating (FBG) inscription. Subsequently, these fibers may be used as part of the main gain stage cavity of a laser or as part of a Master Oscillator Power Amplifier (MOPA) design.

## Multimode Large Core Fibers

Multimode pumps typically use fiber with a 105µm core diameter and a 125µm cladding diameter. Fibercore offers two variants (pg. 80) of this standard pump fiber: MM(105/125)0.15 with a 0.15 NA and MM(105/125)0.22 with a 0.22 NA. The 0.22 NA variant displays improved bend losses in comparison with the 0.15 NA version, offering versatility to the fiber routing design.

## Pre-Amplifier Fibers

Depending on the fiber laser architecture, pre-amplifiers are often used to reduce the gain level required from the power amplifier in a MOPA system. Fibercore offers a ytterbium doped, core pump fiber (pg. 70), DF1100 for a 1060nm pre-amplifier and a full range of erbium doped fibers in the IsoGain™ range (pg. 64), but specifically I-15(980/125)HC offers a high absorption level to enable short fiber lengths.

## PM and Polarizing Fibers

Fibercore offers a polarization maintaining (PM) erbium doped fiber (pg. 67), DHB1500 with the ability to amplify and maintain polarization for PM fiber laser applications. As well as the doped fibers, Fibercore offers passive PM fibers within the Telecoms PM Fiber range (pg. 52), suitable for wavelengths from 980nm through to 1550nm and beyond. For applications that require a single polarization state, the HB-Z Zing™ (pg. 57) polarizing fiber range can act as an all-fiber distributed polarizer with variants at 1060nm and 1550nm. To avoid Polarization Dependent Gain (PDG), particularly in laser diode seeded MOPA systems, Telecoms PM Fiber makes an excellent choice for use in Lyot depolarizers.





# SM Fiber

For Harsh Environments, Ultra Bend Insensitive, RGB and Near Infra Red

## For ultraviolet, visible and near IR transmission, EDFA pigtailling, sensors & tethered platforms

The single-mode (SM) range of fibers has been designed to perform in a wide range of challenging applications offering wavelengths between 488nm and beyond 1650nm.

The SM-SC range of fibers both extends the range into the UV and also enables use in harsh environments. The fiber offers minimal photo-darkening and reduced susceptibility to the effects of hydrogen ingress when compared with conventional, germanosilicate cored fibers.

The SM range of fibers are offered with a range of numerical apertures from 0.11 to 0.31. The high NA variants reduce bend-induced loss to levels dramatically below those of standard telecommunication fibers. Thus, allowing them to be used in diameters of 10mm or smaller.

The high germania content fibers have considerably enhanced photosensitivity, making them ideal for the fabrication of fiber Bragg gratings (FBGs).

A range of harsh environment coatings are available, including carbon, polyimide and high temperature acrylate.

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### Ranges of specialty single-mode optical fiber:

#### SM Fiber For Visible RGB Through To Near IR:

For visible and near IR transmission, EDFA pigtailling, acoustic sensors and depolarized FOGs

#### High Temperature Acrylate Coated SM Fiber:

For medium to high temperature applications

#### Polyimide Coated SM Fiber:

For embedded and high temperature applications

#### Dual Band Carbon Coated SM Fiber

For harsh environments with medium to high temperature applications

#### Pure Silica Core SM Fiber:

For hydrogen, radiation and UV applications

# SM Fiber For Visible RGB Through To Near IR

## 450nm to 1750nm single-mode transmission

- 125/245 $\mu$ m fiber for SM transmission from 450nm - 1750nm
- 80/170 $\mu$ m fiber for high reliability, small form-factor telecom components
- Ultra-low & low profile, bend-insensitive fiber for de-polarized FOGs, acoustic sensors & small form-factor sensor components
- High NAs for enhanced bend-insensitivity
- High Ge content offering intrinsic photosensitivity for FBG inscription without hydrogenation

### Typical applications:

- Hydrophones/Geophones
- Telemetry
- Down-link fibers
- FBGs
- DTS/DAS/DSS
- Laser diode pigtails
- Biomedical probes
- Couplers

## Specifications

125 $\mu$ m diameter SM specialty fibers

	SM450	SM600	SM750	SM800 (5.6/125)	SM980 (3.7/125)	SM980 (4.5/125)	SM980 (5.8/125)
<b>Operating Wavelength (nm)</b>	488 - 633	633 - 780	780 - 830	830 - 980	980	980 - 1550	
<b>Cut-Off Wavelength (nm)</b>	350 - 470	500 - 600	610 - 750	660 - 800	870 - 970		
<b>Numerical Aperture</b>	0.10 - 0.14				0.21 - 0.23	0.17 - 0.19	0.13 - 0.15
<b>Mode Field Diameter (<math>\mu</math>m)</b>	2.8 - 4.1 @488nm	3.6 - 5.3 @633nm	4.5 - 6.5 @780nm	4.7 - 6.9 @830nm	3.4 - 4.0 @980nm	4.2 - 4.9 @980nm	5.3 - 6.4 @980nm
<b>Attenuation (dB/km)</b>	$\leq$ 50 @488nm	$\leq$ 15 @633nm	$\leq$ 5.0 @780nm	$\leq$ 5.0 @830nm	$\leq$ 2.0 @980nm		
<b>Proof Test (%)</b>	1, 2 or 3 (100, 200 or 300 kpsi)						
<b>Cladding Diameter (<math>\mu</math>m)</b>	125 $\pm$ 1						
<b>Core Cladding Concentricity (<math>\mu</math>m)</b>	$\leq$ 0.75	$\leq$ 1.0			$\leq$ 0.50		
<b>Coating Diameter (<math>\mu</math>m)</b>	245 $\pm$ 7						
<b>Coating Type</b>	Dual Acrylate						

## Specifications continue

125 $\mu$ m diameter SM specialty fibers

	SM1500			
	(4.2/125)	(6.4/125)	(7.8/125)	(9/125)
<b>Operating Wavelength (nm)</b>	1520 - 1650			
<b>Cut-Off Wavelength (nm)</b>	1350 - 1520			
<b>Numerical Aperture</b>	0.29 - 0.31	0.19 - 0.21	0.15 - 0.17	0.13 - 0.15
<b>Mode Field Diameter (<math>\mu</math>m)</b>	4.0 - 4.5 @1550nm	6.0 - 6.8 @1550nm	7.4 - 8.6 @1550nm	8.5 - 9.9 @1550nm
<b>Attenuation (dB/km) @1550nm</b>	$\leq$ 1.5	$\leq$ 0.5	$\leq$ 0.4	$\leq$ 0.35
<b>Proof Test (%)</b>	1, 2 or 3 (100, 200 or 300 kpsi)			
<b>Cladding Diameter (<math>\mu</math>m)</b>	125 $\pm$ 1			
<b>Core Cladding Concentricity (<math>\mu</math>m)</b>	$\leq$ 0.50	$\leq$ 0.75		
<b>Coating Diameter (<math>\mu</math>m)</b>	245 $\pm$ 7			
<b>Coating Type</b>	Dual Acrylate			
<b>Operating Temperature (<math>^{\circ}</math>C)</b>	-55 to +85			

Reduced diameter SM specialty fibers

	SM800(4.2/80)	SM980(4.5/80)	SM1250(5.4/80)	SM1250(9/80)
<b>Operating Wavelength (nm)</b>	830 - 980	980 - 1550	1310 - 1550	
<b>Cut-Off Wavelength (nm)</b>	660 - 800	870 - 970	1150 - 1250	
<b>Numerical Aperture</b>	0.14 - 0.18	0.17 - 0.19	0.19 - 0.21	0.11 - 0.13
<b>Mode Field Diameter (<math>\mu</math>m)</b>	3.8 - 4.9 @830nm	4.2 - 4.9 @980nm	5.0 - 5.7 @1310nm	8.2 - 9.9 @1310nm
<b>Attenuation (dB/km)</b>	$\leq$ 3.0 @830nm	$\leq$ 2.0 @980nm	$\leq$ 1.0 @1310nm	$\leq$ 2.0 @1310nm
<b>Proof Test (%)</b>	1, 2 or 3 (100, 200 or 300 kpsi)			
<b>Cladding Diameter (<math>\mu</math>m)</b>	80 $\pm$ 1			
<b>Core Cladding Concentricity (<math>\mu</math>m)</b>	$\leq$ 0.50			
<b>Coating Diameter (<math>\mu</math>m)</b>	170 $\pm$ 5			
<b>Coating Type</b>	Dual Acrylate			
<b>Operating Temperature (<math>^{\circ}</math>C)</b>	-55 to +85			



## Specifications continued

	SM1500				
	(4.2/50)	(4.2/80)	(5.3/80)	(6.4/80)	(7.8/80)
Operating Wavelength (nm)	1520 - 1650				
Cut-Off Wavelength (nm)	1350 - 1520				
Numerical Aperture	0.29 - 0.31		0.23 - 0.25	0.19 - 0.21	0.15 - 0.17
Mode Field Diameter (μm)	4.0 - 4.5 @1550nm		5.0 - 5.6 @1550nm	6.0 - 6.8 @1550nm	7.4 - 8.6 @1550nm
Attenuation (dB/km) @1550nm	≤2.0	≤1.5	≤0.8	≤0.5	≤0.35
Proof Test (%)	1, 2 or 3 (100, 200 or 300 kpsi)				
Cladding Diameter (μm)	50 ± 1	80 ± 1			
Core Cladding Concentricity (μm)	≤0.50				
Coating Diameter (μm)	110 ± 6	170 ± 5			
Coating Type	Single Acrylate	Dual Acrylate			
Operating Temperature (°C)	-55 to +85				

# High Temperature Acrylate Coated SM Fiber

- High temperature acrylate coatings to withstand temperatures up to 150°C continuous
- Low profile, bend insensitive fibers for downhole seismic sensors, high temperature distributed pressure sensors, temperature sensors, down-links and telemetry
- Enhanced photosensitivity

### Typical applications:

- Geophones
- DTS, DAS, DSS and DPS
- Embedded sensors
- Fiber Bragg Gratings (FBGs)
- Temperature sensors

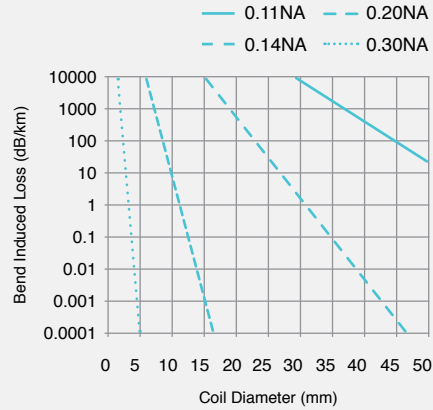
## Specifications

	SM1500 (5.3/80)HT	SM1500 (6.4/80)HT	SM1500 (6.4/125)HT	SM1500 (7.8/125)HT	SM1500 (9/125)HT
Operating Wavelength (nm)	1520 - 1650				
Cut-Off Wavelength (nm)	1350 - 1520				
Numerical Aperture	0.23 - 0.24	0.19 - 0.21		0.15 - 0.17	0.13 - 0.15
Mode Field Diameter (μm)	5.0 - 5.6 @1550nm	6.0 - 6.8 @1550nm		7.3 - 8.3 @1550nm	8.5 - 9.9 @1550nm
Attenuation (dB/km) @1550nm	≤0.8	≤0.5		≤0.4	≤0.35
Proof Test (%)	1, 2 or 3 (100, 200 or 300 kpsi)				
Cladding Diameter (μm)	80 ± 1		125 ± 1		
Core Cladding Concentricity (μm)	≤0.5			≤0.75	≤0.4
Coating Diameter (μm)	170 ± 5		245 ± 7		
Coating Type	High Temperature Acrylate				
Operating Temperature (°C)	-55 to +150				

# Polyimide Coated SM Fiber

For embedded and high temperature applications

- Polyimide coated enabling survival at temperatures up to 300°C
- Ultra-low and low profile, bend insensitive fiber for downhole seismic geophone sensors and high temperature distributed pressure and temperature sensors
- Enhanced photosensitivity
- Maintains composite material strength when embedded



### Typical applications:

- Downhole sensors
- Geophones
- DTS, DAS, DSS and DPS
- Embedded sensors
- FBGs
- Biomedical in vivo sensors
- High temperature sensors

## Specifications

	SM1250 (10.4/125)P *	SM1500 (4.2/125)P	SM1500 (6.4/125)P	SM1500 (7.8/125)P	SM1500 (9/125)P
Operating Wavelength (nm)	1260 - 1650	1520 - 1650			
Cut-Off Wavelength (nm)	1190 - 1330	1350 - 1520			
Numerical Aperture	0.11 - 0.14	0.29 - 0.31	0.19 - 0.21	0.15 - 0.17	0.13 - 0.15
Mode Field Diameter (μm)	9.6 - 11.2 @1550	4.0 - 4.5 @1550nm	6.0 - 6.8 @1550nm	7.4 - 8.6 @1550nm	8.5 - 9.9 @1550nm
Attenuation (dB/km)	≤0.7 @1310nm ≤0.6 @1550nm	≤2.5 @1550nm	≤0.75 @1550nm	≤0.7 @1550nm	≤0.6 @1550
Proof Test (%)	1 or 2 (100 or 200 kpsi)				
Cladding Diameter (μm)	125 ± 1				
Core Cladding Concentricity (μm)	≤0.75	≤0.5	≤0.75		
Coating Diameter (μm)	155 ± 5				
Coating Type	Polyimide				
Operating Temperature (°C)	-55 to +300				

\* Special polyimide, for strip and recoat FBGs, available.

## Specifications continued

	SM1500 (4.2/50)P	SM1500 (4.2/80)P	SM1500 (5.3/80)P	SM1500 (6.4/80)P	SM1500 (7.8/80)P
Operating Wavelength (nm)	1520 - 1650				
Cut-Off Wavelength (nm)	1350 - 1520				
Numerical Aperture	0.29 - 0.31		0.23 - 0.25	0.19 - 0.21	0.15 - 0.17
Mode Field Diameter (μm)	4.0 - 4.5 @1550nm		5.1 - 5.6 @1550nm	6.0 - 6.8 @1550nm	7.4 - 8.6 @1550nm
Attenuation (dB/km) @1550nm	≤3.0	≤2.5	≤1.5	≤0.75	≤0.7
Proof Test (%)	1 or 2 (100 or 200 kpsi)				
Cladding Diameter (μm)	50 ± 2	80 ± 2			
Core Cladding Concentricity (μm)	≤1.0	≤0.5	≤0.5		≤0.75
Coating Diameter (μm)	71 ± 5	102 ± 5			
Coating Type	Polyimide				
Operating Temperature (°C)	-55 to +300				

# Dual Band Carbon Coated SM Fiber

- Hermetic coating
- High operating temperature, up to 150°C and 300°C
- Low attenuation
- Excellent core cladding concentricity
- Hydrogen resistant

## Typical applications:

- Distributed temperature sensors (DTS)
- Distributed acoustic sensors (DAS)
- Distributed strain sensors (DSS)

## Specifications

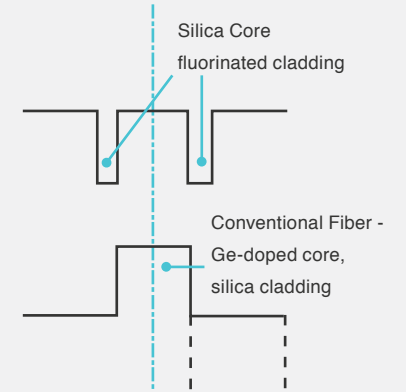
	SM1250(10.4/125)CHT	SM1250(10.4/125)CP
Operating Wavelength (nm)	1260 - 1650	
Cut-Off Wavelength (nm)	1190 - 1330	
Numerical Aperture	0.11 - 0.14	
Mode Field Diameter (μm)	9.6 - 11.2	
Attenuation (dB/km)	<0.6 @ 1310nm <0.4 @ 1550nm	<0.7 @ 1310nm <0.6 @ 1550nm
Proof Test (%)	1 or 2 (100 or 200 kpsi)	
Cladding Diameter (μm)	125 ± 2	
Core Cladding Concentricity (μm)	≤1.0	
Coating Diameter (μm)	245 ± 15	155 ± 5
Coating Type	Carbon High Temperature Acrylate	Carbon Polyimide
Operating Temperature (°C)	-55 to +150	-55 to +300

# Pure Silica Core SM Fiber

- Excellent hydrogen resistance
- Reduced radiation induced attenuation
- Various NAs for bend insensitivity
- Coatings for temperature use up to 150°C and 300°C
- Carbon option for hermetic sealing
- Hydrogen test data available

## Typical applications:

- DTS/DAS/DSS
- Sensing in radiation environments
- Microscopy
- Sensing using UV light



- Coiled acoustic
- Biomedical probes
- Sensing in hydrogen environments

See specification details on page 36.

## Coatings Order Guide

Dual Layer Acrylate = No order code

Polyimide = P

Carbon = C

Carbon High Temperature = CHT

Carbon Polyimide = CP

## Order Code Example

SM1250SC(9/125) with a Carbon High Temperature coating: SM1250SC(9/125)CHT

## Specifications

	SM300-SC	SM400-SC	SM1250SC (9/125)*	SM1500SC (7/80)	SM1500SC (7/125)
<b>Operating Wavelength (nm)</b>	320 - 430	405 - 532	1260 - 1650	1520 - 1650	
<b>Cut-Off Wavelength (nm)</b>					
<b>Dual Layer Acrylate</b>	≤310	305 - 400	1190 - 1330	1350 - 1520	
<b>Polyimide (P)</b>	-	-	-	1400 - 1500	
<b>Numerical Aperture</b>	0.12 - 0.14		0.13 - 0.15	0.17 - 0.19	
<b>Mode Field Diameter (μm)</b>	2.0 - 2.4 @350nm	2.5 - 3.4 @480nm	8.3 - 9.6 @1550nm	6.7 - 7.6 @1550nm	
<b>Attenuation (dB/km)</b>					
<b>Dual Layer Acrylate</b>	≤70 @350nm	≤50 @430nm ≤30 @532nm	≤0.6 @1310nm ≤0.4 @1550nm	≤0.4 @1550nm	≤0.7 @1550nm
<b>Polyimide (P)</b>	-	-	≤0.8 @1310nm ≤0.8 @1550nm	-	-
<b>Carbon (C)</b>	-	-	≤0.6 @1310nm ≤0.4 @1550nm	-	-
<b>Carbon High Temperature (CHT)</b>	-	-	≤0.6 @1310nm ≤0.4 @1550nm	-	-
<b>Carbon Polyimide (CP)</b>	-	-	≤0.8 @1310nm ≤0.8 @1550nm	-	-
<b>Proof Test (%)</b>	1 or 2 (100 or 200 kpsi)				
<b>Cladding Diameter (μm)</b>	125 ± 1		80 ± 1		125 ± 1
<b>Core Cladding Concentricity (μm)</b>	≤0.75		≤0.7	≤0.75	
<b>Coating Diameter (μm)</b>					
<b>Dual Layer Acrylate</b>	245 ± 7			170 ± 5	245 ± 7
<b>P</b>	-	-	155 ± 5	105 ± 5	155 ± 5
<b>CP</b>	-	-	155 ± 5	-	155 ± 5
<b>C and CHT</b>	-	-	245 ± 15	-	245 ± 15
<b>Coating Type</b>	Dual Layer Acrylate		Dual Layer Acrylate P*, C, CHT, CP	Dual Layer Acrylate P	Dual Layer Acrylate P, C, CHT, CP
<b>Operating Temperature (°C)</b>					
<b>Dual Layer Acrylate</b>	-55 to +85				
<b>P</b>	-	-	-55 to +300		
<b>CP</b>	-	-	-55 to +300	-	-55 to +300
<b>C and CHT</b>	-	-	-55 to +150	-	-55 to +150

\* Special polyimide, for strip and recoat FBGs, available.





# Photosensitive Fiber

For Temperature, Strain and Biomedical Sensors and FBGs

## High photosensitivity fibers for rapid manufacture of FBGs

Fibercore's photosensitive (PS) series of fibers have a high germania and boron co-doped core composition, enabling high reflectivity gratings to be written without the need to hydrogen-load. The mode field diameters of the boron co-doped fibers are engineered so gratings may be spliced into standard telecommunications, or pigtailed fiber with minimal excess loss.

Fibercore offers a series of high germania SM1500 single-mode fibers for distributed sensors and splice free sensor arrays. The cores of these fibers contain more than 5X the germania content of standard telecommunications fibers. This enables gratings to be written with or without hydrogen loading, whilst maintaining low attenuation around 1550nm. The addition of polyimide coated versions of these fibers extends the range, to cover high temperature harsh environment applications.

### Typical applications:

- Temperature sensors
- Strain sensors
- Biomedical sensors
- 3D shape sensing
- Pressure sensors

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### There are two ranges in this section:

#### Boron Doped Photosensitive Fiber:

Intrinsically photosensitive fibers for Bragg grating fabrication

#### Highly Germanium Doped Fiber:

High NA single-mode fibers in three different fiber diameters for writing FBGs with or without hydrogenation

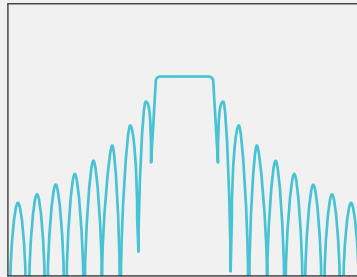
# Boron Doped Photosensitive Fiber

Intrinsically photosensitive for grating fabrication

- Rapid formation of high reflectivity FBGs
  - Without hydrogenation
- For use 'straight from the shelf'
- Strong and consistent photosensitivity

#### Typical applications:

- FBGs
- Fiber lasers
- Temperature sensors



- Compatible with standard telecommunications and pigtailed fibers
- Minimal excess loss during splicing

- Strain sensors
- Biomedical sensors

## Specifications

	PS750	PS980	PS1250/1500
Operating Wavelength (nm)	780 - 980	980 - 1310	1260 - 1650
Cut-Off Wavelength (nm)	610 - 750	850 - 950	1100 - 1260
Numerical Aperture	0.12 - 0.14		
Mode Field Diameter (μm)	4.4 - 5.9 @780nm	5.6 - 6.8 @980nm	8.8 - 10.6 @1550nm
Attenuation (dB/km)	30 (typical) @780nm	20 (typical) @980nm	10 (typical) @1310nm 120 (typical) @1550nm
Proof Test (%)	1 (100 kpsi)		
Polarization Mode	-	-	≤0.002 (typical)
Dispersion (ps/m)	@1310nm		
Cladding Diameter (μm)	125 ± 1		
Coating Diameter (μm)	245 ± 7		
Coating Type	Dual Acrylate		
Operating Temperature (°C)	-55 to +85		

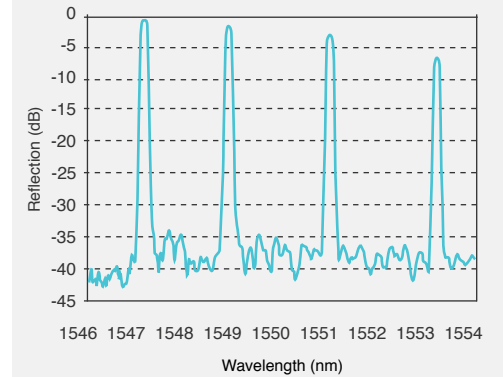
# Highly Germanium Doped Fiber

Intrinsically photosensitive fibers for grating fabrication in distributed strain and temperature sensors

- More than 5X Germania level of standard telecommunications fibers
- Suitable for inscription of long arrays with or without hydrogen loading

#### Typical applications:

- Temperature sensors
- Strain sensors
- Biomedical sensors



- High temperature polyimide coating variants available for harsh environment applications (see page 33 - Polyimide Coated SM Fiber)

- Hydrophones
- Geophones
- Fiber Bragg Gratings (FBGs)

## Specifications

	SM1500(4.2/50)	SM1500(4.2/80)	SM1500(4.2/125)
Operating Wavelength (nm)	1520 - 1650		
Cut-Off Wavelength (nm)	1350 - 1520		
Numerical Aperture	0.29 - 0.31		
Mode Field Diameter (μm)	4.0 - 4.5 @1550nm		
Attenuation (dB/km)	≤2.0 @1550nm	≤1.5 @1550nm	
Proof Test (%)	1, 2 or 3 (100, 200 or 300 kpsi)		
Cladding Diameter (μm)	50 ± 1	80 ± 1	125 ± 1
Core Cladding	≤0.5		
Concentricity (μm)	≤0.5		
Coating Diameter (μm)	110 ± 5	170 ± 5	245 ± 7
Coating Type	Single Acrylate	Dual Acrylate (Single by Special Order)	
Operating Temperature (°C)	-55 to +85		



## Multicore Fiber

For Medical Shape Sensing,  
Data Center Transmission Cables  
and Temperature/Strain Sensors

### Multicore fibers for medical shape sensing, data center transmission cables and temperature/strain sensing

In the telecoms sector, multicore fibers can be used to dramatically reduce the amount of space required for cables and connectors in data centers and exchanges. By combining multiple signal lines into a single connector, space division multiplexing schemes can be utilized to save space and give high bandwidth cables. For the biomedical sector, the fiber has photosensitive cores, allowing Fiber Bragg Grating (FBG) inscription into each core, giving the ability to use the fiber as a 3D shape sensor, as deployed in catheters and other medical tools for minimally invasive procedures.

#### Typical application sectors:

- Biomedical
- Telecommunications
- Components
- Defence
- Industrial

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#### There are two ranges in this section:

##### Multicore Fiber:

4 and 7 core variants for 1550nm sensor and telecommunication applications

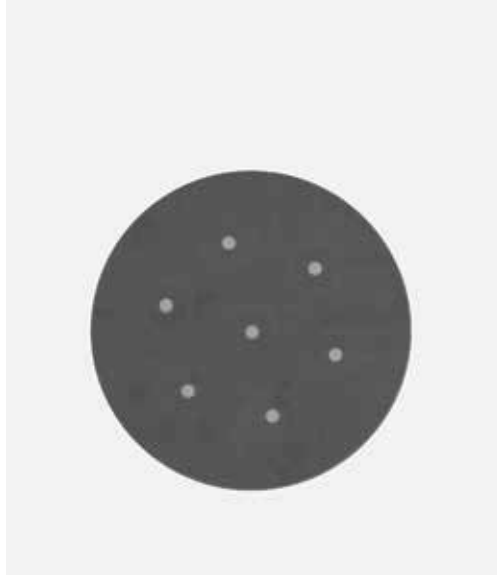
##### Fan Outs:

Packaged 3D waveguide unit to breakout the signal lines of the multicore fibers

# Multicore Fiber

## Single fiber with multiple cores

- Simultaneous transmission of different signals down different cores
- Photosensitive core designs for FBG inscription
- Suitable for 3D shape sensing applications using Spun Multicore Fiber SSM-7C1500(6.1/125)
- Can be used as the transmission line for high data rate cables in data centers
- Custom designs possible – more cores, mismatched cores, different core positions



### Typical applications:

- 3D shape sensing
- Data center transmission cables
- Temperature and strain sensors
- Structural Health Monitoring (SHM)
- Active Optical Cables (AOC)
- Space Division Multiplexing (SDM) transmission cables
- Super computing
- Quantum Key Distribution (QKD) (non-spun)

## Specifications

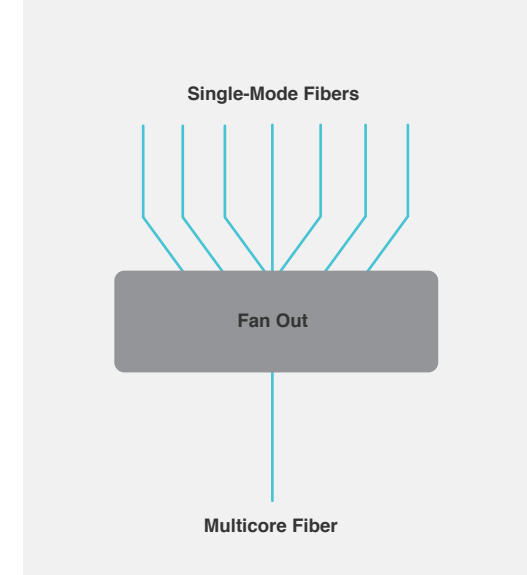
	SM-4C1500 (8.0/125)/001	SM-7C1500 (6.1/125)	SSM-7C1500 (6.1/125)
Operating Wavelength (nm)	1520 - 1650		
Cut-Off Wavelength (nm)	1300 - 1500		
Numerical Aperture	0.14 - 0.17	0.20 - 0.22	
Mode Field Diameter (μm)	7.4 - 8.5 @1550nm	5.7 - 6.5 @1550nm	
Proof Test (%)	1 (100 kpsi)		
Cladding Diameter (μm)	125 ± 1		
Core Spacing (μm)	50 (nominal)	35 (nominal)	
Core Position Shape	Square	Hexagon plus central core	Hexagon plus central core Spun
Coating Diameter (μm)	245 ± 7		200 ± 7
Coating Type	Dual Acrylate		
Operating Temperature (°C)	-55 to +85		

# Fan Outs

- Broad flat spectral response
- Compact package size
- High data rates
- Scalable manufacturing technique

### Typical applications:

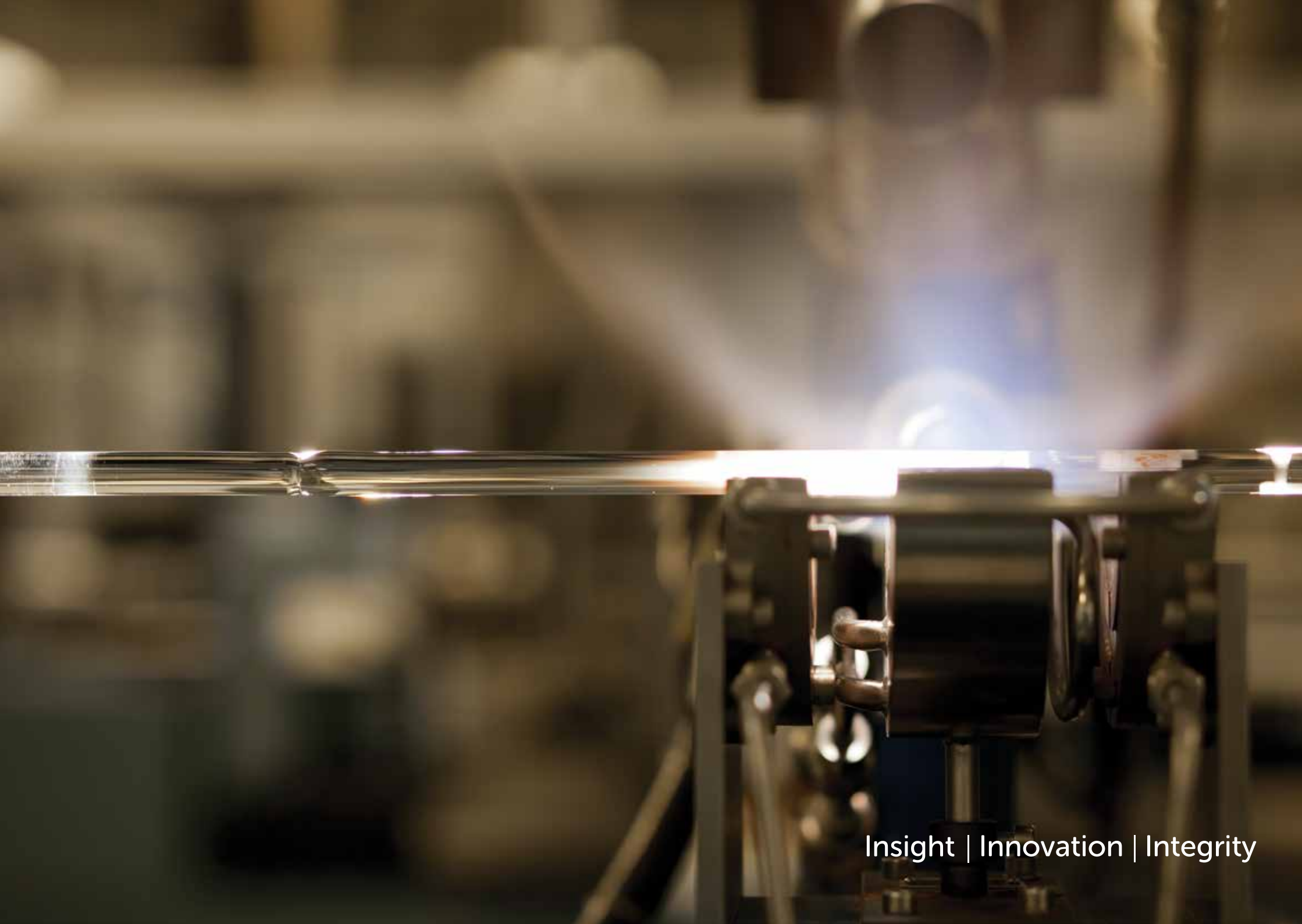
- 3D shape sensing
- 2D bend sensing
- Active Optical Cables (AOCs)
- High bandwidth telecommunications
- Distributed sensing



## Specifications

	FAN-4C	FAN-7C
Operating Wavelength (nm)	1550	
Insertion Loss (dB)	≤1.0	
Polarization Dependant Loss (dB)	≤1.0	
Number of Cores	4	7
Crosstalk (dB)	≤-50	
Core Configuration	Square	Hexagon plus central core
Input Fiber Type	SMF-28 or Equivalent	
Output Fiber Type	SM-4C1500(8.0/125)	SM-7C1500(6.1/125) SSM-7C1500(6.1/125)
Operating Temperature (°C)	0 to +80	
Connectorization	FC/APC on SMF (other connectorization options available)	





Insight | Innovation | Integrity



## PM Fiber

For Fiber Optic Gyros, Sensor,  
Telecoms, EDFAs and  
All Fiber Polarizers

### HiBi is designed for high-performance interferometric and polarimetric sensors, integrated optics and coherent communications

The Bow-Tie Stress Applying Parts (SAPs) act as opposing wedges generating optimum stress distribution within the fibers, giving the very best in performance. Our Bow-Tie fibers can be customized for optimum performance for each particular application.

- 90 million meters in service worldwide
- More than 1,000,000m shipped every month

#### Typical applications:

- Coherent communications
- Biomedical imaging
- Fiber optic gyroscopes
- Metrology
- Fused tape couplers
- All-fiber polarizers

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#### Application specific variants:

##### Standard PM Fiber:

125/250 $\mu$ m, bend-insensitive fibers for sensor and research applications between 488nm and 1550nm

##### Polyimide Coated PM Fiber:

125/145 $\mu$ m, polyimide coated fibers for high temperature embedded sensor and medical applications at 830nm, 1310nm or 1550nm

##### Telecoms PM Fiber:

125/245 $\mu$ m and 125/400 $\mu$ m, 9 $\mu$ m (nominal) MFD fibers for telecommunications and EDFA applications at wavelengths between 980nm and 1550nm

##### PM Gyro Fiber:

80/175 $\mu$ m, broad temperature range, dual coated fibers for fiber optic gyro applications at 830nm, 1310nm or 1550nm

##### Pure Silica Core PM Fiber:

Photodarkening resistant PM fiber for UV and blue wavelengths

##### Zing™ Polarizing Fiber:

80/170 $\mu$ m and 125/245 $\mu$ m, short beat-length fibers for high performance, all-fiber polarizers

## Standard PM Fiber

### Bend insensitive fibers for sensor and research applications

- Seven standard wavelengths, 488nm to 1550nm
- Maximum birefringence – Minimum stress
- Exceptional polarization maintaining ability

#### Typical applications:

- Interferometric sensors
- Diode pigtailed
- Coherent beam delivery
- Modulators
- Delay lines
- Spectroscopy
- Biomedical sensors
- Optical Coherence Tomography (OCT)

### Specifications

	HB450	HB600	HB750	HB800	HB1000	HB1250	HB1500
<b>Operating Wavelength (nm)</b>	488 - 633	633 - 780	780 - 830	830 - 1060	1060 - 1300	1300 - 1550	1520 - 1650
<b>Cut-Off Wavelength (nm)</b>	350 - 470	500 - 600	610 - 750	600 - 800	840 - 1020	1030 - 1270	1230 - 1520
<b>Numerical Aperture</b>	0.10 - 0.13		0.14 - 0.18				
<b>Mode Field Diameter (μm)</b>	3.0 - 4.1 @488nm	2.8 - 3.7 @633nm	3.5 - 4.6 @780nm	3.7 - 4.9 @830nm	4.8 - 6.3 @1060nm	5.8 - 7.9 @1310nm	7.0 - 9.2 @1550nm
<b>Attenuation (dB/km)</b>	≤100 @488nm	≤15 @633nm	≤8 @780nm	≤5 @830nm	≤3 @1060nm	≤2 @1310nm	≤2 @1550nm
<b>Beat-Length (mm) @633nm</b>	≤2.0						
<b>Proof Test (%)</b>	1 (100 kpsi)						
<b>Cladding Diameter (μm)</b>	125 ± 1						
<b>Core Cladding Concentricity (μm)</b>	≤0.75						≤1.0
<b>Coating Diameter (μm)</b>	245 ± 7						
<b>Coating Type</b>	Dual Layer Acrylate						
<b>Operating Temperature (°C)</b>	-55 to +85						

## Polyimide Coated PM Fiber

### For embedded sensor, medical and high temperature applications

- Survives composite embedding temperatures up to 300°C
- Maintains composite material strength when embedded
- Suitable for autoclave sterilization temperatures

#### Typical applications:

- High temperature sensors
- Downhole sensors
- Interferometric sensors
- Medical probes
- Embedded sensors

### Specifications

	HB800P	HB1250P	HB1500P
<b>Operating Wavelength (nm)</b>	830 - 1200	1300 - 1550	1520 - 1650
<b>Cut-Off Wavelength (nm)</b>	600 - 800	1030 - 1270	1230 - 1520
<b>Numerical Aperture</b>	0.14 - 0.18		
<b>Mode Field Diameter (μm)</b>	3.7 - 5.0 @830nm	5.8 - 7.8 @1310nm	7.0 - 9.2 @1550nm
<b>Attenuation (dB/km)</b>	≤5 @830nm	≤2 @1310nm	≤2 @1550nm
<b>Beat-Length (mm) @633nm</b>	≤2.0		
<b>Proof Test (%)</b>	1 (100 kpsi)		
<b>Cladding Diameter (μm)</b>	125 ± 2		
<b>Core Cladding Concentricity (μm)</b>	≤1.0		
<b>Coating Diameter (μm)</b>	155 ± 5		
<b>Coating Type</b>	Polyimide		
<b>Operating Temperature (°C)</b>	-55 to +300		

# Telecoms PM Fiber

## For EDFA pumps, Raman pump Lyot depolarizers and telecommunications applications

- Ultra-short beat-length variants for superior polarization performance
- Splice compatible with both standard SM fibers and other PM fibers
- Available in both 245 $\mu$ m and 400 $\mu$ m coating diameters
- Tested in accordance with Telecordia GR-20-CORE
- Excellent geometry for splicing

### Typical applications:

- Pump diode pigtailed
- Erbium Doped Fiber Amplifier (EDFA)
- Cable Television (CATV)

- Interferometric sensors
- Lyot depolarizers

## Specifications

	HB980T	HB1250T (245)	HB1250T (400)	HB1480T (245)	HB1480T (400)	HB1500T (245)	HB1500T (400)
Operating Wavelength (nm)	980 - 1310	1300 - 1480		1480 - 1550		1520 - 1650	
Cut-Off Wavelength (nm)	870 - 970	1100 - 1290		1290 - 1450		1290 - 1520	
Numerical Aperture	0.13 - 0.15	0.11 - 0.13					
Mode Field Diameter ( $\mu$ m)	5.3 - 6.4 @980nm	8.1 - 9.9 @1310nm		9.1 - 10.8 @1480nm		9.6 - 11.7 @1550nm	
Attenuation (dB/km)	$\leq 3$ @980nm	$\leq 2$ @1310nm		$\leq 2$ @1480nm		$\leq 2$ @1550nm	
Beat-Length (mm) @633nm	$\leq 2.0$						
Proof Test (%)	1 or 2 (100 or 200 kpsi)						
Cladding Diameter ( $\mu$ m)	125 $\pm$ 1						
Core Cladding Concentricity ( $\mu$ m)	$\leq 0.6$						
Coating Diameter ( $\mu$ m)	245 $\pm$ 7	400 $\pm$ 20	245 $\pm$ 7	400 $\pm$ 20	245 $\pm$ 7	400 $\pm$ 20	
Coating Type	Dual Layer Acrylate						
Operating Temperature ( $^{\circ}$ C)	-55 to +85						

## Specifications continued

### Ultra-short beat-length

	HB980T(6.6/125)	HB1250T(9/125)	HB14XXT
Operating Wavelength (nm)	980 - 1310	1260 - 1650	1300 - 1650
Cut-Off Wavelength (nm)	870 - 970	1100 - 1250	1100 - 1290
Numerical Aperture	0.11 - 0.13		
Mode Field Diameter ( $\mu$ m)	6.1 - 7.1 @980nm	8.1 - 9.9 @1310nm	9.5 - 11.5 @1465nm
Attenuation (dB/km)	$\leq 2$ @980	$\leq 2$ @1310nm	$\leq 2$ @1480nm
Beat-Length (mm) @633nm	$\leq 1.2$		
Proof Test (%)	1 or 2 (100 or 200 kpsi)		
Cladding Diameter ( $\mu$ m)	125 $\pm$ 1		
Core Cladding Concentricity ( $\mu$ m)	$\leq 0.4$		$\leq 0.6$
Coating Diameter ( $\mu$ m)	245 $\pm$ 7		
Coating Type	Dual Layer Acrylate		
Operating Temperature ( $^{\circ}$ C)	-55 to +85		

# PM Gyro Fiber

## The No.1 fiber for fiber optic gyroscopes

### Typical applications:

- FOGs
- Current sensors
- Delay lines

- High polarization extinction in coiled applications
- -55°C to +85°C in-coil operating range
- Tight coating diameter tolerance for high accuracy coil winding
- 80µm OD saves space and enhances lifetime
- Radiation tolerant variants for space applications
- High reliability in coiled applications
- High temperature coating variant available for downhole FOGs

## Specifications

### Short beat-length fiber

	HB800G-SB	HB1500G-SB	HB1500G-RT-SB
Operating Wavelength (nm)	810 - 1000	1520 - 1650	
Cut-Off Wavelength (nm)	660 - 800	1360 - 1520	
Numerical Aperture	0.14 - 0.18	0.19 - 0.21	
Mode Field Diameter (µm)	3.7 - 5.0 @830nm	6.0 - 7.0 @1550nm	
Attenuation (dB/km)	≤5 @830nm	≤1.5 @1550nm	≤2 @1550nm
Beat-Length (mm) @633nm	≤1.0		≤1.15
Proof Test (%)	1 (100 kpsi), 2 (200 kpsi) or greater upon request		
Cladding Diameter (µm)	80 ± 1		
Core Cladding Concentricity (µm)	≤1.0		
Coating Diameter (µm)	165 ± 5	155 ± 5	165 ± 5
Coating Type	Dual Layer Acrylate		
Radiation Tolerant	No	Yes	
Operating Temperature (°C)	-55 to +85		

\* **SB** - Short Beat-Length \* **RT** - Radiation Tolerant \* **HI** - High Index

## Specifications continued

### Standard gyro fiber

	HB800G	HB1250G	HB1500G	HB1500G-RT	HB1500G-HI
Operating Wavelength (nm)	810 - 1000	1280 - 1520	1520 - 1650		
Cut-Off Wavelength (nm)	660 - 800	1030 - 1270	1230 - 1520		1360 - 1520
Numerical Aperture	0.14 - 0.18				0.19 - 0.21
Mode Field Diameter (µm)	3.7 - 4.9 @830nm	5.8 - 7.8 @1310nm	6.9 - 9.3 @1550nm		6.0 - 6.9 @1550nm
Attenuation (dB/km)	≤5 @830nm	≤2 @1310nm	≤2 @1550nm		≤3 @1550nm
Beat-Length (mm) @633nm	≤1.5				
Proof Test (%)	1 (100 kpsi), 2 (200 kpsi) or greater upon request				
Cladding Diameter (µm)	80 ± 1				
Core Cladding Concentricity (µm)	≤1.0				
Coating Diameter (µm)	165 ± 5	170 ± 5		155 ± 5	
Coating Type	Dual Layer Acrylate				
Radiation Tolerant	No		Yes	No	
Operating Temp (°C)	-55 to +85				

\* **SB** - Short Beat-Length \* **RT** - Radiation Tolerant \* **HI** - High Index

# Pure Silica Core PM Fiber

## Photodarkening resistant PM fiber for UV and blue wavelengths

- Germanium-free pure silica core, designed to remove photodarkening effects
- Polarization maintaining design for short wavelength lasers and sensors
- Single-mode down to 350nm
- Compatible with MM125 coreless end-cap fiber
- Shorter wavelengths available upon request

### Typical applications:

- Confocal microscopy
- Environmental monitoring
- DNA sequencing
- Flow cytometry

## Specifications

	HB450-SC
Operating Wavelength (nm)	430 - 650
Cut-Off Wavelength (nm)	350 - 420
Numerical Aperture	0.11 - 0.13
Mode Field Diameter (μm)	3.0 - 3.6 @488nm
Attenuation (dB/km)	≤30 @488nm
Beat-Length (mm) @633nm	≤2.5
Proof Test (%)	1 (100 kpsi)
Cladding Diameter (μm)	125 ± 1
Coating Diameter (μm)	245 ± 7
Core Concentricity (μm)	≤0.75
Operating Temperature (°C)	-55 to +85

# Zing™ Polarizing Fiber

## Bow-Tie single polarization fibers for all-fiber polarizers

- Wide and stable polarizing window with a range of deployment conditions
  - Consistently low loss and high PER of 30dB+
  - Extreme birefringence with excellent handling characteristics
  - Functional tunability
- Typical applications:**
- Fiber lasers
  - Laser diodes
  - Fiber Optic Gyroscopes (FOGs)
  - Current sensors
  - Interferometric sensors

## Specifications

	HB830Z (5/80)	HB1060Z (7/125)	HB1310Z (9/80)	HB1550Z (11/80)	HB1550Z (11/80) - 50mm *	HB1550Z (11/125)
Operating Wavelength (nm)	830	1064	1310	1550		
20dB Fast Edge*	≤790	≤1015	≤1260	≤1500		
3dB Slow Edge*	≥860	≥1105	≥1360	≥1600		
Polarization Extinction Ratio* (dB)	≥30					
Mode Field Diameter (μm)	4.1 - 7.7 @830nm	6.0 - 8.0 @1064nm	7.0 - 10.3 @1310nm	8.5 - 13.5 @1550nm	10.0 - 12.5 @1550nm	
Attenuation (dB/km)	≤20					
Proof Test (%)	1 (100 kpsi)					
Cladding Diameter (μm)	80 ± 1	125 ± 1	80 ± 1		125 ± 1	
Core Concentricity (μm)	≤1.0					
Coating Diameter (μm)	170 ± 5	245 ± 7	170 ± 5		245 ± 7	
Coating Type	Dual Layer Acrylate					
Operating Temperature (°C)	-55 to +85					

\* Typical polarizing performance with deployment conditions of 5m length in a coil.

\* Zing™ fibers are designed to provide the polarizing window in a 90mm coil diameter.

Variants with an \* are designed for smaller diameters of 50mm.

To tune the fiber for your application, changing the length of the fiber and/or the coil diameter, can alter the central wavelength and operating bandwidth. For more information and to discuss your precise requirements, contact us at [sales@fibercore.com](mailto:sales@fibercore.com)



## Spun Fiber

For Current Sensors,  
Current Transformers  
and Faraday Effect Sensors

## Spun Fiber

**Fibercore's spun fiber is primarily designed for fiber optic Faraday effect current transformers where high stability fiber design is critical to enable high accuracy current sensing**

The Spun fiber allows highly sensitive and accurate current sensing over a wide range of environmental conditions including temperature variation and vibration, making it suitable for current transformers deployed outdoors in real life applications. When used in conjunction with Fibercore's PM fiber for delay lines and Zing™ for depolarizers, world-class current sensors can be achieved.

### Bow-Tie spun fiber for Faraday effect current sensors

- Circularly birefringent
- Supported by full range of complementary fibers
- Higher Verdet constant at 1310nm than at 1550nm

#### Typical applications:

- Current sensors
- Current transformers
- Faraday effect sensors

---

#### Products in this range:

##### Spun HiBi Fiber:

- Circularly birefringent
- Thermally stable
- Vibrationally stable
- Highest accuracies possible

## Specifications

Spun HiBi

	<b>SHB1250 (7.3/80) - 2.5mm</b>	<b>SHB1250 (7.3/80)</b>	<b>SHB1250 (7.3/125)</b>	<b>SHB1500 (8.9/125)</b>
<b>Operating Wavelength (nm)</b>		1260 - 1510		1510 - 1650
<b>Cut-Off Wavelength (nm)</b>		1100 - 1250		1360 - 1500
<b>Numerical Aperture</b>		0.14 - 0.17		0.13 - 0.16
<b>Mode Field Diameter (μm)</b>		6.2 - 8.4 @1310nm		7.9 - 9.9@1550nm
<b>Attenuation (dB/km)</b>		≤5 @1310nm		≤3 @1550nm
<b>Circular Beat-Length (mm)</b>		63 - 125 @1310nm		72 - 144 @1550nm
<b>Spin Pitch (mm) Nominal</b>	2.5		4.8	
<b>Twist Test (Turns/m)</b>		≤1.0		
<b>Proof Test (%)</b>		1 (100 kpsi)		
<b>Cladding Diameter (μm)</b>	80 ± 1			125 ± 1
<b>Core Cladding Concentricity (μm)</b>		≤1.0		
<b>Coating Diameter (μm)</b>	165 ± 5			245 ± 7
<b>Coating Type</b>	Dual Layer Acrylate			
<b>Operating Temperature (°C)</b>	-55 to +85			







# Doped Fiber

For Amplifiers and Lasers

**Fibercore offers a number of different doped fibers including erbium doped fiber for various 'C' and 'L' amplifier configurations and ASE applications, all supported by our GainMaster™ simulation software to help you design even the most complex EDFAs**

**Typical applications:**

- DWDM systems
- 'Metro' EDFA's
- Low power fiber lasers
- CATV systems

**Products in this range**

**Erbium Doped Fiber IsoGain™ Multichannel:**

Erbium doped fibers for high channel-count DWDM systems

**Erbium Doped Fiber AstroGain™:**

Space grade erbium doped fibers

**PM Erbium Doped Fiber:**

Polarization maintaining erbium doped fiber

**Dual Clad Erbium/Ytterbium Doped Fiber:**

All-glass erbium/ytterbium co-doped dual clad fiber. Field-proven in commercial CATV systems

**Isolating Wavelength Division Multiplexer CP-IWDM:**

Designed for cladding pump applications with double clad erbium/ytterbium doped fiber

**Other Doped Fibers:**

Pump ranges at 780nm to 830nm and 900nm to 1064nm. Output ranges at around 1088nm and 1075nm to 1100nm. Ideal for student lab classes, low power fiber lasers and single channel amplifiers and fiber lasers

**OEM Amplifier GainBlock:**

Packaged passive optical unit for integration into amplifiers and fiber lasers

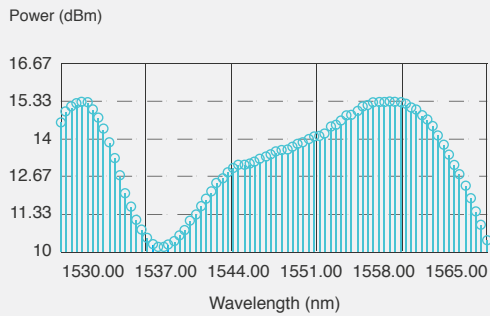
# Erbium Doped Fiber IsoGain™

## Erbium doped fibers for high channel-count DWDM systems

- Optimized core composition for high channel-count DWDM systems' EDFAs
- World-class leading conversion efficiency
- Suitable for C and L-band amplifiers

### Typical applications:

- EDFAs/telecoms
- Fiber lasers
- Biomedical illumination
- Optical Coherence Tomography (OCT)



- ASE light sources
- Gyros
- Current sensors
- Distributed sensor systems

## Specifications

### High Efficiency C-Band Erbium Doped Fibers

	I-4(980/125)	I-4(980/125)HC	I-4(980/125)HP	I-6(980/125)
<b>Cut-Off Wavelength (nm)</b>	870 - 970	1050 - 1320	1100 - 1320	870 - 970
<b>Numerical Aperture</b>	0.22 - 0.24		0.19 - 0.22	0.22 - 0.24
<b>Mode Field Diameter (μm)</b>	5.4 - 6.6 @1550nm	5.2 - 5.8 @1550nm	5.7 - 6.6 @1550nm	5.5 - 6.3 @1550nm
<b>Absorption (dB/m) @1531nm</b>	5.0 - 6.7	7.7 - 9.4		7.2 - 8.4
<b>Proof Test (%)</b>	1 (100 kpsi)			
<b>Attenuation (dB/km) @1200nm</b>	≤10			
<b>Polarization Mode Dispersion (ps/m)</b>	≤0.005			
<b>Cladding Diameter (μm)</b>	125 ± 1			
<b>Core Concentricity (μm)</b>	≤0.3			
<b>Coating Diameter (μm)</b>	245 ± 7			
<b>Coating Type</b>	Dual Layer Acrylate			
<b>Operating Temperature (°C)</b>	-55 to +85			

## Specifications continued

### L-Band and C-Band Erbium Doped Fibers

	I-12 (980/125)	I-12 (980/125)HC	I-15 (980/125)HC	I-25 (980/125)
<b>Cut-Off Wavelength (nm)</b>	900 - 970	1200 - 1320		900 - 970
<b>Numerical Aperture</b>	0.21 - 0.23	0.23 - 0.26		
<b>Mode Field Diameter (μm)</b>	5.7 - 6.6 @1550nm	5.0 - 5.5 @1550nm	4.8 - 5.4 @1550nm	5.2 - 6.3 @1550nm
<b>Absorption (dB/m)</b>	14 - 21 @1531nm	17 - 21 @1531nm	27 - 33 @1531nm	35 - 45 @1531nm
<b>Proof Test (%)</b>	1 (100 kpsi)			
<b>Attenuation (dB/km)</b>	≤10 @1200nm			
<b>Polarization Mode Dispersion (ps/m)</b>	≤0.005			
<b>Cladding Diameter (μm)</b>	125 ± 1			
<b>Core Concentricity (μm)</b>	≤0.3			
<b>Coating Diameter (μm)</b>	245 ± 7			
<b>Coating Type</b>	Dual Layer Acrylate			
<b>Operating Temperature (°C)</b>	-55 to +85			

### Reduced Cladding Erbium Doped Fiber For Mini and Micro EDFAs

	I-25H(1480/80)
<b>Cut-Off Wavelength (nm)</b>	900 - 1075
<b>Numerical Aperture</b>	≥0.30
<b>Mode Field Diameter (μm)</b>	3.8 - 4.7 @1550nm
<b>Absorption (dB/m)</b>	23 - 27 @1531nm
<b>Proof Test (%)</b>	1 (100 kpsi)
<b>Attenuation (dB/km)</b>	≤30 @1200nm
<b>Polarization Mode Dispersion (ps/m)</b>	≤0.005
<b>Cladding Diameter (μm)</b>	80 ± 1
<b>Core Concentricity (μm)</b>	≤0.5
<b>Coating Diameter (μm)</b>	160 ± 5
<b>Coating Type</b>	Dual Layer Acrylate
<b>Operating Temperature (°C)</b>	-55 to +85

EDFA simulation software, **GainMaster™** is available on [fibercore.com](http://fibercore.com)

# Erbium Doped Fiber AstroGain™

## Space grade erbium doped fibers

- AG980H for high duty cycle space applications
- AG980L for low duty cycle space applications
- Optimized trivalent core matrix for space operation
- High efficiency designs for maximum electrical-to-optical power conversion
- High reliability mechanical design

### Typical applications:

- Amplifiers for inter-satellite communications
- Light sources for earth observation missions
- Light sources and amplifiers for large scale sensing missions

## Specifications

	AG980H	AG980L
<b>Cut-Off Wavelength (nm)</b>	900 - 970	
<b>Numerical Aperture</b>	0.21 - 0.24	
<b>Mode Field Diameter (μm)</b>	5.4 - 6.9 @1550nm	
<b>Absorption (dB/m)</b>	5.0 - 7.1 @1531nm	
<b>Proof Test (%)</b>	2 (200 kpsi)	
<b>Attenuation (dB/km)</b>	≤10 @1200nm	
<b>Polarization Mode Dispersion (ps/m)</b>	≤0.005	
<b>Cladding Diameter (μm)</b>	125 ± 1	
<b>Core Concentricity (μm)</b>	≤0.3	
<b>Coating Diameter (μm)</b>	245 ± 7	
<b>Coating Type</b>	Dual Layer Acrylate	
<b>Operating Temperature (°C)</b>	-55 to +85	

EDFA simulation software, **GainMaster™** is available on [fibercore.com](http://fibercore.com)

# PM Erbium Doped Fiber

## Polarization maintaining erbium doped fiber

- DHB1500 matched to IsoGain™ I-12(980/125)
- DHB1500-LA designed with lower absorption for higher efficiencies
- Polarization extinction levels of up to -30dB over typical gain lengths of 8 - 14 meters
- Designed for 980nm pumping

### Typical applications:

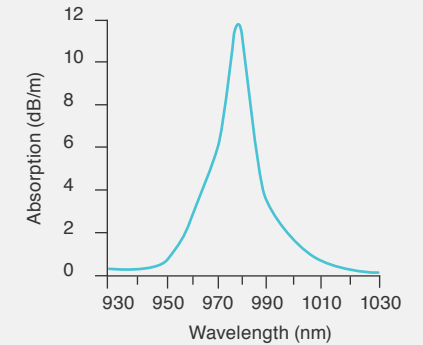
- EDFAs
- Coherent communications
- Amplified Spontaneous Emission (ASE) light source
- Fiber lasers

## Specifications

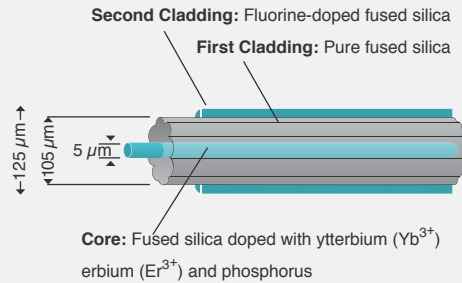
	DHB1500	DHB1500-LA
<b>Cut-Off Wavelength (nm)</b>	860 - 960	
<b>Numerical Aperture</b>	0.22 - 0.26	0.22 - 0.24
<b>Mode Field Diameter (μm)</b>	5.1 - 6.7 @1550nm	5.5 - 6.7 @1550nm
<b>Absorption (dB/m)</b>	10 (nominal) @980nm 12 - 27 @1531nm	3.0 - 5.5 @1531nm
<b>Beat-Length (mm) @633</b>	≤4.0	
<b>Proof Test (%)</b>	1 (100 kpsi)	
<b>Attenuation (dB/km)</b>	≤20 @1200nm	≤15 @1200nm
<b>Cladding Diameter (μm)</b>	125 ± 1	
<b>Core Cladding Concentricity (μm)</b>	≤1.0	
<b>Coating Diameter (μm)</b>	245 ± 7	
<b>Coating Type</b>	Dual Layer Acrylate	
<b>Operating Temperature (°C)</b>	-55 to +85	

**LA** - Low absorption

EDFA simulation software, **GainMaster™** is available on [fibercore.com](http://fibercore.com)



# Dual Clad Erbium / Ytterbium Doped Fiber



## All-glass erbium/ytterbium co-doped dual clad fiber

- Optimized for efficient energy transfer
- Can be cleaved and spliced with standard equipment

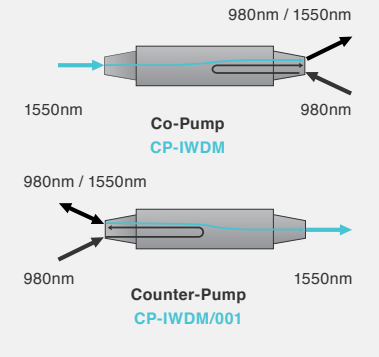
### Typical applications:

- High power Erbium Doped Fiber Amplifiers (EDFAs)
- Ytterbium/Erbium Doped Fiber Amplifier (YEDFA)
- Fiber lasers
- Light Radar (LIDAR)
- Cable Television (CATV)

## Specifications

	CP1500Y
<b>Laser Core</b>	
<b>Composition</b>	Phosphosilicate with erbium and ytterbium
<b>Operating Wavelength (nm)</b>	1520 - 1570
<b>Numerical Aperture</b>	0.20 - 0.22
<b>Mode Field Diameter (μm)</b>	5.6 - 6.4 @1550nm
<b>Cut-Off Wavelength (nm)</b>	1300 - 1450
<b>Attenuation (dB/km)</b>	≤200 @1310nm
<b>Absorption (dB/m)</b>	19 (nominal) @1550nm
<b>Pump Guide</b>	
<b>Composition</b>	Pure silica with F-doped silica cladding
<b>Numerical Aperture</b>	0.24 - 0.28
<b>Mean Pump Guide Diameter (μm)</b>	85 - 105
<b>Absorption (dB/m)</b>	1 (nominal) @940nm
<b>General Guide</b>	
<b>Proof Test (%)</b>	1 (100 kpsi)
<b>Coating Type</b>	Dual Layer Acrylate
<b>Cladding Diameter (μm)</b>	125 ± 1
<b>Coating Diameter (μm)</b>	245 ± 7
<b>Operating Temperature (°C)</b>	-55 to +85

# Isolating Wavelength Division Multiplexer CP-IWDM



- Combines a high-power multimode pump and a single-mode signal to a single SMM900 dual clad pump-signal fiber output

- Designed for cladding-pump applications with CP1500Y
- Provides multiplexing and isolation in one small package

### Typical applications:

- High power Erbium Doped Fiber Amplifiers (EDFAs)
- Fiber lasers
- WDM systems
- Cable Television (CATV)

## Specifications

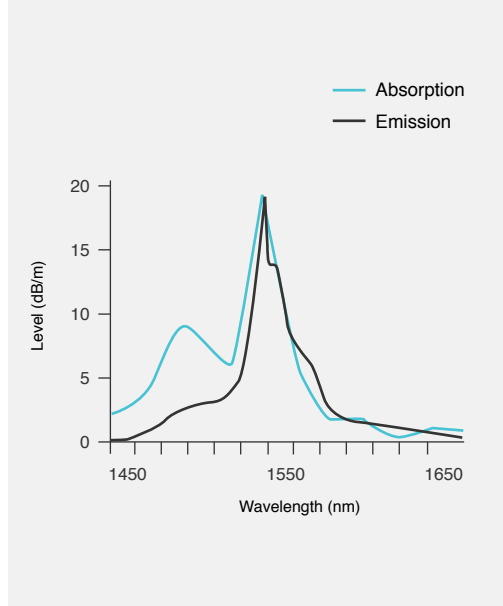
<b>General Mechanical</b>	Package Size (mm)	5.5 x 54
	Operating Temperature (°C)	0 to +70
	Storage Temperature (°C)	-40 to +85
<b>General Optical</b>	Directivity (dB)	≥40
	Polarization Mode Dispersion (ps)	≥0.25
	Polarization Dependant Loss (dB)	≥0.1
	Isolation @23°C (dB)	≥31
	Signal Wavelength Isolation (dB) (1 to 3)	≥12
<b>S Single-Mode Fiber</b>	Cladding Diameter (μm)	125
	Operating Wavelength (nm)	1550
	Numerical Aperture nominal	0.12
	Max Input @1550nm (mW)	300
<b>P Multimode Input</b>	Cladding Diameter (μm)	125
	Pump Guide Diameter (μm) nominal	105
	Numerical Aperture nominal	0.22
	Max Input @970nm (mW)	5000
<b>C Dual Clad Fiber</b>	Cladding Diameter (μm)	125
	Single-Mode Cut-Off Wavelength (nm)	870 - 970
	Single-Mode NA	0.18 - 0.20
	Pump Guide Diameter (μm) nominal	105
	Pump Guide NA nominal	0.22

## Other Doped Fibers

- Core pumped designs
- Emission at 1060, 1085 and 1550nm
- Splice compatible with fused taper couplers
- Low pump threshold designs

### Typical applications:

- Fiber lasers
- Amplified Spontaneous Emission (ASE) light source
- Erbium Doped Fiber Amplifier (EDFA)
- Cable Television (CATV)
- Educational kits



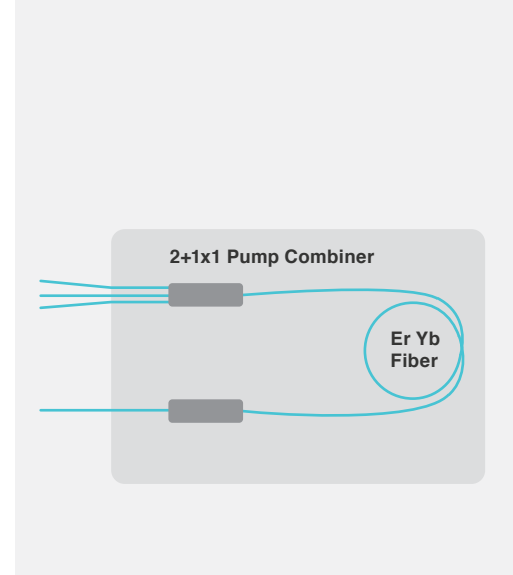
## OEM Amplifier GainBlock

Packaged passive optical unit for integration into amplifiers and fiber laser

- Compact package (70 x 90 x 10mm)
- High output power, up to 5W
- High efficiency
- Flat spectral gain

### Typical applications:

- High power amplifiers
- Fiber lasers
- LIDAR

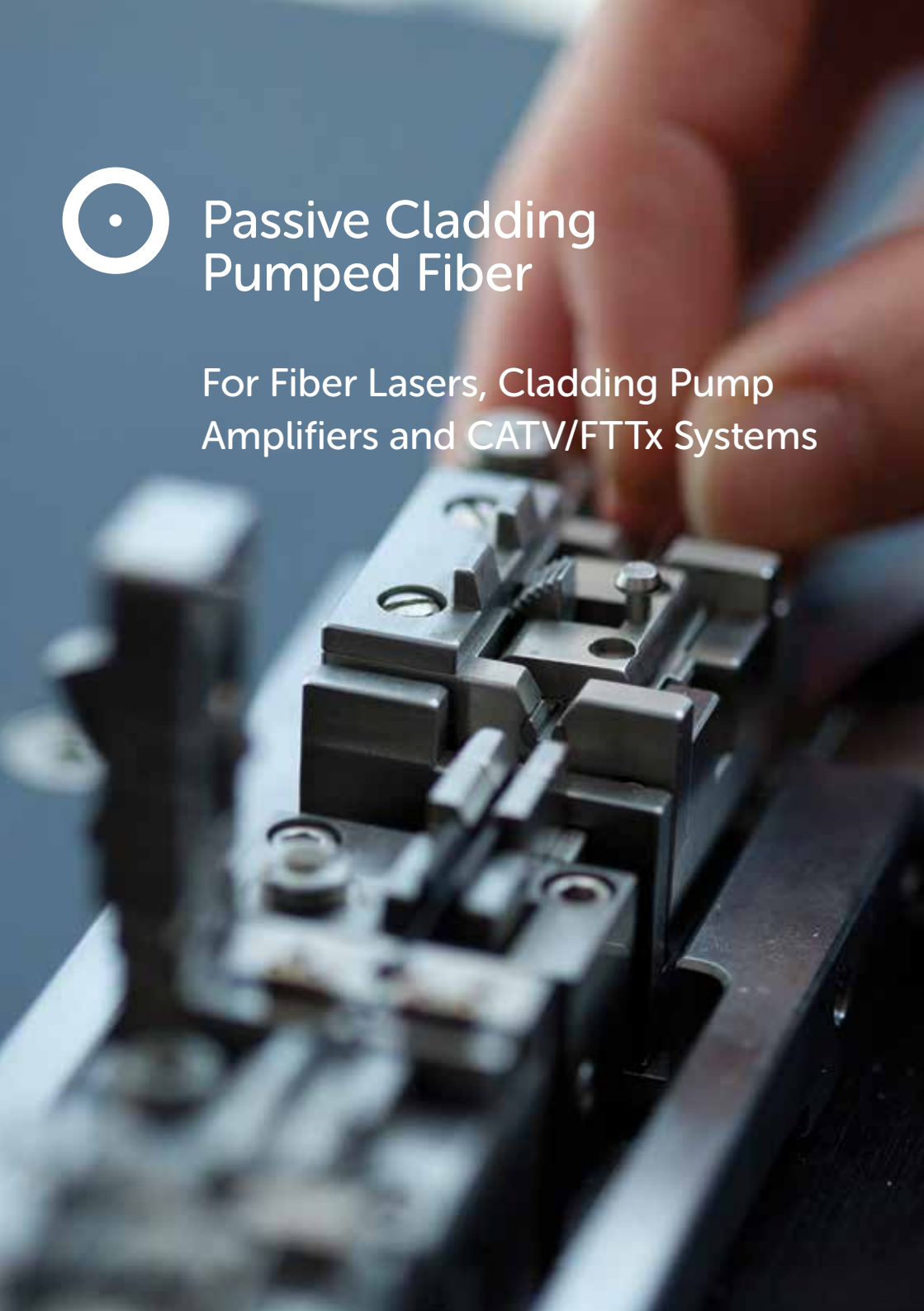


## Specifications

	DF1000	DF1100	DF1500Y
<b>Operating Wavelength (nm)</b>	1085	1030 - 1100	1550
<b>Cut-Off Wavelength (nm)</b>	875 - 1025	800 - 900	950 - 1050
<b>Numerical Aperture</b>	0.18 - 0.22	0.14 - 0.17	0.20 - 0.24
<b>Mode Field Diameter (μm)</b>	3.9 - 5.0 @1085nm	5.1 - 6.3 @1085nm	5.3 - 6.8 @1550nm
<b>Absorption (dB/m)</b>	4.5 (nominal) @780nm 8.5 (nominal) @810nm 3.5 (nominal) @830nm	1500 (nominal) @975nm	1000 (nominal) @975nm 10 - 15 @1047nm 20 (nominal) @1532nm
<b>Attenuation (dB/km)</b>	≤20 @1085nm	≤50 @1200nm	≤200 @1200nm
<b>Proof Test (%)</b>	1 (100 kpsi)		
<b>Cladding Diameter (μm)</b>	125 ± 1		
<b>Core Cladding Concentricity (μm)</b>	≤0.5		
<b>Coating Diameter (μm)</b>	245 ± 7		
<b>Coating Type</b>	Dual Layer Acrylate		
<b>Operating Temperature (°C)</b>	-55 to +85		
<b>Dopants</b>	Neodymium (Nd)	Ytterbium (Yb)	Erbium / Ytterbium (Er/Yb)

## Specifications

	GB1500-5W
<b>Operating Wavelength (nm)</b>	1550 - 1565
<b>Output Power (W)</b>	5
<b>Input Power Range (mW)</b>	10 - 100
<b>Noise Figure @ Pin: 10mW (dB)</b>	8
<b>Signal Gain (dB)</b>	17 - 27
<b>Gain Flatness @ 25°C &amp; Gain: 27dB (dB)</b>	~1.5
<b>Pump Power to Reach 5W (940nm) (W)</b>	~12
<b>Pump Port 1&amp;2</b>	0.6m of MM 105/125 0.22 NA fiber with 0.9mm loose buffer
<b>Input Port</b>	0.6m of standard SMF fiber with 0.9mm tight buffer
<b>Output Port</b>	0.6m of standard SMF fiber with 0.9mm tight buffer
<b>Power to Dissipate (W)</b>	~10
<b>Operating Temperature (°C)</b>	-20 to +60



## Passive Cladding Pumped Fiber

For Fiber Lasers, Cladding Pump Amplifiers and CATV/FTTx Systems

**Fibercore offer two families of double clad fiber: low index polymer coated double clad fibers and an all silica double clad fiber**

**Typical applications:**

- CATV & FTTx systems
- Cladding pump amplifiers
- Fiber lasers

---

**Products in this range:**

**Low Index Double Clad Passive Fiber:**

The low index coated double clad passive fibers are designed for high power amplifiers and fiber lasers at 1060nm and 1550nm where stable management of high power optical powers is crucial

**All Silica Double Clad Fiber:**

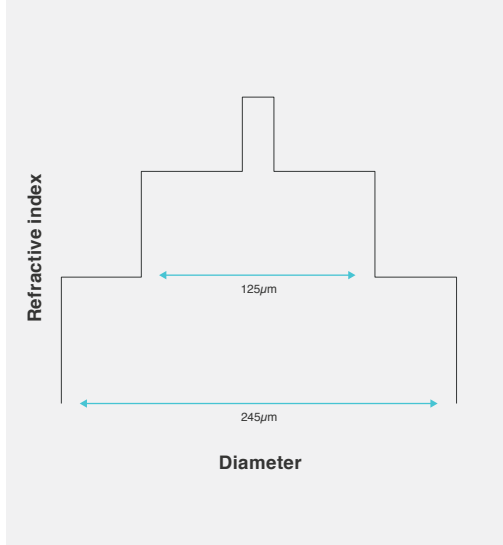
The all silica double clad fiber gives the benefit of not requiring low index recoating at the strip point. The fiber can be stripped, cleaved and spliced like any standard optical fiber

# Low Index Double Clad Passive Fiber

- High power handling capability
- 1060nm and 1550nm variants
- Splice compatible with Fibercore doped fibers
- Range of core NAs available

## Typical applications:

- High power amplifiers
- Fiber lasers
- LIDAR
- Biomedical probes
- Beam delivery
- Pump combiners



## Specifications

	DC1060(10/125)0.08	DC1500(11/125)0.12	DC1500(6/125)0.21
<b>Single-Mode Core</b>			
<b>Mode Field Diameter (µm)</b>	11.0 @1060nm (nominal)	9.5 - 11.5 @1550nm	5.6 - 6.5 @1550nm
<b>Core Numerical Aperture</b>	0.07 - 0.09	0.11 - 0.13	0.20 - 0.22
<b>Cut-Off Wavelength (nm)</b>	960 - 1040	1360 - 1520	1290 - 1520
<b>Core Attenuation (dB/km)</b>	≤20 @1060nm	≤1 @1550nm	
<b>Core Concentricity (µm)</b>	≤0.5		
<b>Core Size (µm)</b>	9 - 11	9 (nominal)	5 (nominal)
<b>Pump Guide</b>			
<b>Cladding Attenuation (dB/km)</b>	≤15 @1095nm		
<b>Cladding Numerical Aperture</b>	0.45 (nominal)		
<b>Cladding Diameter (µm)</b>	125 ± 1		
<b>General</b>			
<b>Operating Wavelength (nm)</b>	1060	1550	
<b>Coating Diameter (µm)</b>	245 ± 7		
<b>Proof Test (%)</b>	1 (100 kpsi)		
<b>Coating Material</b>	Low index fluoroacrylate		
<b>Operating Temperature (°C)</b>	-55 to +85		

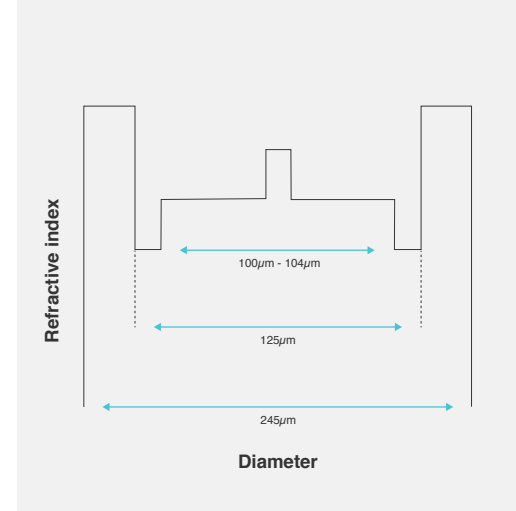
# All Silica Double Clad Fiber

## Double clad component fiber

- Designed for use with CP1500Y
- Combines both single-mode and multimode characteristics
- Compatible with SM980(4.5/125) and other 900/1500nm dual wavelength fibers

## Typical applications:

- Pump combiners
- High power amplifiers (EDFA/YEDFA)
- Cable Television (CATV)
- Fiber lasers
- Biomedical probes



## Specifications

	SMM900
<b>Single-Mode Core</b>	
<b>Mode Field Diameter (µm)</b>	6.5 - 8.2 @1550nm
<b>Numerical Aperture</b>	0.18 - 0.20
<b>Cut-Off Wavelength (nm)</b>	870 - 970
<b>Attenuation (dB/km)</b>	4 (nominal) @1550nm
<b>Core Concentricity (µm)</b>	≤0.75
<b>Pump Guide</b>	
<b>Diameter (µm)</b>	100 - 104
<b>Numerical Aperture</b>	0.23 - 0.25
<b>General</b>	
<b>Cladding Diameter (µm)</b>	125 ± 1
<b>Proof Test (%)</b>	1 (100 kpsi)
<b>Coating Diameter (µm)</b>	245 ± 7
<b>Coating Type</b>	Dual Layer Acrylate
<b>Operating Temperature (°C)</b>	-55 to +85



## MM Fibers

For Harsh Environments

## Multimode Fibers

**Multimode fibers for sensing and telecommunications with specialized coatings for harsh environment**

The multimode (MM) fibers are available in Graded Index (GRIN) variants with 50 $\mu$ m and 62.5 $\mu$ m germanium doped cores. In addition to these are pure silica core GRIN fibers specifically designed for long term use in downhole hydrogen environments as experienced in the Oil & Gas industry.

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**Products in this range:**

**Graded Index Multimode Fiber:**

For high bandwidth sensing up to 150°C and 300°C

**Large Core Fiber:**

Designed for pump power delivery

**Graded Index Multimode Pure Silica Core Fiber:**

For high bandwidth terrestrial sensing in hydrogen and/or radiation environments



# Graded Index Multimode Fiber

- High bandwidth
- Carbon coating options for reduced hydrogen sensitivity
- High temperature coatings for 150°C and 300°C
- 50µm and 125µm variants

## Typical applications:

- DTS
- Telemetry
- Downhole monitoring

## Specifications

	GIMM(50/125)		GIMM(62.5/125)	
<b>Operating Wavelength (nm)</b>	600 - 1750			
<b>Numerical Aperture</b>	0.18 - 0.22		0.25 - 0.30	
<b>Attenuation (dB/km)</b>	@850nm	@1300nm	@850nm	@1300nm
<b>High Temperature (HT)</b>	≤3.2	≤1.0	≤3.2	≤1.0
<b>Carbon High Temperature (CHT)</b>	≤3.2	≤1.0	≤3.2	≤1.0
<b>Polyimide (P)</b>	≤4.0	≤2.0	≤4.0	≤2.0
<b>Carbon Polyimide (CP)</b>	≤4.0	≤2.0	≤4.0	≤2.0
<b>Proof Test (%)</b>	1 or 2 (100 or 200 kpsi)			
<b>Bandwidth (MHz.km)</b>	400/400 @850/1300		160/160 @850/1300	
<b>Cladding Diameter (µm)</b>	HT & P: 125 ± 1 CP & CHT: 125 ± 2			
<b>Core Cladding Concentricity (µm)</b>	≤2.0			
<b>Coating Diameter (µm)</b>	HT & CHT: 245 ± 15 P & CP: 155 ± 5			
<b>Core Diameter (µm) (nominal)</b>	50		62.5	
<b>Coating Type</b>	HT, P, CHT & CP			
<b>Operating Temperature (°C)</b>	HT & CHT: -50 to +150 P & CP: -50 to +300			

For Coatings Order Guide see pg. 35

# Graded Index Multimode Pure Silica Core Fiber

- Coatings available for 150°C and 300°C
- Graded Index profile
- High bandwidth
- Hermetic coating option
- Hydrogen resistance

## Typical applications:

- Distributed temperature sensing
- Pipeline monitoring
- Fire detection systems
- Production/injection monitoring
- DTS in hydrogen
- DTS in radiation

## Specifications

	GIMMSC (50/125)HT	GIMMSC (50/125)CHT	GIMMSC (50/125)P	GIMMSC (50/125)CP
<b>Operating Wavelength (nm)</b>	600 - 1750			
<b>Numerical Aperture</b>	0.18 - 0.22			
<b>Attenuation (dB/km)</b>	≤3.0 @850nm ≤1.2 @1300nm			
<b>Proof Test (%)</b>	1 or 2 (100 or 200 kpsi)			
<b>Bandwidth (MHz.km)</b>	300/300 @850/1300			
<b>Cladding Diameter (µm)</b>	125 ± 1	125 ± 2	125 ± 1	125 ± 2
<b>Core Cladding Concentricity (µm)</b>	≤2.0			
<b>Core Diameter (µm) (nominal)</b>	50			
<b>Coating Diameter (µm)</b>	245 ± 15		155 ± 5	
<b>Coating Type</b>	High Temperature Acrylate	Carbon High Temperature Acrylate	Polyimide	Carbon Polyimide
<b>Operating Temperature (°C)</b>	-50 to +150		-50 to +300	

# Large Core Fiber

- Wide range of coatings available
- High and low OH variants available, optimized for UV or visible/NIR applications
- Broad selection of core diameters for high power applications
- Highly customizable designs, alternative designs available by request
- ETFE and Nylon buffers available on request

## Typical applications:

- Fiber laser beam delivery fiber
- Biomedical devices including optical power delivery within catheters
- Endoscopes
- Spectroscopy
- Pump diode pigtails

## Specifications

	MM(105/125)0.15	MM(105/125)0.22
Operating Wavelength (nm)	500 - 1600	
OH Level	Low (High OH for UV wavelengths also available)	
Numerical Aperture	0.13 - 0.17	0.20 - 0.24
Core Diameter (μm)	105 ± 2	
Core Composition	Silica	
Proof Test (%)	1 (100 kpsi)	
Cladding Composition	Fluorosilicate	
Cladding Diameter (μm)	125 ± 1	
Coating Diameter (μm)	245	
Coating Type	Acrylate	
Operating Temperature (°C)	-40 to +85	

## Specifications continued

	MMSC (200/220)0.22P	MMSC (300/330)0.22	MMSC (400/440)0.22	MMSC (600/660)0.22
Operating Wavelength (nm)	500 - 1600			
OH Level	Low (High OH for UV wavelengths also available)			
Numerical Aperture	0.20 - 0.24			
Core Diameter (μm)	200 ± 3	300 ± 6	400 ± 8	600 ± 10
Core Composition	Silica			
Proof Test (%)	1 (100 kpsi)	0.7 (70 kpsi)		
Cladding Composition	Fluorosilicate			
Cladding Diameter (μm)	220 ± 2	330 ± 7	440 ± 9	660 ± 11
Coating Diameter (μm)	335	560		840
Coating Type	Acrylate (Polyimide, Silicone and Low Index Acrylate Coatings also available)			
Operating Temperature (°C)	-40 to +85			



## FBGs

Fibercore offers two types of FBGs:

- **Femtosecond laser written FBGs for high mechanical strength and reduced hydrogen, radiation and UV photodarkening effects, suitable for use in harsh environments.**
- **Standard UV written FBGs for spectrally demanding applications, suitable for use in standard sensor and telecommunications environments.**

The femtosecond laser written FBGs are written through the coating, without the need to strip and recoat. This maintains the inherently high mechanical strength of the fiber, making FBGs ideal for high strain and high reliability applications. The femtosecond inscription method also allows FBGs to be written into non-photosensitive glass, allowing FBGs to be written into pure silica core fibers that have reduced attenuation sensitivity to hydrogen, radiation and UV. This allows the FBGs to be used in harsh environments that might be experienced in the Oil & Gas industry, nuclear environments and UV laser applications.

Standard UV written FBGs are available using the standard strip and recoat method. These FBGs offer a higher level of FBG specification with a greater flexibility on the spectral design, ideal for spectrally demanding applications in the sensing and telecommunications industries.

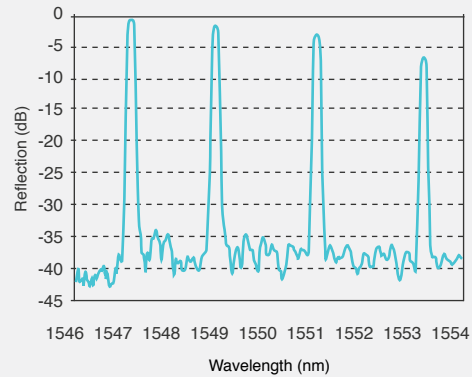
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### Typical applications:

- Temperature sensing
- Strain sensing
- Hydrophone and geophone acoustic sensing
- Laser wavelength locking
- Wavelength division multiplexing

# FBGs

- High mechanical strength FBGs
- Hydrogen darkening resistant variants
- Radiation induced attenuation resistant variants
- UV photodarkening resistant variants
- Flexible spectral characteristics



## Typical applications:

- Temperature sensing
- Strain sensing
- Hydrophone and geophone acoustic sensing
- Laser wavelength locking
- Wavelength division multiplexing

## Specifications

	Femtosecond FBG	UV Written FBG
<b>Central Wavelength (nm)</b>	790 - 850 1520 - 1590	970 - 1620
<b>Wavelength Tolerance (nm)</b>	±0.2 (standard) ±0.1 (optional)	±0.5 (standard) ±0.25 (optional)
<b>Reflectivity (%)</b>	<1 - >80	1 - 99
<b>FWHM Bandwidth (nm)</b>	0.4 - 1	0.1 - 3
<b>FBG Length (mm)</b>	≤150	1 - 25
<b>FBG Profile</b>	Uniform or Apodized	
<b>Chirp</b>	No	Not chirped (standard) Chirped (optional)
<b>FBG Arrays</b>	Optional	
<b>Fiber Type</b>	SM, MM	SM, PM
<b>Fiber Cladding Diameters (μm)</b>	125, 80	125, 80, 60, 50
<b>Fiber Core Composition</b>	Germanium Doped Pure Silica	Germanium Doped

Please note: Each parameter is inherently linked, therefore not all values are independently achievable.





## Complementary Products

**At Fibercore, we understand you may require additional complementary products.**

**With this in mind we have put together a range of products to enhance the specialty optical fibers we offer. Should you need something else, simply ask and we will see what we can do.**

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**There are seven ranges of complementary products:**

**Fiber Optic Cables:**

High performance cables engineered for harsh environments including Oil & Gas, Subsea and Avionics applications

- Downhole Fiber Optic Cable
- Slickline Fiber Optic Cable
- Wireline Fiber Optic Cable
- Fiber In Metal Tube
- Wire Armored Metal Tube

**Ruggedized Sleeving and Buffering:**

A range of sleeving options to ruggedize our specialty fibers for use in different environments

**Pigtails and Patchcords:**

All our fibers are available ruggedized and connectorized if required. Whether you wish to use SM, PM or MM Fiber, we can supply them as patchcords or pigtails to your specified length

**Fibercore Fiber Cleavers:**

High precision cleaver for use with both reduced-clad and 125µm fiber offering both perpendicular and angled cleaves

**Coreless Fiber:**

For beam expanding and hermetic sealing

**Quarter Wave Plate Fiber:**

For manufacturing all-fiber quarter wave plates

# Fiber Optic Cables

## Specialty high performance cables engineered for harsh environments

In many applications, the optical fiber must be contained within a cable structure to ensure it survives the environment in which it is designed to be deployed. The best fiber in the World cannot overcome an improperly designed or manufactured cable. Fibercore brings over 20 years of cable design knowledge and manufacturing expertise to create cable designs that are customized to the rigors of specific environments. Fibercore specializes in the harshest of environments, ranging from cryogenic applications to the some of the hottest enhanced oil recovery wells. Fibercore extends to a network of manufacturing facilities, each with a particular strength and are not limited to in-house capabilities. For the most challenging applications, Fibercore delivers the best solution.

## Goals in Designing Fiber Optic Cables

- Enable deployment of optical fiber
- Preserving optical transmission characteristics
- Optimizing the attribute to be measured
- Protecting from ecological/mechanical stress
- Providing reliable transmission throughout design life of cable

## Cable Applications

### Oil&Gas

Fiber optics are used for measuring a variety of attributes in an oil or gas well including: distributed temperature, distributed acoustic energy, and strain. This is also used alongside telemetry for fiber optic point sensors, such as pressure sensors and fiber Bragg gratings (FBGs). The types of cables used in the industry include: permanently installed fiber optic cables, logging cables (both wireline and slickline) and surface cables. With the information these types of cables can yield, the reservoir engineer can optimize the production from the oil or gas field thus improving the return on investment.

### Industrial Sensing

There are many environments where knowledge of the temperature, strain, acoustic energy or other attributes is beneficial to the user. Applications such as pipelines, LNG facilities, waterways, industrial facilities, power cables, dams, power generation facilities like nuclear, coal or gas have used fiber optics successfully to gain insight into their operation. Each of these applications would use slightly different cable structures to provide not only the robustness necessary for long term use, but also to optimize the measurement of the attribute desired.

**Products in this range:**  
[Downhole Fiber Optic Cable](#)  
[Slickline Fiber Optic Cable](#)

[Wireline Fiber Optic Cable](#)  
[Fiber In Metal Tube](#)  
[Wire Armored Metal Tube](#)

# Downhole Fiber Optic Cable

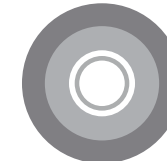
Fibercore offers a range of designs for downhole fiber optic cable to meet the specific requirements of your oil or gas well. These types of cables are permanently installed either cemented in behind the casing or strapped to the production tubing. The optical fibers can be used to sense temperature and listen to well bore activities along the entire length of the cable and can be used for telemetry to point fiber optic sensors, such as pressure sensors and strain sensors.

This information provides key data to the reservoir engineer to better manage both the well and the reservoir. Design variables include type and number of optical fibers, metal types to deal with different corrosive environments, thicknesses of metal tubes to handle different pressure requirements and outer encapsulations for improved handling and abrasion resistance.

## Typical Cable Cross Sections



Bare Downhole Cable



11mm Round Encapsulated  
Downhole Cable



11x11mm Square Encapsulated  
Downhole Cable

## Specifications

Available options

<b>Temperature Ratings (°C)</b>	85 <150 <300 (Higher temperature ratings available upon request)
<b>Outer Encapsulation Options (11mm round and 11x11mm square)</b>	Polypropylene, Nylon, Santoprene, PVDF, ETFE, ECTFE, FEP

Tube Material	Outer Diameter (mm)	Inner Diameter (mm)	Wall Thickness (mm)
316L Stainless Steel	6.35 (0.250")	4.57 (0.180")	0.89 (0.035")
	6.35 (0.250")	3.86 (0.152")	1.245 (0.049")
Incoloy 825	6.35 (0.250")	4.57 (0.180")	0.89 (0.035")
	6.35 (0.250")	3.86 (0.152")	1.245 (0.049")

## Slickline Fiber Optic Cable

Fibercore offers a range of slickline fiber optic cables suitable for logging wells directly or to be incorporated into a coiled tube. The portfolio utilizes a fiber in metal tube to house and protect the optical fibers and to ensure that the excess fiber length is controlled appropriately. As with the permanent downhole fiber optic cables, these fibers can be used to sense temperature and listen to well bore activities along the entire length of the cable and

can be used for telemetry to point fiber optic sensors, such as pressure sensors and strain sensors that are incorporated into a tool. This information provides key information to the reservoir engineer to better manage the well and the reservoir. Design variables include: type and number of optical fibers, metal types to deal with different corrosive environments and thicknesses of metal tubes to handle different pressure requirements.

### Typical Cable Cross Sections



Single Outer Tube Slickline



Multilayer Slickline

### Specifications

Available options

Temperature Ratings (°C)	85
	<150
	<300

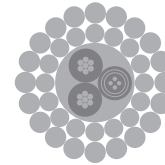
Tube Material	Outer Diameter (mm)	Inner Diameter (mm)	Wall Thickness (mm)
316L Stainless Steel	3.175 (0.125")	1.75 (0.069")	0.71 (0.028")
	3.175 (0.125")	1.96 (0.077")	0.60 (0.024")
	4.000 (0.157")	2.57 (0.101")	0.71 (0.028")
	4.000 (0.157")	2.36 (0.093")	0.82 (0.032")
Incoloy 825	3.175 (0.125")	1.75 (0.069")	0.71 (0.028")
	3.175 (0.125")	1.96 (0.077")	0.60 (0.024")
	4.000 (0.157")	2.57 (0.101")	0.71 (0.028")
	4.000 (0.157")	2.36 (0.093")	0.82 (0.032")

## Wireline Fiber Optic Cable

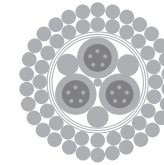
Fibercore, in conjunction with selected partners, offer wireline logging cables that utilize Fibercore's hydrogen resistant, high temperature fibers. The optical fibers are protected in a hermetic metal tube to provide the necessary protection for incorporation into the wireline cable. By working closely with our partners, Fibercore ensures that our designs meet the rigorous requirements of wireline logging cables in regards to temperature, corrosion resistance and strength.

Optical fibers that are incorporated within these cables are used for telemetry to the tool, but can also be monitored for distributed temperature and acoustics, providing additional information for management of the well. In addition to the optical fibers, these cables can include insulated copper elements that can be used to power a tractor, components in the tool or for other sensors.

### Typical Cable Cross Sections



Electro-Optic Wireline



All Optical Wireline

### Specifications

Available options

Temperature Ratings (°C)	85
	<150
	<300
(Higher temperatures may be available upon request depending on application specifics)	

## Fiber In Metal Tube

Fibercore provides fiber in metal tubes (FIMTs) in different sizes, wall thickness and metal types. FIMTs are used in a variety of applications due to the hermeticity of the tube, strength, crush resistance, corrosion resistance and fiber density. Some of these applications include downhole

fiber optic cables, logging cables, power cables, cryogenic applications, industrial monitoring, subsea cables and many more.

### Typical Cable Cross Sections



0.84mm



2.4mm



3.2mm



4.0mm



6.35mm

### Specifications

Available options

<b>Temperature Ratings (°C)</b>	85 <150 <300 (Higher temperature ratings available upon request)
<b>Outer Tube Materials</b>	304 Stainless Steel 316 Stainless Steel Incoloy 825 Inconel 625 (Other materials may be available upon request)
<b>Diameter Range</b>	0.84mm to 6.35mm (0.033" to 0.250") (Diameters are available in 0.1mm increments)
<b>Wall Thickness Range</b>	0.127mm to 0.3mm (0.005" to 0.12")

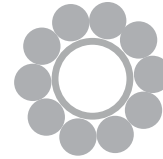
Outer buffering over the FIMT is available upon request.

## Wire Armored Metal Tube

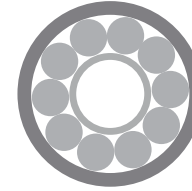
Fibercore provides fiber in wire armored metal tubes, enabling further robustness to the FIMT. FIMTs are prone to kinking and crushing, so are typically not used as a standalone product. With the addition of a high strength stranded wire layer over the FIMT, the handling characteristics improve tremendously along with crush performance and tensile strength.

The tube construction incorporates stainless steel components to provide improved corrosion resistance and an optional outer polymer jacket is also available upon request. Typical applications for wire armored metal tubes are for tactical applications (deploy/re-deploy), hydrological studies, industrial sensing, power cable monitoring and more applications.

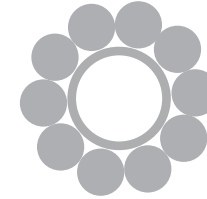
### Typical Cable Cross Sections



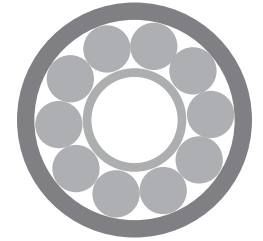
2.1mm



2.1mm Jacketed



2.8mm



2.8mm Jacketed

### Specifications

Available options

<b>Temperature Ratings (°C)</b>	85 <150 <300 (Higher temperature ratings available upon request)
<b>Construction</b>	316L Stainless Steel tube 316L Stainless Steel wires Optional outer sheath (polyamide, other types upon request) Up to 8 optical fibers
<b>Diameter Range</b>	2.8mm to 4.8mm
<b>Weight Range</b>	18kg to 46kg
<b>Maximum Operational Tension</b>	750N to 2600N
<b>Minimum Bend Radius</b>	20xDiameter



# Ruggedized Sleeving and Buffering

## Protects valuable fiber

- Options available from 900µm tight buffer to 3mm diameter cable
- Available in blue (for PM fiber), orange (MM fiber) and yellow (for other fiber), or other colours by request
- Provide essential protection for indoor and outdoor applications
- Fully compatible with the Fibercore range of connectors

## Enables rapid fabrication of short custom cables

- Available without the fiber or connectors
- Nylon pull-cord allows ruggedization of virtually any fiber

### Typical applications:

- Sensor cables
- Medical probes
- Beam delivery

## Specifications

	900µm Hytrel®	LT3 (0.5/0.9)	LT3 (1.0/1.8)
<b>Sheath Outer Coating (mm)</b>	0.9		3.0
<b>Sheath Material</b>	Hytrel®		PVC
<b>Loose Tube Outer Diameter (mm)</b>	-	0.9mm (0.5 Bore)	1.8mm (1.0 Bore)
<b>Loose Tube Inner Diameter (mm)</b>	-	0.5	1.0
<b>Loose Tube Material</b>	-		Nylon (without fiber) Hytrel® (with fiber)
<b>Reinforcement</b>	-		Aramid Yarn
<b>Pull Cord</b>	No		Yes

# Pigtails and Patchcords

## For specialty single-mode fiber and polarization maintaining fiber

- Reliable, demountable connection for ease of fiber use
- Choice of Generic or Premium for optimum PM Fiber performance

### Typical applications:

- Fiber laser beam delivery
- Oil & Gas sensor cables
- Medical probes
- High bit rate data transmission

## Connector Specifications

Type	Single-Mode Connectors		Polarization Maintaining Connectors			
			Premium		Generic	
<b>End Face Angle</b>	0°	8°	0°	8°	0°	8°
<b>Insertion Loss (dB)</b>	0.2 Typical (0.4 Max)				0.4 Typical (0.5 Max)	
<b>Return Loss (dB)</b>	50	65	50	60	50	60
<b>Repeatability (dB)</b>	±0.2					
<b>Service Life (Cycles)</b>	500					
<b>Extinction Ratio (dB)</b>	Not applicable		28 typical (25 min)		25 typical (20 min)	22 typical (20 min)
<b>Keyway Size</b>	Narrow 1.95 ± 0.05mm Wide 2.15 ± 0.05mm					
<b>Temperature Range (°C)</b>	-40 to +80					
<b>Connector Types</b>	DIN UPC, E2000 APC, E2000 UPC, FC UPC, FC APC, LC APC, LC UPC, SC UPC, SMA, ST UPC					

For sleeving options and selection guide see data sheet [www.fibercore.com/product/pigtails-and-patchcords](http://www.fibercore.com/product/pigtails-and-patchcords)

# Fibercore Fiber Cleavers

## High strength and angled fiber cleavers

- High precision cleaving
- Cleaves single-mode and PM optical fibers
- Suitable for 80µm and 125µm fibers
- 50µm clad fiber custom design cleaver available upon request

### Typical applications:

- Cleaving
- Splicing
- Fiber optic production lines
- Fiber sensors
- Fiber lasers

## Specifications

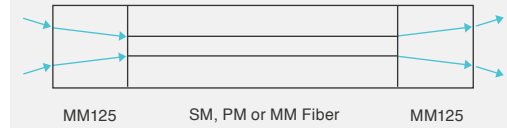
Designation	Perpendicular Cleavers		Angled Cleavers		
	HSTC-2001/080	HSTC-2001/125	HSAFC-20xx/080	HSAFC-20xx/125	FAC-08
Cladding Diameter (µm)	80	125 or 140	80	125	125 SM or PM
End-Face Angle	Typical <0.3° (<0.5° for 80mm PM)		Choice of: 4°, 6°, 8°, 10°, 12°		8° (±1°)
Minimum Cleave Length (mm) *	3		2		8 minimum - set by fiber holder
Blade Life	>10,000 operations		>20,000 operations		10,000
Cleaver Dimensions	72 x 78 x 90mm / 3 x 3 x 3.5 inches				57 x 29 x 80mm / 2.25 x 1.14 x 3.15 inches
Weight	500g/1.1lbs				200g/0.44lbs

\* Minimum cleave length may vary depending upon fiber and coating diameter specified

# Coreless Fiber

## For beam expanding and hermetic sealing

- Allows beam expansion at the end face of a small core fiber
- Larger MFD reduces end face power density
- Reduces power density related end effects
- Reduces Fresnel back reflection coupling efficiency
- Hermetically seals Photonic Crystal Fibers (PCF) and holey fibers



### Typical applications:

- Fiber lasers
- Laser diodes
- Microscopy

## Specifications

	MM125	MM125HT
Cladding Diameter (µm)		125 ± 1
Coating Diameter (µm)		245 ± 15
Proof Test (%)		1 (100 kpsi)
Coating Type	Acrylate	High Temperature Acrylate
Temperature Range (°C)	-55 to +85	-55 to +150

# Quarter Wave Plate Fiber

## For manufacturing all-fiber quarter wave plates

- Capable of converting linear polarization to circular polarization
- Designed for optical compatibility with Spun HiBi current sensor fibers
- High splice compatibility with Fibercore sensor fibers

### Typical applications:

- Current sensors
- Polarimetric systems
- Quarter wave plates

## Specifications

	HB1250(7.3/125)QW	HB1550(8.9/125)QW
Operating Wavelength (nm)	1310	1550
Cut-Off Wavelength (nm)	≤1270	1200 - 1500
Numerical Aperture	0.13 - 0.17	
Mode Field Diameter (μm)	6.2 - 8.4 @1310nm	7.9 - 9.9 @1550nm
Attenuation (dB/km)	≤5 @1310nm	≤5 @1550nm
Beat-Length (mm) @633nm	3.0 - 4.3	
Proof Test (%)	1 (100 kpsi)	
Cladding Diameter (μm)	125 ± 1	
Coating Diameter (μm)	245 ± 15	
Core Concentricity (μm)	≤1	





## Additional Services

# Test, Measurement and Other Laboratory Services

As a leading manufacturer of specialty fiber, Fibercore maintains a state-of-the-art test and measurement laboratory

Fibercore have combined over 30 years' experience in the industry with an unsurpassed reputation for technical expertise and service. The facility enables Fibercore to provide a variety of services.

**We offer multiple options in this group:**

### Hydrogen Testing:

Custom built facility to fully evaluate the performance of optical fibers

### Qualification and Reliability Testing:

Full testing facilities available from our highly skilled team of experts using our dedicated T&M laboratory

### Fiber Test and Measurement:

Detailed test facilities in accordance with ISO 10012-1 (BS5781) and our BS EN ISO9001(2008) Quality System, undertaken by our team of experts

### Fusion Splicing:

For PM and rare-earth doped fibers

### Development Projects and Custom Fiber:

If the success of your project relies on the availability of a custom single-mode optical fiber, provided that it is based on silica-glass. Fibercore has the capability to develop that fiber on your behalf

### Custom and Multifiber Cables:

Fibercore can supply its range of specialty optical fibers, custom-cabled to suit highly complex deployments and demanding environments

## Fibercore's commitment to...

### Quality: ISO 9001:2015

Fibercore is dedicated to supplying customers with exceptional quality products, service, and support. Accredited to ISO9001, Fibercore maintains traceability to all critical elements and materials in the fiber that is manufactured. The unique identification of every length of fiber ensures that all test and manufacturing data can be easily accessed.

Fully documented procedures and instructions provide consistency and uniformity of products. Controlled test plans implemented through calibrated equipment guarantees the fiber is matched to your process.

### Environment: ISO 14001:2015

Fibercore is committed to reducing its environmental impact, be this through the prevention of pollution or the reduction of resource and energy use.

An ISO14001 certified management system was installed by in-house staff to manage all aspects of Fibercore's environmental management including the permit under which Fibercore operates.

### Health & Safety: OHSAS 18001:2007

Fibercore continues its commitment to quality by the addition of an Occupational Health & Safety Management System to our procedures.

### RoHS 2 and REACH

Our products all comply with RoHS 2 requirements and with REACH

### Conflict Minerals

Fibercore is committed to ensuring that neither its products nor the processes involved in their manufacture contain or utilize minerals sourced from Conflict Regions. Fibercore will continue to review its position under Section 1502 of the US Dodd-Frank Wall Street Reform and Consumer Protection Act.

Copies of these certificates, as well as our policies can be downloaded from our website at [www.fibercore.com](http://www.fibercore.com) or contact us at [info@fibercore.com](mailto:info@fibercore.com)

## A-Z of Acronyms

<b>AOC</b>	Active Optical Cable	<b>LIDAR</b>	Light Radar
<b>ASE</b>	Amplified Spontaneous Emission	<b>MFD</b>	Mode Field Diameter
<b>C</b>	Carbon and Acrylate	<b>MM</b>	Multimode
<b>CATV</b>	Cable Television	<b>NA</b>	Numerical Aperture
<b>CHT</b>	Carbon and High Temperature Acrylate	<b>nm</b>	Nanometer
<b>CP</b>	Carbon and Polyimide	<b>OBS</b>	Ocean Bottom Seismic
<b>DAS</b>	Distributed Acoustic Sensing	<b>OCT</b>	Optical Coherence Tomography
<b>dB</b>	Decibel	<b>OD</b>	Outer Diameter
<b>DPS</b>	Distributed Pressure Sensing	<b>OEM</b>	Original Equipment Manufacturer
<b>DSS</b>	Distributed Strain Sensing	<b>P</b>	Polyimide
<b>DTS</b>	Distributed Temperature Sensing	<b>PCF</b>	Photonic Crystal Fibers
<b>DWDM</b>	Dense Wavelength Division Multiplexing	<b>PER</b>	Polarization Extinction Ratio
<b>EDFA</b>	Erbium Doped Fiber Amplifier	<b>PM</b>	Polarization Maintaining
<b>EFL</b>	Excess Fiber Length	<b>PS</b>	Photosensitive
<b>EMI</b>	Electromagnetic Interference	<b>RIA</b>	Radiation Induced Attenuation
<b>FBG</b>	Fiber Bragg Grating	<b>RIP</b>	Refractive Index Profile
<b>FC/APC</b>	Ferrule Connector / Angled Physical Contact	<b>RLG</b>	Ring Laser Gyroscope
<b>FIMT</b>	Fiber In Metal Tube	<b>RT</b>	Radiation Tolerant
<b>FOG</b>	Fiber Optic Gyroscope	<b>SAGD</b>	Steam Assisted Gravity Drainage
<b>FTTx</b>	Fiber To The x	<b>SAP</b>	Stress Applying Part
<b>Ge</b>	Germanium	<b>SB</b>	Short Beat-Length
<b>GRIN</b>	Graded Index	<b>SC</b>	Silica Core
<b>HI</b>	High Index	<b>SDM</b>	Space Division Multiplexing
<b>HiBi</b>	High Birefringence	<b>SHM</b>	Structural Health Monitoring
<b>HT</b>	High Temperature Acrylate	<b>SM</b>	Single-Mode
<b>IR</b>	Infrared	<b>SMF</b>	Single-Mode Fiber
<b>IWDM</b>	Isolating Wavelength Division Multiplexer	<b>SM-SC</b>	Single-Mode Pure Silica Core
<b>LCT</b>	Laser Communications Terminals	<b>μm</b>	Micron
<b>LDA</b>	Laser Doppler Anemometer	<b>UV</b>	Ultraviolet
		<b>VSP</b>	Vertical Seismic Profiling
		<b>WDM</b>	Wavelength Division Multiplexer
		<b>YEDFA</b>	Ytterbium Erbium Doped Fiber Amplifier



## REPRESENTATIVES

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We have representatives in the following countries. The most up to date information including contact details can be found on our website.

**[Fibercore.com/representatives](http://Fibercore.com/representatives)**

CHINA	PHILIPPINES
INDIA	RUSSIA
INDONESIA	SINGAPORE
ISRAEL	SOUTH KOREA
JAPAN	TAIWAN
MALAYSIA	THAILAND



