

# MEDICAL

FIBER OPTIC SOLUTIONS FOR MEDICAL APPLICATIONS



**Safety**

**Reliability**

**Ease of handling**

**Sterilizability**

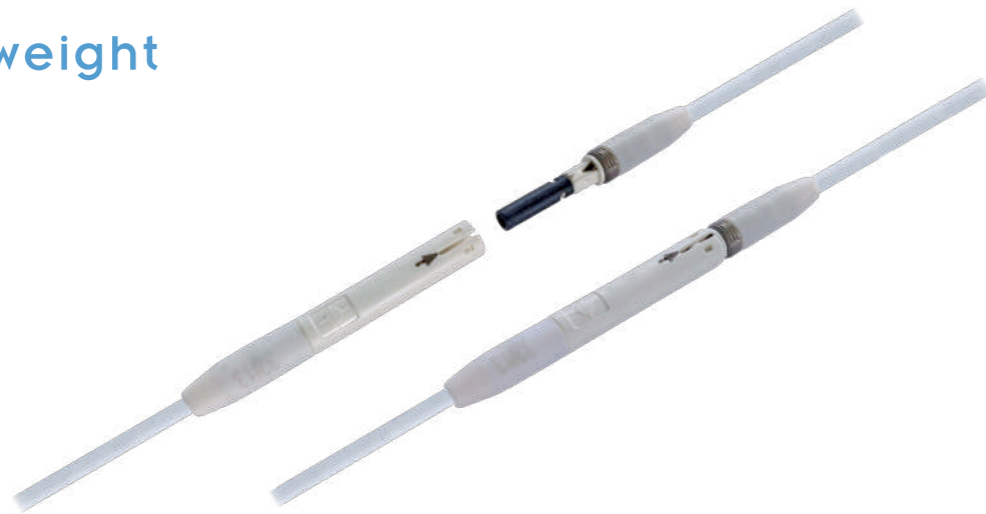
**Easy product identification**

**Ingress protection**

**Insensitivity to magnetic fields**

**High performance**

**Lightweight**



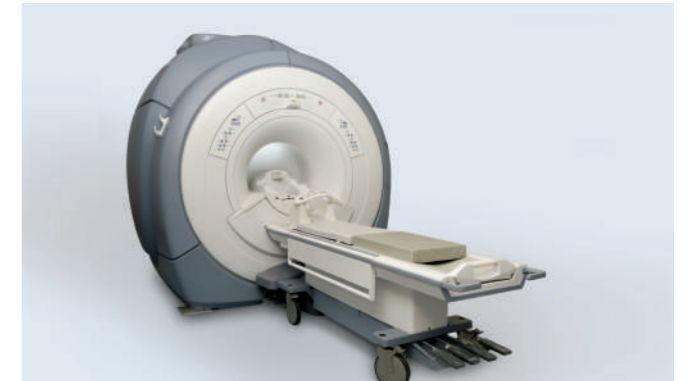
## FIBER OPTIC SOLUTIONS FOR MEDICAL APPLICATIONS

Fiber optic technology is opening exciting new fields of application in the medical industry. The physical characteristics of fiber make it a natural choice for many uses. Optical fiber has become widely used in imaging, laser delivery systems, illumination, sensors and equipment interconnects. Optical fibers provide a compact and flexible conduit for light or data delivery in diagnostic and interventional medical applications. In order to be effective, optical fibers require robust, precise interconnects that integrate seamlessly into the medical theater. Diamond has the expertise to make these interconnects a reality.

Fiber optic solutions applicable for several medical sectors, such as:

- ILLUMINATION
- LASER SIGNAL DELIVERY
- IMAGE TRANSFER
- SENSOR AND EQUIPMENTS

### ■ DIAGNOSTIC DEVICES

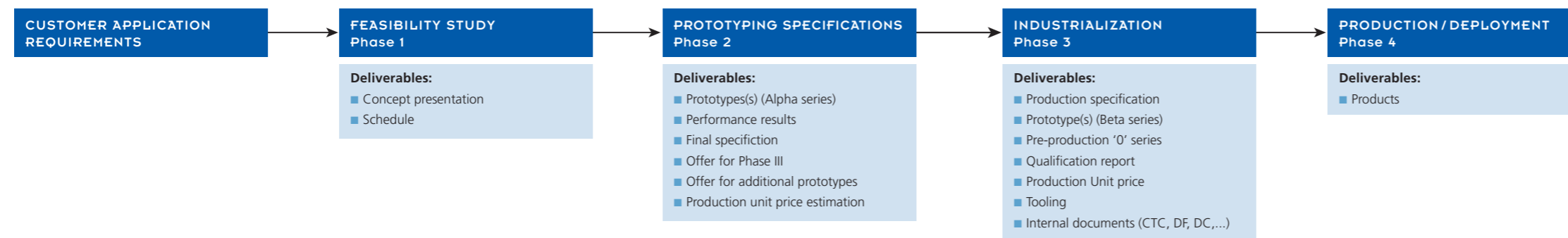
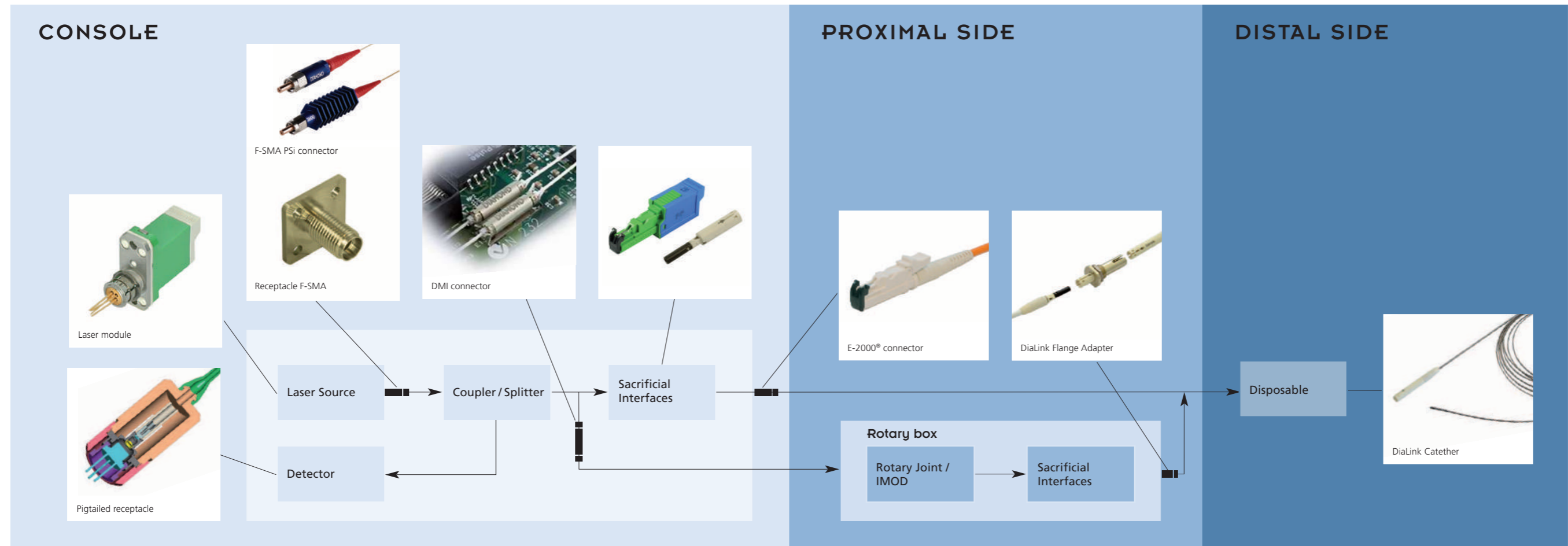


### ■ SURGICAL INSTRUMENTATION



### ■ THERAPEUTIC APPLICATIONS





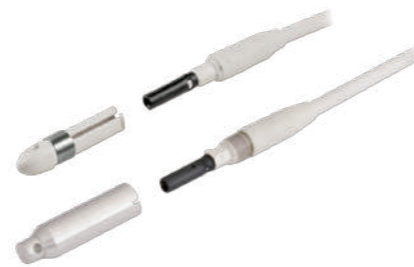
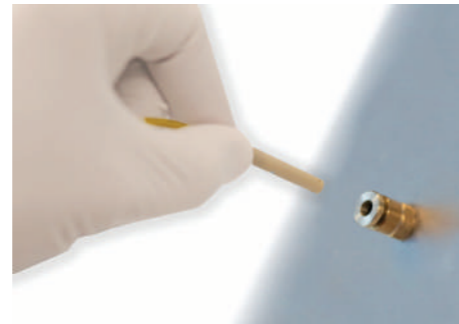
## DiaLink CONNECTOR SYSTEM

### DiaLink Connector System (Patent Pending)

The DiaLink has been developed focusing on the specific needs in medical applications such as small footprint, circular design and easy handling.

Some main features of the DiaLink:

- Only 5mm diameter
- Circular design
- Push-pull
- Protected ferrules
- EtO Sterilizable
- Non-magnetic version possible
- ISO Class 7 Packaging possible
- Perfect cylindrical structure and great mass homogeneity; ideal for high speed of revolutions
- Easy integration within rotary joints



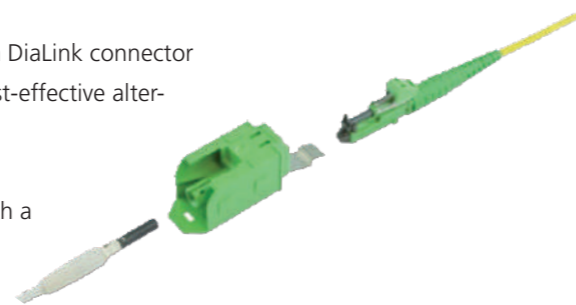
A continuously growing number of applications in the medical field is requiring Fiber Optic connectors instead of the well-known copper based solutions. Here the challenge is to develop a Fiber Optic connector as "user friendly" as the most copper based interconnections.

DIAMOND achieved this with the DiaLink, combining the **push-pull technology** for easy handling, with the reduced need of cleaning thanks to the **protected end-faces**. Moreover the small diameter circular design allows smaller designs for medical devices and the **integration within rotary joints** which are requiring a well-balanced connector in order to avoid vibrations.

### DiaLink Hybrid Adapter

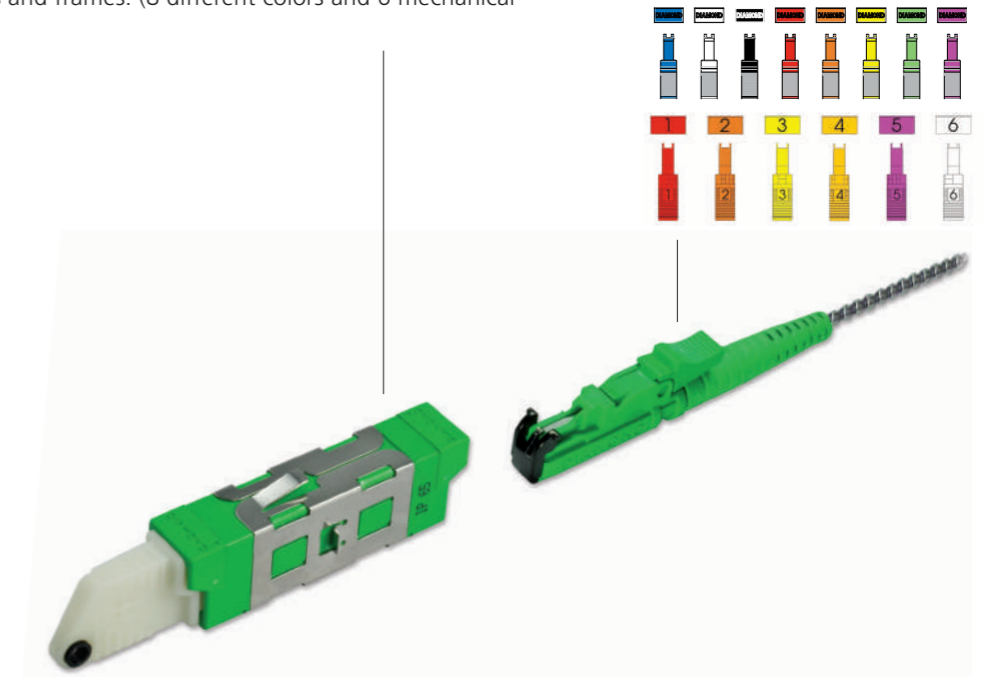
The DiaLink Hybrid Adapter is used to directly mate a DiaLink connector with an F-3000™ (LC) connector system, and is a cost-effective alternative to hybrid patch assemblies.

The Hybrid Adapter can be mounted into a panel with a cut-out of an F-3000™ (LC) standard duplex mating adapter.



## E-2000® CONNECTOR SYSTEM

Interchangeable color-coded and mechanically-keyed thumb-latches and frames. (8 different colors and 6 mechanical key options).



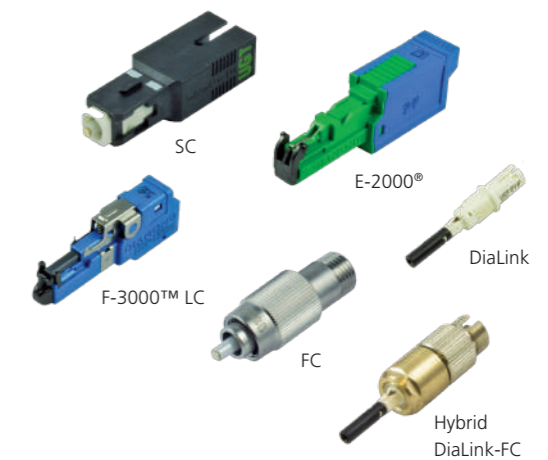
### Features

- Cap and shutter protection
- Push-pull connection
- High precision repeatability
- Color and mechanical coding
- Optional non-magnetic components
- EtO-sterilizable
- IP65 rating
- Positive tactile feedback
- Large number of accessories available

## Sacrificial Interfaces

For applications where a disposable connection is needed or high mating cycles are involved a sacrificial interface has been developed in order to avoid damages on the costly devices.

Several types of packaging are feasible into Clean Room environments, up to ISO Class 7.



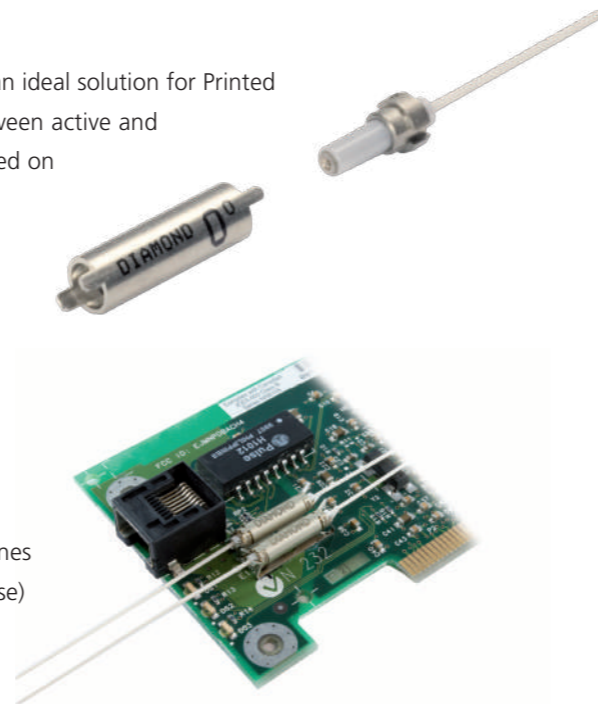
## DMI (Diamond Micro Interface)

Thanks to its minimal space requirement, the DMI connector system is an ideal solution for Printed Circuit Board (PCB) applications as well as a high quality interface between active and passive components of fiber optic installations. DMI connectors are based on standard Ø 2.5 mm ferrules.

For replacing a splice, Diamond offers the DMI which is designed to operate with any type of fibers with excellent optical performances.

### DMI features and benefits

- Minimum space requirement (footprint of 4.5 x 21 mm)
- Consistent high performance solution
- Available in PC, APC and PM termination
- Available in PS on custom request to comply with laser safety guidelines (tested with 10 Watts optical power for 1 hour and 3W continuous use)
- Standard Diamond 2.5mm ferrule with Active Core Alignment (ACA)
- Easy installation by use of standard clip-on system
- DMI assembly tool is available.



## F-SMA (SMA905) connector and adapters

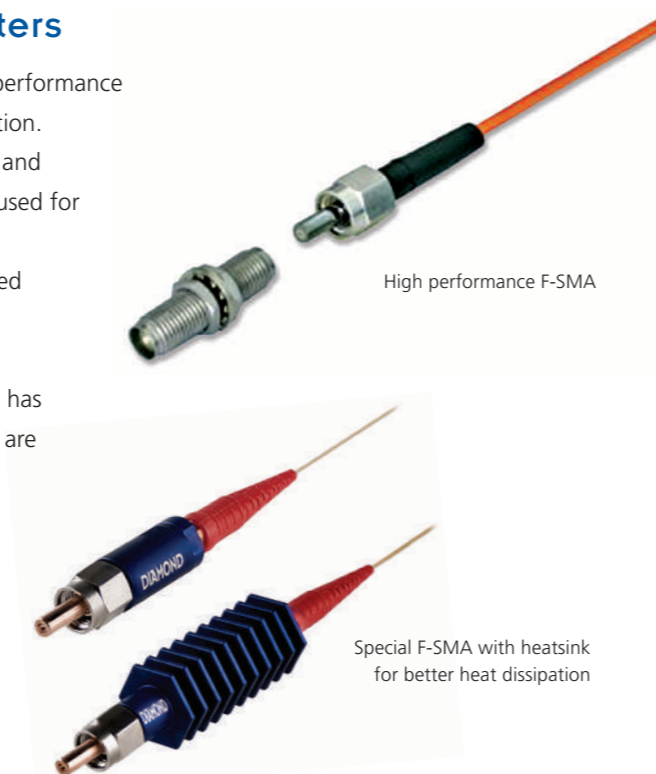
Diamond offers two different F-SMA (SMA 905) Multimode high performance connector types, depending on the beam power level and application. The first one is the Standard Version with Multimode 50 µm fiber, and with large core Multimode fiber with tight mechanical tolerances used for higher power levels.

The second one is the Free standing F-SMA (PSi) version mainly used for medium-high power laser delivery and thermal management in various applications.

The connector is compatible with the IEC 61754-22 standard, and has a large use in medical applications. Customized F-SMA assemblies are available upon request.

### Features

- Custom drilled hole sizes from 80µm to 2300µm
- Suitable for high power laser delivery
- Suitable for high temperature applications
- High thermal conduction ferrule
- High uniform heat dissipation
- Compact size and robust metal connector
- Tight mechanical tolerances



## Solutions for light injection

### Module Active transmitter and Receiver MAT/MAR

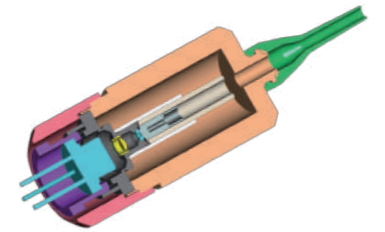
MAT active device transmitter modules permit the direct coupling of optical signals into fibers terminated with E-2000® connectors. (MAR receivers perform the reverse receiving function). Achieved light injection > 55%.



### Pigttailed Laser with Active Laser Welding

Thanks to a special lens and the diode active alignment on X/Y/Z axis, the light injection is more than 55%.

Solutions are available for SM and PM fibers and can be assembled with all Diamond connector types.



## Receptacle IMOD

The Interface Module (IMOD) allows a free space launch of a connector. Various options are available to fix the ferrule in a location optimal for your application.

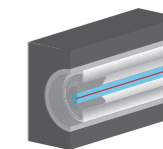


Fig.1 Without any stopper; for applications which doesn't require specific tolerances or exact ferrule axial positioning.

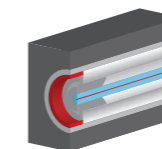


Fig. 2 With ferrule ZrO2 cylinder stopper, for a good axial repeatability.

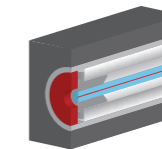


Fig. 3 With ferrule front face stopper, for superior axial repeatability.

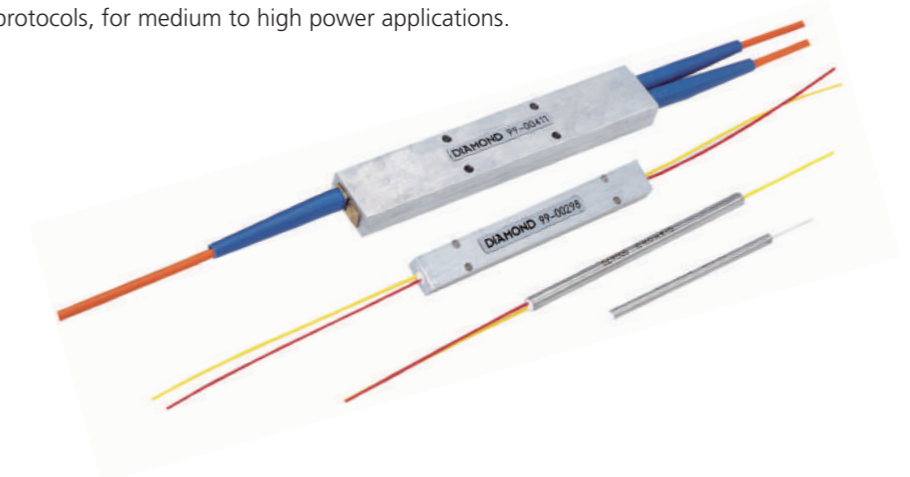


These options can be adapted to most mechanical interface for PC and APC versions, such as: E-2000®, SC, F-3000®, ST™, F-SMA, LSA (DIN)/AVIM®, FC, Mini AVIM®.

## Assembling and packaging of combiners and modules

Diamond offers packaging and assembling of various modules and combiner including any necessary test measurements and testing protocols, for medium to high power applications.

- Couplers/Splitters
- Isolators
- Modulators
- Laser diodes
- Receiver diodes
- Combiners
- Amplifiers
- Switches



## POWER SOLUTION EXPANDED BEAM TECHNOLOGIES FOR PROXIMAL AND DISTAL SIDES

Diamond uses different methods for expanded beam alignment, depending on the final use of the assembly. The main expanded beam types can be defined as following: spliced GRIN lenses and spliced glass rod-, or endcap which allows a **Diverging, Collimated or Focused exit beam**. These technologies are also suitable for high power applications.

### Non-contact optical interfaces

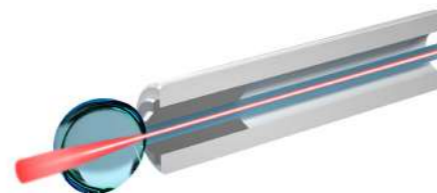
#### PSf Free Space (Diverging)

A glass rod is spliced at the end of a SM fiber. This allows the beam to be expanded before it exits the glass, diminishing the power density at the glass-air interface. This technique is used for high-power applications, at the injection or at the output to minimize the chance of burns at the interface. Diamond provides the SM Power Solution Freespace Optical Interface using this technology



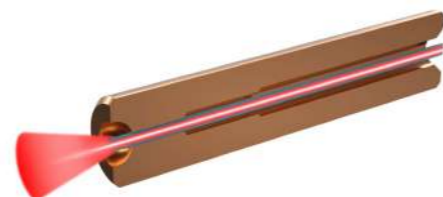
#### PSb Ball Lens (X-BEAM)

A ferrule is placed behind a ball lens which is glued into a housing. This technology expands and collimates the transmission signal and reduces the impact of both misalignment as well as endface contamination. Depending on the concentricity, the expanded beam exits the lens at a certain angle. To minimize this exit angle, Diamond uses the ACA process.



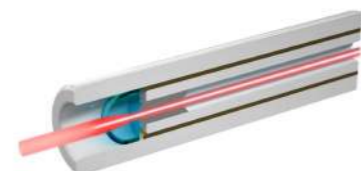
#### PSi Free Standing

The fiber-end free from epoxy glue allows proper thermal dissipation in the region of maximum power density. A proprietary design of mode-stripper can be integrated to obtain laser power confinement in the fiber core. The amount of power stripped out from the cladding is a function of the laser Beam Product Parameter (BPP) and of the receiving fiber core diameter and numerical aperture (NA).



#### PSc Collimator Systems

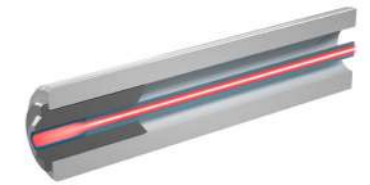
Collimators are for use in a wide variety of optical systems. These modules are designed to collimate or focus light exiting an optical fiber to a desired beam diameter or spot size a specific distance away. Collimators are used with laser diodes, photodiodes, acoustic-optic modulators and other fiber optic devices where a specific output is needed.



### Contact optical interfaces

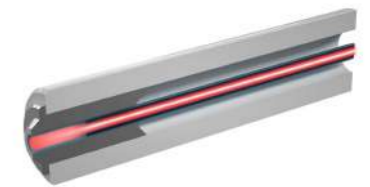
#### PS Collimated

Diamond offers the Power Solution optical Interface which expands the MFD of a SM fiber by splicing a GRIN lens at the extremity. The MFD at the end of the connector is thus expanded by a factor of 4 to 5, increasing the contact surface by a factor of about 15. As a result the heat issues decrease but cleanliness of the connectors and mating adapters is still important.



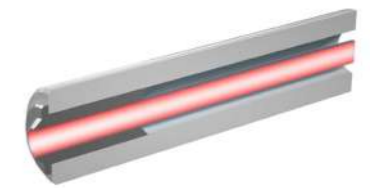
#### PM-PS Collimated Polarization Maintaining

Polarization plays an important role in the industrial photonics market and when coupled with medium-high power application, creates a highly critical interface. Sensors and communication systems have been designed using Polarization Maintaining or Polarizing fibers. Special connectors are required for such applications, because the connection must be made with a certain orientation. Only connectors with an orientation key are capable of properly terminating these fibers.



#### PSm (Power Solution Multimode)

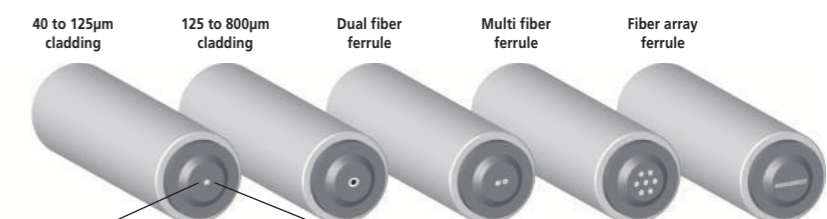
No standards for large MM connectors has been defined with high power application in mind. The quality of the contact is critical and the standard SM fiber optical interface is not sufficient. Diamond has established a new Optical Interface, the PSm, to fill this void and help end-users to source reliable connectors for these applications. The optical interfaces use 100% concentricity measurement control and optical geometry measurements. A special visual inspection completes the Optical Interface definition.



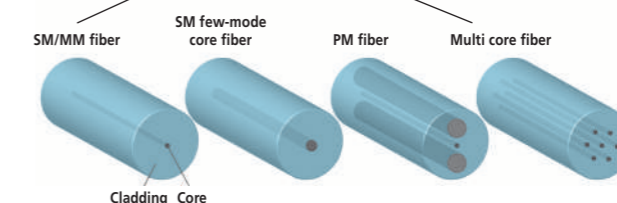
### Multi-channel concept

Diamond can provide high-end customized solutions for multi-channel concepts, thanks to its patented composite ferrule, which allows the Active Core Alignment (ACA), and the Active Polarization Orientation (APO). Furthermore Diamond can offer fiber optic products that satisfy customer specific requirements thanks to its know-how, competencies and vertical integrated structure in mechanical, optical, assembly and measurement fields.

#### Ferrule design



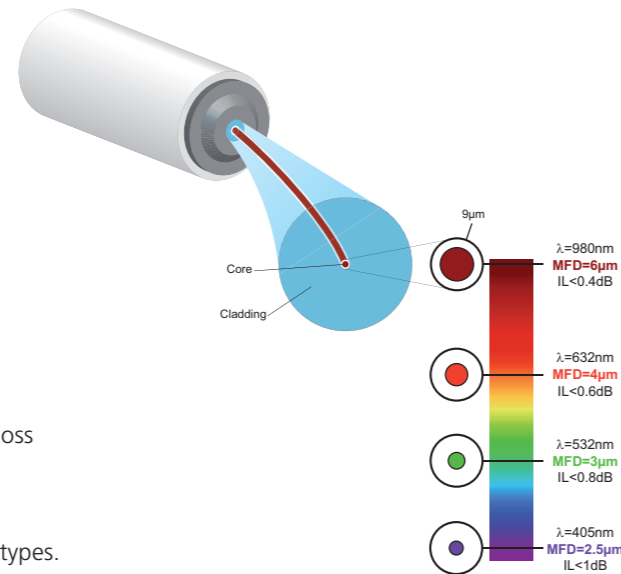
#### Fiber types



## DIAMOND'S TECHNOLOGIES

### VIS/NIR using Diamond Active Core Alignment (ACA)

Visible and NIR wavelengths are commonly used in medical applications for either diagnostic or treatment, such as OCT or spectrometry on living tissue. Small core fibers are used in those cases, with high power on some occasion. Transmission of light require in most cases high quality contact as Diamond can uniquely provide.



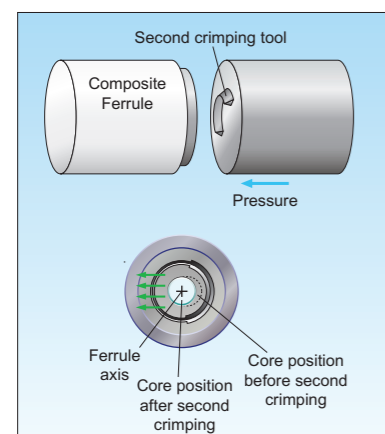
#### Features

- Extremely low lateral offset for Low insertion loss
- Ultra high polish for high return loss
- Available for: E-2000®, F-3000®, DMI, FC, LSA (DIN), AVIM®, Mini AVIM®, SC connector types.

### Active Core Alignment (ACA)

The challenges of small core fibers can be addressed only with technologies dedicated such as Diamond Active Core Alignment (ACA).

Composite ferrules allow performing the active core alignment, controlling either the lateral offset (SM) or the exit angle (PS). A plastic deformation of the metal (Titanium) insert permanently optimizes one of these parameters.



Diamond composite ferrule

### Fiber Optic Jacketing

Diamond assemblies can be offered with the following plastic and metal flexible jacketing to protect the Fiber from breaking.

#### Plastic tubes

- Elastomer (Hytrell)
- PEEK (Victrex 450)
- PA (Nylon)
- PTFE (Teflon)

#### Metal tubes

- Stainless steel Semi-Interlock Double Spring Tube (SIDSP)

#### Features

- By inserting a stainless steel wire into the spiral valley of the semi-inter tube greater bending radius limitation is achieved
- In addition the radius can be adjusted by modifying the wire diameter and number of wires inserted
- Doubling the stainless steel wire will produce a stable outer tube diameter with increased stability
- Almost no elasticity, which provides optimum protection for Optical Fibers, especially, for the quartz-and Hollow Fiber types
- Sheathing: PVC, Olefin, Silicon, PUR



### Vacuum baking

Vacuum baking, which is an artificial acceleration of the process of outgassing, is used at Diamond to release volatile compounds from several parts at the following specifications:

- Vacuum: up to  $10^{-2}$  mbar
- Temperature: up to 200 °C



### Cleaning and packaging

Diamond can offer products cleaned and packaged under ISO class 7 cleanroom conditions:

- Measurement
- Cleaning
- Vacuum backing
- Vacuum packaging



## ASSEMBLIES CONFIGURATION

Proximal SIDE Distal SIDE



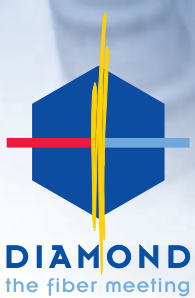
Mechanical interface

Jacket

Coating / Cladding / Fiber

Proximal side Optical Interface	Fiber types	Distal side Optical Interface
PS Power Solution collimated	Single mode	Cleaved
PM-PS Power Solution collimated PM	Multimode step index	Cleaved and polished
PSm Power Solution multimode	Multimode gradient index	PS Power Solution collimated
PSf Power Solution free space	Polarization maintaining	PSf Power Solution free space
PSb Power Solution ball lens	Polarizing	PSi Power Solution lensed
PSi Power Solution free standing	Polycrystal fiber	
PSc Power Solution collimator system	Multi-core fiber	
	Custom fiber	
Proximal end Mechanical Interface	Core diameter (µm)	Product length tolerance
E-2000™	2.3 - 1000	-0 / +0.15m (L<20m)
F-3000™		-0 / +0.2m (20m<L<50m)
DMI	Cladding diameter (µm)	-0 / +0.1m+0.2%L (L>50m)
F-SMA	50 - 1200	+/- 4mm (upon demand)
SC	Coating	Packaging
FC	Acrylate	Standard
AVIM™ / Mini AVIM™	Silicone	Cleanroom ISO 7
ST™	Polyimide	
DIN (LSA)	HardClad	
DiaLink	Metalized	
	Buffer / Jacket	
	Elastomer (Hytrel)	
	PEEK (Victrex 450®)	
	PA (Nylon®)	
	PFTE (Teflon®)	
	Stainless steel	





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