

PHOTONICS

INDUSTRIAL FIBER OPTIC INTERCONNECT SOLUTIONS

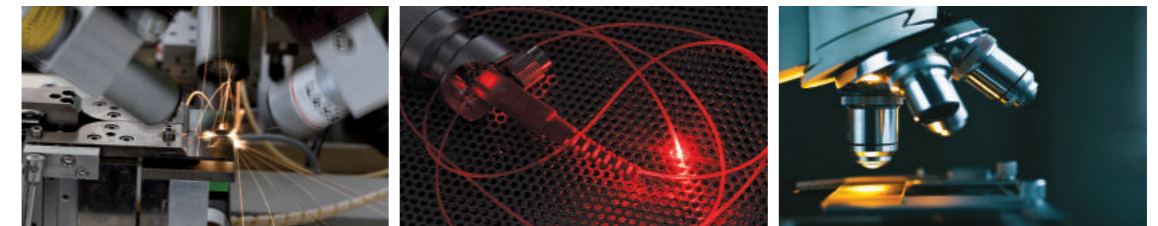




PHOTONICS

Fiber Optics are being used increasingly in commercial applications because of its bandwidth capacity, environmental durability, and its ability to be deployed in numerous applications and markets. The light transmitted by fiber optics can be used as a power source, a digital signal transfer, or for analog analysis in sensing and measurement applications.

In the past optical fibers were used primarily in the data and telecom industries, but new research has resulted in many new applications for fiber optic components. These applications cover markets such as: bio-medical, measurement instruments, laser delivery and sensing.



Fiber optic solutions that satisfy the increasing demands for customer specific challenges and requirements, can only be offered from companies like Diamond who exhibit the following competencies thanks to a vertically integrated structure:

Mechanical

- Integrated Ceramic production (pressing, sintering, machining)
- Precision metal machining (drilling, milling, EDM), with expertise in hard metals, (Ti, WC, Kovar, stainless)
- High quality plastic injection
- Ultra-high precision lapping
- Ultra-high precision drilling
- Fiber-ferrule polishing

Optical

- Fiber Active Core Alignment (ACA)
- Active Polarization Orientation (APO)
- Expanded beam technology: contact (PS), non contact (PSf, PSb, PSI, PSc, PM-PS)
- Splice technology (MM, SM, PM, dissimilar fiber, PCF fibers)

Assembly

- Epoxy Polymerization
- Modules termination (Active or Passive, PM, PS)
- Vacuum sealing (epoxy)
- Active component alignment and laser welding
- Clean room packaging

Measurement

- High quality and reliable test and measurement of fiber optic components, in an accredited laboratory with the capability to simulate multiple environments.

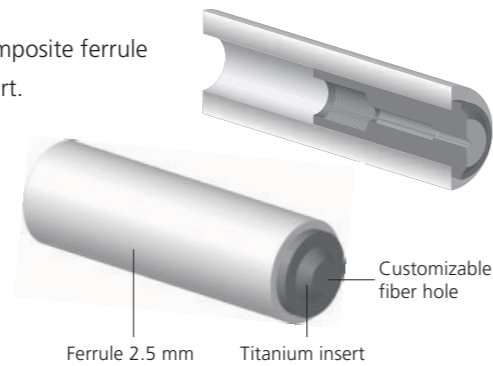
DIAMOND TECHNOLOGIES FOR FIBER OPTICS

Composite ferrule

Diamond technologies are all based on a composite ferrule. Instead of a full ceramic ferrule, Diamond has opted for a composite ferrule formed of a zirconia ceramic sleeve and a titanium metal insert.

Advantages

- Custom drill sizes from 80µm to 800µm
- Superior ultra polishing
- Allows plastic deformation for our Active Core Alignment
- Custom ferrules for multi-fiber technology
- Ferrule with ultra low Outside Diameter (OD) tolerance



Active Core Alignment (ACA)

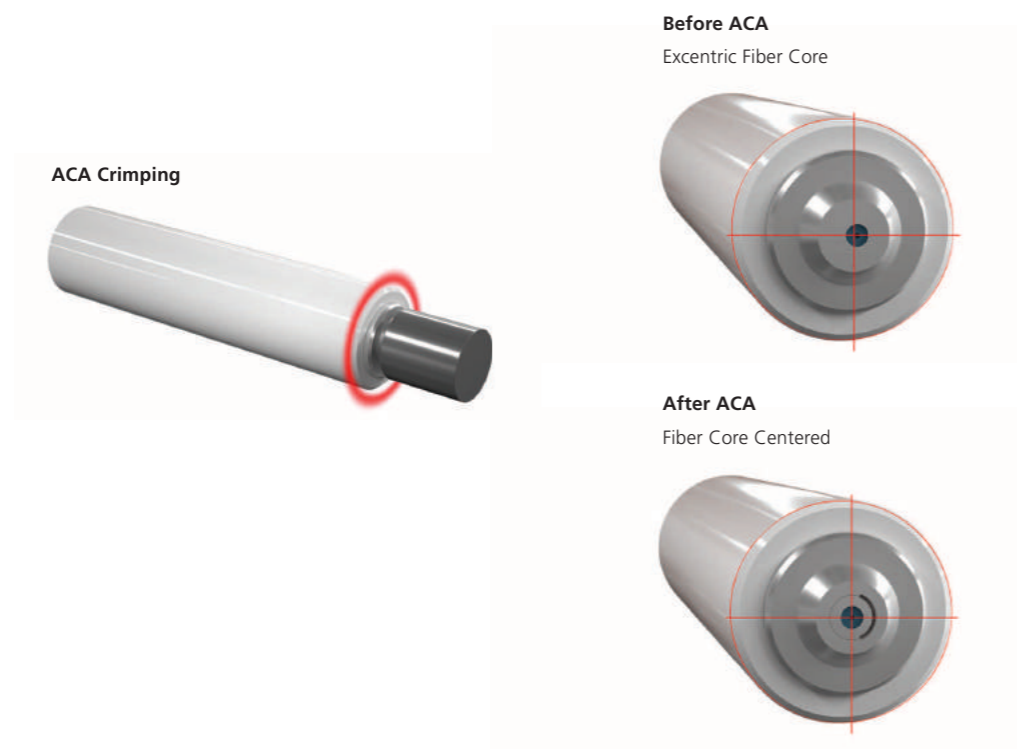
Insertion Loss mainly depends on two parameters; the lateral offset between the two fiber cores and the angular offset (between the two fiber core axis).

Diamond's Active Core Alignment (ACA) is the technology Diamond utilizes to control these variables.

During this process the endface is permanently deformed, after the fiber has been polymerized in place, in order to center the core of the fiber with the mechanical axis of the ferrule.

Advantages

- Ultra low Insertion Loss (IL)
 - 0.1dB Grade for SM Telecom fibers
 - low IL for small core diameters
- High Return Loss (RL)
- Applicable on PM fibers, outperforming IL performance of any other technology
- Available in all products



0.1dB Grade - SM Ultra Low Loss

The 0.1dB Grade is Diamond's proposal for a Grade A definition for IEC quality grade standards. At this time there is no formal definition for the Grade A in IEC standards, nevertheless, Diamond is promoting this quality grade under the 0.1dB Grade name.

0.1 dB Grade Optical Interface

- ACA, eccentricity < 0.125µm
- Exit angle < 0.4°
- 0.1dB Grade ferrules: low diameters tolerance < 0.2µm
- Ultra polish with 100% Endface inspection

This quality grade retains its name for the performance obtained with ITU G.652 D fiber which corresponds to a 0.1dB at 97% limit, random mated according to IEC 61300-3-34.

Applications

- High quality networks
- High speed networks and equipments
- Interferometry systems

VIS/NIR - SM Low Wavelength

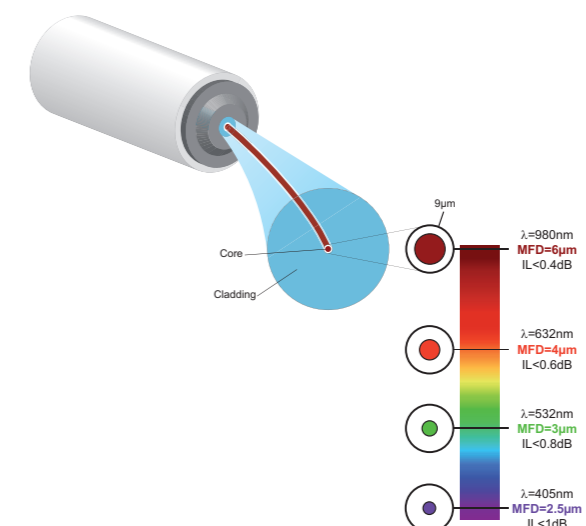
Small core fibers used mostly for visible and near infrared wavelengths (VIS/NIR), have not been addressed by standard groups. The ACA technology allows Diamond to provide the following specifications.

VIS/NIR Optical Interface

- ACA, eccentricity < 0.125µm
- Exit angle < 0.6°
- 0.1dB Grade ferrules: low diameters tolerance < 0.2µm
- Ultra polish with 100% Endface inspection

Applications

- Bio-Medical diagnostics and treatment
- Visible light laser



OPTICAL AND CONNECTOR INTERFACES

As a global company Diamond standardizes its products according to existing IEC standards. Each termination is composed of an optical interface and a connector interface. The following section lists the applicable standards for Diamond's products. For complete information please refer to our website catalog.

Connector Interfaces – IEC 61754

This standard is a collection of physical features on a connector assembly that defines a specified style. It consists of those minimum features that are functionally critical during the mating and un-mating sequences of the connector with its counterpart component. The interface defines the sizes, relative locations, and tolerances for each of the features. It includes references, definitions, and rules for creating and interpreting the standard drawings.

Optical Interfaces – IEC 61755

An optical interface standard is a multi-part collection of the requirements necessary in order to comply with the optical functionality specifications for a defined interface between two optical fibers. It consists of those essential features that are functionally critical to the optical attenuation and return loss performance of an optical interface in the mated condition. This standard provides general information on single-mode optical interfaces, defining the location of the fiber core in relation to the datum target and the following key parameters: lateral offset, end face separation, end face angle, end face high index layer condition.

Connector and Optical interface Combination

Connector Interface	Standard		Optical Interface							
	SM	MM	Ultra Low Loss or (0.1dB Grade)	VIS/NIR	PS	PSi	PSf	PM	PM-PS	
E-2000™	x	x	x	x	x		x	x	x	IEC 61754-15
F-3000™	x	x	x	x	x		*	x		IEC 61754-28
DMI	x	x	x	x	x		x	x	x	Diamond
FC	x	x	*	x	*		x	x	*	IEC 61754-13 * other standards (TIA, EN) exist too
LSA (DIN)	x	x	*	x	*		*	x		IEC 61754-3
AVIM™	x	x	*	x			*	x		ESCC 3420/002
Midi AVIM™	x	x	x	x			x	x		ESCC 3420/001
Mini AVIM™	x	x	x	x	x		x	x	x	ESCC 3420/001
Micro AVIM™	x	x	x	x	x		x	x	x	ESCC 3420/001
SC	x	x	x	x	*		*	x	*	IEC 61754-4
ST™	x	x								IEC 61754-2
MU	x	x								IEC 61754-6
F-SMA		x								IEC 61754-22
DiaLink	x	x		x						IEC 61754-32
	IEC 61755-1	IEC 61755-1	Diamond	Diamond	Diamond	Diamond	Diamond	Diamond	Diamond	Standards

* available on demand, but not qualified

In the following pages the emphasis is on Diamond Optical Interfaces.

For details on Connector Interfaces and IEC standardized Optical Interfaces, please refer to our standard catalog.



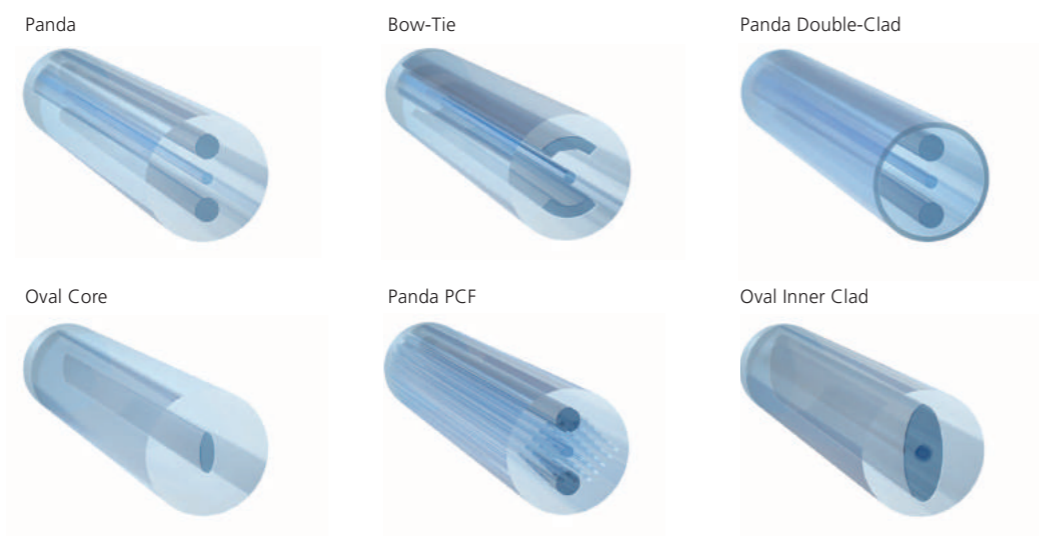
Field interferometers benefitting from robust, ultra high performance Diamond environmental DMI/Micro AVIM™ PM.



End customer application using Diamond's E-2000™ PM low wavelength to analyze DNA structure.

POLARIZATION ORIENTATION (PO)

Polarization plays an important role in the industrial photonics market. Sensors and communication systems have been designed using Polarization Maintaining or Polarizing fibers. DIAMOND supplies high-quality solutions to Polarization Maintaining (PM) and Polarizing (PZ) fiber optical interfaces for optimal control of the signal's polarization state.



The connector key for a Polarization Maintaining connector can be aligned to the stress members (Passive Polarization Orientation, PPO) or to the true optical axis (Active Polarization Orientation, APO).

Advantages

- Ultra low Insertion Loss
- High Extinction Ratio
- High Return Loss

PM (Polarization Maintaining) optical interface

The use of Diamond Active Polarization Orientation with a special Active Core Alignment process, limit any residual stress in sensitive PM and PZ fiber. Low Insertion Losses (IL) combined with high Polarization Extinction Ratios (PER) and higher Return Losses (RL) are achieved over very broad spectral ranges thanks to a combination of accurate optical and mechanical design. The PM+ products use a refined assembly process allowing for higher PER value.

PM Optical interfaces

- | | | | |
|--|---------|------------------|------------|
| ■ Exit angle | < 0.6° | ■ Ferrule radius | 10±20 mm |
| ■ 0.1dB Grade ferrules with diameter tolerance | < 0.2µm | ■ Core apex | <62.5 µm |
| ■ Polarization angular error | < ±2° | ■ Fiber height | -50±200 nm |
| ■ Ultra polish with 100% Endface inspection | | | |

Applications fields

- | | | | |
|----------------|----------------------|-------------|---------------------------|
| ■ Biomedicine | ■ Telecommunications | ■ Metrology | ■ Surveillance & Security |
| ■ Spectroscopy | ■ Lasertechnology | ■ Sensorics | ■ Lithography |

PM product family

Depending on the application, different optical performances are required. In order to meet these requirements, the PM product family is divided into two classifications. First, the PM+ with the highest PER values and the best mechanical properties. Second, the PM standard class with very good optical values and a wide range of different connector types.

PM+ connectors

The best Polarization Extinction rate

The PM+ connector types are designed to achieve the highest possible and Polarization Extinction Ratio (PER), this with excellent Insertion Loss (IL) and Return Loss (RL) values. The optical performance is guaranteed by the selected connector variants with good mechanical properties and low angular tolerances.

Thanks to very high PER values, the PM+ connector family opens up new possibilities in the development and design of new measuring and diagnostic devices.



Advantages and features

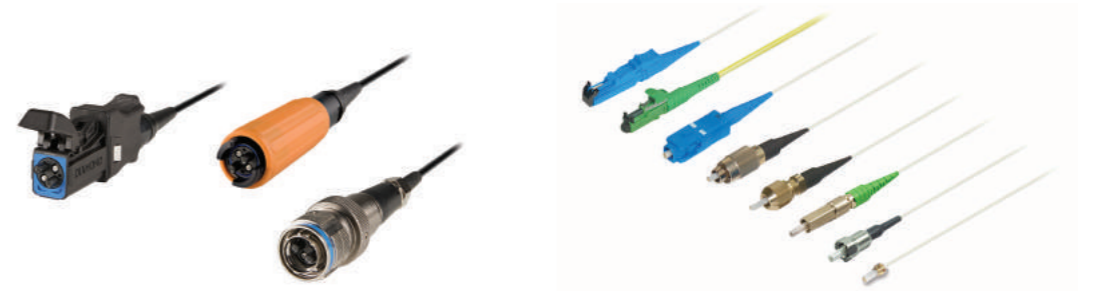
- Active Polarization Orientation (APO) method
- Excellent low Insertion Loss (IL) values
- Highest PER Value
- Homologated fiber for wavelength ranges from 532 to 1550nm



PM connectors

For a wide range of connector types

Thanks to good optical values and a large number of connector variants, there is a suitable connector in the right configuration for a large number of applications.



Advantages and features

- Active Polarization Orientation (APO) method
- Excellent low Insertion Loss (IL) values
- Designed and tested for uncontrolled environment of category U
- Homologated fiber types for wavelength ranges from 405 to 1625nm
- Customer specific configurations

Available PM connectors

- E-2000™, F-3000™, AVIM™, Midi AVIM™, Mini AVIM™, Micro AVIM™, DMI, SC, FC, LSA (DIN), HE-2000™, MIL-83526 DM, MIL-38999 DM size 13

POWER SOLUTION EXPANDED BEAM TECHNOLOGIES

Diamond uses different methods for expanded beam alignment, depending on the final use of the assembly. In this section, we will present the technologies using a GRIN lens spliced at the end of a fiber to realize a collimated beam dedicated to a connection. Other Expanded Beam technologies exist for non-contact connection and input/output application.

These expanded MFD resulting from the use of a collimated beam, diminish the power density at the glass air interface. Un-wanted particles at the glass air interface (the connector endfaces) will resist to more power before causing a failure in a connection.

PS (Power Solution collimated)

The Power Solution (PS) optical interface is based on contact Expanded Beam GRIN lens technology. It has been qualified at 1550nm using ITU G.652-D and ITU G.657-B3 fibers up to 5W using E-2000 and at 1050nm using Corning HI-1060 fiber at 1W using F-3000 connectors.

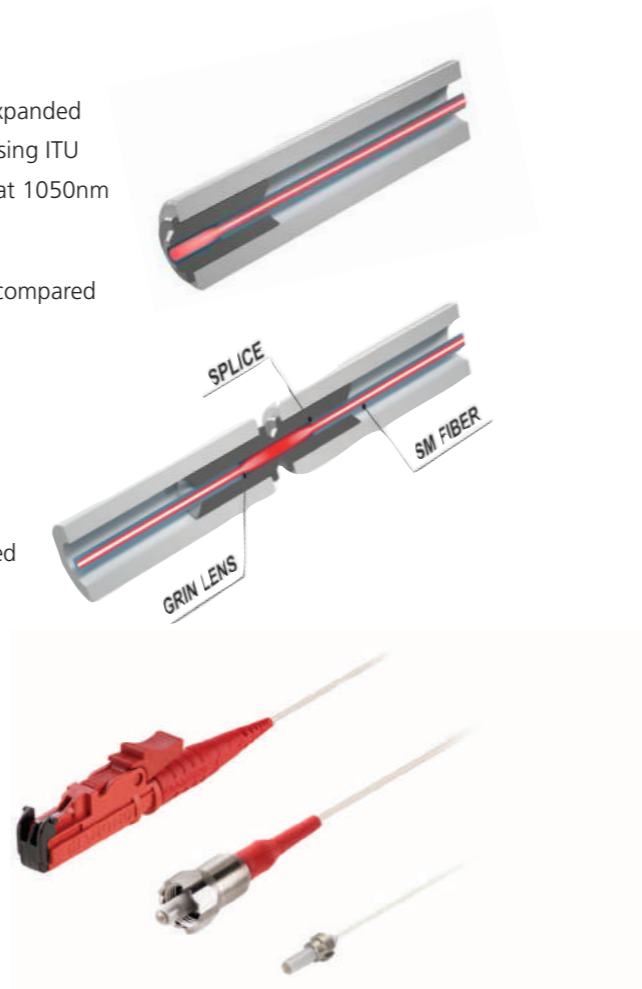
In these products, the MFD surface is increased by a factor 15 compared to the SM MFD.

PS Optical Interface:

- 0.1dB Grade ferrules with diameter tolerance <math>< 0.2\mu\text{m}</math>
- ACA with low exit angle <math>< 0.15^\circ</math>
- Eccentricity <math>< 3.5\mu\text{m}</math>, keyed
- Ultra polish with 100% endface inspection

Applications

- Raman (1310 to 1550nm) amplifiers
- EDFA (980nm to 1060nm) amplifiers
- 100G backbones (DWDM)
- High power (SM > 300mW CW) networks
- Collimator replacements for detectors
- Low power, high contamination environments



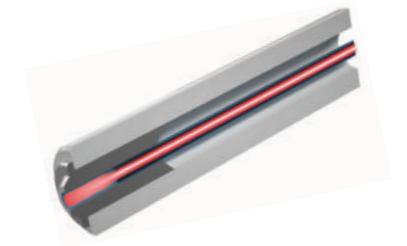
PM-PS (Power Solution collimated for PM fibers)

Polarization Maintaining (PM) fibers using the Power Solution (PS) optical interface benefit from the same Expanded Beam GRIN lens benefits. This more delicate technology has been homologated only on specific fibers and require a full homologation for any new fibers. A limited choice of connector mechanical interface is compatible with these products: E-2000™, DMI / Micro AVIM™, Mini AVIM™.

In these products, the MFD surface is increased by a factor 15 compared to the PM MFD.

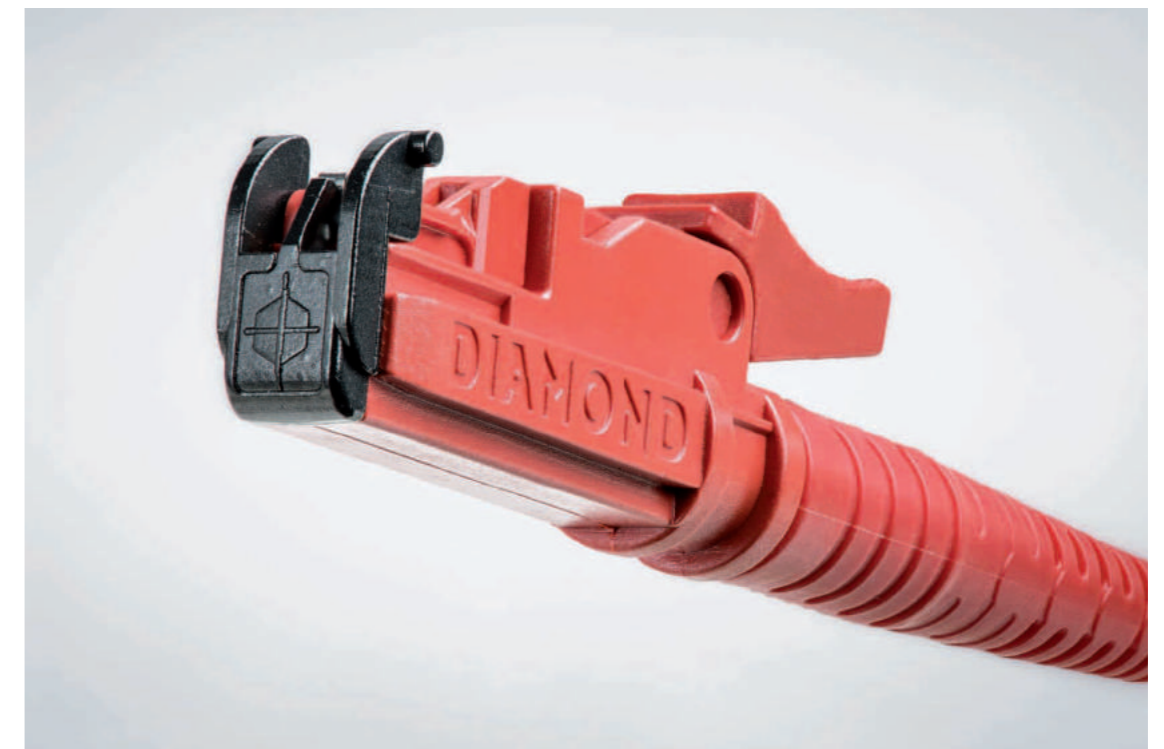
PS Optical Interface:

- 0.1dB Grade ferrules with diameter tolerance <math>< 0.2\mu\text{m}</math>
- ACA with low exit angle <math>< 0.15^\circ</math>
- Polarization slow axis – Key angle $\pm 2^\circ$
- Ultra polish with 100% endface inspection for PC 0° and APC 4°



Applications

- Free Space Telecommunication
- RF over fiber
- Lidar
- Sensing



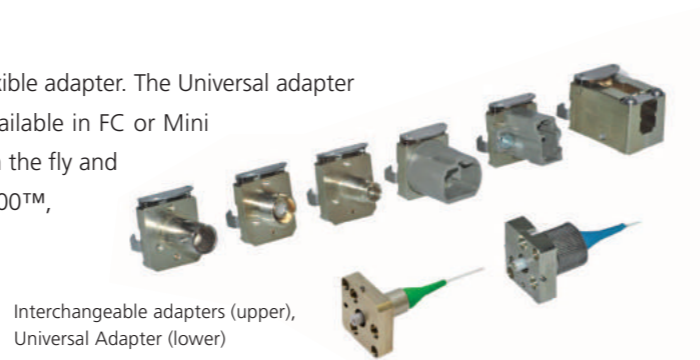
E-2000™ PS connector

SPECIAL INTERFACE PRODUCTS

Applications with fibers are not only based on physical contact, but also other types of interfaces. Light must be injected in fibers and must get out to illuminate a target too. In some cases, feedthrough to go through dissimilar ambient are necessary. The following products corresponds to the standardized solutions developed for these applications. Others are regularly designed or customized for specific applications.

MAS – MULTIPURPOSE ADAPTER SYSTEM

The Multipurpose Adapter System (MAS) is a hybrid flexible adapter. The Universal adapter is mounted on a chassis or used on a bench and is available in FC or Mini AVIM™. The other side of the adapter is changeable on the fly and is available in the following mechanical interfaces: E-2000™, SC, LSA DIN, ST™, F-3000™ (100% compatible with the LC), FC (wide and narrow key).



Interchangeable adapters (upper),
Universal Adapter (lower)

Advantages

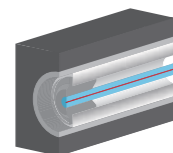
- Easy use
- Low insertion loss
- Large choice of mechanical interface
- Easy cleaning of internal connectors

Applications:

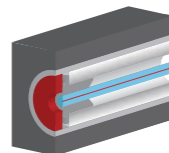
- Measurement instruments
- Light sources

IMOD – INTERFACE MODULE

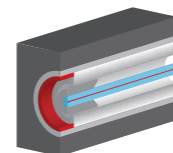
The Interface Module (IMOD) is used to terminate a connector for free space applications. Various options are available to fix the ferrule in a location optimal for your application.



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



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



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™, LSA (DIN), FC, Mini AVIM™ and F-SMA (SMA 905).

Advantages

- Easy implementation
- High Position Reproducibility
- Long service life

Applications:

- Laser launch
- Instrument front panel connection
- Custom adapters



V-FT – VACUUM FEEDTHROUGH

Feedthroughs have been produced by Diamond for twenty years using a proven epoxy sealing technology. Diamond has standardized this sealing process and is now offering an off-the-shelf solution for the Vacuum Feedthroughs.

Diamond offers V-FT's based on a standard ConFlat (CF) flange, (DN16 size, OD 40mm). These flanges can be used with rubber seals for High Vacuum, or with one-time-use copper seals for Ultra-High Vacuum. Thanks to the MAS universal flange, most of the optical connectors can be mounted on the atmospheric side. Whereas on the vacuum side, due to the environment limitations, only the following connectors are available; AVIM™, Mini AVIM™, FC, DMI, DIN (LSA).



Advantages

- Low leak rate at wide temperature range
- Low Insertion Loss
- Fiber type independent
- Compatible with all Optical Interfaces
- Wide range of mechanical interface
- Wide range of flange accessories

Applications

- Semiconductor vacuum Chamber
- Space pressurized vessels
- Vacuum fiber qualification
- Nuclear plant

Reference Patchcords

Reference connectors are a critical component in metrology and have been defined in detail for telecom applications in IEC 61755-2-4 and IEC 61755-2-5.

To comply with these standards, Optical reference connectors are manufactured with specific tolerances and selected single mode fiber with restricted tolerances on the Mode Field Diameter (MFD). Only this way can the measurement attenuation variability be limited in reference connectors. The repeatability of those measurements can be contained to ± 0.1 dB when randomly varying the reference connectors.

Diamond manufactures high performance reference connectors using the standardized composite ferrule, as well as "Active Core Alignment" (ACA) technology, which allows for the minimization of the fiber core eccentricity and the control of the angular misalignment.

Diamond can provide reference connectors on other fibers not defined in the IEC standards with similar specification, where eccentricity and exit angle are always defined and measured. Individual fiber specification can change with each fibers.



LABORATORY

The test and calibration laboratory at DIAMOND SA has been accredited by the Swiss Accreditation Service SAS since March 2002. We are accredited as testing laboratory STS 333 for fiber optic components and as calibration laboratory SCS 101 for fiber optic measurement instruments in accordance with the standard ISO / IEC 17025:2005. The accredited test and calibration laboratory STS 333 / SCS 101 performs measurements, tests and calibrations not only for DIAMOND SA, subsidiaries and DIAMOND representatives all over the world but also directly for external customers.



ISO 7 cleanroom

The worldwide market for fibre optic solutions used within fields that are very sensitive to environmental contamination, such as medicine, laboratories, space, research, life sciences and industry, is experiencing steady growth. Diamond has responded to this growing demand by creating a new ISO 7 cleanroom (class 10'000 according to FED STD 209E), in order to supply products such as connector sets, pigtails, patchcords, adapters and mechanical parts that are cleaned and packaged in a controlled environment.

Processes inside the Diamond cleanroom include cleaning, drying, controlling and packaging, and these are preceded by a preparation and preconditioning process outside the cleanroom.

For details of the processes, or to enquire about a customized process, please contact us.

Cleanroom main characteristics

- **Class:** ISO 7 (according to norm DIN EN ISO 14644-1)
- **Type:** Turbulent air flow
- **Flow rate:** Min. 40 air exchanges/h
- **Filters:** 3 ULPA U15 filters
- **Air flow:** 3,600 m³/h total
- **Overpressure:** 24 Pa
- **ESD-compliant:** Yes
- **Surface:** 40 m²
- **Power supply:** Lights and filters are under UPS





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