

LASER

FIBER OPTIC SOLUTIONS FOR LASER INDUSTRY

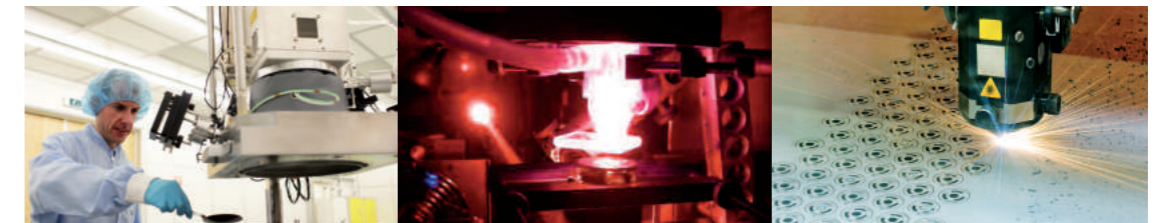




LASER

Optical fibers provide one of the most practical methods for laser power delivery in a broad variety of technical and commercial fields and play a prime role in enabling many new applications. The link between light sources and optical targets are supported by optical interfaces that more and more often consist of fiber optic connectors.

The knowledge of both performances and limitations of such interfaces is essential to the optimization of any fiber optic based system. With more than 35 years of experience in development, manufacturing, and testing of fiber optic interconnects, Diamond possesses all the know-how necessary to provide the best solution in every situation.



Diamond's vertically integrated approach covers all aspects of a fiber interconnect:

Mechanics

- In-house ceramics production
- Precision machining with extensive expertise with hard and soft metals (Ti, WC, stainless steel, Kovar,...)
- High-precision plastic molding
- Ultra-high quality surface polishing and lapping

Optics

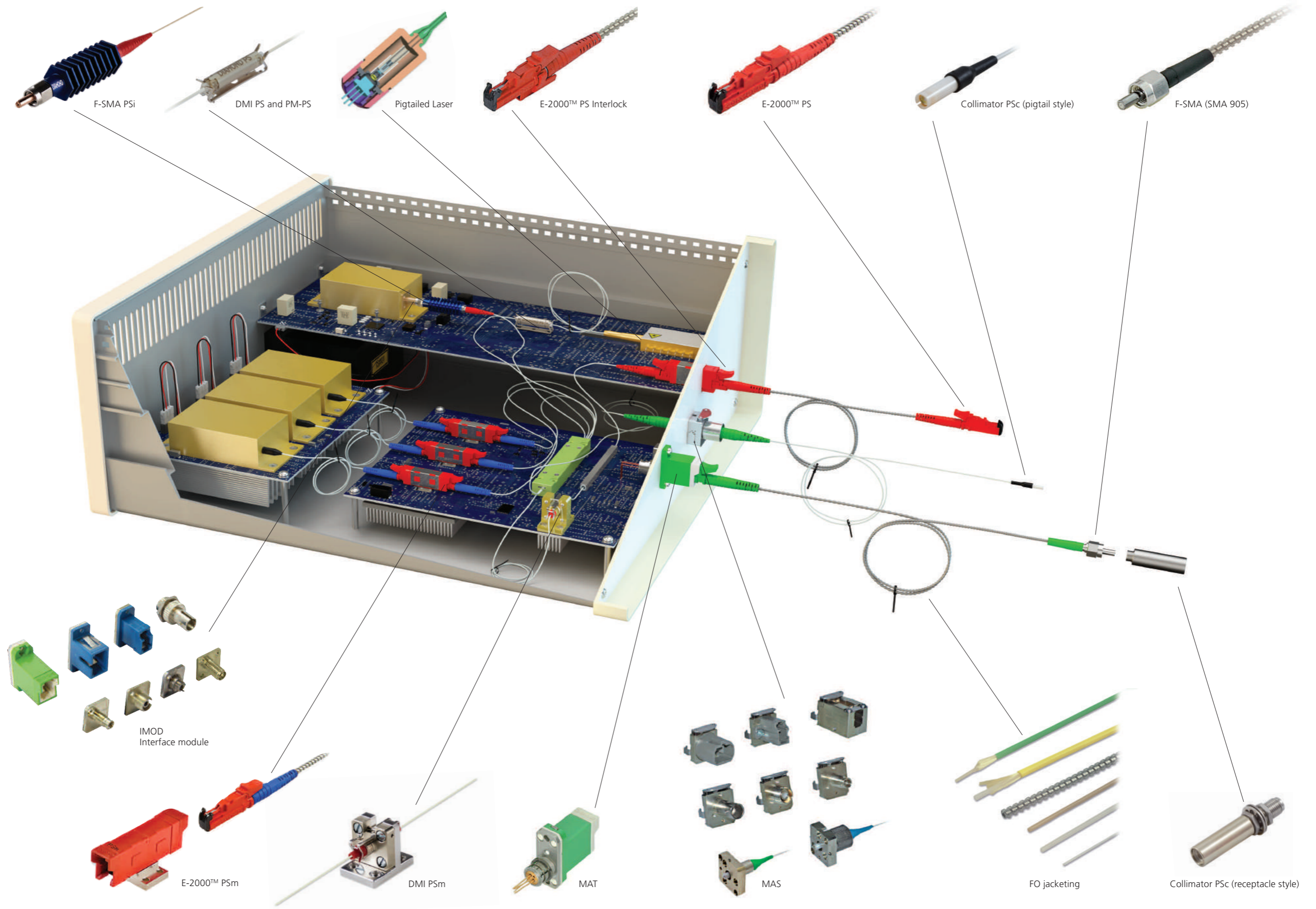
- Fiber active core alignment (ACA)
- Active polarization orientation (APO)
- Wide variety of optical interfaces
- Splicing expertise

Assembly

- Active optical alignment of subassemblies
- Component packaging via epoxies or laser welding
- Vacuum and cryogenic interfaces
- Assembly in controlled environment (clean room) ISO 7

Testing

- Accredited test laboratory for opto-mechanical product characterization and qualification
- Calibration of optical test instruments

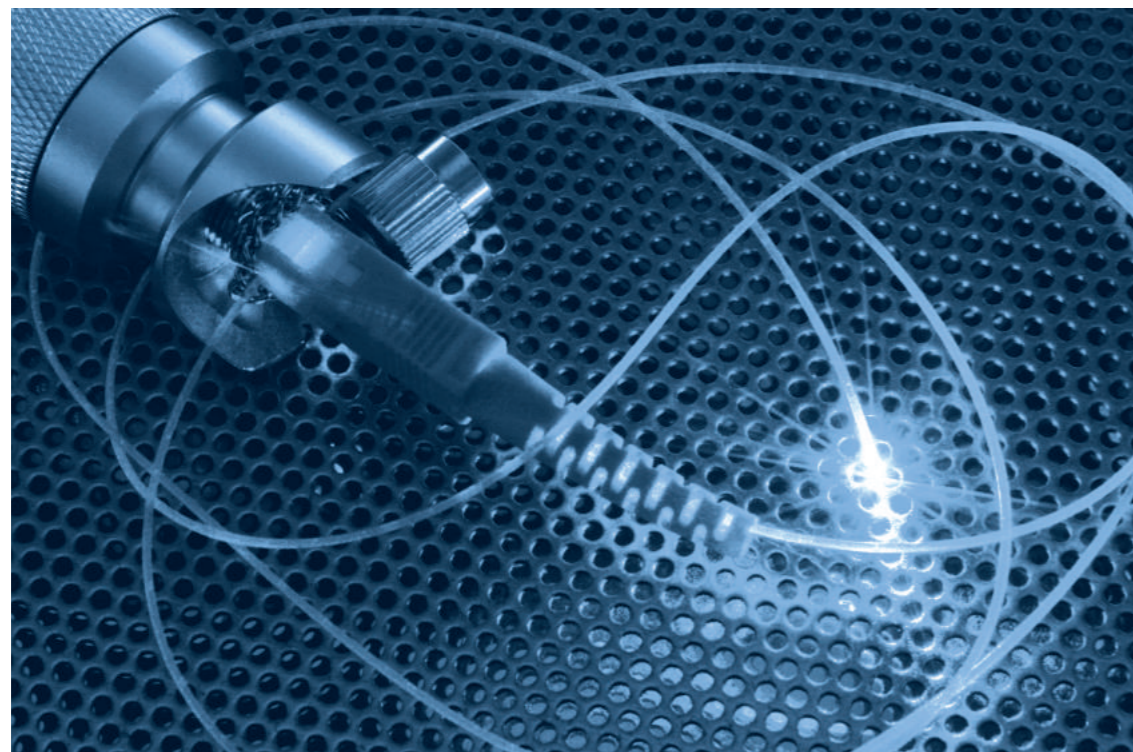
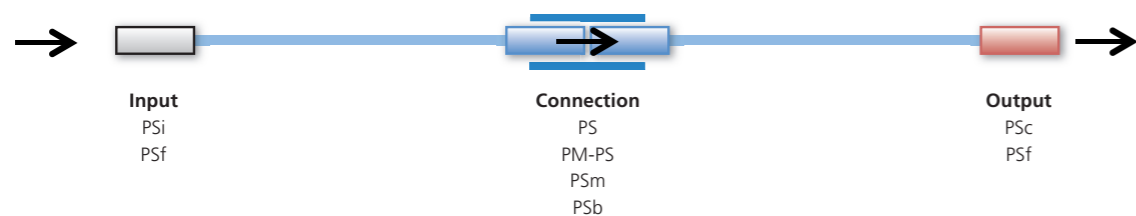


OPTO-MECHANICAL PATH CONFIGURATION

Diamond's modular approach offers the maximum flexibility towards both individual connection and global system performance optimization along an optical link. Depending upon local conditions and constraints different interface solutions may be better suited:

- Interface position fiber-to-fiber connection, coupling between fiber and (from or to) free-space
- Fiber type standard SM, MM fibers or other specialty fibers (PM, low-NA, double-clad, ...)
- Power level optical and thermal power management
- Operating wavelength optimization of transmission efficiency

Suitable interface types



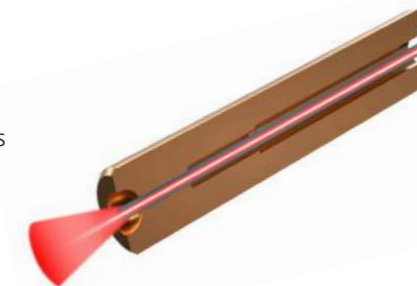
POWER SOLUTION OPTICAL INTERFACE TECHNOLOGIES

Diamond's connectors rely upon different techniques to manage high optical power densities at the fiber's transition, all based upon the expansion of the optical beam. The increase of the spot size and the consequent decrease of the local power density are exploited to reduce the risk of reversible or catastrophic failures due to thermo-mechanical effects.

PSi (Power Solution injection)

Diamond's PSi interfaces are specifically conceived to operate in a non-contact configuration where high-power optical beams –up to hundreds of W– are coupled from free-space into a fiber. The fiber's characteristics and the beam profile in free space will determine the amount of dissipated power that the PSi connector must sustain. Materials' choice and connectors' geometry are then decided in order to properly encapsulate the free-standing fiber into a highly conductive metal ferrule that can be optionally coupled to a heat radiator. Different configurations are available depending on whether the fiber system operates in a cladding-mode guiding or in a cladding-mode stripping regime.

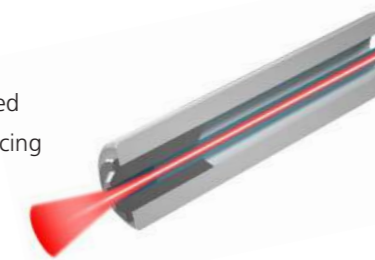
The PSi interface comes as an F-SMA connector based upon a high-precision copper ferrule that accommodates fibers with up to 1000 μm diameter. Optimized radiators operate either with natural or forced convection. Thermal polishing of the fiber's front facet and AR coatings are available.



PSf (Power Solution free-space)

The PSf interface relies upon a non-contact configuration where the power density at the glass-air interface is substantially reduced compared to the conventional fiber's power concentration. This is achieved by splicing a transparent endcap to the fiber so that the guided beam may diverge and expand before hitting the material transition interface. The same principle applies when focusing a high-power beam into a fiber. This technology can be applied to MM as well as to SM fibers, including PM fibers.

Diamond's PSf interface can be encapsulated in virtually every connector's body. Spot size at the glass-air interface and beam divergence will depend upon the choice of fiber and length of the endcap.



PS & PM-PS (Power Solution for standard and polarization sensitive PM/PZ fibers)

Diamond's PS interfaces are contact solutions for SM fibers that allow supporting higher optical powers at the connectors' mating surface. Compared to standard SM fibers, the mode size is expanded 4-5 times and collimated by splicing an endcap consisting of a GRIN fiber section. This effectively reduces the power density at the connector's surface, which decreases the risk of catastrophic damages or, alternatively, improves the connector's resilience towards dust.

This technology can be applied to standard SM fibers as well as to polarization maintaining or polarizing fibers. Once the endcapped fiber is encapsulated into the ferrule, the latter can be assembled into most connectors' bodies, although E-2000™, F-3000™, Mini-AVIM and DMI remain the preferred choice.

Thanks to active core alignment techniques, low insertion loss values combined with high return losses are supplied at power levels of up to 6 W for qualified fibers. For polarization sensitive applications, active polarization orientation provides the best axes alignment.



PSm (Power Solution mated configuration)

Driven by the laser industry's need for modularity and flexibility, for optical powers in the range of 10 W and higher Diamond has developed a contact PSm interface that provides a pluggable alternative to permanent fiber splicing. In the absence of recognized standards, especially for large-core MM fibers connectors, Diamond manufactures optical interfaces with superior quality both in terms of axial alignment –thanks to the active core alignment– as well as in terms of fiber's surface polishing. Every single connector is checked 100% in order to provide the best optical performance and the highest possible reliability.

Besides the fiber connectors, a major role is played by the mating adapter. Diamond's versions have been redesigned to support heavier thermal loads while maintaining the required robustness and ease of use.

PSm interfaces are available in the E-2000™ and DMI form for MM fibers with typical core sizes of 100 and 200 μm. The sustained optical powers are in the range of hundreds of Watts depending on the specifics of the fiber and the connector configuration. Although optical connectors should never be disconnected in the presence of high powers, the E-2000™ connector can be supplied with additional interlock features that can be exploited to increase safety.



PSb (Power Solution ball lens)

The PSb arrangement is a non-contact interface that allows for an expansion of the beam size of a MM fiber by means of an external spherical lens. The opto-mechanical alignment between fiber, ferrule, and lens relies upon the active core alignment. The size of the collimated beam in free-space is sufficient to ensure a safe handling of medium to high optical power levels even in the presence of surface contaminants.

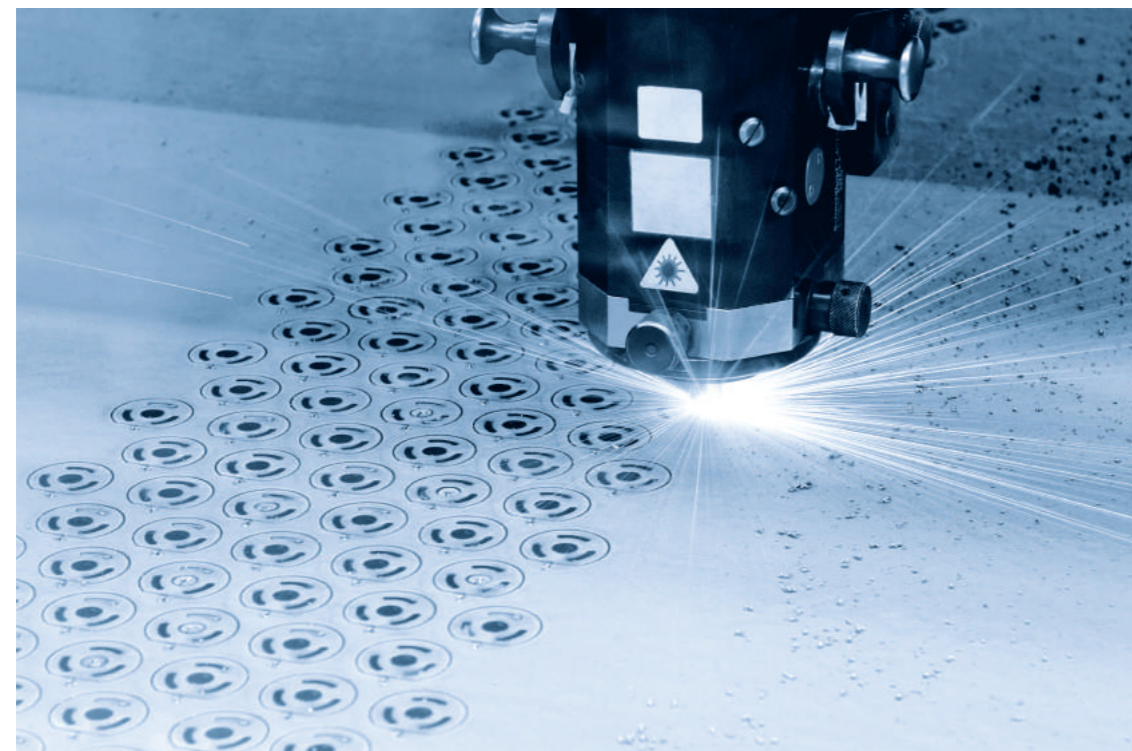
PSb interfaces are typically encapsulated into rugged connectors such as Diamond's X-BEAM PS, which contains up to four fiber-lens termini.



PSc (Power Solution collimators)

Fiber collimators are assembled by combining SM or MM fibers with a properly dimensioned plano-convex lens, which will define both the size and the divergence of the beam in free-space. Having a lens diameter that matches the ferrule's size results in very compact collimators that can be easily integrated into connector sleeves or receptacles.

PSc's are available for a wide selection of fibers supporting a broad range of wavelengths. Anti-reflection coatings can be offered if needed.

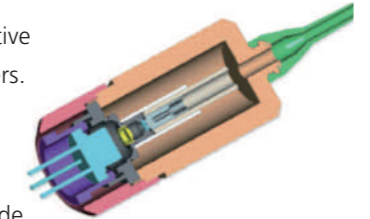


ACTIVES MODULES

Diamond has the know-how needed to provide light coupling between fibers and opto-electronic elements such as semiconductor laser diodes and photodetectors. The active positioning of the fiber with respect to the emitting or receiving semiconductor device can be made either permanent or temporary but in both cases with micrometer alignment accuracy. This allows for high coupling efficiencies and high connection repeatability.

Fiber-pigtailed emitters and receivers

Diamond has developed assembly procedures that allow for the precise active alignment of optical fibers in front of either light emitters or photoreceivers. Depending upon the beam characteristics, collimating lenses may be positioned and co-packaged into the modules.



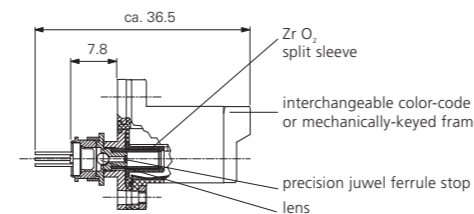
The technology is well suited for combining active optical elements inside TO-cans of different sizes together with a broad variety of optical fibers such as MM, SM and even PM fibers. Customized solutions available upon request.

Connector-pluggable modules

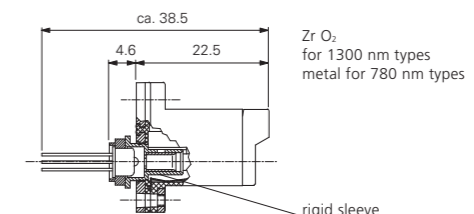
Active optical elements can be packaged into dedicated fiber-optic mating adapters to allow for a direct coupling with fiber connectors. Diamond's technology provides a very accurate active positioning of the fiber in front of the light-emitting (MAT) or receiving (MAR) element with an exceptionally high repeatability. Collimating lenses may be co-packaged if needed.



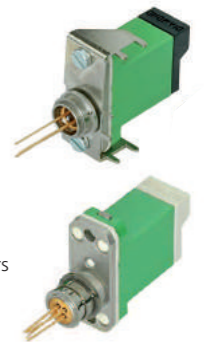
Diamond's approach supports most fiber types and most connector bodies, still the E-2000™ version remains the preferred choice due to its ease of use and superior mechanical precision.



Construction for LD source transmitters (3 axis alignment)



Construction for LED source transmitters and receivers (2 axis alignment)



Connectorization of fiber-pigtailed modules

Diamond's technology allows for the connectorization of fiber-pigtailed active modules such as light sources, photoreceivers, optical modulators, optical amplifiers and switches. Depending upon the custom-defined fiber and connector choice, the active core alignment and the active polarization orientation techniques may be applied to provide the best possible connection performance.

ACCESSORIES

The functionality of an optical fiber interface can be expanded with features that may provide safety and monitoring capabilities. Furthermore, the system flexibility and modularity may be enhanced by allowing for a rapid and seamless swap of connector type.

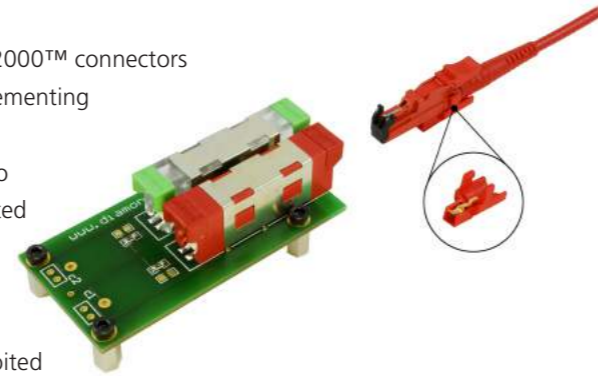
Interlock

For security, safety, or monitoring purposes the E-2000™ connectors can be equipped with additional features for implementing interlock functionalities around this interface.

The electro-mechanical features make it possible to verify that E-2000™ connectors are properly inserted into modules or mating adapters so that the optical path is correctly set up. Unlocking the connector will immediately translate into the opening of an electrical circuit, which can be exploited to trigger all necessary countermeasures.

The interlock functionality can be added to any E-2000™ connector regardless of the kind of fiber or beam expansion technology used inside the ferrule.

Note: the automatic shutters of E-2000™ connectors are not meant for blocking high-power beams or for long-term protection or safety purposes.



Interface MODules (IMOD)

Diamond offers a set of connector adapters specifically conceived to provide fixtures that allow for precise and repeatable coupling between fiber connectors and free-space.

These adapters rely upon the same technology and geometry that defines the precise positioning and alignment of ferrules inside a fiber connection.

This product can accommodate flat- (PC) or angled-polished (APC) connectors for most of the existing connector types.

IMOD are available in three different configurations

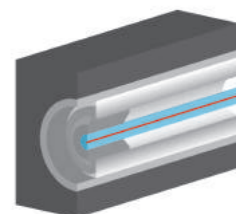


Fig.1 Without any stopper; for applications which do not require specific tolerances or exact ferrule axial positioning.

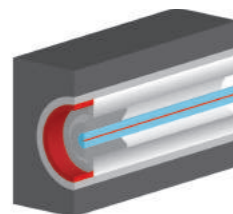


Fig.2 With ferrule ZrO2 cylinder stopper, for good axial repeatability.

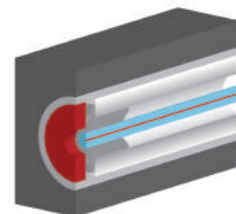
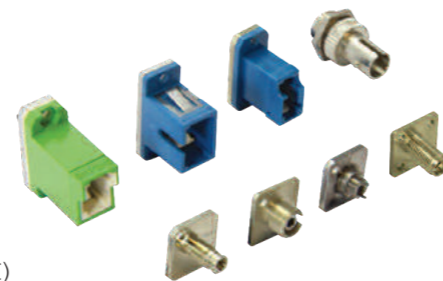


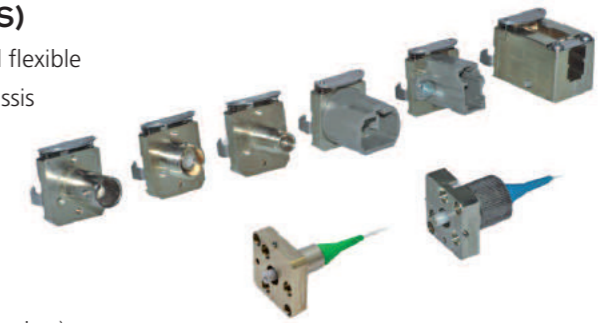
Fig.3 With ferrule front face stopper, for superior axial repeatability.



Multipurpose Adapter System (MAS)

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 interfaces.

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).



Features

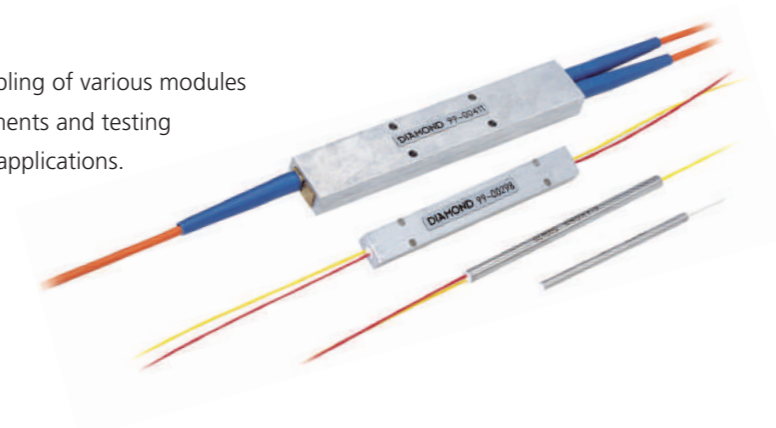
- Easy use and easy cleaning of internal connectors
- Low insertion loss

Fiber couplers

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

Modules examples:

- Couplers/Splitters
- Isolators
- Combiners
- Circulators



Fiber optic jacketing

Diamond assemblies can be offered with the following plastic and metal flexible jacketing to protect the fiber:

Plastic tubes

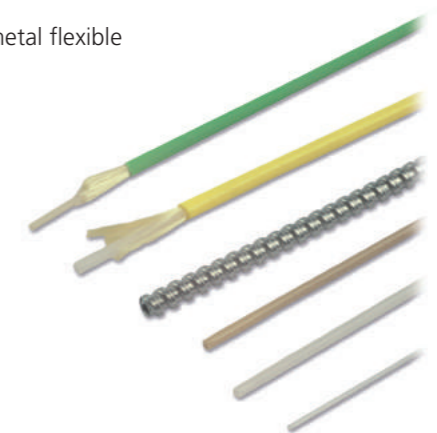
- Elastomer (Hytrel)
- PEEK (Victrex 450)
- PA (Nylon)
- PTFE (Teflon)

Metal tubes

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

Features

- Tight bending radius limitation
- In addition the radius can be adjusted by modifying the wire diameter and number of wires inserted
- Almost no elasticity, which provides optimum protection for optical fibers, especially, for the quartz-and hollow fiber types
- Sheathing: PVC, Olefin, Silicon, PUR



TESTING CAPABILITIES

For opto-mechanical product tests, quality control and qualifications Diamond relies since 2002 upon an internal, fully independent, test laboratory qualified by the Swiss Accreditation Service SAS. The laboratory has a STS 333 accreditation for fiber-optic component testing as well as a SCS 101 accreditation for the calibration of fiber-optic measurement instruments according to ISO/IEC 17025 :2005.

The laboratory is equipped to perform a wide variety of tests both on the optical or mechanical product performance under different environmental conditions according to IEC, ISO, Telcordia or MIL standard requirements. Additional characterization procedures that have not yet been standardized are also possible, particularly in relation to the use of high-power lasers.

These testing services are also available to customers.



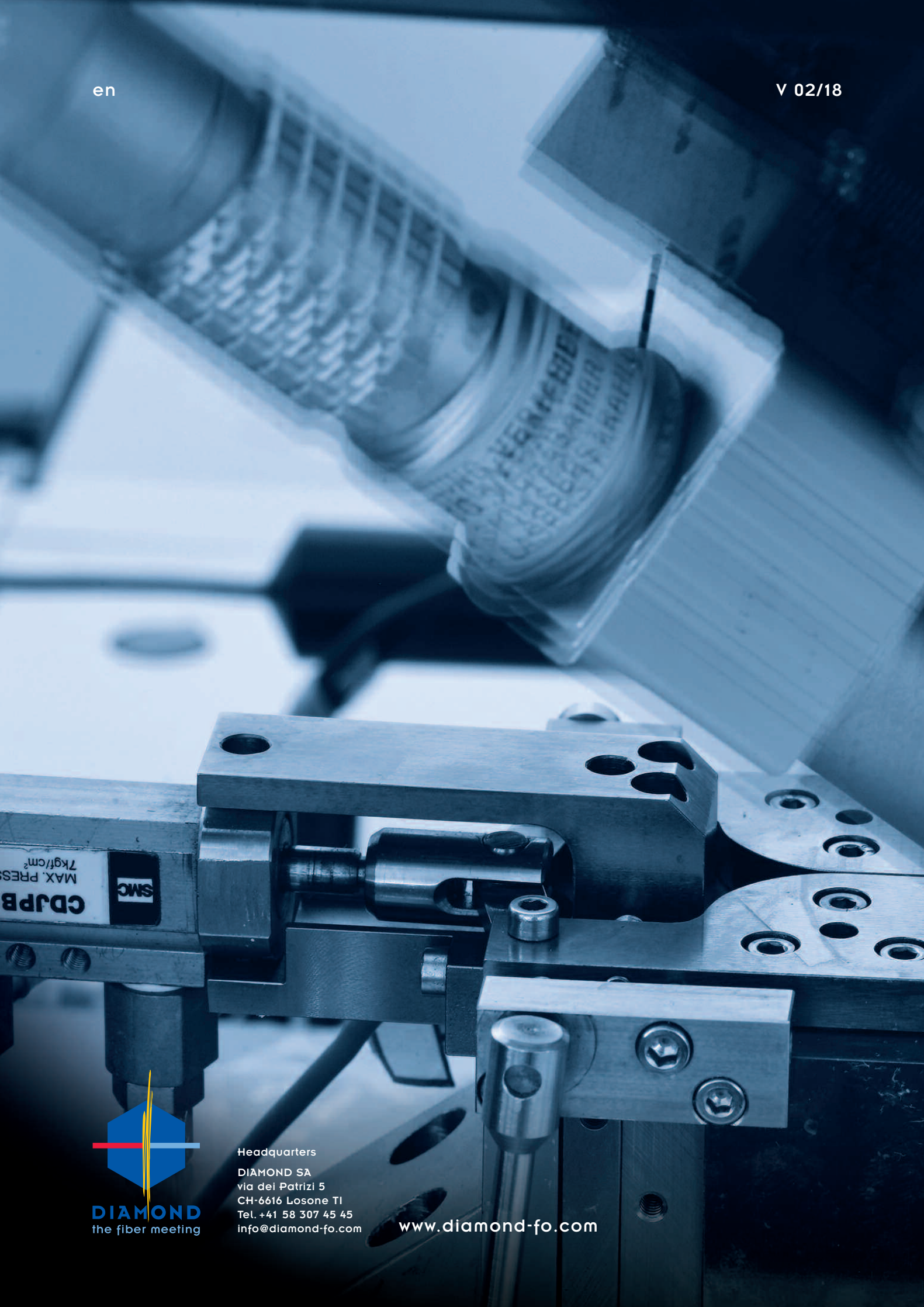
ISO 7 Cleanroom

For particularly demanding markets such as the medical, the space, life sciences industry sectors, Diamond offers a dedicated controlled environment where to perform part of the product processing. In an ISO 7 cleanroom (class 10'000 according to FED STD 1209E) products can be cleaned, dried, inspected and packaged before delivery. Specific custom procedures may be implemented upon request.

Cleanroom main characteristics:

- **Class:** ISO 7 (norm DIN EN ISO 14644-1)
- **Filters:** 3 ULPA U15 filters
- **ESD-compliant:** Yes
- **Surface:** 40 m²





Headquarters

DIAMOND SA
via dei Patrizi 5
CH-6616 Losone TI
Tel. +41 58 307 45 45
info@diamond-fo.com

www.diamond-fo.com