



Fiber Bragg Gratings Integrated inside Fiber Optics Connectors

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Outline

Fiber optics connectors as packages

- Fiber sensors
- Requirements on the package
 - optical, mechanical, and thermal constraints

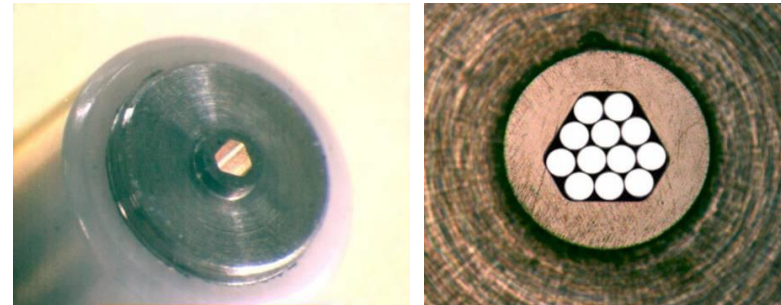
Diamond SA (Losone, TI)

- Technologies
- Connector solutions
- Applications & performances

Summary

Fiber optics connectors as packages

Fiber optics connectors provide {
■ protection
■ manipulability
■ operability } to the fibers hosted inside



Optical fibers are sensors

- intentional (FBG, fiber reflectors or scatterers)
- unintentional (bare fiber)

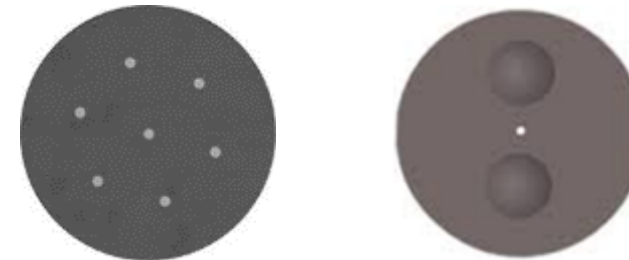
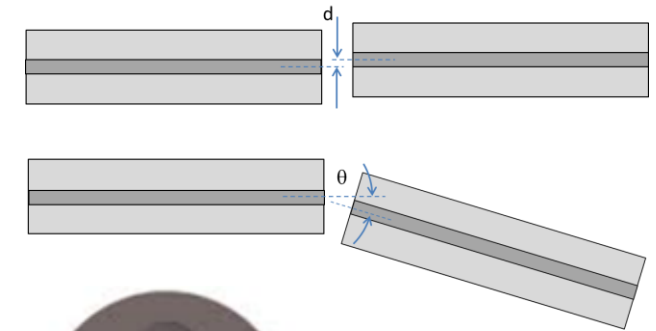
Requirements on fiber connectors

Goal: maintain desired level of optical performance across transition between two fibers

- attenuation or insertion loss IL
- reflections or return loss RL
- polarization extinction ratio PER (in polarization sensitive applications)

Mechanical constraints

- axial alignment between the cores of the two mating fibers
 - lateral offset
 - axial tilt
- relative angular orientation between two mating fibers



Thermal constraints

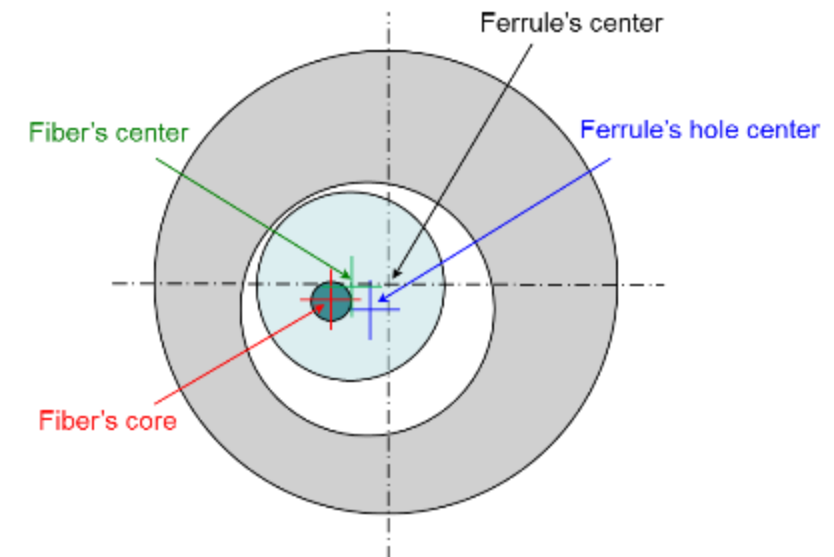
- optical performance should or should not be influenced by internal/external temperature



Axial core alignment

- requirements (bring the fiber's core to the center)
 - lateral offset within $\sim 1\mu\text{m}$ (standard IEC telecom 1310 nm – 1550 nm)
 - not satisfactory for shorter wavelengths (smaller MFD)
 - ➔ IL grows quadratically with offset ←

- limitations
 - standard monoblock ferrules rely upon intrinsic geometric/manufacturing tolerances

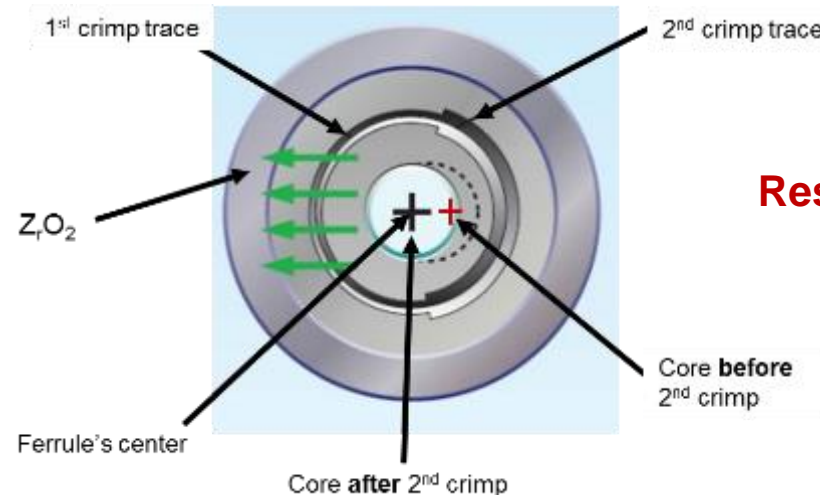
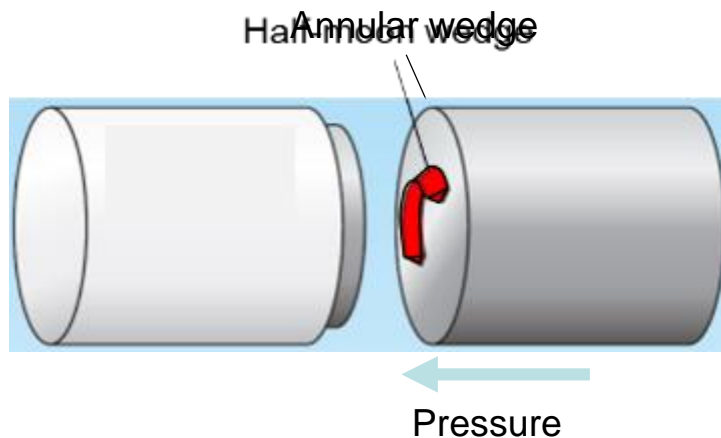
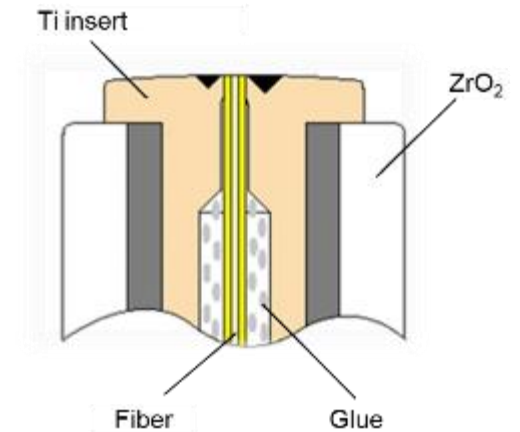


Diamond's technologies



Active core alignment

- Diamond's composite ferrule
 - ceramic housing with Ti insert
 - manipulation of fiber position by plastic metal deformation
- 2-step centering procedure
 - 1st step: close fiber-metal gap
 - 2nd step: core centering

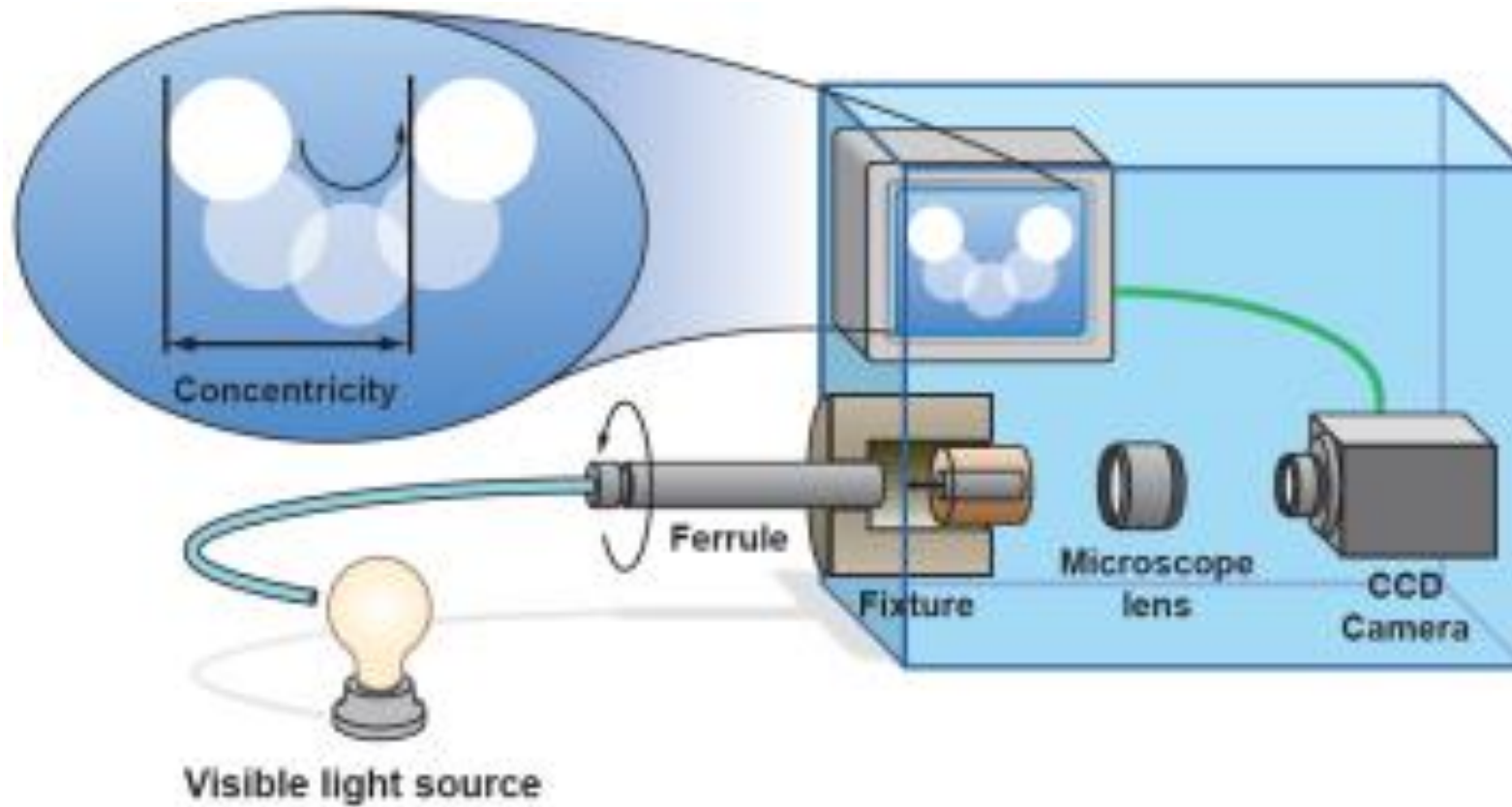


**Residual eccentricity
< 0.125 μm**

Diamond's technologies



Core eccentricity measurement

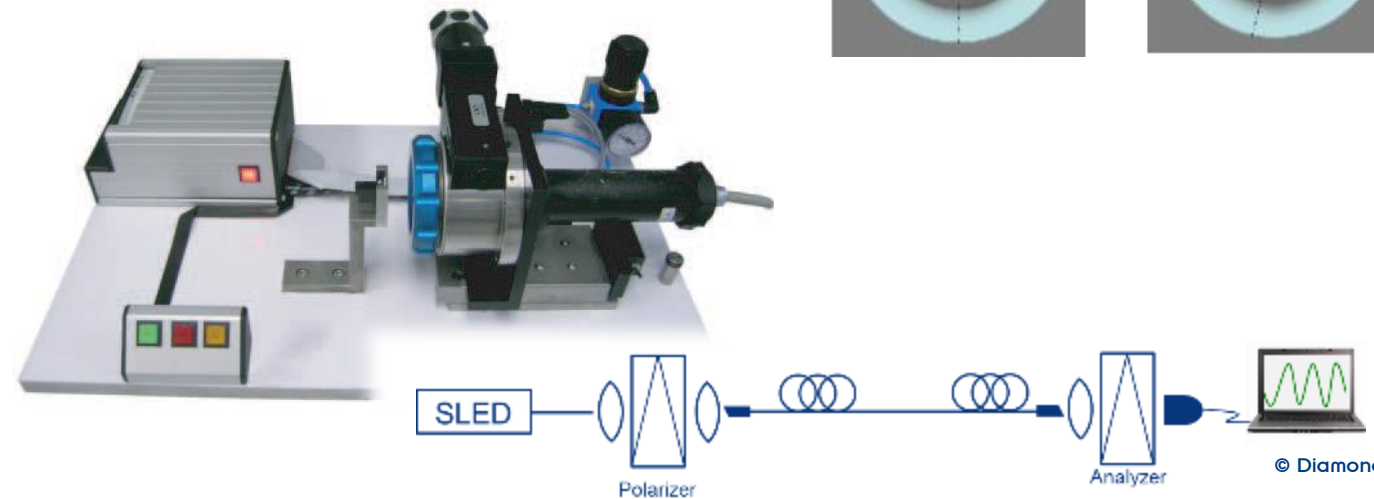
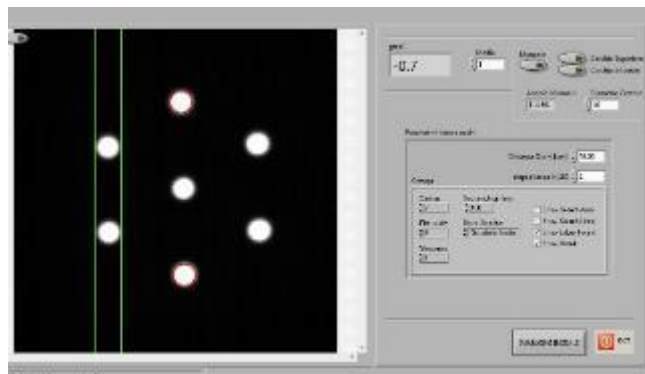
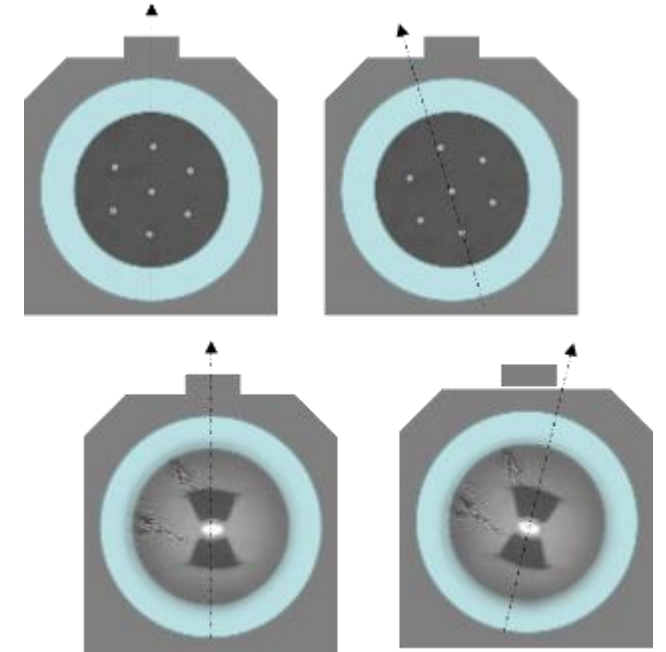


Diamond's technologies



Angular orientation

- mandatory for arrangements lacking cylindrical symmetry
 - multi-core fibers → impact losses
 - polarization maintaining (PM) fibers → impact extinction ratio
- active angular alignment
 - via image processing
 - via direct measurement determination of optical axes

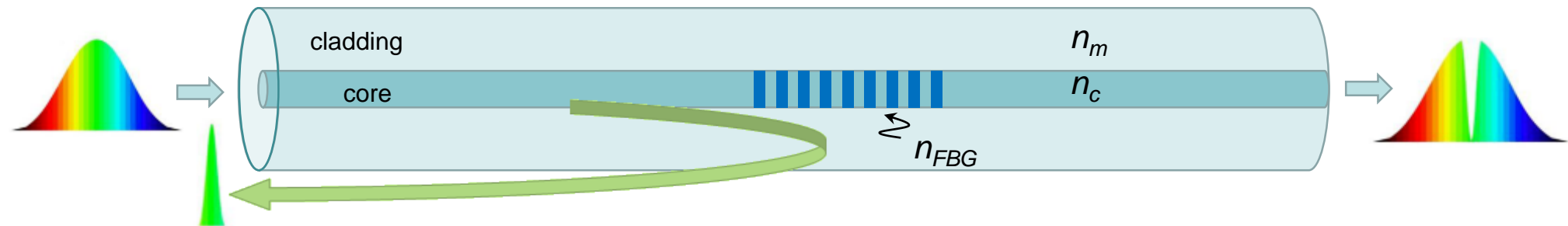


Another applications

Fiber Bragg Gratings (FBG)

■ operation principle

- wavelength sensitive reflectivity/transmissivity due to periodic modulation of refractive index



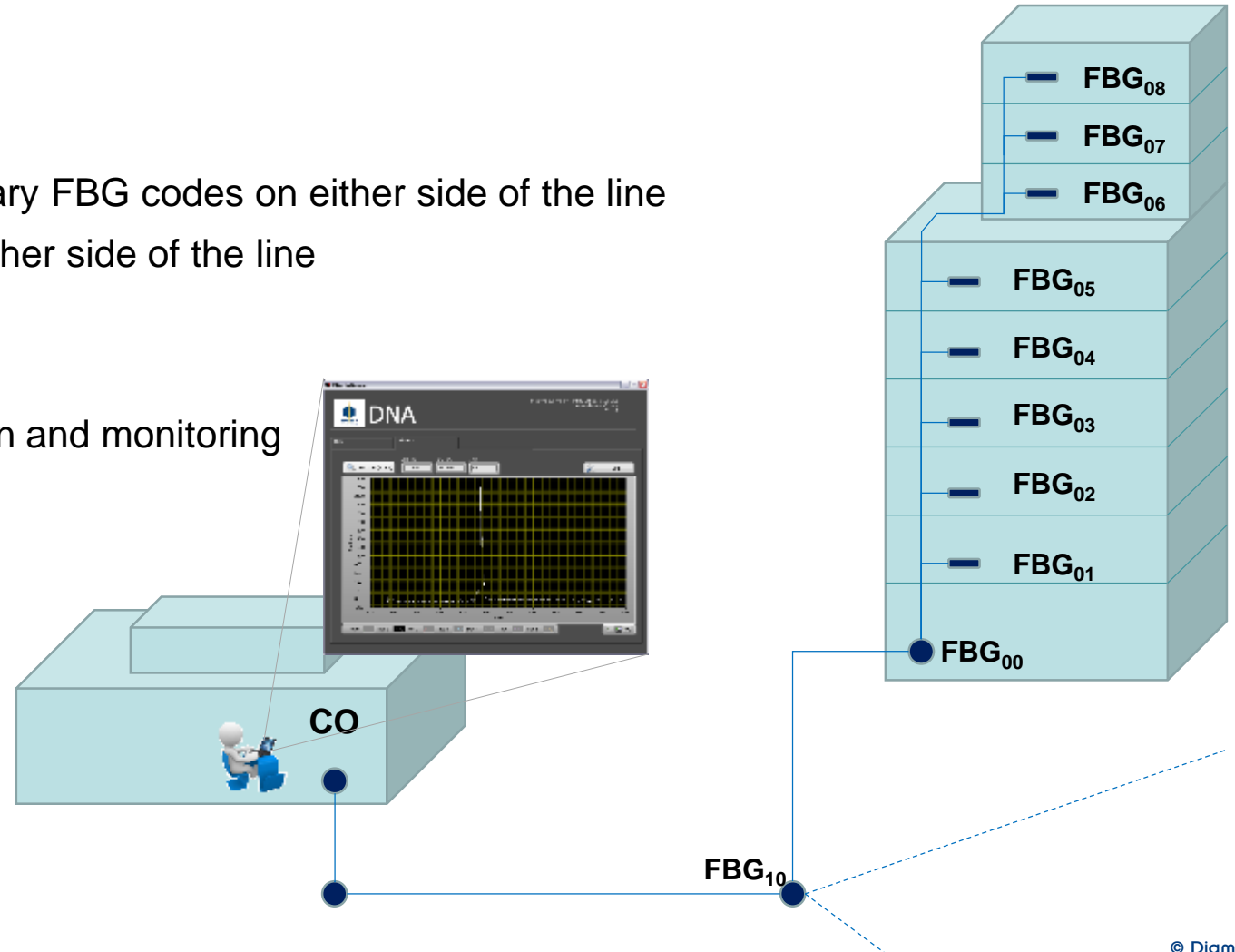
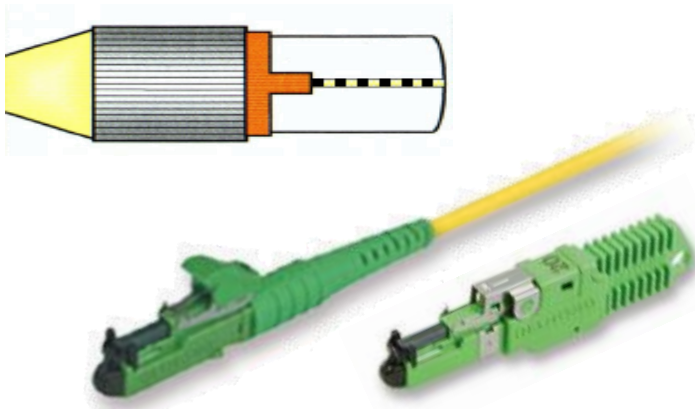
■ applications

- sensing temperature, mechanical strain/stress, acoustic
- shape sensing
- optical labeling

Optical labeling

Line integrity / network monitoring

- operation principle
 - install permanent or temporary FBG codes on either side of the line
 - interrogate remotely from either side of the line
- advantages
 - transparent to data traffic
 - simplified network installation and monitoring
 - one-man show



Conclusions

Fiber optic connectors...

- ... are known worldwide and deployed in billions
- ... are packages for fiber optics micro-sensors
 - fiber-to-fiber connector
 - FBGs
 - medical probes
- ... are packages built with submicron accuracy
 - core-to ferrule eccentricity $< 0.15 \mu\text{m}$
 - ferrule's outer diameter: $2499.1 \mu\text{m} \pm 0.1 \mu\text{m}$

... are micro-packages.

For more: www.diamond-fo.com

Questions?

