

# Capability overview: kineFLEX Vacuum fiber delivery system

The vacuum-compatible kineFLEX® fiber delivery systems are designed and manufactured using Qioptiq's broad knowledge of fiber optic performance in extreme environments. Each vacuum compatible kineFLEX® fiber optic is designed in partnership with the OEM or researchers using it. The capabilities shown here are examples of what Qioptiq has provided in the past. Please be aware that some feature combinations may not be possible.

The standard kineFLEX is a robust laser beam delivery system for precision measurement applications. Designed around pre-focused and integrated optical assemblies the fiber is mode matched to your laser to achieve transmission efficiencies greater than 60%. (See standard kineFLEX datasheet for more information).

## Applications for vacuum compatible fibers:

- Lithography
- Space research
- Interferometry
- Metrology
- Precision alignment positioning
- Semiconductor manufacturing
- Ultra-clean environment
- High vacuum environment
- Deep UV environment

Until recently, applications using laser based optical metrology in high vacuum, have been limited to free space beam steering through optical windows in vacuum chambers.

Vacuum fibers have been used for distance measuring interferometry for wafer stage positioning using highly coherent, frequency stabilized lasers. They are also useful for angular measurements by use of position sensitive detectors with low coherence diode lasers.

## Product feature highlights:

- Single-Mode, Polarization Maintaining, Multi-Mode or Multi-Channel fiber types
- TEM<sub>00</sub> output – circular beam, diffraction limited, Gaussian and spatially filtered – from SM PM fiber
- Extremely stable output beam, with the world's smallest beam wander at <1μrad/°C
- Align once. Lock position. Detach and re-insert with highly repeatable performance
- Single fiber core from "air side" to "vacuum side", minimizes optical noise
- "Plug & Play" - true modularity for system design
- Athermalised opto-mechanical design, insensitive to thermal effects.
- Truly co-linear beams for multiple laser wavelengths
- Options available for various wavelength ranges and wavelength combinations
- Bespoke OEM versions available (custom beam shaping, various lengths, opto-mechanics, mounts, custom inputs and outputs, flanges, collection fibers etc.)



**Vacuum compatible kineFLEX fiber systems usually include:**

- Laser-to-fiber coupler (kineMATIX®)
- Input collimation optics
- Output termination
- Environmentally compatible jackets
- Interface bulkhead flange separating "air side" from "vacuum side"

Notably, the kineFLEX vacuum fiber includes option for zero interconnects. It can be manufactured from one single-mode, polarization maintaining fiber core that runs continuously from "air side" to "vacuum side", with no breaks.

**kineMATIX manipulator mount**

The laser-to-fiber coupler used with the kineFLEX systems is the kineMATIX®. It is a 4-axis manipulator with a quick release mechanism for reliable removal and replacement of optical fibers. The manipulator has outstanding stability once set, without loss of alignment. This provides true 'Plug & Play' and flexibility of instrument design.

**Vacuum fiber section**

The vacuum section of the fiber has been designed to be compatible with low out-gassing conditions and to prevent damage through handling and integration. Every system is tested for leaks at the feedthrough, and for hydrocarbon and water outgassing.

**Customization**

There are no "standard" vacuum compatible fibers. They are each designed and manufactured for a specific application. As well as choice of fiber lengths, operating wavelengths and optional interconnects, a complete customization service is available for OEM applications.

**Indicative Technical Specifications**

Specifications	
Wavelengths (nm)	UV – VIS – NIR
Input Power (mW)	<100 CW, <500 CW or custom
Input beam (mm)	Ø0.7mm or custom
Beam pointing stability	<1µrad/°C
Throughput efficiency from Ø0.7mm input	> 60 % multi-λ SM PM fiber > 65 % single-λ SM PM fiber
Fiber types	SM, PM, MM, Multi-channel and metal coated options
Fiber length: air	1m, 2m, 3m or custom
Fiber jacket: air	Stainless steel OD 5mm, 3mm, 3.8mm, 10mm
Bulkhead Flange	Industry standard or custom
Fiber length: vac.	1m, 2m, 3m or custom
Fiber jacket: vac.	Vacuum conditioned jacket or bare fiber
Output options	
Collimated:	Ø0.7mm or custom Standard dimensions: Ø12mm x 50mm standard, Ø12mm x 25mm short, Ø6mm x 25mm picoFLEX™ Beam angle: < ±0.5 mrad Beam position < ±0.15mm
Connector:	FCP, APC, FCP8, ST

**Benefits of kineFLEX fiber in vacuum environment**

Replacing free space bulk optics with kineFLEX fiber optics offers some benefits such as:

- Robust beam delivery and faster tool assembly
- Remove scattered light from vacuum window
- Retain alignment to sample during laser servicing
- Uniquely, improve pointing stability to <1µrad/°C
- Uniquely, achieve a lower noise system by removing the optical noise from the bulkhead fiber-to-fiber interconnects, since a kineFLEX vacuum fiber can be made from one continuous fiber core. Hence, you can use the same fiber core from "air side" into "vacuum side" and only the fiber jacket will change at the bulkhead interface.

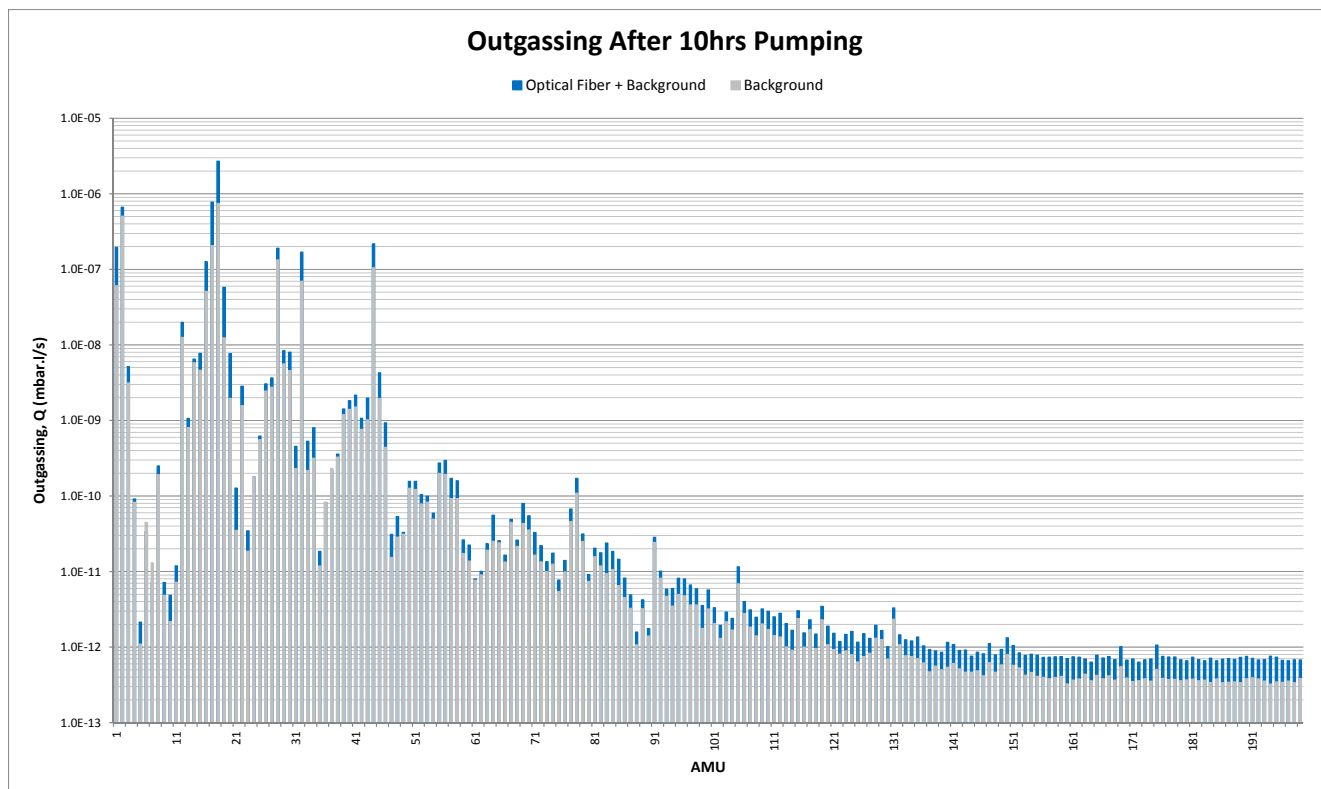
## Indicative Environmental Specifications

Specifications	“Air side”	“Vacuum side”	Units
Storage temperature	10 to 50	10 to 50	°C
Operating temperature	10 to 40	-10 to +50	°C
Operating pressure	Atmospheric	$\leq 1 \times 10^{-9}$	Torr
Operating humidity	Non-condensing	See outgassing specs-	-
Outgassing (H <sub>2</sub> O)	N/A	Application specific	mbar l/s
Outgassing (HxCy) AMU 50-300	N/A	Application specific	mbar l/s
Helium Leak Rate (seal integrity tested)	N/A	Application specific	mbar l/s

## RGA Testing

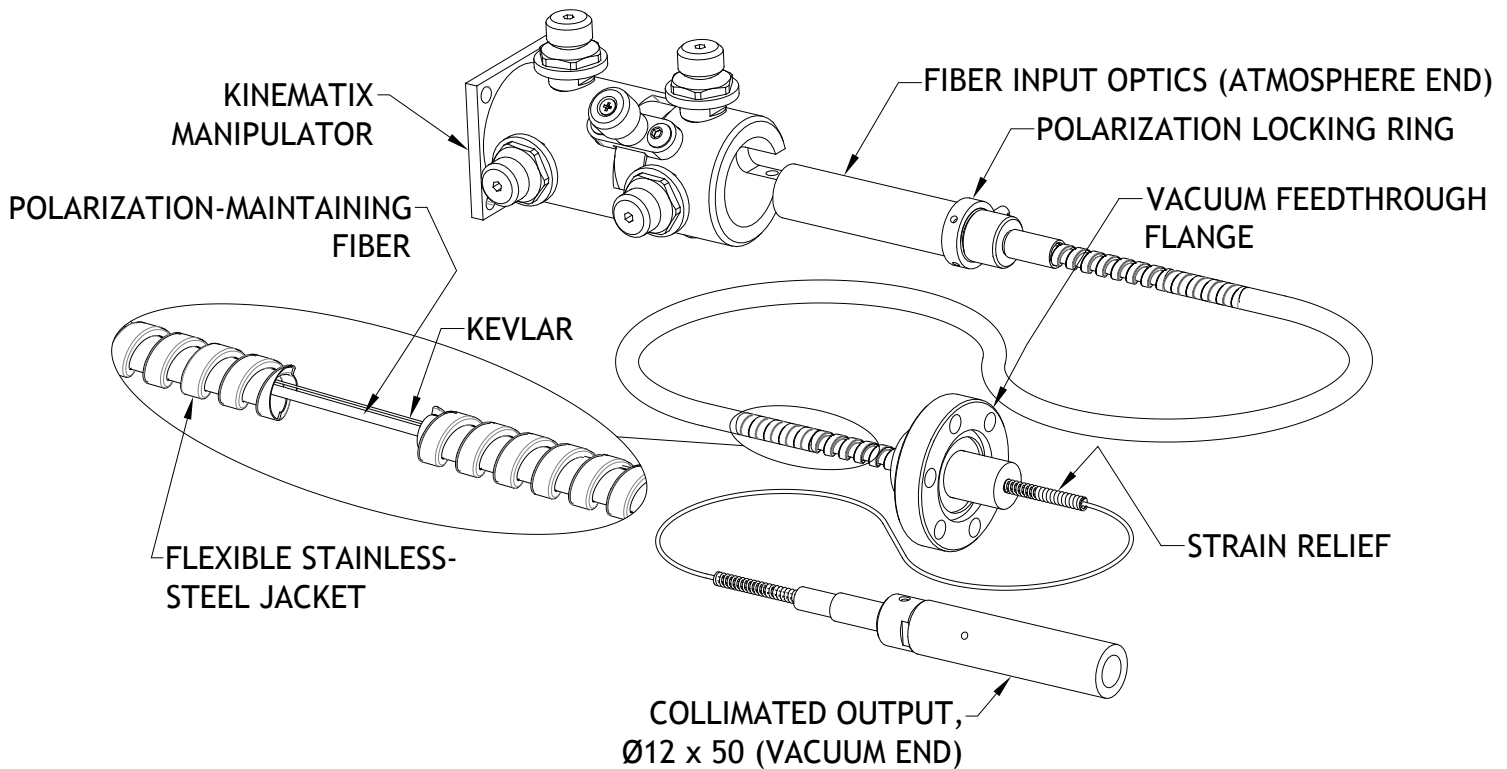
Qioptiq can perform Residual Gas Analysis (RGA) testing in-house, if required and if requested with order. A minimum batch size may apply for this test.

### Example of outgassing measurement using Qioptiq’s RGA



### Examples of possible RGA testing levels

System Parameter	Unit	Jacketed fiber	Bare fiber feed-through
System Outgassing - H <sub>2</sub> O	mbar.l/s	$\leq 8.0 \times 10^{-7}$	$\leq 6.0 \times 10^{-7}$
System Outgassing - CxHy, 45-100AMU	mbar.l/s	$\leq 8.0 \times 10^{-9}$	$\leq 8.0 \times 10^{-10}$
System Outgassing - CxHy, 101-200AMU	mbar.l/s	$\leq 1.5 \times 10^{-9}$	$\leq 2.0 \times 10^{-10}$
Helium leak rate	mbar.l/s	$\leq 1.0 \times 10^{-9}$	$\leq 1.0 \times 10^{-9}$



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