



LE VERRE FLUORÉ

FIBER SOLUTIONS

CATALOG
2022



LE VERRE FLUORÉ
FIBER SOLUTIONS

Le Verre Fluoré,
a pioneer and world
expert in **fluoride glass**
technologies



Our company

Le Verre Fluoré was founded in 1977 after the discovery of fluoride glasses by Poulain Brothers at Rennes University in 1974. Since then, we have been thriving in the world of fluoride glass technology as an expert company in this field.

45 years of continuous R&D effort that led to outstanding pioneering achievements.

In addition to the definition of the classical ZBLAN glass (1979), LVF produced the first fluorozirconate glass fibers (1983), the first fluoroindate glass fibers (1992), the first single mode fluoride fibers (1988), the first laser fibers (1989), and the first polarization maintaining fibers (1996).

For fiber laser and amplifier application, **double clad fibers** have been developed, with specific D-shaped cores in order to optimize their efficiency. A variety of **rare earth doped fibers** have been manufactured, allowing numerous laser and amplification applications, thanks to dozens of active transitions, in **visible, near infrared** and **mid-infrared** regions.

In particular, LVF is the undisputed leader for fibers operating in the mid-infrared 2-5 μ m band, offering today the **most transparent fluoride fibers of the market**.

An extended offer that satisfies customer requirements

Thanks to its unique expertise, LVF can also design and manufacture **custom fibers** that meet customer needs (geometry, numerical aperture, rare earth content, cut-off wavelength...).

Additionally, LVF offers a large range of **fiber components** such as fiber **patch cables**, fiber **bundles**, **end caps**, **splices**, **hermetic feedthroughs** and **flow cells**, enabling the integration and extended use of our fibers, such as for example in laser and spectroscopy applications.

A wide offer of bulk glasses

We provide any kind of doped and undoped **bulk glasses** (parallelepipeds, tubes, rods, ribbons, prisms...). Our fluoride doped ribbons are today used as robust **fluorescent solid-state dyes**.

A mature technology that enables industrial solutions

LVF fluoride technology is integrated in products co-developed with our partners. **Supercontinuum sources**, commercialized by **Leukos**, and **OEM fiber lasers**, commercialized by our sister company, **LumIR Lasers**, are powered by LVF fiber technology.

A growing company driven by innovations and challenges for a sustainable future

In 2021, in order to respond to the growing demand for fibers, we engaged redevelopment work of our facilities and hired new talented collaborators. Our **industrial capacity** has increased and batches are now produced daily. This growth is driven by the health sector, with an increasing demand for fibers in dental and surgery laser systems.

Our ribbons production capacity has increased to satisfy a growing demand for solid-state dyes for calibration of DNA sequencing instruments.

LVF is becoming a pre-eminent supplier for instruments in the medical field.

In the same way, we wish to develop new solutions powered by our fluoride glass technology that will be useful to human kind.

Create a better future
is our leitmotiv!



Our products

Our fibers can be divided in four main categories:

- **ZFG** (Zirconium ZrF₄ Fluoride Glass) = fluorozirconate fibers
Exhibit a high transparency from **0.3 up to 4.5 µm**
- **IFG** (Indium InF₃ Fluoride Glass) = fluoroindate fibers
Exhibit a high transparency from **0.3 up to 5.5 µm**
- **AFG** (Aluminium AlF₃ Fluoride Glass) = fluoroaluminate fibers,
generally used for **end capping** solutions.
- **GeG** (Germanium oxyde GeO₂ based Glass) = germanate fibers,
Exhibit a **high power handling** and **chemical stability** around **2.7-3.0 µm**.



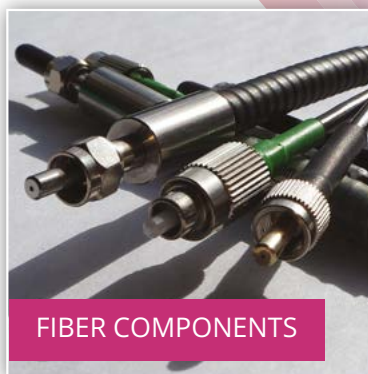
PASSIVE FIBERS



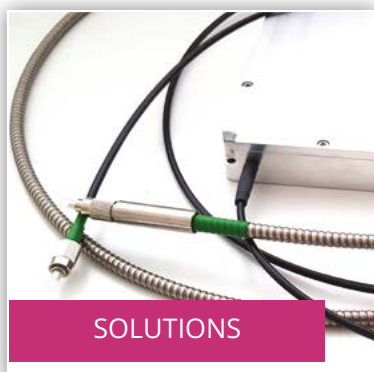
ACTIVE FIBERS



BULK FLUORIDE GLASSES



FIBER COMPONENTS



SOLUTIONS

Le Verre Fluoré
provides **the most
transparent fluoride
fibers** of the market.

Applications



MEDICAL



Fluoride glass technology allows very efficient transmission and laser emission from UV to mid-infrared, enabling new fiber lasers sources and components for medical applications. Our new germanate fibers enable efficient power handling and pigtail of Er:YAG /Er:YSGG lasers.

Er:YAG and Er:YSSG laser fiber delivery

LVF offers a new range of germanate multimode fibers that are the fibers of choice for power handling and pigtail of Er:YAG /Er:YSGG lasers used in surgery and dentistry.

2.8 μm fiber laser

2.8 μm fiber lasers (10 W CW) for dentistry, surgery, dermatology are commercialized since 2019 by LumIR Lasers, a spin-off of COPL and LVF.

Mid-IR diagnosis

Mid-IR supercontinuum, backscatter probes and cables are key components for mid-IR diagnosis.

Solid-state fluorescent dyes

LVF offers rare earth doped glass fluorescent dyes for yellow, red, green fluorescence...

For example, our bulks are used to calibrate DNA sequencing instruments.



INDUSTRY/ENVIRONMENT



Fluoride glass is a key technology for many mid-infrared industrial applications.

Process control

Mid-IR spectroscopy

Many molecules used in industry exhibit spectral absorption in the 2-5.5 μm range. LVF offers a large portfolio of solutions to transmit mid-IR light in industrial environment.

Wet paint thickness sensor

LVF has developed and patented a complete solution to measure in real-time paint thickness for coil coating and metallic packaging: Targazh.

Mid-IR ellipsometry, mid-IR OCT

Leukos and LVF are associated to propose robust, efficient and cost-effective mid-infrared supercontinuum laser sources: Electro-MIR.

Material processing

Glass cutting

2.8 μm is the most relevant wavelength to cut glass. A 100 W CW laser emitting @2.8 μm is under development.

Plastic cutting

3.5 μm is a very relevant wavelength to cut plastic. A 5 CW laser already allows plastic cutting.

QCL/ICL pigtail

Thanks to its low Fresnel losses (4% typical, 1% with AR coating) and its high transmission up to 5.5 μm , InF3 fibers are the natural solution for QCL/ICL pigtail.

Applications



RESEARCH

Thanks to its outstanding properties, fluoride glass allows innovative laser developments from UV to mid-infrared.

Fluoride glass fiber lasers

LVF has hundreds of rare-earth doped fibers in stock and can design and manufacture custom fibers for lasers & amplifiers.

Mid-IR spectroscopy and optical measurements

LVF proposes patch cables and bundles for optical set-up.

Mid-IR supercontinuum

Thanks to their performances, LVF non linear single mode fibers allow very flat and broadband output spectrum.

Fluorescence

LVF manufactures custom rare earth doped fluoride glass bulks for fluorescence studies.



SPATIAL/ASTRONOMY

Since 1987, LVF is the reference company for astronomy developments operating in K-band ($1.9 \mu\text{m}$ – $2.4 \mu\text{m}$). For more than 35 years, cutting edge solutions and mid infrared fibers have been developed to comply needs of the most innovative astronomical projects.

Telescope coupling

Ultra low-loss, low birefringence, low dispersion single mode ZBLAN fiber in K-band ($1.9 \mu\text{m}$ – $2.4 \mu\text{m}$).

Mode scrambling

Octagonal core multimode fiber for mode scrambling in K-band.

Polarization rotator

Fluoride fiber subsystem to align interferometer arms polarizations in order to optimize its contrast.

Differential delay line

Low birefringence and homogeneous fiber segments in terms of dispersion to equilibrate optical paths.

Fused X fiber coupler

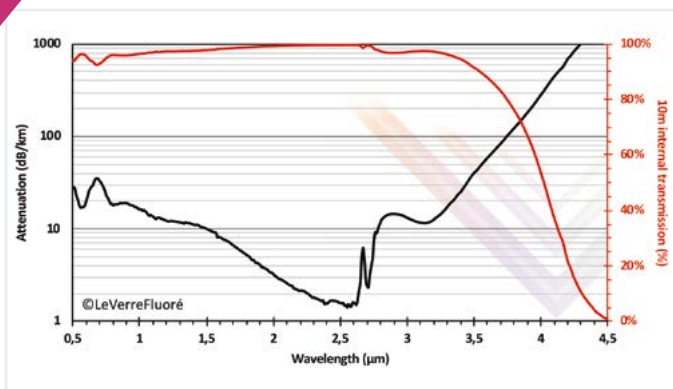
centered @ $2.2 \mu\text{m}$.

Projects involving Le Verre Fluoré Mid IR fiber technology include: AVIRIS, FLUOR, OHANA, GRAVITY, SPIRou, SPIP, EXOMARS.

Consult our website to learn more



Discover our range of standard ZFG multimode fibers

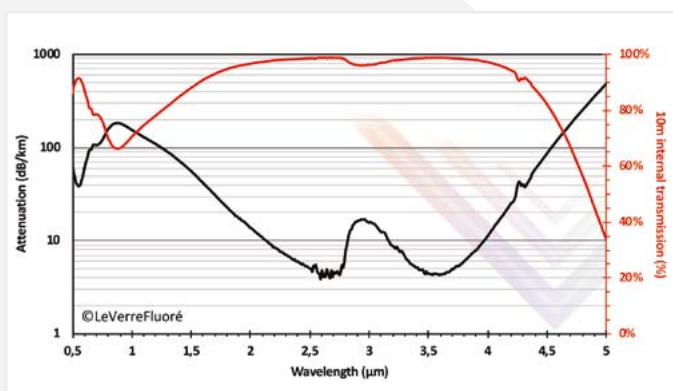


Specifications

Operating wavelength	0.3 – 4.5 μm
Typical optical loss @ 2.5μm	< 10 dB/km
Fresnel loss (backwards reflection)	4% per face (air)
Coating material	UV curable acrylate
Operating temperature	– 180 to 150 °C

Standard fiber	Core/ clad diameter	Numerical aperture	Short term bend radius	Long term bend radius	Price/m
ZFG MM (0.15) 90/150	90/150 μm	0.15	≥ 15 mm	≥ 45 mm	25 €
ZFG MM (0.20) 100/160	100/160 μm	0.20	≥ 15 mm	≥ 45 mm	50 €
ZFG MM (0.20) 200/260	200/260 μm	0.20	≥ 25 mm	≥ 75 mm	70 €
ZFG MM (0.20) 300/360	300/360 μm	0.20	≥ 35 mm	≥ 100 mm	140 €
ZFG MM (0.20) 400/460	400/460 μm	0.20	≥ 45 mm	≥ 120 mm	220 €
ZFG MM (0.20) 600/680	600/680 μm	0.20	≥ 70 mm	≥ 150 mm	480 €

Discover our range of standard IFG multimode fibers

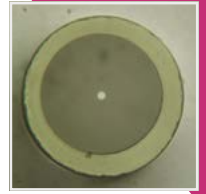


Specifications

Operating wavelength	0.3 – 5.5 μm
Typical optical loss @ 3.5μm	< 10 dB/km
Fresnel loss (backwards reflection)	4% per face (air)
Coating material	UV curable acrylate
Operating temperature	– 180 to 150 °C

Standard fiber	Core/ clad diameter	Numerical aperture	Short term bend radius	Long term bend radius	Price/m
IFG MM (NA) 100/160	100/160 μm	0.20/0.30	≥ 15 mm	≥ 45 mm	80 €
IFG MM (NA) 200/260	200/260 μm	0.20/0.30	≥ 25 mm	≥ 75 mm	130 €
IFG MM (NA) 300/360	300/360 μm	0.20/0.30	≥ 40 mm	≥ 100 mm	250 €
IFG MM (NA) 400/460	400/460 μm	0.20/0.30	≥ 55 mm	≥ 120 mm	440 €
IFG MM (NA) 600/680	600/680 μm	0.20/0.30	≥ 90 mm	≥ 150 mm	950 €

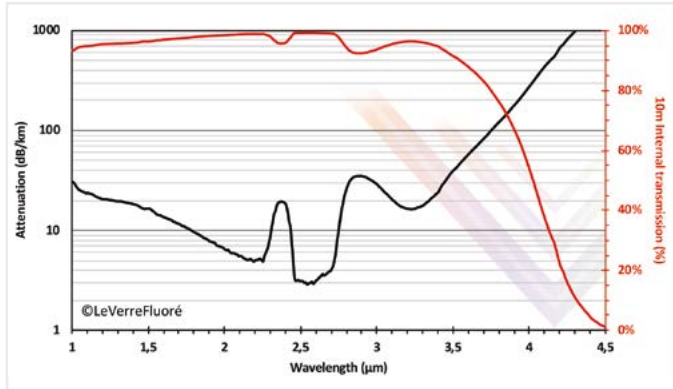
Discover our range of standard ZFG single mode fibers



Single mode

Note that, thanks to their non linear properties, our single mode fibers are widely used for supercontinuum generation and are integrated in commercial supercontinuum sources Electro-MIR 4100 and 4800, developed in collaboration with LEUKOS.

Find out more about our fiber non linear properties on our website.

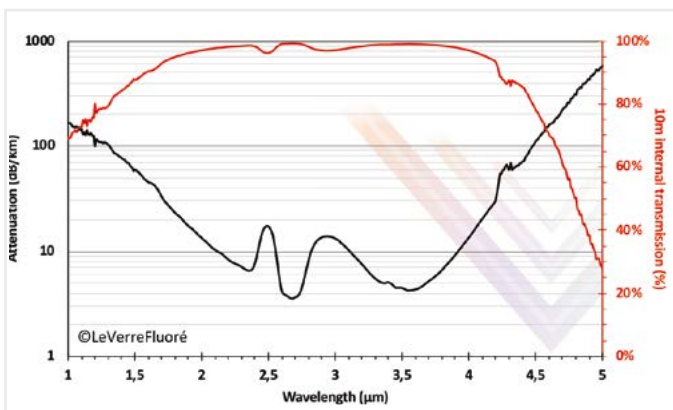


Specifications

Typical background loss	< 10 dB/km
Fresnel loss (backwards reflection)	4% per face (air)
Coating material	UV curable acrylate
Operating temperature	- 180 to 150 °C

Standard fiber	Core/ clad diameter	Numerical aperture	Cutoff wavelength	Operating wavelength	Short term bend radius	Long term bend radius	Price/m
ZFG SM [1.95] 6.5/125	6.5/125 μm	0.23	1.95 μm	0.3-3.90 μm	≥ 15 mm	≥ 45 mm	40 €
ZFG SM [2.55] 8.5/125	8.5/125 μm	0.23	2.55 μm	0.3-4.5 μm	≥ 15 mm	≥ 45 mm	110 €
ZFG SM [2.2] 7.5/150	7.5/150 μm	0.23	2.2 μm	0.3-4.0 μm	≥ 15 mm	≥ 45 mm	155 €
ZFG SM [2.3] 14/250	14/250 μm	0.125	2.3 μm	0.3-4.1 μm	≥ 25 mm	≥ 75 mm	330 €

Discover our range of standard IFG single mode fibers



Specifications

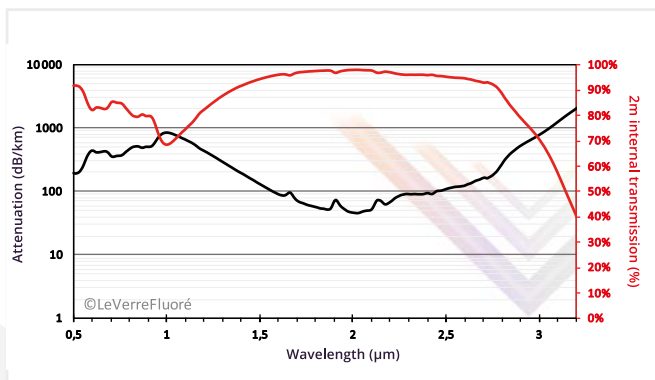
Typical background loss	< 15 dB/km
Fresnel loss (backwards reflection)	4% per face (air)
Coating material	UV curable acrylate
Operating temperature	- 180 to 150 °C

Standard fiber	Core/ clad diameter	Numerical aperture	Cutoff wavelength	Operating wavelength	Short term bend radius	Long term bend radius	Price/m
IFG SM [2.95] 7.5/125	7.5/125 μm	0.30	2.95 μm	0.3-5.5 μm	≥ 15 mm	≥ 45 mm	200 €
IFG SM [3.3] 8.5/125	8.5/125 μm	0.30	3.3 μm	0.3-5.5 μm	≥ 15 mm	≥ 45 mm	200 €
IFG SM [3.7] 9.5/125	9.5/125 μm	0.30	3.7 μm	0.3-5.5 μm	≥ 15 mm	≥ 45 mm	200 €



Discover our range of standard GeG multimode fibers

LVF offers a new range of germanate GeO₂ multimode fibers that exhibit a high power handling and chemical stability around 2.7-3.0 μm . These are the fibers of choice for Er:YAG /Er:YSGG laser power handling and pigtail.



Specifications

Operating wavelength	2 μm – 3 μm
Typical optical losses	< 300 dB/km @ 2.78 μm < 500 dB/km @ 2.94 μm
Fresnel loss (backwards reflection)	8.6% per face (air)
Coating material	Polyimide + hytrel
Typical pulse energy handling	600 mJ @ 2.78 μm
Operating temperature	– 180 to 150 $^{\circ}\text{C}$

Standard fiber	Core/ clad diameter	Numerical aperture	Short term bend radius	Long term bend radius	Price/m
GeG MM (0.18) 200/260 *	200/260 μm	0.18	≥ 25 mm	≥ 75 mm	180 €
GeG MM (0.18) 450/500	450/500 μm	0.18	≥ 50 mm	≥ 130 mm	660 €
GeG MM (0.18) 600/680 *	600/680 μm	0.18	≥ 70 mm	≥ 150 mm	1080 €

* Available soon

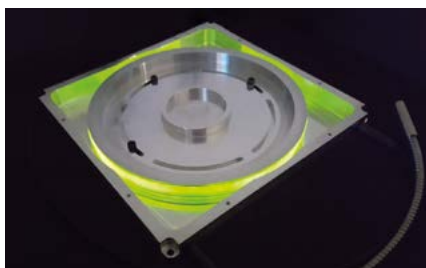
Qualification and proof tests for multiwatt applications

For applications in which several watts of a CW or pulsed laser need to be injected in the fiber, we recommend an additional **IR screening**.

In addition to our standard screening, which enables the selection of fiber segments without main scattering points, we can perform an infrared screening that enables the identification of absorbing points - that might constitute weakness points for power handling, and then select the very best fiber segments.

Customized laser qualification and proof tests can be performed according to customer specific requirements. Fibers can be qualified with the customer laser in our lab.

Discover our range of active rare earth doped fibers

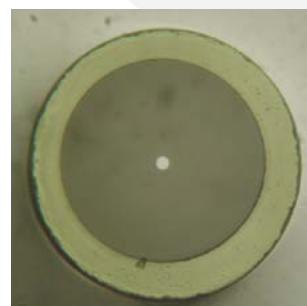


Thanks to their high rare earth solubility (Er, Ho, Tm, Dy, Pr, Yb, Nd, Ce, Sm... up to 100 000 ppm) and low phonon energy, dozens of transitions are active in fluoride glasses.

As a result, combined to their high transparency, fluoride fibers are used for **laser generation** and **amplification** in the **visible, near-infrared and mid-infrared** ranges.

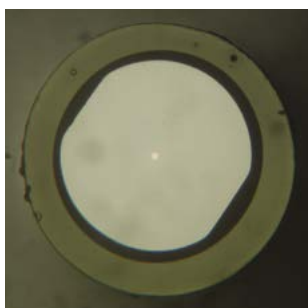
Some single mode fibers (not exhaustive list)

Rare earth	Molar content	Øcore/clad	Cutoff wavelength	Typical application
Dy	2000 ppm	12.5/125 µm	2.6 µm	Yellow laser
Tm	5000 ppm	3/125 µm	0.9 µm	Laser and amplifier (TDFA) around 1.5 µm
Ho	5000 ppm	7.5/125 µm	2.4 µm	Laser around 2.9 µm
Dy	2000 ppm	16/250 µm	2.6 µm	Laser around 3.3 µm
Dy	5000 ppm	12.5/125 µm	2.74 µm	Laser around 4.3 µm



Some double-cladding fibers (not exhaustive list)

LVF delivers a large variety of ZFG or IFG double cladding fibers. Most of them exhibit a double D-shape on the first cladding in order to improve the pump absorption. Hereinafter, some significant realizations with LVF RE-doped fibers.



Rare earth	Molar content	Øcore/clad	Cutoff wavelength	Typical application
Praseodymium	8000 ppm	7.5/115*125/180 µm	0.78 µm	Red laser
Thulium	25000 ppm	20/200/300 µm	NA	Laser @2.3 µm
Erbium	70 000 ppm	15/240*260/290 µm	2.5 µm	Laser @2.9 µm
Polarization maintaining version				PM laser @2.9 µm
Erbium	70 000 ppm	35/300*330/380 µm	NA	Amplifier @2.9 µm Q-switched laser @2.9 µm
Thulium / Dysprosium	50000/5000 ppm	12/115*125/180 µm	2.7 µm	Laser @3.1 µm
Erbium	10 000 ppm	16.5/240*260/290 µm	2.7 µm	Laser around 3.5 µm
Holmium	100 000 ppm	15/240*260/290 µm	3.5 µm	Laser around 3.9 µm

Standard rare earth doped fibers prices

Fiber	Specifications	Price/m
ZFG single mode fiber	Øclad = 125 µm	from 220 €
IFG single mode fiber	Øclad = 125 µm	from 300 €
ZFG double cladding double D-shape Er-doped fiber	Øcore/1 st clad/2 nd clad = 15/240*260/290 µm (λc = 2.2 µm)	from 600 €

λc : cutoff wavelength

Discover our range of **fiber patch cables**

Any Passive or Active fiber manufactured by LVF can be wired.

Main features:

- Standard cable length: up to 50 m
- Connectors: SMA 905, FC/PC, FC/APC, Diamond, custom
- Protective standard tubing : hytrel, Kevlar, stainless steel jacket or peek



Examples of fiber patch cables specifications

	Standard fiber	Price per cable 1m / 2m
SINGLE MODE	ZFG SM [1.95] 6.5/125	182 € / 229 €
	IFG SM [2.95] 7.5/125	342 € / 549 €
MULTIMODE	ZFG MM (0.20) 200/260	212 € / 289 €
	IFG MM (0.20) 200/260	272 € / 409 €

Insertion loss – core/ferrule concentricity

Standard connector	< 2µm
Optimized connector	< 0.5 µm additional cost: + 100 € /connector



Discover our range of **fiber bundles and probes**



Fiber bundles & backscatter probes main features

Fiber content	Up to hundreds
Fiber arrangement	Linear, round, square..., coherent or not
Connector	SMA 905, FC/PC, FC/APC, Diamond, custom
Protective standard tubing	Hytrel (diameter: 0.9 mm), Kevlar (diameter: 4 mm), Stainless steel jacket (diameter: 7 mm), Peek jacket (diameter: 0.9 mm)

Applications

- Splitting light source into several channels
- Combining light from several sources
- Light illumination & Detection channels (backscatter probes)
- Qualified for **harsh environment**
- Qualified for **industrial use**



Discover our **endcapping** and **splicing** solutions



In order to ensure **long term stability** of fluoride fiber systems in case of applications such as laser generation or Er-YAG laser delivery, LVF offers end capping solutions.

Main benefits are:

- Reduced **power density** at the output face
- Protection of the fiber tip in case of **emission around 2.8 μm**

LVF provides **fluoride splices** between multimode, single mode or double cladding fibers. **Silica-fluoride splices** are also possible depending on requirements.

Discover our range of **hermetic feedthroughs**



Our hermetic feedthroughs are compatible with any wired active or passive fiber.

- Customized number of channels
- Housing material: stainless steel
- With standard flange or not (stand alone)
- Qualified **up to $1.5 \cdot 10^{-9} \text{ mbar.l.s}^{-1}$**
- Qualified for **industrial use**

Discover our **flow cells**

LVF flow cells will allow you to **analyze liquid samples** flowing in the cell by the way of a crosswise **optical control** in **UV, visible and mid-infrared**.

- Qualified for **industrial infrared spectroscopy** from 0.3 up to 5.5 μm
- Liquids and gases analysis
- Qualified for **harsh environment**
- Standard SMA 905, FC/PC, FC/APC and custom connector adapters



Discover our **QCI** and **ICL** pigtailing solutions



Photo: ©Alpes Lasers

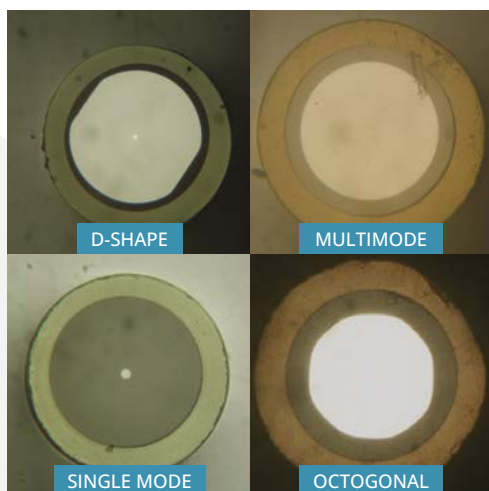
Thanks to their low losses and transmission up to 5.5 μm , our fluoride fibers are particularly adapted to ICL/QCL pigtailing.

Discover our range of **custom fibers** and **bulk glasses**

Custom fibers

If you cannot find a fiber that complies your needs among our **hundreds of designs in stock**, LVF experts will support you to design a **fiber dedicated** to your **application**.

Customize!

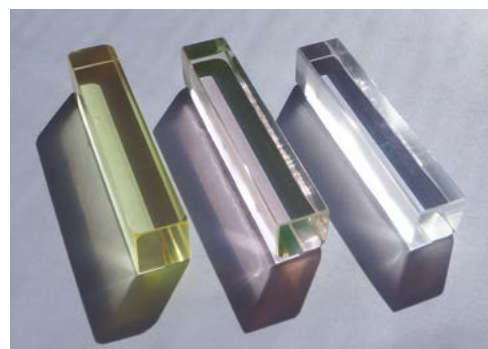


	SINGLE MODE	MULTIMODE
Core size	$\geq 1 \mu\text{m}$	Up to $1000 \mu\text{m}$
Numerical aperture	0.06-0.35	0.12-0.32
Cut off	$\geq 200 \text{ nm}$	NA
Rare earth	Doped or co-doped (Er, Ho, Dy, Tm, Pr, Yb, Sm, Ce, ...) Up to 100 000 ppm	
Specificity	<ul style="list-style-type: none"> • Double Cladding (Circular, Double D-Shape or Octagonal 1st clad) • Polarization Maintaining 	<ul style="list-style-type: none"> • Octagonal core • Double cladding
Minimum order quantity (NRE included)	From 8000€ depending on design	From 5000€ depending on design

Bulk glasses and fluorescent solid-state dyes

LVF can provide any kind of **bulk fluoride glasses** such as parallelepipeds, ribbons, rods or tubes, prisms...

Those bulks can be **homogeneously doped or co-doped with rare earths** (Er, Pr, Ho, Tm, Dy, Ho/Tm, Er/Pr, Pr/Yb...) depending on your requirements.



Typical bulk specifications

RE concentration	Up to 100 000 ppm +/- 100 ppm	
Polishing	Standard grade	High grade
Thickness tolerance	+/- 100 μm	+/- 10 μm
Width tolerance	+/- 200 μm	+/- 50 μm
Surface roughness *	70 Angstrom RMS	50 Angstrom RMS
Defects in polished surface *	–	20/10 Scratch/Dig

* other grades available upon special request

Our bulk fluoride glasses can be used as robust **fluorescent solid-state dye**, **wavelength reference material**, **light converter**, as well as for glass science, study of specific properties of fluoride glasses, in **UV**, **visible** and **mid-infrared** ranges.
Ex.: calibration/detection of UV sources with visible sensors (UV to VIS light conversion), detection of NIR sources (NIR to VIS light conversion), calibration of spectrometers and imagers (spectral calibration: fluorescence or absorption spikes at specific wavelengths).

Discover our range of mid-infrared solutions



Fiber modules (laser, amplifier)

In order to make our fibers **easier to handle** and **directly integrable** in a final commercial system, LVF can deliver fiber modules.

The required fiber length is integrated in a **robust housing** and connectorized with FC/PC, FC/APC, SMA or custom connectors depending on customer need. This is a **plug-and-play** module.

Depending on power requirements, an **endcap** might also be spliced at the input and/or output of the fiber.

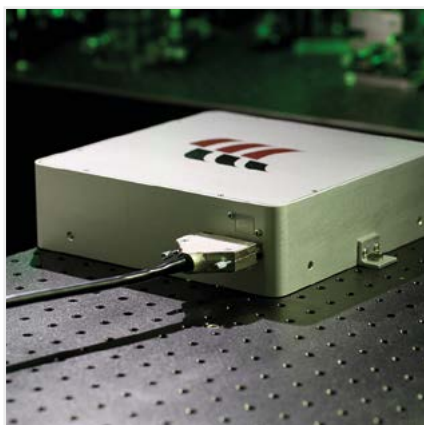


Supercontinuum sources

Electro-MIR 4100 and **4800** are the commercial supercontinuum sources born from **LVF** over 40 years' experience in fluoride fibers and **LEUKOS** over 10 years' experience in the field of supercontinuum laser.

Thanks to their high brightness from 700 up to 4100 or 4800 nm, they are an ideal solution for mid infrared applications such as infrared spectrometry, spectral fingerprinting and countermeasures (IRCM).

Robust and **compact**, unique solutions are proposed in order to ensure **long term reliability** and **industrial compliance**.



Continuous wave 2.8 lasers

Experts at Quebec City's **COPL** – premier research center for midinfrared fiber lasers - and **LVF** have teamed up to launch **LumIR Lasers**, a new force for innovation in mid-IR fiber lasers.

LumIR 2800 lasers delivers affordable 2.8 μm CW fiber lasers available in 1 to 10 W output powers. All products are currently available as OEM solutions ready to bring unprecedented capabilities to your application, particularly for medical (dentistry, skin resurfacing, ...), industrial (polymer processing, food marking, ...) or research purposes.

LumIR 3200 laser emitting at 3.1-3.3 μm with power up to 5 W is planned for release in 2022.



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