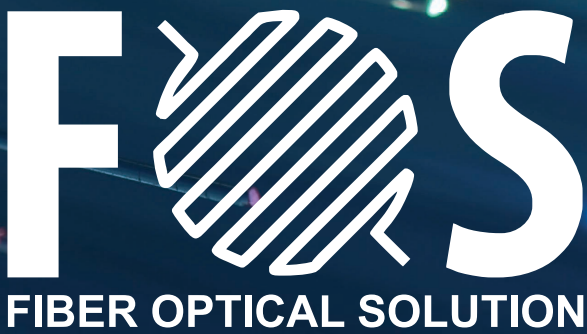


- *Fiber-optic Gyroscopes*
- *Inertial Measurement Units*
- *Strapdown Inertial Navigation Systems*
- *Integrated optical devices*
- *Polarization maintaining fiber*
- *Radiation hard optical fiber*



# Catalogue



# Fiber Optical Solution

Research and Production Company

## LiNbO<sub>3</sub> Integrated Optic Components Factory



### Podraga Street 2A

- Development and production of integrated optical circuits on LiNbO<sub>3</sub> and fiber optic sensors

## Main production Facility and Office

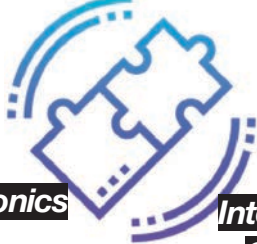


### Grants Street 15

- Development and production of fiber optic gyroscopes, inertial measurement units and inertial navigation systems
- Production of special optical fibers

Riga, Latvia

### Fiber Optics



Electronics

Integrated Optics

Mechanics

“Fiber Optical Solution” is vertically integrated company specializing in high precision **Fiber Optic Gyroscopes (FOG)** production. The company has a unique combination of all the technologies essential for FOG production which considerably cuts net cost of the final devices.

“Fiber Optical Solution” is a supplier of high precision FOG's and other Inertial Navigation Systems to more than 20 companies worldwide.

# Production

## Systems

Single axis  
Fiber Optic  
Gyroscopes



Three axis  
Fiber Optic  
Gyroscopes



Inertial  
Measurement  
Units



Strapdown  
Inertial Navigation  
Systems



## Components

Polarization  
Maintaining  
Optical Fiber



Radiation hard  
Optical Fiber



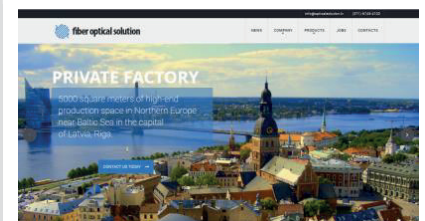
Fiber Optic  
Components



Integrated  
Optical  
Components



[opticalsolution.lv/products](http://opticalsolution.lv/products)



- Latest company news
- Company information
- Products catalogue
- Contacts

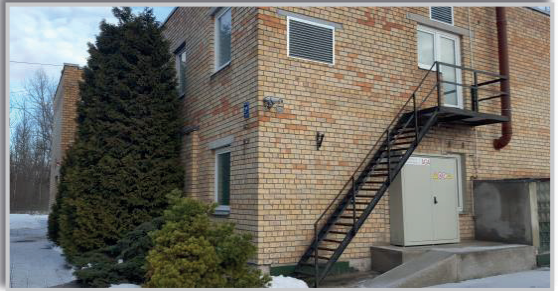
Can be found on our website  
[opticalsolution.lv](http://opticalsolution.lv)

# LiNbO<sub>3</sub> based Integrated Optic Elements and Components Factory

"Fiber Optical Solution" offers a wide range of **integrated-optical elements** manufactured using niobate crystals wafers "Fiber Optical Solution" as one of the world leaders in the field of developed technologies, which are based on the methods of high-temperature proton exchange, annealed proton exchange and reverse proton exchange. Control of optical radiation by means of integrated electro-optic phase modulators and/or photorefractive Bragg gratings.

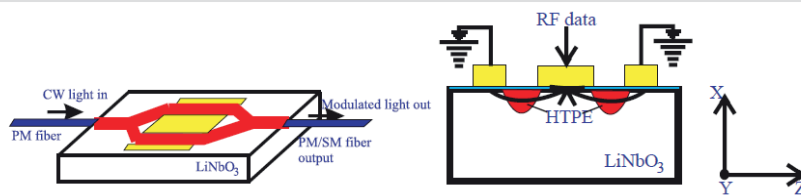
## Processes:

- Annealing Proton Exchange.
- High Temperature Proton Exchange (Soft Proton Exchange).
- Dielectric and metal deposition: clean room class 1000 (200 square meters) equipped with e-beam and sputtering machines).
- Photolithography: clean room class 100 (35 square meters) equipped with new Mask aligner (KARL SUSS MA6) and tracks (spin-coating and developing).
- Fiber pigtailing.
- Cutting, grinding and precise polishing.
- Characterization of waveguides and devices.



### MIOC specifications:

Operating wavelength	$\lambda=1550$ nm
Half wave voltage	<3 V
Polarization extinction ratio	>25 dB
Intensity modulation	<0.1 %
Fiber-to-fiber insertion loss	<6 dB



**Multifunctional integrated optical chip (MIOC)** is a monoblock hermetic product. It includes a linear polarizer, Y-junction coupler and two pairs of electro-optic phase modulators.



**Dicing & Polishing**



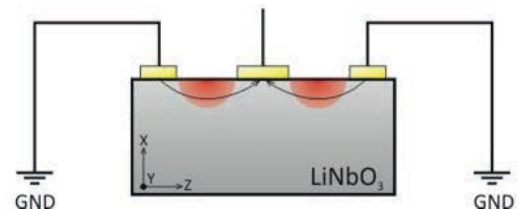
**Metal & dielectric film deposition**



**Optical testing**



**Optical testing**



**Mechanical treatment**



**Chemical treatment**



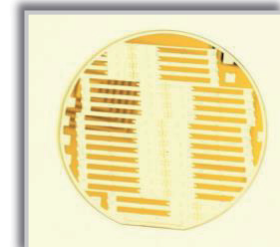
**Pigtailing**



**Mask aligning and development**



**Proton Exchange**



**Multifunctional integrated optical chip (MIOC)**



# Division for Polarization Maintaining Fibers (PANDA) and fiber optical components fabrication

Fiber Optical Solution's PANDA-type polarization maintaining (PM) fiber design uses two stress applying parts to create high birefringence, resulting in fibers with excellent polarization maintaining properties. Fiber Optical Solution's PM fibers have high birefringence and exceptionally tight dimensional specifications, critical for manufacturing high precision high-performance gyro-coils.



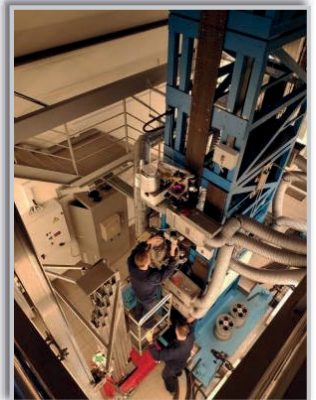
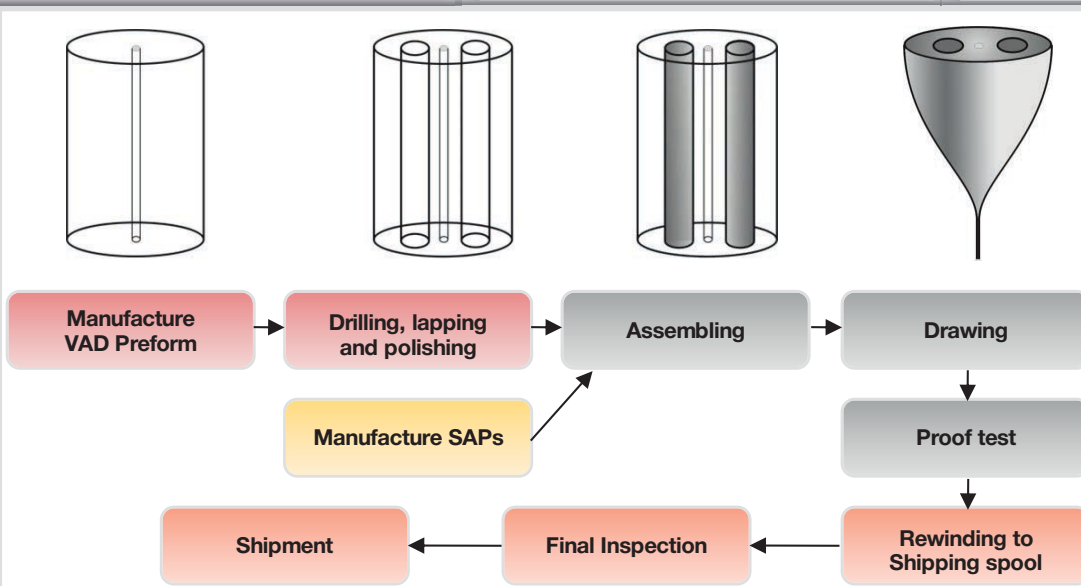
Fiber cross-section

### Processes:

- MCVD Preforms manufacturing system.
- Two fiber draw towers.
- Effluent gas scrubber (for two MCVD systems).
- Gas control and mixing system ( $\text{SiCl}_4$ ,  $\text{POCl}_3$ ,  $\text{GeCl}_4$ ,  $\text{BBr}_3$ ).
- Ultrasonic cleaner for coating extrusion system
- Fiber preform lathes.
- Gas drier and purifier.
- System for preform etching.
- Reels for fibers.
- Measurement equipment.
- System for testing fiber waveguide at rewind.

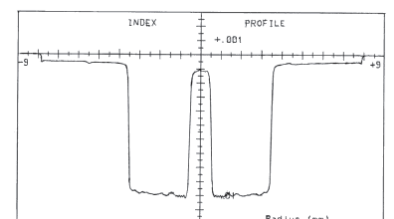
### Fiber Specifications:

Operating wavelength	1.55 $\mu\text{m}$
Mode Field Diameter	6.5 $\mu\text{m}$
Cladding Diameter	80-125 $\mu\text{m}$
Coating Diameter	160-175 $\mu\text{m}$
Numerical Aperture	0.13
Polarization crosstalk (h-parameter)	$<10^{-5} \text{ m}^{-1}$
Attenuation	$< 2 \text{ dB/km}$
Cutoff Wavelength	1300nm-1450nm
Beat Length	$<3\text{mm}$
Stress Type	PANDA



### Radiation hard polarization maintaining fiber

We have developed the technology for forming fluorine-doped silica glass light-reflecting cladding with  $\Delta n \sim -(8.5 - 9.5) \times 10^{-3}$  using  $\text{SiF}_4$  as fluorine-agent.



# Fiber Optic Gyroscopes

Our closed loop **fiber optic gyroscopes** (FOGs) are all-solid-state devices which offer a combination long life, high reliability, exceptional accuracy and low noise along with the potential of low mass-production cost. The fundamental principle is based on Sagnac effect. Our **FOGs** have so-called minimum configuration that provides reciprocal optical paths for two beams counter-propagating in a fiber loop.



**SFOS-200**



**SFOS-501**



**SFOS-1000**

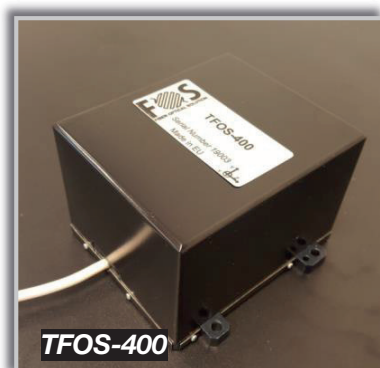


**SFOS-2000**

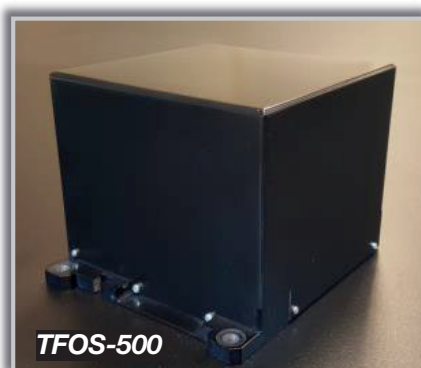


**SFOS-5000**

Fiber Optical Solution's single- and three-axis **FOGs** consist of the one light source at 1550 nm wavelengths (superluminescent diode – SLD), depolarizer, one or three photodetectors, fiber splitters to divide the light into two or three parts, one or three sets of ring interferometers to sense one or three orthogonal angular rate, and signal processing circuits. In this design a multifunction integrated optical chip (MIOC) is used for splitting the light into clockwise and counterclockwise waves, light polarization and for electro-optic imparting a phase modulation to the lightwaves in the loop. The signal processing design is based on conversion of the photodetector signal to a digital demodulation and integration. The loop is closed by driving the integrated optical phase modulator with a voltage ramp whose slope is proportional to rotation rate.



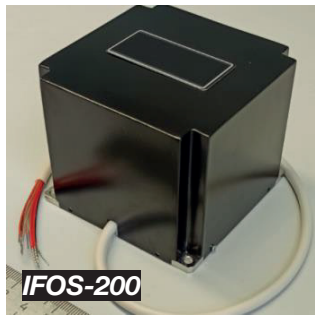
**TFOS-400**



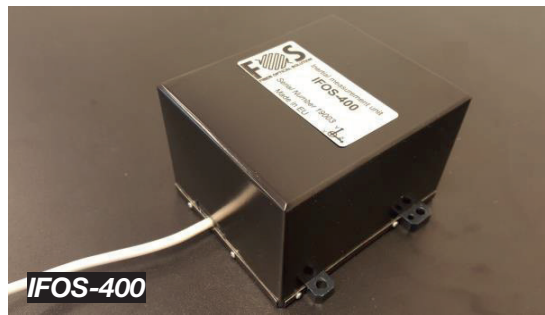
**TFOS-500**

Parameter	SFOS-200 (1 axis)	SFOS-501 (1-axis)	SFOS-1000 (1-axis)	SFOS-2000 (1-axis)	SFOS-5000 (1-axis)	TFOS-400 (3-axis)	TFOS-500 (3-axis)
Range of measured angular rate, %/s	±550	±250 (optional ±1000)	±550 (optional ±90)	±30	±12	±540	±400
Bias drift at stabilized temperature (100 s-averaging, 1σ), %/hour	≤0.1 ~0.001 (Allan variance)	≤0.03 ~0.005 (Allan variance)	≤0.005 ~0.001 (Allan variance)	≤0.003 ~0.0005 (Allan variance)	≤0.0015 ~0.0001 (Allan variance)	≤0.1 ~0.01 (Allan variance)	≤0.1 ~0.007 (Allan variance)
Bias drift at changing temperature from -40°C to +60°C (100 s-averaging, 1σ), %/hour	≤0.7	≤0.1	≤0.03	≤0.05	-	≤0.3	≤0.3
Scale factor error in temperature range -40°C to +60°C (1σ), ppm	≤800	≤300	≤100	≤100	≤20	≤200	≤200
Bandwidth, Hz	>1000 (user defined)						
Random walk (Allan variance), %/hour	≤0.015	≤0.003	≤0.0007	≤0.0005	≤0.0001	≤0.01	≤0.007
<b>Physical Characteristics</b>							
Power supply, V	5±0.25	5±0.25	5±0.25	5±0.25	5±0.25	5±0.25	27±5
Power consumption, W	≤6	≤7	≤7	≤7	≤7	≤7	≤8
Weight (net), kg	0.2	0.35	0.9	1.7	2.5	0.7	1.2
Dimensions, mm	Ø70×28	Ø100×30	Ø150×405	Ø250×45	Ø250×45	80×95×62.5	110×110×92
Operational temperature range	-40°C ~ +60°C	-40°C ~ +60°C	-40°C ~ +60°C	-40°C ~ +60°C	-40°C ~ +60°C	-40°C ~ +60°C	-40°C ~ +60°C
Output	RS-485	RS-485	RS-485	RS-485	RS-485	RS-422	RS-422

# Inertial Measurement Units



**IFOS-200**



**IFOS-400**

Fiber Optical Solution's inertial measurement units **IFOS-200** and **IFOS-400** are miniature FOG with low-noise MEMS accelerometers (3 triads of MEMS utilized and combined)

More Fiber Optical Solution's IMU models and latest specifications you can find using this link:

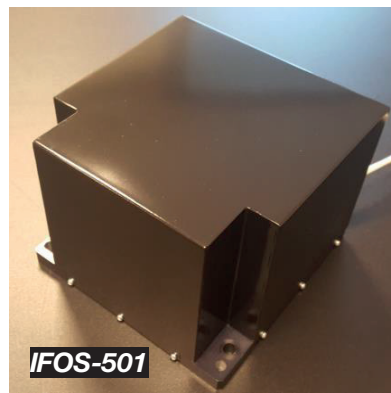


[opticalsolution.lv/products/inertial-measurement-units/](http://opticalsolution.lv/products/inertial-measurement-units/)



**IFOS-500**

Inertial measurement unit **IFOS-500** is based on Fiber Optical Solution's three axis closed loop fiber optic gyroscope **TFOS-500** and three pendulum accelerometers.



**IFOS-501**

Inertial measurement unit **IFOS-501** is based on Fiber Optical Solution's three closed loop fiber optic gyroscopes **SFOS-501** and three pendulum accelerometers.



**IFOS-1000**

High-precision inertial measurement unit **IFOS-1000** is based on Fiber Optical Solution's three fiber optic gyroscopes **SFOS-1000** and three pendulum accelerometers.

Parameter	IFOS-200	IFOS-400	IFOS-500	IFOS-501	IFOS-1000
<b>Gyro</b>					
Range of measured angular rate, %/s	±950	±550	±400	±250 (optional ±1000)	±550
Bias drift at fixed temperature (100s-averaging, 1σ), %/hour	≤0.2 ~0.015 (Allan variance)	≤0.1 ~0.007 (Allan variance)	≤0.1 ~0.005 (Allan variance)	≤0.03 ~0.002 (Allan variance)	≤0.005 ~0.0005 (Allan variance)
Bias drift at changing temperature from -40°C to +60°C (100s-averaging, 1σ), %/hour	≤0.5 (*≤0.2)	≤0.3(*≤0.2)	≤0.3(*≤0.1)	≤0.1(*≤0.05)	≤0.05(*≤0.02)
Scale factor error in temperature range -40°C to +60°C (1σ), ppm	≤300(*≤150)	≤200(*≤150)	≤200(*≤100)	≤200(*≤100)	≤100(*≤50)
Random walk (Allan variance), %/hour	≤0.02	≤0.01	≤0.007	≤0.005	≤0.0007
Bandwidth, Hz	>1000 (user defined)				
<b>Accelerometers</b>					
Range of measured acceleration, g	±10g	±10g	±10g to ±40g	±10g to ±40g	±10g to ±40g
Bias drift at constant temperature, mg	≤1.0	≤1.0	≤0.5	≤0.1	≤0.05
Velocity random walk, μg/√Hz	≤80	≤80	≤20	≤20	≤15
Scale factor error in temperature range -40°C to +60°C (1σ), ppm	≤500(*≤150)	≤500(*≤150)	≤300(*≤100)	≤300(*≤100)	≤100
<b>Physical Characteristics</b>					
Misalignment, °	≤0.08(*≤0.015)				
Output sample rate	up to 2000 Hz				
Power supply, V	5±0.25	5±0.25	5±0.25	27±5	27±5
Power consumption, W	≤7 W	≤7 W	≤10 W	≤20 W	≤20 W
Digital output interface	RS-485	RS-422	RS-485 or RS-422	RS-422	RS-422
Operation temperature	-40°C ~ +60°C				
Dimensions, mm	75x75x60	80 x 95 x 65	110 x 110 x 90	140 x 140 x 110	171 x 224 x 233
Weight, kg	0.5	0.7	1.4	3	8.4

\* - improved calibration spec.

# Strapdown Inertial Navigation Systems (SINS)

Fiber Optical Solution's fiber-optic strapdown inertial navigation systems (SINS) have complete solid-state design with no rotating or other moving parts. Because it has no moving parts, there is nothing to go out of alignment and therefore it never requires recalibrating and is totally maintenance free. They have very high reliability (MTBF) and no maintenance requirements during its service life.



Designed for autonomous navigation and guidance of aviation, land, marine and subsea vehicles, Fiber Optical Solution's strapdown inertial navigation systems are compact, robust and maintenance-free, low-consumption units.

Performance	For land and air navigation	For marine navigation	For land and air navigation	For marine navigation	For land and air navigation
	NavFOS-500K	NavFOS-500M	NavFOS-501	NavFOS-501M	NavFOS-1000
	Alignment in static conditions	Alignment in dynamic conditions / tossing	Alignment in static conditions	Alignment in dynamic conditions / tossing	Alignment in static conditions
Pure SINS performance (inertial mode), accuracy:					
▪ position (1-hour error)	8 km	8 km	4 km	4 km	1.6 km
▪ velocity	2 m/s	2 m/s	1 m/s	1 m/s	0.4 m/s
▪ heading	<0.3×sec(lat)°	<0.3×sec(lat)°	<0.1×sec(lat)°	<0.1×sec(lat)°	<0.03×sec(lat)°
▪ pitch and roll	<0.1°	<0.1°	<0.05°	<0.05°	<0.02°
GPS-GLONASS/SINS performance					
▪ position accuracy	20 m	20 m	20 m	20 m	20 m
▪ velocity accuracy	0.1 m/s	0.1 m/s	0.1 m/s	0.1 m/s	0.1 m/s
Initialization time	10 min (available options 15, 5 min)				
Gyro bias drift (1σ)	≤ 0.04 °/h	≤ 0.04 °/h	≤ 0.02 °/h	≤ 0.02 °/h	≤ 0.005 °/h
Accelerometer bias drift (1σ)	≤ 5·10 <sup>-4</sup> g	≤ 5·10 <sup>-4</sup> g	≤ 1·10 <sup>-4</sup> g	≤ 1·10 <sup>-4</sup> g	≤ 5·10 <sup>-5</sup> g
Interfaces	RS-422 (MIL-STD-1553B option available)				
Power supply	27±5 V DC	27±5 V DC	27±5 V DC	27±5 V DC	27±5 V DC
Power consumption	15 W	20 W	22 W	24 W	24 W
Size, mm	240×160×110	343×185×120	286×163×124	338×185×150	171×224×252
Weight	3.4 kg	6.4 kg	4.8 kg	8.2 kg	8.9 kg
Operating ranges					
▪ angular rate	≤ 400 °/s	≤ 400 °/s	≤ 1000 °/s	≤ 1000 °/s	≤ 550 °/s
▪ linear accelerations	Up to 10 g	Up to 10 g	Up to 10 g	Up to 10 g	Up to 10 g
▪ vibration	Up to 2000 Hz	Up to 2000 Hz	Up to 2000 Hz	Up to 2000 Hz	Up to 2000 Hz
▪ temperature range	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C

## ***Fiber Optical Solution***

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