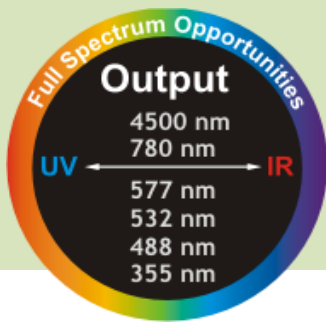
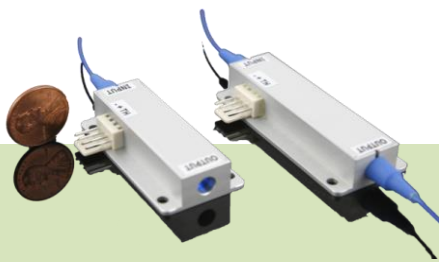


# PPLN Optical Mixers

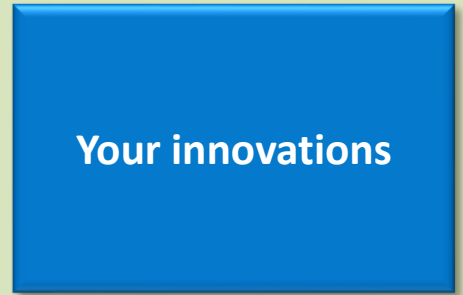


Compact, Robust and Maintenance-free optical frequency converters for full-spectrum applications

Your trusted value co-creation partner

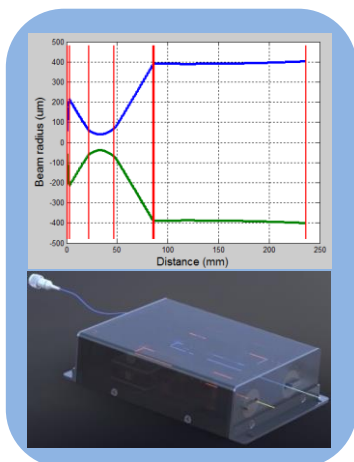
**HCP**  
HC PHOTONICS CORP.

**HC Photonics** provides a compact, robust and maintenance-free module for optical wavelength conversion called “Mixer”. Integrated with Periodically-Poled nonlinear crystals (e.g. PPLN or PPLT bulk or waveguide chips) as well as optics and electronics, the mixer provides high conversion efficiency from UV to mid-IR. Numerous successful cases are applied in Quantum, Industrial Productivity, Bio & Medicine, Spectroscopy & Environment, Space & Defense, Science & Research, etc.



The success of HCP product does not come easy. Every single device is examined microscopically. At design phase, optical beam path simulation is performed with the nonlinear crystal for optimal parameters, including the conversion efficiency and other beam characteristics. Moving forward to engineering development phase, the mixers are set to go through a variety of reliability tests, i.e. thermal/humidity cycling, ingress protection examination, and vibration/shock verification in compliance with Telcordia standard. Among the key tasks is the perfection of final touch before delivery. Environmental qualifications, such as temperature cycling, drop and vibration test are performed on each mixer to ensure the quality.

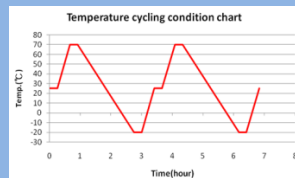
### Simulation



### Integration



### Qualification Test



- Temperature cycling**
- Damp Heat**
- Dry Heat**
- IPXX**
- Shock**
- Vibration**

With these strict quality criteria, we believe our precision alignment capability and photonics packaging technology could surely meet all requirements from innovative ideas to volume production.

# High Power Waveguide Mixer & Tunable Mixer

**NEW**

Telecom band & Quantum

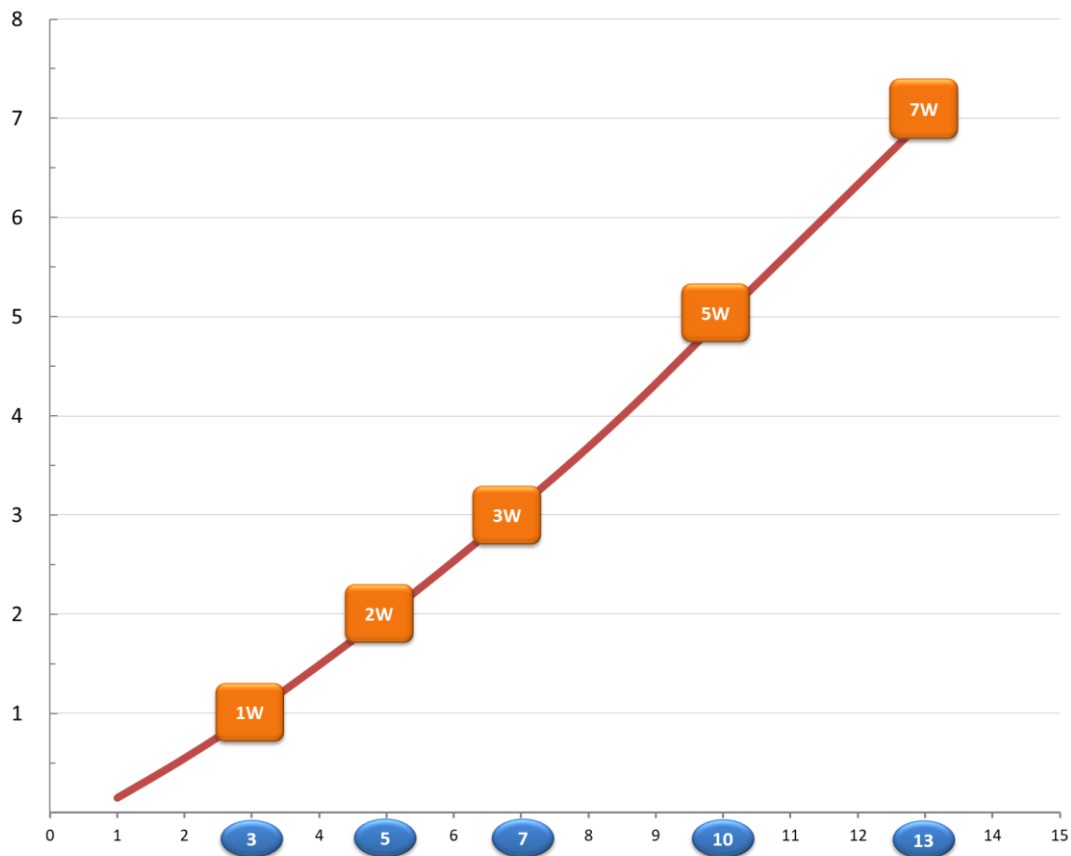


- High efficiency (up to 65%)
- High power (up to **7W/8.5W** out of PM fiber/free-space)
- Compact/Robust package (~18 cc only)
- Wide & Custom Wavelengths
- Fiber & Free-space Delivery
- **Commercial volume available now**

Waveguide solutions with high power endurance in compact footprints remain paramount in our design philosophy. HCP aims to turn the light into something feasible and affordable. Thus countless efforts are merged into the preliminary 7W/8.5W waveguide mixers. This breakthrough not only obscures the line between waveguide and bulk chip solution, but inspires even more in the territory of photonic application!

## 1x1 FIFO Waveguide Mixer – High efficient & High power

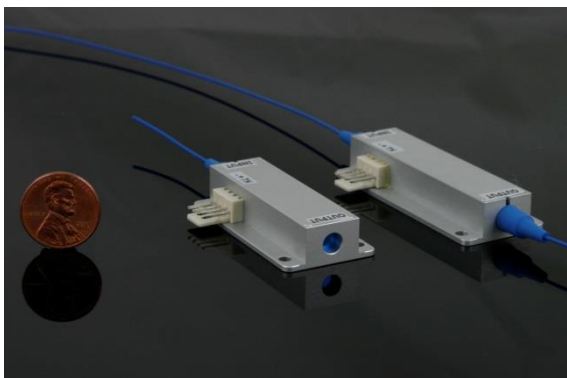
780nm power -Watt



1560nm Pump power - Watt

# Waveguide Mixer

## Standard 1x0 & 1x1 Mixer



- High efficiency (up to 65%)
- High power (up to **8.5W** free-space out)
- Compact/Robust package
- Custom Wavelengths(output UV to MIR)
- Fiber & Free-space Delivery
- **Commercial volume available now**

PPLN waveguide mixer is made with **PPLN waveguide chips** for continuous wave (CW) and pulsed laser(fs, ps and ns). Via different nonlinear frequency conversion processes (e.g. SHG, SFG, DFG...), the PPLN waveguide mixer provides the output wavelength from UV to mid-IR with superb conversion efficiency and exceptional high power up to Watts level.

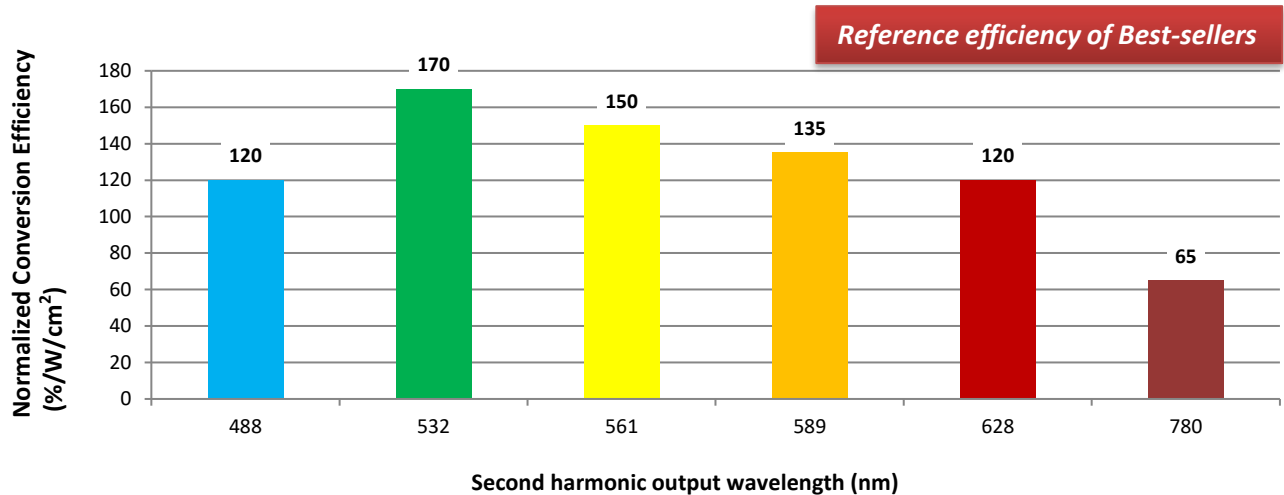
Unlike the conventional technology for low power only, our unique design breaks the confinement of technical barrier and pushes ahead the power handling capability to Watts level while remaining compact and robust. 7W/8.5W out of single mode PM780 fiber/free-space with 13W pump at 1560nm CW is the spotlight you definitely cannot miss!

### Best-seller

Waveguide Mixer – SHG						
Series	B	G	Y	O	R	T
Range (nm)	450-495	495-560	560-580	580-620	620-700	700-800
Best seller, $\lambda^{*1}$	<u>488nm</u>	<u>532nm</u> <u>555nm</u>	<u>561nm</u>	<u>589nm</u>	<u>628nm</u>	<u>775nm</u> <u>780nm</u>
Overall Efficiency <sup>*2</sup>	80%/W	120%/W	105%/W	90%/W	80%/W	50%/W
Fiber output <sup>*2</sup>	Yes, ~80% coupling efficiency from waveguide to single mode PM fiber					

1. The wavelengths of the best sellers are within +/- 0.5 nm typically. Custom wavelengths are available upon request.
2. The listed overall efficiency is baseline for volume production and reference only at low power regime with single longitudinal mode input. In general, the efficiency could be doubled with multi-longitudinal mode lasers e.g. **180%/W for 1064 nm SHG to 532 nm**. High power versions are also available.

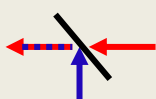
## Specifications



Optics	unit	Spec.		
		Minimum	Typical	Maximum
Beam quality, M <sup>2</sup>				≤1.2
Output beam (TEM00) ellipticity		1.2-2.0		
Output polarization state		Vertical or Horizontal, PER>20dB		
Back reflection for IR wavelength	dB		-40	
Fiber coupled output	%	75	80	
Mechanics	unit	Spec.		
Typical housing dimension (LxWxH)	mm	60x25x10.5, 70x25x10.5(fiber-out)		
Beam height	mm	5.25+/-0.5		
Electrics	unit	Spec.		
Electrical connector		Molex (4P)		
Typical thermoelectric cooler		~3.9V, ~1.7A maximum		
Environment	unit	Spec.		
Storage temperature (no humidity)	°C	-20	-	70
Operating ambient temperature range	°C	10	25	35
Operating rel. humidity (non condensing)	%RH	10	-	85
Restriction of hazardous substances directive (RoHs)		Declaration of Conformity to 2011/65/EU		

## Options:

### Wavelength Combiner



A free space module combines arbitrary optical wavelengths into waveguide mixer with low insertion loss.

### Filter Module



The filter module with free space/fiber input & output removes the undesired wavelengths for up to 100dB between residual pump and converted signal.

### Control unit



A control unit allows to set and read the crystal temperature for phase-matching optimization. Photodiode signal can also be viewed at power monitoring option.

### Fiber adaptor package



The waveguide mixers could be integrated into a housing that provides FC/APC fiber adaptor interface with collimation optics. Simply plug & play, life is just that easy!

# Bulk Mixer

## Standard 1x0 & 1x1 Mixer



- High output power
- Excellent beam quality
- Robust package
- Broad wavelength selection
- Fiber delivery

PPLN bulk mixer is made with **PPLN bulk chips** for continuous wave (CW) and pulsed lasers(fs, ps, and ns). Via different nonlinear wavelength conversion processes (e.g. SHG, SFG, DFG...etc), the PPLN bulk mixer provides the polarization maintained output from UV to mid-IR with output power up to 10W CW either free-space or fiber output.

### Best-seller

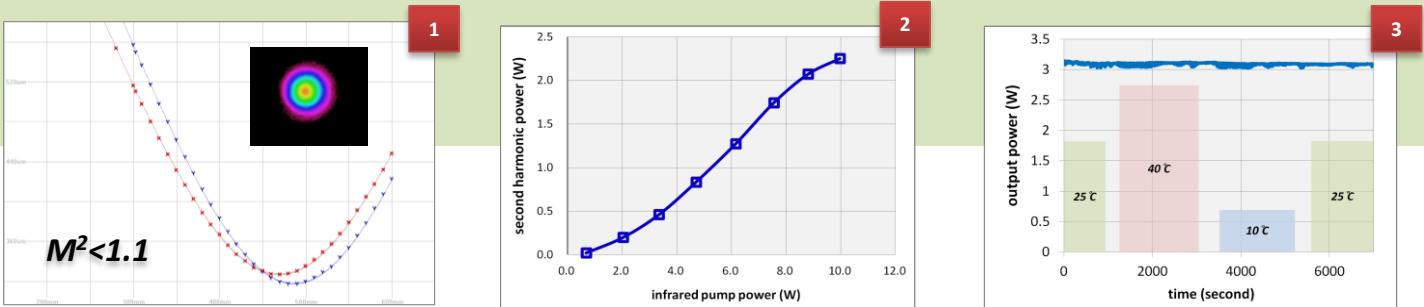
Five color series corresponding to the different wavelength range are our Best-sellers. They are designed for specific applications such as laser microscopy or atom trapping. Detailed specifications are shown below. Alternatives are also available upon request.

	Bulk Mixer – SHG <sup>*1</sup>				
Color	B	G	Y	O	R
Range (nm)	450-495	495-560	560-580	580-620	620-800
Best seller, $\lambda$ <sup>*2</sup>	473nm, <u>488nm</u>	515nm, <u>532nm</u> , 543nm	<u>561nm</u>	<u>589nm</u> , 594nm	<u>775nm</u> , <u>780nm</u> , 785nm
Power <sup>*3</sup> (max)	1W	2W	3W	4W	6W
Pump	Diode	Diode/Yb&Yb+/Raman lasers			Diode/Er laser

1. Second-Harmonic Generation (SHG)
2. The wavelengths are within +/- 0.5 nm. Other custom wavelengths are open for discussion.
3. SHG power is pump dependent. Typical output coupling efficiency from chip to single mode PM fiber is >80%. Higher efficiency is also achievable. Please contact us with your pump conditions (power, linewidth, pulse width, repetition rate...) for further evaluation.

# Specifications

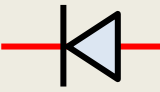
Optics	unit	Spec.		
		Minimum	Typical	Maximum
Beam quality, $M^2$				$\leq 1.2$
Reference diameter of collimated output beam	mm	0.9	1	1.1
Output beam (TEM00) ellipticity	%			$\leq 10$
Residual IR/output power rejection ratio	dB			-40
Output polarization state		Horizontal, PER>20dB		
Back reflection for IR wavelength	dB		-45	-42
Fiber coupled output	%		75	
Mechanics	unit	Spec.		
		Minimum	Typical	Maximum
Typical housing dimension (L*W*H)	mm	150x50x35		
Beam height	mm	18.9±0.5		
Statistic beam angle	mrad	-7.5	0	7.5
Electrics	unit	Spec.		
		Minimum	Typical	Maximum
Electrical connector		Hirose HR 10G-10R-10P(73)		
Thermoelectric cooler		~3.2V, ~4A maximum		
Environment	unit	Spec.		
		Minimum	Typical	Maximum
Storage temperature (no humidity)	°C	-20	-	70
Operating ambient temperature range	°C	10	25	35
Operating rel. humidity (non condensing)	%RH	10	-	85
Restriction of hazardous substances directive (RoHs)		Declaration of Conformity to 2011/65/EU		



- (1) The typical beam quality of collimated output from the bulk mixer
- (2) The typical power scaling curve of the second harmonic generation from the bulk mixer-G at 532nm
- (3) Temperature cycling(-20-70 °C) test before delivery


## Options:

**Power Monitoring**



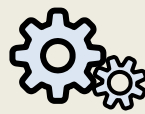
Photodiode for the output power monitoring with a voltage signal  $V_{pd}$  (typically 3V at maximum output power) allows auto-power control (APC) mode operation.

**Filter Module**




The filter module with free space/fiber input & output removes the undesired wavelengths for up to 100dB between residual pump and converted signal.

**Control unit**



A controller allows to set and read the crystal temperature for phase-matching optimization. Photodiode signal can also be viewed at power monitoring option.

**Customer Inspiration**



We are open to discuss the possibility of integrating other components. Don't hesitate to contact us and share your innovative ideas!

# Cavity Mixer



- Cavity enhanced for higher efficiency
- Wavelength from UV/Visible to NIR/MIR
- Fiber delivery optional
- Wavelength tunable up to few-hundred nm
- Convenient, compact and robust

Cavity configuration is an alternative way to enhance nonlinear frequency conversion. To fit all kinds of applications, HCP develops a versatile cavity mixer platform with a users-friendly interface. This structure seamlessly adapts to various form, including external pump OPO (EP-OPO), Intra-cavity OPO (IC-OPO), Intra-cavity SFG (IC-SFG), Intra-cavity DFG (IC-DFG) etc. They are widely applied for generating NIR signal wavelengths between 1.4-2 um and MIR idler wavelengths between 2.3-4.5 um.

## Best-seller

ICOPO-B & ICOPO-TB series are optical parametric oscillator (OPO) mixers, particularly designed for ultra-low input power. The intra-cavity structure utilizes the high circulating power in the cavity so as to reach the threshold efficiently. With accumulation of years-experience, now HCP proudly presents the series of 3 different wavelength ranges together with software and controller!

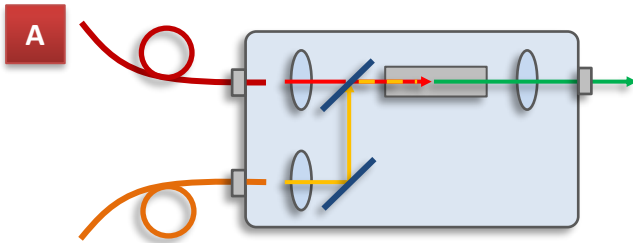
Parameter	unit	ICOPO-B <sup>1</sup> & ICOPO-TB <sup>2</sup>
Signal/Idler Wavelength	nm	α series: 1560-1880/2500-3300 β series: 1495-1640/3000-3700 γ series: 1440-1510/3600-4080
Signal/Idler Output Power	mW	α series: 250/100 β series: 250/90 γ series: 200/70
Linewidth	GHz	300
Beam Quality		TEM00, Signal M2<1.2, Idler M2<1.5
Polarization		Linear, >20dB

1. ICOPO-B: broad bandwidth (few nm), specific wavelength within α,β,γ range could be designed

2. ICOPO-TB: tunable (few hundred nm)

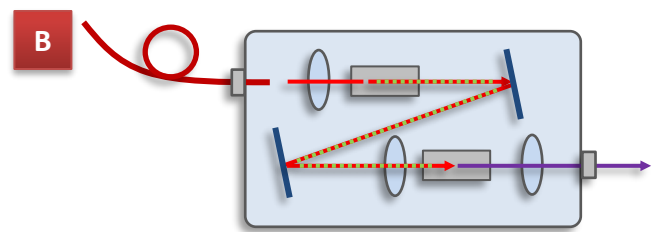


## 2x0/2x1 Mixer



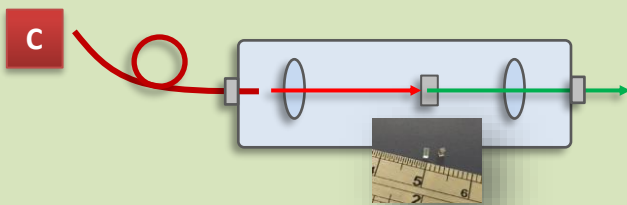
Sum Frequency Generation (SFG)  
Difference Frequency Generation (DFG)  
Optical Parametric Amplification (OPA)

## Cascaded Mixer

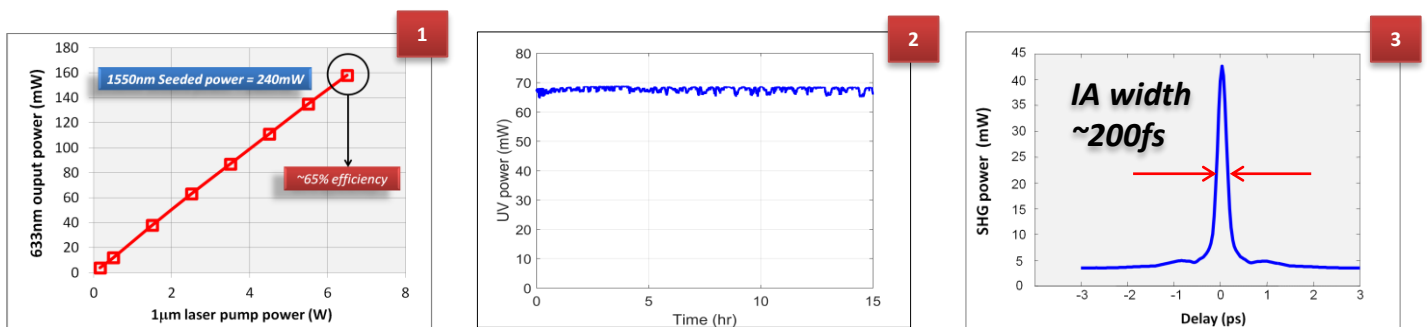


Third-Harmonic Generation (THG)  
Fourth-Harmonic Generation (FHG)

## Ultrafast mixer



(A) 2x0/2x1 Mixer configuration goes with two fiber-coupled inputs, out with either free-space converted beam or fiber-coupled. The free-spaced optical design inside the module reduces loss of beam combination.  
(B) Cascaded Mixer configuration includes two frequency conversion stages, e.g. one sum-frequency generation(SFG) followed by a SHG, which is equivalent to frequency tripling(THG).  
(C) An ultrafast mixer with tiny crystal inside can convert a broad spectrum of ultrafast pulses.



- (1) 1550nm and 1064nm lasers are combined to generate 633nm output by Sum-Frequency Generation (SFG) 2x0 mixer. 633nm output power vs. pump source is shown in depiction (1).
- (2) UV (355nm) is generated from 3.5W infrared by a Third Harmonic Generation (THG) cascaded mixer. The stability (measured power vs. time) is shown at depiction (2).
- (3) 780nm ultrashort pulse is generated from an ultrafast erbium-doped fiber laser by a SHG ultrafast mixer with >50% conversion efficiency. Measured correlation trace is shown at depiction (3).

## How to select YOUR mixer?

1. Check the nonlinear conversion configuration you would like to proceed (e.g. SHG, SFG, DFG, OPO/OPG, SPDC...etc.)

2. Select the corresponding mixer type as well as the optional parts for specified application.

-1x0: fiber in, free-space out  
-1x1: fiber in, fiber out  
-2x0: 2 fibers in, free-space out  
-2x1: 2 fibers in, 1 fiber out

3. Contact HC Photonics directly or the local representative for further information about mixers with custom options.

# Distributors



Ver. Jan-24

## **China**

YuChen Optics  
ycoptics.com

## **France**

Opton Laser International  
optonlaser.com

## **Germany**

GWU-Lasertechnik Vertriebsges. mbH  
gwu-lasertechnik.de

## **Israel**

Bi-Pol Electro-Optics Ltd.  
bi-pol.com

## **Japan**

Optronscience, Inc.  
eng.opt-ron.com

Japan DEVICE Ltd.  
j-device.com

Broadband, Inc.  
www.bblaser.com

## **United Kingdom**

Photonic Solutions Ltd.  
photonicsolutions.co.uk