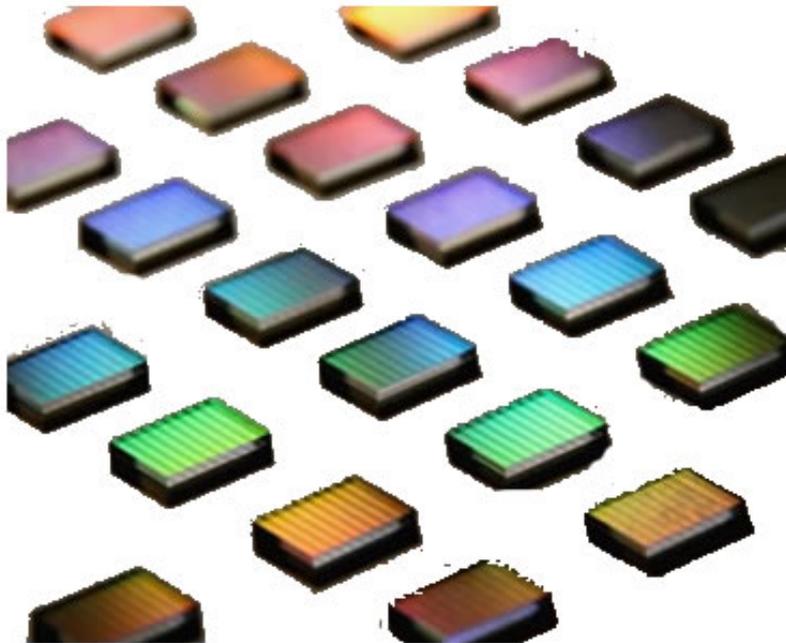


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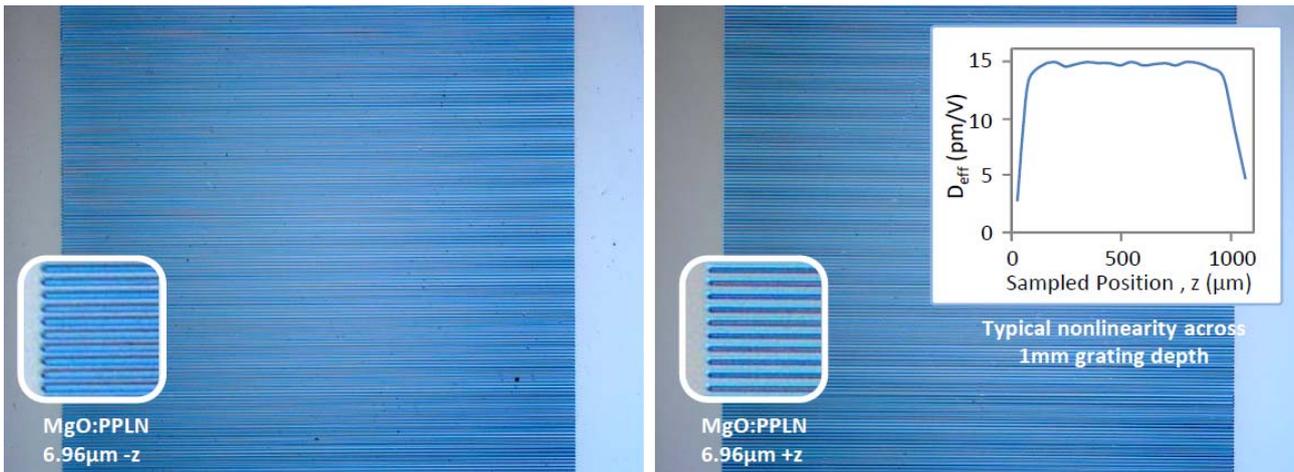
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MgO:PPLN for efficient wavelength conversion

Adding 5% magnesium-oxide to lithium niobate significantly increases the optical and photorefractive resistance of the crystal while preserving its high nonlinear coefficient. This allows more stable operation at visible wavelengths and lower temperature operation than a similar undoped crystal. MgO:PPLN can be operated at temperatures as low as room temperature and in some cases, without temperature stabilisation. With temperatures from ambient up to 200°C, MgO:PPLN offers significantly wider wavelength operation than undoped PPLN.

Specially developed for red-green-blue generation and high power mid-IR operation, our proprietary MgO:PPLN poling process offers high fidelity periods from 4.5µm to 33µm+ and is ideal for volume manufacture. As shown below, our MgO:PPLN domains are poled through the entire thickness of the sample, providing maximum optical aperture.

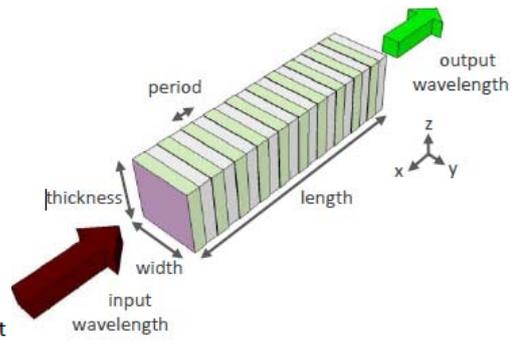
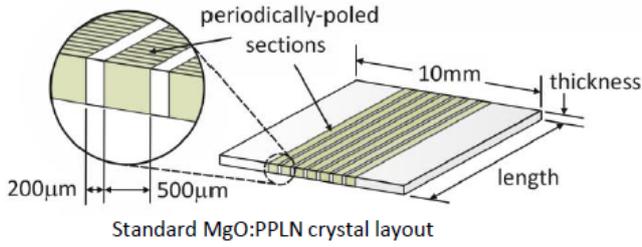


Our MgO:PPLN crystals are designed to work with a wide range of common laser wavelengths. Each off-the-shelf device includes multiple gratings for flexible temperature and wavelength operation. MgO:PPLN has a wide operating temperature range from 30-200°C.

Crystal lengths are 0.3mm to 1mm for short-pulse femtosecond lasers and 10mm to 40mm for ns to CW systems. Our standard crystals are supplied clip-mounted and off-the-shelf. Custom crystal lengths, thicknesses, AR coatings, and grating designs are also available upon request.



1, 10, 20 & 40mm clip-mounted MgO:PPLN



- Multi-band AR coated
- Flatness $<\lambda/4@633\text{nm}$
- Parallel to $\pm 5\text{minutes}$
- Better than 70:30 mark-to-space ratio
- Polished to 20-10 scratch dig
- Fewer than two 100µm edge chips per facet

Pictorial representation of a PPLN grating where laser light focused into the grating is converted to another wavelength. This can be achieved with the correct poling period, crystal temperature, and z-axis polarization.



Frequency doubling from 1530-1620nm



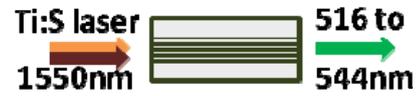
Frequency doubling from 1925-2250nm



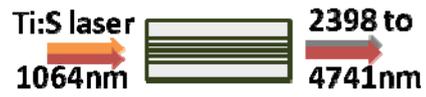
OPO crystal for mid-IR generation



Frequency doubling for green generation



SFG crystal for green generation

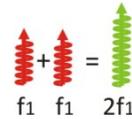


DFG crystal for mid-IR generation

MgO:PPLN for SHG: visible and near-IR wavelengths

Second Harmonic Generation:

- High efficiency frequency doubling of IR lasers to visible and shorter near-IR wavelengths
- Available in 0.5mm and 1.0mm apertures
- Mounted and double-band AR coated

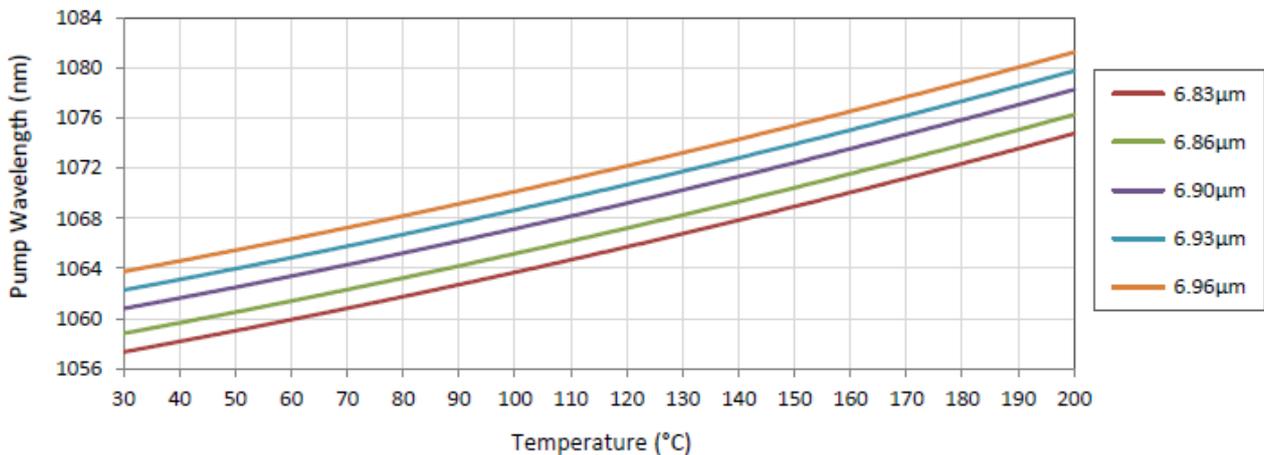


Applications:

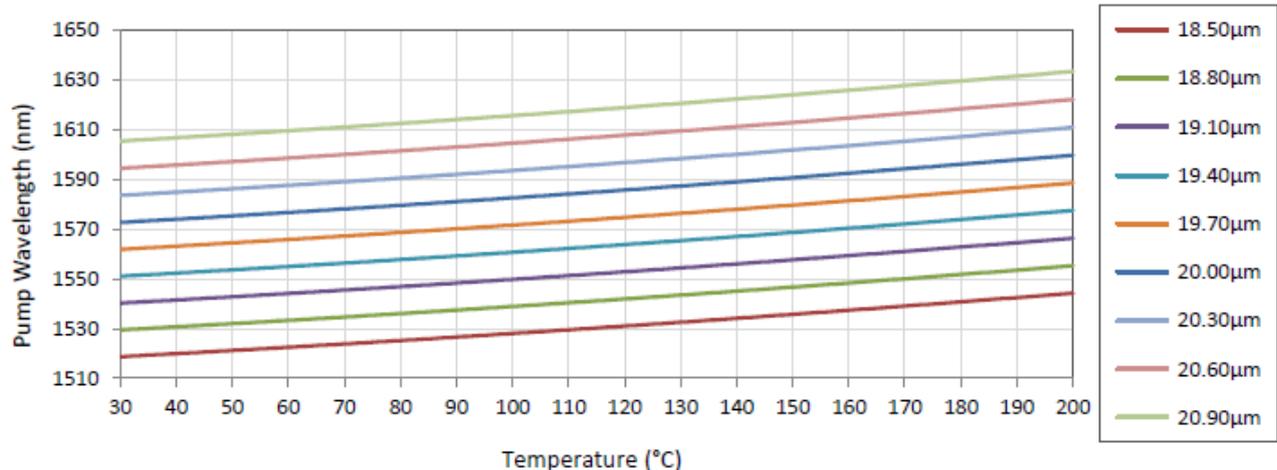
- Green and blue generation
- Scientific & medical
- Frequency comb stability
- Fluorescence microscopy

Our SHG MgO:PPLN crystals are designed to work with a wide range of common laser wavelengths. Each device has several gratings to allow phase matching at different temperatures. The visible wavelength devices contain multiple gratings designed for phase matching of the nominal pump wavelength typically between 30-200°C. Tuning to temperatures up to 200°C allows phase matching to longer wavelengths. All of our products undergo rigorous quality inspection and are supplied clip-mounted and off-the-shelf. Custom crystal lengths, thicknesses, AR coatings, and grating designs are also available upon request.

Calculated temperature vs. phase matching wavelength tuning curve of MSHG1064



Calculated temperature vs. phase matching wavelength tuning curve of MSHG1550-0.5



part #	pump (nm)	output (nm)	grating periods (μm)	temperature tuning range ($^{\circ}\text{C}$)	thickness (mm)	standard* lengths (mm)
STCS-MSHG976-0.5	976 (970 – 992)	488 (485 – 498)	5.17, 5.20, 5.23, 5.26, 5.29	30 – 200	0.5	1, 3, 5, 10, 20
STCS-MSHG1020-1.0	1020 (1008-1036)	510 (503-518)	5.84, 5.98, 6.08	30 – 200	1.0	1, 3, 5, 10, 20, 40
STCS-MSHG1030-0.5	1030 (1024 – 1047)	515 (512 – 524)	6.16, 6.19, 6.23, 6.26, 6.29	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1047-0.5	1047 (1040 – 1064)	523.5 (520 – 532)	6.48, 6.52, 6.55, 6.59, 6.62	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1064-0.5	1064 (1058 – 1080)	532 (529 – 540)	6.83, 6.86, 6.90, 6.93, 6.96	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1064-1.0	1064 (1058 – 1080)	532 (529 – 540)	6.83, 6.86, 6.90, 6.93, 6.96	30 – 200	1.0	1, 3, 5, 10, 20, 40
STCS-MSHG1080-0.5	1080 (1060-1116)	540 (530-558)	6.90, 7.10, 7.30, 7.50, 7.70	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1120-1.0	1120 (1106-1158)	560 (553-579)	7.87, 7.99, 8.11, 8.23, 8.35, 8.47, 8.59	30 – 200	1.0	1, 3, 5, 10, 20, 40
STCS-MSHG1180-0.5	1180 (1166-1220)	590 (583-610)	9.20, 9.40, 9.60, 9.80, 10.00	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1230-0.5	1230 (1216-1262)	615 (608-631)	10.40, 10.55, 10.70, 10.85, 11.00	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1320-0.5	1320 (1284-1336)	660 (642-668)	12.10, 12.30, 12.50, 12.70, 12.90	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1350-0.5	1350 (1296-1422)	675 (648-711)	12.40, 12.80, 13.20, 13.60, 14.00, 14.40, 14.80, 15.20	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1420-0.5	1420 (1350-1490)	710 (675-745)	13.83, 13.96, 14.08, 14.55, 15.10, 15.60, 16.10, 16.60, 17.10	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG1550-0.5	1550 (1530 – 1620)	775 (765 – 810)	18.50, 18.80, 19.10, 19.40, 19.70, 20.00, 20.30, 20.60, 20.90	30 – 200	0.5	0.3, 0.5, 1, 3, 5, 10, 20, 40
STCS-MSHG1550-1.0	1550 (1545 – 1610)	775 (773 – 805)	19.20, 19.50, 19.80, 20.10, 20.40	30 – 200	1.0	1, 3, 5, 10, 20, 40
STCS-MSHG1650-0.5	1650 (1605 – 1720)	825 (803 – 860)	20.90, 21.20, 21.50, 21.80, 22.10, 22.40, 22.70, 23.00, 23.30	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG2100-0.5	2100 (1925-2270)	1050 (963-1135)	28.40, 29.00, 29.60, 30.20, 30.80, 31.40, 32.00, 32.60, 33.20	30 – 200	0.5	1, 3, 5, 10, 20, 40
STCS-MSHG2100-1.0	2100 (1968-2270)	1050 (984-1135)	29.60, 30.20, 30.80, 31.40, 32.00, 32.60, 33.20	30 – 200	1.0	1, 3, 5, 10, 20, 40
STCS-MSHG2600-1.0	2600 (2260-3300)	1300 (1130-1650)	34.00, 34.80, 35.50, 35.80, 35.97	30 – 200	1.0	1, 3, 5, 10, 20, 40

*custom crystal lengths from 0.3mm to 50mm available upon request

MgO:PPLN for OPO, DFG and SFG

The wide transmission range and non-critical walk-off angle of MgO:PPLN make this material ideal for generating wavelengths throughout the mid-IR.

Based on our standard design layout, our MgO:PPLN OPO (optical parametric oscillator), DFG (difference frequency generation) and SFG (sum frequency generation) crystals are designed to work with common pump wavelengths at 1064nm, tunable 775nm and 1550nm. Our OPO and DFG crystals cover a broad continuous tuning range from the near-IR to beyond 4.5µm in the mid-IR, whilst our SFG crystals are designed for tunable green generation.

Our crystals undergo quality inspection and are supplied off-the-shelf. Our crystals are AR coated and clip-mounted, ready for use with our ovens and controller.

Optical Parametric Oscillation / Generation:

- Widely tunable mid-IR from a 1064nm pump source
- Also suitable for DFG
- Temperature tuning from 30-200°C
- Available in 0.5mm and 1.0mm apertures
- Mounted and triple-band AR coated



Applications:

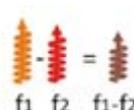
- Mid-IR spectroscopy
- Environmental monitoring
- LIDAR & laser counter measures

part #	pump (nm)	signal (nm)	idler (nm)	grating periods (µm)	thickness (mm)	standard* lengths (mm)
STCS-MOPO15-0.5	515	640 – 1030	1030 – 2530	6.00, 6.26, 6.53, 6.81, 7.10, 7.40, 7.71, 8.03, 8.36	0.5	1, 3, 5, 10, 20, 40
STCS-MOPO1-0.5	1064	1410 – 2128	2128 – 4340	27.91, 28.28, 28.67, 29.08, 29.52, 29.98, 30.49, 31.02, 31.59	0.5	1, 3, 5, 10, 20, 40
STCS-MOPO1-1.0	1064	1480 – 2128	2128 – 3785	29.52, 29.98, 30.49, 31.02, 31.59	1.0	1, 3, 5, 10, 20, 40
STCS-MOPO2-1.0	1064	1342 – 1460	3945 – 5135	25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5	1.0	1, 3, 5, 10, 20, 40, 50
STCS-MOPO3-1.0	1064	1430 – 2085	2085 – 4185	28.5, 29.0, 29.5, 30.0, 30.5, 31.0, 31.7	1.0	1, 3, 5, 10, 20, 40, 50

*custom crystal lengths from 0.3mm to 50mm available upon request

Difference Frequency Generation:

- Temperature tuning 30-200°C
- Available in 0.5mm and 1.0mm apertures
- Mounted and triple-band AR coated



Applications:

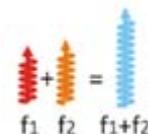
- Mid-IR spectroscopy
- Environmental monitoring
- LIDAR & laser counter measures

part #	pumps (nm)	output (nm)	grating periods (μm)	thickness (mm)	standard* lengths (mm)
STCS-MDFG1-0.5	737 – 786 & 1064	2398 – 3008	18.50, 18.80, 19.10, 19.40, 19.70, 20.00, 20.30, 20.60, 20.90	0.5	1, 3, 5, 10, 20, 40
STCS-MDFG2-0.5	775 – 869 & 1064	2853 – 4741	20.90, 21.20, 21.50, 21.80, 22.10, 22.40, 22.70, 23.00, 23.30	0.5	1, 3, 5, 10, 20, 40
STCS-MDFG3-1.0	1480 – 2128 & 1064	2128 – 3785	29.52, 29.98, 30.49, 31.02, 31.59	1.0	1, 3, 5, 10, 20, 40
STCS-MDFG4-0.5	885 – 1210 & 1550	2063 – 5516	24.06, 24.63, 25.23, 25.86, 26.53, 27.22, 27.96, 28.74, 29.56, 30.43, 31.35, 32.33, 33.37, 34.48, 35.67, 36.95	0.5	1, 3, 5, 10, 20, 40

*custom crystal lengths from 0.3mm to 50mm available upon request

Sum Frequency Generation:

- Combines fixed 1550nm and tunable 780nm or 810nm pump sources to provide tunable green wavelengths
- 0.5mm apertures
- Mounted and triple-band coated



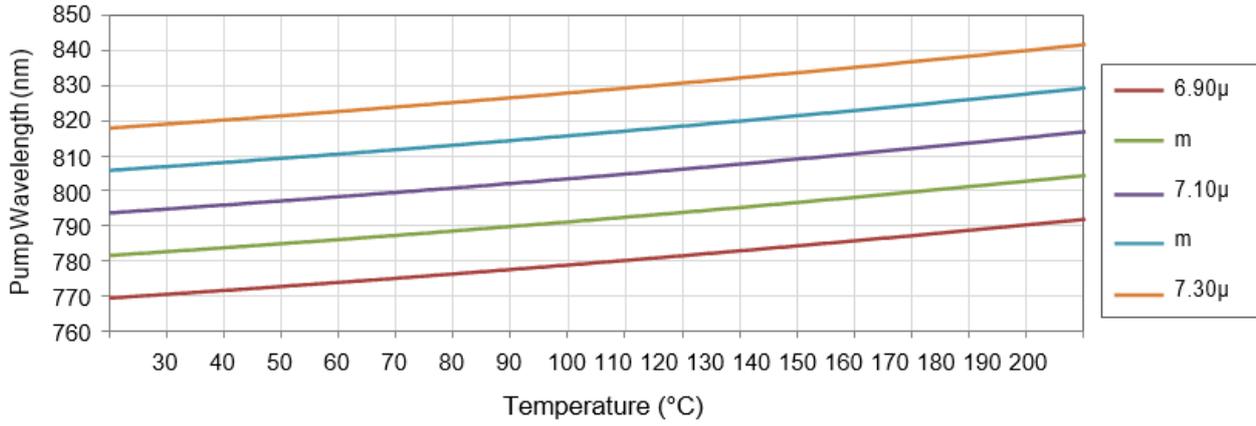
Applications:

- Cascaded THG from 1550nm
- Quantum optics

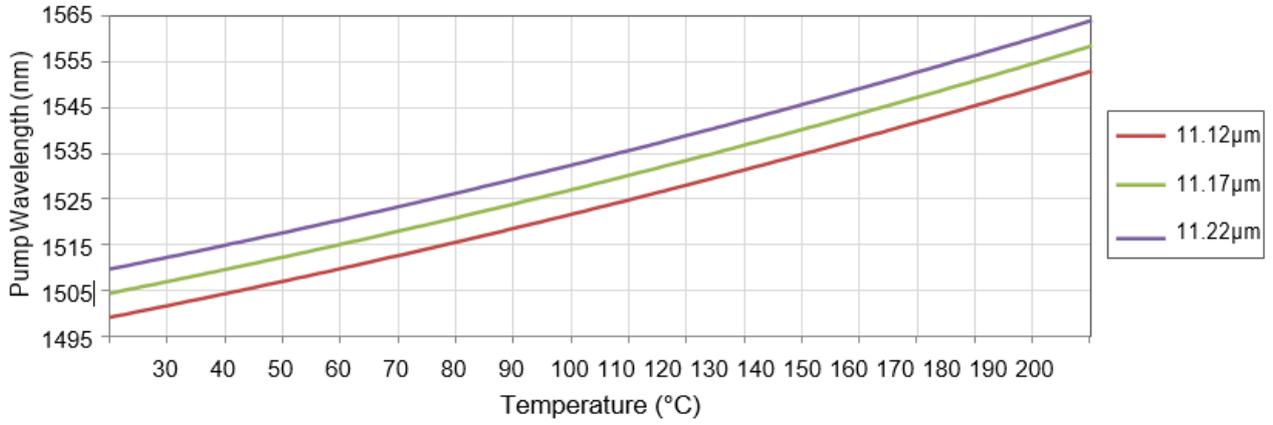
part #	pump (nm)	output (nm)	grating periods (μm)	thickness (mm)	standard lengths* (mm)
STCS-MSFG1-0.5	775 – 840 & 1550	516 – 544	6.90, 7.10, 7.30, 7.50, 7.70	0.5	1, 3, 5, 10, 20, 40
STCS-MSFG578-0.5	1280 – 1365 & 1030	570 – 587	8.70, 8.80, 8.90, 9.00, 9.10	0.5	1, 3, 5, 10, 20, 40
STCS-MSFG612-0.5	1000 – 1025 & 1550	608 – 617	10.40, 10.55, 10.70, 10.85, 11.00	0.5	1, 3, 5, 10, 20, 40
STCS-MSFG626-0.5	1550 – 1560 & 1051	618 – 628	11.12, 11.17, 11.22	0.5	1, 3, 5, 10, 20, 40
STCS-MSFG637-0.5	1520 – 1590 & 1070	628 – 640	11.60, 11.65, 11.70, 11.75, 11.80	0.5	1, 3, 5, 10, 20, 40
STCS-MSFG647-0.5	1085 – 1160 & 1550	638 – 663	12.10, 12.30, 12.50, 12.70, 12.90	0.5	1, 3, 5, 10, 20, 40

*custom crystal lengths from 0.3mm to 50mm available upon request

Calculated temperature vs. phase matching wavelength tuning curve of MSFG1 with 1550nm pump



Calculated temperature vs. phase matching wavelength tuning curve of MSFG626 with 1051nm pump



Custom MgO:PPLN for R&D to high-volume OEM

We provide a versatile basis for the design and manufacture of unique PPLN crystals. Our custom design and fabrication service provides application-specific technical consultation with specialist grating design and contract manufacture, resulting in a wavelength conversion solution tailored to your target laser system. We offer a range of custom design packages including:

- one-off crystals
- OEM prototyping
- Large-volume manufacture

If our stock crystals do not meet your requirements, our engineering team is available to find the best crystal solution for your interaction. Our custom fabrication service involves consultation with the customer for design of the full grating layout, mask design, wafer poling, dicing, polishing and AR coating.

Your custom crystal can be designed to have a standard multi-grating layout, so that you can continue to use our temperature control systems, or your own unique design that is customised to your OEM laser system.

We can manufacture single crystals as small as $<1\text{mm}^3$ for compact intra-cavity designs, or several millimetres wide aperture gratings with a long crystal length for high power applications.

Custom Designs for Non-standard Interactions:

PPLN crystals can be designed with aperiodic grating patterns to enable tailored spectral or thermal performance.

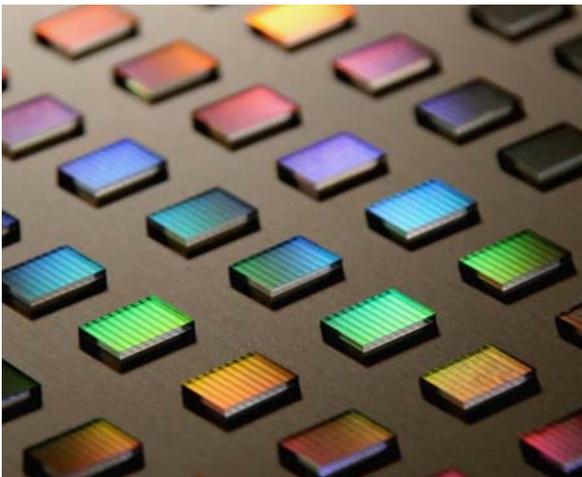
Periodic Custom designs:

- Specific poling periods with custom AR coating
- Specific poling periods with wider aperture
- Non-standard length and custom aperture angles

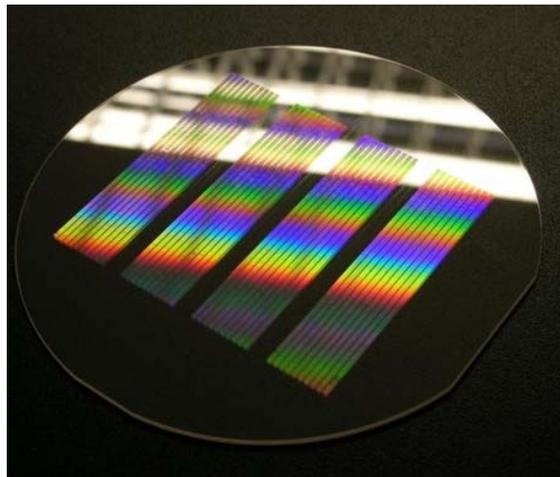
Aperiodic Custom designs:

- Linear period chirped gratings
- Non-linear period chirped gratings

Please contact our design team to discuss your custom grating requirement.



MgO:PPLN crystals



Custom MgO:PPLN wafer

MgO:PPLN Applications

Chemical fingerprints can be identified for homeland security applications. PPLN devices are designed for efficient frequency conversion of lasers allowing you to reach wavelengths that cannot be achieved with conventional solid state lasers, diode lasers etc.

For example, you can use PPLN to:

- frequency double a 1064nm laser to 532nm, a technique used for green laser pointers
- convert 1064nm to 3 μ m, used for gas detection or microscopy imaging techniques
- generate a narrow linewidth laser source for targeting a specific atomic transition for laser cooling and trapping.

Alternatively, PPLN has often been used to frequency double a high power tuneable 1550nm fibre source as a low cost and compact alternative to the Ti:Sapphire laser. Such a source can be used in microscopy systems for live-cell imaging, or terahertz time-domain spectroscopy where

PPLN devices are commonly used for high power mid-IR generation in an optical parametric oscillator. Tunable mid-IR systems are used in a wide range of microscopy imaging techniques as well as spectroscopy applications for environmental imaging. With pulse energies in excess of 1mJ, these mid-IR sources are also used in the defence industry for laser countermeasures and LIDAR systems.

Our MgO:PPLN has a wide range of applications:

Femtosecond Lasers

- THz generation
- Metrology
- Frequency comb stabilization

Green Lasers

- Laser projectors
- Seabed surveying

Bio-Photonics

- CARS microscopy
- Fluorescence-based microscopy
- DNA sequencing

Quantum Optics

- Quantum computing
- Precision navigation systems

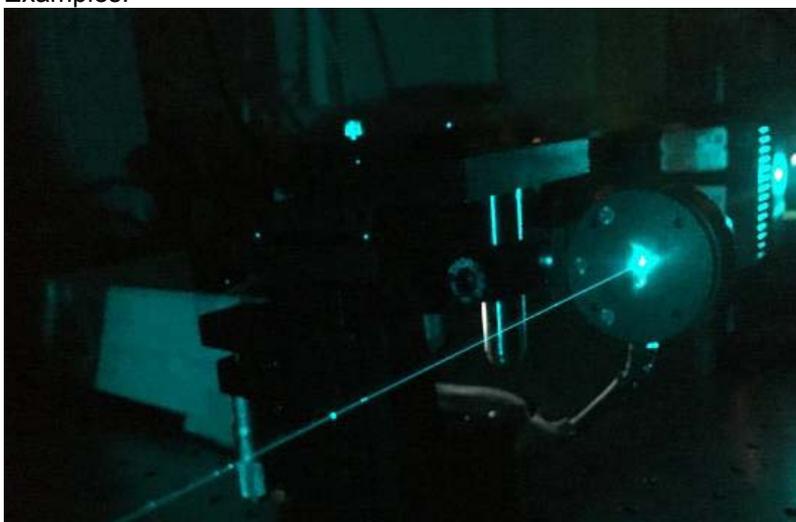
Defence

- Laser countermeasures
- Trace gas detection LIDAR

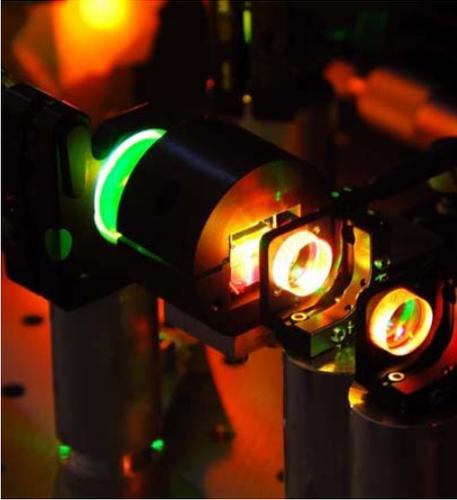
Aerospace

- Environmental monitoring
- Remote sensing Interferometry

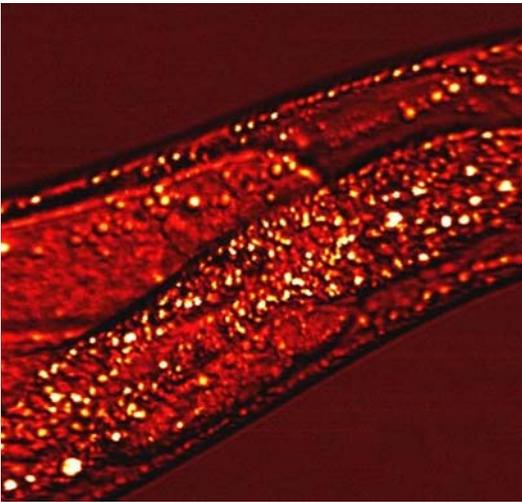
Examples:



Picosecond cascaded frequency doubling with two crystals from 1952nm to 488nm. *By Lin Xu, ORC, Uni. Of Southampton*



Nanosecond optical parametric oscillator for mid-IR generation Image courtesy of Elforlight 1952nm to 488nm By Lin Xu, ORC, Uni. Of Southampton



CARS microscopy image of elegans worm

PPLN ovens, temperature controllers and accessories

Our optical engineers have designed a range of PPLN crystal clips, ovens, temperature controllers and mounting accessories, providing a complete PPLN system for easy integration into your optical arrangement.

Our PPLN clips are easily mounted into the oven using the auto-locating pins. These also allow the PPLN clips to be swapped in and out with negligible realignment of the optical train.

Several sprung pins in the oven top hold the PPLN crystal clip securely in place. The oven and PPLN crystal can then be mounted in any orientation, flexible to your choice of optical arrangement.

We recommend the OC2 temperature controller for high thermal PV oven series. The PV Oven Series is specially designed to provide secure mounting and robust thermal stability for our PPLN crystals.

Key Features:

- Auto-locating dowel pins for alignment-free insertion
- Temperature stability of $\pm 0.01^{\circ}\text{C}$ with OC2 controller
- Various mounting options available

Part number	Crystal length	Oven length	PPLN clip
STCS-PV10	1mm, 10mm	22mm	PC1, PC10
STCS-PV20	20mm	32mm	PC20
STCS-PV40	40mm	53mm	PC40
STCS-PV50	50mm	62mm	PC50

PPLN clip kits:

The PPLN Clip Kits provide secure mounting of our PPLN crystals. All our crystals are supplied clip-mounted and ready for use in our ovens.

part #	crystal length	Key Features
STCS-PC1	1mm	<ul style="list-style-type: none"> ■ Simple pin-aligned mounting in PPLN ovens ■ Uniform temperature distribution ■ Spring clips secure the crystal with minimal stress ■ ITO coated glass for electrostatic charge dissipation
STCS-PC10	10mm	
STCS-PC20	20mm	Each clip kit contains: <ul style="list-style-type: none"> ■ a clip body ■ an ITO coated cover glass ■ a number of springs and screws
STCS-PC40	40mm	
STCS-PC50	50mm	



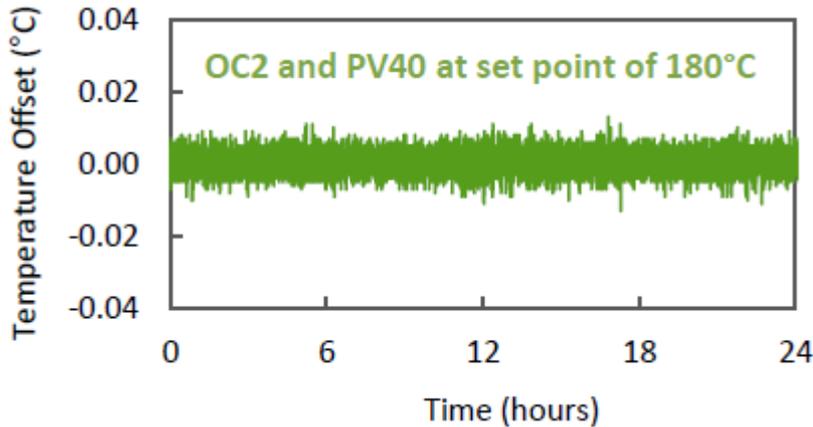
OC2 temperature controller

The OC2 temperature controller is a compact stand-alone benchtop unit for use with our PPLN oven range. The auto-detect feature provides hassle-free, plug- and-play functionality. The user can simply dial in the required temperature and allow the oven to reach optimum stability.



Key features:

- Simple push button interface
- Set point stability $\pm 0.01^{\circ}\text{C}$
- Set point resolution 0.01°C
- Maximum temperature 200°C (250°C upon request)
- PC control interface via USB
- Auto-detect feature for all PPLN crystal ovens



Part number	Control range	Set point resolution	Stability	For ovens	Input
STCS-OC2	Near-ambient to 200°C	0.01°C	$\pm 0.01^{\circ}\text{C}$	PV10, PV20, PV40, PV50	90-240VAC 50-60Hz

PC control:

- Standard USB type B connector
- OC2 software application
- Data saved to .csv format
- Features slow ramping via the Cycle Mode for finding SHG phase matching peak
- LabView Drivers
- PC control upgrade kit available for OC1 units: OC1-USB

Oven-free mounting solutions

Part number	Description	Optical height
STCS-PCMO01	Oven free PC01 clip mount adapter	8mm

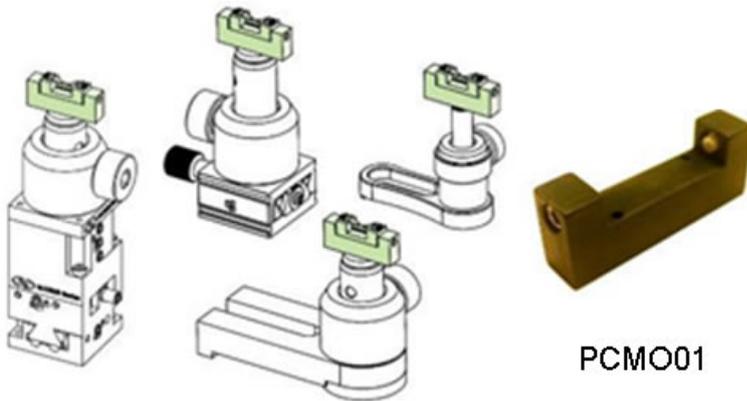
Key features:

- PC01 clip kit secured with two nylon tipped grub screws
- M3 threaded hole
- Each PCMO01 is supplied with an M3 to M4 thread adapter

Example mounting solutions:

- M3 threaded hole allows fixture to $\varnothing 1/2$ " post assemblies
- M3 to M4 thread adapter allows fixture to $\varnothing 1$ " post assemblies

- M4 post assemblies can be fixed on to dovetail translation stages for alignment through all available gratings, as well as fine adjustment through a grating aperture



PPLN mounting example using PCMO01

Post mount adapters

Part number	Description	Optical height
STCS-PVP1	PV10 post mount adapter	25mm
STCS-PVP2	PV20, PV40 and PV50 post mount adapter	25mm



PPLN mounting example using PV10 and PV1

Flexure stage adapters:

- Compatible with standard flexure stages and mounts from major optomechanics suppliers
- PV oven and adapter have an optical height of 25mm above the flexure stage platform
- Riser plate, RP12.5, increases the optical height of standard flexure mounts from 12.5mm to 25mm



Part number	Description	Optical height
STCS-PVP1R	PV10 adapter mount for flexure stages	25mm
STCS-PVP2R	PV20 & PV40 adapter mount for flexure stages	25mm
STCS-RP12.5	12.5mm riser plate for flexure stage mounts	25mm