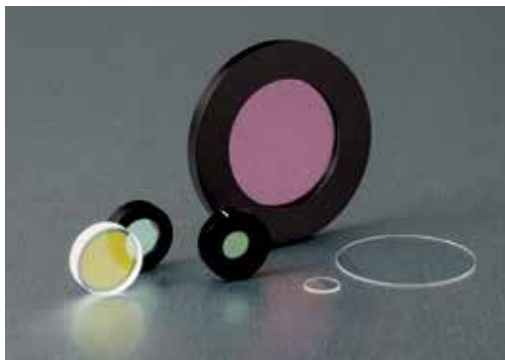




# WAVEPLATES



Waveplates are used in applications where the control, synthesis, or analysis of the polarization state of an incident beam of light is required. Our waveplates are constructed of very high, laser quality crystal quartz upon which low loss anti-reflection coatings are applied. Our waveplates are designed to provide a high laser damage threshold and satisfy the most demanding applications in the ultraviolet, visible and near-infrared wavelength regions. Our custom capabilities include large-area waveplates with diameters greater than 2 inches, custom retardations, as well as low-order quartz waveplates for applications where a large field of view or high stability with retardation and temperature variation is required. Please contact us to learn more.

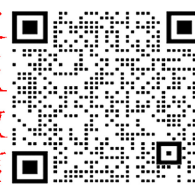
SELECTION GUIDE . . . . .	84
MULTIPLE-ORDER QUARTZ WAVEPLATES . . . . .	86
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DUAL-WAVELENGTH WAVEPLATES . . . . .	85
POLARIZATION ROTATORS . . . . .	90

## Don't see exactly what you are looking for?

CVI Laser Optics specializes in  
prototype to volume production manufacturing!

Give us a call and we will be honored to assist you with your custom needs.

**NOTES:**



## SELECTION GUIDE

PRODUCT TYPE	EFFECT ON POLARIZATION	TYPICAL BANDWIDTH	RETARDATION TOLERANCE	PRODUCT FEATURES	PAGE
LASER GRADE MULTIPLE-ORDER WAVEPLATES, Crystal Quartz: <a href="#">QWPM</a>	$\lambda/2$ or $\lambda/4$ retardation	< 1nm at 532nm (for $\lambda/100$ )	see page 86	Best for specific wavelengths & stable temperature Available either unmounted or ring-mounted Retardation vs. AOI performance better than compound zero order waveplates	86
LASER GRADE ZERO-ORDER COMPOUND WAVEPLATES, CRYSTAL QUARTZ: <a href="#">QWPO</a>	$\lambda/2$ or $\lambda/4$ retardation	30nm at 800nm (for $\lambda/100$ )	see page 88	Increased spectral bandwidth performance Good thermal stability Optically contacted (unmounted or ring-mounted) and air-spaced versions available	88
LASER GRADE DUAL-WAVELENGTH WAVEPLATES, CRYSTAL QUARTZ: <a href="#">QWPD</a>	Retards one wavelength $\lambda/2$ , leaves other unchanged	< 1nm at 532/1064nm	$\lambda/100$ at both wavelengths	Best for specific wavelengths & temperatures Available either unmounted or ring-mounted	85
POLARIZATION ROTATOR, CRYSTAL QUARTZ: <a href="#">RT</a>	Rotates linear polarization by 90°	Single $\lambda$ , but rotation varies smoothly with wavelength	$\pm 0.5^\circ$ rotation tolerance	No alignment required; used at normal incidence Slight temperature dependency (Narrowband) performance	90



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## LASER GRADE DUAL-WAVELENGTH WAVEPLATES: QWPD



### Specifications

Product Code: **QWPD**

**Optical Material:** Laser Grade Crystal Quartz

**Diameter:** 12.7 +0/-0.25mm (unmounted)  
25.4 ±0.127mm (mounted)

**Transmitted Wavefront:**  $\leq \lambda/10$  p-v at 633nm

**Surface Quality:** 10-5 scratch-dig per MIL-PRF-13830b

**Retardation Tolerance:**  
 $< \lambda/100$  at both wavelengths at 23° C

**Clear Aperture:**  $\geq 85\%$  of diameter for the unmounted waveplates

**Anti-reflection Coating:** per surface, see table

**Damage Threshold:** 10 J/cm<sup>2</sup>, 20ns, 20Hz; 1 MW/cm<sup>2</sup> cw at 1064nm

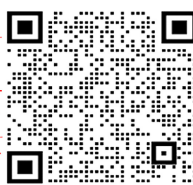
Dual-wavelength waveplates are used in a number of applications to enable selective processing of particular wavelengths. One common application is separation of different wavelengths with a polarizing beamsplitter by rotating the polarization of one wavelength by 90° ( $\lambda/2$  retardation), while leaving the other unchanged. This frequently occurs in nonlinear doubling or tripling laser sources such as Nd:YAG (1064/532/355/266).

The QWPD waveplates use a multiple-order design in which the retardation specifications are met for both wavelengths. This results in a relatively high order waveplate, making them best suited for use only over narrow bandwidth and operating temperature range.

- Precise polarization control for dual wavelength sources
- Readily available for Nd:YAG and harmonics
- Best performance over a low temperature and narrow wavelength range
- Ask about OEM opportunities for other sizes and wavelength retardation combinations

LASER GRADE DUAL-WAVELENGTH WAVEPLATES				
Wavelength 1 (nm)	Wavelength 1 AR Coating	Wavelength 2 (nm)	Wavelength 2 AR Coating	PART NUMBER
355	R < 0.5%	532	R < 0.5%	QWPD-355-2-532-1-05
355	R < 1.3%	1064	R < 0.5%	QWPD-355-2-1064-1-05
532	R < 0.6%	1064	R < 0.3%	QWPD-532-2-1064-1-05
1064	R < 0.3%	532	R < 0.6%	QWPD-1064-2-532-1-05

If you need the waveplate ring mounted, please add '-R10' at the end of the Part Number. The ring mount diameter is 25.4mm. Please refer to page 87 for the dimensions of the ring mount for 12.7mm diameter waveplates.



## LASER GRADE MULTIPLE-ORDER QUARTZ WAVEPLATES: QWPM



CVI Laser Optics precision multiple-order QWPM waveplates are high performance and high energy retarders for single wavelength applications. If your application has a working temperature range of greater than  $\pm 3^{\circ}\text{C}$ , we suggest the QWPO zero-order waveplates.

Ask about OEM opportunities for other wavelengths, retardations, sizes, and/or mounting options. Low order and/or near true zero order options may also be available

## Specifications

Product Code: **QWPM**

**Optical Material:** Laser Grade Crystal Quartz

**Mount Material:** Aluminum 6061-T6; Black Anodized

**Diameter Tolerance:**  $+0/-0.25\text{mm}$  (unmounted)  
 $\varnothing \pm 0.127\text{mm}$  (ring mounted)

**Optical Thickness:** 0.4 - 1.0mm nominal

**Retardation Tolerance:** Refer to table below

**Transmitted Wavefront Error (TWE):**  $< \lambda/10$  p-v at 633nm

**Surface Quality:** 10-5 scratch-dig per MIL-PRF-13830b

**Clear Aperture:**  $\geq 85\%$  of diameter for unmounted waveplates (see Mount CA on next page)

**\*Anti-reflection Coating:**  $R \leq 0.2\%$  per surface

**Adhesion and Durability:** Per MIL-C-48497a, MIL-C-675c

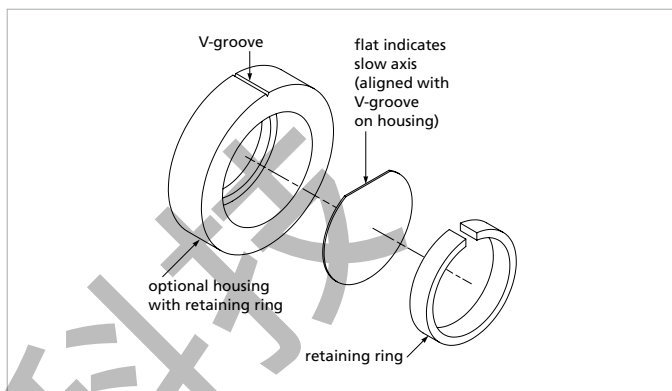
**Damage Threshold:**

17.5 J/cm<sup>2</sup>, 20ns, 20Hz at 1064nm

10 J/cm<sup>2</sup>, 20ns, 20Hz at 532nm

10 J/cm<sup>2</sup>, 20ns, 20Hz at 355nm

2.5 J/cm<sup>2</sup>, 10ns, 20Hz at 266nm



QWPM-series multiple-order waveplates with ring mount

RETARDATION TOLERANCE	
$\lambda$	Achievable Retardation Tolerance at 23°C
1064nm	$\leq 1/850$
800nm	$\leq 1/700$
532nm	$\leq 1/450$
400nm	$\leq 1/350$
355nm	$\leq 1/300$
266nm	$\leq 1/200$

\*Applicable for wavelengths  $\geq 266\text{nm}$



## BUILD YOUR PART NUMBER

STEP-1	STEP-2	STEP-3	STEP-4	STEP-5
PRODUCT CODE	WAVELENGTH	WAVEPLATE DIAMETER CODE	RETARDATION CODE	RING-MOUNT CODE
QWPM	1064	10	2	R15

EXAMPLE: QWPM-1064-10-2-R15

CHOOSE FROM THE OPTIONS BELOW.

### 1. PRODUCT CODE

QWPM

### 2. WAVELENGTH (nm)

select from table to the right

### 3. WAVEPLATE DIAMETER CODE

select from table to the right

### 4. RETARDATION CODE

Retardation in Waves

2

0.500

4

0.250

### 5. RING-MOUNT CODE (optional)

\* select from table below

## QWPM WAVELENGTHS & SIZES OFFERINGS

Wavelength	Waveplate Diameter Code					
	05	08	10	12	15	20
193*	•		•			
244**	•					
248**			•			
266	•		•			
355	•	•	•	•		
400	•		•			
488			•			
515		•				
527	•					
532	•	•	•	•	•	
633	•		•			
670	•		•			
780	•		•			
800			•			
1030	•	•	•			•
1053	•		•		•	•
1064	•	•	•		•	•
1550	•		•			

\* 193 nm waveplates with 0.5" diameter are available in  $\lambda/2$  retardation only \*\* 244 nm and 248 nm waveplates are available in  $\lambda/2$  retardation only

## LASER GRADE WAVEPLATE DIAMETERS AND PROTECTIVE RING MOUNTS

Waveplate Diameter Code	Waveplate Diameter (mm (in.))	Optional Ring Mount Code	Ring Mount CA (in. min)	Ring Mount OD ( $\pm 0.005$ in.)	Ring Mount Thickness ( $\pm 0.005$ in)
05	(0.500)	R10	0.425	1.000	0.250
08	20.0	R10	0.590	1.000	0.250
10	(1.000)	R15	0.850	1.500	0.250
12	30.0	R15	1.000	1.500	0.250
15	(1.500)	R20	1.275	2.000	0.250
20	(2.000)	R30	1.700	3.000	0.250

\* Leave blank to designate waveplate without ring mount



## LASER GRADE ZERO-ORDER QUARTZ WAVEPLATES: QWPC



## Specifications

Product Code: QWPO

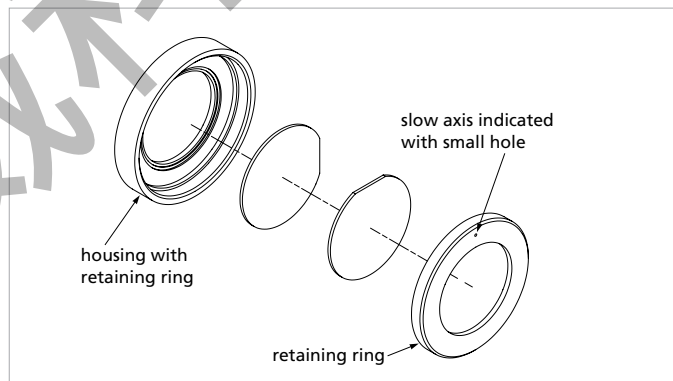
**Optical Material:** Laser Grade Crystal Quartz**Mount Material:** Aluminum 6061-T6; Black Anodized**Mounting/Contacting Options:** optically contacted without a mount, contacted and ring mounted, or air spaced and ring mounted**Diameter Tolerance:**  $+0/-0.25\text{mm}$  (unmounted),  $\varnothing \pm 0.127\text{mm}$  (ring mounted)**Optical Thickness:** 1.0-3.0mm nominal**Retardation Tolerance:** Refer to table below.**Transmitted Wavefront:**  $\leq \lambda/10$  p-v at 633nm**Surface Quality:** 10-5 scratch-dig per MIL-PRF-13830b**Clear Aperture:**  $\geq 85\%$  of diameter for unmounted waveplates**\*Anti-reflection Coating:**  $R \leq 0.2\%$  per surface**Adhesion and Durability:** per MIL-C-48497a, MIL-C-675c**Damage Threshold:**17.5 J/cm<sup>2</sup>, 20ns, 20Hz at 1064nm10 J/cm<sup>2</sup>, 20ns, 20Hz at 532nm10 J/cm<sup>2</sup>, 20ns, 20Hz at 355nm2.5 J/cm<sup>2</sup>, 10ns, 20Hz at 266nm

Zero-order waveplates are the preferred solution for applications with a temperature range of greater than  $\pm 3^\circ\text{C}$  or a wavelength range greater than 2nm. Their increased bandwidth and excellent thermal stability are due to their compound construction, allowing the temperature effects of the single components to cancel each other out, while the difference in phase retardation between the single components results in true zero order retardation. They provide retardations that are a single submultiple of  $2\pi$  in phase.

CVI Laser Optics offers QWPO zero-order waveplates in three different options: optically contacted sans mount, contacted and ring mounted, or air spaced and ring mounted.

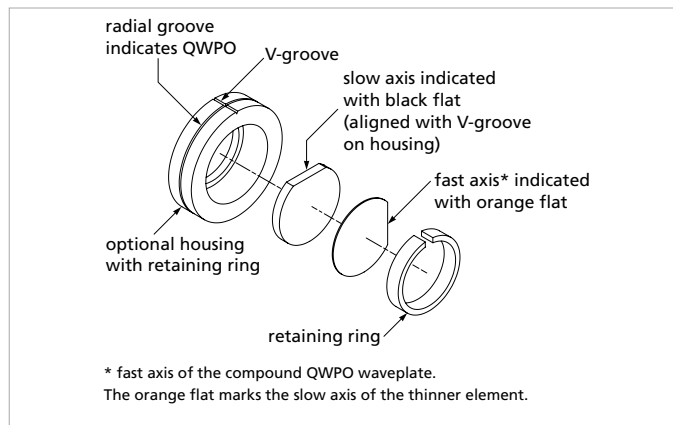
While unmounted, optically contacted waveplates can easily provide larger usable apertures; however, high UV energies can separate optically contacted waveplates. Therefore, CVI Laser Optics recommends air-spaced zero-order waveplates for wavelengths shorter than or equal to 248nm and repetition rates higher than 1 KHz.

Ask about OEM opportunities for other wavelengths, retardations, sizes, and/or mounting options.



QWPO-series zero-order quartz waveplate air-spaced assembly

RETARDATION TOLERANCE	
$\lambda$	Achievable Retardation Tolerance at 23°C
1064nm	$\leq 1/850$
800nm	$\leq 1/700$
532nm	$\leq 1/450$
400nm	$\leq 1/350$
355nm	$\leq 1/300$
266nm	$\leq 1/200$

\*Applicable for wavelengths  $\geq 266\text{nm}$ 

QWPO-series zero-order quartz waveplate with ring mount



## BUILD YOUR PART NUMBER

STEP-1	STEP-2	STEP-3	STEP-4	STEP-5
PRODUCT CODE	WAVELENGTH	WAVEPLATE DIAMETER CODE	RETARDATION CODE	RING-MOUNT CODE
QWPO	532	10	2	R15

EXAMPLE: QWP0-532-10-2-R15

CHOOSE FROM THE OPTIONS BELOW.

### 1. PRODUCT CODE

QWPO

### 2. WAVELENGTH (nm)

select from options table to the left

### 3. WAVEPLATE DIAMETER CODE

select from options table to the right

### 4. RETARDATION CODE

Retardation in Waves

2

0.500

4

0.250

### 5. RING-MOUNT CODE (optional)

select from table below

## QWPO WAVELENGTHS & SIZES OFFERINGS

Wavelength	Waveplate Diameter Code					
	05	08	10	12	15	20
193*			•			
244**	•					
248**		•				
266	•		•			
355	•	•	•	•		
400	•		•			
488			•			
515		•				
532	•	•	•	•	•	
633	•		•			
670			•			
780	•		•		•	
800	•	•	•		•	•
850	•		•			
1030	•	•	•			•
1047**	•					
1053	•		•		•	•
1064	•	•	•		•	•
1550	•		•			

\* 193nm and 244nm zero-order waveplates are provided in air-spaced configuration as standard, in order to maximize laser damage threshold performance. Call an applications engineer to special order contacted configurations for these wavelengths. \*\*244nm, 248nm and 1047nm products are provided with  $\lambda/2$  retardation only

## LASER GRADE WAVEPLATE DIAMETERS AND PROTECTIVE RING MOUNTS

Waveplate Diameter Code	Waveplate Diameter [mm (in.)]	Contacted Waveplates Optional Ring Mount Code	Air-spaced Waveplates Ring-Mount Code	Ring Mount CA (in. min)	Ring Mount OD ( $\pm 0.005$ in.)	Ring Mount Thickness ( $\pm 0.005$ in.)
05	(0.500)	R10	AS10	0.425	1.000	0.250
08	20.0	R10	AS10	0.590	1.000	0.250
10	(1.000)	R15	AS15	0.850	1.500	0.250
12	30.0	R15	AS15	1.000	1.500	0.250
15	(1.500)	R20	AS20	1.275	2.000	0.250
20	(2.000)	R30	AS30	1.700	3.000	0.250



## 90° POLARIZATION ROTATORS: RT



### Specifications

Product Code: **RT**

**Optical Material:** Laser Grade Crystal Quartz

**Diameter Tolerance:**  $+0/-0.25\text{mm}$

**Rotation Tolerance:**  $\pm 0.5^\circ$

**Surface Quality:** 10-5 scratch-dig per MIL-PRF-13830b

**Clear Aperture:**  $\geq 85\%$  of diameter

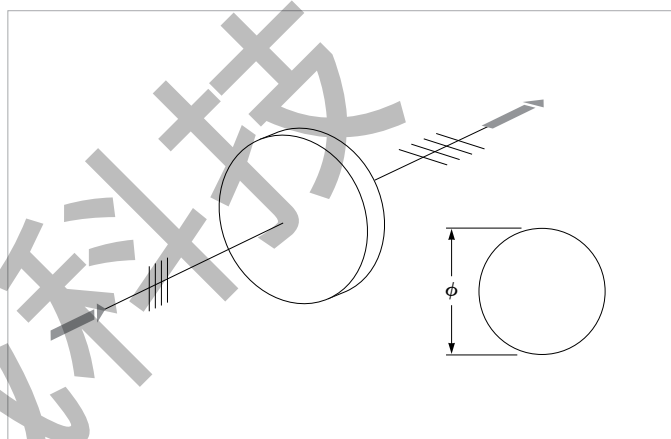
**Damage Threshold:** 10 J/cm<sup>2</sup>, 20ns, 20Hz;  
1 MW/cm<sup>2</sup> cw at 1064nm

**Anti-reflection Coating:**  $R \leq 0.25\%$  per surface

These rotators carry the outstanding feature that their rotation is not dependent on their alignment. They are simply placed in the beam at normal incidence compared to their waveplate counterparts and do not require angular adjustment.

Crystalline quartz rotators, based on circular birefringence, are very convenient, high-damage-threshold devices. They are useful over a narrow bandwidth centered at the design wavelength with only slight temperature dependence. Custom options are available.

- ▶ Alignment-insensitive single wavelength rotator
- ▶ Based on optical activity of crystal quartz
- ▶ Light reflected back will revert to original configuration



RT polarization rotators

### 90° POLARIZATION ROTATORS

Wavelength (nm)	$\phi$ (mm)	Nominal Thickness (mm)	Rotation	Transmitted Wavefront Error p-v @ 633nm	PART NUMBER
1064	25.4	14.3	90°	$< \lambda/6$	RT-10-1064-90