

## **Introduction**

Sawyer Technical Materials, LLC offers high quality cultured quartz crystal for a variety of optical applications - from polarizing optics for lasers to waveplates for telecommunications to windows for scientific and medical instruments. For all of these applications, birefringence and high transmittance over an extended range of wavelengths are essential. Furthermore, it is vital to ensure both high quality and batch-to-batch consistency with respect to optical homogeneity, inclusion and dislocation content. Sawyer's unique combination of experience, technological expertise and manufacturing resources enable the reliable supply of a wide variety of optical grade quartz products that are custom tailored to customer applications. Products can be supplied in a variety of shapes and sizes from bulk crystal in bar form to cubes, prisms, core-drilled tubes and X-ray oriented blanks.

## **Optical Grades Available**

Sawyer Technical Materials, LLC produces three main grades of crystal designed specifically for optical applications.

OPAG Grade – for general optical applications requiring low-inclusion quartz material with seed-free dimensions up to 100mm (X) by 250mm (Y) by 40mm (Z). Primary growth layers for these crystals are perpendicular to the Z-axis (optic axis) and parallel to the X- and Y-axes.

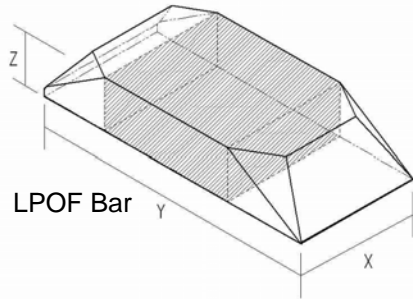
LPOF Grade – originally designed for use in low-pass optical filters, this grade offers quartz that is practically inclusion free. Similar to OPAG grade, primary growth layers for LPOF crystals are perpendicular to the Z-axis.

WP Grade – originally designed for large waveplate applications, this grade also offers practically inclusion free material. WP grade material differs from both OPAG and LPOF grade in that primary growth layers are perpendicular to the X-axis and parallel to the Y- and Z-axes.

## **Forms Available**

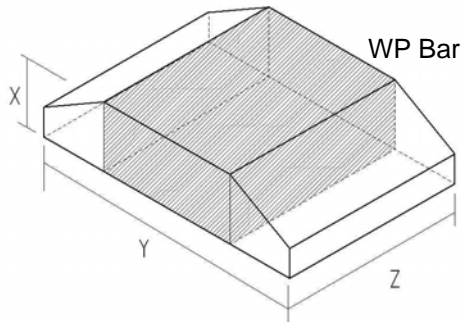
All Sawyer optical grade products are available both as bulk crystals and as fabricated shapes. Bulk crystals can be provided in “as-grown” form, or as “lumbered” bars with primary surfaces ground smooth, dimensioned and oriented to specified tolerances. In addition, a variety of fabricated shapes can be supplied, including blocks, prisms, cylinders and round or rectangular wafers. Standard shapes and dimensions are provided in the tables below, though custom sizes and shapes are available upon request.

	OPAG	LPOF	WP
Dimensions (mm)			
X-axis (max)	100	150	See figure
Y-axis (max)	250	See figure	See figure
Z axis (max)	40	See figure	150



LPOF Typical Dimensions (mm)				
Y-length	75	90	100	110
Max Z-dimension	50	45	40	35

Typical dimensions, natural faceting may cause dimensions to vary slightly



WP Typical Dimensions (mm)				
Y-length	75	90	100	110
Max X-dimension	50	45	40	35

Typical dimensions, natural faceting may cause dimensions to vary slightly

## **Material Properties**

### Crystal quality

Infrared $\alpha^a$	< 0.060 (3500 $\text{cm}^{-1}$ basis)
Inclusions	Near zero (LPOF, WP grades) < 1.2/ $\text{cm}^3$ (OPAG grade)
Etch channel density <sup>a</sup>	< 100/ $\text{cm}^2$
Handedness <sup>b</sup>	Right (left available upon request)
Twins	None
Impurities (ppm)	
Al	< 5.0
Ca	< 5.0
K	< 5.0
Na	< 5.0
Mg	< 1.0
Ti	< 1.0
Cu	< 0.5
Fe	< 0.5
Li	< 0.5
Mn	< 0.5

### Physical properties

Coefficient of thermal expansion	$7.97 \times 10^{-6}/^{\circ}\text{C}$ (// c-axis, 0-80°C) $13.37 \times 10^{-6}/^{\circ}\text{C}$ ( $\perp$ c-axis, 0-80°C)
Thermal conductivity	$10.7 \text{ W/m}^{\circ}\text{C}$ (// c-axis, @ 50°C) $6.21 \text{ W/m}^{\circ}\text{C}$ ( $\perp$ c-axis, @ 50°C)
Specific heat	$0.787 \text{ J/g}^{\circ}\text{C}$ (@ 25°C)
Density	$2.648 \text{ g/cm}^3$
Young's modulus	$97 \text{ Gpa}$ (// c-axis, @ 25°C) $76.5 \text{ Gpa}$ ( $\perp$ c-axis, @ 25°C)

### Optical properties

Transmittance

Refractive index

$\lambda$ (nm)	$n_o$	$n_e$	$\lambda$ (nm)	$n_o$	$n_e$
185.1	1.67750	1.68988	627.8	1.54282	1.55188
193.6	1.65999	1.67343	667.8	1.54155	1.55057
200.1	1.64927	1.66227	706.5	1.54049	1.54947
219.5	1.62497	1.63698	766.5	1.53907	1.54801
242.8	1.60525	1.61650	794.8	1.53848	1.54739
250.3	1.60032	1.61139	844.7	1.53753	1.54640
303.4	1.57955	1.58720	1000.0	1.53503	1.54381
340.4	1.56747	1.57737	1083.0	1.53387	1.54260
404.6	1.55716	1.56671	1541.0	1.52781	1.53630
467.8	1.55103	1.56031	2053.0	1.52005	1.52823
508.0	1.54822	1.55746	2600.0	1.5096	1.5172
546.1	1.54617	1.55535	3000.0	1.4998	1.5070
589.3	1.54425	1.55336	4000.0	1.4654	1.4709

dn/dT @ 640nm

$n_e$	$-0.65 \times 10^{-5}/^{\circ}\text{C}$
$n_o$	$-0.55 \times 10^{-5}/^{\circ}\text{C}$

<sup>a</sup> Measured in accordance with IEC Standard CEI/IEC 758, Second Edition, 1993-04.

<sup>b</sup> Right handedness defined as clockwise rotation of light polarization plane while viewing toward the light source.