

# LN - Lithium Niobate (LiNbO<sub>3</sub>)

## Introduction

Lithium Niobate (LiNbO<sub>3</sub> or LN) is widely used as frequency doublers for wavelength > 1 μm, optical parametric oscillators (OPOs) pumped at 1064 nm as well as quasi-phase-matched (QPM) devices. Additionally due to its large Electro-Optic (E-O) and Acousto-Optic (A-O) coefficients, LiNbO<sub>3</sub> crystal is the most commonly used material for Pockel cells, Q-switches and phase modulators, waveguide substrates, and surface acoustic wave (SAW) wafers, etc. CASTECH can provide LiNbO<sub>3</sub> crystals with high quality and large size for all these applications.

## CASTECH provides

- 50,000 to 100,000 pcs/month of LiNbO<sub>3</sub> wedges used for fiber optical isolators and circulators
- Strict quality control
- Technical support
- Fast delivery
- Competitive price

## Basic Properties

Table 1. Chemical and Physical Properties

Crystal Structure	Trigonal, Space group R3c, Point group 3m
Lattice Parameter	a = 5.148 Å, c = 13.863 Å
Melting Point	1253°C
Curie Temperature	1140°C
Mohs Hardness	5 Mohs
Density	4.64 g/cm <sup>3</sup>
Elastic Stiffness Coefficients	C <sup>E</sup> <sub>11</sub> = 2.33 ( × 10 <sup>11</sup> N/m <sup>2</sup> ) C <sup>E</sup> <sub>33</sub> = 2.77 ( × 10 <sup>11</sup> N/m <sup>2</sup> )

Table 2. Optical and Nonlinear Optical Properties

Transparency Range	420-5200 nm
Optical Homogeneity	~5 × 10 <sup>-5</sup> /cm
Refractive Indices	n <sub>e</sub> = 2.146, n <sub>o</sub> = 2.220 @1300 nm n <sub>e</sub> = 2.156, n <sub>o</sub> = 2.232 @1064 nm n <sub>e</sub> = 2.203, n <sub>o</sub> = 2.286 @632.8 nm
NLO Coefficients	d <sub>33</sub> = 86 × d <sub>36</sub> (KDP) d <sub>31</sub> = 11.6 × d <sub>36</sub> (KDP) d <sub>22</sub> = 5.6 × d <sub>36</sub> (KDP)
Effective NLO Coefficients	d <sub>eff</sub> (I) = d <sub>31</sub> sinθ - d <sub>22</sub> cosθ sin3Φ d <sub>eff</sub> (II) = d <sub>22</sub> cos <sup>2</sup> θ cos3Φ
Sellmeier Equations (λ in μm)	n <sub>o</sub> <sup>2</sup> = 4.9048 + 0.11768 / (λ <sup>2</sup> - 0.04750) - 0.027169 λ <sup>2</sup> n <sub>e</sub> <sup>2</sup> = 4.5820 + 0.099169 / (λ <sup>2</sup> - 0.04443) - 0.02195 λ <sup>2</sup>
Damage Threshold	100 MW/cm <sup>2</sup> (10 ns, 1064 nm)

Table 3. Thermal and Electrical Properties of LiNbO<sub>3</sub>

Thermal Conductivity	38 W/m/K @25 °C
Thermal Expansion Coefficients (at 25°C)	//a, $2.0 \times 10^{-6}/K$ //c, $2.2 \times 10^{-6}/K$
Resistivity	$2 \times 10^{-6} \Omega \cdot \text{cm}$ @200 °C
Dielectric Constants	$\epsilon_{11}^S/\epsilon_0 = 43, \epsilon_{11}^T/\epsilon_0 = 78$ $\epsilon_{33}^S/\epsilon_0 = 28, \epsilon_{33}^T/\epsilon_0 = 32$
Piezoelectric Strain Constant	$D_{22} = 2.04 \times 10^{-11} \text{ C/N}$ $D_{33} = 19.22 \times 10^{-11} \text{ C/N}$
Electro-Optic Coefficients	$\gamma_{33}^T = 32 \text{ pm/V}, \gamma_{33}^S = 31 \text{ pm/V},$ $\gamma_{31}^T = 10 \text{ pm/V}, \gamma_{31}^S = 8.6 \text{ pm/V},$ $\gamma_{22}^T = 6.8 \text{ pm/V}, \gamma_{22}^S = 3.4 \text{ pm/V}$
Half-Wave Voltage, DC	
Electrical field // z, light $\perp$ z;	3.03 KV
Electrical field // x or y, light // z;	4.02 KV

Table 4. Specifications

Dimension Tolerance	$(W \pm 0.1 \text{ mm}) \times (H \pm 0.1 \text{ mm}) \times (L \pm 0.2 \text{ mm})$
Clear Aperture	Central 90% of the diameter
Surface Quality (Scratch/Dig)	20/10 to MIL-PRF-13830B
Flatness	$\lambda/8$ @633 nm
Transmitted Wavefront Distortion	$\leq \lambda/4$ @633 nm
Parallelism	20 arc sec
Perpendicularity	$\leq 15$ arc min
Angle Tolerance	$\leq \pm 0.5^\circ$
Quality Warranty Period	One year under proper use

## AR-coatings

CASTECH provides the following AR-coatings:

- Dual Band AR-coating (DBAR) at 1064/532 nm on both surface, with low reflectance ( $R < 0.2\%$  @1064 nm and  $R < 0.5\%$  @532 nm)
- AR-coating and gold/chrome plated on side faces for E-O applications
- Other coatings are available upon request