Lithium Niobate

optical crystals

Lithium niobate is one of the most versatile and well-developed active optical materials. The crystal finds wide application in electro-optics, acousto-optics, nonlinear optics and guided-wave optics. Fundamental properties making lithium niobate suitable for such uses include a wide transparency range, high electro-optic and nonlinear optic coefficients, very high electro-mechanical coupling coefficients, and chemical and mechanical stability.

Crystal Technology is the world's leading producer of lithium niobate, manufacturing over 70 tons of the material each year. Over twenty-five years of experience and extensive research efforts have resulted in crystal growth and fabrication processes enabling large crystals of unequaled uniformity, both within individual crystals and from one crystal to the next.

SPECIFICATIONS

Following are typical specifications for fabricated crystals of congruent composition lithium niobate. Additional specifications or special tolerances can be quoted on request.

Size	*Linear dimensions up to 100 mm*
Compositional Uniformity	*48.38 ±0.01 mol% Li_2O*
Curie Temperature	*1142.3 ±0.7°C*
Dimension	*±0.25 mm*
Axes Orientation	*±30 arc minutes*
Optical Surface Finish	*10/5 scratch/dig per MIL-O-13830A (uncoated)* *20/10 scratch/dig (coated)*
Wavefront Distortion	*<λ/4/cm @ 633 nm*
Absorption Loss	*<0.15%/cm @ 1.06 µm*
Anti-reflection Coating	*<0.3%/surface*
Clear Aperture	*80% of central area*

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PHYSICAL AND OPTICAL PROPERTIES OF LITHIUM NIOBATE

There exists an abundance of published physical property data on lithium niobate, much of it inconsistent. The following data comprise reports of varying validity of measured properties of congruent composition material. For information on additional property data, consult the reviews referenced below.

Congruent Composition	48.38 mol% Li_2O
Congruent Melting Point	1250°C (approximate)
Curie Temperature	1142.3 ±0.7°C
Point Group	3m
Space Group	R3c
Lattice Constants (hexagonal)	a_H = 5.151 Å
	c_H = 13.866 Å
Density	4.65 g/cm^3
Mechanical Hardness	5 (Mohs)
Specific Heat (@ 25°C)	0.15 cal/g/°C
Thermal Conductivity (@ 25°C)	10^{-2} cal/cm•sec•°C
Thermal Expansion (@ 25°C)	$\alpha_a = 15 \times 10^{-6}$/°C
	$\alpha_c = 7.5 \times 10^{-6}$/°C
Optical Transmission (1cm length)	UV cutoff (1/e): 340 nm
	IR cutoff (1/e): 4600 nm

Dielectric Constants (@ 25°C)

unclamped (ν <500 kHz):	$\varepsilon_{11} = 85$	$\varepsilon_{33} = 28.7$
clamped (ν >10 MHz):	$\varepsilon_{11} = 44$	$\varepsilon_{33} = 27.9$

Electro-optic Coefficients (pm/V @ 633 nm)

	r_{13}	r_{22}	r_{33}	r_{51}	r_z
unclamped:	10	7	33	33	18
clamped:	9	3	31	28	19

Nonlinear Optical Coefficients (pm/V @ 1.06 µm)

$d_{22} = 3$ $d_{31} = -5$ $d_{33} = -33$

Pyroelectric Coefficient (@ 25°C) -8.3×10^{-5}C/°C/m^2

Piezoelectric Strain Coefficients (@ 25°C x 10^{-12} C/N)

$d_{15} = 69.2$	$d_{31} = -0.85$	
$d_{22} = 20.8$	$d_{33} = 6.0$	

Elastic Stiffness Coefficients (constant field @ 25°C in 10^{11} N/m^2)

$C_{11} = 2.030$	$C_{14} = 0.085$	$C_{44} = 0.595$
$C_{12} = 0.573$	$C_{33} = 2.424$	$C_{66} = 0.728$
$C_{13} = 0.752$		

CALCULATED INDICES OF REFRACTION AT ROOM TEMPERATURE

Wavelength (µm)	n_e	n_o
1150.0	2.1519	2.2225
1060.0	2.1561	2.2323
840.0	2.1719	2.2507
693.4	2.1909	2.2726
632.8	2.2028	2.2866
530.0	2.2355	2.3247
514.5	2.2422	2.3326
501.7	2.2486	2.3401
496.5	2.2514	2.3434
488.0	2.2561	2.3489
476.5	2.2627	2.3568
472.7	2.2652	2.3597
465.8	2.2699	2.3653
457.9	2.2760	2.3725
441.6	2.2887	2.3875

PARAMETERS FOR THE TEMPERATURE DEPENDENT SELLMEIER EQUATION

Parameter	n_e	n_o
A_1	4.582	4.9048
A_2	9.921×10^4	1.1775×10^5
A_3	2.109×10^2	2.1802×10^2
A_4	2.194×10^{-8}	2.7153×10^{-8}
B_1	5.2716×10^{-2}	2.2314×10^{-2}
B_2	-4.9143×10^{-5}	-2.9671×10^{-5}
B_3	2.2971×10^{-7}	2.1429×10^{-8}

$$n^2 = A_1 + \frac{A_2 + B_1 F}{\lambda^2 - (A_3 + B_2 F)^2} + B_3 F - A_4 \lambda^2$$

$F = (T - 24.5)(T + 570.5)$
T given in °C
λ given in nm

REVIEWS OF LITHIUM NIOBATE PROPERTY DATA

- Properties of Lithium Niobate, EMIS Data Reviews Series No. 5 (INSPEC, London, 1989).
- R. S. Weis and T. K. Gaylord, "Lithium Niobate: Summary of Physical Properties and Crystal Structure," Applied Physics A 37 (1985) pp. 191-203.
- A. Rauber, "Chemistry and Physics of Lithium Niobate," in Current Topics in Materials Science, vol. 1, Ed E. Kaldis (North-Holland, Amsterdam, 1978) pp. 481-601.
- Landolt-Bornstein, "Numerical data and functional relationships in science and technology," New Series, vol. III/16 and III/28a.

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