Lithium Niobate / Lithium Tantalate

acoustic crystals

Both lithium niobate and lithium tantalate are ferroelectric crystals which possess high Curie temperatures. These crystals exhibit excellent piezoelectric coupling coefficients, making them attractive for ultrasonic device applications. Both crystals are grown by the Czochralski technique which yields large, high quality single crystals in a number of different growth directions. After growth the crystals are poled into single domain at the Curie temperature. The result is a uniform, highly consistent piezoelectric transducer single crystal.

Lithium niobate possesses a number of useful cuts which are now extensively used in transducer applications. Two compressional cuts are popular, the z-cut and the 36° rotated y-cut. The shear mode cuts most commonly used are the x-cut and 163° rotated y-cut. Lithium tantalate also possesses useful cuts for compressional and shear wave mode transducers. The two most popular compressional cuts are the z-cut and the 47° rotated y-cut, while the x-cut and the 165° rotated y-cut are the most commonly used shear mode cuts.

Lithium niobate possesses very large electro-mechanical coupling coefficients – several times larger than quartz – and very low acoustic losses. Because of its Curie temperature of 1142°C, it can be utilized as a high temperature acoustic transducer, such as an accelerometer for jet aircraft. Acoustic wave delay lines and acousto-optic modulators, deflectors and filters now routinely employ lithium niobate for both shear and compressional wave generators because of its high efficiency, broad bandwidth capability, low dielectric constant for all orientations, and consistent repeatability.

Compared to quartz, lithium tantalate has a much larger electro-mechanical coupling and a number of zero temperature coefficient cuts of resonant frequency. As a result, it finds application in communications for acoustic resonator filters of broad bandwidth.

SPECIFICATIONS

	Lithium Niobate	Lithium Tantalate
Size	Diameters up to 100 mm Linear dimensions >250 mm	Diameters up to 75 mm Linear dimensions >50 mm
Tolerance	±0.25 mm to ±0.0025 mm	±0.25 mm to ±0.0025 mm
Compositional Uniformity	48.38 ±0.02 mol% Li_2O	47.7 ±0.16 mol% Li_2O
Curie Temperature	1142.3 ±0.7°C	601 ±5.5°C
Axes Orientation	±30 arc minutes	±30 arc minutes
Surface Finish	Ground or polished to a 10/5 scratch/dig finish per MIL-O-13830A	Ground or polished to a 10/5 scratch/dig finish per MIL-O-13830A

Crystal Technology, Inc.
An EPCOS Company

 DC-17-A 1/06

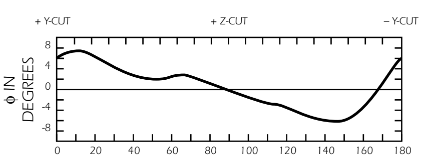
There exists an abundance of published physical property data on lithium niobate and lithium tantalate, much of it inconsistent. The following data comprise reports of varying validity of measured properties of congruent composition material. For information on the measurement tolerance associated with these data and for additional property data, consult the references below.

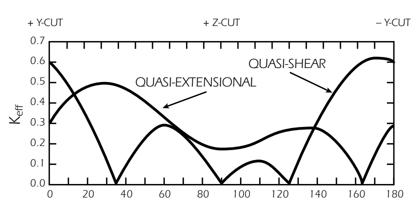
PHYSICAL PROPERTIES OF LITHIUM NIOBATE AND LITHIUM TANTALATE

	Lithium Niobate				**Lithium Tantalate**			
Congruent Melting Point (approximately)	1250°C				1650°C			
Point Group	3m				3m			
Space Group	R3c				R3c			
Lattice Constants (hexagonal)	a_H = 5.151 Å, C_H = 13.866 Å				a_H = 5.154 Å, C_H = 13.784 Å			
Density	4.65 g/cm^3				7.45 g/cm^3			
Mechanical Hardness	5 (Mohs)				5.5 (Mohs)			
Specific Heat (@25°C)	0.15 cal/g/°C				0.06 cal/g/°C			
Thermal Conductivity (@25°C)	10^{-2} cal/cm•sec•°C				3 x 10^{-4} cal/cm•sec•°C			
Thermal Expansion (@25°C)	α_a = 15 x 10^{-6}/°C, α_c = 7.5 x 10^{-6}/°C				α_a = 16 x 10^{-6}/°C. α_c = 4 x 10^{-6}/°C			
Pyroelectric Coefficient (@25°C)	-8.3 x 10^{-5}C/°C/m^2				-2.3 x 10^{-4}C/°C/m^2			
Piezoelectric Stress Constants	e_{15}	e_{22}	e_{31}	e_{33}	e_{15}	e_{22}	e_{31}	e_{33}
(@25°C, coulomb/m^2)	3.76	2.43	0.23	1.33	2.72	1.67	-0.38	1.09
Elastic Stiffness Constants	c_{11}	c_{12}	c_{13}	c_{14}	c_{11}	c_{12}	c_{13}	c_{14}
(constant field, @25°C, 10^{11} newton/m^2)	2.03	0.53	0.75	0.09	2.298	0.440	0.812	-0.104
	c_{33}	c_{44}	c_{66}		c_{33}	c_{44}	c_{66}	
	2.45	0.60	0.75		2.798	0.968	0.929	
Dielectric Constants (@25°C)								
unclamped	ε_{11} = 85		ε_{33} = 28.7		ε_{11} = 54		ε_{33} = 43	
clamped	ε_{11} = 44		ε_{33} = 27.9		___		___	

SELECTIVE PIEZOELECTRIC COUPLING FACTORS AND RESONANT FREQUENCY CONSTANTS (MHz-mm)

	Lithium Niobate	**Lithium Tantalate**
Plate Orientation = X Wave Type = Shear	Coupling Factor = 0.68 Resonant Frequency Constant = 1.838	Coupling Factor = 0.44 Resonant Frequency Constant = 1.906
Plate Orientation = Z Wave Type = Compressional	Coupling Factor = 0.17 Resonant Frequency Constant = 3.615	Coupling Factor = 0.19 Resonant Frequency Constant = 3.040
Plate Orientation = 36° rotated y-cut Wave Type = Quasi-Compressional	Coupling Factor = 0.49 Resonant Frequency Constant = 3.300	
Plate Orientation = 47° rotated y-cut Wave Type = Quasi-Compressional		Coupling Factor = 0.29 Resonant Frequency Constant = 3.080
Plate Orientation = 163° rotated y-cut Wave Type = Quasi-Shear	Coupling Factor = 0.62 Resonant Frequency Constant = 1.866	
Plate Orientation = 165° rotated y-cut Wave Type = Quasi-Shear		Coupling Factor = 0.41 Resonant Frequency Constant = 1.830





Effective coupling factors and angle φ between quasi-compressional wave displacement and plate are normal for rotated y-cuts of $LiNbO_3$.

REFERENCE

- 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 Kaldis (North-Holland, Amsterdam, 1978) pp. 481-601.
- R. T. Smith and F. S. Welsh, "Temperature Dependence of the Elastic,Piezoeletric and Dielectric Constants of Lithium Tantalate and Lithium Niobate", Journal of Applied Physics, vol. 42, no. 6 (1971) pp. 2219-2230.
- A. W. Warner, M. Onoe, G. A. Coquin, "Determination of Elastic and Piezoelectric Constants for Crystal in Class (3m)", Journal of Acoustical Society of America, vol. 42, no. 6 (1967) pp. 1223-1231.

Crystal Technology, Inc.
An EPCOS Company

1040 East Meadow Circle
Palo Alto, California 94303
www.crystaltechnology.com

Tel: (650) 856-7911
Fax: (650) 354-0173