

Properties of Stoichiometric LiNbO₃

Properties		【Stoichiometric】 LiNbO ₃ (SLN)
Crystal system		Trigonal
Space group		R3c
Curie temperature	T _c (°C)	~ 1200 ~ 1220(MgO doped)
[Li ₂ O]:[Nb ₂ O ₅] mol ratio (estimated from T _c)		49.9: 50.1
Lattice parameters	c ₀ (nm)	0.51482
	a ₀ (nm)	1.3857
Absorption edge ¹ data	nm	305
Refractive indices (@633nm)	n _o	2.2865
	n _e	2.1898
Birefringence	n _o -n _e	0.0967
Linear EO constants ²	r ₃₃ (pm/V)	29.0 at 633nm
Nonlinear optical constants ³	d ₃₁ (pm/V)	4.7
	d ₃₃ (pm/V)	23.8
Domain switching E-field ⁴ (coercive field) data	E _c (kV/mm)	< 4
Thermal conductivity ⁵ data	W/(m·K)	5.97 5.62 (MgO doped)
Laser damage threshold (MgO doped only)	GW/cm ²	~ 14 (at 1053nm, 1ns pulse)
Photorefractive damage threshold ⁶ data (MgO doped only)	MW/cm ²	2 (at 532nm, cw)
GRIIRA ⁷ data	ppm/cm ²	~ 300

¹ Y. Furukawa et al., "Improved Properties of Stoichiometric LiNbO₃ for Electro-Optic Applications", J. Intel. Mat. Sys. Struc. **10**, p.470(1999)

² S. Mori et al., The 55th Spring Meeting, 2008, The Jpn. Soc. Appl.Phys. 28a-ZG-4, p.1222 (2008)

³ I. Shoji et al., The 67th Autumn Meeting, 2006, The Jpn. Soc. Appl. Phys. 30p-ZX-2, p.1080 (2006)

⁴ V. Gopalan et al. "The role of nonstoichiometry in 180°domain switching of LiNbO₃ crystals", Appl. Phys. Lett. **72**, p.1981 (1998)

⁵ K. Kitamura et al., Oyo buturi **74**, p.573 (2005)

⁶ Y. Furukawa et al., "Stoichiometric Mg:LiNbO₃ as an effective material for nonlinear optics", Opt. Lett. **23**, p.1981 (1998)

⁷ Y. Furukawa et al., "Elimination of photorefractive and green-induced-infrared-absorption in MgO-doped near-stoichiometric LiNbO₃"
Topical meeting on Advanced Solid-State Lasers (ASSL), p.480 (2000)

◆ Absorption spectra

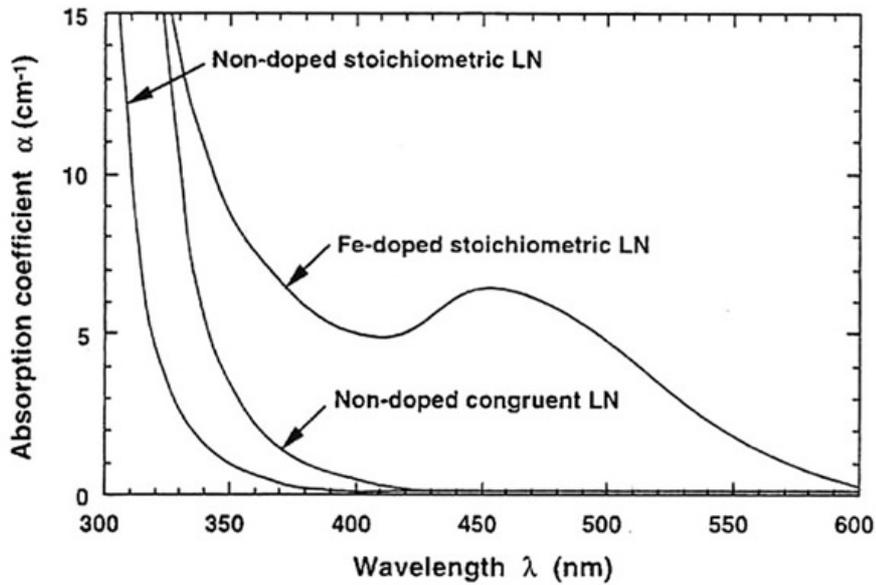


Figure 5. Absorption spectra of as-grown LiNbO_3 crystals.

◆ Switching fields

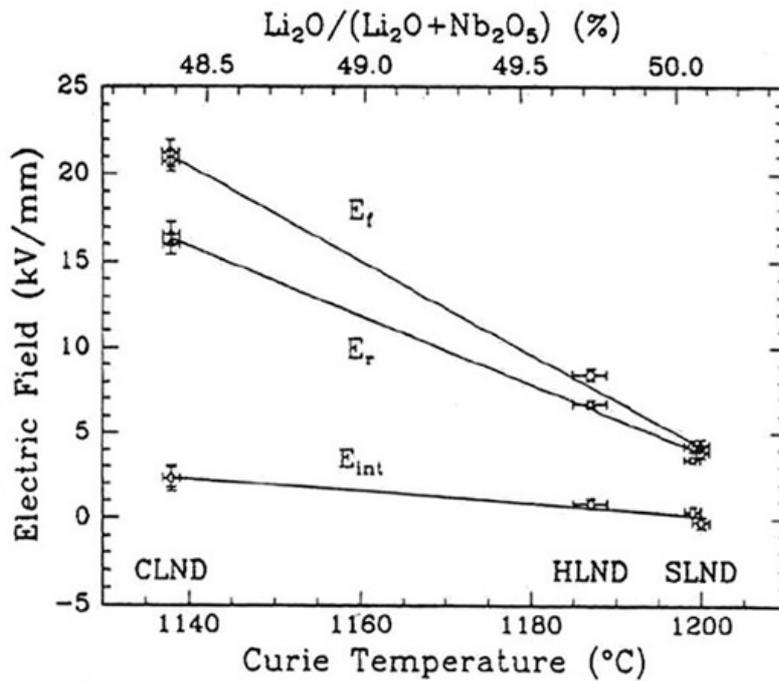


FIG. 2. The switching fields, E_f for forward poling and E_r for reverse poling, and internal field E_{int} as a function of the measured Curie temperatures, T_c , of LiNbO_3 crystals with low hydrogen content (samples CLND, SLND, and HLND).

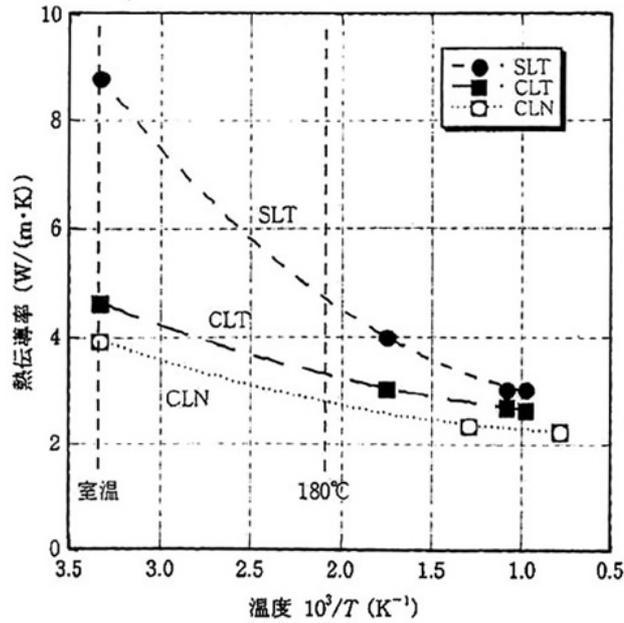


図9 SLT, CLT, CLNの熱伝導率の温度依存性, 熱伝導率は温度と反比例し, 室温から200°Cまで上昇すると著しく減少する.

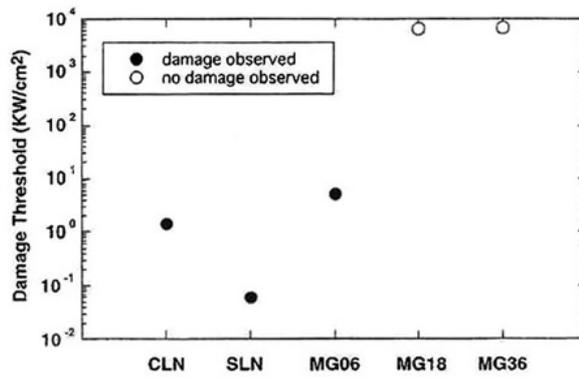


Fig. 1. Photorefractive damage threshold for CLN (congruent LiNbO₃), SLN (stoichiometric LiNbO₃), MG06 (MgO 0.6-mol. % doped SLN), MG18 (MgO 1.8-mol. % doped SLN), and MG36 (MgO 3.6-mol. % doped SLN).

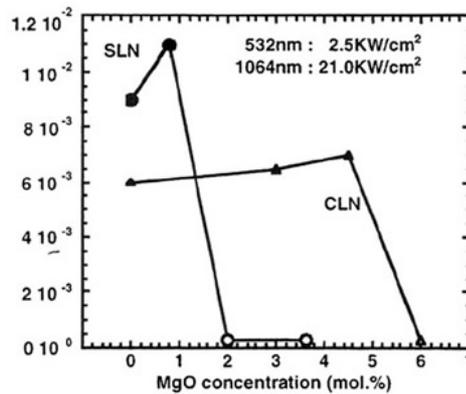


Fig. 3. Green induced infrared absorption versus MgO concentration in SLN and CLN crystals.

定比LiTaO3 特性比較表

特性		【当社開発】 定比組成 LiTaO3 (SLT)	CLT比較
		スーパーLT	
結晶系		三方晶	
空間群		R3c	
キュリー温度 :T _c (°C) ¹	表	T _c (°C) 690 695 (MgO-doped)	
[Li ₂ O]:[Ta ₂ O ₅]モル比 (T _c より推定)		49.95 : 50.05	
格子定数 c (nm)		c ₀ (nm) 0.51509	
格子定数 a (nm)		a ₀ (nm) 1.3773	
吸収端 (nm) ²	表	nm 270	
屈折率 ³	表	n _o 2.1770 @633nm	
		n _e 2.1745 @633nm	
複屈折		n _e -n _o -0.0025 @633nm	
線形電気光学定数 ⁴		r ₃₁ (pm/V) 8.4 @633nm	
		r ₃₃ (pm/V) 30.5 @633nm	
非線形光学定数 ⁵ (CLTに対する測定値)	表	d ₃₁ (pm/V) 0.85	
		d ₃₃ (pm/V) 13.8	
分極反転電圧 (室温.抗電界) ⁶		E _c (kV/mm) < 1.7	CLTの約1/13
熱伝導率 ⁷	表	W/(m・K) 8.78 8.43 (MgO-doped)	CLTの約2倍
Photorefractiveダメージ閾値 ⁸	表	MW/cm ² @532nm 2	CLTの約200倍
GRIIRA ⁹	表	ppm/cm @3.6kW/cm ² CW Green <100 ~50 (MgO-doped)	CLTの1/3以下

¹M.Nakamura et al., "Refractive Indices in Undoped and MgO-doped Near-Stoichiometric LiTaO3 Crystals", Jpn. J. Appl. Phys. **41** L465 (2002)

²Handbook of Advanced Electronic and Photonic Materials and Devices, edited by H.S. Nalwa, "Volume 4: Ferroelectrics and Dielectrics", Chapter 2, p.62 (2001)

² V.Gopalan et al., Crystal Growth, Characterization, and Domain Studies in Lithium Niobate and Lithium Tantalate Ferroelectrics

³M.Nakamura et al., "Refractive Indices in Undoped and MgO-doped Near-Stoichiometric LiTaO3 Crystals", Jpn. J. Appl. Phys. **41** L465 (2002)

⁴Onuki, K., Uchida, N., Saku, T., "Interferometric Method for Measuring Electro-optic Coefficients in Crystals", J. Opt. Soc. Am. **62** (1972) 1030

⁵I.Shoji et al., "Absolute scale of second-order nonlinear-optical coefficients" J.Opt. Soc. Am. B **14** p.2268 (1997)

⁶T.Hatanaka et al. "Quasi-phase-matched optical parametric oscillation with periodically poled stoichiometric LiTaO3", J.Opt. Soc. Am. B **14** p.2268 (1997)

⁷K. Kitamura et al., Oyo buturi **74**, p.573 (2005)

⁸K.Kitamura et al., "Non-stoichiometric control of LiNbO3 and LiTaO3 in ferroelectric domain engineering for optical devices", Ferroelectrics **257**, p.235 (2001)

⁹K.Kitamura et al., "Non-stoichiometric control of LiNbO3 and LiTaO3 in ferroelectric domain engineering for optical devices", Ferroelectrics **257**, p.235 (2001)

◆キュリー温度

Table 1. Curie temperatures of the undoped and MgO (0.5 and 1-mol%)-doped SLT crystals, CLT crystal and ceramics of known [Li]/[Ta] ratio.

Sample	Curie temperature, T_c [°C]
SLT	688
MgO 0.5 mol% SLT	694
MgO 1 mol% SLT	695
CLT	604
Ceramics (Li/Ta=49.9/50.1)	686
Ceramics (Li/Ta=50/50)	694

◆吸収端

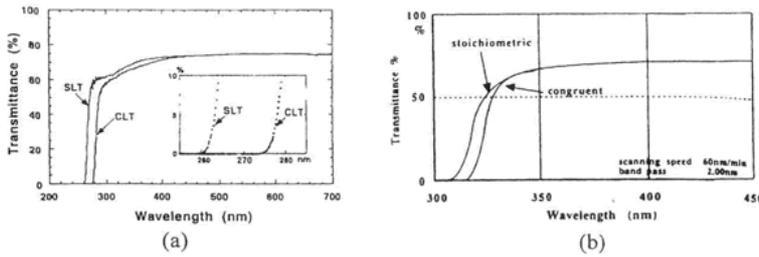
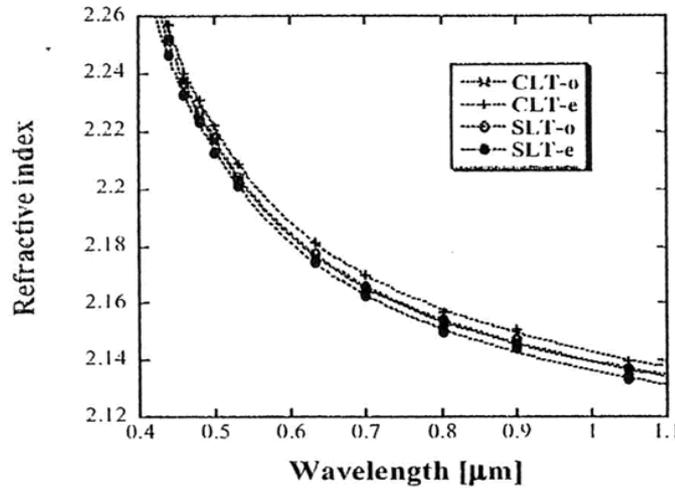


Fig. 5. (a) Transmittance spectrum of congruent and stoichiometric LiTaO_3 crystals. Reprinted from *J. Cryst. Growth*, 116, K. Kitamura et al., 327, © (1992), with permission from Elsevier Science. (b) Transmittance spectrum of congruent and stoichiometric LiNbO_3 crystals.

◆屈折率



◆非線形光学定数

Table 10. Absolute Magnitudes of Second-Order Nonlinear-Optical Coefficients (pm/V)^a

Crystal	d_{ij}	Wavelength (Method of Measurement)					
		1.313 μm (SHG)	1.064 μm (SHG)	0.852 μm (SHG)	0.532 μm		0.488 μm (PF)
				DFG	PF		
Congruent LiNbO_3	d_{33}	19.5	25.2	25.7			
	d_{31}	3.2	4.6	4.8	4.3	4.3	4.8
1% MgO: LiNbO_3	d_{33}	20.3	24.9	27.5			
	d_{31}	3.2	4.6	4.8			
5% MgO: LiNbO_3	d_{33}	20.3	25.0	28.4			
	d_{31}	3.4	4.4	4.9			4.9
LiTaO_3	d_{33}	10.7	13.8	15.1			
	d_{31}		0.85				
KNbO_3	d_{33}	16.1	19.6	22.3			
	d_{31}	9.2	10.8	11.0			
	d_{15}		12.5				
KTP	d_{33}	11.1	14.6	16.6			
	d_{31}		3.7				
	d_{22}		2.2				
	d_{15}	2.6	3.7	3.9			
KDP	d_{24}	1.4	1.9	1.9			
Quartz	d_{36}		0.39				
	d_{11}		0.30				

^aThe wavelengths shown are the fundamental wavelengths for SHG and the pump wavelengths for DFG and PF.

◆熱伝導率

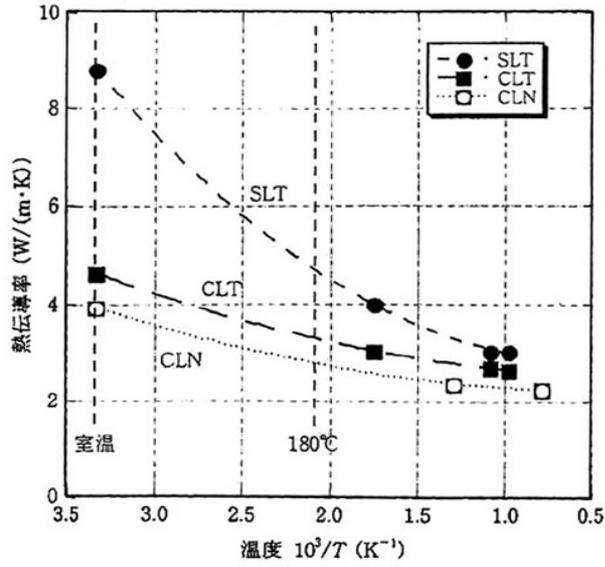


図9 SLT, CLT, CLNの熱伝導率の温度依存性, 熱伝導率は温度と反比例し, 室温から200℃まで上昇すると著しく減少する.

◆Photorefractiveダメージ閾値

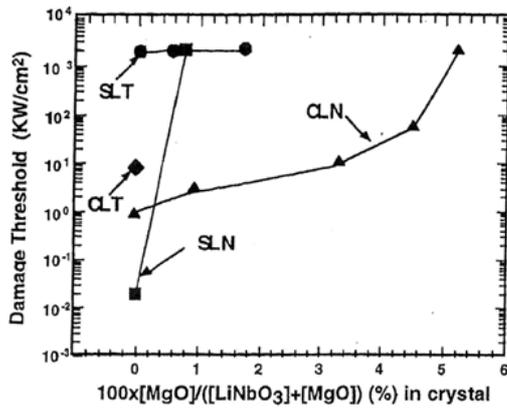


Figure 3. Photorefractive damage threshold behavior as a function of the MgO concentration in LiNbO₃ and LiTaO₃ crystals.

◆GRIIRA

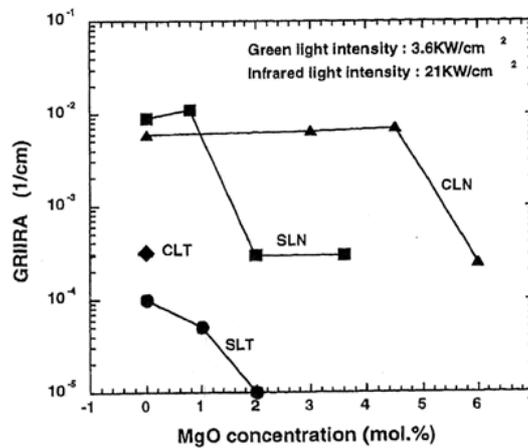


Figure 2. Green induced infrared absorption (GRIIRA) versus MgO concentration in LiNbO₃ and LiTaO₃ crystals.