23. Dielectrics and Electrooptics

Gagik G. Gurzadyan, Pancho Tzankov

The present chapter describes the physical properties of dielectrics and includes the following data:

1. *Low-frequency properties*, i. e., density and Mohs hardness, thermal conductivity, static dielectric constant, dissipation factor (loss tangent), elastic stiffness and elastic compliance, and piezoelectric strain
2. *High-frequency* (*optical*) *properties*, i. e., elastooptic and electrooptic coefficients, optical transparency range, two-photon absorption coefficient, refractive indices and their temperature variation, dispersion relations (Sellmeier equations), and second and/or third-order nonlinear dielectric susceptibilities.

A large amount of the information in this chapter is taken from the compilations of low- and high-frequency properties of dielectric crystals in Landolt–Börnstein, Group III, Vols. 29 and 30, especially Vol. 30b. Since 1992–1993, the date of publication of the first of these volumes, a large amount of new data on the physical properties of dielectrics has appeared in the literature. In particular, various linear and nonlinear optical properties of new crystals in the borate family have been (re)measured. Among these are: beta barium borate (BBO), lithium triborate (LBO), cesium borate (CBO), cesium lithium borate (CLBO) and new organic crystals such as deuterated L-arginine phosphate (DLAP) and 2-methyl-4-nitro-*N*-methylaniline (MNMA). This situation has encouraged us to refresh the knowledge about these crystals by adding new data from publications from the last decade. We have also included the most commonly used isotropic materials. The criteria for the selection of 124 dielectrics out of several hundred were their wide range of application and the availability of most of the above-mentioned data.

One of our aims was to produce a reader-friendly compilation. For this purpose, all data on dielectrics are presented in a unified form in tables that are similar for both isotropic materials and crystals of various symmetry classes. Moreover, *all* data for each particular material are collected together in one place. Sections 23.1–23.2 serve as a brief introduction to the various physical phenomena and to the definitions, symbols, and abbreviations used. All numerical data are presented in Sect. 23.4. The tables in this chapter are arranged according to piezoelectric classes in order of decreasing symmetry. Guidelines for searching for (and finding!) the required parameter in these tables can be found in Sect. 23.3.

The following Table 23.1 presents a list of the 124 different substances which have been selected to be described in Sect. 23.4.

The physical quantities used to describe the properties of the dielectric substances are drawn up in Table 23.2.

W. Martienssen, H. Warlimont (Eds.), *Springer Handbook of Materials Data*, https://doi.org/10.1007/978-3-319-69743-7_23

Table 23.1 Alphabetical list of described crystals and isotropic dielectrics

Name of material	Formula	Symbol
α-Aluminium oxide (sapphire)	Al_2O_3	
Aluminium phosphate (berlinite)	$AlPO_4$	
Ammonium dideuterium phosphate	$ND_4D_2PO_4$	AD*P or DADP
Ammonium dihydrogen arsenate	$NH_4H_2AsO_4$	ADA
Ammonium dihydrogen phosphate	$NH_4H_2PO_4$	ADP
Ammonium sulfate	$(NH_4)_2SO_4$	
β-Barium borate	BaB_2O_4	BBO
Barium fluoride	BaF_2	
Barium formate	$Ba(COOH)_2$	
Barium magnesium fluoride	$BaMgF_4$	BMF
Barium nitrite monohydrate	$Ba(NO_2)_2 \cdot H_2O$	
Barium sodium niobate (*banana*)	$Ba_2NaNb_5O_{15}$	
Barium titanate	$BaTiO_3$	
Beryllium oxide (bromellite)	BeO	
Bismuth germanium oxide	$Bi_{12}GeO_{20}$	BGO
Bismuth silicon oxide (sillenite)	$Bi_{12}SiO_{20}$	BSO
Bismuth triborate	BiB_3O_6	BIBO
BK7 Schott glass		BK7
Cadmium germanium arsenide	$CdGeAs_2$	
Cadmium germanium phosphide	$CdGeP_2$	
Cadmium selenide	$CdSe$	
Cadmium sulfide (greenockite)	CdS	
Cadmium telluride (Irtran-6)	$CdTe$	
Calcite (calcspar, Iceland spar)	$CaCO_3$	
Calcium fluoride (fluorite, fluorspar, Irtran-3)	CaF_2	
Calcium tartrate tetrahydrate	$Ca(C_4H_4O_6) \cdot 4H_2O$	L-CTT
Cesium dideuterium arsenate	CsD_2AsO_4	CD*A or DCDA
Cesium dihydrogen arsenate	CsH_2AsO_4	CsDA or CDA
Cesium lithium borate	$CsLiB_6O_{10}$	CLBO
Cesium triborate	CsB_3O_5	CBO
m-Chloronitrobenzene	$ClC_6H_4NO_2$	CNB
Copper bromide	$CuBr$	
Copper chloride (nantokite)	$CuCl$	
Copper gallium selenide	$CuGaSe_2$	
Copper gallium sulfide	$CuGaS_2$	
Copper iodide	CuI	
2-Cyclooctylamino-5-nitropyridine	$C_{13}H_{19}N_3O_2$	COANP
Deuterated L-arginine phosphate	$(ND_xH_{2-x})_2^+(CND)(CH_2)_3CH$ $(ND_yH_{3-y})^+COO^- \cdot D_2PO_4^- \cdot D_2O$	DLAP
Diamond	C	
4-(*N*,*N*-Dimethylamino)-3-acetamido-nitrobenzene (*N*-[2-(dimethylamino)-5-nitrophenyl]-acetamide)	$C_{10}H_{13}N_3O_3$	DAN
N,*N*-Dimethyl-4-nitroaniline	$C_8H_{10}N_2O_2$	MNMA
Dipotassium tartrate hemihydrate	$K_2C_4H_4O_6 \cdot 0.5H_2O$	DKT
Gadolinium molybdate	$Gd_2(MoO_4)_3$	GMO
Gallium antimonide	$GaSb$	
Gallium arsenide	$GaAs$	
Gallium nitride	GaN	
Gallium phosphide	GaP	
Gallium selenide	$GaSe$	
Gallium sulfide	GaS	
Germanium	Ge	
Indium antimonide	$InSb$	

Table 23.1 (continued)

Name of material	Formula	Symbol
Indium arsenide	InAs	
Indium phosphide	InP	
α-Iodic acid	HIO_3	
Lead molybdate	$PbMoO_4$	
Lead titanate	$PbTiO_3$	
Lithium fluoride	LiF	
Lithium formate monohydrate	$LiCOOH \cdot H_2O$	LFM
Lithium gallium oxide (lithium metagallate)	$LiGaO_2$	
α-Lithium iodate	$LiIO_3$	
Lithium niobate	$LiNbO_3$	
Lithium niobate (MgO-doped)	$MgO:LiNbO_3$	
Lithium sulfate monohydrate	$Li_2SO_4 \cdot H_2O$	
Lithium tantalate	$LiTaO_3$	
Lithium tetraborate	$Li_2B_4O_7$	
Lithium triborate	LiB_3O_5	LBO
Magnesium fluoride	MgF_2	
Magnesium oxide	MgO	
Magnesium silicate (forsterite)	Mg_2SiO_4	
α-Mercury sulfide (cinnabar)	HgS	
3-Methyl-4-nitropyridine-1-oxide	$C_6N_2O_3H_6$	POM
m-Nitroaniline (3-nitrobenzenamine, *meta*-nitroaniline)	$C_6H_4(NO_2)NH_2$	mNA
Poly(methyl methacrylate) (Plexiglas®)	$(C_5H_8O_2)_n$	PMMA
Potassium acid phthalate	$KH(C_8H_4O_4)$	
Potassium bromide	KBr	
Potassium chloride (sylvine, sylvite)	KCl	
Potassium dideuterium arsenate	KD_2AsO_4	KD*A or DKDA
Potassium dideuterium phosphate	KD_2PO_4	KD*P or DKDP
Potassium dihydrogen arsenate	KH_2AsO_4	KDA
Potassium dihydrogen phosphate	KH_2PO_4	KDP
Potassium fluoroboratoberyllate	$KBe_2BO_3F_2$	KBBF
Potassium iodide	KI	
Potassium lithium niobate	$K_3Li_2Nb_5O_{15}$	KLINBO
Potassium niobate	$KNbO_3$	
Potassium pentaborate tetrahydrate	$KB_5O_8 \cdot 4H_2O$	KB5
Potassium sodium tartrate tetrahydrate (Rochelle salt)	$KNa(C_4H_4O_6) \cdot 4H_2O$	
Potassium titanate (titanyl) phosphate	$KTiOPO_4$	KTP
Potassium titanyl arsenate	$KTiOAsO_4$	KTA
Rubidium dideuterium arsenate	RbD_2AsO_4	RbD*A, RD*A, or DRDA
Rubidium dideuterium phosphate	RbD_2PO_4	RbD*P, RD*P, or DRDP
Rubidium dihydrogen arsenate	RbH_2AsO_4	RbDA or RDA
Rubidium dihydrogen phosphate	RbH_2PO_4	RbDP or RDP
Rubidium titanate (titanyl) phosphate	$RbTiOPO_4$	RTP
D(+)-Saccharose (sucrose)	$C_{12}H_{22}O_{11}$	
Silicon	Si	
α-Silicon carbide	SiC	
α-Silicon dioxide (quartz)	SiO_2	
Silicon dioxide (fused silica)	SiO_2	
Silver antimony sulfide (pyrargyrite)	Ag_3SbS_3	
Silver arsenic sulfide (proustite)	Ag_3AsS_3	
Silver gallium selenide	$AgGaSe_2$	
Silver gallium sulfide (silver thiogallate)	$AgGaS_2$	

Table 23.1 (continued)

Name of material	Formula	Symbol
Sodium ammonium tartrate tetrahydrate (ammonium Rochelle salt)	$Na(NH_4)C_4H_4O_6 \cdot 4H_2O$	
Sodium chlorate	$NaClO_3$	
Sodium chloride (rock salt, halite)	NaCl	
Sodium fluoride	NaF	
Sodium nitrite	$NaNO_2$	
Strontium fluoride	SrF_2	
Strontium titanate	$SrTiO_3$	
Tellurium	Te	
Tellurium dioxide (paratellurite)	TeO_2	
Thallium arsenic selenide	Tl_3AsSe_3	Thallium arsenic selenide (TAS)
Titanium dioxide (rutile)	TiO_2	
Tourmaline	$(Na, Ca)(Mg, Fe)_3B_3Al_6Si_6(O, OH, F)_{31}$	
Triglycine sulfate	$(CH_2NH_2COOH)_3 \cdot H_2SO_4$	TGS
Urea	$(NH_2)_2CO$	
Yttrium aluminate	$YAlO_3$	YAP or YALO
Yttrium aluminium garnet	$Y_3Al_5O_{12}$	YAG
Yttrium lithium fluoride	$YLiF_4$	YLF
Yttrium vanadate	YVO_4	YVO
Zinc germanium diphosphide	$ZnGeP_2$	
Zinc oxide (zincite)	ZnO	
Zinc selenide	ZnSe	
α-Zinc sulfide (wurtzite)	ZnS	
Zinc telluride	ZnTe	

Table 23.2 Used physical quantities, their symbols and their units

Symbol	Physical quantity	Unit
B_{ij} (B_m)	Relative dielectric impermeability	Dimensionless
C	Capacitance	C/V
c_{ijkl} (c_{mn})	Elastic stiffness tensor	10^9 Pa = GPa
D	Electric displacement field (or electric flux density)	C/m^2
d_{ijk} (d_{in})	Piezoelectric strain tensor	10^{-12} C/N
E	Electric field	V/m
n	Refractive index	Dimensionless
P	Polarization (dipole moment per unit volume of matter)	C/m^2
p_{ijkl} (p_{mn})	Elastooptic tensor	Dimensionless
q_{ijkl} (q_{mn})	Piezooptic tensor	$10^{-9}\,Pa^{-1} = GPa^{-1}$
r_{ijk} (r_{mk})	Electrooptic coefficient	10^{-12} m/V = pm/V
r^S_{mk}, r^T_{mk}	Electrooptic coefficient at constant strain or stress, respectively	10^{-12} m/V = pm/V
S_{ij} (S_m)	Strain tensor	Dimensionless
s_{ijkl} (s_{mn})	Elastic compliance tensor	$10^{-12}\,Pa^{-1} = TPa^{-1}$
T_{ij} (T_m)	Stress tensor	10^9 Pa = GPa
$\tan\delta$	Dissipation factor (loss tangent)	Dimensionless
ϱ	Density	g/cm^3
ε_0	Dielectric constant (or permittivity) of free space (vacuum),	8.854×10^{-12} C/(V m)
ε	Relative dielectric constant (permittivity)	Dimensionless
κ_{ij}	Thermal conductivity	W/(m K)
v^s_{mn}	Sound velocity in the direction mn	m/s
$\chi_{ij}(\chi^{(1)}_{ij})$	Linear dielectric susceptibility	Dimensionless
$\chi^{(2)}_{ijk}$, d_{ijk} (d_{im})	Second-order nonlinear dielectric susceptibility	10^{-12} m/V = pm/V
$\chi^{(3)}_{ijkl}$	Third-order nonlinear dielectric susceptibility	$10^{-22}\,m^2/V^2$

23.1 Dielectric Materials: Low-Frequency Properties

23.1.1 General Dielectric Properties

Density

The density of a substance is defined as the mass per unit volume of the substance

$$\varrho = \frac{m}{V} \,, \tag{23.1}$$

where V is the volume occupied by a mass m. The density is thus a measure of the volume concentration of mass.

Mohs Hardness Scale

In 1832, Mohs introduced a hardness scale ranging from 1 to 10, based on ten minerals:

1. Talc, $Mg_3H_2SiO_{12}$
2. Gypsum, $CaSO_4 \cdot 2H_2O$
3. Iceland spar, $CaCO_3$
4. Fluorite, CaF_2
5. Apatite, $Ca_5F(PO_4)_3$
6. Orthoclase, $KAlSi_3O_8$
7. Quartz, SiO_2
8. Topaz, $Al_2F_2SiO_4$
9. Corundum, Al_2O_3
10. Diamond, C.

Thermal Conductivity

A temperature gradient between different parts of a solid causes a flow of heat. In an isotropic medium, the heat flux of thermal energy h (i. e., the heat transfer rate per unit area normal to the direction of heat flow) is given by

$$h = -\kappa \operatorname{grad} T \,, \tag{23.2}$$

where κ is the thermal conductivity. In a crystal, this expression is replaced by

$$h_i = -\kappa_{ij} \frac{\partial T}{\partial x_j} \,. \tag{23.3}$$

Here κ_{ij} is the thermal-conductivity tensor. Note that other notations are also used in the literature, e.g., $\kappa \equiv \lambda$ or $\kappa \equiv k$.

23.1.2 Static Dielectric Constant (Low-Frequency)

In isotropic and cubic dielectric materials, the electric displacement field D, the electric field E, and the polarization P are connected by the relation

$$D = \varepsilon_0 E + P = \varepsilon_0 (1 + \chi) E \,, \tag{23.4}$$

where $\varepsilon_0 = 8.854 \times 10^{-12}\,\mathrm{C/(V\,m)}$ is the dielectric constant (or permittivity) of free space (vacuum), and χ is the *dielectric susceptibility*. The relative dielectric constant of the material is defined as

$$\varepsilon = 1 + \chi \,, \tag{23.5}$$

and therefore (23.4) becomes

$$D = \varepsilon_0 \varepsilon E \,. \tag{23.6}$$

In anisotropic crystals, these equations should be written in tensor form

$$D_i = \varepsilon_0 \varepsilon_{ij} E_j \,, \quad \varepsilon_{ij} = 1 + \chi_{ij} \,. \tag{23.7}$$

The following relations are valid

$$\varepsilon_{ij} = \varepsilon_{ji} \,, \quad \chi_{ij} = \chi_{ji} \,. \tag{23.8}$$

Note that other notations are also used in the literature, e.g., $\varepsilon \equiv \varepsilon_r$, or $\varepsilon \equiv \kappa$ and $\varepsilon_0 \equiv \kappa_0$.

23.1.3 Dissipation Factor

The capacitance C of a capacitor filled with a dielectric is

$$C = \frac{\varepsilon_0 \varepsilon A}{d} \,, \tag{23.9}$$

where A is the area of the two parallel plates and d is the spacing between them. For a lossy dielectric the relative dielectric constant ε can be represented in a complex form

$$\varepsilon = \varepsilon' - \mathrm{i}\varepsilon'' \,. \tag{23.10}$$

The imaginary part is the frequency-dependent conductivity

$$\sigma(\omega) = \omega \varepsilon_0 \varepsilon'' \,, \tag{23.11}$$

where ω is the frequency. The dissipation factor (or loss tangent) is defined as

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \,. \tag{23.12}$$

and in anisotropic crystals

$$\tan\delta_1 = \frac{\varepsilon''_{11}}{\varepsilon'_{11}} \,, \quad \tan\delta_2 = \frac{\varepsilon''_{22}}{\varepsilon'_{22}} \,,$$
$$\tan\delta_3 = \frac{\varepsilon''_{33}}{\varepsilon'_3} \,. \tag{23.13}$$

The quality factor Q of the dielectric is the reciprocal of the dissipation factor

$$Q = \frac{1}{\tan\delta} \,. \tag{23.14}$$

23.1.4 Elasticity

Hooke's law states that for sufficiently small deformations the strain is directly proportional to the stress. Thus the strain tensor **S** and the stress tensor **T** obey the relation

$$S_{ij} = s_{ijkl} T_{kl} \,, \tag{23.15}$$

where s_{ijkl} is called the *elastic compliance constant* (or compliance, or elastic constant). The *elastic stiffness constant* (or stiffness, or Young's modulus) is the reciprocal tensor

$$c_{ijkl} = s_{ijkl}^{-1} \,, \tag{23.16}$$

and for the stress tensor we have

$$T_{ij} = c_{ijkl} S_{kl} \,. \tag{23.17}$$

In the matrix notation for the elastic compliance and stiffness, we have

$$S_m = s_{mn} T_n \quad \text{and} \quad T_m = c_{mn} S_n \,, \tag{23.18}$$

where

$$\begin{aligned} s_{ijkl} &= s_{mn} && \text{when both } m \text{ and } n \text{ are } 1, 2, \text{ or } 3 \,, \\ 2s_{ijkl} &= s_{mn} && \text{when either } m \text{ or } n \text{ is } 4, 5, \text{ or } 6 \,, \\ 4s_{ijkl} &= s_{mn} && \text{when both } m \text{ and } n \text{ are } 4, 5, \text{ or } 6 \,, \\ c_{ijkl} &= c_{mn} && \text{for all } m \text{ and } n \,, \end{aligned} \tag{23.19}$$

and

$$\begin{aligned} S_{ij} &= S_m && \text{when } m \text{ is } 1, 2, \text{ or } 3 \,, \\ S_{ij} &= \frac{1}{2} S_m && \text{when } m \text{ is } 4, 5, \text{ or } 6 \,, \\ T_{ij} &= T_m && \text{for all } m \,. \end{aligned} \tag{23.20}$$

For relations between tensor and matrix notation, see Table 23.3. The sound velocity v^{s}_{mn} in the direction mn in a crystal is given by

Table 23.3 The relations between ij (tensor notation) and m (matrix notation), jk and n, and kl and n

Tensor notation	11	22	33	23 or 32	31 or 13	12 or 21
Matrix notation	1	2	3	4	5	6

$$v^{\mathrm{s}}_{mn} = \sqrt{\frac{c_{mn}}{\varrho}} \,. \tag{23.21}$$

23.1.5 Piezoelectricity

The phenomenon of the development of an electric moment P_i if a stress T_{jk} is applied to a crystal is called the direct piezoelectric effect

$$P_i = d_{ijk} T_{jk} \,, \tag{23.22}$$

where d_{ijk} is the piezoelectric strain tensor (or the piezoelectric moduli). The relation $d_{ijk} = d_{ikj}$ reduces the number of independent tensor components to 18. The matrix notation is introduced for the piezoelectric strain as follows

$$\begin{aligned} d_{ijk} &= d_{in} && \text{when } n = 1, 2, \text{ or } 3 \,, \\ 2d_{ijk} &= d_{in} && \text{when } n = 4, 5, \text{ or } 6 \,, \end{aligned} \tag{23.23}$$

and thus

$$P_i = d_{in} T_n \,. \tag{23.24}$$

The relations between jk and n are presented in Table 23.3.

The converse piezoelectric effect is described by

$$S_{jk} = d_{ijk} E_i \tag{23.25}$$

and, correspondingly,

$$S_n = d_{in} E_i \,. \tag{23.26}$$

23.2 Optical Materials: High-Frequency Properties

23.2.1 Crystal Optics: General

The dielectric properties of a medium at optical frequencies are given by

$$D = \varepsilon_0 \varepsilon E \,, \tag{23.27}$$

where ε_0 is the dielectric constant of free space and ε is the relative dielectric constant of the material. From Maxwell's equations, the velocity of propagation of electromagnetic waves through the medium is given by

$$v = \frac{c}{\sqrt{\varepsilon}} \,, \tag{23.28}$$

where c is the velocity in vacuum (the relative magnetic permeability is taken as 1). The refractive index $n = c/v$ is therefore $n = \sqrt{\varepsilon}$.

In an anisotropic medium

$$D_i = \varepsilon_0 \varepsilon_{ij} E_j \,. \tag{23.29}$$

In this general case, two waves of different velocity may propagate through the crystal. The relative dielectric impermeabilities are defined as the reciprocals of the principal dielectric constants

$$B_i = \frac{1}{\varepsilon_i} = \frac{1}{n_i^2} . \qquad (23.30)$$

23.2.2 Photoelastic Effect

The photoelastic effect is the effect in which a change of the refractive index is caused by stress. The changes in the relative dielectric impermeabilities are

$$\Delta B_{ij} = q_{ijkl} T_{kl} , \qquad (23.31)$$

where the q_{ijkl} are the piezooptic coefficients. The photoelastic effect can also be expressed in terms of the stress

$$\Delta B_{ij} = p_{ijrs} S_{rs} , \qquad (23.32)$$

where the $p_{ijrs} = q_{ijkl} c_{klrs}$ are the (dimensionless) elastooptic coefficients. In matrix notation,

$$\Delta B_m = q_{mn} T_n \quad \text{and} \quad \Delta B_m = p_{mn} S_n . \qquad (23.33)$$

Note that $q_{mn} = q_{ijkl}$ when $n = 1, 2$, or 3 and $q_{mn} = 2q_{ijkl}$ when $n = 4, 5$, or 6; $p_{mn} = p_{ijrs}$ (Table 23.3).

23.2.3 Electrooptic Effect

The electrooptic effect is the effect in which a change in the refractive index of a crystal is produced by an electric field

$$n = n_0 + aE_0 + bE_0^2 + \dots , \qquad (23.34)$$

where a and b are constants and n_0 is the refractive index at $E_0 = 0$. The linear electrooptic effect (Pockels effect) is due to the first-order term aE_0. In isotropic dielectrics and in crystals with a center of symmetry, $a = 0$, and only the second-order term bE_0^2 and higher even-order terms exist (Kerr effect).

The changes in the relative dielectric impermeabilities are

$$\Delta B_{ij} = r_{ijk} E_k , \qquad (23.35)$$

where the r_{ijk} are the electrooptic coefficients. Since $r_{ijk} = r_{jik}$, the number of independent tensor components is 18, and the above formula can be written in matrix notation (Table 23.3)

$$\Delta B_m = r_{mk} E_k \quad (m = 1, 2, \dots, 6,\ k = 1, 2, 3) . \qquad (23.36)$$

23.2.4 Nonlinear Optical Effects

The dielectric polarization $\boldsymbol{P}$ is related to the electromagnetic field $\boldsymbol{E}$ at optical frequencies by the material equation of the medium

$$\boldsymbol{P}(\boldsymbol{E}) = \varepsilon_0 (\chi^{(1)} \boldsymbol{E} + \chi^{(2)} \boldsymbol{E}^2 + \chi^{(3)} \boldsymbol{E}^3 + \dots) , \qquad (23.37)$$

where $\chi^{(1)} = n^2 - 1$ is the linear dielectric susceptibility, and $\chi^{(2)}$, $\chi^{(3)}$, etc. are the nonlinear dielectric susceptibilities.

The Miller delta formulation is

$$\varepsilon_0 E_i(\omega_3) = \delta_{ijk} P_j(\omega_1) P_k(\omega_2) , \qquad (23.38)$$

where the Miller coefficient

$$\delta_{ijk} = \frac{1}{2\varepsilon_0} \frac{\chi_{ijk}^{(2)}(\omega_3)}{\chi_{ii}^{(1)}(\omega_1)\chi_{jj}^{(1)}(\omega_2)\chi_{kk}^{(1)}(\omega_3)} , \qquad (23.39)$$

has a small dispersion and is almost constant for a wide range of crystals.

For anisotropic media, the coefficients $\chi^{(1)}$ and $\chi^{(2)}$ are, in general, second- and third-rank tensors, respectively. In practice, the tensor

$$d_{ijk} = \left(\frac{1}{2}\right) \chi_{ijk} \qquad (23.40)$$

is used instead of χ_{ijk}. Usually the *plane* representation of d_{ijk} in the form d_{il} is used; the relations between jk and l are presented in Table 23.3.

The Kleinman symmetry conditions

$$\begin{aligned} &d_{21} = d_{16}, \quad d_{23} = d_{34}, \quad d_{14} = d_{25} = d_{36} , \\ &d_{26} = d_{12}, \quad d_{31} = d_{15}, \quad d_{32} = d_{24}, \quad d_{35} = d_{13} \end{aligned} \qquad (23.41)$$

are valid in the case of no dispersion of the electronic nonlinear polarizability.

The following three-wave interactions in crystals with a square nonlinearity ($\chi^{(2)} \neq 0$) are possible:

- Second-harmonic generation (SHG), $\omega + \omega = 2\omega$
- Sum frequency generation (SFG) or up-conversion, $\omega_1 + \omega_2 = \omega_3$
- Difference frequency generation (DFG) or down-conversion, $\omega_3 - \omega_2 = \omega_1$
- Optical parametric oscillation (OPO), $\omega_3 = \omega_2 + \omega_1$.

For efficient frequency conversion, the phase-matching condition $\boldsymbol{k}_1 + \boldsymbol{k}_2 = \boldsymbol{k}_3$, where the $\boldsymbol{k}_i$ are the wave vectors for ω_1, ω_2, and ω_3, respectively, must be satisfied. Two types of phase matching can be defined

type I: $\mathrm{o} + \mathrm{o} \to \mathrm{e}$ or $\mathrm{e} + \mathrm{e} \to \mathrm{o}$;

and

type II: $\mathrm{o} + \mathrm{e} \to \mathrm{e}$ or $\mathrm{o} + \mathrm{e} \to \mathrm{o}$.

These can be represented with a shortened notation as follows

$$\begin{aligned}
&\text{ooe: o} + \text{o} \to \text{e} \quad \text{or} \quad \text{e} \to \text{o} + \text{o}\,;\\
&\text{eeo: e} + \text{e} \to \text{o} \quad \text{or} \quad \text{o} \to \text{e} + \text{e}\,;\\
&\text{eoe: e} + \text{o} \to \text{e} \quad \text{or} \quad \text{e} \to \text{e} + \text{o}\,;\\
&\text{oeo: o} + \text{e} \to \text{o} \quad \text{or} \quad \text{o} \to \text{e} + \text{o}\,.
\end{aligned}$$

In the shortened notation (ooe, eoe, ...), the frequencies satisfy the condition $\omega_1 < \omega_2 < \omega_3$, i. e., the first symbol refers to the longest-wavelength radiation, and the last symbol refers to the shortest-wavelength radiation. Here the ordinary beam, or o-beam is the beam with its polarization normal to the principal plane of the crystal, i. e., the plane containing the wave vector $\boldsymbol{k}$ and the crystallophysical axis Z (or the optical axis, for uniaxial crystals). The extraordinary beam, or e-beam is the beam with its polarization in the principal plane. The third-order term $\chi^{(3)}$ is responsible for the optical Kerr effect.

Uniaxial Crystals

For uniaxial crystals, the difference between the refractive indices of the ordinary and extraordinary beams, the birefringence Δn, is zero along the optical axis (the crystallophysical axis Z) and maximum in a direction normal to this axis. The refractive index for the ordinary beam does not depend on the direction of propagation. However, the refractive index for the extraordinary beam $n^{\mathrm{e}}(\theta)$, is a function of the polar angle θ between the Z axis and the vector $\boldsymbol{k}$

$$n^{\mathrm{e}}(\theta) = n_{\mathrm{o}} \left(\frac{1 + \tan^2\theta}{1 + (n_{\mathrm{o}}/n_{\mathrm{e}})^2 \tan^2\theta} \right)^{1/2} , \qquad (23.42)$$

where n_{o} and n_{e} are the refractive indices of the ordinary and extraordinary beams, respectively in the plane normal to the Z axis, and are termed the *principal values*. If $n_{\mathrm{o}} > n_{\mathrm{e}}$ the crystal is called *negative*, and if $n_{\mathrm{o}} < n_{\mathrm{e}}$ it is called *positive*. For the o-beam, the indicatrix of the refractive indices is a sphere with radius n_{o}, and for the e-beam it is an ellipsoid of rotation with semiaxes n_{o} and n_{e}. In the crystal, in general, the beam is divided into two beams with orthogonal polarizations; the angle between these beams ρ is the *birefringence* (or *walk-off*) angle.

Equations for calculating phase-matching angles in uniaxial crystals are given in [23.1–4].

Biaxial Crystals

For biaxial crystals, the optical indicatrix is a bilayer surface with four points of interlayer contact, which correspond to the directions of the two optical axes. In the simple case of light propagation in the principal planes XY, YZ, and XZ, the dependences of the refractive indices on the direction of light propagation are represented by a combination of an ellipse and a circle. Thus, in the principal planes, a biaxial crystal can be considered as a uniaxial crystal; for example, a biaxial crystal with $n_Z > n_Y > n_X$ in the XY plane is similar to a negative uniaxial crystal with $n_{\mathrm{o}} = n_Z$

$$n^{\mathrm{e}}(\varphi) = n_Y \left(\frac{1 + \tan^2\varphi}{1 + (n_Y/n_X)^2 \tan^2\varphi} \right)^{1/2} , \qquad (23.43)$$

where φ is the azimutal angle. Equations for calculating phase-matching angles for propagation in the principal planes of biaxial crystals are given in [23.3–6].

23.3 Guidelines for Use of Tables

Tables 23.5–23.23 are arranged according to piezoelectric classes in order of decreasing symmetry (Table 23.4), and alphabetically within each class. They contain a number of columns placed on two pages, even and odd. The following properties are presented for each dielectric material: density ϱ, Mohs hardness, thermal conductivity κ, static dielectric constant ε_{ij}, dissipation factor $\tan\delta$ at various temperatures and frequencies, elastic stiffness c_{mn}, elastic compliance s_{mn} (for isotropic and cubic materials only), piezoelectric strain tensor d_{in}, elastooptic tensor p_{mn}, electrooptic coefficients r_{mk} (the latter two at 633 nm unless otherwise stated), optical transparency range, temperature variation of the refractive indices $\mathrm{d}n/\mathrm{d}T$, refractive indices n (the latter two at 1.064 μm unless otherwise stated), dispersion relations (Sellmeier equations), second-order nonlinear dielectric susceptibility d_{ij}, and third-order nonlinear dielectric susceptibility $\chi^{(3)}_{ijk}$ (for isotropic and cubic materials only) (the latter two at 1.064 μm unless otherwise stated). For isotropic materials, the two-photon absorption coefficient β is also included.

The numerical values of the elastic and elastooptic constants are often averages of three or more measurements, as presented in [23.7–11]. In such cases, the corresponding Landolt–Börnstein volume is cited together with the most reliable (latest) reference. The standard deviation of the averaged value is given in parentheses. Vertical bars $\|$ mean the modulus of the corresponding quantity. The absolute scale for the

Table 23.4 Number of independent components of the various property tensors

Symmetry point group	Dielectric tensor[a] ε_{ij}	Elastic tensor c_{mn} or s_{mn}	Piezoelectric tensor d_{imn}	Elastooptic tensor p_{mn} or q_{mn}	Electrooptic tensor r_{mk}	Nonlinear susceptibility tensors[b] $\chi^{(2)}$	$\chi^{(3)}$	Table number
Isotropic	1 (1)	2	0	2	0	0 (0)	1 (1)	Table 23.5
Cubic:								
432 (O)	1 (1)	3	0	3	0	0 (0)	2 (2)	
$m3m$ (O_h)	1 (1)	3	0	3	0	0 (0)	2 (2)	Table 23.6
$\bar{4}3m$ (T_d)	1 (1)	3	1	3	1	1 (1)	2 (2)	Table 23.7
23 (T)	1 (1)	3	1	4	1	1 (1)	3 (2)	Table 23.8
Hexagonal:								
$6/mmm$ (D_{6h})	2 (2)	5	0	6	0	0 (0)	4 (3)	
$6/m$ (C_{6h})	2 (2)	5	0	8	0	0 (0)	6 (3)	
622 (D_6)	2 (2)	5	1	6	1	1 (1)	4 (3)	
$\bar{6}m2$ (D_{3h})	2 (2)	5	1	6	1	1 (1)	4 (3)	Table 23.9
$\bar{6}$ (C_{3h})	2 (2)	5	2	8	2	2 (2)	6 (3)	
$6mm$ (C_{6v})	2 (2)	5	3	6	3	3 (2)	4 (3)	Table 23.10
6 (C_6)	2 (2)	5	4	8	4	4 (3)	6 (3)	Table 23.11
Trigonal:								
$\bar{3}m$ (D_{3d})	2 (2)	6	0	8	0	0 (0)	5 (4)	Table 23.12
$\bar{3}$ (C_{3i})	2 (2)	7	0	12	0	0 (0)	10 (5)	
32 (D_3)	2 (2)	6	2	8	2	2 (2)	5 (4)	Table 23.13
3 m (C_{3v})	2 (2)	6	4	8	4	4 (3)	5 (4)	Table 23.14
3 (C_3)	2 (2)	7	6	12	6	6 (5)	10 (5)	
Tetragonal:								
$4/mmm$ (D_{4h})	2 (2)	6	0	7	0	0 (0)	5 (4)	Table 23.15
$4/m$ (C_{4h})	2 (2)	7	0	10	0	0 (0)	8 (6)	Table 23.16
422 (D_4)	2 (2)	6	1	7	1	1 (1)	5 (4)	Table 23.17
$\bar{4}2m$ (D_{2d})	2 (2)	6	2	7	2	2 (1)	5 (4)	Table 23.18
$4mm$ (C_{4v})	2 (2)	6	3	7	3	3 (2)	5 (4)	Table 23.19
$\bar{4}$ (S_4)	2 (2)	7	4	10	4	4 (2)	8 (6)	
4 (C_4)	2 (2)	7	4	10	4	4 (3)	8 (6)	
Orthorhombic:								
mmm (D_{2h})	3 (3)	9	0	12	0	0 (0)	9 (6)	Table 23.20
222 (D_2)	3 (3)	9	3	12	3	3 (1)	9 (6)	Table 23.21
$mm2$ (C_{2v})	3 (3)	9	5	12	5	5 (3)	9 (6)	Table 23.22
Monoclinic:								
$2/m$ (C_{2h})	4 (3)	13	0	20	0	0 (0)	16 (9)	
2 (C_2)	4 (3)	13	8	20	8	8 (4)	16 (9)	Table 23.23
m (C_s)	4 (3)	13	10	20	10	10 (6)	16 (9)	
Triclinic:								
$\bar{1}$ (C_i)	9 (3)	21	0	36	0	0 (0)	30 (15)	
1 (C_1)	9 (3)	21	18	36	18	18 (10)	30 (15)	

[a] The number of principal refractive indices n_i is given in parentheses
[b] The number of independent components for the case of Kleinman symmetry conditions is given in parentheses

second-order nonlinear susceptibilities of crystals is based on [23.12–14]. The second-order susceptibilities for all crystals measured relative to a standard crystal have been recalculated accordingly. In particular, all previous measurements relative to KDP and quartz have been normalized to d_{36} (KDP) $= 0.39\,\mathrm{pm/V}$ and d_{11} (SiO_2) $= 0.30\,\mathrm{pm/V}$. These data lead to an accurate, self-consistent set of absolute second-order nonlinear coefficients [23.14]. All numerical data are for room temperature (300 K) and in SI units.

23.4 Tables of Numerical Data for Dielectrics and Electrooptics

Table 23.5 Isotropic materials

	General	Static dielectric constant	Dissipation factor	Elastic stiffness tensor	Elastic compliance tensor	Elastooptic tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **κ (W/(m K))**	**ε_{11}^{S}** **ε_{11}^{T}**	**$\tan\delta_1$** **(f (Hz))**	**c_{11}** **c_{12}** **(10^9 Pa)**	**s_{11}** **s_{12}** **(10^{-12} Pa^{-1})**	**p_{11}** **p_{12}**
BK7 Schott glass	2.510 – 1.114 [23.15]			92.325 (145) – [23.16]	12[b] −2[b] [23.17]	– 0.198 (22) [23.16]
Poly(methylmethacrylate), $(C_5H_8O_2)_n$ (PMMA, Plexiglas)	1.190 2–3 0.2 [23.22]	3.65 (19)[a] [23.23]	0.06 (50 Hz) [23.23]	9.282 (30) – [23.16]	300[b] 8.9[b] [23.23]	
Silicon dioxide, SiO_2 (Fused silica, fused quartz, vitreous quartz)	2.202 5–6 1.38 [23.25]	3.5[a] [23.26]	14 (5) 5×10^{-4} (1 MHz) [23.26]	77.806 (185) – [23.16]	14[b] −2.1[b] [23.26]	– 0.243 (17) [23.16]

[a] This value for ε_{11} is neither at constant stress nor at constant strain

[b] The elastic compliances are at constant electric field (s^E) and have been calculated from the Young's modulus via $Y_0 = 1/s^E$ and from the shear modulus via $G = [2(s_{11}^E - s_{12}^E)]^{-1}$

[c,d] Dispersion relations (λ (µm), $T = 20\,°C$):

[c] $n^2 = 1 + \frac{1+1.03961212\lambda^2}{\lambda^2-0.00600069867} + \frac{0.231792344\lambda^2}{\lambda^2-0.0200179144} + \frac{1.01046945\lambda^2}{\lambda^2-103.560653}$

[d] $n^2 = 1 + \frac{1+0.6961663\lambda^2}{\lambda^2-(0.0684043)^2} + \frac{0.4079426\lambda^2}{\lambda^2-(0.1162414)^2} + \frac{0.8974794\lambda^2}{\lambda^2-(9.896161)^2}$

General optical properties	**Refractive index**	**Two-photon absorption coefficient β**	**Nonlinear dielectric susceptibility $\chi^{(3)}_{1111}$**
Transparency range (µm) **dn/dT (10^{-5} K^{-1})**	***n***	**(10^{-9} cm/W)**	**(10^{-22} m^2/V^2)**
0.35–2.8 [23.17, 18] 0.28 (0.546 µm) [23.17]	**1.5067** [23.17] For dispersion relation, see [23.18][c]	0.006 (351 nm) [23.19] 0.0029 (532 nm) [23.20]	2.7 ± 0.2 [23.21]
0.27–1.1 –	**1.503** (0.436 µm) **1.493** (0.546 µm) **1.489** (0.633 µm) **1.481** (1.052 µm) [23.24]		
0.17–4.0 [23.27] 1.5 (0.21 µm) 1.0 (0.4 µm) 1.2 (2.0 µm) 1.0 (3.7 µm) [23.28]	**1.5343** (0.2139 µm) **1.4872** (0.3022 µm) **1.4601** (0.5461 µm) **1.4494** (1.083 µm) **1.4372** (2.0581 µm) **1.3994** (3.7067 µm) For dispersion relation, see [23.28][d]	0.75 (212.8 nm) [23.29] 0.5 (216 nm) [23.30] 0.08 (248 nm) [23.31] 0.045 (266 nm) [23.32]	1.8 [23.33] 1.7 ± 0.3 [23.34]

Table 23.6 Cubic, point group $m3m$ (O_h) materials

	General	Static dielectric constant	Dissipation factor	Elastic stiffness tensor	Elastic compliance tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε_{11}	$\tan\delta_1$ (f (Hz))	c_{11} c_{44} c_{12} (10^9 Pa)	s_{11} s_{44} s_{12} (10^{-12} Pa^{-1})
Barium fluoride, BaF_2	4.89 3 11 [23.25, 27]	7.33 [23.25]		91.1 (10) 25.3 (4) 41.2 (15) [23.7]	15.2 (1) 39.6 (7) −4.7 (1) [23.7]
Calcium fluoride, CaF_2 (fluorite, fluorspar, Irtran-3)	3.179 4.0 9.71 [23.25, 27]	7.4 [23.43]		165 (2) 33.9 (3) 47 (3) [23.7]	6.93 (14) 29.5 (3) −1.52 (11) [23.7]
Diamond, C	3.52 10 660 (0 °C) [23.27, 46]	5.5−10.0 [23.43]		1077 (2) 577 (1) 124.7 (6) [23.7]	0.951 (2) 1.732 (3) −0.0987 (6) [23.7]
Germanium, Ge	5.33 6 58.61 [23.25]	16.6 [23.25]		129 (3) 67.1 (5) 48 (3) [23.7]	9.73 (5) 14.90 (12) −2.64 (11) [23.7]
Lithium fluoride, LiF	2.639 4 4.01 [23.25]	9.1 [23.25]		112 (2) 63.5 (6) 46 (3) [23.7]	11.6 (1) 15.8 (2) −3.35 (13) [23.7]
Magnesium oxide, MgO	3.58 – 42 [23.25]	9.7 [23.43]	0.009 (10 GHz) [23.58]	294 (6) 155 (3) 93 (5) [23.7]	4.01 (4) 6.46 (12) −0.96 (2) [23.7]
Potassium bromide, KBr	2.753 1.5 4.816 [23.25]	4.9 [23.25]		34.5 (3) 5.1 (2) 5.5 (4) [23.7]	30.3 (6) 196 (6) −4.2 (3) [23.7]
Potassium chloride, KCl (sylvine, sylvite)	1.99 2 6.53 [23.25]	4.6 [23.43]		40.5 (4) 6.27 (6) 6.9 (3) [23.7]	25.9 (1) 159 (1) −3.8 (3) [23.7]
Potassium iodide, KI	3.12 – 2.1 [23.25]	5.6 [23.43]		27.4 (5) 3.70 (4) 4.3 (2) [23.7]	38.2 (8) 270 (3) −5.2 (3) [23.7]

Elastooptic tensor	General optical properties	Refractive index[a]		Nonlinear dielectric susceptibility
p_{11} p_{12} p_{44} $p_{11}-p_{12}$	Transparency range (μm) $dn/dT\,(10^{-5}\,K^{-1})$	n A B C	D E F G	$\chi^{(3)}_{1111}$ $\chi^{(3)}_{1122}$ $\chi^{(3)}_{1133}$ $(10^{-22}\,m^2/V^2)$
0.11 0.26 0.02 −0.14 (589−633 nm) [23.35–37]	0.14−12.2 [23.38] −1.60 (0.633 μm) [23.39, 40] −0.6 (0.150 μm) −1.0 (0.590 μm) −1.1 (15.0 μm) [23.41]	**1.678** (0.150 μm) **1.557** (0.200 μm) **1.5118** (0.266 μm) **1.4744** (0.590 μm) **1.4683** (1.05 μm) **1.4441** (6.00 μm)	**1.4027** (9.00 μm) **1.3865** (11.0 μm) **1.305** (15.0 μm) For dispersion relations, see [23.41][b]	1.548 ± 0.17 – 0.636 ± 0.06 (0.575; 0.613 μm) [23.42]
0.027 0.198 0.02 −0.17 (550−650 nm) [23.35, 36, 44]	0.135−9.4 [23.38] −1.04 (0.633 μm) [23.45] −0.1 (0.150 μm) −1.5 (0.590 μm) −1.0 (12.0 μm)	**1.577** (0.150 μm) **1.495** (0.200 μm) **1.4621** (0.266 μm) **1.4338** (0.590 μm) **1.4286** (1.05 μm) **1.3856** (6.00 μm)	**1.3268** (9.00 μm) **1.268** (11.0 μm) **1.230** (12.0 μm) For dispersion relations, see [23.41][c]	0.8 ± 0.24 0.36 ± 0.1 (0.575; 0.613 μm) [23.42]
−0.25 0.04 0.17 −0.30 (1) (514−633 nm) [23.47]	0.24−27 1.01 (0.546 μm) 0.96 (30 μm) [23.48, 49]	**2.7151** (0.2265 μm) **2.4190** (0.578 μm) **2.3914** (1.064 μm)	For dispersion relation, see [23.50][d]	$\chi^{(3)}_{1122} = 4.87(12)$ $\chi^{(3)}_{1111} + 3\chi^{(3)}_{1122} = 30 \pm 0.8$ (both at 0.407 μm) [23.42] $\chi^{(3)}_{1111} + 3\chi^{(3)}_{1133} = 65 \pm 20$ (0.53 μm) [23.51]
	1.8−15 [23.52] –	**4.0038** (10.6 μm) 9.28156 6.72880 0.44105	0.21307 3870.1 0 0 [23.53][e]	56 000 ± 28 000 34 000 ± 1200 – (10.6 and 9.5 μm) [23.54]
0.02 0.13 −0.04 (1) −0.10 (589−633 nm) [23.44, 55]	0.120−6.60 –	**1.387** 1 0.9259 0.005441	6.96747 1075 0 0 [23.56][e]	1.12 (24) 0.50 – (0.6943 and 0.7456 μm) [23.57]
−0.25 −0.01 −0.10 −0.24 (589 nm) [23.44, 59]	0.35−6.8 [23.60] 1.95 (0.365 μm) 1.65 (0.546 μm) 1.36 (0.768 μm) [23.61]	**1.7217** 1 1.111033 0.00507606	0.8460085 0.01891186 7.808527 723.2345 [23.62][e]	+1.4 (2) – +0.77 (15) (0.6943 and 0.7456 μm) [23.57]
0.22 0.17 (546−600 nm) [23.63] 0.02 0.04 (488−600 nm) [23.64]	0.200−30 [23.38] −3.93 (0.458 μm) −4.19 (1.15 μm) −4.11 (10.6 μm) [23.39]	**1.5435** For dispersion relation, see [23.56][f]		15.7 [23.65] 5.8 [23.66] 6.2 (0.6943 and 0.7456 μm) [23.57]
0.23 0.17 0.02 0.05 (546−600 nm) [23.63, 64, 67, 68]	0.18−23.3 [23.38] −3.49 (0.458 μm) −3.62 (1.15 μm) −3.48 (10.6 μm) [23.39]	**1.4792** For dispersion relation, see [23.56][g]		6.7 [23.65] 1.9 [23.66] 0.8 (0.6943 and 0.7456 μm) [23.57]
1.21 0.15 −0.031 [23.39] –	0.32−42 [23.25] −4.15 (0.458 μm) −4.47 (1.15 μm) −3.08 (30 μm) [23.39]	**1.6393** For dispersion relation, see [23.56][h]		1.4 ± 0.3 (0.6943 and 0.7456 μm) [23.57] – –

Table 23.6 (continued)

Material	General ϱ (g/cm^3) Mohs hardness κ (W/(m K))	Static dielectric constant ε_{11}	Dissipation factor $\tan\delta_1$ (f (Hz))	Elastic stiffness tensor c_{11} c_{44} c_{12} (10^9 Pa)	Elastic compliance tensor s_{11} s_{44} s_{12} (10^{-12} Pa^{-1})
Silicon, Si	2.329 7 163.3 [23.25]	11.0–12.0 [23.43]		165 (2) 79.1 (6) 63 (1) [23.7]	7.73 (8) 12.70 (9) −2.15 (4) [23.7]
Sodium chloride, NaCl (rock salt, halite)	2.17 2 1.15 [23.25]	5.9 [23.43]		49.1 (5) 12.8 (1) 12.8 (1) [23.7]	22.9 (5) 78.3 (8) −4.8 (1) [23.7]
Sodium fluoride, NaF	2.558 – 3.746 [23.25]	6 [23.25]		97.0 (4) 28.1 (3) 24.2 (10) [23.7]	11.50 (6) 35.6 (4) −2.30 (7) [23.7]
Strontium fluoride, SrF_2	4.24 – 1.42 [23.25]	7.69 [23.25]		124 (1) 31.8 (3) 44 (1) [23.7]	9.86 (4) 31.5 (3) −2.57 (5) [23.7]
Strontium titanate, $SrTiO_3$	5.12 6–6.5 12 [23.81]	300 [23.58]	0.02 (10 GHz) [23.58]	316 (2) 123 (1) 102 (1) [23.7]	3.75 (3) 8.15 (8) −0.92 (1) [23.7]
Yttrium aluminium garnet, $Y_3Al_5O_{12}$ (YAG)	4.56 8–8.5 13.4 [23.86]			333 (3) 114 (1) 111 (3) [23.7]	3.61 (4) 8.74 (4) −0.90 (2) [23.7]

[a] The refractive index is given in bold type to distinguish it from the constants A, B, etc. in the dispersion relation.

[b,c,d,e,f,g,h,i,j,k] Dispersion relations (λ (µm), $T = 20\,°\mathrm{C}$):

[b] $n^2 = 1.33973 + \frac{0.81070\lambda^2}{\lambda^2 - 0.10065^2} + \frac{0.19652\lambda^2}{\lambda^2 - 29.87^2} + \frac{4.52469\lambda^2}{\lambda^2 - 53.82^2}$;

[c] $n^2 = 1.33973 + \frac{0.69913\lambda^2}{\lambda^2 - 0.09374^2} + \frac{0.11994\lambda^2}{\lambda^2 - 21.18^2} + \frac{4.35181\lambda^2}{\lambda^2 - 38.46^2}$;

[d] $n^2 = 2.37553 + \frac{0.0336440\lambda^2}{\lambda^2 - 0.028} - \frac{0.0887524}{(\lambda^2 - 0.028)^2} - 2.40455 \times 10^{-6}\lambda^2 + 2.21390 \times 10^{-9}\lambda^4$;

[e] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E} + \frac{F\lambda^2}{\lambda^2 - G}$;

[f] $n^2 = 1.39408 + \frac{0.79221\lambda^2}{\lambda^2 - 0.0213} + \frac{0.01981\lambda^2}{\lambda^2 - 0.0299} + \frac{0.15587\lambda^2}{\lambda^2 - 0.0350} + \frac{0.17673\lambda^2}{\lambda^2 - 3674} + \frac{2.0621\lambda^2}{\lambda^2 - 7695}$;

[g] $n^2 = 1.26486 + \frac{0.30523\lambda^2}{\lambda^2 - 0.0100} + \frac{0.41620\lambda^2}{\lambda^2 - 0.0172} + \frac{0.18870\lambda^2}{\lambda^2 - 0.0262} + \frac{2.6200\lambda^2}{\lambda^2 - 4959}$;

[h] $n^2 = 1.47285 + \frac{0.16512\lambda^2}{\lambda^2 - 0.0166} + \frac{0.41222\lambda^2}{\lambda^2 - 0.0306} + \frac{0.44163\lambda^2}{\lambda^2 - 0.0350} + \frac{0.16076\lambda^2}{\lambda^2 - 0.0480} + \frac{0.33571\lambda^2}{\lambda^2 - 4822} + \frac{1.92474\lambda^2}{\lambda^2 - 9612}$

[i] $n^2 = 1.00055 + \frac{0.19800\lambda^2}{\lambda^2 - 0.00250} + \frac{0.48398\lambda^2}{\lambda^2 - 0.0100} + \frac{0.38696\lambda^2}{\lambda^2 - 0.0164} + \frac{0.25998\lambda^2}{\lambda^2 - 0.0250} + \frac{0.08796\lambda^2}{\lambda^2 - 1640} + \frac{3.17064\lambda^2}{\lambda^2 - 3719} + \frac{0.30038\lambda^2}{\lambda^2 - 14482}$;

[j] $n^2 = 1.33973 + \frac{0.7097\lambda^2}{\lambda^2 - 0.09597^2} + \frac{0.1788\lambda^2}{\lambda^2 - 26.03^2} + \frac{3.8796\lambda^2}{\lambda^2 - 45.60^2}$;

[k] $n^2 = 3.2968230 - 0.0166197\lambda^2 + 0.0126503\lambda^{-2} + 0.0069986\lambda^{-4} - 0.0013968\lambda^{-6} + 0.0001088\lambda^{-8}$

Elastooptic tensor	General optical properties	Refractive index[a]		Nonlinear dielectric susceptibility
p_{11} p_{12} p_{44} $p_{11}-p_{12}$	Transparency range (μm) $dn/dT\,(10^{-5}\,K^{-1})$	n A B C	D E F G	$\chi^{(3)}_{1111}$ $\chi^{(3)}_{1122}$ $\chi^{(3)}_{1133}$ $(10^{-22}\,m^2/V^2)$
−0.094 0.017 −0.051 −0.111 (3390 nm) [23.69–72]	1.1−6.5 [23.52] –	**3.4176** (10.6 μm) 1 10.6684293 0.09091219	0.003043475 1.2876602 1.54133408 1 218 820 [23.73][e] [23.74]	24 300 [23.75] – 33 000 [23.66] at 10.6 and 11.8 μm $\chi^{(3)}_{1111} = 2800$ $\chi^{(3)}_{1122} = 1340$ [23.76]
0.128 0.171 −0.01 −0.04 (589−633 nm) [23.67, 68, 77]	0.2−16 [23.38] −3.42 (0.458 μm) −3.54 (0.633 μm) −3.63 (3.39 μm) [23.39]	**1.5313** For dispersion relation, see [23.56][i]		6.7 [23.65] 2.78 [23.66] at 0.6943 and 0.7456 μm – $\chi^{(3)}_{1111} = 9.5 \pm 2$, $\chi^{(3)}_{1133} = 4.0 \pm 1.2$ [23.57]
0.03 0.14 – −0.10 (589−633 nm) [23.77–79]	0.135−11.2 [23.80] −1.19 (0.458 μm) −1.32 (0.633 μm) −1.25 (3.39 μm) [23.39]	**1.32** 1.41572 0.32785 0.0137	3.18248 1646 0 0 [23.56][e]	1.4 [23.65] – –
0.080 0.269 0.018 −0.189 [23.35, 36]	0.13−11 −0.9 (0.150 μm) −1.2 (0.590 μm) −0.4 (14.0 μm) [23.41]	**1.59** (0.150 μm) **1.50** (0.200 μm) **1.47** (0.266 μm) **1.4380** (0.590 μm) **1.433** (1.05 μm) **1.404** (6.00 μm)	**1.37** (9.00 μm) **1.33** (11.0 μm) **1.25** (14.0 μm) For dispersion relations, see [23.41][j]	0.82 ± 0.2 – 0.56 ± 0.8 (0.575; 0.613 μm) [23.42]
|0.15| |0.095| |0.072| – [23.82]	0.41−5.1 [23.83, 84] –	**2.3104** 1 3.042143 0.02178287	1.170065 0.08720717 30.83326 1101.3146 [23.85][e]	≈ 2000 – ≈ 1000 (0.6943 and 0.7456 μm) [23.57]
−0.029 0.0091 −0.0615 −0.038 [23.87]	0.21−5.3 [23.88] 0.905 [23.88]	**1.8422** (0.5 μm) **1.8258** (0.7 μm) **1.8186** (0.9 μm) **1.8152** (1.05 μm) **1.8149** (1.064 μm)	For dispersion relation[k], see [23.89]	

Table 23.7 Cubic, point group $\bar{4}3m$ (T_d) materials

	General	Static dielectric constant	Dissipation factor	Elastic stiffness tensor	Piezoelectric strain tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^T_{11}	tan δ_1 (f (Hz))	c_{11} c_{44} c_{12} (10^9 Pa)	d_{14} (10^{-12} C/N)	p_{11} p_{12} p_{44} $p_{11}-p_{12}$
Cadmium telluride, CdTe (Irtran-6)	5.855 3 6.28 [23.81]	9.65 (−196 °C) [23.90] 11.00 (23 °C) [23.91]		53.5 (2) 20.2 (2) 36.9 (3) [23.7]	1.68 (8) (−196 °C) [23.90]	−0.152 −0.017 −0.057 −0.135 (10 600 nm) [23.92]
Copper bromide, CuBr		7.9 (8) (22 °C) [23.99] 6.6 (−193 °C) [23.100]		43.5 14.7 34.9 [23.101]	16 (1) [23.102]	0.072 0.195 −0.083 −0.123 [23.103]
Copper chloride, CuCl (nantokite)	4.136 – –	8.3 (5) 9.2 (5) [23.107, 108]		45.4 13.6[a] 36.3 [23.109]	27.2 (5) [23.102]	0.120 0.250 −0.082 −0.130 [23.103]
Copper iodide, CuI	5.60 – –	– 6.5 (−269 °C) [23.100]		45.1 18.2[a] 30.7 [23.100]	7 (1) [23.102]	3.032 0.151 −0.068 −0.119 [23.103]
Gallium antimonide, GaSb	5.614 4.5 32 [23.114]	15 [23.115] 15.7[b] [23.114]		88.4 (9) 43.4 (9) 40.3 (8) [23.7]	−2.9 [23.115]	
Gallium arsenide, GaAs	5.3169 4.5 46.05 [23.17]	12.95 (10) [23.119] 13.08 [23.91]	0.001 (2.5−10 GHz) [23.120]	118 (1) 59.4 (2) 53.5 (5) [23.7]	−2.7 [23.115]	−0.16 −0.13 −0.05 −0.03 (1150 nm) [23.103, 121]
Gallium phosphide, GaP	4.138 5 110 [23.114]	11.1[b] [23.130]		141 (3) 71.2 (21) 62.4 (12) [23.7]		−0.151 −0.082 −0.074 −0.069 [23.87]
Indium antimonide, InSb	5.78 – 18 [23.114]	16.8[b] [23.114] 17 [23.115]		66.2 (7) 30.2 (3) 35.9 (22) [23.7]	−2.35 [23.115]	0.46 0.58 0.064 (10.6 µm) – [23.134, 135]
Indium arsenide, InAs	5.70 3.8 27 [23.114]	15.5[b] [23.114] 14.5 [23.115]		84.4 (17) 39.6 (1) 46.4 (19) [23.7]	−1.14 [23.115]	

Electrooptic tensor	General optical properties	Refractive index	Nonlinear dielectric susceptibility	
r^T_{41} (10^{-12} m/V)	Transparency range (μm) dn/dT (10^{-5} K^{-1})	n A B C D E	Second order d_{14} (10^{-12} m/V)	Third order $\chi^{(3)}_{1111}$ $\chi^{(3)}_{1122}$ $\chi^{(3)}_{1133}$ (10^{-22} m^2/V^2)
6.8 (10.6 μm) [23.93]	0.85–29.9 [23.84] For temperature-dependent dispersion relations, see [23.94]	**2.693** (14 μm) 1 6.1977889 0.100533 3.2243821 5193.55 [23.95][c]	170 ± 60 (10.6 μm) 60 ± 24 (28 μm) [23.96–98]	
−2.5 (5) [23.104][f]	0.50–20 [23.105] –	**2.3365** (0.4358 μm) **2.152** (0.532 μm) **2.045** (1.064 μm) **2.025** (10.6 μm) [23.99, 105, 106]	−6.5 ± 1.3 (1.064 μm) [23.106] −5.0 ± 1.5 (10.6 μm) [23.105]	
−4.97 (50) [23.110]	0.45–15 [23.105] –	**1.9216** 3.580 0.03162 0.1642 0.09288 0 [23.111][c]	−5.7 ± 1.1 (1.064 μm) [23.106] −4.15 ± 1.2 (10.6 μm) [23.105]	
18 [23.112, 113][g]	0.50–20 [23.105] –	**2.5621** (0.4358 μm) **2.378** (0.532 μm) **2.245** (1.064 μm) [23.105, 106]	−4.7 ± 1.0 (1.064 μm) [23.106] −5.0 ± 1.5 (10.6 μm) [23.105]	
	1.8–20 [23.27, 84] –	**3.820** (1.8 μm) **3.898** (3.0 μm) **3.824** (5.0 μm) **3.843** (10 μm) [23.116]	+628 ± 63 (10.6 μm) [23.117, 118]	
1.43 (7) (1.15 μm) 1.24 (4) (3.39 μm) 1.51 (5) (10.6 μm) [23.122]	0.900–17.3 [23.123] 25 (1.15 μm) 20 (3.39 μm) 20 (10.6 μm) [23.124]	**3.5072** 3.5 7.497 0.167 1.935 1382 [23.125][c]	d_{36} = 170 (1.064 μm) [23.13, 14, 126, 127] d_{36} = 83 (10.6 μm) [23.12, 14, 128]	6700 [23.54] 1400 [23.129] 1700 [23.54] (all at 10.6 μm)
−0.76 (3) [23.131]	0.54–10.5 20 (0.546 μm) 16 (0.633 μm) [23.132]	**3.1057** For dispersion relation, see [23.133][d]	100 [23.130, 132] 58 (10.6 μm) [23.132]	
	8–30 [23.84] –	**3.904** (14 μm) **3.745** (28 μm) [23.96]	660 [23.126] 2280 ± 270 (10.6 μm) [23.136] 580 (28 μm) [23.96]	[23.137, 138]
	3.9–20 [23.84] 50 (4 μm) 40 (6 μm) 30 (10 μm) [23.124]	**3.49** (10.6 μm) 11.1 0.71 6.5076 2.75 2084.8 [23.139][c]	346 (1.058 μm) [23.126] 249 (10.6 μm) [23.117, 118]	≈ 25 000 (10.6 and 9.5 μm) [23.54]

Table 23.7 (continued)

	General	Static dielectric constant	Dissipation factor	Elastic stiffness tensor	Piezoelectric strain tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^T_{11}	tan δ_1 (f (Hz))	c_{11} c_{44} c_{12} (10^9 Pa)	d_{14} (10^{-12} C/N)	p_{11} p_{12} p_{44} $p_{11}-p_{12}$
Indium phosphide, InP	4.78 – 68 [23.114]	12.56 (20)[b]	[23.140]	101.1 45.6 56.1 [23.141]		
Zinc selenide, ZnSe	5.26 3–4 19 [23.148]	9.12 9.12 [23.90]		86.4 (39) 40.2 (18) 51.5 (34) [23.7]	1.1 (1) [23.90]	|0.100| |0.065| |0.065| (633 nm) [23.149] −0.10 (10 600 nm) [23.150]
Zinc telluride, ZnTe	6.34 6 18 [23.156]	10.10 10.10 [23.90]		71.5 (6) 31.1 (3) 40.8 (1) [23.7]	0.91 (5) [23.90]	−0.144 −0.094 −0.046 [23.157] −0.040 [23.158]

[a] The elastic stiffness was measured at constant electric field (c^E)
[b] This value for ε_{11} is neither at constant stress nor at constant strain
[c,d,e] Dispersion relations (λ (µm), $T = 20\,°$C)
[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$
[d] $n^2 = 1 + \frac{1.390\lambda^2}{\lambda^2 - 0.0296} + \frac{4.131\lambda^2}{\lambda^2 - 0.05476} + \frac{2.570\lambda^2}{\lambda^2 - 0.1190} + \frac{2.056\lambda^2}{\lambda^2 - 757.35}$
[e] $n^2 = 1 + \frac{4.2980149\lambda^2}{\lambda^2 - 0.03688810} + \frac{0.62776557\lambda^2}{\lambda^2 - 0.14347626} + \frac{2.8955633\lambda^2}{\lambda^2 - 2208.4920}$
[f] r^S_{41}
[g] $n^3 r_{41}$

Electrooptic tensor	**General optical properties**	**Refractive index**	**Nonlinear dielectric susceptibility**	
r^T_{41} (10^{-12} m/V)	**Transparency range (μm)** dn/dT (10^{-5} K^{-1})	n A B C D E	**Second order** d_{14} (10^{-12} m/V)	**Third order** $\chi^{(3)}_{1111}$ $\chi^{(3)}_{1122}$ $\chi^{(3)}_{1133}$ (10^{-22} m^2/V^2)
1.45 (1.06 μm) [23.142]	0.98–20 [23.143] 8.3 (5 μm) 8.2 (10.6 μm) 7.7 (20 μm) [23.144]	**3.44** 7.255 2.316 0.39225 2.765 1084.7 [23.145, 146][c]	136 (1.058 μm) [23.147] 105 ± 11 (10.6 μm) [23.136]	
1.8 [23.151, 152] 2.2 (10.6 μm) [23.153]	0.47–19 [23.123] –	**2.48** For dispersion relation, see [23.39][e]	+103 [23.123] +80 (10.6 μm) [23.98, 154]	1.05×10^7 (0.4606 μm) 2650 (0.532 μm) 1680 (1.064 μm) (all for $\|\chi^{(3)}\|$) [23.155]
4.27 (0.616 μm) [23.151, 152]	0.59–25 [23.14] –	**2.69** (10.6 μm) 4.27 3.01 0.142 0 0 [23.159][c]	3.47 [23.123] +90 (10.6 μm) [23.97, 98]	

Table 23.8 Cubic, point group 23 (T) materials

	General	Static dielectric constant	Dissipation factor	Elastic stiffness tensor	Piezoelectric strain tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **κ (W/(m K))**	ε^S_{11} ε^T_{11}	**tan δ_1** **(f (Hz))**	c_{11} c_{44} c_{12} **(10^9 Pa)**	d_{14} **(10^{-12} C/N)**
Bismuth germanium oxide, $Bi_{12}GeO_{20}$ (BGO)	9.239 5 [23.160] –	38.0 (4) [23.161] 40 [23.162]	0.0035 [23.162]	126.0 26.9 34.2 [23.163]	37.58 (4) [23.164]
Bismuth silicon oxide, $Bi_{12}SiO_{20}$ (BSO, sillenite)	9.2 5 [23.160] –	42 (1) [23.172] 64 (2) [23.173]	0.0004 (> 1 MHz) [23.173]	129 (2) 24.7 (2) 29.4 (12) [23.7]	
Sodium chlorate, $NaClO_3$	2.488 – –	4.8 5.85 [23.179]		49.6 (5) 11.6 (2) 14.7 (6) [23.7]	−1.74 [23.180]

[a] Dispersion relation (λ (µm), $T = 20\,°C$): $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E} + \frac{F\lambda^2}{\lambda^2 - G}$

Elastooptic tensor	**Electrooptic tensor**	**General optical properties**	**Refractive index**	**Nonlinear dielectric susceptibility**
p_{11} p_{12} p_{44} $p_{11}-p_{12}$	r^{T}_{41} (10^{-12} m/V)	**Transparency range (μm)** dn/dT (10^{-5} K^{-1})	n A B C D E	d_{14} (10^{-12} m/V)
0.12 0.10 0.09 (1) 0.01 [23.165–170]	4.1 (1)	0.385–7 [23.160, 171] –	**2.55** (0.633 μm) [23.160]	
0.16 0.13 0.12 0.015 [23.174, 175]	4.25–5.0 [23.176–178]	0.390–6 [23.160, 171] –	**2.54** (0.633 μm) [23.160]	
0.162 0.24 −0.0198 −0.078 [23.181]	0.36 (0.4 μm) 0.39 (0.59 μm) [23.182]		**1.512** (0.6943 μm) For dispersion relation, see [23.183][a]	0.43 (0.6943 μm) [23.184]

Table 23.9 Hexagonal, point group $\bar{6}m2$ (D_{3h}) materials

	General	Static dielectric tensor	Elastic stiffness tensor	Elastooptic tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **$\kappa \perp c$** **$\kappa \parallel c$** **(W/(m K))**	**ε^S_{11}** **ε^S_{33}** **ε^T_{11}** **ε^T_{33}**	**c_{11}** **c_{33}** **c_{44}** **c_{12}** **c_{13}** **(10^9 Pa)**	**p_{11}** **p_{12}** **p_{13}** **p_{31}** **p_{33}** **p_{44}**
Gallium selenide, GaSe	5.0 2 9.0 ($\perp c$) 8.25 ($\parallel c$) [23.185]	7.45[a] 7.1[a] 9.80[a] 8.0 (3) [23.186]	106.4 (37) 35.8 (15) 10.2 (5) 30.0 (25) 12.1 (4) [23.7]	$\vert p_{12}/p_{13}\vert < 0.05$ [23.187]
Gallium sulfide, GaS	3.86 2 – –		127 (19) 42 (11) 12.0 (73) 35.7 (45) 14.3 (81) [23.7]	

[a] From IR measurements. ε^S is ε at optical frequencies

[b] Dispersion relation (λ (mm), $T = 20\,°C$): $n^2 = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \frac{D}{\lambda^6} + \frac{E\lambda^2}{\lambda^2 - F}$

Electrooptic tensor	**General optical properties**	**Refractive index**		**Nonlinear dielectric susceptibility**
r^T_{13} r^T_{33} r^T_{41} r^T_{51} **(10^{-12} m/V)** **at $\lambda = 633$ nm**	**Transparency range (µm)**	n_o *A* *B* *C* *D* *E* *F*	n_e *A* *B* *C* *D* *E* *F*	d_{31} d_{33} **(10^{-12} m/V)**
22 ($n_o^3 r_{11}$) [23.188, 189]	0.62–20 [23.190]	**2.9082** 7.443 0.4050 0.0186 0.0061 3.1485 2194 [23.191][b]	**2.5676** 5.76 0.3879 0.2288 0.1223 1.8550 1780 [23.191][b]	$d_{22} = 54$ pm/V (10.6 µm) [23.192–194]
	0.420			$d_{16} = 84$ pm/V (0.6943 µm) [23.195]

Table 23.10 Hexagonal, point group $6mm$ (C_{6v}) materials

	General	Static dielectric tensor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	c_{11} c_{33} c_{44} c_{12} c_{13} (10^9 Pa)	d_{31} d_{33} d_{15} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44}
Beryllium oxide, BeO (bromellite)	3.010 – 370 – [23.46]	6.82[a] 7.62[a] [23.196]	460.6 491.6 147.7 126.5 88.4 [23.197]	−0.12 (3) +0.24 (6) – – [23.198]	
Cadmium selenide, CdSe	5.67 3.25 6.2 (⊥ c) 6.9 (‖ c) [23.205]	9.53 10.20 9.70 10.65 [23.90]	74.1 83.6 13.17 45.2 39.3 [23.90][b]	−3.80 (11) 7.81 (23) −10.1(4) – [23.206, 207]	[23.208, 209]
Cadmium sulfide, CdS (greenockite)	4.82 3−3.5 14 (⊥ c) 16 (‖ c) [23.205]	8.67 (7) 9.53 (7) 8.92 (7) 10.20 (7) [23.215, 216]	88.4 (47) 95.2 (22) 15.0 (3) 55.4 (39) 48.0 (22) [23.7, 217]	−5.09 (9) [23.215, 216] +9.71 (29) [23.215, 216] −11.91 (39) [23.215, 216] < 0.05 [23.8]	−0.142 −0.066 −0.057 −0.041 −0.20 ≈ |0.054| [23.87, 218]
Gallium nitride, GaN	6.15 – 1300 – [23.222]	9.5 (3) 10.4 (3) [23.223][a]	296 267 24.1 130 158 [23.224]		
α-Silicon carbide, SiC	3.217 – 490 [23.46] –	$\varepsilon_{33} = 6.65$ [23.227]	502 565 169 95 56 [23.228]		[23.229–231]
Zinc oxide, ZnO (zincite)	5.605 – 29 [23.46] –	8.33 (8) 8.81 (10) 8.67 (9) 11.26 (12) [23.233, 234]	207.0 209.5 44.8 117.7 106.1 [23.233, 234][b]	−5.12 (6) [23.233, 234] 12.3 (2) [23.233, 234] −8.3 (3) [23.233, 234] < 0.2 [23.8]	|0.221| |0.099| −0.090 |0.089| −0.263 −0.061 [23.91]

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r_{13}^T r_{33}^T r_{51}^T $(10^{-12}$ m/V) at $\lambda = 633$ nm	Transparency range (μm) dn_o/dT $(10^{-5}\ K^{-1})$ dn_e/dT $(10^{-5}\ K^{-1})$	n_o A B C D E	n_e A B C D E	d_{31} d_{33} d_{15} $(10^{-12}$ m/V)
1.33 (r_{51}^T) [23.199, 200]	0.21–7, 15–25 [23.201] 0.818 [23.202] 1.34 [23.202]	**1.7055** 1 1.92274 0.0062536 1.24209 94.344 [23.203][c]	**1.7204** 1 1.96939 0.0073788 1.24209 109.82 [23.203][c]	0.23 0.32 – [23.154, 204]
1.8 (r_{13}^S) 4.3 (r_{33}^S) [23.210]	0.75–20 [23.211, 212] – –	**2.5375** 4.2243 1.768 0.227 3.12 3380 [23.213][c]	**2.5572** 4.2009 1.8875 0.2171 3.6461 3629 [23.213][c]	−29 (10.6 μm) [23.98] +55 (10.6 μm) [23.98] 23 ± 3 (1.054 mm) [23.214]
2.45 (8) 2.75 (8) 1.7 (3) (all at 10.6 μm) [23.122]	0.53–16 [23.123] 5.86 (10.6 μm) 6.24 (10.6 μm) [23.219]	**2.212** (10.6 μm) 5.235 −0.1819 0.1651 0 [23.220][d] –	**2.225** (10.6 μm) 5.239 0.2076 0.1651 0 [23.220][d] –	16 [23.221] 32 [23.221] 18 [23.221] −16 (d_{31}, 10.6 μm) [23.12, 14] −16 (d_{32}, 10.6 μm) [23.12, 14] 32 (d_{33}, 10.6 μm) [23.12, 14]
0.57 ± 0.11 (r_{31}) 1.91 ± 0.35 (r_{33}) [23.225]	0.37 – –	**2.33** 3.60 1.75 0.0655 4.1 319 [23.223]	**2.35** 5.35 5.08 315.4 0 [23.223] –	21 44 25.5 [23.226]
	0.51–4 – –	**2.5830** 1 5.5515 0.026406 0 [23.227][c] –	**2.6225** 1 5.7382 0.028551 0 [23.227][c] –	5 50 [23.232] –
−1.4 (r_{13}^S) +2.6 (r_{33}^S) [23.210, 235, 236] −3.1 (r_{51}^T) at 396 nm [23.237]	0.38–6.0 – –	**1.939** 2.81418 0.87968 0.09254 0.00711 [23.203][e] –	**1.955** 2.80333 0.94470 0.09024 0.00714 [23.203][e] –	+1.7 ± 0.15 −5.6 ± 0.15 1.8 ± 0.15 [23.154, 221]

Table 23.10 (continued)

	General	Static dielectric tensor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **$\kappa \perp c$** **$\kappa \parallel c$** **(W/(m K))**	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	c_{11} c_{33} c_{44} c_{12} c_{13} **(10^9 Pa)**	d_{31} d_{33} d_{15} d_h **(10^{-12} C/N)**	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44}
α-Zinc sulfide, α-ZnS (wurtzite, zinc blende)	4.09 – 27 [23.46] –	8.58 8.52 8.60 (5) 8.57 (7) [23.238, 239]	122.0 140.2 28.5 58.0 46.8 [23.238, 239][b]	−1.1 (0) +3.2 (1) −2.8 (1) +1.0 [23.240, 241]	−0.115 0.017 0.025 0.0271 −0.13 −0.0627 [23.242]

[a] These values for ε_{ij} are neither at constant stress nor at constant strain
[b] The elastic stiffness constant were measured at constant electric field (c^E)
[c,d,e] Dispersion relations (λ(mm), $T = 20\,°$C):
[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$
[d] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$
[e] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} - D\lambda^2$

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^T_{13} r^T_{33} r^T_{51} (10^{-12} m/V) at $\lambda = 633$ nm	Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{31} d_{33} d_{15} (10^{-12} m/V)
0.92 1.85 [23.235, 236] –	0.35–23 [23.123] – –	**2.213** (10.6 μm) 3.4175 1.7396 0.07166 0 [23.203][e] –	**2.219** (10.6 μm) 3.4264 1.7491 0.07150 0 [23.203][e] –	−18.9 ± 6.3 +37.3 ± 12.6 21.4 ± 8.4 (all at 10.6 μm) [23.98, 243]

Table 23.11 Hexagonal, point group 6 (C_6) materials

	General	Static dielectric tensor	Elastic stiffness tensor	Piezoelectric strain tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	c_{11} c_{33} c_{44} c_{12} c_{13} (10^9 Pa)	d_{31} d_{33} d_{14} d_{15} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{16} p_{31} p_{33} p_{44} p_{45}
Barium nitrite monohydrate, $Ba(NO_2)_2 \cdot H_2O$	3.179 – – – –	– – 7.56 (8) 6.78 (7) [23.244]	54.2 29.9 11.2 27.5 17.8 [23.244][b]	−1.73(17) +3.27 (16) +0.47 (9) −1.03 (10) [23.244]	
α-Lithium iodate, $LiIO_3$	4.490 4 1.27 ($\perp c$) 0.65 ($\parallel c$) [23.246, 247]	7.9 (4) (−20 °C) [23.248] 5.9 (3) (−20 °C) [23.248] 8.25[a] (0 °C) [23.249] 6.53[a] (0 °C) [23.249]	82.5 (8) 55.9 (23) 18.0 (3) 31.9 (8) 20.8 (87) [23.7, 250][b]	3.5 [23.8, 251, 252] 48.5 [23.8, 251, 252] 73 (7) [23.249] 55.5 [23.8, 251, 252]	|0.32| – |0.24| |0.03| |0.41| |0.23| [23.253] – –

[a] The values for ε_{ij} are neither at constant stress nor at constant strain
[b] The elastic stiffness constants were measured at constant electric field (c^E)
[c] Dispersion relation (λ (mm), $T = 20\,°C$): $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric
r^T_{13} r^T_{33} r^T_{41} r^T_{51} (10^{-12} m/V) at $\lambda = 633$ nm	Transparency range (µm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o *A* *B* *C* *D*	n_e *A* *B* *C* *D*	d_{31} d_{33} (10^{-12} m/V)
+3.47 (10) +3.31 (13) −0.85 (21) −0.41 (10) [23.244]	0.4−2 [23.245] – –	**1.6266** (0.5 µm) 1.99885 0.542910 0.04128 0.01012 [23.245][c]	**1.5238** (0.5 µm) 1.48610 0.775625 0.01830 0.00090 [23.245][c]	1.14 [23.245] –
6.4 4.2 3.1 7.9 (r^S_{51}) [23.254, 255]	0.3−6.0 [23.256, 257] −9.38 [23.258] −8.25 [23.258]	**1.8571** 3.415716 0.047031 0.035306 0.008801 [23.259][c]	**1.7165** 2.918692 0.035145 0.028224 0.003641 [23.259][c]	4.4 4.5 [23.12, 14]

Table 23.12 Trigonal, point group $\bar{3}m$ (D_{3d}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Elastic compliance tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **$\kappa \perp c$** **$\kappa \parallel c$** **(W/(m K))**	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	**tan δ_1** **tan δ_3**	c_{11} c_{33} c_{44} c_{12} c_{13} c_{14} **(10^9 Pa)**	s_{11} s_{33} s_{44} s_{12} s_{13} s_{14} **(10^{-12} Pa^{-1})**
α-Aluminium oxide, Al_2O_3 (sapphire)	3.98 9 33 ($\perp c$) 35 ($\parallel c$) [23.260]	9.4 11.5 [23.58][a]	0.0001 [23.58] –	496 (3) 499 (4) 146 (3) 159 (10) 114 (3) −23 (1) [23.7, 261]	2.35 2.17 6.95 −0.70 −0.38 0.46 [23.261]
Calcite, $CaCO_3$ (calcspar, Iceland spar)	2.71 3 3.00 ($\perp c$) 3.40 ($\parallel c$) (50 °C) [23.264]	8.0[a,b] [23.43]		144 (3) 84.3 (26) 33.5 (7) 54.2 (47) 51.2 (34) −20.5 (2) [23.7, 265]	11.4 (2) 17.3 (5) 41.4 (12) −4.0 (4) 4.5 (4) 9.5 (5) [23.7]

[a] These values for ε_{11} are neither at constant stress nor at constant strain
[b] It is not clear which relative dielectric constant ε_{ij} is specified
[c] Dispersion relation (λ (µm), $T = 20\,°C$): $n^2 = 1 + \frac{A\lambda^2}{\lambda^2-B} + \frac{C\lambda^2}{\lambda^2-D} + \frac{E\lambda^2}{\lambda^2-F}$
[d] For crystals grown by heat exchanger method (HEM)

Elastooptic tensor	General optical properties	Refractive index	
p_{11} p_{12} p_{13} p_{14} p_{31} p_{33} p_{41} p_{44}	Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o A B C D E F	n_e A B C D E F
−0.23 −0.03 0.02 0.00 0.04 −0.20 0.01 −0.10 (644 nm) [23.262]	0.147−5.2 [23.88] – –	**1.7655** (0.7 μm) 1.077 0.0033 1.025 0.0114 5.04 151.2 [23.263][c,d]	**1.7573** (0.7 μm) 1.041 0.0004 1.030 0.0141 3.55 123.8 [23.263][c,d]
0.062 0.147 0.186 −0.011 0.241 0.139 −0.036 −0.058 (514 nm) [23.266]	0.2−2.3 0.21 (0.633 μm) 1.19 (0.633 μm) [23.27]	**1.6428** (1.042 μm) [23.267]	**1.4799** (1.042 μm) [23.267]

Table 23.13 Trigonal, point group 32 (D_3) materials

	General	Static dielectric tensor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	c_{11} c_{33} c_{44} c_{12} c_{13} c_{14} (10^9 Pa)	d_{11} d_{14} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{14} p_{31} p_{33} p_{41} p_{44}
Aluminium phosphate, $AlPO_4$ (berlinite)	2.620 6.5 ≈ 6 [23.46] –	5.88 [23.8, 268] – 4.73 4.62 [23.269, 270]	67.0 (26) 87.2 (10) 42.9 (4) 9.3 (14) 13.1 (21) −12.7 (5) [23.7, 271][a]	−3.0 1.3 [23.272, 273]	
α-Mercuric sulfide, HgS (cinnabar)	8.05 2–2.5 – –	14.0 (3) 25.5 (5) 15.0 (3) 25.5 (5) [23.275]	35.36 50.92 21.40 7.02 8.66 11.3 [23.276][b]	19.1 ≈ |1.7| [23.8, 277]	– – |0.445| – – |0.115| [23.278] – –
Potassium fluoroboratoberyllate, $KBe_2BO_3F_2$ (KBBF)					
α-Silicon dioxide, SiO_2 (quartz)	2.6485 7 6.5 (⊥ c) 11.7 (∥ c) [23.205]	4.435 4.640 4.520 4.640 [23.283]	86.6 (3) 106.4 (12) 58.0 (7) 6.7 (9) 12.4 (16) 17.8 (3) [23.7][a]	+2.3 −0.67 [23.284, 285]	0.16 0.27 0.27 −0.030 0.29 0.10 −0.047 −0.079 (589 nm) [23.286]
Tellurium, Te	6.25 2–2.5 2.0 (⊥ c) 3.4 (∥ c) [23.290]	33 [23.291] 53 [23.291] – 37 [23.292]	33 (1) 71 (3) 31.8 (25) 9.1 (7) 24.5 (15) (−)12.4 (15) [23.7]	+55 +50 [23.293]	0.164 0.138 0.146 −0.04 −0.086 0.038 0.28 0.14 (10.6 µm) [23.294]

[a] These values are approximately the constant-field values c^E

[b] c^E at constant electric field

[c,d,e] Dispersion relations (λ (µm), $T = 20\,°C$):

[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$

[d] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} - D\lambda^2$

[e] $n_o^2 = 1 + \frac{0.663044\lambda^2}{\lambda^2 - 0.0036} + \frac{0.517852\lambda^2}{\lambda^2 - 0.0112} + \frac{0.175912\lambda^2}{\lambda^2 - 0.0142} + \frac{0.565380\lambda^2}{\lambda^2 - 78.216} + \frac{1.675299\lambda^2}{\lambda^2 - 430.23}$

$n_e^2 = 1 + \frac{0.665721\lambda^2}{\lambda^2 - 0.0036} + \frac{0.503511\lambda^2}{\lambda^2 - 0.0112} + \frac{0.214792\lambda^2}{\lambda^2 - 0.0142} + \frac{0.539173\lambda^2}{\lambda^2 - 77.30} + \frac{1.807613\lambda^2}{\lambda^2 - 390.85}$

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^T_{11} r^T_{41} $(10^{-12}$ m/V) at $\lambda = 633$ nm	Transparency range (μm) dn_o/dT $(10^{-5}$ $K^{-1})$ dn_e/dT $(10^{-5}$ $K^{-1})$	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{11} $(10^{-12}$ m/V)
		1.5161 (1 μm) [23.274]	**1.5285** (1 μm) [23.274]	0.53 [23.221] $d_{14} = 0.013$ [23.221]
3.1 1.55 [23.279]	0.63–13.5 [23.280] – –	**2.7041** 4.1506 2.7896 0.1328 1.1378 705 [23.213][c]	**2.9909** 4.0101 4.3736 0.1284 1.5604 705 [23.213][c]	50 (10.6 μm) [23.281]
	0.155–3.5 [23.282] – –	**1.487** (0.4 μm) 1 1.169725 0.00624 0.009904 [23.282][d] –	**1.410** (0.4 μm) 1 0.956611 0.0061926 0.027849 [23.282][d] –	0.76 [23.282]
−0.445 (10) +0.1904 (50) [23.287]	0.15–4.5 [23.264] −0.62 (546 nm) −0.7 (546 nm) [23.61]	**1.5350** (1 μm) For dispersion relation, see [23.61][e]	**1.5438** (1 μm) For dispersion relation, see [23.61][e]	0.30 [23.12–14, 128, 288, 289]
	3.8–32 [23.84] – –	**4.7979** (10.6 μm) 18.5346 4.3289 3.9810 3.78 11.813 [23.213][c]	**6.2483** (10.6 μm) 29.5222 9.3068 2.5766 9.235 13.521 [23.213][c]	598 (10.6 μm) [23.295]

Table 23.14 Trigonal, point group $3m$ (C_{3v}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{12} c_{13} c_{14} (10^9 Pa)	d_{22} d_{31} d_{33} d_{15} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{14} p_{31} p_{33} p_{41} p_{44}
β-Barium borate, BaB_2O_4 (BBO)	3.849 4 1.2 ($\perp c$) 1.6 ($\parallel c$) [23.205]	– – 6.7 8.1 [23.296]	$< 10^{-3}$ $< 10^{-3}$ (10–50 °C, 1–100 kHz) [23.296]	123.8 53.3 7.8 60.3 49.4 12.3 [23.296]		
Lithium niobate, $LiNbO_3$	4.628 5–5.5 4.6 [23.148]	43.9 (22) [23.304] 23.7 (12) [23.304] 85.2 [23.305] 28.7 [23.305]	0.0015 (4) 0.0011 (3) (1 GHz) [23.304]	202 (2) 244 (5) 60.2 (6) 55 (2) 72 (5) 8.5 (7) [23.7][a]	20.7 (1) [23.306] −0.86 (2) [23.306] +16.2 (1) [23.306] 74.0 (3) [23.306] 6.310 (14) [23.307]	−0.031 (9) 0.082 (9) 0.135 (7) −0.076 (15) 0.170 (14) 0.069 (5) −0.150 (10) 0.147 (100) [23.11][b]
Lithium niobate (5% MgO-doped) $MgO:LiNbO_3$						
Lithium tantalate, $LiTaO_3$	7.45 5.5	42.6 42.8 53.6 43.4 [23.305]	0.0013 (4) 0.0007 (3) (1 GHz) [23.304]	230 (2) 276 (6) 96 (1) 42 (6) 79 (4) −11 (1) [23.7, 317, 318]	8.5 [23.319] −3.0 [23.319] 9.2 [23.319] 26 [23.319] 2.000 (12) [23.307]	−0.081 0.081 0.093 −0.026 0.089 −0.044 −0.085 0.028 [23.320, 321]
Silver antimony sulfide, Ag_3SbS_3 (pyrargyrite)	5.83 2–2.5 – –	– – 21.7 (7) 24.7 (7) [23.325]		52.7 35.6 11.6 26.3 28.0 −0.4 [23.325, 326][c]	16.2 −19.5 62.2 31.6 – [23.327, 328]	

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^T_{13} r^T_{22} r^T_{33} r^T_{51} (10^{-12} m/V) at $\lambda = 633$ nm	**Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})**	**n_o A B C D E F**	**n_e A B C D E F**	**d_{31} d_{33} d_{22} d_{15} (10^{-12} m/V)**
+0.27 (2) −2.41 (3) +0.29 (3) +1.7 (1) [23.297]	0.189−3.5 [23.296, 298–301] −1.66 [23.296] −0.93 [23.296]	**1.6551** 2.7359 0.01878 0.01822 0.01471 0.0006081 0.0000674 [23.302][h]	**1.5426** 2.3753 0.01224 0.01667 0.01627 0.0005716 0.00006305 [23.302][h]	2.16 ± 0.08 (d_{22}) [23.12, 14, 303]
+9.6 +6.8 +30.9 +32.6 [23.308, 309]	0.33−5.5 [23.310] $dn_o/dT = 0.141$ [23.311][f] $dn_o/dT = 2.0$ [23.312][g] $dn_e/dT = 3.85$ [23.311][f] $dn_e/dT = 7.6$ [23.312][g]	**2.2340** 4.91296 0.116275 0.048398 0.0273 [23.311][i] – –	**2.1554** 4.54528 0.091649 0.046079 0.0303 [23.311][i] – –	−4.6 −25 [23.13, 14] – –
11.2 (5) – 36.0 (5) – (for 10.7% MgO) [23.313]	0.4−5 [23.314–316] – –	**2.2272** 4.9017 0.112280 0.049656 0.039636 [23.314, 315][i] – –	**2.1463** 4.5583 0.091806 0.048086 0.032068 [23.314, 315][i] – –	−4.69 [23.303] |25| [23.13] – –
4.5 0.3 27 15 (all for r^S at 3.39 μm) [23.322]	0.4−5.5 – –	**2.1366** (1.058 μm) [23.323]	**2.1406** (1.058 μm) [23.323]	−1.0 ± 0.2 −16 ± 2 +1.7 ± 0.2 [23.154, 324] –
	0.7−14 [23.329] – –	**2.9458** 1 6.585 0.16 0.1133 225 [23.329][j] –	**2.7956** 1 5.845 0.16 0.0202 225 [23.329][j] –	7.8 (10.6 μm) – 8.2 (10.6 μm) – [23.3, 4, 295, 330]

Table 23.14 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{12} c_{13} c_{14} (10^9 Pa)	d_{22} d_{31} d_{33} d_{15} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{14} p_{31} p_{33} p_{41} p_{44}
Silver arsenic sulfide, Ag_3AsS_3 (proustite)	5.63 2–2.5 – –	20.2 (2) 20.2 (2) 21.5 22.0 [23.325]		56.76 37.0 9.12 30.4 30.4 −0.16 [23.325]	12.1 −13.8 30 −20 [23.325] –	|0.056| |0.082| |0.068| – |0.103| |0.100| |≈ 0.01| (1150 nm) – [23.331, 332]
Thallium arsenic selenide, Tl_3AsSe_3 (TAS)	7.83 2–3 – –			[23.339]		[23.339]
Tourmaline, (Na, Ca)(Mg, Fe)$_3$B$_3$Al$_6$ Si$_6$(O, OH, F)$_{31}$	3.0–3.2 7–7.5 3.03 ($\perp c$) 2.92 ($\parallel c$) (125 °C) [23.344][d]	6.3[e] [23.284] 7.1[e] [23.284] 8.2 [23.345] 7.5 [23.345]		277 (19) 163 (11) 64 (3) 65 (24) 32 (20) −6.9 (25) [23.7]	−0.3 [23.345] −0.34 [23.345] −1.8 [23.345] −3.6 [23.345] 4.00 (6) [23.346, 347] [23.346, 347]	

[a] These values are approximately the constant-field values c^E

[b] p^E at constant electric field

[c] c^E at constant electric field

[d] The thermal conductivities have been interpolated from $\kappa(\perp c) = 0.108 \times T^{0.556}$ and $\kappa(\parallel c) = 0.492 \times T^{0.297}$, valid for temperature ranges of 398.2–723.2 K and 393.2–729.2 K, respectively [23.344]

[e] These values for ε_{ij} are neither at constant stress nor at constant strain

[f] Fabricated by vapor transport equilibration (VTE)

[g] Stoichiometric melt

[h,i,j,k] Dispersion relations (λ (µm), $T = 20\,°C$):

[h] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2 + E\lambda^4 - F\lambda^6$

[i] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$

[j] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$

[k] $n^2 = A + \frac{B}{\lambda^2 - C} + \frac{D}{\lambda^2 - E}$

Electrooptic tensor	**General optical properties**	**Refractive index**		**Nonlinear dielectric susceptibility**
r^T_{13} r^T_{22} r^T_{33} r^T_{51} **(10^{-12} m/V)** **at $\lambda = 633$ nm**	**Transparency range (μm)** **dn_o/dT (10^{-5} K^{-1})** **dn_e/dT (10^{-5} K^{-1})**	n_o A B C D E F	n_e A B C D E F	d_{31} d_{33} d_{22} d_{15} **(10^{-12} m/V)**
2.0 [23.333, 334] 1.05 (4) [23.335] 0.22 [23.333, 334] 3.4 (5) [23.335]	0.6–13 [23.336] – –	**2.8163** 9.220 0.4454 0.1264 1733 1000 [23.337][k] –	**2.5822** 7.007 0.3230 0.1192 660 1000 [23.337][k] –	10.4 (10.6 μm) – 16.6 (10.6 μm) 10.8 (10.6 μm) [23.336, 338]
	1.28–17 [23.340] −4.52 [23.341] +3.55 [23.341]	**3.331** (11 μm) 1 10.210 0.197136 0.522 625 [23.341][j] –	**3.152** (11 μm) 1 8.993 0.197136 0.308 625 [23.341][j] –	d_{eff} SHG 10.6 μm: 67.5 [23.338, 340] 36.5 [23.295, 340] 29 [23.342] 20 [23.343]
$r^S_{13} = 1.7$ [23.348] $r^T_{22} = 0.3$ (589 nm) [23.349] $r^S_{33} = 1.7$ [23.348]		**1.6274** 1 1.6346 0.010734 0 [23.350][j] – –	**1.6088** 1 1.57256 0.011346 0 [23.350][j] – –	0.13 (3) 0.47 (6) 0.07 (1) 0.23 (4) [23.323]

Table 23.15 Tetragonal, point group $4/mmm$ (D_{4h}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Elastic compliance tensor	Elastooptic tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **$\kappa \perp c$** **$\kappa \parallel c$** **(W/(m K))**	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	**tan δ_1**	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} **(10^9 Pa)**	s_{11} s_{33} s_{44} s_{66} s_{12} s_{13} **(10^{-12} Pa^{-1})**	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Magnesium fluoride, MgF_2	3.177 6 21 (⊥ c) 30 (∥ c) [23.205]	5.85 4.87 [23.25][a]		138 (7) 201 (10) 56.5 (5) 96 (2) 88 (7) 62 (4) [23.7]	12.6 (1) 6.0 (3) 17.7 (2) 10.5 (2) −7.2 (2) −1.7 (1) [23.7]	0.041 0.119 0.078 −0.099 0.014 – −0.0475 [23.351]
Titanium dioxide, TiO_2 (rutile)	4.26 6−6.5 8.8 (⊥ c) (40 °C) 12.6 (∥ c) [23.264]	85 190 [23.81][a]	0.017 [23.81] –	269 (3) 480 (5) 124 (1) 192 (2) 177 (4) 146 (6) [23.7]	6.8 (3) 2.60 (1) 8.06 (5) 5.21 (5) −4.0 (3) −0.85 (3) [23.7]	0.012 (4) 0.162 (16) −0.157 (12) −0.092 (9) −0.059 (3) 0.020 −0.060 [23.352]
Yttrium vanadate, YVO_4 (YVO)	4.22 5 5.32 (⊥ c) 5.10 (∥ c) [23.58]					

[a] These values for ε_{ij} are neither at constant stress nor at constant strain
[b,c,d] Dispersion relations (λ (μm), $T = 20\,°$C):
[b] $n_o^2 = 1.27620 + \frac{0.60967\lambda^2}{\lambda^2-0.08636^2} + \frac{0.0080\lambda^2}{\lambda^2-18.0^2} + \frac{2.14973\lambda^2}{\lambda^2-25.0^2}$; $n_e^2 = 1.25385 + \frac{0.66405\lambda^2}{\lambda^2-0.088504^2} + \frac{1.0899\lambda^2}{\lambda^2-22.2^2} + \frac{0.1816\lambda^2}{\lambda^2-24.4^2} + \frac{2.1227\lambda^2}{\lambda^2-40.6}$
[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2-C} + \frac{D\lambda^2}{\lambda^2-E}$
[d] $n^2 = A + \frac{B}{\lambda^2-C} - D\lambda^2$

General optical properties	Refractive index		Nonlinear dielectric susceptibility
Transparency range (μm) **dn_o/dT (10^{-5} K^{-1})** **dn_e/dT (10^{-5} K^{-1})**	n_o A B C D E	n_e A B C D E	$\chi^{(3)}$
0.12–7.5 0.17 (0.4 μm) 0.23 (0.4 μm) [23.25]	**1.48** (0.150 μm) **1.423** (0.200 μm) **1.3776** (0.590 μm) **1.373** (1.05 μm) **1.32** (6.00 μm) **1.29** (7.50 μm) For dispersion relations, see [23.41][b]	**1.49** (0.150 μm) **1.437** (0.200 μm) **1.3894** (0.590 μm) **1.385** (1.05 μm) **1.33** (6.00 μm) **1.30** (7.50 μm) For dispersion relations, see [23.41][b]	[23.25]
0.42–4.0 [23.83] 0.4 (0.4 μm) [23.353] −0.9 (0.4 μm) [23.353]	**2.4851** 5.913 0.2441 0.0803 0 [23.353][c] –	**2.7488** 7.197 0.3322 0.0843 0 [23.353][c] –	[23.354]
0.4–5 0.85 0.3 [23.355]	**1.9573** 3.77834 0.069736 0.04724 0.0108133 [23.355][d] –	**2.1652** 4.59905 0.110534 0.04813 0.0122676 [23.355][d] –	

Table 23.16 Tetragonal, point group $4/m$ (C_{4h}) materials

	General	Elastic stiffness tensor	Elastic compliance tensor	Elastooptic tensor
Material	**ϱ (g/cm^3)** **Mohs hardness** **$\kappa \perp c$** **$\kappa \parallel c$** **(W/(m K))**	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} c_{16} **(10^9 Pa)**	s_{11} s_{33} s_{44} s_{66} s_{12} s_{13} s_{16} **(10^{-12} Pa^{-1})**	p_{11} p_{12} p_{13} p_{16} p_{31} p_{33} p_{44} p_{45} p_{61} p_{66}
Lead molybdate, $PbMoO_4$	6.95 2.5–3 150 ($\perp c$) 150 ($\parallel c$) [23.356]	107.2 (19) 93.2 (13) 26.4 (3) 34.8 (8) 61.9 (55) 52.0 (8) −15.8 (18) [23.7]	20.8 (2) 16.3 (8) 37.9 (4) 42.3 (20) −11.8 (6) −5.0 (5) 14.8 (12) [23.357]	0.253 (23) 0.253 (23) 0.273 (43) 0.015 (4) 0.163 (20) 0.298 (12) 0.04 (0) −0.01 (0) 0.025 (21) 0.046 (5) (477–633 nm) [23.358]
Yttrium lithium fluoride, $YLiF_4$ (YLF)	3.995 4–5 7.2 ($\perp c$) 5.8 ($\parallel c$) [23.360]	121 156 40.9 17.7 60.9 52.6 −7.7 [23.361]	12.8 7.96 24.4 63.6 −6.0 −2.3 8.16 [23.361]	

[a,b] Dispersion relations (λ (µm), $\lambda > 0.5\,\mu$m, $T = 20\,°$C):

[a] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C}$

[b] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$

General optical properties	**Refractive index**	
Transparency range (μm) **dn_o/dT (10^{-5} K^{-1})** **dn_e/dT (10^{-5} K^{-1})**	$\boldsymbol{n_o}$ ***A*** ***B*** ***C***	$\boldsymbol{n_e}$ ***A*** ***B*** ***C***
0.42−5.5 [23.359] $-(3.0 \pm 0.2)n_o$ $-(1.8 \pm 0.2)n_e$ [23.356]	**2.38** (633 nm) [23.359] 1 4.0650407 0.0536585 [23.356][a]	**2.25** (633 nm) [23.359] 1 3.7037037 0.0400000 [23.356][a]
0.18−6.7 −0.2 −0.43 [23.355]	**1.448** 1.38757 0.70757 0.00931 0.18849 50.99741 [23.355][b]	**1.470** 1.31021 0.84903 0.00876 0.53607 134.9566 [23.355][b]

Table 23.17 Tetragonal, point group 422 (D_4) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{14} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Tellurium dioxide, TeO_2 (paratellurite)	5.99 4 3.0 (3) [23.362] –	22.7 [23.363] 24.9[a] [23.364] 22.9 (10) [23.363] 24.7 (15) [23.363]	0.0011 0.012 (100 kHz) [23.363]	55.9 (2) 105.5 (4) 26.7 (2) 66.3 (4) 51.6 (3) 23.9 (22) [23.7]	8.13 (70) [23.363]	0.007 0.187 0.340 0.091 0.240 −0.17 −0.046 [23.365]

[a] This value for ε_{33} is neither at constant stress nor at constant strain

[b] Dispersion relation (λ (µm), $T = 20\,°C$): $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^{T}_{41} $(10^{-12}\,m/V)$ at $\lambda = 633\,nm$	Transparency range (μm) dn_o/dT $(10^{-5}\,K^{-1})$ dn_e/dT $(10^{-5}\,K^{-1})$	n_o A B C D E	n_e A B C D E	d_{14} $(10^{-12}\,m/V)$
0.62 [23.366]	0.35–6 [23.367] 0.9 (0.644 μm) 0.8 (0.644 μm) [23.368]	**2.2005** 1 2.584 0.0180 1.157 0.0696 [23.368][b]	**2.3431** 1 2.823 0.0180 1.542 0.0692 [23.368][b]	0.39 [23.369]

Table 23.18 Tetragonal, point group $\bar{4}2m$ (D_{2d}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{14} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Ammonium dideuterium phosphate, $ND_4D_2PO_4$ (AD*P, DADP)	1.885 [23.370, 371] – – –	70[a] [23.372] 26[a] [23.372] 72 [23.373] 22 [23.373]	0.003 0.015 (1 kHz) [23.372]	62.1 29.9 9.1 6.1 −5 14 [23.373][b]	10 75 [23.373]	– – – – – – 0.04 [23.374, 375]
Ammonium dihydrogen arsenate, $NH_4H_2AsO_4$ (ADA)	2.310 – – –	74 [23.382] 13 [23.382] 75 [23.383] 14 [23.383]		67.5 30.2 6.85 6.39 −10.6 16.5 [23.384]	36.5 27.5 [23.385, 386]	
Ammonium dihydrogen phosphate, $NH_4H_2PO_4$ (ADP)	1.80 2.0 1.26 (⊥ c) 0.71 (‖ c) (315 K) [23.264]	55.5 (15) 15.0 (5) 56.0 (15) 15.5 (5) [23.107, 108]	0.001 0.004 (1 kHz) [23.372]	67.3 (27) 33.7 (7) 8.6 (2) 6.02 (6) 5.0 (13) 19.8 (6) [23.7]	1.76 48.31 [23.388]	0.302 (12) 0.252 (17) 0.204 (33) 0.191 (6) 0.219 (49) −0.058 −0.088 (17) (589−633 nm) [23.389]
Cadmium germanium arsenide, $CdGeAs_2$	5.60 3.5−4 4.18 [23.156] –			98.0 86.6 43.2 42.3 60.5 59.6 [23.392]		
Cadmium germanium phosphide, $CdGeP_2$						
Cesium dideuterium arsenate, CsD_2AsO_4 (CD*A, DCDA)		– – 74 61 [23.372][c,d]	0.57 0.38 (1 kHz) [23.372][c,d]		10.5 125.4 [23.396][c]	0.223 0.271 0.160 0.206 0.133 −0.061 [23.397, 398] –

Electrooptic tensor	**General optical properties**	**Refractive index**		**Nonlinear dielectric susceptibility**
r^T_{41} r^T_{63} (10^{-12} m/V)	Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{36} (10^{-12} m/V)
	0.22−1.7 [23.376–379] – –	**1.5049** 2.279481 1.215879 57.97555433 0.010761 0.013262977 [23.376][e]	**1.4659** 2.151161 1.199009 126.6005279 0.009652 0.009712103 [23.376][e]	0.43 (0.6943 μm) [23.380, 381]
33.5 (550 nm) 9.2 (550 nm) [23.292, 372]	0.22−1.2 [23.376] −4.56 [23.387] 1.25 [23.387]	**1.5550** 2.443449 2.017752 57.83514282 0.016757 0.018272821[23.376][e]	**1.5081** 2.275962 1.59826 126.8851303 0.014296 0.016560859 [23.376][e]	0.43 [23.376]
26.0 (633 nm) 8.7 (633 nm)	0.18−1.53 [23.376, 390] −4.93 [23.387] 0 [23.387]	**1.5065** 2.302842 15.102464 400 0.01112165 0.013253659 [23.391][e]	**1.4681** 2.163510 5.919896 400 0.009616676 0.012989120 [23.391][e]	0.47 [23.12, 14]
	2.5−15 [23.393] – –	**3.5046** (10.6 μm) 10.1064 2.2988 1.0872 1.6247 1370 [23.213][f]	**3.5911** (10.6 μm) 11.8018 1.2152 2.6971 1.6922 1370 [23.213][f]	282 (10.6 μm) [23.393, 394]
	0.9−12 [23.394] – –	**3.1422** (10.6 μm) 5.9677 4.2286 0.2021 1.6351 671.33 [23.395][f]	**3.1563** (10.6 μm) 6.1573 4.0970 0.2330 1.4925 671.33 [23.395][f]	100 (10.6 μm) [23.394]
– 38.8 (700 nm) [23.399]	0.27−1.66 [23.400] −2.33 [23.387] −1.67 [23.387]	**1.5499** 2.40817 2.2112173 126.871163 0.015598 0.019101728 [23.376][e]	**1.5341** 2.345809 0.651843 127.3304614 0.015141 0.016836101 [23.376][e]	0.402 [23.400]

Table 23.18 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{14} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Cesium dihydrogen arsenate, CsH_2AsO_4 (CsDA, CDA)	3.53 – – –	58.0[a] [23.401][d] 34.0[a] [23.401][d] 61 [23.372][d] 29 [23.372][d]	15 13 (1 kHz) [23.372]	51.6 39.9 6.66 1.7 0.56 1.33 [23.402, 403]	5.6 (10) 123 (8) [23.404, 405]	0.238 (58) 0.225 (0) 0.211 (19) 0.200 (4) 0.220 (12) −0.042 |0.065| (633 nm) [23.397, 398]
Cesium lithium borate, $CsLiB_6O_{10}$ (CLBO)	– 4 – –					
Copper gallium selenide, $CuGaSe_2$						
Copper gallium sulfide, $CuGaS_2$	4.45 – – –	9.3[a] 10[a] [23.104]				
Potassium dideuterium arsenate, KD_2AsO_4 (KD*A, DKDA)	2.890 [23.411][c] – – –	71[a] 33[a,d] [23.372] (≈ 90% deuterated)	0.02 0.20 (1 kHz) [23.372][d] (≈ 90% deuterated)	74.6 69.3 9.88 6.17 12.4 33.9 [23.412]	22.5 24.8 [23.412] (≈ 90% deuterated)	
Potassium dideuterium phosphate, KD_2PO_4 (KD*P, DKDP)	2.355 2.5 2.09 (⊥ c) 1.86 (∥ c) [23.376]	47.1 (24)[a] [23.187][c] 48 [23.382][c] – 50 (2) [23.414][c]	0.0068 (17) 0.0072 (18) (1 GHz) [23.304][c]	67.4 54.5 12.6 5.94 −5.8 12.2 [23.415]	– 58 [23.414][c]	0.241 0.247 0.245 0.236 0.245 −0.035 −0.072 [23.416, 417]
Potassium dihydrogen arsenate, KH_2AsO_4 (KDA)	2.87 – – –	53 [23.421] 18 [23.421] 53.7 [23.422] 21.0 [23.422]	0.007 0.008 (10 GHz) [23.421]	64.8 48.2 10.75 6.63 0.77 13.6 [23.423]	17.1 19.1 [23.412]	– – – – – – 0.020 [23.374, 375]

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^T_{41} r^T_{63} (10^{-12} m/V)	Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{36} (10^{-12} m/V)
– 19.1 (700 nm) [23.292]	0.26–1.43 [23.400] −2.87 [23.387] −2.21 [23.387]	**1.5514** 2.420405 1.403336 57.82416181 0.016272 0.018005614 [23.376][e]	**1.5356** 2.350262 0.685328 127.2688578 0.015645 0.014820871 [23.376][e]	0.402 [23.400]
	0.18–2.75 [23.406] $-0.104\lambda^2+0.035\lambda-1.291$ [23.407] $0.331\lambda^2-0.243\lambda-0.84$ [23.407]	**1.4854** 2.2145 0.00890 0.02051 0.01413 [23.407][g] –	**1.4352** 2.0588 0.00866 0.01202 0.00607 [23.407][g] –	0.86 [23.406]
	0.73–17 [23.408] – –	**2.8358** (1.0 μm) **2.7430** (2.0 μm) **2.7133** (6.0 μm) [23.408]	**2.8513** (1.0 μm) **2.7510** (2.0 μm) **2.7192** (6.0 μm) [23.408]	27 (10.6 μm) [23.408]
1.76 (633 nm) – [23.104]	0.52–12 [23.409] 5.9 [23.410] 6.0 [23.410]	**2.4360** (10.6 μm) 4.0984 2.1419 0.1225 1.5755 738.43 [23.409][f]	**2.4201** (10.6 μm) 4.4834 1.7316 0.1453 1.7785 738.43 [23.409][f]	9.0 (10.6 μm) [23.409]
– 18.2 (550 nm) [23.292]	0.22–2.3 [23.413] – –			0.39 [23.376]
8.8 (4) (546 nm) [23.418] 25.8 (633 nm) [23.419]	0.2–2.1 [23.377, 420] −3.1 [23.387] −2.1 [23.387]	**1.4928** 1.661145 0.586015 0.016017 0.691194 30 [23.395][f]	**1.4555** 1.687499 0.44751 0.017039 0.596212 30 [23.395][f]	0.37 [23.12, 14]
12.5 (550 nm) 10.9 (550 nm) [23.372, 399]	0.216–1.67 [23.376, 377, 380, 381] −3.95 [23.387] −2.27 [23.387]	**1.5509** 2.424647 3.742954 126.9036045 0.015841 0.018624061 [23.376][e]	**1.5059** 2.262579 0.769288 127.0537007 0.013461 0.016165851 [23.376][e]	0.41 [23.221]

Table 23.18 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{14} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Potassium dihydrogen phosphate, KH_2PO_4 (KDP)	2.3383 2.5 1.34 ($\perp c$) (42 °C) 1.21 ($\parallel c$) [23.264]	42.5 (15) 20.0 (5) 43.2 (15) 20.8 (5) [23.107, 108]	0.004 (9.2 GHz) [23.424] 0.0005 (1 GHz) [23.107, 108]	71.2 (14) 57 (1) 12.6 (4) 6.2 (1) −5.0 (11) 14.1 (14) [23.7]	3.5 (15) 22.4 (10) [23.404, 405]	0.256 (18) 0.254 (19) 0.224 (34) 0.227 (8) 0.200 (54) −0.265 (10) −0.063 (6) (589−633 nm) [23.416, 417]
Rubidium dideuterium arsenate, RbD_2AsO_4 (RbD*A, RD*A, DRDA)	3.333 – – –	72[a] 41[a,c] [23.372]	1.6 2.3 (1 kHz) [23.372][c]	49.3 38.6 9.48 4.08 −19.3 4.9 [23.429]	14.6 45.8[c] [23.429]	
Rubidium dideuterium phosphate, RbD_2PO_4 (RbD*P, RD*P, DRDP)		– 72[a] [23.430, 431]		[23.432, 433][c]	3.3 (3) 52 (1)	
Rubidium dihydrogen arsenate, RbH_2AsO_4 (RbDA, RDA)	3.28 – – –	54.5[a] 28.5[a] [23.435]	2.1 5.2 [23.435]	51.0 39.2 10.4 4.31 −18.9 2.3 [23.429]	9.9 28.5 [23.401, 429]	0.227 0.239 0.200 0.205 0.182 [23.436, 437] – 0.023 [23.374, 375]
Rubidium dihydrogen phosphate, RbH_2PO_4 (RbDP, RDP)	2.805 – – –	42.0 26.5 41.4 27 [23.441, 442]	0.034 0.051 (38.6 GHz) [23.441, 442]	63 (7) 50.0 (55) 10.6 (7) 3.56 (7) −6.0 (6) 10.6 (72) [23.7]	4.0 (3) 37 (1) [23.432, 433]	0.247 0.265 0.248 0.229 0.248 −0.032 −0.032 [23.416, 417]
Silver gallium selenide, $AgGaSe_2$	5.71 3−3.5 1.1 ($\perp c$) 1.0 ($\parallel c$) [23.205]	– – 10.5 12.0 [23.445]			9.0 3.7 [23.445]	

Electrooptic tensor	**General optical properties**	**Refractive index**		**Nonlinear dielectric susceptibility**
r^T_{41} r^T_{63} $(10^{-12}\,\mathrm{m/V})$	**Transparency range (μm)** $\mathrm{d}n_o/\mathrm{d}T$ $(10^{-5}\,\mathrm{K}^{-1})$ $\mathrm{d}n_e/\mathrm{d}T$ $(10^{-5}\,\mathrm{K}^{-1})$	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{36} $(10^{-12}\,\mathrm{m/V})$
−8.277 (7) (589 nm) +10.22 (589 nm) [23.425]	0.174−1.57 [23.390, 420, 426] −3.4 [23.387] −2.87 [23.387]	**1.4938** 2.259276 0.01008956 0.012942625 13.00522 400 [23.427, 428][f]	**1.4599** 2.132668 0.008637494 0.012281043 3.2279924 400 [23.427, 428][f]	0.39 [23.12, 14]
– 21.4 (550 nm) [23.399]	0.26−1.7 [23.376] – –	**1.5392** 2.373255 1.979528 126.9867549 0.01543 0.015836964 [23.376][e]	**1.5091** 2.270806 0.275372 58.08499107 0.013592 0.01596609 [23.376][e]	0.31 [23.376]
	0.22−1.5 [23.376, 434] – –	**1.4913** 2.235596 0.010929 0.001414783 2.355322 126.8547185 [23.376][e]	**1.4681** 2.152727 0.010022 0.001379157 0.691253 127.0144778 [23.376][e]	0.38 [23.376]
13.5 (550 nm) [23.372] 14.8 (550 nm) [23.399]	0.26−1.46 [23.438] −3.37 [23.387] −2.21 [23.387]	**1.5405** 2.390661 3.487176 126.7648558 0.015513 0.018112315 [23.376][e]	**1.5105** 2.27557 0.720099 26.6309092 0.013915 0.01459264 [23.376][e]	0.4 (0.694 μm) [23.439, 440]
10.3 14.3 [23.443, 444]	0.22−1.5 [23.376, 434] −3.74 [23.387] −2.73 [23.387]	**1.4926** 2.249885 0.01056 0.007780475 3.688005 127.1998253 [23.376][e] –	**1.4700** 2.159913 0.009515 0.00847799 0.988431 127.692938 [23.376][e] –	0.36 [23.439]
4.5 (1.15 μm) 3.9 (1.15 μm) [23.446]	0.71−18 [23.447] 4.5 (3.39 μm) [23.448] 7.6 (3.39 μm) [23.448]	**2.7008** 4.6453 2.2057 0.1879 1.8377 1600 [23.213][f] –	**2.6800** 5.2912 1.3970 0.2845 1.9282 1600 [23.213][f] –	33 (10.6 μm) [23.12, 14]

Table 23.18 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	$\tan\delta_1$ $\tan\delta_3$ (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{14} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Silver gallium sulfide (silver thiogallate), $AgGaS_2$	4.58 3–3.5 1.5 ($\perp c$) 1.4 ($\parallel c$) [23.205]	10 14 [23.449][a]		87.9 75.8 24.1 30.8 58.4 59.2 [23.450, 451]		
Urea, $(NH_2)_2CO$	1.318 <2.5 – –	5–8[a] [23.43]		23.5 51.0 6.2 0.50 −0.50 7.5 [23.456]		
Zinc germanium diphosphide, $ZnGeP_2$	4.12 5.5 35 ($\perp c$) 36 ($\parallel c$) [23.205]	15 12 [23.104][a]				[23.461, 462]

[a] These values for ε_{ij} are neither at constant stress nor at constant strain
[b] The elastic stiffness constants were measured at constant electric field (c^E)
[c] May be only partially deuterated
[d] *Adhav* and *Vlassopoulous* [23.372] measured arsenates with low resistivity ($\approx 10^8\,\Omega$ cm), and as a result their $\tan\delta$ values are high and ε may also be high. The data for RDA in [23.372] are incorrectly labeled ADA (remarks of the compiler)
[e,f,g,h] Dispersion relations (λ (µm), $T = 20\,°$C):
[e] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D}{\lambda^2 - E}$
[f] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E}$
[g] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$
[h] $n^2 = A + \frac{B}{\lambda^2 - C} + \frac{D(\lambda^2 - E)}{(\lambda^2 - E) + F}$

Electrooptic tensor	General optical properties	Refractive index		Nonlinear dielectric susceptibility
r^T_{41} r^T_{63} (10^{-12} m/V)	Transparency range (μm) dn_o/dT (10^{-5} K^{-1}) dn_e/dT (10^{-5} K^{-1})	n_o *A* *B* *C* *D* *E*	n_e *A* *B* *C* *D* *E*	d_{36} (10^{-12} m/V)
4.0 (2) 3.0 (1) [23.452]	0.47–13 [23.453] For d*n*/d*T*, [23.454, 455]	**2.4540** 3.40684 2.40065 0.09311 2.06248 950 [23.455][f] –	**2.4012** 3.60728 1.94792 0.11066 2.24544 1030.7 [23.455][f] –	17.5 (1.06 μm) [23.12, 14] 11.2 (10.6 μm) [23.12, 14]
+1.03 (633 nm) −0.75 (633 nm) [23.457]	0.2–1.8 [23.458] – –	**1.4811** 2.1823 0.0125 0.03 0 [23.459][h] – –	**1.5825** 2.51527 0.0240 0.03 0.0202 1.52 0.08771 [23.459][h]	1.18 (0.6 μm) [23.458, 460]
1.8 (5 μm) – [23.463]	0.74–12 [23.464] 21.18 [23.410] 23.01 [23.410]	**3.2324** 4.4733 5.26576 0.13381 1.49085 662.55 [23.465, 466][f] –	**3.2786** 4.63318 5.34215 0.14255 1.45785 662.55 [23.465, 466][f] –	69 (10.6 μm) [23.12, 464]

Table 23.19 Tetragonal, point group $4mm$ (C_{4v}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) **Mohs hardness** $\kappa \perp c$ $\kappa \parallel c$ (W/(m K))	ε^S_{11} ε^S_{33} ε^T_{11} ε^T_{33}	tan δ_1 tan δ_3 (f (kHz))	c_{11} c_{33} c_{44} c_{66} c_{12} c_{13} (10^9 Pa)	d_{31} d_{33} d_{15} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{31} p_{33} p_{44} p_{66}
Barium titanate, $BaTiO_3$[a]	6.02 – 1.34 [23.46] –	1970 109 2920 168 [23.467]	0.13 – (24 GHz) [23.468]	243 147.9 54.9 120 128 123 [23.469][b]	−33.4 +68.5 647.0 [23.469] –	[23.449, 470]
Lead titanate, $PbTiO_3$	7.9 – – –	102 (3) 33.5 (10) 130–140 105–110 [23.475]	0.02–0.05 0.02–0.05 (0.1 GHz) [23.475]	$s^E_{11} = 7.2$ $s^E_{33} = 32.5$ $s^E_{44} = 12.2$ $s^E_{66} = 7.9$ $s^E_{12} = -2.1$ [23.476, 477][c]	−25 +117 61 [23.476, 477] –	
Lithium tetraborate, $Li_2B_4O_7$	2.44 5 – –	78.80 71.45 82.61 87.92 [23.480]		130.9 (42) 55.4 (11) 57.3 (14) 46.4 (7) 1.5 (12) 30 (4) [23.7]		
Potassium lithium niobate, $K_3Li_2Nb_5O_{15}$ (KLINBO)	4.3 – – –	271 83 306 115 (405 °C) [23.485][d]		220 109 68 70 74 59 [23.485][b,d]	−14 57 68 [23.485][d] –	

[a] Top-seeded solution grown (TSSG) $BaTiO_3$
[b] The elastic stiffness constants were measured at constant electric field (c^E)
[c] Units not specified in original, but probably 10^{-12} Pa^{-1}
[d] The stoichiometry was $K_{2.89}Li_{1.55}Nb_{5.11}O_{15}$ instead of $K_3Li_2Nb_5O_{15}$
[e,f] Dispersion relations (λ (µm), $T = 20\,°C$):
[e] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$
[f] $n^2 = A + \frac{B}{\lambda^2 - C} + \frac{D(\lambda^2 - E)}{(\lambda^2 - E) + F}$

Electrooptic tensor	**General optical properties**	**Refractive index**		**Nonlinear dielectric susceptibility**
r^{T}_{13} r^{T}_{33} r^{T}_{51} **(10^{-12} m/V)** **at $\lambda = 633$ nm**	**Transparency range (μm)** **dn_o/dT (10^{-5} K^{-1})** **dn_e/dT (10^{-5} K^{-1})**	n_o *A* *B* *C* *D* *E* *F*	n_e *A* *B* *C* *D* *E* *F*	d_{31} d_{33} **(10^{-12} m/V)**
8 105 1300 [23.471]	0.14–10 – –	**2.3218** 1 4.195 0.04964 0 [23.472][e] – –	**2.2894** 1 4.073 0.04456 0 [23.472][e] – –	−14.4 −5.4 [23.473, 474]
13.8 (r^{S}_{13}) 5.9 (r^{S}_{33}) [23.478]	0.6–6 [23.479] – –	**2.5715** 1 5.359 0.0502 0 [23.479][e] – –	**2.5690** 1 5.365 0.0471 0 [23.479][e] – –	+35.3 −7.0 [23.479]
+3.74 +3.67 −0.11 [23.481]	0.17–3.5 [23.482, 483] ≈ 0.1 [23.483] ≈ 0.3 [23.483]	**1.5968** (1.1 μm) 2.564310 0.012337 0.013103 0.019075 [23.483][f] – –	**1.5422** (1.1 μm) 2.386510 0.010664 0.012878 0.012813 [23.483][f] – –	0.12 0.93 [23.484]
8.9 [23.486, 487] 78 [23.486, 487] 80 [23.488]	0.4–5 [23.486, 487, 489] – –	**2.208** 1 3.708 0.04601 0 [23.323][e] – –	**2.112** 1 3.349 0.03564 0 [23.323][e] – –	11.8 (0.8 μm) [23.489] 10.5 [23.486, 487]

Table 23.20 Orthorhombic, point group *mmm* (D_{2h}) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Elastic compliance	Piezooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε_{11} ε_{22} ε_{33}	$\tan\delta_1$	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	s_{11} s_{22} s_{33} s_{44} s_{55} s_{66} s_{12} s_{13} s_{23} (10^{-12} Pa^{-1})	
Magnesium silicate, Mg_2SiO_4 (forsterite)	3.217 7 5.12 [23.344]	6.2[a] [23.43]		328.5 (13) 200.0 (1) 235.3 (7) 66.9 (6) 81.3 (1) 80.9 (2) 68.0 (16) 68.7 (7) 72.8 (6) [23.7]	3.37 5.84 4.93 15.0 12.3 12.4 −0.85 −0.71 −1.56 [23.7]	$q_{11}+q_{12}+q_{13}=0.16$ $q_{21}+q_{22}+q_{23}=0.20$ $q_{31}+q_{32}+q_{33}=0.27$ (589 nm) [23.490]
Yttrium aluminate, $YAlO_3$ (YAP, YALO)	5.35 8.5 11 [23.260]	16–20[a] [23.58]	0.001 [23.58]			

[a] It is not clear which relative dielectric constant ε_{ij} is specified

[b] Dispersion relation (λ (µm), $T = 20\,°C$): $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C}$

General optical	**Refractive index**		
Transparency range (µm) **dn_X/dT (10^{-5} K^{-1})** **dn_Y/dT (10^{-5} K^{-1})** **dn_Z/dT (10^{-5} K^{-1})**	***n_X*** ***A*** ***B*** ***C***	***n_Y*** ***A*** ***B*** ***C***	***n_Z*** ***A*** ***B*** ***C***
0.27–5.9 [23.88] 1.45 [23.491] – 0.98 [23.491]	**1.9111** (1 µm) 1 2.61960 0.012338 [23.492][b]	**1.9251** (1 µm) 1 2.67171 0.012605 [23.492][b]	**1.9337** (1 µm) 1 2.70381 0.012903 [23.492][b]

Table 23.21 Orthorhombic, point group 222 (D_2) materials

	General	Static dielectric tensor	Elastic stiffness	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3)	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{14} d_{25} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Barium formate, $Ba(COOH)_2$	3.261	6.9[a] [23.493, 494] 6.7[a] [23.493, 494] 5.2[a] [23.493, 494] 7.9 [23.345] 5.9 [23.345] 7.5 [23.345]	$s^E_{44} = 78.5$ $s^E_{55} = 60$ $s^E_{66} = 82.5$ [23.345]	−5.6 (5) −10.2 (10) +1.9 (1) [23.8, 495]	
Cesium triborate, CsB_3O_5 (CBO)	3.357				
α-Iodic acid, HIO_3	4.64	7.5 12.4 8.1 [23.345][a]	57(2) 43 (1) 30.0 (3) 21 (1) 16 (1) 17.8 (13) 6 (3) 15 (2) 11.5 (5) [23.7]	−26(1) −18 (1) +28 (1) [23.8, 499]	0.418 (16) 0.308 (330) 0.313 (56) 0.304 (36) 0.322 (31) 0.307 (57) 0.527 (48) 0.340 (31) 0.377 (103) −0.077 (66) 0.107 (12) 0.092 (8) [23.11]
3-Methyl 4-nitropyridine 1-oxide, $C_6N_2O_3H_6$ (POM)	1.55	3.77 5.41 3.77 [23.505][a]	13.29 18.14 12.20 7.8 5.2 5.4 4.9 −2.6 10.6 [23.506]		0.45 0.53 0.49 0.53 0.57 0.42 0.36 0.70 0.64 −0.078 −0.074 −0.046 (514.5 nm) [23.506]

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{41} r^T_{52} r^T_{63} (10^{-12} m/V)	**Transparency range (μm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X A B C D	n_Y A B C D	n_Z A B C D	d_{14} d_{25} d_{36} (10^{-12} m/V)
+1.81 (18) −2.03 (20) +0.48 (10) [23.495]	0.245−2.2, 4.8−5.1 [23.496] – – –	**1.6214** 2.619 0.0177 0.039 0 [23.496][b]	**1.5819** 2.491 0.0184 0.035 0 [23.496][b]	**1.5585** 2.421 0.016 0.042 0 [23.496][b]	0.10 0.11 0.11 [23.496]
	0.170−3.0 [23.497] – – –	**1.5194** 2.3035 0.01378 0.01498 0.00612 [23.498][b]	**1.5505** 2.3704 0.01528 0.01581 0.00939 [23.498][b]	**1.5781** 2.4753 0.01806 0.01752 0.01654 [23.498][b]	1.5 [23.497] – –
6.6 (3) 7.0 (5) 6.0 (3) [23.500, 501]	0.35−1.6 $E \parallel a$ 0.35−2.2 $E \parallel c$ [23.502, 503] – –	**1.8129** 2.5761 0.6973 0.05550736 0.0201 [23.503][c]	**1.9273** 2.4701 1.2054 0.05044516 0.0152 [23.503][c]	**1.9500** 2.6615 1.1316 0.05202961 0.0398 [23.503][c]	8.3 [23.504] – –
|3.6(6)| |5.1(4)| |2.6(3)| [23.507]	0.4−3.3 [23.508] – – –	**1.625** 2.4529 0.1641 0.128 0 [23.508][c]	**1.668** 2.4315 0.3556 0.1276 0.0579 [23.508][c]	**1.829** 2.5521 0.7962 0.1289 0.0941 [23.508][c]	5.3−6.0 [23.508] – –

Table 23.21 (continued)

	General	Static dielectric tensor	Elastic stiffness	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3)	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{14} d_{25} d_{36} (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Potassium sodium tartrate tetrahydrate, $KNa(C_4H_4O_6) \cdot 4H_2O$ (Rochelle salt)	1.767	245 – – 1100 11.1 9.2 [23.345]	40 (16) 55 (25) 63 (23) 11.9 (38) 3.1 (2) 10.0 (16) 24 (29) 32 (20) 23.8 (438) [23.7]	2300 −56 11.8 [23.345]	0.35 0.41 0.42 0.37 0.28 0.34 0.36 0.35 0.36 −0.030 0.0046 −0.025 (589 nm) [23.509]
Sodium ammonium tartrate tetrahydrate, $Na(NH_4)C_4H_4O_6 \cdot 4H_2O$ (Ammonium Rochelle salt)		10 (1)[a] 10 (1)[a] 10 (1)[a] [23.516] 9.0 8.9 10.0 [23.345]	36.8 50.9 55.4 10.6 3.03 8.70 27.2 30.8 34.7 [23.345]	≈ 13 38 ≈ 7 [23.517, 518]	−0.48 −0.61 −0.68 −0.55 −0.76 −0.83 −0.44 −0.57 −0.71 0.0077 0.013 −0.0026 (589 nm) [23.519]

[a] The relative dielectric constant ε_{ij} was measured neither at constant stress nor at constant strain

[b,c] Dispersion relations (λ (µm), $T = 20\,°C$):

[b] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$

[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} - D\lambda^2$

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{41} r^T_{52} r^T_{63} (10^{-12} m/V)	**Transparency range (μm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X A B C D	n_Y A B C D	n_Z A B C D	d_{14} d_{25} d_{36} (10^{-12} m/V)
8.3 [23.510, 511] – –	< 250 nm to > 850 nm −6.54 [23.512, 513] −5.57 [23.512, 513] −6.00 [23.512, 513]	**1.49540** (585 nm) [23.514] **1.5622** (260 nm) [23.512, 513]	**1.49183** (585 nm) [23.514] **1.5576** (260 nm) [23.512, 513] $A = 1$ $B = 1.1851057$ $C = 0.0113636$ $D = 0$ [23.512, 513][c]	**1.49001** (585 nm) [23.514] **1.5566** (260 nm) [23.512, 513]	$\chi^{(3)}_{zzzz} = 0.8 \times 10^{-22}$ m^2/V^2 $\chi^{(3)}_{xxxx} = 0.4 \times 10^{-22}$ m^2/V^2 (at 576.8 and 627 nm) [23.515]
$r_{52} = 2.1$ [23.520, 521]		**1.4984** (589 nm) [23.522, 523]	**1.4996** (589 nm) [23.522, 523]	**1.4953** (589 nm) [23.522, 523]	

Table 23.22 Orthorhombic, point group $mm2$ (C_{2v}) materials

	General	**Static dielectric tensor**	**Dissipation factor**	**Elastic stiffness tensor**	**Piezoelectric tensor**	**Elastooptic tensor**
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	tan δ_1 tan δ_2 tan δ_3 (T (°C), f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{31} d_{32} d_{33} d_{15} d_{24} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Ammonium sulfate, $(NH_4)_2SO_4$		– – 8[a] (−60 °C) [23.524, 525]		35.2 29.7 36.0 9.5 7.0 10.3 14.1 15.7 17.3 [23.526]		0.26 [23.527, 528] |0.27| [23.526] |0.26| [23.526] |0.23| [23.526] ≈ |0.27| [23.526] |0.25| [23.526] |0.23| [23.526] ≈ |0.26| [23.526] ≈ 0.26 [23.526] 0.02 [23.526] ≤ |0.02| [23.526] ≈ 0.01 [23.11, 526]
Barium magnesium fluoride, $BaMgF_4$ (BMF)		14 [23.531] 8 [23.531] 8.5 [23.531] 14.75 (74)[a] 8.24 (41)[a] 8.40 (42)[a] [23.532]		104 81 130 32.1 55.1 24.7 28.7 63.7 35.8 [23.532]	+2.5 (3) −4.1 (4) +8.0 (2) −5.3 (5) −1.2 (1) [23.532] –	
Barium sodium niobate, $Ba_2NaNb_5O_{15}$ (*banana*)	5.41 – 3.5 [23.533]	215 205 20 238 (5) 228 (5) 430 [23.534][b]	0.0068 (17) – 0.0024 (6) (25 °C, 1 GHz) [23.304]	239 247 135 65 66 76 104 50 52 [23.535][c]	−6.8 −6.9 34 32 45 [23.536] –	$p_{66} = 0.0021$ [23.537, 538]
Calcium tartrate tetrahydrate, $Ca(C_4H_4O_6) \cdot 4H_2O$ (L-CTT)		14.3 10 20 [23.541][a]	0.9 – – (30 °C, 100 Hz) [23.541, 542]			
m-Chloronitrobenzene, $ClC_6H_4NO_2$ (CNB)						

Electrooptic tensor	General optical properties	Refractive index			Nonlinear dielectric susceptibility
r^T_{13} r^T_{23} r^T_{33} r^T_{42} r^T_{51} (10^{-12} m/V)	Transparency range (μm) dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X *A* *B* *C* *D* *E* *F*	n_Y *A* *B* *C* *D* *E* *F*	n_Z *A* *B* *C* *D* *E* *F*	d_{31} d_{32} d_{33} d_{15} d_{24} (10^{-12} m/V)
$r_c = 0.4$ [23.529]					0.27 0.29 0.50 [23.530] – –
	0.185–10 [23.496]	**1.4436** 2.077 0.0076 0.0079 0 [23.496][h] – –	**1.4604** 2.1238 0.0086 0 0 [23.496][h] – –	**1.4674** 2.1462 0.00736 0.009 0 [23.496][h] – –	0.022 0.033 0.009 – 0.024 [23.496]
15 (1) 13 (1) 48 (2) 92 (4) 90 (4) [23.534]	0.37–5 [23.534, 539, 540] −2.5 [23.534] – 8 [23.534]	**2.2573** 1 3.9495 0.04038894 0 [23.534][i] – –	**2.2571** 1 3.9495 0.04014012 0 [23.534][i] – –	**2.1694** 1 3.6008 0.03219871 0 [23.534][i] – –	−12 −12 −16.5 12 11.4 [23.534]
	0.28–1.4 [23.543] – – –	**1.5125** 1 1.26 0.0127273 0 [23.543][i] – –	**1.5220** 1 1.30 0.0121495 0 [23.543][i] – –	**1.5477** 1 1.38 0.0094521 0 [23.543][i] – –	< 0.015 0.20 0.14 1.73 0.90 [23.543]
		1.6557 2.4882 0.2384 0.1070 0.0091 [23.544][i] – –	**1.6626** 2.5411 0.2148 0.1122 0.0135 [23.544][i] – –	**1.624** 2.2469 0.3722 0.0810 0.0092 [23.544][i] – –	4.6 4 7.8 [23.544] – –

Table 23.22 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	tan δ_1 tan δ_2 tan δ_3 (T (°C), f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{31} d_{32} d_{33} d_{15} d_{24} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
2-Cyclooctylamino-5-nitropyridine, $C_{13}H_{19}N_3O_2$ (COANP)	1.24 – –					
N,*N*-Dimethyl-4-nitroaniline, $C_8H_{10}N_2O_2$ (MNMA)						
Gadolinium molybdate, $Gd_2(MoO_4)_3$ (GMO)		– – 9.6 – – 10.2 [23.550]		55 (4) 71 (3) 101 (3) 25.2 (8) 25.8 (2) 33.1 (3) 12.8 (46) 23.5 (45) 27.2 (76) [23.7][c]	1.5 [23.551] 0.2 [23.8] 0.5 [23.551] – – –	0.19 0.31 0.175 0.215 0.235 0.175 0.185 0.23 0.115 −0.033 −0.028 0.035 [23.552] (515−633 nm)
Lithium formate monohydrate, $LiCOOH \cdot H_2O$ (LFM)	1.46 – –	3.24 [23.556, 557] – – 4.5 (5)[a] [23.558, 559] 5.0 (5)[a] [23.558, 559] 6.0 (3)[a] [23.558, 559]		19.15 33.55 41.98 15.02 5.31 4.89 8.62 8.40 22.77 [23.556, 557][c]	−2.1 (2) −6.7 (5) +9.2 (7) −15.0 (10) +1.2 (2) [23.558–561]	

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{13} r^T_{23} r^T_{33} r^T_{42} r^T_{51} (10^{-12} m/V)	**Transparency range (μm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X A B C D E F	n_Y A B C D E F	n_Z A B C D E F	d_{31} d_{32} d_{33} d_{15} d_{24} (10^{-12} m/V)
0.63 [23.545] – – – –	0.41–... [23.546] – – –	**1.6100** 2.3320 0.2215 0.1686 0 [23.546][i] – –	**1.6383** 2.3994 0.2469 0.1500 0 [23.546][i] – –	**1.7170** 2.5104 0.3689 0.1780 0 [23.546][i] – –	11.3 24 10.8 [23.547, 548] – –
8 ± 2 – 7.5 ± 2 [23.549] – –	0.5–2 [23.549] – – –	**1.936** 1.6797 1.7842 0.1571 0 [23.549][i] – –		**1.506** 2.1798 0.0736 0.1757 0 [23.549][i] – –	13 – 2.6 12 [23.549] –
+2.15 (16) −2.31 (16) +0.123 (15) – – [23.553, 554]		**1.8141** 1 2.2450 0.022693 0 [23.323][i] – –	**1.8145** 1 2.24654 0.0226803 0 [23.323][i] – –	**1.8637** 1 2.41957 0.0245458 0 [23.323][i] – –	−2.3 +2.3 −0.04 −4.1 +4 [23.154, 555] –
−1.0 (1) +3.2 (2) −2.6 (2) +1.0 (2) +2.4 (2) [23.558–561]	0.23–1.2 [23.562, 563] – – –	**1.3595** (1 μm) 1.4376 0.4045 0.01692601 0.0005 [23.564][i] – –	**1.4694** (1 μm) 1.6586 0.5006 0.023409 0.0127 [23.564][i] – –	**1.5055** (1 μm) 1.6714 0.5928 0.02534464 0.0153 [23.564][i] – –	−0.13 −0.60 +0.94 [23.12] – –

Table 23.22 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	tan δ_1 tan δ_2 tan δ_3 (T (°C), f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{31} d_{32} d_{33} d_{15} d_{24} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Lithium gallium oxide, $LiGaO_2$ (Lithium metagallate)	4.187 7.5 –	7.0 [23.8] 6.0 [23.8] 8.3 [23.565] 7.18 [23.8] 6.18 [23.8] 8.78 [23.8]		140 120 140 57.1 47.4 69.0 14 28 31 [23.565][c]	−2.5 [23.565] −4.7 [23.565] +8.6 [23.565] −6.9 [23.565] −6.0 [23.565] +0.9 [23.8, 277]	
Lithium triborate, LiB_3O_5 (LBO)	2.47 6 3.5 [23.205]					
m-Nitroaniline; (3-nitrobenzenamine, meta-Nitroaniline), $C_6H_4(NO_2)NH_2$ (mNA)		3.9 4.2 4.6 [23.572][a]				
Potassium acid phthalate, $KH(C_8H_4O_4)$		6.00 (2) 3.87 (2) 4.34 (2) [23.577, 578] – – 4.34[a] [23.579]		17.6 13.3 17.0 4.86 7.59 6.23 7.4 10.4 5.0 [23.577, 578]	−15.3 (0) +8.8 (0) +5.5 (0) −7.1 (0) +4.3 (0) [23.577, 578] –	−0.61 −0.25 −0.52 −0.58 −0.36 −0.60 −0.84 −0.36 −0.90 −0.26 −0.63 −0.13 (589 nm) [23.580]

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{13} r^T_{23} r^T_{33} r^T_{42} r^T_{51} (10^{-12} m/V)	**Transparency range (μm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X *A* *B* *C* *D* *E* *F*	n_Y *A* *B* *C* *D* *E* *F*	n_Z *A* *B* *C* *D* *E* *F*	d_{31} d_{32} d_{33} d_{15} d_{24} (10^{-12} m/V)
	0.3–5 [23.243, 566] – – –	**1.7477** (0.5 μm) [23.567]	**1.7768** (0.5 μm) [23.567]	**1.7791** (0.5 μm) [23.567]	+0.066 −0.14 +0.57 [23.154, 566] – –
	0.16–2.6 [23.568] −18 [23.569] −136 [23.569] −(63 + 21λ) [23.569]	**1.5656** 2.4542 0.01125 0.01135 0.01388 0 0 [23.570][j]	**1.5905** 2.5390 0.01277 0.01189 0.01849 4.3025×10^{-5} 2.9131×10^{-5} [23.570][j]	**1.6055** 2.5865 0.01310 0.01223 0.01862 4.5778×10^{-5} 3.2526×10^{-5} [23.570][j]	−0.67 0.85 0.04 [23.12, 14, 568, 569, 571] – –
7.4 (7) 0.1 (6) 16.7 (2) [23.573] – –	0.5–2 [23.574, 575] – – –	**1.631** 2.469 0.1864 0.16 0.0199 [23.576][i] – –	**1.678** 2.6658 0.1626 0.1719 0.0212 [23.576][i] – –	**1.719** 2.8102 0.1524 0.175 0.0294 [23.576][i] – –	20 1.6 21 [23.544] – –
$r_b \approx 1.8$ [23.579]	0.3–1.7 With a narrow absorption Band at 1.14 μm [23.581] – – –	**1.63** (1.1 μm) [23.581]	**1.64** (1.1 μm) [23.581]	**1.48** (1.1 μm) [23.581]	0.21 (d_{31}, 1.15 μm) 0.06 (d_{32}, 1.15 μm) 0.65 (d_{31}, 0.63 μm) 0.15 (d_{32}, 0.63 μm) – [23.581]

Table 23.22 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	$\tan\delta_1$ $\tan\delta_2$ $\tan\delta_3$ (T (°C), f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{31} d_{32} d_{33} d_{15} d_{24} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Potassium niobate, $KNbO_3$	4.617 – > 3.5 [23.582]	37 (2) 780 (50) 24 (2) 160 (10) 1000 (80) 55 (5) (25 °C) [23.583]	0.003 0.002 0.01 (25 °C) [23.583]	226 270 280 74.3 25.0 95.5 96 [23.583] – –	+9.8 (7) −19.5 (20) +24.5 (15) [23.584] 215 (5) 159 (5) [23.583] –	$\|0.197\|^d$ $\|0.115\|^d$ $\|0.109\|^e$ $\|0.130\|^d$ $\|0.234\|^d$ $\|0.005\|^e$ $\|0.64\|^d$ $\|0.153\|^d$ $\|0.075\|^e$ $\|0.57\|^d$ $\|0.45\|^d$ [23.585] –
Potassium pentaborate tetrahydrate, $KB_5O_8 \cdot 4H_2O$ (KB5)	1.74 2.5 –	5.5 4.6 4.5 [23.589] – – –		58.2 35.9 25.5 16.4 4.63 5.7 22.9 17.4 23.1 [23.589]	−0.35 −2.3 +5.5 +4.7 +20.3 [23.590] –	
Potassium titanyl arsenate, $KTiOAsO_4$ (KTA)	3.45 3 –	– – – 12 (1) 12 (1) 18 (1) [23.596, 597]				
Potassium titanate (titanyl) phosphate, $KTiOPO_4$ (KTP)	3.02 5 2 (∥ X) 3 (∥ Y) 3.3 (∥ Z) [23.603]	11.6 (2) 11.0 (2) 15.4 (3) 11.9 (2) 11.3 (2) ≥ 17.5 (4) [23.604]	$\lesssim 0.004$ ≤ 0.004 < 0.005 ($10-10^3$ MHz) ≈ 0.017 0.017 ≈ 0.35 (100 kHz) [23.604]	159 154 175 [23.605] – – – – – –		

Electrooptic tensor	General optical properties	Refractive index			Nonlinear dielectric susceptibility
r^T_{13} r^T_{23} r^T_{33} r^T_{42} r^T_{51} (10^{-12} m/V)	**Transparency range (μm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X *A* *B* *C* *D* *E* *F*	n_Y *A* *B* *C* *D* *E* *F*	n_Z *A* *B* *C* *D* *E* *F*	d_{31} d_{32} d_{33} d_{15} d_{24} (10^{-12} m/V)
34 (2) 6 (1) 63.4 (10) 450 (30) 120 (10) [23.585]	0.4–4.5 [23.376] For temperature-dependent dispersion relations, see [23.586]	**2.2576** 1 1.44121874 0.07439136 2.54336918 0.01877036 0.02845018 [23.587][k]	**2.2195** 1 1.33660410 0.06664629 2.49710396 0.01666505 0.02517432 [23.587][k]	**2.1194** 1 1.04824955 0.06514225 2.37108379 0.01433172 0.01943289 [23.587][k]	+11 [23.12–14] −13 [23.12–14] −19.5 [23.12–14] 16 [23.588] 17 [23.588]
	0.165–1.4 [23.591] – – –	**1.4917** (0.5 μm) 1 1.1790826 0.0087815 0 [23.592, 593][i] – –	**1.4380** (0.5 μm) 1 1.0280852 0.0090222 0 [23.592, 593][i] – –	**1.4251** (0.5 μm) 1 0.9919090 0.0093289 0 [23.592, 593][i] – –	0.04 0.003 0.05 (all at 0.5 μm) – – [23.12, 594, 595]
15 (1) 21 (1) 40 (1) – – [23.596, 597]	0.35–5.3 [23.596–598] – – –	**1.782** 1.90713 1.23552 0.0387775 0.01025 [23.599][i] – –	**1.790** 2.15912 1.00099 0.0477160 0.01096 [23.599][i] – –	**1.868** 2.14786 1.29559 0.0516153 0.01436 [23.599][i] – –	2.9 5.2 12.0 – – [23.12, 14, 600–602][l]
+9.5 (5) +15.7 (8) +36.3 (18) 9.3 (9) 7.3 (7) [23.604]	0.35–4.5 [23.606, 607] 0.61 [23.608][m] 0.83 [23.608][m] 1.45 [23.608][m]	**1.7381** 3.0065 0.03901 0.04251 0.01327 [23.609][h,m] – –	**1.7458** 3.0333 0.04154 0.04547 0.01408 [23.609][h,m] – –	**1.8302** 3.3134 0.05694 0.05658 0.01682 [23.609][h,m] – –	2.2 3.7 14.6 1.9 3.7 [23.13][l]

Table 23.22 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^T_{11} ε^T_{22} ε^T_{33}	$\tan\delta_1$ $\tan\delta_2$ $\tan\delta_3$ (T (°C), f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} (10^9 Pa)	d_{31} d_{32} d_{33} d_{15} d_{24} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{21} p_{22} p_{23} p_{31} p_{32} p_{33} p_{44} p_{55} p_{66}
Rubidium titanate (titanyl) phosphate, $RbTiOPO_4$ (RTP)		23[f] (25 °C) [23.610–612]		143 142 175 33 40 57 [23.605] – – –		
Sodium nitrite, $NaNO_2$	2.168 – –	8 [23.618] 5.2 [23.618] 4.18 [23.618] 7.4 [23.619] 5.5 [23.619] 5.0 [23.619]	0.004 0.006 0.015 (3.3 GHz) [23.618]	30.6 (3) 56 (2) 64 (2) 12 (1) 9.9 (1) 5.0 (3) 12.5 (1) 15.6 (53) 14.6 (48) [23.7]	−1.1 −2.8 +1.6 +9.3 −20.2 – [23.8, 619]	|0.44| [23.620] |0.37| [23.620] |0.36| [23.620] |0.39| [23.620] |0.33| [23.620] |0.27| [23.620] |0.18| [23.620] |0.19| [23.620] |0.15| [23.620] −0.050[g] [23.621] −0.30 [23.621] −0.10[g] [23.621]

[a] These values for ε_{ij} are neither at constant stress nor at constant strain
[b] Stoichiometric crystal
[c] c^E at constant electric field
[d] p^E at constant electric field
[e] $p^*_{i3} = p^E_{i3} - r^S_{i3} e_{333}/\varepsilon_0 \varepsilon^S_{33}$, where r^S_{i3} is the electrooptic-tensor element $i3$ at zero strain, e_{333} is the piezoelectric-tensor element 333, and ε^S_{33} is the relative-dielectric-constant element 33 at constant strain
[f] Element of ε unspecified, but probably ε_{11} or ε_{33}
[g] $p^{\text{eff}}_{ijkl} = p^E_{ijkl} - r^S_{ijm} a_m a_n e_{nkl} / \boldsymbol{a} \cdot \boldsymbol{\varepsilon} \cdot \boldsymbol{a}$, where r^S is the electrooptic tensor, $\boldsymbol{a}$ is a unit acoustic-wave propagation vector and $\boldsymbol{\varepsilon}$ is the dielectric-constant tensor at the frequency of the acoustic wave
[h,i,j,k] Dispersion relations (λ (µm), $T = 20$ °C):
[h] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$
[i] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} - D\lambda^2$
[j] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2 + E\lambda^4 - F\lambda^6$
[k] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} + \frac{D\lambda^2}{\lambda^2 - E} - F\lambda^2$
[l] Note reversals between d_{31} and d_{32} (also between d_{15} and d_{24}) for KTA and KTP given in [23.12] and [23.13]
[m] For flux-grown crystals

Electrooptic tensor	General optical properties	Refractive index			Nonlinear dielectric susceptibility
r^T_{13} r^T_{23} r^T_{33} r^T_{42} r^T_{51} (10^{-12} m/V)	**Transparency range (µm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X *A* *B* *C* *D* *E* *F*	n_Y *A* *B* *C* *D* *E* *F*	n_Z *A* *B* *C* *D* *E* *F*	d_{31} d_{32} d_{33} d_{15} d_{24} (10^{-12} m/V)
+9.7 (9) +10.8 (9) +22.5 (9) +14.9 (9) −7.6 (9) [23.613–615]	0.35−4.5 [23.616, 617] – – –	**1.7569** 2.56666 0.53842 0.06374 0.01666 [23.617][i] – –	**1.7730** 2.34868 0.77949 0.05449 0.0211 [23.617][i] – –	**1.8540** 2.77339 0.63961 0.08151 0.02237 [23.617][i] – –	3.3 4.1 17.3 [23.601] – –
$r_{42} = -3.0$ (2) $r_{51} = -1.9$ (2) (at 546 nm) [23.622]	0.35−3.4 and 5−8 [23.623, 624] – – –	**1.3395** 1 0.727454 0.0118285 0 [23.623][i] – –	**1.4036** 1 0.978108 0.0112296 0 [23.623][i] – –	**1.6365** 1 1.616683 0.0222073 0 [23.623][i] – –	0.11 2.9 0.14 0.11 2.8 [23.625]

Table 23.23 Monoclinic, point group 2 (C_2) materials

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^S_{13} ε^T_{11} ε^T_{22} ε^T_{33} ε^T_{13}	tan δ_1 tan δ_2 tan δ_3 (f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} c_{15} c_{25} c_{35} c_{46} (10^9 Pa)	d_{21} d_{22} d_{23} d_{14} d_{16} d_{25} d_{34} d_{36} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{15} p_{21} p_{22} p_{23} p_{25} p_{31} p_{32} p_{33} p_{35} p_{44} p_{46} p_{51} p_{52} p_{53} p_{55} p_{64} p_{66}
Bismuth triborate, BiB_3O_6 (BIBO)	4.9 [23.626] – –					
Deuterated L-arginine phosphate, $(ND_xH_{2-x})_2^+(CND)(CH_2)_3CH(ND_yH_{3-y})^+COO^- \cdot D_2PO_4^- \cdot D_2O$ (DLAP)	≈ 1.5 3 –			17.477 (111) 31.996 (89) 31.575 (72) – – – – – – – – – – [23.16]		
4-(*N*,*N*-Dimethylamino)-3-acetamidonitrobenzene (*N*-[2-(dimethylamino)-5-nitrophenyl]-acetamide, DAN)						

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{12} r^T_{22} r^T_{32} r^T_{41} r^T_{43} r^T_{52} r^T_{61} r^T_{63} (10^{-12} m/V) (at $\lambda = 633$ nm)	**Transparency range (µm)** dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X A B C D	n_Y A B C D	n_Z A B C D	d_{21} d_{22} d_{23} d_{25} (10^{-12} m/V)
	0.27−6.25 [23.626] – – –	**1.9190** 3.6545 0.0511 0.0371 0.0226 [23.627][a]	**1.7585** 3.0740 0.0323 0.0316 0.01337 [23.627][a]	**1.7854** 3.1685 0.0373 0.0346 0.01750 [23.627][a]	2.3 (2) 2.53 (8) 1.3 (1) 2.3 (2) [23.627] (see also [23.628])
	0.25−1.3 [23.629] −3.64 −5.34 −6.69 (all at 532 nm [23.630])	**1.4960** 2.2352 0.0118 0.0146 0.00683 [23.629][a]	**1.5584** 2.4313 0.0151 0.0214 0.0143 [23.629][a]	**1.5655** 2.4484 0.0172 0.0229 0.0115 [23.629][a]	0.48 0.685 −0.80 −0.22 [23.12, 14, 629]
	0.485−2.27 [23.631] – – –	**1.517** 2.1390 0.147408 0.3681 [23.631][b] –	**1.636** 2.3290 0.307173 0.3933 [23.631][b] –	**1.843** 2.5379 0.719557 0.4194 [23.631][b] –	1.1 3.9 37.5 1.1 [23.631, 632]

Table 23.23 (continued)

	General	Static dielectric tensor	Dissipation factor	Elastic stiffness tensor	Piezoelectric tensor	Elastooptic tensor
Material	ϱ (g/cm^3) Mohs hardness κ (W/(m K))	ε^S_{11} ε^S_{22} ε^S_{33} ε^S_{13} ε^T_{11} ε^T_{22} ε^T_{33} ε^T_{13}	$\tan\delta_1$ $\tan\delta_2$ $\tan\delta_3$ (f (kHz))	c_{11} c_{22} c_{33} c_{44} c_{55} c_{66} c_{12} c_{13} c_{23} c_{15} c_{25} c_{35} c_{46} (10^9 Pa)	d_{21} d_{22} d_{23} d_{14} d_{16} d_{25} d_{34} d_{36} d_h (10^{-12} C/N)	p_{11} p_{12} p_{13} p_{15} p_{21} p_{22} p_{23} p_{25} p_{31} p_{32} p_{33} p_{35} p_{44} p_{46} p_{51} p_{52} p_{53} p_{55} p_{64} p_{66}
Dipotassium tartrate hemihydrate, $K_2C_4H_4O_6 \cdot 0.5H_2O$ (DKT)	1.987 – –	6.44 5.80 6.49 0.005 [23.345][d] – – – –		35.7 (86) 39 (17) 62 (10) 9.0 (5) 11.7 (19) 8.3 (1) 17.8 (9) 22.5 (99) 13.5 (37) 1.8 1.2 (1) 5.9 (27) 0.54 (18) [23.7]	−0.8 4.5 −5.3 7.9 3.4 −6.4 −12.2 −23.2 1.6 [23.633]	
Lithium sulfate monohydrate, $Li_2SO_4 \cdot H_2O$	– – ≈ 4 [23.636]	5.16[d] [23.637, 638] 10.3[d] [23.637, 638] 4.95[d] [23.637, 638] – 5.6 [23.345] 10.3 [23.345] 6.5 [23.345] 0.07 [23.345]		54.9 70.5 61.8 14.0 24.2 27.0 26.3 11.4 17.1 6.5 15.7 −5.2 −26.5 [23.345][e]	−3.6 +16.3 +1.7 +0.7 −2.0 −5.0 −2.13 −4.2 14.4 [23.633]	
D(+)-Saccharose, $C_{12}H_{22}O_{11}$ (sucrose)	– > 2.5 –				1.47 −3.41 0.73 1.25 −2.41 −0.87 −4.21 0.423 [23.640] –	

Electrooptic tensor	**General optical properties**	**Refractive index**			**Nonlinear dielectric susceptibility**
r^T_{12} r^T_{22} r^T_{32} r^T_{41} r^T_{43} r^T_{52} r^T_{61} r^T_{63} (10^{-12} m/V) (at $\lambda = 633$ nm)	Transparency range (μm) dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X *A* *B* *C* *D*	n_Y *A* *B* *C* *D*	n_Z *A* *B* *C* *D*	d_{21} d_{22} d_{23} d_{25} (10^{-12} m/V)
		1.4832 (1.014 μm) [23.634]	**1.5142** (1.014 μm) [23.634]	**1.5238** (1.014 μm) [23.634]	$d_{21} = 0.11$ $d_{22} = 3.9$ $d_{14} = 0.17$ (all at 0.6943 μm) [23.635]
+8.5 (4) +6.5 (4) +4.5 (5) 0 −1.2 (7) −0.7 (2) +0.41 (2) +0.8 (6) [23.639]		**1.4521** [23.323]	**1.4657** [23.323]	**1.4752** [23.323]	$d_{22} = 0.38 \pm 0.06$ $d_{23} = 0.27 \pm 0.04$ $d_{34} = 0.23 \pm 0.04$ [23.323]
	0.192−1.35 [23.641] – – –	**1.5278** 1.8719 0.466 0.0214 0.0113 [23.641][c]	**1.5552** 1.9703 0.4502 0.0238 0.0101 [23.641][c]	**1.5592** 2.0526 0.3909 0.252 0.0187 [23.641][c]	[23.641, 642]

Table 23.23 (continued)

<table>
<tr><th></th><th>General</th><th>Static dielectric tensor</th><th>Dissipation factor</th><th>Elastic stiffness tensor</th><th>Piezoelectric tensor</th><th>Elastooptic tensor</th></tr>
<tr><td>Material</td><td>ϱ (g/cm^3)
Mohs hardness
κ (W/(m K))</td><td>ε^S_{11}
ε^S_{22}
ε^S_{33}
ε^S_{13}
ε^T_{11}
ε^T_{22}
ε^T_{33}
ε^T_{13}</td><td>tan δ_1
tan δ_2
tan δ_3
(f (kHz))</td><td>c_{11}
c_{22}
c_{33}
c_{44}
c_{55}
c_{66}
c_{12}
c_{13}
c_{23}
c_{15}
c_{25}
c_{35}
c_{46}
(10^9 Pa)</td><td>d_{21}
d_{22}
d_{23}
d_{14}
d_{16}
d_{25}
d_{34}
d_{36}
d_h
(10^{-12} C/N)</td><td>p_{11}
p_{12}
p_{13}
p_{15}
p_{21}
p_{22}
p_{23}
p_{25}
p_{31}
p_{32}
p_{33}
p_{35}
p_{44}
p_{46}
p_{51}
p_{52}
p_{53}
p_{55}
p_{64}
p_{66}</td></tr>
<tr><td>Triglycine sulfate,
$(CH_2NH_2COOH)_3 \cdot H_2SO_4$
(TGS)</td><td></td><td>9.38[d] [23.643]
20[d] [23.644]
6.00[d] [23.643]
1.17 (2)[d] [23.643]
9 [23.645]
40 [23.645]
6.6 [23.645]</td><td>0.043
–
–
(9.6 GHz)
[23.644]</td><td>41.7
32.1
33.6
9.40
9.39
6.31
17.3
18.1
20.7
4.1
−0.6
7.7
−0.6
[23.646–648]</td><td>23.5 (0)
7.9 (1)
25.3 (0)
2.7 (0)
−4.5 (0)
24.3 (1)
−3.20 (1)
2.8 (0)
–
[23.646, 647]</td><td>|0.204| [23.649, 650]
|0.162| [23.649, 650]
|0.175| [23.649, 650]
–
|0.172| [23.649, 650]
|0.208| [23.649, 650]
|0.150| [23.649, 650]
|0.083| [23.651]
|0.204| [23.649, 650]
|0.169| [23.649, 650]
|0.151| [23.649, 650]
–
|0.273| [23.651]
|0.276| [23.651]
–
|0.075| [23.651]
–
–
|0.075| [23.651]
–</td></tr>
</table>

[a,b,c] Dispersion relations (λ (µm), $T = 20\,°\mathrm{C}$):

[a] $n^2 = A + \frac{B}{\lambda^2 - C} - D\lambda^2$

[b] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C}$

[c] $n^2 = A + \frac{B\lambda^2}{\lambda^2 - C} - D\lambda^2$

[d] These values for ε_{ij} are neither at constant stress nor at constant strain

[e] The elastic stiffness constant were measured at constant electric field (c^E)

Electrooptic tensor	General optical properties	Refractive index			Nonlinear dielectric susceptibility
r^T_{12} r^T_{22} r^T_{32} r^T_{41} r^T_{43} r^T_{52} r^T_{61} r^T_{63} (10^{-12} m/V) (at $\lambda = 633$ nm)	Transparency range (μm) dn_X/dT (10^{-5} K^{-1}) dn_Y/dT (10^{-5} K^{-1}) dn_Z/dT (10^{-5} K^{-1})	n_X A B C D	n_Y A B C D	n_Z A B C D	d_{21} d_{22} d_{23} d_{25} (10^{-12} m/V)
70 [23.652, 653] – 54 [23.652, 653] – – 1 [23.654, 655] – –					$d_{23} = 0.3$ at 0.6943 μm [23.656]

References

23.1 D.N. Nikogosyan, G.G. Gurzadyan: Kvantovaya Elektron. **13**, 2519–2520 (1986)

23.2 D.N. Nikogosyan, G.G. Gurzadyan: Sov. J. Quantum Electron. **16**, 1663–1664 (1986)

23.3 V.G. Dmitriev, G.G. Gurzadyan, D.N. Nikogosyan: *Handbook of Nonlinear Optical Crystals*, 2nd edn. (Springer, Berlin, Heidelberg 1997)

23.4 V.G. Dmitriev, G.G. Gurzadyan, D.N. Nikogosyan: *Handbook of Nonlinear Optical Crystals*, 3rd edn. (Springer, Berlin, Heidelberg 1999)

23.5 D.N. Nikogosyan, G.G. Gurzadyan: Kvantovaya Elektron. **14**, 1529–1541 (1987)

23.6 D.N. Nikogosyan, G.G. Gurzadyan: Sov. J. Quantum Electron. **17**, 970–977 (1987)

23.7 A.G. Every, A.K. McCurdy: *Second and Higher Order Elastic Constants*, Landolt–Börnstein, New Series, Vol. III/29 (Springer, Berlin, Heidelberg 1992), ed. by D.F. Nelson, O. Madelung

23.8 W.R. Cook Jr.: *Piezoelectric, Electrostrictive, Dielectric Constants, Electromechanical Coupling Factors*, Landolt–Börnstein, New Series, Vol. III/29 (Springer, Berlin, Heidelberg 1993), ed. by D.F. Nelson, O. Madelung

23.9 W.R. Cook Jr.: *Electrooptic Coefficients*, Landolt–Börnstein, New Series, Vol. III/30 (Springer, Berlin, Heidelberg 1996), ed. by D.F. Nelson

23.10 D.F. Nelson: *Piezooptic, Electrooptic Constants of Crystals*, Landolt–Börnstein, New Series, Vol. III/30 (Springer, Berlin, Heidelberg 1996), ed. by D.F. Nelson

23.11 K. Vedam: *Piezooptic, Elastooptic Coefficients*, Landolt–Börnstein, New Series, Vol. III/30 (Springer, Berlin, Heidelberg 1996), ed. by D.F. Nelson

23.12 D.A. Roberts: IEEE J. Quantum Electron. **QE-28**, 2057 (1992)

23.13 I. Shoji, T. Kondo, A. Kitamoto, M. Shirane, R. Ito: J. Opt. Soc. Am. B **14**, 2268 (1997)

23.14 F. Charra, G.G. Gurzadyan: *Nonlinear Dielectric Susceptibilities*, Landolt–Börnstein, New Series, Vol. III/30 (Springer, Berlin, Heidelberg 2000), ed. by D.F. Nelson

23.15 Layertec: Data Sheet – Material Data (Layertec GmbH, Mellingen 2003)

23.16 G.W. Faris, L.E. Jusinski, A.P. Hickman: J. Opt. Soc. Am. B **3**, 587–599 (1993)

23.17 Opto-Technological Laboratory: Data Sheet – Catalog of Optical Materials (Opto-Technological Laboratory, St. Petersburg 2003)

23.18 Melles Griot: Data Sheet – Optics: Windows and Optical Flats (Melles Griot, Rochester 2003)

23.19 W.L. Smith: Optical materials, Part I. In: *CRC Handbook of Laser Science and Technology*, Vol. 3, ed. by M.J. Weber (CRC, Boca Raton 1986) pp. 229–258

23.20 W.T. White III, M.A. Henesian, M.J. Weber: J. Opt. Soc. Am. B **2**, 1402–1408 (1985)

23.21 D. Milam, M.J. Weber: J. Appl. Phys. **47**, 2497–2501 (1976)

23.22 D.G. Cahill, R.O. Pohl: Phys. Rev. B **35**, 4067–4073 (1987)

23.23 Röhm Plexiglas: Data Sheet – Technical Data (Röhm Plexiglas, Darmstadt 2003)

23.24 I.D. Nikolov, C.D. Ivanov: Appl. Opt. **39**, 2067–2070 (2000)

23.25 Crystran: Data Sheet – Materials (Crystran, Poole 2002)

23.26 Schott Lithotec: Data Sheet – Products and Applications (Schott Lithotec AG, Jena 2003)

23.27 D.E. Gray: *American Institute of Physics Handbook* (McGraw-Hill, New York 1972)

23.28 I.H. Malitson: J. Opt. Soc. Am. **55**, 1205–1209 (1965)

23.29 Y.A. Repeyev, E.V. Khoroshilova, D.N. Nikogosyan: J. Photochem. Photobiol. B **12**, 259–274 (1992)

23.30 G.G. Gurzadyan, R.K. Ispiryan: Int. J. Nonlin. Opt. Phys. **1**, 533–540 (1992)

23.31 T. Tomie, I. Okuda, M. Yano: Appl. Phys. Lett. **55**, 325–327 (1989)

23.32 P. Liu, W.L. Smith, H. Lotem, J.H. Bechtel, N. Bloembergen, R.S. Adhav: Phys. Rev. B **17**, 4620–4632 (1978)

23.33 R. Adair, L.L. Chase, S.A. Payne: Phys. Rev. B **39**, 3337–3349 (1989)

23.34 R. DeSalvo, A.A. Said, D.J. Hagan, E.W. Van Stryland, M. Sheik-Bahac: IEEE J. Quantum Electron. **QE-32**, 1324–1333 (1996)

23.35 O.V. Shakin, M.F. Bryzhina, V.V. Lemanov: Fiz. Tverd. Tela **13**, 3714–3716 (1971)

23.36 O.V. Shakin, M.F. Bryzhina, V.V. Lemanov: Sov. Phys. Solid State **13**, 3141–3142 (1972)

23.37 E.D.D. Schmidt, K. Vedam: J. Phys. Chem. Solids **27**, 1563–1566 (1966)

23.38 A. Smakula: *Harshaw Optical Crystals* (Harshaw Chemical, Cleveland 1967)

23.39 A. Feldman, D. Horowitz, R.M. Waxier, M.J. Dodge: Erratum, Natl. Bur. Stand. (USA) Techn. Note 993 (1979)

23.40 A. Feldman, R.M. Waxler: Phys. Rev. Lett. **45**, 126–129 (1980)

23.41 H.H. Li: J. Phys. Chem. Ref. Data **9**, 161–289 (1980)

23.42 M.D. Levenson, N. Bloembergen: Phys. Rev. B **10**, 4447–4463 (1974)

23.43 ASI Instruments: Data Sheet – Dielectric Constant Reference Guide (ASI Instruments, Houston 2003)

23.44 R. Waxler: IEEE J. Quantum Electron. **QE-7**, 166–167 (1971)

23.45 I.H. Malitson: Appl. Opt. **2**, 1103–1107 (1963)

23.46 S.S. Ballard, J.S. Browder: Thermal properties. In: *Optical Materials, CRC Handbook of Laser Science and Technology*, Vol. 4, ed. by M.J. Weber (CRC, Boca Raton 1987) pp. 49–54

23.47 A.D. Papadopoulos, E. Anastassakis: Phys. Rev. B **43**, 9916–9923 (1991)

23.48 G.N. Ramachandran: Proc. Indian Acad. Sci. A **25**, 266–279 (1947)

23.49 J. Fontanella, R.L. Johnston, J.H. Colwell, C. Andeen: Appl. Opt. **16**, 2949–2951 (1977)

23.50 D.F. Edwards, E. Ochoa: J. Opt. Soc. Am. **71**, 607 (1981)
23.51 M.D. Levenson, C. Flytzanis, N. Bloembergen: Phys. Rev. B **6**, 3962–3965 (1972)
23.52 D.E. McCarthy: Appl. Opt. **2**, 591–603 (1963)
23.53 N.P. Barnes, M.S. Piltch: J. Opt. Soc. Am. **69**, 178–180 (1979)
23.54 J.J. Wynne: Phys. Rev. **178**, 1295–1303 (1969)
23.55 H. Braul, C.A. Plint: Solid State Commun. **38**, 227–230 (1981)
23.56 H.H. Li: J. Phys. Chem. Ref. Data **5**, 329–528 (1976)
23.57 P.D. Maker, R.W. Terhune: Phys. Rev. **137**, A801–A818 (1965)
23.58 MarkeTech: Data Sheet – Non-Metallic Crystals (MarkeTech International, Port Townsend 2002)
23.59 K.V.K. Rao, V.G.K. Murty: Acta Crystallogr. **17**, 788–789 (1964)
23.60 A.J. Moses: *Optical Materials Properties*, Handbook of Electronic Materials, Vol. 1 (IFI/Plenum, New York 1971)
23.61 T. Radhakrishnan: Proc. Indian Acad. Sci. A **33**, 22–34 (1951)
23.62 R.F. Stephens, I.H. Malitson: Natl. Bur. Stand. J. Res. **49**, 249 (1952)
23.63 K. Vedam, E.D.D. Schmidt, W.C. Schneider: In: *Optical Properties of Highly Transparent Solids*, ed. by S.S. Mitra, B. Bendow (Plenum, New York 1975) pp. 169–175
23.64 J.P. Szczesniak, D. Cuddeback, J.C. Corelli: J. Appl. Phys. **47**, 5356–5359 (1976)
23.65 C.C. Wang, E.L. Baardsen: Phys. Rev. **185**, 1079–1082 (1969)
23.66 W.K. Burns, N. Bloembergen: Phys. Rev. B **4**, 3437–3450 (1971)
23.67 V.M. Maevskii, A.B. Roitsin: Fiz. Tverd. Tela **31**, 294–296 (1989)
23.68 V.M. Maevskii, A.B. Roitsin: Sov. Phys. Solid State **31**, 1448–1449 (1989)
23.69 D.K. Biegelsen: Phys. Rev. Lett. **32**, 1196–1199 (1974)
23.70 D.K. Biegelsen: Erratum, Phys. Rev. Lett. **33**, 51 (1974)
23.71 A.A. Berezhnoi, V.M. Fedulov, K.P. Skornyakova: Fiz. Tverd. Tela **17**, 2785–2787 (1975)
23.72 A.A. Berezhnoi, V.M. Fedulov, K.P. Skornyakova: Sov. Phys. Solid State **17**, 1855–1856 (1975)
23.73 B. Tatian: Appl. Opt. **23**, 4477–4485 (1984)
23.74 D.F. Edwards, E. Ochoa: Appl. Opt. **19**, 4130 (1980)
23.75 N. Bloembergen, W.K. Burns, M. Matsukoda: Opt. Commun. **1**, 195 (1969)
23.76 J.J. Wynne, G.D. Boyd: Appl. Phys. Lett. **12**, 191–192 (1968)
23.77 W. Kucharczyk: Physica B **172**, 473–490 (1991)
23.78 A.V. Pakhnev, M.P. Shaskol'skaya, S.S. Gorbach: Izv. Vyssh. Uchebn. Zaved., Fiz. **12**, 28–34 (1975)
23.79 A.V. Pakhnev, M.P. Shaskol'skaya, S.S. Gorbach: Sov. Phys. J. **18**, 1662 (1975)
23.80 P. Billard: Acta Electron. **6**, 75–169 (1962)
23.81 Princeton Scientific: Data Sheet – Crystalline Materials (Princeton Scientific, Princeton 2003)
23.82 J. Reintjes, M.B. Schulz: J. Appl. Phys. **39**, 5254–5258 (1968)
23.83 M.D. Beals, L. Merker: Mater. Des. Eng. **51**, 12–13 (1960)
23.84 D.E. McCarthy: Appl. Opt. **7**, 1997 (1968)
23.85 M.O. Manasreh, D.O. Pederson: Phys. Rev. B **30**, 3482–3485 (1984)
23.86 S. Musikant: *Optical Materials: An Introduction to Selection and Application* (Marcel Dekker, New York 1985)
23.87 R.W. Dixon: J. Appl. Phys. **38**, 5149–5153 (1967)
23.88 L.G. DeShazer, S.C. Rand, B.A. Wechsler: Laser crystals. In: *Optical Materials*, *CRC Handbook of Laser Science and Technology*, Vol. 5, ed. by M.J. Weber (CRC, Boca Raton 1987) pp. 281–338
23.89 K.L. Ovanesyan, A.G. Petrosyan, G.O. Shirinyan, A.A. Avetisyan: Izv. Akad. Nauk SSSR, Ser. Neorg. Mater. **17**, 459–462 (1981)
23.90 D. Berlincourt, H. Jaffe, L.R. Shiozawa: Phys. Rev. **129**, 1009–1017 (1963)
23.91 H. Sasaki, K. Tsoubouki, N. Chubachi, N. Mikoshiba: J. Appl. Phys. **47**, 2046–2049 (1976)
23.92 R. Weil, M.J. Sun: In: *Int. Symp. Cadmium Telluride Mater. Gamma-Ray Detect.*, *Strasbourg*, Tech. Dig.,1971) pp. XIX-1–6-XIX
23.93 J.E. Kiefer, A. Yariv: Appl. Phys. Lett. **15**, 26–27 (1969)
23.94 N.P. Barnes, M.S. Piltch: J. Opt. Soc. Am. **67**, 628 (1977)
23.95 A.G. DeBell, E.L. Dereniak, J. Harvey, J. Nissley, J. Palmer, A. Selvarajan, W.L. Wolfe: Appl. Opt. **18**, 3114–3115 (1979)
23.96 G.H. Sherman, P.D. Coleman: J. Appl. Phys. **44**, 238 (1973)
23.97 R.C. Miller, W.A. Nordland: Phys. Rev. B **5**, 4931–4934 (1972)
23.98 J. Pastrnak, L. Roskovcova: Phys. Status Solidi **14**, K5–K8 (1966)
23.99 E.H. Turner, I.P. Kaminow, C. Schwab: Phys. Rev. B **9**, 2524–2529 (1974)
23.100 R.C. Hanson, J.R. Hallberg, C. Schwab: Appl. Phys. Lett. **21**, 490–492 (1972)
23.101 B. Prevot, C. Carabatos, C. Schwab, B. Hennion, F. Moussa: Solid State Commun. **13**, 1725–1727 (1973)
23.102 A. Boese, E. Mohler, R. Pitka: J. Mater. Sci. **9**, 1754–1758 (1974)
23.103 D.K. Biegelsen, J.C. Zesch, C. Schwab: Phys. Rev. B **14**, 3578–3582 (1976)
23.104 E.H. Turner, E. Buehler, H. Kasper: Phys. Rev. B **9**, 558–561 (1974)
23.105 D.S. Chemla, P. Kupecek, C. Schwartz, C. Schwab, A. Goltzene: IEEE J. Quantum Electron. **QE-7**, 126 (1971)
23.106 R.C. Miller, W.A. Nordland, S.C. Abrahams, J.L. Bernstein, C. Schwab: J. Appl. Phys. **44**, 3700 (1973)
23.107 L.M. Belyaev, G.S. Belikova, G.F. Dobrzhanskii, G.B. Netesov, Y.V. Shaldin: Fiz. Tverd. Tela **6**, 2526–2528 (1964)
23.108 L.M. Belyaev, G.S. Belikova, G.F. Dobrzhanskii, G.B. Netesov, Y.V. Shaldin: Sov. Phys. Solid State **6**, 2007–2008 (1965)

23.109 R.C. Hanson, K. Helliwell, C. Schwab: Phys. Rev. B **9**, 2649–2654 (1974)
23.110 E. Mohler, B. Thomas: Phys. Status Solidi (b) **79**, 509–517 (1977)
23.111 A. Feldman, D. Horowitz: J. Opt. Soc. Am. **59**, 1406–1408 (1969)
23.112 T.G. Okroashvili: Opt. Spektrosk. **47**, 798–800 (1979)
23.113 T.G. Okroashvili: Opt. Spectrosc. **47**, 442–443 (1979)
23.114 Ioffe Institute: Database (Ioffe Institute, St. Petersburg 2003)
23.115 G. Arlt, P. Quadflieg: Phys. Status Solidi **25**, 323–330 (1968)
23.116 B.O. Seraphin, H.E. Bennett: In: *Semiconductors and Semimetals*, Vol. 3, ed. by R.K. Willard, R.C. Beer (Academic Press, New York 1967)
23.117 J.J. Wynne, N. Bloembergen: Phys. Rev. **188**, 1211 (1969)
23.118 J.J. Wynne, N. Bloembergen: Erratum, Phys. Rev. B **2**, 4306 (1970)
23.119 K.S. Champlin, R.J. Erlandson, G.H. Glover, P.S. Hauge, T. Lu: Appl. Phys. Lett. **11**, 348–349 (1967)
23.120 T.E. Walsh: RCA Rev. **27**, 323–335 (1966)
23.121 A. Feldman, R.M. Waxler: J. Appl. Phys. **53**, 1477–1483 (1982)
23.122 M. Sugie, K. Tada: Jpn. J. Appl. Phys. **15**, 421–430 (1976)
23.123 R.A. Soref, H.W. Moos: J. Appl. Phys. **35**, 2152 (1964)
23.124 M. Bertolotti, V. Bogdanov, A. Ferrari, A. Jascow, N. Nazorova, A. Pikhtin, L. Schirone: J. Opt. Soc. Am. B **7**, 918–922 (1990)
23.125 A.H. Kachare, W.G. Spitzer, J.E. Fredrickson: J. Appl. Phys. **47**, 4209 (1976)
23.126 R.K. Chang, J. Ducuing, N. Bloembergen: Phys. Rev. Lett. **15**, 415–418 (1965)
23.127 W.D. Johnston Jr., I.P. Kaminow: Phys. Rev. **188**, 1209–1211 (1969)
23.128 B.F. Levine, C.G. Bethea: Appl. Phys. Lett. **20**, 272–274 (1972)
23.129 E. Yablonovitch, C. Flytzanis, N. Bloembergen: Phys. Rev. Lett. **29**, 865–868 (1972)
23.130 D.R. Nelson, E.H. Turner: J. Appl. Phys. **39**, 3337–3343 (1968)
23.131 Y. Berezashvili, S. Machavariani, A. Natsvlishvili, A. Chirakadze: J. Phys. D **22**, 682–686 (1989)
23.132 M.M. Choy, R.L. Byer: Phys. Rev. B **14**, 1693–1705 (1976)
23.133 D.F. Parsons, P.D. Coleman: Appl. Opt. **10**, 1683–1685 (1971)
23.134 Y.X. Ilisavskii, L.A. Kutakova: Fiz. Tverd. Tela **23**, 3299–3307 (1981)
23.135 Y.X. Ilisavskii, L.A. Kutakova: Sov. Phys. Solid State **23**, 1916–1920 (1981)
23.136 C.C. Lee, H.Y. Fan: Phys. Rev. B **9**, 3502 (1974)
23.137 C.K.N. Patel, R.E. Slusher, P.A. Fleury: Phys. Rev. Lett. **17**, 1011–1014 (1966)
23.138 H. McKenzie, D.J. Hagan, H.A. Al-Attar: IEEE J. Quantum Electron. **22**, 1328 (1986)
23.139 O.G. Lorimor, W.G. Spitzer: J. Appl. Phys. **36**, 1841–1844 (1965)
23.140 L.G. Meiners: J. Appl. Phys. **59**, 1611–1613 (1986)
23.141 D.N. Nichols, D.S. Rimai, R.J. Sladek: Solid State Commun. **36**, 667–669 (1980)
23.142 K. Tada, N. Suzuki: Jpn. J. Appl. Phys. **19**, 2295–2296 (1980)
23.143 T.S. Moss: *Optical Properties of Semiconductors* (Academic Press, New York 1959) p. 224
23.144 Y. Tsay, B. Bendow, S.S. Mitra: Phys. Rev. B **5**, 2688–2696 (1972)
23.145 J. Stone, M.S. Whalen: Appl. Phys. Lett. **41**, 1140–1142 (1982)
23.146 A.N. Pikhtin, A.D. Yas'kov: Sov. Phys. Semicond. **12**, 622–626 (1978)
23.147 R. Braunstein, N. Ockman: *Interactions of Coherent Optical Radiation with Solids*, Final Report, Office of Naval Research (Department of Navy, Washington, DC 1964), ARPA Order No. 306–362
23.148 A.A. Blistanov, V.S. Bondarenko, N.V. Perelomova, F.N. Strizhevskaya, V.V. Tchakalova, M.P. Shaskolskaya: *Acoustic Crystals* (Nauka, Moscow 1982), in Russian
23.149 E. Krjmki, R. Laiho, T. Levola: Physica **429**, 3–18 (1982)
23.150 G.R. Mariner, K. Vedam: Appl. Opt. **20**, 2878–2879 (1981)
23.151 I.I. Adrianova, A.A. Berezhnoi, K.K. Dubenskii, V.A. Sokolov: Fiz. Tverd. Tela **12**, 2462–2464 (1970)
23.152 I.I. Adrianova, A.A. Berezhnoi, K.K. Dubenskii, V.A. Sokolov: Sov. Phys. Solid State **12**, 1972–1973 (1970)
23.153 C. Kojima, T. Shikama, S. Kuninobu, A. Kawabata, T. Tanaka: Jpn. J. Appl. Phys. **8**, 1361–1362 (1969)
23.154 R.C. Miller, W.A. Nordland: Phys. Rev. B **2**, 4896–4902 (1970)
23.155 A. Chergui, J.L. Deiss, J.B. Grun, J.L. Loison, M. Robino, R. Besermann: Appl. Surf. Sci. **96**, 874 (1996)
23.156 A.V. Novoselova (Ed.): *Physical-Chemical Properties of Semiconductors – Handbook* (Nauka, Moscow 1979), in Russian
23.157 M. Yamada, K. Yamamoto, K. Abe: J. Phys. D **10**, 1309–1313 (1977)
23.158 S. Adachi, C. Hamaguchi: J. Phys. Soc. Jpn. **43**, 1637–1645 (1977)
23.159 D.T.F. Marple: J. Appl. Phys. **35**, 539 (1964)
23.160 Alkor Technologies: Data Sheet – Optical Crystals (Alkor Technologies, St. Petersburg 2002)
23.161 E.A. Kraut, B.R. Tittman, L.J. Graham, T.C. Lim: Appl. Phys. Lett. **17**, 271–272 (1970)
23.162 R.E. Aldrich, S.L. Hou, M.L. Harvill: J. Appl. Phys. **42**, 493–494 (1971)
23.163 M. Krzesinska: Ultrasonics **24**, 88–92 (1986)
23.164 J. Zelenka: Czech. J. Phys. B **28**, 165–169 (1978)
23.165 V.V. Kucha, V.I. Mirgorodskii, S.V. Peshin, A.T. Sobolev: Pis'ma Zh. Tekh. Fiz. **10**, 124–126 (1984)
23.166 V.V. Kucha, V.I. Mirgorodskii, S.V. Peshin, A.T. Sobolev: Sov. Tech. Phys. Lett. **10**, 51–52 (1984)
23.167 A. Reza, G. Babonas, D. Senuliene: Liet. Fiz. Rink. **26**, 41–47 (1986)
23.168 A. Reza, G. Babonas, D. Senuliene: Sov. Phys. Collect. **26**, 33–38 (1986)

23.169 P.I. Ropot: Opt. Spektrosk. **70**, 371–375 (1991)
23.170 P.I. Ropot: Opt. Spectrosc. **70**, 217–220 (1991)
23.171 V.M. Skorikov, I.S. Zakharov, V.V. Volkov, E.A. Spirin: Inorgan. Mater. **38**, 172–178 (2002)
23.172 H. Schweppe, P. Quadflieg: IEEE Trans. Sonics Ultrason. **21**, 56–57 (1974)
23.173 Y.R. Reddy, L. Sirdeshmukh: Phys. Status Solidi (a) **103**, K157–K160 (1987)
23.174 G.A. Babonas, A.A. Reza, E.I. Leonov, V.I. Shandaris: Zh. Tekh. Fiz. **55**, 1203–1205 (1985)
23.175 G.A. Babonas, A.A. Reza, E.I. Leonov, V.I. Shandaris: Sov. Phys. Tech. Phys. **30**, 689–690 (1985)
23.176 F. Vachss, L. Hesselink: Opt. Commun. **62**, 159–165 (1987)
23.177 P. Bayvel, M. McCall, R.V. Wright: Opt. Lett. **13**, 27–29 (1988)
23.178 P. Bayvel: Sens. Actuators **16**, 247–254 (1989)
23.179 A.D. Prasad Rao, P. da R. Andrade, S.P.S. Porto: Phys. Rev. B **9**, 1077–1084 (1974)
23.180 R. Bechmann: Proc. R. Phys. Soc. B **64**, 323–337 (1951)
23.181 T.S. Narasimhamurty: Proc. Indian Acad. Sci. A **40**, 167–175 (1954)
23.182 H.-J. Weber: Acta Crystallogr. A **35**, 225–232 (1979)
23.183 S. Chandrasekhar: Proc. R. Soc. A **259**, 531 (1961)
23.184 H.J. Simon, N. Bloembergen: Phys. Rev. **171**, 1104 (1968)
23.185 Eksma: Data Sheet – Optics and Optomechanics (Eksma, Vilnius 2003)
23.186 P.C. Leung, G. Andermann, W.G. Spitzer, C.A. Mead: J. Phys. Chem. Solids **27**, 849–855 (1966)
23.187 M. Tanaka, M. Yamada, C. Hamaguchi: J. Phys. Soc. Jpn. **38**, 1708–1714 (1975)
23.188 V.I. Sokolov, V.K. Subashiev: Fiz. Tverd. Tela **14**, 222–228 (1972)
23.189 V.I. Sokolov, V.K. Subashiev: Sov. Phys. Solid State **14**, 178–183 (1972)
23.190 K.L. Vodopyanov, L.A. Kulevskii, V.G. Voevodin, A.I. Gribenyukov, K.R. Allakhverdiev, T.A. Kerimov: Opt. Commun. **83**, 322–326 (1991)
23.191 K.L. Vodopyanov, I.A. Kulevskii: Opt. Commun. **118**, 375 (1995)
23.192 G.B. Abdullaev, L.A. Kulevsky, A.M. Prokhorov, A.D. Saleev, E.Y. Salaev, V.V. Smirnov: Pisma Zh. Eksp. Teor. Fiz. **16**, 130 (1972)
23.193 G.B. Abdullaev, L.A. Kulevsky, A.M. Prokhorov, A.D. Saleev, E.Y. Salaev, V.V. Smirnov: JETP Lett. **16**, 90–92 (1972)
23.194 P.J. Kupecek, E. Batifol, A. Kuhn: Opt. Commun. **11**, 291–295 (1974)
23.195 G.A. Akundov, A.A. Agaeve, V.M. Salmanov, Y.P. Sharorov, I.D. Yaroshetskii: Sov. Phys. Semicond. **7**, 826–827 (1973)
23.196 C.A. Arguello, D.L. Rousseau, S.P.S. Porto: Phys. Rev. **181**, 1351–1363 (1969)
23.197 C.F. Cline, H.L. Dunegan, G.W. Henderson: J. Appl. Phys. **38**, 1944 (1967)
23.198 S.B. Austerman, D.A. Berlincourt, H.H.A. Krueger: J. Appl. Phys. **34**, 339–341 (1963)
23.199 D.A. Belogurov, T.G. Okroashvili, Y.V. Shaldin, V.A. Maslov: Opt. Spektrosk. **54**, 298–301 (1983)
23.200 D.A. Belogurov, T.G. Okroashvili, Y.V. Shaldin, V.A. Maslov: Opt. Spectrosc. **54**, 177–179 (1983)
23.201 R.J. Morrow, H.W. Newkirk: Rev. Int. Hautes Temp. Refract. **6**(2), 99–104 (1969)
23.202 H.W. Newkirk, D.K. Smith, J.S. Kahn: Am. Mineral. **51**, 141–151 (1966)
23.203 M. Bass (Ed.): *Handbook of Optics*, Vol. 2 (McGraw-Hill, New York 1995)
23.204 J. Jerphagnon, H.W. Newkirk: Appl. Phys. Lett. **18**, 245–247 (1971)
23.205 J.D. Beasley: Appl. Opt. **33**, 1000–1003 (1994)
23.206 E.F. Tokarev, G.S. Pado, L.A. Chernozatonskii, V.V. Drachev: Fiz. Tverd. Tela **15**, 1593–1595 (1973)
23.207 E.F. Tokarev, G.S. Pado, L.A. Chernozatonskii, V.V. Drachev: Sov. Phys. Solid State **15**, 1064–1065 (1973)
23.208 A.A. Reza, G.A. Babonas: Fiz. Tverd. Tela **16**, 1414–1418 (1974)
23.209 A.A. Reza, G.A. Babonas: Sov. Phys. Solid State **16**, 909–911 (1974)
23.210 S.H. Wemple, M. DiDomenico Jr.: Appl. Solid State Sci. **3**, 263–283 (1972)
23.211 A.A. Davydov, L.A. Kulevsky, A.M. Prokhorov, A.D. Savelev, V.V. Smirnov: Pisma Zh. Eksp. Teor. Fiz. **15**, 725 (1972)
23.212 A.A. Davydov, L.A. Kulevsky, A.M. Prokhorov, A.D. Savelev, V.V. Smirnov: JETP Lett. **15**, 513 (1972)
23.213 G.C. Bhar: Appl. Opt. **15**, 305 (1976)
23.214 A. Penzkofer, M. Schaffner, X. Bao: Opt. Quantum Electron. **22**, 351 (1990)
23.215 I.A. Dan'kov, G.S. Pado, I.B. Kobyakov, V.V. Berdnik: Fiz. Tverd. Tela **21**, 2570–2575 (1979)
23.216 I.A. Dan'kov, G.S. Pado, I.B. Kobyakov, V.V. Berdnik: Sov. Phys. Solid State **21**, 1481–1483 (1979)
23.217 I.B. Kobyakov, V.M. Arutyunova: Zh. Tekh. Fiz. **58**, 983 (1988)
23.218 K. Vedam, T.A. Davis: Phys. Rev. **181**, 1196–1201 (1969)
23.219 R. Weil, D. Neshmit: J. Opt. Soc. Am. **67**, 190–195 (1977)
23.220 S.J. Czyzak, W.M. Baker, R.C. Crane, J.B. Howe: J. Opt. Soc. Am. **47**, 240 (1957)
23.221 R.C. Miller: Appl. Phys. Lett. **5**, 17–19 (1964)
23.222 E.K. Sichel, J.I. Pankove: J. Phys. Chem. Solids **38**, 330 (1977)
23.223 A.S. Barker, M. Ilegems: Phys. Rev. B **7**, 743–750 (1973)
23.224 V.A. Savastenko, A.U. Sheleg: Phys. Status Solidi (a) **48**, K135 (1978)
23.225 X.C. Long, R.A. Myers, S.R.J. Brueck, R. Ramer, K. Zheng, S.D. Hersee: Appl. Phys. Lett. **67**, 1349–1351 (1995)
23.226 I. Ishidate, K. Inone, M. Aoki: Jpn. J. Appl. Phys. **19**, 1641–1645 (1980)
23.227 S. Singh, J.R. Potopowicz, L.G. Van Uitert, S.H. Wemple: Appl. Phys. Lett. **19**, 53–56 (1971)
23.228 G. Arlt, G.R. Schodder: J. Acoust. Soc. Am. **37**, 384 (1965)
23.229 M. Gospodinov, P. Sveshtarov, N. Petkov, T. Milenov, V. Tasev, A. Nikolov: Bulg. J. Phys. **16**, 520–522 (1989)
23.230 S.A. Geidur: Opt. Spektrosk. **49**, 193–195 (1980)

23.231 S.A. Geidur: Opt. Spectrosc. **49**, 105–106 (1980)
23.232 P.M. Lundquist, W.P. Lin, G.K. Wong, M. Razeghi, J.B. Ketterson: Appl. Phys. Lett. **66**, 1883–1885 (1995)
23.233 E.E. Tokarev, I.B. Kobyakov, I.P. Kuz'mina, A.N. Lobachev, G.S. Pado: Fiz. Tverd. Tela **17**, 980–986 (1975)
23.234 E.E. Tokarev, I.B. Kobyakov, I.P. Kuz'mina, A.N. Lobachev, G.S. Pado: Sov. Phys. Solid State **17**, 629–632 (1975)
23.235 I.P. Kaminow, E.H. Turner: Appl. Opt. **5**, 1612–1628 (1966)
23.236 I.P. Kaminow, E.H. Turner: Proc. IEEE **54**, 1374–1390 (1966)
23.237 O.W. Madelung, E. Mollwo: Z. Phys. **249**, 12–30 (1971)
23.238 I.A. Dan'kov, I.B. Kobyakov, S.Y. Davydov: Fiz. Tverd. Tela **24**, 3613–3620 (1982)
23.239 I.A. Dan'kov, I.B. Kobyakov, S.Y. Davydov: Sov. Phys. Solid State **24**, 2058–2063 (1982)
23.240 L.B. Kobyakov: Kristallografiya **11**, 419–421 (1966)
23.241 L.B. Kobyakov: Sov. Phys. Crystallogr. **11**, 369–371 (1966)
23.242 N. Uchida, S. Saito: J. Appl. Phys. **43**, 971–976 (1972)
23.243 R.C. Miller, S.C. Abrahams, R.L. Barns, J.L. Bernstein, W.A. Nordland, E.H. Turner: Solid State Commun. **9**, 1463–1465 (1971)
23.244 S. Haussühl: Acta Crystallogr. A **34**, 547–550 (1978)
23.245 A.A. Abdullaev, A.V. Vasil'eva, G.F. Dobrzhanskii, Y.N. Polivanov: Sov. J. Quantum Electron. **7**, 56–59 (1977)
23.246 Y.V. Burak, K.Y. Borman, I.S. Girnyk: Fiz. Tverd. Tela **26**, 3692–3694 (1984)
23.247 Y.V. Burak, K.Y. Borman, I.S. Girnyk: Sov. Phys. Solid State **26**, 2223–2224 (1984)
23.248 S. Haussühl: Acustica **23**, 165–169 (1970)
23.249 S. Haussühl: Phys. Status Solidi (b) **29**, K159–K162 (1968)
23.250 J. Wang, H. Li, L. Zhang, R. Wang: Acta Acust. **11**, 338 (1986)
23.251 N.A. Zakharov, A.V. Egorov, N.S. Kozlova, O.G. Portnov: Fiz. Tverd. Tela **30**, 3166–3168 (1988)
23.252 N.A. Zakharov, A.V. Egorov, N.S. Kozlova, O.G. Portnov: Sov. Phys. Solid State **30**, 1823–1824 (1988)
23.253 A.W. Warner, D.A. Pinnow, J.G. Bergman Jr, G.R. Crane: J. Acoust. Soc. Am. **47**, 791–794 (1970)
23.254 O.G. Vlokh, I.A. Velichko, L.A. Laz'ko: Kristallografiya **20**, 430–432 (1975)
23.255 O.G. Vlokh, I.A. Velichko, L.A. Laz'ko: Sov. Phys. Crystallogr. **20**, 263–264 (1975)
23.256 G. Nath, H. Nehmanesch, M. Gsänger: Appl. Phys. Lett. **17**, 286–288 (1970)
23.257 S.V. Bogdanov (Ed.): *Lithium Iodate – Growth, Properties and Applications* (Nauka, Novosibirsk 1980), in Russian
23.258 D.J. Gettemy, W.C. Harker, G. Lindholm, N.P. Barnes: IEEE J. Quantum Electron. **QE-24**, 2231 (1988)
23.259 K. Kato: IEEE J. Quantum Electron. **QE-21**, 119 (1985)
23.260 M.J. Weber: Insulating crystal lasers. In: *CRC Handbook of Lasers with Selected Data on Optical Technology*, ed. by R.J. Pressley (Chemical Rubber, Cleveland 1971) pp. 371–417
23.261 T. Goto, O.L. Anderson, I. Ohno, S. Yamamoto: J. Geophys. Res. **94**, 7588 (1989)
23.262 R.M. Waxler, E.N. Farabaugh: J. Res. Natl. Bur. Stand. A **74**, 215–220 (1970)
23.263 A.C. DeFranzo, B.G. Pazol: Appl. Opt. **32**, 2224–2234 (1993)
23.264 E.M. Voronkova, B.N. Grechushnikov, G.I. Distler, I.P. Petrov: *Optical Materials for the Infrared Technique* (Nauka, Moscow 1965), in Russian
23.265 N.N. Khromova: Izv. Akad. Nauk SSSR, Ser. Neorg. Mater. **23**, 1500 (1987)
23.266 D.F. Nelson, P.D. Lazay, M. Lax: Phys. Rev. B **6**, 3109–3120 (1972)
23.267 E. Carvallo: Compte Rendus **126**, 950 (1898)
23.268 Z.P. Chang, G.R. Barsch: IEEE Trans. Sonics Ultrason. **23**, 127–135 (1976)
23.269 I.M. Sil'vestrova, O.A. Aleshko-Ozhevskii, Y.V. Pisarevskii, A.A. Shternberg, G.S. Mironova: Fiz. Tverd. Tela **29**, 3454–3456 (1987)
23.270 I.M. Sil'vestrova, O.A. Aleshko-Ozhevskii, Y.V. Pisarevskii, A.A. Shternberg, G.S. Mironova: Sov. Phys. Solid State **29**, 1979–1980 (1987)
23.271 H.A.A. Sidek, G.A. Saunders, H. Wang, B. Xu, J. Han: Phys. Rev. B **36**, 7612 (1987)
23.272 I.M. Sil'vestrova, Y.V. Pisarevskii, O.V. Zvereva, A.A. Shternberg: Kristallografiya **32**, 792–794 (1987)
23.273 I.M. Sil'vestrova, Y.V. Pisarevskii, O.V. Zvereva, A.A. Shternberg: Sov. Phys. Crystallogr. **32**, 467–468 (1987)
23.274 W.L. Bond: J. Appl. Phys. **36**, 1674–1677 (1965)
23.275 J. Sapriel, R. Lancon: Proc. IEEE **61**, 678–679 (1973)
23.276 I.M. Silvestrova, V.A. Kuznetsov, N.A. Moiseeva, E.P. Efremova, Y.V. Pisarevskii: Fiz. Tverd. Tela **28**, 180 (1986)
23.277 H. Jaffe, D.A. Berlincourt: Proc. IEEE **53**, 1372–1386 (1965)
23.278 J. Sapriel: Appl. Phys. Lett. **19**, 533–535 (1971)
23.279 E.H. Turner: IEEE J. Quantum Electron. **QE-3**, 695 (1967)
23.280 W.L. Bond, G.D. Boyd, H.L. Carter Jr.: J. Appl. Phys. **38**, 4090–4091 (1967)
23.281 G.D. Boyd, T.J. Bridges, E.G. Burkhardt: IEEE J. Quantum Electron. **4**, 515 (1968)
23.282 C. Chen, Z. Xu, D. Deng, J. Zhang, G.K.L. Wong, B. Wu, N. Ye, D. Tang: Appl. Phys. Lett. **68**, 2930–2932 (1996)
23.283 R. Bechmann: Phys. Rev. **110**, 1060–1061 (1958)
23.284 W.G. Cady: *Piezoelectricity* (McGraw-Hill, New York 1946)
23.285 P.H. Carr: J. Acoust. Soc. Am. **41**, 75–83 (1967)
23.286 T.S. Narasimhamurty: J. Opt. Soc. Am. **59**, 682–686 (1969)
23.287 A.J. Rogers: Proc. R. Soc. A **353**, 177–192 (1977)
23.288 J. Jerphagnon, S.K. Kurtz: Phys. Rev. B **1**, 1739 (1970)
23.289 F. Hache, A. Zeboulon, G. Gallot, G.M. Gale: Opt. Lett. **20**, 1556–1558 (1995)
23.290 I.S. Grigoriev, E.Z. Melikhov (Eds.): *Physical Quantities Handbook* (Emergoatomizdat, Moscow 1991)
23.291 H. Wagner: Z. Phys. **193**, 218–234 (1966)

23.292 G. Arlt, P. Quadflieg: Phys. Status Solidi **32**, 687–689 (1969)
23.293 P. Grosse: *Die Festkörpereigenschaften von Tellur*, Springer Tracts in Modern Physics, Vol. 48 (Springer, Berlin, Heidelberg 1969) p. 65
23.294 D. Souilhac, D. Billeret, A. Gundjan: Appl. Opt. **28**, 3993–3996 (1989)
23.295 J.H. McFee, G.D. Boyd, P.H. Schmidt: Appl. Phys. Lett. **17**, 57–59 (1970)
23.296 D. Eimerl, L. Davis, S. Velsko, E.K. Graham, A. Zalkin: J. Appl. Phys. **62**, 1968–1983 (1987)
23.297 L. Bohaty, J. Liebertz: Z. Kristallogr. **192**, 91–95 (1990)
23.298 C. Chen, B. Wu, A. Jiang, G. You: Sci. Sin. B **28**, 235 (1985)
23.299 L.J. Bromley, A. Guy, D.C. Hanna: Opt. Commun. **67**, 316–320 (1988)
23.300 G.G. Gurzadyan, A.S. Oganesyan, A.V. Petrosyan, R.O. Sharkhatunyan: Zh. Tekh. Fiz. **61**, 152–154 (1991)
23.301 G.G. Gurzadyan, A.S. Oganesyan, A.V. Petrosyan, R.O. Sharkhatunyan: Sov. Phys. Tech. Phys. **36**, 341–342 (1991)
23.302 D. Zhang, Y. Kong, J.-Y. Zhang: Opt. Commun. **184**, 485–491 (2000)
23.303 R.C. Eckardt, H. Masuda, Y.X. Fan, R.L. Byer: IEEE J. Quantum Electron. **QE-26**, 922–933 (1990)
23.304 J.R. Teague, R.R. Rice, R. Gerson: J. Appl. Phys. **46**, 2864–2866 (1975)
23.305 R.T. Smith, F.S. Welsh: J. Appl. Phys. **42**, 2219–2230 (1971)
23.306 T. Yamada, N. Niizeki, H. Toyoda: Jpn. J. Appl. Phys. **6**, 151–155 (1967)
23.307 R.A. Graham: Ferroelectrics **10**, 65–69 (1976)
23.308 K.F. Hulme, P.H. Davies, V.M. Cound: J. Phys. C **2**, 855–857 (1969)
23.309 J.D. Zook, D. Chen, G.N. Otto: Appl. Phys. Lett. **11**, 159–161 (1967)
23.310 M.V. Hobden, J. Warner: Phys. Lett. **22**, 243 (1966)
23.311 D.H. Jundt, M.M. Fejer, R.L. Byer: IEEE J. Quantum Electron. **26**, 135–138 (1990)
23.312 J.E. Midwinter: J. Appl. Phys. **39**, 3033–3038 (1968)
23.313 R.J. Holmes, Y.S. Kim, C.D. Brandle, D.M. Smyth: Ferroelectrics **51**, 41–45 (1983)
23.314 A.L. Aleksandrovskii, G.I. Ershova, G.K. Kitaeva, S.P. Kulik, I.I. Naumova, V.V. Tarasenko: Kvantovaya Elektron. **18**, 254–256 (1991)
23.315 A.L. Aleksandrovskii, G.I. Ershova, G.K. Kitaeva, S.P. Kulik, I.I. Naumova, V.V. Tarasenko: Sov. J. Quantum Electron. **21**, 225–227 (1991)
23.316 Y. Chang, J. Wen, H. Wang, B. Li: Chin. Phys. Lett. **9**, 427–430 (1992)
23.317 I. Tomeno, N. Hirano: J. Phys. Soc. Jpn. **50**, 1809 (1981)
23.318 I. Tomeno, N. Hirano: J. Phys. Soc. Jpn. **51**, 339 (1982)
23.319 T. Yamada, H. Iwasaki, N. Niizeki: Jpn. J. Appl. Phys. **8**, 1127–1132 (1969)
23.320 L.P. Avakyants, D.F. Kiselev, N.N. Shchitov: Fiz. Tverd. Tela **18**, 2129–2130 (1976)
23.321 L.P. Avakyants, D.F. Kiselev, N.N. Shchitov: Sov. Phys. Solid State **18**, 1242–1243 (1976)
23.322 E.H. Turner: In: *Meet. Opt. Soc. Am., Tech. Dig. Pap. A13, San Francisco* (1966)
23.323 S. Singh: Nonlinear optical materials. In: *CRC Handbook of Lasers with Selected Data on Optical Technology*, ed. by R.J. Pressley (Chemical Rubber, Cleveland 1971) pp. 489–525
23.324 R.C. Miller, A. Savage: Appl. Phys. Lett. **9**, 169–171 (1966)
23.325 C. O'Hara, N.M. Shorrocks, R.W. Whatmore, O. Jones: J. Phys. D **15**, 1289–1299 (1982)
23.326 Y.M. Olikh: Phys. Status Solidi (a) **80**, K81 (1983)
23.327 Y.M. Olikh: Fiz. Tverd. Tela **25**, 2222–2225 (1983)
23.328 Y.M. Olikh: Sov. Phys. Solid State **25**, 1282–1283 (1983)
23.329 J.D. Feichtner, R. Johannes, G.W. Roland: Appl. Opt. **9**, 1716–1717 (1970)
23.330 W.B. Gandrud, G.D. Boyd, J.H. McFee, F.H. Wehmeier: Appl. Phys. Lett. **16**, 59–61 (1970)
23.331 I.I. Zubrinov, V.I. Semenov, D.V. Sheloput: Fiz. Tverd. Tela **15**, 2871–2873 (1973)
23.332 I.I. Zubrinov, V.I. Semenov, D.V. Sheloput: Sov. Phys. Solid State **15**, 1921–1922 (1974)
23.333 I.V. Kityk: Fiz. Tverd. Tela **33**, 1826–1833 (1991)
23.334 I.V. Kityk: Sov. Phys. Solid State **33**, 1026–1030 (1991)
23.335 J. Warner: Brit. J. Appl. Phys. II **1**, 949–950 (1968)
23.336 K.F. Hulme, O. Jones, P.H. Davies, M.V. Hobden: Appl. Phys. Lett. **10**, 133–135 (1967)
23.337 R.F. Lucy: Appl. Opt. **11**, 1329 (1972)
23.338 D.S. Chemla, P.J. Kupecek, C.A. Schwartz: Opt. Commun. **7**, 225–228 (1973)
23.339 V.V. Lomanov: *Acoustooptical Radioelectronic System Devices* (Nauka, Leningrad 1988) pp. 48–61
23.340 J.D. Feichtner, G.W. Roland: Appl. Opt. **11**, 993–998 (1972)
23.341 M.D. Ewbank, P.R. Newman, N.L. Mota, S.M. Lee, W.L. Wolfe, A.G. DeBell, W.A. Harrison: J. Appl. Phys. **51**, 3848–3852 (1980)
23.342 R.C.Y. Auyeung, D.M. Zielke, B.J. Feldman: Appl. Phys. B **48**, 293 (1989)
23.343 D.R. Suhre: Appl. Phys. B **52**, 367–370 (1991)
23.344 Y.S. Touloukian, R.W. Powell, C.Y. Ho, P.G. Klemens: *Thermal Conductivity, Non-Metallic Solids*, Thermal Properties of Matter, Vol. 2 (IFI/Plenum, New York 1970)
23.345 W.P. Mason: *Piezoelectric Crystals and Their Applications to Ultrasonics* (Van Nostrand, New York 1950)
23.346 I.S. Zheludev, M.M. Tagieva: Kristallografiya **7**, 589–592 (1962)
23.347 I.S. Zheludev, M.M. Tagieva: Sov. Phys. Crystallogr. **7**, 473–475 (1963)
23.348 I.P. Kaminow, E.H. Turner: In: *CRC Handbook of Lasers with Selected Data on Optical Technology*, ed. by R.J. Pressley (Chemical Rubber, Cleveland 1971) pp. 447–459
23.349 F. Pockels: Abh. Kgl. Ges. Wiss. Göttingen **39**, 1–204 (1894)
23.350 M.J. Weber (Ed.): *Handbook of Laser Science and Technology*, Vol. 3 (CRC, Boca Raton 1986)

23.351 S. Chang, H.R. Carleton: In: *In: Basic Optical Properties of Materials*, National Bureau of Standards Special Publication, Vol. 574, ed. by A. Feldman (National Bureau of Standards, Boulder 1980) pp. 213–216
23.352 M.H. Grimsditch, A.K. Ramdas: Phys. Rev. B **22**, 4094–4096 (1980)
23.353 J.R. DeVore: J. Opt. Soc. Am. **41**, 416–419 (1951)
23.354 H.J. Eichler, H. Fery, J. Knof, J. Eichler: Z. Phys. B **28**, 297–306 (1977)
23.355 Bluelightning Optics: Data Sheet – Product (Bluelightning Optics, Beijing 2002)
23.356 G.C. Coquin, D.A. Pinnow, A.W. Warner: J. Appl. Phys. **42**, 2162–2168 (1971)
23.357 K. Wu, W. Hua: Acta Acust. (China) **12**, 64 (1987)
23.358 I.L. Chistyi, L. Csillag, V.F. Kitaeva, N. Kroo, N.N. Sobolev: Phys. Status Solidi (a) **47**, 609–615 (1978)
23.359 Almaz Optics: Data Sheet – Optical Components (Almaz Optics, Marlton 2002)
23.360 B.W. Woods, S.A. Payne, J.E. Marion, R.S. Hughes, L.E. Davis: J. Opt. Soc. Am. B **8**, 970–977 (1991)
23.361 P. Blanchfield, G.A. Saunders: J. Phys. C **12**, 4673 (1979)
23.362 A.W. Warner, D.L. White, W.A. Bonner: J. Appl. Phys. **11**, 4489–4495 (1972)
23.363 Y. Ohmachi, N. Uchida: J. Appl. Phys. **41**, 2307–2311 (1970)
23.364 G. Arlt, H. Schweppe: Solid State Commun. **6**, 783–784 (1968)
23.365 Y. Ohmachi, N. Uchida: Rev. Electr. Commun. Lab. **20**, 529–541 (1972)
23.366 M.D. Ewbank, F.R. Newman: J. Appl. Phys. **53**, 1150–1153 (1982)
23.367 G.H. Sherman, P.D. Coleman: IEEE J. Quantum Electron. **QE-9**, 403–409 (1973)
23.368 N. Uchida: Phys. Rev. **4**, 3736 (1971)
23.369 Y. Fujii, S. Yoshida, S. Misawa, S. Mackawa, T. Sakudo: Appl. Phys. Lett. **31**, 815–816 (1977)
23.370 E.N. Volkova, A.N. Izrailenko: Kristallografiya **28**, 1217–1219 (1983)
23.371 E.N. Volkova, A.N. Izrailenko: Sov. Phys. Crystallogr. **28**, 716–717 (1983)
23.372 R.S. Adhav, A.D. Vlassopoulos: IEEE J. Quantum Electron. **QE-10**, 688 (1974)
23.373 W.P. Mason, B.T. Matthias: Phys. Rev. **88**, 477–479 (1952)
23.374 A.S. Vasilevskaya, A.S. Sonin: Kristallografiya **14**, 713–716 (1969)
23.375 A.S. Vasilevskaya, A.S. Sonin: Sov. Phys. Crystallogr. **14**, 611–613 (1970)
23.376 D. Eimerl: Ferroelectrics **72**, 95–139 (1987)
23.377 A.S. Sonin, A.S. Vasilevskaya: *Electrooptic Crystals* (Atomizdat, Moscow 1971)
23.378 A.S. Vasilevskaya, E.N. Volkova, V.A. Koptsik, L.N. Rashkovich, T.A. Regulskaya, I.S. Rez, A.S. Sonin, V.S. Suvorov: Kristallografiya **12**, 518 (1967)
23.379 A.S. Vasilevskaya, E.N. Volkova, V.A. Koptsik, L.N. Rashkovich, T.A. Regulskaya, I.S. Rez, A.S. Sonin, V.S. Suvorov: Sov. Phys. Crystallogr. **12**, 446 (1967)
23.380 V.S. Suvorov, A.S. Sonin, I.S. Rez: Zh. Eksp. Teor. Fiz. **53**, 491 (1967)
23.381 V.S. Suvorov, A.S. Sonin, I.S. Rez: Sov. Phys. JETP **26**, 23 (1967)
23.382 Clevite Corp.: Reference Data on Linear Electro-Optic Effects (Clevite, Cleveland 1967)
23.383 H. Jaffe: In: *Meet. Opt. Soc. Am., Cleveland*, Tech. Dig.,1950)
23.384 R.S. Adhav: J. Acoust. Soc. Am. **43**, 835 (1968)
23.385 G.K. Afanaseva: Kristallografiya **13**, 1024 (1968)
23.386 G.K. Afanaseva: Sov. Phys. Crystallogr. **13**, 1024 (1968)
23.387 N.P. Barnes, D.J. Gettemy, R.S. Adhav: J. Opt. Soc. Am. **72**, 895 (1982)
23.388 F. Hoff, B. Stadnik: Electron. Lett. **2**, 293 (1966)
23.389 T.S. Narasimhamurty, K. Veerabhadra Rao, H.E. Pettersen: J. Mater. Sci. **8**, 577–580 (1973)
23.390 F.M. Johnson, J.A. Duardo: Laser Focus **11**, 31 (1967)
23.391 F. Zernike: J. Opt. Soc. Am. **55**, 91 (1965)
23.392 T. Hailing, G.A. Saunders, W.A. Lambson: Phys. Rev. B **26**, 5786 (1982)
23.393 R.L. Byer, H. Kildal, R.S. Feigelson: Appl. Phys. Lett. **19**, 237–240 (1971)
23.394 G.D. Boyd, E. Buehler, F.G. Storz, J.H. Wernick: IEEE J. Quantum Electron. **QE-8**, 419–426 (1972)
23.395 G.C. Ghosh, G.C. Bhar: IEEE J. Quantum Electron **QE-18**, 143 (1982)
23.396 R.S. Adhav: In: *76 Annu. Meet. Acoust. Soc. Am., Cleveland*, Tech. Dig,1968), Paper No. 79
23.397 B.A. Strukov, T.P. Spiridonov, N.N. Tkachev, K.A. Minaeva, M.Y. Kozhevnikov: Izv. Akad. Nauk SSSR Ser. Fiz. **53**, 1320–1326 (1989)
23.398 B.A. Strukov, T.P. Spiridonov, N.N. Tkachev, K.A. Minaeva, M.Y. Kozhevnikov: Bull. Acad. Sci. USSR, Phys. Ser. **53**, 86–92 (1989)
23.399 R.S. Adhav: J. Opt. Soc. Am. **59**, 414–418 (1969)
23.400 K. Kato: IEEE J. Quantum Electron. **QE-10**, 616 (1974)
23.401 R.S. Adhav: J. Appl. Phys. **46**, 2808 (1975)
23.402 A.T. Anistratov, V.G. Martynov, L.A. Shabanova, I.S. Rez: Fiz. Tverd. Tela **21**, 1354 (1979)
23.403 A.T. Anistratov, V.G. Martynov, L.A. Shabanova, I.S. Rez: Sov. Phys. Solid State **21** (1979)
23.404 M.P. Zaitseva, Y.I. Kokorin, A.M. Sysoev, I.S. Rez: Kristallografiya **27**, 146–151 (1982)
23.405 M.P. Zaitseva, Y.I. Kokorin, A.M. Sysoev, I.S. Rez: Sov. Phys. Crystallogr. **27**, 86–89 (1982)
23.406 Y. Mori, I. Kuroda, S. Nakajima, T. Sasaki, S. Nakai: Appl. Phys. Lett. **67**, 1818–1820 (1995)
23.407 N. Umemura, K. Kato: Appl. Opt. **36**, 6794 (1997)
23.408 G.D. Boyd, H.M. Kasper, J.H. McFee, F.G. Storz: IEEE J. Quantum Electron. **QE-8**, 900–908 (1972)
23.409 G.D. Boyd, H. Kasper, J.H. McFee: IEEE J. Quantum Electron. **7**, 563–573 (1971)
23.410 G.C. Bhar, G. Ghosh: J. Opt. Soc. Am. **69**, 730–733 (1979)
23.411 C.W. Fairall, W. Reese: Phys. Rev. B **6**, 193–199 (1972)
23.412 R.S. Adhav: J. Appl. Phys. **39**, 4091 (1968)
23.413 R.S. Adhav: J. Appl. Phys. **39**, 4095–4098 (1968)
23.414 T.R. Sliker, S.R. Burlage: J. Appl. Phys. **34**, 1837–1840 (1963)

23.415 L.A. Shuvalov, A.V. Mnatsakanyan: Kristallografiya **11**, 222 (1966)
23.416 L.P. Avakyants, D.F. Kiselev, N.V. Perelomova, V.I. Sugrei: Fiz. Tverd. Tela **25**, 580–582 (1983)
23.417 L.P. Avakyants, D.F. Kiselev, N.V. Perelomova, V.I. Sugrei: Sov. Phys. Solid State **25**, 329–330 (1983)
23.418 J.H. Ott, T.R. Sliker: J. Opt. Soc. Am. **54**, 1442–1444 (1964)
23.419 M.I. Zugrav, A. Dumitrica, A. Dumitras, N. Comaniciu: Cryst. Res. Technol. **17**, 475–480 (1982)
23.420 R. Danelyus, A. Piskarskas, V. Sirutkaitis, A. Stabinis, Y. Yasevichyute: *Parametric Generators of Light and Picosecond Spectroscopy* (Mokslas, Vilnius 1983)
23.421 I.P. Kaminow: Phys. Rev. A **138**, 1539–1543 (1965)
23.422 D.A. Berlincourt, D.R. Curran, H. Jaffe: In: *Physical Acoustics*, Vol. 1A, ed. by W.P. Mason (Academic Press, New York 1964) pp. 1169–1270
23.423 S. Haussühl: Z. Kristallogr. **120**, 401 (1964)
23.424 I.P. Kaminow, G.O. Harding: Phys. Rev. **129**, 1562–1566 (1963)
23.425 K. Veerabhadra Rao, T.S. Narasimhamurty: J. Phys. C **11**, 2343–2347 (1978)
23.426 W.L. Smith: Appl. Opt. **6**, 1798 (1977)
23.427 F. Zernike: J. Opt. Soc. Am. **54**, 1215 (1964)
23.428 F. Zernike: Erratum, J. Opt. Soc. Am. **55**, 210 (1965)
23.429 R.S. Adhav: J. Phys. D **2**, 171–175 (1969)
23.430 E.N. Volkova, B.M. Berezhnoi, A.N. Izrailenko, A.V. Mishchenko, L.N. Rashkovich: Izv. Akad. Nauk SSSR, Ser. Fiz. **35**, 1858–1861 (1971)
23.431 E.N. Volkova, B.M. Berezhnoi, A.N. Izrailenko, A.V. Mishchenko, L.N. Rashkovich: Bull. Acad. Sci. USSR, Phys. Ser. **35**, 1690–1693 (1971)
23.432 L.A. Shuvalov, I.S. Zheludev, A.V. Mnatsakanyan, T.-Z. Ludupov, I. Fiala: Izv. Akad. Nauk SSSR, Ser. Fiz. **31**, 1919–1922 (1967)
23.433 L.A. Shuvalov, I.S. Zheludev, A.V. Mnatsakanyan, T.-Z. Ludupov, I. Fiala: Bull. Acad. Sci. USSR, Phys. Ser. **31**, 1963–1966 (1967)
23.434 K. Kato, A.J. Alcock, M.C. Richardson: Opt. Commun. **11**, 5 (1974)
23.435 R.S. Adhav: J. Phys. D **2**, 177–182 (1969)
23.436 K.S. Aleksandrov, A.T. Anistratov, A.R. Zamkov, I.S. Rez: Fiz. Tverd. Tela **19**, 1863–1866 (1977)
23.437 K.S. Aleksandrov, A.T. Anistratov, A.R. Zamkov, I.S. Rez: Sov. Phys. Solid State **19**, 1090–1091 (1977)
23.438 K. Kato: Opt. Commun. **13**, 93 (1975)
23.439 J.E. Pearson, G.A. Evans, A. Yariv: Opt. Commun. **4**, 366–367 (1972)
23.440 K. Kato: IEEE J. Quantum Electron. **QE-10**, 622 (1974)
23.441 I.S. Zheludev, T.-Z. Ludupov: Kristallografiya **10**, 764–766 (1965)
23.442 I.S. Zheludev, T.-Z. Ludupov: Sov. Phys. Crystallogr. **10**, 645–646 (1966)
23.443 Y.K. Shaldin, D.A. Belogurov: Opt. Spektrosk. **35**, 693–701 (1973)
23.444 Y.K. Shaldin, D.A. Belogurov: Opt. Spectrosc. **35**, 403–407 (1973)
23.445 H. Horinaka, H. Nozuchi, H. Sonomura, T. Miyauchi: Jpn. J. Appl. Phys. **22**, 546 (1983)
23.446 H. Horinaka, H. Sonomura, T. Migauchi: Jpn. J. Appl. Phys. **21**, 1485–1488 (1982)
23.447 R.L. Byer, M.M. Choy, R.L. Herbst, D.S. Chemla, R.S. Feigelson: Appl. Phys. Lett. **24**, 65–68 (1974)
23.448 N.P. Barnes, D.J. Gettemy, J.R. Hietanen, R.A. Iannini: Appl. Opt. **28**, 5162–5168 (1989)
23.449 V.M. Cound, P.H. Davies, K.F. Hulme, D. Robertson: J. Phys. C **3**, L83–L84 (1970)
23.450 M.H. Grimsditch, G.D. Holah: Phys. Rev. B **12**, 4377 (1975)
23.451 M.H. Grimsditch, G.D. Holah: J. Phys. Colloqres **36**, C3–C185 (1975)
23.452 M.G. Cohen, M. DiDomenico Jr., S.H. Wemple: Phys. Rev. B **1**, 4334–4337 (1970)
23.453 D.S. Chemla, P.J. Kupecek, D.S. Robertson, R.C. Smith: Opt. Commun. **3**, 29 (1971)
23.454 G.C. Bhar, D.K. Ghosh, P.S. Ghosh, D. Schmitt: Appl. Opt. **22**, 2492 (1983)
23.455 J.J. Zondy, D. Touahri: J. Opt. Soc. Am. B **14**, 1331 (1997)
23.456 A. Yoshihara, E.R. Bernstein: J. Chem. Phys. **77**, 5319 (1982)
23.457 L. Bohaty: Z. Kristallogr. **163**, 307–309 (1983)
23.458 J.M. Halbout, S. Blit, W. Donaldson, C.L. Tang: IEEE J. Quantum Electron. **QE-15**, 1176–1180 (1979)
23.459 M.J. Rosker, K. Cheng, C.L. Tang: IEEE J. Quantum Electron. **21**, 1600 (1985)
23.460 K. Betzler, H. Hesse, P. Loose: J. Mol. Struct. **47**, 393–396 (1978)
23.461 G. Ambrazevicius, G. Babonas: Liet. Fiz. Sb. **18**, 765–774 (1978)
23.462 G. Ambrazevicius, G. Babonas: Sov. Phys. Collection **18**, 52–59 (1978)
23.463 S.R. Sashital, R.R. Stephens, J.F. Lotspeich: J. Appl. Phys. **59**, 757–760 (1986)
23.464 G.D. Boyd, E. Buehler, F.G. Storz: Appl. Phys. Lett. **18**, 301–304 (1971)
23.465 G.C. Bhar, L.K. Samanta, D.K. Ghosh, S. Das: Kvantovaya Elektron. **14**, 1361 (1987)
23.466 G.C. Bhar, L.K. Samanta, D.K. Ghosh, S. Das: Sov. J. Quantum Electron. **17**, 860 (1987)
23.467 D. Berlincourt, H. Jaffe: Phys. Rev. **111**, 143–148 (1958)
23.468 W.J. Merz: Phys. Rev. **76**, 1221–1225 (1949)
23.469 A. Schaefer, H. Schmitt, A. Dörr: Ferroelectrics **69**, 253–266 (1986)
23.470 K. Tada, K. Kikuchi: Jpn. J. Appl. Phys. **19**, 1311–1315 (1980)
23.471 M. Zgonik, P. Bernasconi, M. Duelli, R. Schlesser, P. Günter, M.H. Garrett, D. Rytz, Y. Zhu, X. Wu: Phys. Rev. B **50**, 5941–5949 (1994)
23.472 S.H. Wemple, M. DiDomenico Jr., I. Camlibel: J. Phys. Chem. Solids **29**, 1797–1803 (1968)
23.473 R.C. Miller, D.A. Kleinman, A. Savage: Phys. Rev. Lett. **11**, 146–149 (1963)
23.474 R.C. Miller, W.A. Nordland: Opt. Commun. **1**, 400–402 (1970)
23.475 A.V. Turik, N.B. Shevchenko, V.G. Gavrilyachenko, E.G. Fesenko: Phys. Status Solidi (b) **94**, 525–528 (1979)
23.476 V.G. Gavrilyachenko, E.G. Fesenko: Kristallografiya **16**, 640–641 (1971)

23.477 V.G. Gavrilyachenko, E.G. Fesenko: Sov. Phys. Crystallogr. **16**, 549–550 (1971)
23.478 E.H. Turner: Unpublished work
23.479 S. Singh, J.P. Remeika, J.R. Potopowicz: Appl. Phys. Lett. **20**, 135–137 (1972)
23.480 Molecular Technology: Data Sheet – World of Crystals (Molecular Technology GmbH, Berlin 2002)
23.481 L. Bohaty, S. Haussühl, J. Liebertz: Cryst. Res. Technol. **24**, 1159–1163 (1989)
23.482 R. Komatsu, T. Sugawara, K. Sassa, N. Sarukura, Z. Liu, S. Izumida, Y. Segawa, S. Uda, T. Fukuda, K. Yamanouchi: Appl. Phys. Lett. **70**, 3492–3494 (1997)
23.483 T. Sugawara, R. Komatsu, S. Uda: Solid State Commun. **107**, 233 (1998)
23.484 S.I. Furusawa, O. Chikagawa, S. Tange, T. Ishidate, H. Orihara, Y. Ishibashi, K. Miwa: J. Phys. Soc. Jpn. **60**, 2691–2693 (1991)
23.485 M. Adachi, A. Kawabata: Jpn. J. Appl. Phys. **17**, 1969–1973 (1978)
23.486 L.G. Van Uitert, S. Singh, H.J. Levinstein, J.E. Geusic, W.A. Bonner: Appl. Phys. Lett. **11**, 161–163 (1967)
23.487 L.G. Van Uitert, S. Singh, H.J. Levinstein, J.E. Geusic, W.A. Bonner: Erratum, Appl. Phys. Lett. **12**, 224 (1968)
23.488 M. Adachi, T. Shiosaki, A. Kawabata: Ferroelectrics **27**, 89–92 (1980)
23.489 J.J.E. Reid: Appl. Phys. Lett. **62**, 19–21 (1993)
23.490 J.L. Kirk, K. Vedam: J. Phys. Chem. Solids **33**, 1251–1255 (1972)
23.491 M.J. Dodge: Refractive index. In: *Optical Materials, CRC Handbook of Laser Science and Technology*, Vol. 4, ed. by M.J. Weber (CRC, Boca Raton 1987) pp. 21–47
23.492 K.W. Martin, L.G. DeShazer: Appl. Opt. **12**, 941–943 (1973)
23.493 R. Kiriyama: Science (Tokyo) **17**, 239–240 (1947)
23.494 R. Kiriyama: Chem. Abstr. **45**, 2278 (1951)
23.495 M.S. Madhava, S. Haussühl: Z. Kristallogr. **141**, 25–30 (1975)
23.496 P.S. Bechthold, S. Haussühl: Appl. Phys. **14**, 403–410 (1977)
23.497 Y. Wu, T. Sasaki, S. Nakai, A. Yokotani, H. Tang, C. Chen: Appl. Phys. Lett. **62**, 2614–2615 (1993)
23.498 K. Kato: IEEE J. Quantum Electron. **QE-31**, 169–171 (1995)
23.499 S. Haussühl: Acta Crystallogr. A **24**, 697–698 (1968)
23.500 E.N. Volkova, V.A. Dianova, A.L. Zuev, A.N. Izrailenko, A.S. Lipatov, V.N. Parygin, L.N. Rashkovich, L.E. Chirkov: Kristallografiya **16**, 346–349 (1971)
23.501 E.N. Volkova, V.A. Dianova, A.L. Zuev, A.N. Izrailenko, A.S. Lipatov, V.N. Parygin, L.N. Rashkovich, L.E. Chirkov: Sov. Phys. Crystallogr. **16**, 284–286 (1971)
23.502 S.K. Kurtz, T.T. Perry, J.G. Bergman Jr.: Appl. Phys. Lett. **12**, 186–188 (1968)
23.503 H. Naito, H. Inaba: Optoelectronics **4**, 335 (1972)
23.504 G.R. Crane: J. Chem. Phys. **62**, 3571 (1975)
23.505 P. Günter: Ferroelectrics **75**, 5–23 (1987)
23.506 J. Sapriel, R. Hierle, J. Zyss, M. Bossier: Appl. Phys. Lett. **55**, 2594–2596 (1989)
23.507 M. Sigelle, R. Hierle: J. Appl. Phys. **52**, 4199–4204 (1981)
23.508 J. Zyss, D.S. Chemla, J.F. Nicoud: J. Chem. Phys. **74**, 4800–4811 (1981)
23.509 T.S. Narasimhamurty: Phys. Rev. **186**, 945–948 (1969)
23.510 A.T. Anistratov, S.X. Mel'nikova: Kristallografiya **17**, 149–152 (1972)
23.511 A.T. Anistratov, S.X. Mel'nikova: Sov. Phys. Crystallogr. **17**, 119–121 (1972)
23.512 N.A. Romanyuk, A.M. Kostetskii: Fiz. Tverd. Tela **18**, 1489–1491 (1976)
23.513 N.A. Romanyuk, A.M. Kostetskii: Sov. Phys. Solid State **18**, 867–869 (1976)
23.514 J. Valasek: Phys. Rev. **20**, 639–664 (1922)
23.515 G.B. Hadjichristov, P.P. Kircheva, N. Kirov: J. Mol. Struct. **382**, 33–37 (1996)
23.516 Y. Takagi, Y. Makita: J. Phys. Soc. Jpn. **13**, 272–277 (1958)
23.517 V.V. Gladkii, V.K. Magataev, V.A. Kirikov: Fiz. Tverd. Tela **19**, 1102–1106 (1977)
23.518 V.V. Gladkii, V.K. Magataev, V.A. Kirikov: Sov. Phys. Solid State **19**, 641–644 (1977)
23.519 M.S. Khan, T.S. Narasimhamurty: Solid State Commun. **43**, 941–943 (1982)
23.520 I.V. Berezhnoi, R.O. Vlokh: Fiz. Tverd. Tela **30**, 2223–2225 (1988)
23.521 I.V. Berezhnoi, R.O. Vlokh: Sov. Phys. Solid State **30**, 1282–1284 (1988)
23.522 N.R. Ivanov, D. Khusravov, L.A. Shuvalov, N.M. Shchagina: Izv. Akad. Nauk SSSR, Ser. Fiz. **43**, 1691–1701 (1979)
23.523 N.R. Ivanov, D. Khusravov, L.A. Shuvalov, N.M. Shchagina: Bull. Acad. Sci. USSR, Phys. Ser. **43**, 121–129 (1979)
23.524 A.T. Anistratov, V.G. Martynov: Kristallografiya **15**, 308–312 (1970)
23.525 A.T. Anistratov, V.G. Martynov: Sov. Phys. Crystallogr. **15**, 256–260 (1970)
23.526 Y. Luspin, G. Hauret: C. R. Hebd. Seances Acad. Sci., Ser. B **274**, 995 (1972)
23.527 V.G. Martynov, K.S. Aleksandrov, A.T. Anistratov: Fiz. Tverd. Tela **15**, 2922–2926 (1973)
23.528 V.G. Martynov, K.S. Aleksandrov, A.T. Anistratov: Sov. Phys. Solid State **15**, 1950–1952 (1974)
23.529 J. Fousek, C. Konak: Ferroelectrics **12**, 185–187 (1976)
23.530 K. Suzuki, K. Inoue, M. Shibuya: J. Phys. Soc. Jpn. **43**, 1457–1458 (1977)
23.531 M. Eibschütz, H.J. Guggenheim, S.H. Wemple, I. Camlibel, M. DiDomenico Jr.: Phys. Lett. A **29**, 409–410 (1969)
23.532 K. Recker, F. Wallrafen, S. Haussühl: J. Cryst. Growth **26**, 97–100 (1974)
23.533 J.D. Barry, C.J. Kennedy: IEEE J. Quantum Electron. **QE-11**, 575–579 (1975)
23.534 S. Singh, D.A. Draegert, J.E. Geusic: Phys. Rev. B **2**, 2709–2724 (1970)
23.535 A.W. Warner, G.A. Coquin, J.L. Fink: J. Appl. Phys. **40**, 4353 (1969)

23.536 T. Yamada, H. Iwasaki, N. Niizeki: J. Appl. Phys. **41**, 4141–4147 (1970)
23.537 R.O. Vlokh, I.P. Skab: Fiz. Tverd. Tela **34**, 3250–3255 (1992)
23.538 R.O. Vlokh, I.P. Skab: Sov. Phys. Solid State **34**, 1739–1741 (1992)
23.539 J.E. Geusic, H.J. Levinstein, J.J. Rubin, S. Singh, L.G. Van Uitert: Appl. Phys. Lett. **11**, 269–271 (1967)
23.540 J.E. Geusic, H.J. Levinstein, J.J. Rubin, S. Singh, L.G. Van Uitert: Erratum, Appl. Phys. Lett. **12**, 224 (1968)
23.541 S.K. Gupta, H.B. Gon, K.V. Rao: Ferroelectr. Lett. **7**, 15–19 (1987)
23.542 S.K. Gupta, H.B. Gon, K.V. Rao: J. Mater. Sci. Lett. **6**, 4–6 (1987)
23.543 C. Medrano, P. Günter, H. Arend: Phys. Status Solidi **143**, 749–754 (1987)
23.544 A. Carenco, J. Jerphagnon, A. Perigaud: J. Chem. Phys. **66**, 3806–3813 (1977)
23.545 M.Y. Antipin, T.V. Timofeeva, R.D. Clark, V.N. Nesterov, F.M. Dolgushin, J. Wu, A.J. Leyderman: Mater. Chem. **11**, 351–358 (2001)
23.546 C. Bosshard, K. Sutter, P. Günter, G. Chapuis, R.J. Twieg, D. Dobrowolsky: Proc. SPIE **1017**, 207–211 (1988)
23.547 P. Günter, C. Bosshard, K. Sutter, H. Arend, G. Chapuis, R.J. Twieg, D. Dobrowolski: Appl. Phys. Lett. **50**, 486–488 (1987)
23.548 C. Bosshard, K. Sutter, P. Günter: Ferroelectrics **92**, 387–393 (1989)
23.549 K. Sutter, C. Bosshard, M. Ehrensperger, P. Günter, R.J. Twieg: IEEE J. Quantum Electron. **QE-24**, 2362–2366 (1988)
23.550 L.E. Cross, A. Fouskova, S.E. Cummins: Phys. Rev. Lett. **21**, 812–814 (1968)
23.551 C. Scheiding, G. Schmidt, H.D. Kürsten: Krist. Tech. **8**, 311–321 (1973)
23.552 J. Sapriel, R. Vacher: J. Appl. Phys. **48**, 1191–1194 (1977)
23.553 Y.V. Shaldin, D.A. Belogurov, T.M. Prokhortseva: Fiz. Tverd. Tela **15**, 1383–1387 (1973)
23.554 Y.V. Shaldin, D.A. Belogurov, T.M. Prokhortseva: Sov. Phys. Solid State **15**, 936–938 (1973)
23.555 R.C. Miller, W.A. Nordland, K. Nassau: Ferroelectrics **2**, 97–99 (1971)
23.556 M.P. Zaitseva, L.A. Shabanova, B.I. Kidyarov, Y.I. Kokorin, S.I. Burkov: Kristallografiya **28**, 741–744 (1983)
23.557 M.P. Zaitseva, L.A. Shabanova, B.I. Kidyarov, Y.I. Kokorin, S.I. Burkov: Sov. Phys. Crystallogr. **28**, 439–440 (1983)
23.558 A.L. Aleksandrovskii, A.N. Izrailenko, L.N. Razhkovich: Kvantovaya Elektron. **1**, 1261–1264 (1974)
23.559 A.L. Aleksandrovskii, A.N. Izrailenko, L.N. Razhkovich: Sov. J. Quantum Electron. **4**, 699–700 (1974)
23.560 A.L. Aleksandrovskii: Prib. Tekh. Eksp. **1**, 205–206 (1974)
23.561 A.L. Aleksandrovskii: Instrum. Exp. Tech., USSR **17**, 234–235 (1974)
23.562 S. Singh, W.A. Bonner, J.R. Potopowicz, L.G. Van Uitert: Appl. Phys. Lett. **17**, 292–294 (1970)
23.563 F.B. Dunning, F.K. Tittel, R.F. Stebbings: Opt. Commun. **7**, 181 (1973)
23.564 H. Naito, H. Inaba: Optoelectronics **5**, 256 (1973)
23.565 S. Nanamatsu, K. Doi, M. Takahashi: Jpn. J. Appl. Phys. **11**, 816–822 (1972)
23.566 R.C. Miller, W.A. Nordland, E.D. Kolb, W.L. Bond: J. Appl. Phys. **41**, 3008–3011 (1970)
23.567 P.V. Lenzo, E.G. Spencer, J.P. Remeika: Appl. Opt. **4**, 1036–1037 (1965)
23.568 C. Chen, Y. Wu, A. Jiang, B. Wu, G. You, R. Li, S. Lin: J. Opt. Soc. Am. B **6**, 616–621 (1989)
23.569 S.P. Velsko, M. Webb, L. Davis, C. Huang: IEEE J. Quantum Electron. **27**, 2182–2192 (1991)
23.570 K. Kato: IEEE J. Quantum Electron. **QE-30**, 2950–2952 (1994)
23.571 S. Lin, Z. Sun, B. Wu, C. Chen: J. Appl. Phys. **67**, 634 (1990)
23.572 K. Araki, T. Tanaka: Jpn. J. Appl. Phys. **11**, 472–479 (1972)
23.573 J.L. Stevenson: J. Phys. D **6**, L13–L16 (1973)
23.574 B.L. Davydov, L.G. Koreneva, E.A. Lavrovsky: Radiotekh. Elektron. **19**, 1313 (1974)
23.575 B.L. Davydov, L.G. Koreneva, E.A. Lavrovsky: Radio Eng. Electron. Phys. **19**(6), 130 (1974)
23.576 S.K. Kurtz, J. Jerphagnon, M.M. Choy: In: *Elastic, Piezoelectric, Pyroelectric, Piezooptic, Electrooptic Constant, and Nonlinear Dielectric Susceptibilities of Crystals*, Landolt–Börnstein, New Series, Vol. III/11, ed. by K.H. Hellwege (Springer, Berlin, Heidelberg 1979) pp. 671–743
23.577 L.M. Belyaev, G.S. Belikova, A.B. Gilvarg, I.M. Silvestrova: Kristallografiya **14**, 645–651 (1969)
23.578 L.M. Belyaev, G.S. Belikova, A.B. Gilvarg, I.M. Silvestrova: Sov. Phys. Crystallogr. **14**, 544–549 (1970)
23.579 A. Miniewicz, A. Samoc, J. Sworakowski: J. Mol. Electron. **4**, 25–29 (1988)
23.580 M.S. Khan, T.S. Narasimhamurty: J. Mater. Sci. Lett. **1**, 268–270 (1982)
23.581 G.S. Belyaev, G.S. Belikova, A.G. Gilvarg, M.P. Golovei, I.N. Kalinkina, G.I. Kosourov: Opt. Spectrosc. **29**, 522 (1970)
23.582 Y. Uematsu, T. Fukuda: Jpn. J. Appl. Phys. **12**, 841–844 (1973)
23.583 E. Wiesendanger: Ferroelectrics **6**, 263–281 (1974)
23.584 P. Günter: Jpn. J. Appl. Phys. **16**, 1727–1728 (1977)
23.585 M. Zgonik, R. Schlesser, I. Biaggio, I. Voit, J. Tscherry, P. Günter: J. Appl. Phys. **74**, 1287–1297 (1993)
23.586 D.H. Jundt, P. Günter, B. Zysset: Nonlinear Opt. **4**, 341–345 (1993)
23.587 B. Zysset, I. Biaggio, P. Günter: J. Opt. Soc. Am. B **9**, 380–386 (1992)
23.588 Y. Uematsu: Jpn. J. Appl. Phys. **13**, 1362–1368 (1974)
23.589 W.R. Cook Jr., H. Jaffe: Acta Crystallogr. **10**, 705–707 (1957)
23.590 T. Krajewski, Z. Tylczynski, T. Breczewski: Acta Phys. Polonica A **47**, 455–466 (1975)
23.591 J.A. Paisner, M.L. Spaeth, D.C. Gerstenberger, I.W. Ruderman: Appl. Phys. Lett. **32**, 476–478 (1978)

23.592 W.R. Cook, L.H. Hubby Jr.: J. Opt. Soc. Am. **66**, 72 (1976)
23.593 F.B. Dunning, R.G. Stickel Jr.: Appl. Opt. **15**, 3131 (1976)
23.594 H.J. Dewey: IEEE J. Quantum Electron. **QE-12**, 303 (1976)
23.595 Y. Wu, C. Chen: Wuli Xuebao (Acta Phys. Sin.) **35**, 1–6 (1986)
23.596 J.D. Bierlein, H. Vanherzeele, A.A. Ballman: Appl. Phys. Lett. **54**, 783–785 (1989)
23.597 J.D. Bierlein, H. Vanherzeele, A.A. Ballman: Erratum, Appl. Phys. Lett. **61**, 3193 (1992)
23.598 A.H. Kung: Appl. Phys. Lett. **65**, 1082–1084 (1994)
23.599 D.L. Fenimore, K.L. Schepler, U.B. Ramabadran, S.R. McPherson: J. Opt. Soc. Am. B **12**, 794–796 (1995)
23.600 L.T. Cheng, L.K. Cheng, J.D. Bierlein, F.C. Zumsteg: Appl. Phys. Lett. **63**, 2618–2620 (1993)
23.601 L.K. Cheng, L.T. Cheng, J. Galperin, P.A.M. Hotsenpiller, J.D. Bierlein: J. Cryst. Growth **137**, 107–115 (1994)
23.602 K. Kato: IEEE J. Quantum Electron. **QE-30**, 881–883 (1994)
23.603 J.D. Bierlein, H. Vanherzeele: J. Opt. Soc. Am. B **6**, 622–633 (1989)
23.604 J.D. Bierlein, C.B. Arweiler: Appl. Phys. Lett. **49**, 917–919 (1986)
23.605 V.V. Aleksandrov, T.S. Velichkina, V.I. Voronkova, L.V. Koltsova, I.A. Yakovlev, V.K. Yanovskii: Solid State Commun. **69**, 877 (1989)
23.606 A.C. Aleksandrovsky, S.A. Akhmanov, V.A. Dyakov, N.I. Zheludev, V.I. Pryalkyn: Kvantovaya Elektron. **12**, 1333 (1985)
23.607 A.C. Aleksandrovsky, S.A. Akhmanov, V.A. Dyakov, N.I. Zheludev, V.I. Pryalkyn: Sov. J. Quantum Electron. **15**, 885 (1985)
23.608 W. Wiechmann, S. Kubota, T. Fukui, H. Masuda: Opt. Lett. **18**, 1208–1210 (1993)
23.609 K. Kato: IEEE J. Quantum Electron. **QE-27**, 1137–1140 (1991)
23.610 V.K. Yanovskii, V.I. Voronkova, A.P. Leonov, S.Y. Stefanovich: Fiz. Tverd. Tela **27**, 2516–2517 (1985)
23.611 V.K. Yanovskii, V.I. Voronkova, A.P. Leonov, S.Y. Stefanovich: Sov. Phys. Solid State **27**, 1508–1509 (1985)
23.612 V.K. Yanovskii, V.I. Voronkova: Phys. Status Solidi (a) **93**, 665–668 (1980)
23.613 J.Y. Wang, Y.G. Liu, J.Q. Wei, L.P. Shi, M. Wang: Z. Kristallogr. **191**, 231–238 (1990)
23.614 J.Y. Wang, Y.G. Liu, J.Q. Wei, L.P. Shi, M. Wang: Guisuanyan Xuebao **18**, 165–170 (1990)
23.615 J.Y. Wang, Y.G. Liu, J.Q. Wei, L.P. Shi, M. Wang: Chem. Abstr. **114** (1991)
23.616 F.C. Zumsteg, J.D.D. Bierlein, T.E. Gier: J. Appl. Phys. **47**, 4980 (1976)
23.617 Y.S. Oseledchik, A.I. Pisarevsky, A.L. Prosvirin, V.N. Lopatko, L.E. Kholodenkov, E.F. Titkov, A.A. Demidovich, A.P. Shkadarevich: *Proc. Laser Opt. Conf* (Leningrad Univ. Press, Leningrad 1990)
23.618 E. Nakamura: J. Phys. Soc. Jpn. **17**, 961–966 (1962)
23.619 K. Hamano, K. Negishi, M. Marutake, S. Nomura: Jpn. J. Appl. Phys. **2**, 83–90 (1963)
23.620 H. Shimizu, M. Tsukamoto, Y. Ishibashi, Y. Takagi: J. Phys. Soc. Jpn. **38**, 195–201 (1975)
23.621 G. Hauret, J.P. Chapelle, L. Taurel: Phys. Status Solidi (a) **11**, 255–261 (1972)
23.622 A.R. Johnston, T. Nakamura: J. Appl. Phys. **40**, 3656–3658 (1969)
23.623 K. Iio: J. Phys. Soc. Jpn. **34**, 138 (1973)
23.624 D.S. Chemla, E. Batifol, R.L. Byer, R.L. Herbst: Opt. Commun. **11**, 57 (1974)
23.625 K. Inoue, T. Ishidate: Ferroelectrics **7**, 105–106 (1974)
23.626 B. Teng, J. Wang, Z. Wang, H. Jiang, X. Hu, R. Song, H. Liu, Y. Liu, J. Wei, Z. Shao: J. Cryst. Growth **224**, 280–283 (2001)
23.627 H. Hellwig, J. Liebertz, L. Bohaty: J. Appl. Phys. **88**, 240 (2000)
23.628 Z. Lin, Z. Wang, C. Chen, M.-H. Lee: J. Appl. Phys. **90**, 5585 (2001)
23.629 D. Eimerl, S. Velsko, L. Davis, F. Wang, G. Loiacono, G. Kennedy: IEEE J. Quantum Electron. **QE-25**, 179–193 (1989)
23.630 C.E. Barker, D. Eimerl, S.P. Velsko: J. Opt. Soc. Am. B **8**, 2481–2492 (1991)
23.631 P. Kerkoc, M. Zgonik, K. Sutter, C. Bosshard, P. Günter: J. Opt. Soc. Am. B **7**, 313–319 (1990)
23.632 I. Biaggio, P. Kerkoc, L.-S. Wu, P. Günter, B. Zysset: J. Opt. Soc. Am. B **9**, 507–517 (1992)
23.633 R. Bechmann: *Elastic, Piezoelectric, Piezooptic and Electrooptic Constants of Crystals*, Landolt–Börnstein, New Series, Vol. III/1 (Springer, Berlin, Heidelberg 1966) pp. 40–123
23.634 M.V. Hobden: J. Appl. Phys. **38**, 4365 (1967)
23.635 A. Sonin, A.A. Filimonov, S.V. Suvorov: Sov. Phys. Solid State **10**, 1481 (1968)
23.636 B.M. Suleiman, A. Lundén, E. Karawacki: Solid State Ion. **136/137**, 325–330 (2000)
23.637 C.S. Brown, R.C. Kell, R. Taylor, L.A. Thomas: Proc. IEE Part B: Electron. Comm. Eng. **109**, 99–114 (1962)
23.638 C.S. Brown, R.C. Kell, R. Taylor, L.A. Thomas: IRE Trans. Compon. Parts **9**, 193–211 (1962)
23.639 L. Bohaty, S. Haussühl, G. Nohl: Z. Kristallogr. **139**, 33–38 (1974)
23.640 W.F. Holman: Ann. Phys. **29**, 160–178 (1909)
23.641 J.M. Halbout, C.L. Tang: IEEE J. Quantum Electron. **QE-18**, 410–415 (1982)
23.642 M.J. Rosker, C.L. Tang: IEEE J. Quantum Electron. **20**, 334 (1984)
23.643 G. Brosowki, G. Luther, H.E. Muser: Phys. Status Solidi (a) **14**, K15–K17 (1972)
23.644 P.P. Craig: Phys. Lett. **20**, 140–142 (1966)
23.645 F. Jona, G. Shirane: *Ferroelectric Crystals* (MacMillan, New York 1962)
23.646 V.P. Konstantinova, I.M. Silvestrova, K.S. Aleksandrov: Kristallografiya **4**, 69–73 (1959)
23.647 V.P. Konstantinova, I.M. Silvestrova, K.S. Aleksandrov: Sov. Phys. Crystallogr. **4**, 63–67 (1960)
23.648 S. Haussühl, J. Albers: Ferroelectrics **15**, 73 (1977)
23.649 B.A. Strukov, K.A. Minaeva: Prib. Tekh. Eksp. **29**, 157–160 (1986)

23.650 B.A. Strukov, K.A. Minaeva: Instrum. Exp. Tech. (USSR) Part II **29**, 1413–1416 (1986)
23.651 J. Berdowski, A. Opilski, J. Szuber: J. Tech. Phys. (Poland) **18**, 211–217 (1977)
23.652 N.R. Ivanov, S.Y. Benderskii, L.A. Shuvalov: Kristallografiya **22**, 115–125 (1977)
23.653 N.R. Ivanov, S.Y. Benderskii, L.A. Shuvalov: Sov. Phys. Crystallogr. **22**, 64–69 (1977)
23.654 N.R. Ivanov, L.A. Shuvalov: Kristallografiya **11**, 760–765 (1966)
23.655 N.R. Ivanov, L.A. Shuvalov: Sov. Phys. Crystallogr. **11**, 648–651 (1967)
23.656 A.S. Sonin, V.S. Suvorov: Sov. Phys. Solid State **9**, 1437 (1967)