Single Crystal Products

SHINKOSHA

since 1947

Products

Shinkosha develops and manufactures hight-performanced single-crystal for optics and various fields with technologies based on its long experience and state of the art appliances.

Alumina single-crystals

- White sapphire single-crystals (Al_2O_3)
- Ruby single-crystals ($Cr:Al_2O_3$)

High-function substrates

- Sapphire single-crystals (Al_2O_3)
- Strontium titanate single-crystals ($SrTiO_3$)
- Lanthanum strontium aluminum tantalate single-crystals $(LaAlO_3)_{0.3}$ - $(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ [Abbreviation LSAT]
- Lanthanum aluminate single-crystals ($LaAlO_3$)
- Magnesia single-crystals (MgO)
- Neodymium gallate single-crystals ($NdGaO_3$)
- Spinel single-crystals ($MgAl_2O_4$)
- Yttria stabilized zirconia single-crystals ($Y:ZrO_2$) [Abbreviation: YSZ]
- Titania (rutile) single-crystals (TiO_2)

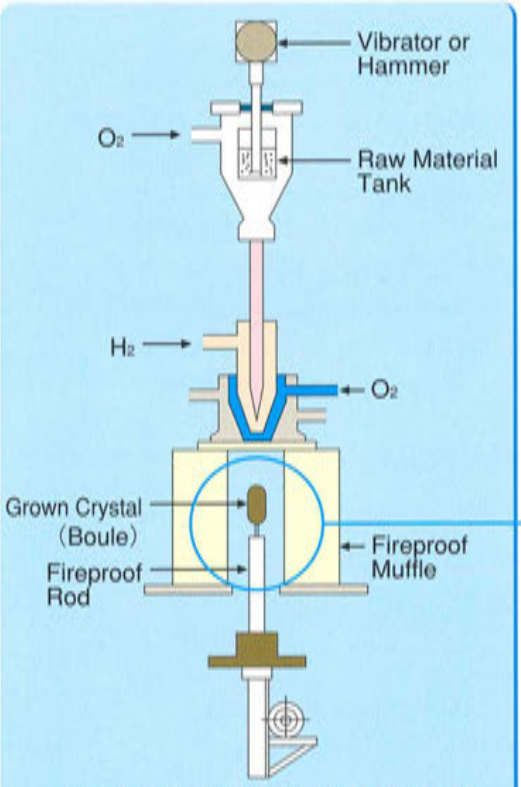
Optical crystals

- Rutile single-crystals (TiO_2)

We provide crystal growth and precision processing services for special single-crystals.

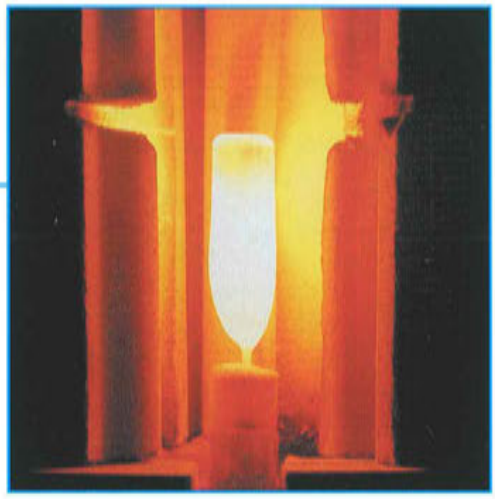
Introducing single-crystal production methods

Verneuil method (Flame fusion method)

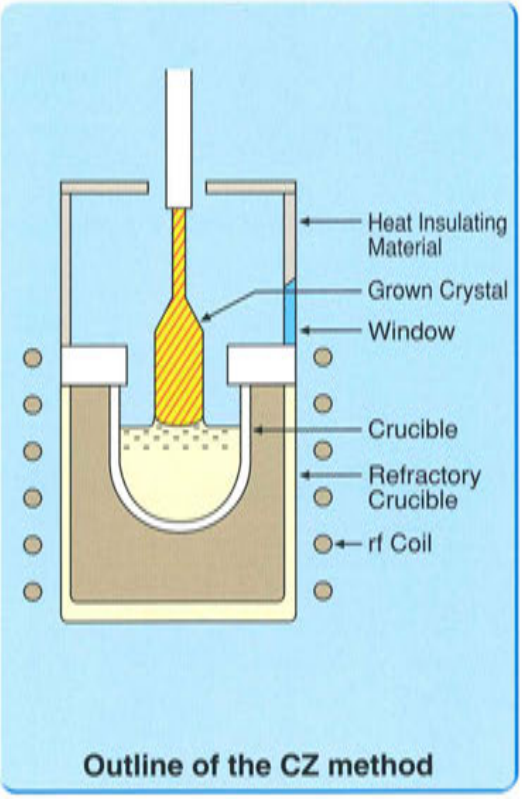


Outline of the Verneuil method

Raw material powder is passed through a oxygen-hydrogen flame (about 2,800 degrees C) and melt down. The drips of molten materials are accumulated on a seed crystal and grow into a boule. This method makes it easy to produce crystals in a relatively short time. Since no crucible is used, the crystals have high purity.



CZ method (Czochralski method)



Outline of the CZ method

Materials are molten in a crucible.
A seed crystal is put on the surface of molten materials in a crucible, and pulled up with rotation to grow. The major heating method is high-frequency induction heating or resistance heating. The CZ method is suitable for growing large and high-quality crystals.

Features of alumina single-crystals

Sapphire and Ruby are high-purity alumina (Al_2O_3) single-crystals with excellent resistance to abrasion, heat, and chemicals, as well as high thermal conductivity and insulating functions. They allow a wide range of wavelength, to pass through, from infrared to near-ultraviolet, and are used in a variety of applications including electronic and optical components.

Characteristics

Chemical composition : Al_2O_3 (Sapphire) / Cr: Al_2O_3 (Ruby)

Crystal systems : Rhombohedreal systems ($R\bar{3}c$) (Generally handled as hexagonal crystals)

Lattice constant* : a=0.47588nm c=1.2992nm

Density* : 3.987g/cm^3

Melting point* : 2,040℃ (*JCPDS No. 42-1468)

Thermal conductivity : 42W/m·K (25℃)
25W/m·K (100℃)

Specific heat : 0.75kJ/kg·℃ (25℃)

Thermal expansion coefficient : 〈⊥C axis〉
6.9×10^{-6}/℃ (200℃)
8.9×10^{-6}/℃ (1000℃)
〈//c axis〉
7.6×10^{-6}/℃ (200℃)
10.0×10^{-6}/℃ (1000℃)

Chemical resistance (dissolved weight) : (A sapphire specimen (□25×0.5t) was put in a solution for 6 days)
No change in weight (△=0g)
HCl (35%, 20℃)
HNO_3 (50%, 20℃)
H_3PO_4 (60%, 100℃)
H_2SO_4 (95%, 100℃)
NaOH (30%, 100℃)
Micro change in weight
HF (46%, 60℃) (△=0.0038g/day)

Transmittance : See Fig. 1

Refractive index : n_o=1.768, n_e=1.760 (λ=590m)

Dielectric constant : 9.41 (//c-axis, 30GHz)

Dielectric loss resistivity : 3×10^{-6} (//c-axis, 30GHz)

Resistivity : 10^{14}Ωcm (25℃)
10^{11}Ωcm (500℃)
10^{8}Ωcm (1000℃)
10^{4}Ωcm (1500℃)

Threshold voltage : 480 kV/cm (60Hz)

Hardness : 〈Mohs〉 9 (*Dianond=10, Quartz=7)
〈Vickers〉 1400~2300 (e.g. : a-plane 1750)

Young's modulus : 425GPa (⊥c)
460GPa (//c)

Poisson ratio : 0.30 (⊥c/⊥c)
0.16 (//c/⊥c)
0.18 (⊥c///c)

Bending strength : 320~930MPa

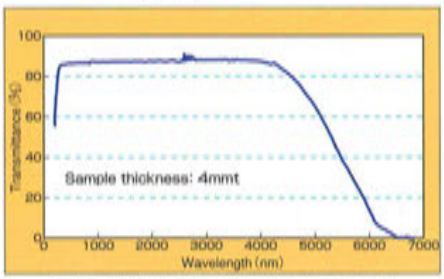


Fig. 1 Transmittance diagram of sapphire

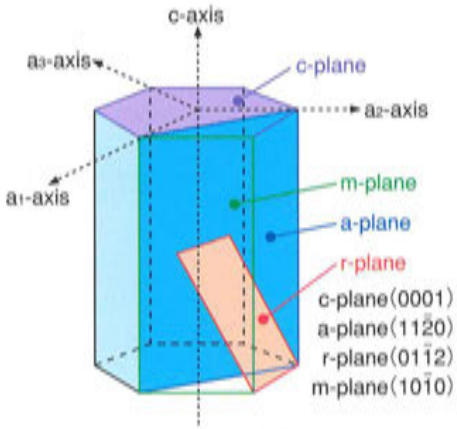


Fig. 2 Plane orientation drawing of sapphire

Applications of alumina single-crystals

1.Sapphire substrates

Precision-polished substrates of sapphire single-crystals are used in a wide range of applications: blue LED and LD devices, SAW (surface acoustic wave) devices, and SOS (silicon-on-sapphire) wafers which are alternative to SOI (silicon insulators) for semiconductors in high-reliability equipments.

2.Sapphire laser caps

A laser cap is a window material for airtight packages, which protects semiconductor laser devices from degradation. Sapphire laser caps are used in systems that need high reliability, including submarine optical communications systems. Shinkosha's laser caps have very excellent polished surface precision. We accept orders for special or demanding specifications, too.

3.Alumina single-crystal evaporation material

Alumina single-crystal evaporation material is for forming evaporated films. This material is useful, when a high-quality evaporated film is required, beacuse of its high purity and small amount of gas generation. For this reason, this material is optimal for evaporation coating of semiconductor parts.

4.Alumina single-crystal polisher (Product name: S-Powder)

S-Powder is high-purity alumina powder. The micro particles have an even grain size, and are free of sharp edges, unlike fused alumina polishers. S-Powder is used for ultra-precision finishing of metal products, polishing of lenses and semiconductors, and as chemical catalyst carriers.

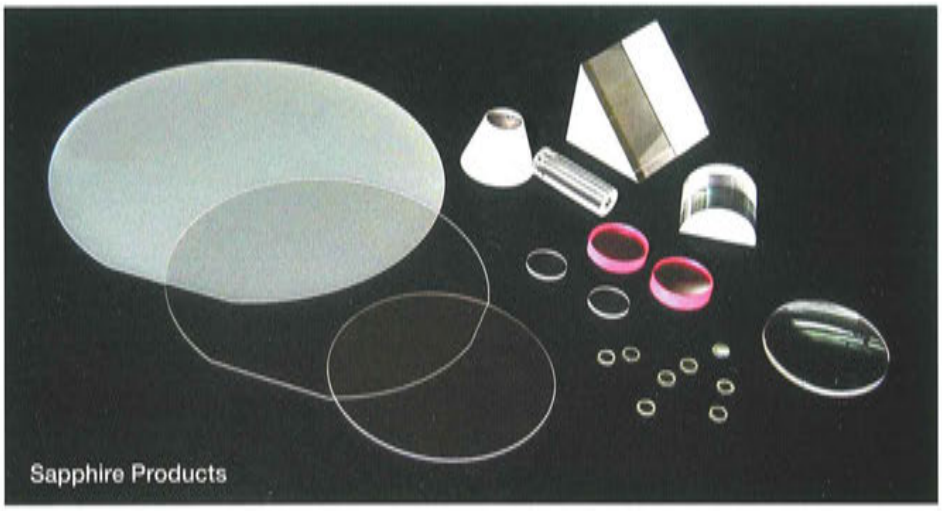
5.Windows for watches

Alumina single-crystal is used as window materials for watches because of its scratch resistance owing to its high hardness.

6.Others

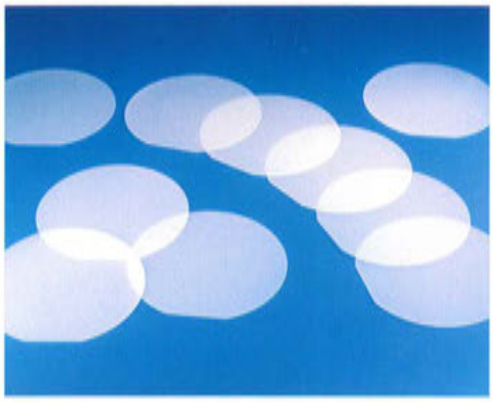
Analytic sapphire cells / endoscope glasses for medical use / ultra-microtomes for medical use / erythrocyte measurement disks / sight glasses for high-temperature, pressure furnaces / sight glasses for semiconductor production equipment / sight glasses for vacuum containers / xenon lamp windows / cooling plates for LCD projectors / infrared transmittance windows (gas sensors and fire sensors) / coin sensors / mode selectors / ruby plungers / magnetic tape cleaners / insulator plates / thermocouple protector plates / optical R-processed prisms / ball lenses / sapphire tubes / spinning guides / bearing jewels, etc.

Upon customers' request, we accept orders for special and consigned processing of various single- and poly-crystals.



Sapphire Products

Features of high-function substrates



Shinkosha supplies oxide single-crystal substarates that are suitable for epitaxial growth of superconductors, compound semiconductors, and dielectrics. Please choose the best substrate material for your requirements - the crystal type, lattice constant and dielectric constant. With high-precision processing technologies, we ensure the high quality of finished substrate surfaces. We can also provide specific substrates by combining standard specifications with a variety of options.

Characteristics

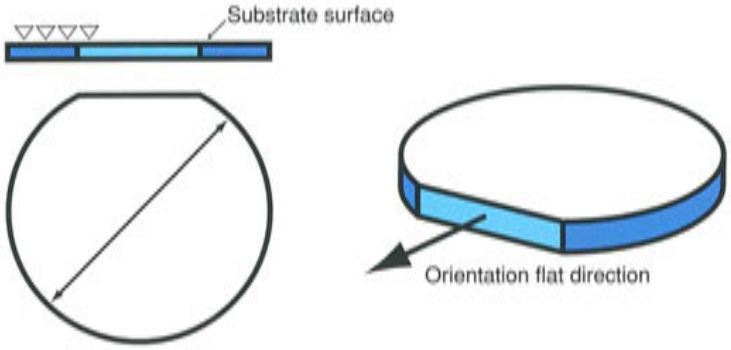
Crystal names	Structural lattice constant (Å) ※Å = 0.1 nm	Fusing point (℃)	Dielectric constant (300K,1MHz)	Specific gravity (g/cm³)	Thermal expansion coefficient (10^{-6}/℃)	Remarks on applications	Standard substrate surface	Maximun shape	Applications
Al_2O_3 (Sapphire)	Trigonal a=4.7588 c=12.992	2040	9.41 (30GHz)	3.99	7.5	GaN substrates SAW devices	(0001) (11$\bar{2}$0) (01$\bar{1}$2)	φ101.6	GaN SAW devices
$MgAl_2O_4$ (Spinel)	Cubic a=8.086	2130	8～9	3.61	7.8	GaN substrates	(111) (100)	φ50.8	GaN
$(LaAlO_3)_{0.3}$-$(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT)	Cubic a=7.736	1840	22	6.79	10	Superconductor substrates	(100)	φ50.8	Superconductivity
$LaAlO_3$ (LAO)	Rhombohedreal a=5.365 c=13.11	2100	15～22	6.52	12.6	Superconductor substrates →Cubic crystal (>530k)	(100)	φ50.8	Superconductivity →Cubic (>420℃)
$NdGaO_3$ (NGO)	Orthorhombic a=5.431 b=5.499 c=7.710	1650	20～25	7.56	10	Superconductor substrates	(100) (001)	φ50.8	Superconductivity
$SrTiO_3$ (STO)	Cubic a=3.905	2080	310	11.1	11.1	Superconductor substrates →Cubic crystal (<110k)	(100) (110) (111)	20×20	Superconductivity →Tetragonal (<110k)
MgO	Cubic a=4.213	2800	10	3.59	13.5	Superconductor substrates	(100)	φ50.8	Superconductivity
Y:ZrO_2 (YSZ)	Cubic a=5.139	2500	27	6.05	10.3	Superconductor substrates Y≒10%	(100) (111)	φ50.8	Superconductivity Y_2O_3≒10mol%
TiO_2 (Rutile)	Tetragonal a=4.594 c=2.958	1840	113 (1KHz)	4.25	9.2	Photocatalyst prism polarizers	(100) (110) (001)	20×20	Light catalytic prisms Polarizers

Standard specifications of high-function substrates

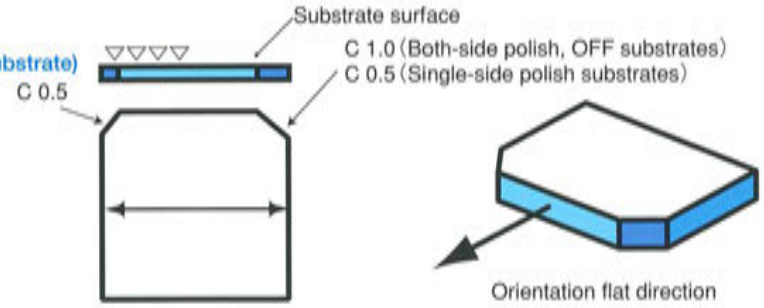
Standard shape : (depends on material)
- 10×10×0.5mm t
- 15×15×0.5mm t
- ϕ50.8×0.5mm t
- ϕ50.8×0.33mm t, others

Standard outline tolerance: ±0.10 mm or more
Standard thichness tolerance: ±0.05 mm
Crystal axis tolerance: ±0.5°
Orientation flat surface tolerance: ±1°
Polishing: Single- and double-side polishing

(Circular substrate)

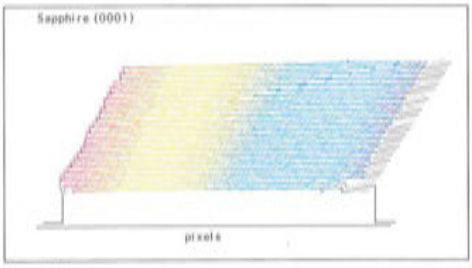


(Rectangular substrate)

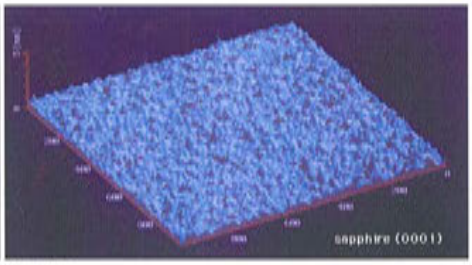


Flatness: 10λ～λ/10 (λ=632.8 nm)
*Depends on substrate size and material.

Surface roughness: (Guaranteed value) Ra ≦ 1.0 nm, Rmax ≦5.0 nm
(Typical value) Ra ≦ 0.2 nm, Rmax ≦1.0 nm
(*Measurement range: 1 μm²)



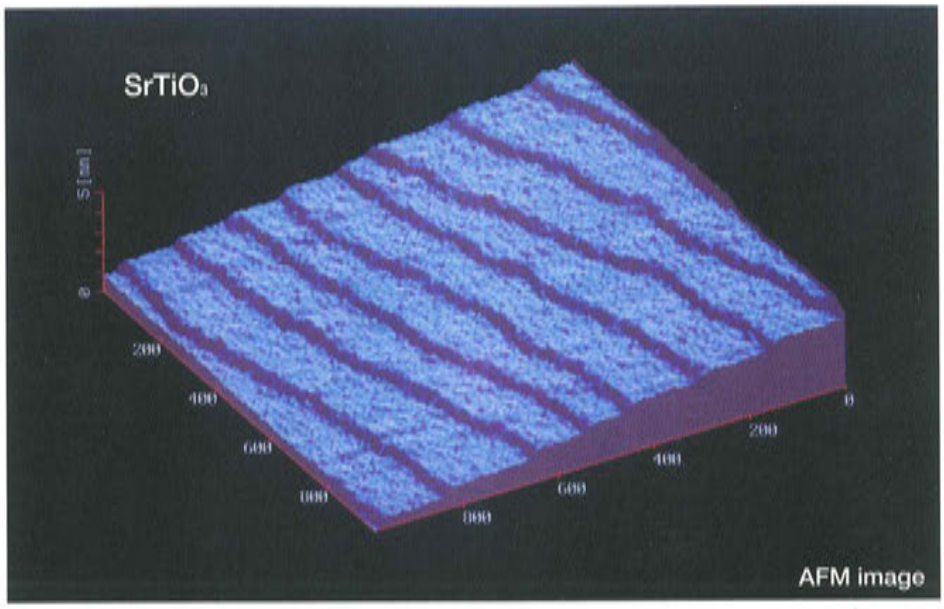
Sapphire
Microscopic image of 10×10×0.5t substrate
laser interference



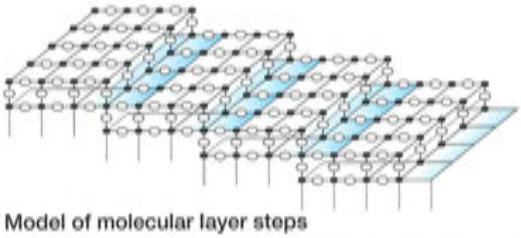
Sapphire
AFM (atomic force microscope) photo of
substrate surface

Special specifications

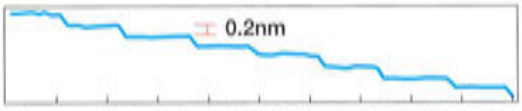
SPECIAL SPECIFICATIONS Molecular layer STEP substrates



The surface of a STEP substrate is composed of molecular layer steps and atomic level flat terraces. For Perovskite-type crystals, outmost atomic layers have a uniform site in either A or B with high cleanliness.



Model of molecular layer steps



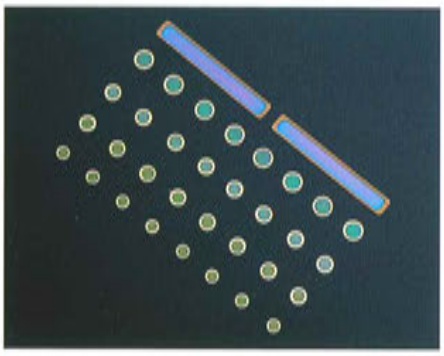
Cross-section profile of sapphire c-plane molecular layer step substrates

RHEED pattern
(parallel incidence of steps)

Types	Orientation	Crystal axis precision (degrees)	Size (mm)	Roughness on terrace surface Ra (nm)	Step height (nm)
Al_2O_3	(0001) $(11\bar{2}0)$ $(01\bar{1}2)$	≦0.5	≦ϕ101.6	≦0.05	0.21 0.25 0.35
$LaAlO_3$	(100)		≦ϕ50.8		0.4
$SrTiO_3$	(100)		≦ϕ20		0.4

Sapphire laser caps

- Optimal strength for high-reliable component (five times stronger than glass).
- No deterioration caused by high power laser output.
- Excellent radiation performance (thermal conductivity) by 40 times of glass.
- No variation in extincton ratio by strict control of c-axis.
- Specially shaped items are available including box-shaped windows and tapered types.
- High transmission by superb AR coating.
- High airtightness and strength by superb metalization coating.
- Available to join with the Kovar ring.



Sapphire laser cap

Sapphire axis specification

C:C-axis
A:Random

Diameter Thickness

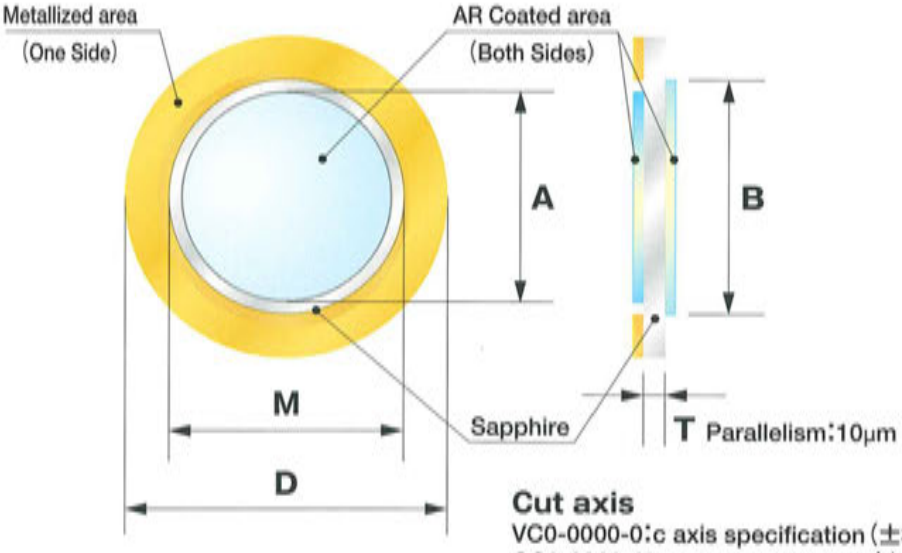
V C D – 36 30 – W

Method
V:Verneuil
C:CZ

Type of Metalization
D:Thin film (Cr-Ni-Au)
M:Mo/Mn Metalization (Mo/Mn-Ni-Au)
N:No coating

AR coating regulations

W :	1270~1650nm	T>98%
C :	1520~1610nm	T>99%
P :	980±30nm 1480±30nm	T>99%
A :	980±30nm	T>99%
S :	1450~1520nm	T>99%



Cut axis
VC0-0000-0:c axis specification (±3°)
CC0-0000-0:c axis specification (±1°)

For your reference

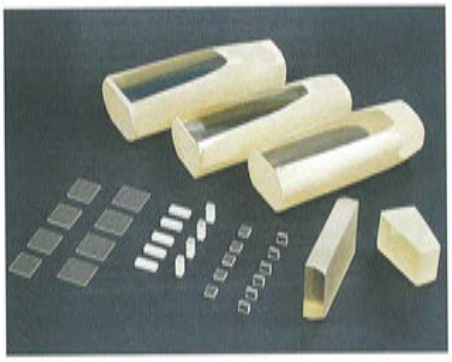
(Unit:mm)

Unit No.	OD (D)	Thickness (T)	Metalized ID (M)	AR OD (A)	AR OD (B)
2828	ϕ2.8±0.05	0.28±0.05	ϕ2.0±0.15	ϕ1.70±0.1	ϕ2.2±0.1
3328	ϕ3.3±0.05	0.28±0.05	ϕ2.3±0.15	ϕ2.00±0.1	ϕ2.5±0.1
3528	ϕ3.5±0.05	0.28±0.05	ϕ2.5±0.15	ϕ2.25±0.1	ϕ2.8±0.1
3628	ϕ3.6±0.05	0.28±0.05	ϕ2.5±0.15	ϕ2.25±0.1	ϕ2.8±0.1
3630	ϕ3.6±0.05	0.30±0.05	ϕ2.5±0.15	ϕ2.25±0.1	ϕ2.8±0.1
4228	ϕ4.2±0.05	0.28±0.05	ϕ3.3±0.15	ϕ3.00±0.1	ϕ3.4±0.1

Optical crystals

Features of rutile single-crystals

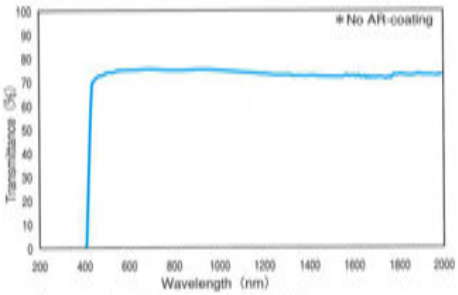
Rutile single-crystals have a large refractive index and high birefringence, and are therefore suitable for optical applications including polarizers and polarizing prisms. The rutile single-crystals also exhibit high thermal and chemical stability. We produce and process high-quality rutile single-crystals with few crystal defects. We meet customers' demands for a wide range of rutile single-crystal applications, including AR coating, specific products and large products.



[Rutile features]

- Crystal system : Tetragonal system
- Lattice constant : a=4.594 Å
  c=2.958 Å
  *Å= 0.1 nm
- Density : 4.26 g/cm^3
- Fusing point : 1840 ℃
- Hardness (Mohs) : 6.5

●Transmittance



(AR coating)
- Refractive index : 0.2% @Central wavelength ±30nm
- Wavelength range : 900 ~ 1700nm

●Birefringence

Rutile refractive index

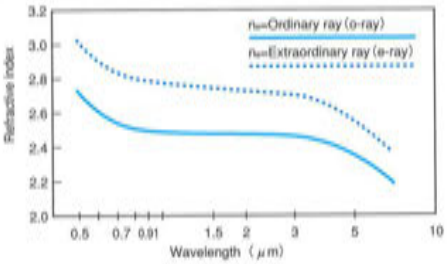
Approximate polynomial n=Wavelength (nm)

$$n=\sqrt{A_0+A_1\lambda^4+A_2\lambda^2+\frac{A_3}{\lambda^2}+\frac{A_4}{\lambda^4}+\frac{A_5}{\lambda^6}+\frac{A_6}{\lambda^8}}$$

Coefficient value

	ne	no
A_0	7.240917153	5.961140419
A_1	$2.939424513\times10^{-16}$	$1.203698909\times10^{-16}$
A_2	$-4.766577824\times10^{-8}$	$-3.594107718\times10^{-8}$
A_3	2.777526495×10^{8}	2.171927231×10^{8}
A_4	7.624599633×10^{16}	4.144448919×10^{16}
A_5	$-2.490420866\times10^{-29}$	$-1.117658287\times10^{-29}$
A_6	5.446360975×10^{21}	2.631172261×10^{21}

●Refractive index



●Comparison with other crystals

		TiO_2	YVO_4	$LiNbO_3$
Thermal expansion coefficient (/℃)	c-axis	9.19×10^{-6}	11.37×10^{-6}	16.7×10^{-6}
	a-axis	7.14×10^{-6}	4.43×10^{-6}	7.0×10^{-6}
Refractive index @1.55μm	no	2.444	1.938	2.219
	ne	2.694	2.138	2.140
Birefringence @1.55μm		0.250	0.200	0.079
Hardness in mohs		6.5	5	5

SHINKOSHA

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