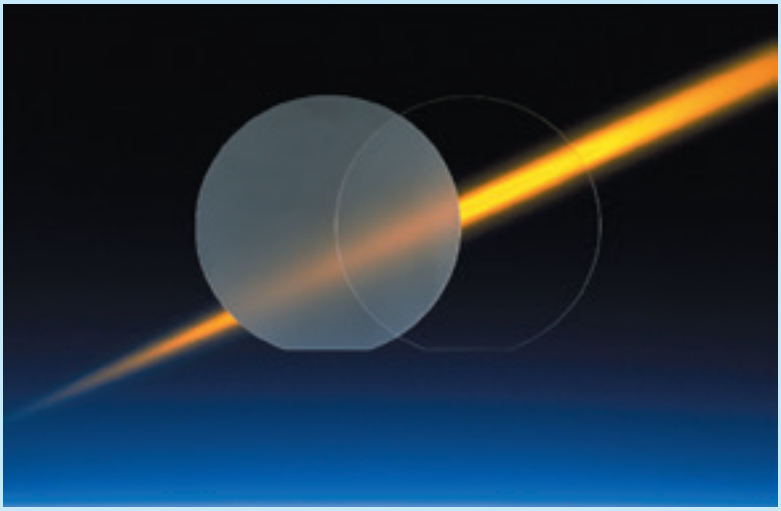
THE NEW VALUE FRONTIER

KYOCERA



SINGLE CRYSTAL SAPPHIRE

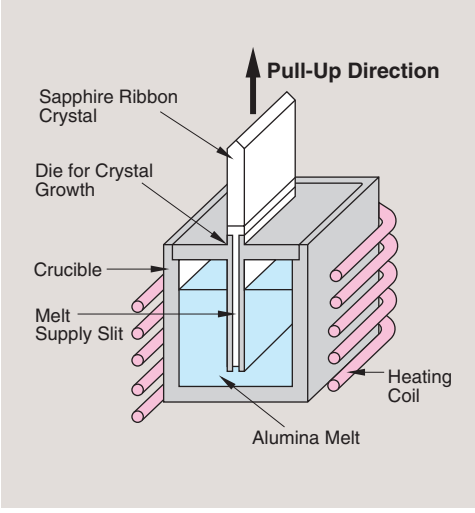
SINGLE CRYSTAL SAPPHIRE

Single Crystal Sapphire is playing an ever-increasingly important role as a material for, high reliablility Electronics today due to its excellent mechanical characteristics, chemical stability and light transmission.

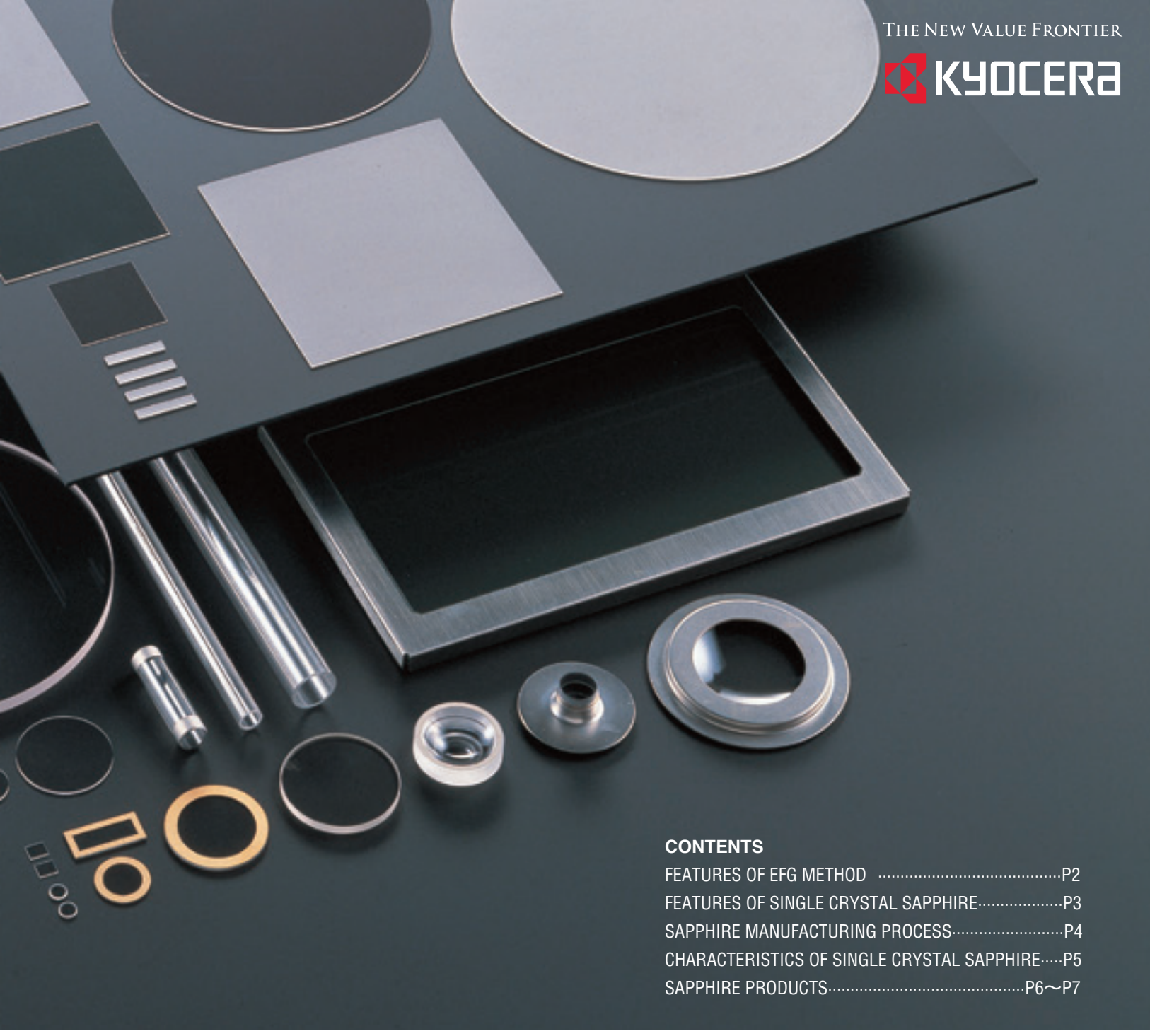
Kyocera mass-produces Single Crystal Sapphire in a vertically integrated manner. From "pulling up" the raw material with EFG (Edge-Defined Film-Fed Growth) methods to machining, Kyocera produces and supplies various products with large diameters or specific shape requirements.

FEATURES OF EFG METHOD

- **Large Size Material**
  Sizing-up of materials allows for a broader range of applications and uses.
- **Production of Single Crystal Sapphire in Any Desired Sectional Shape**
  Since any desired sectional shape can be obtained in the form of ribbons, tubes, rods, and others, cutting processes can be eliminated, allowing for a reduction in cost.
- **Control of Crystal Orientation**
  Any axis and plane can be produced by instituting proper control during crystal growth.



EFG Method



THE NEW VALUE FRONTIER

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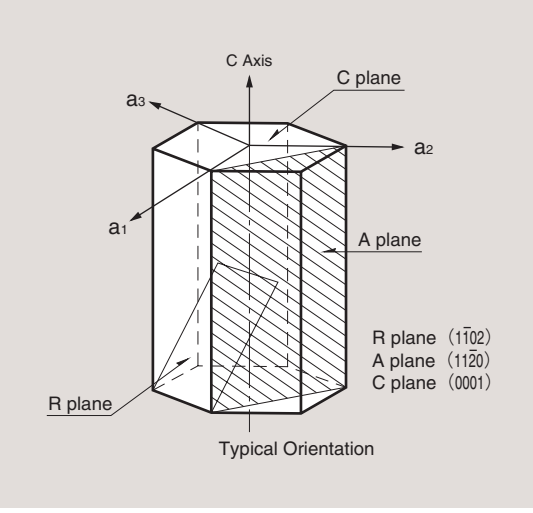
CONTENTS



Unit Cell of Sapphire

FEATURES OF SINGLE CRYSTAL SAPPHIRE

- **High Strength, High Rigidity, High Anti-Abrasion, High Anti-Heat, High Anti-Corrosion Characteristics, and High Anti-Plasma Characteristics.**
  Because of these characteristics, Single Crystal Sapphire is widely used for precision mechanical parts.
- **Stable Dielectric Constant, Very Low Dielectric Loss, Good Electrical Insulation**
  Single Crystal Sapphire is used as a material for substrates in super-high frequency regions. It is also used as an insulation material and microwave window. Single Crystal Sapphire has become indispensable in the Electronics Industries.
- **Excellent Light Transmission**
  Single Crystal Sapphire is used for various kinds of vacuum equipment, windows in reaction furnace, scanner windows and caps for optical communication due to its excellent mechanical characteristics and heat resistance.
- **Good Thermal Conductivity and High Heat Resistance**
  Excellent thermal conductivity at low temperatures allows Single Crystal Sapphire as a transparent material to be used in many diverse fields requiring thermal conduction and heat radiation.

SAPPHIRE MANUFACTURING PROCESS

Sapphire Manufacturing Process

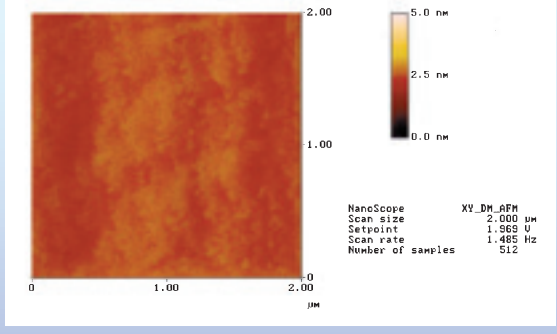
Growth of Raw Material

Grinding

Lapping

Polishing

(Ra:≦1Å)

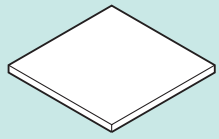


Shape and Specifications

(unit: mm)

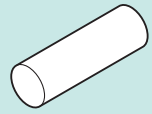
Substrate

Dimensions	Crystal Orientation
Width 200max.	R plane ±2deg
Leugth 300max.	A plane ±2deg
Thickness0.1~20	C plane ±2deg



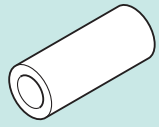
Rod

Dimensions	Crystal Orientation
Diameter 0.5~20	C Axis in
Length 1,000max.	Longitudinal
	Direction



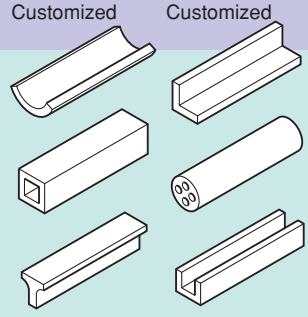
Tube

Dimensions	Crystal Orientation
Inner Diameter 1.3~50	C Axis in
Tube Thickness 0.25~5	Longitudinal
Length:1,000mm max.	Direction



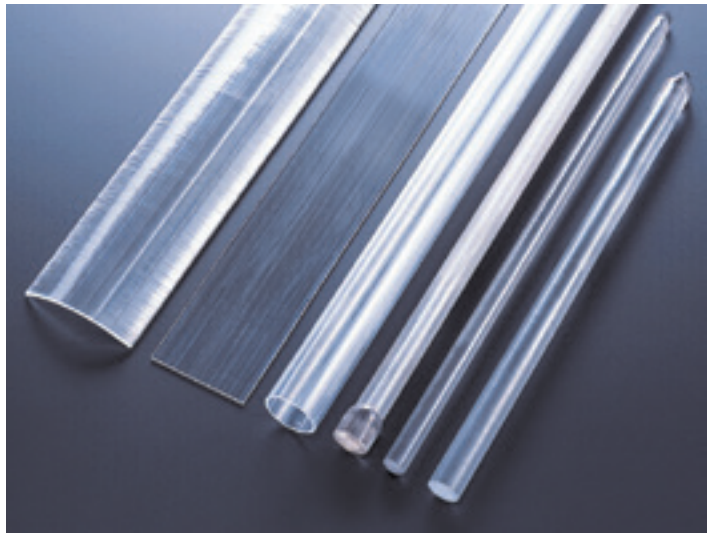
Others

Dimensions	Crystal Orientation
To be Customized	To be Customized



※Shapes other than above are available.

As-Grown Materials



CHARACTERISTICS OF SINGLE CRYSTAL SAPPHIRE

Characteristics of Kyocera's Single Crystal Sapphire

Mechanical Characteristics	Crystallographic Structure	Hexagonal System a=4.763Å c=13.003Å Rhombohedral Single crystal
	Reference Density	3.97×10^3kg/m^3
	Vickers Hardness	22.5GPa (HV1 (Load=9.807N))
	Flexural Strength	690MPa
	Tensile Strength	2250MPa (Diameter0.25mm Filament 25℃)
	Compressive Strength	2,940MPa
	Young's Modulus	470GPa
	Poisson's Ratio	0.18~0.29
Thermal Characteristics	Melting Point	2,053℃
	Coefficient of Linear Thermal Expansion	40~400℃ C parallel to Caxis 7.7×10^{-6}/℃ 40~400℃ C perpendicular to Caxis 7.0×10^{-6}/℃
	Thermal Conductivity	20℃ 42W/(m·k)
	Specific Heat	0.75×10^3J/(kg·K)
	Emittance	<0.02 (λ=2.6~3.7μm880℃)
Electrical Charactdristics	Dielectric strength	48×10^6V/m
	Volume Resistance	20℃ >10^{14}Ω·cm 500℃ 10^{11}Ω·cm
	Dielectric Constant	C parallel to Caxis 11.5 (1MHz) C perpendicular to Caxis 9.3 (1MHz)
	Dielectric Loss Angle	<1 ($\times10^{-4}$) (1MHz)
	Loss Factor	— ($\times10^{-4}$)
	Dielectric Loss Tangent	10^{-4} max.
Optical Characteristics	Index of Reflection	No=1.768 Ne=1.760 @589nm
	Optical Transmission	Refer to Fig.5

※These figures are representative.
※Each Crystal Orientation has different characteristics.

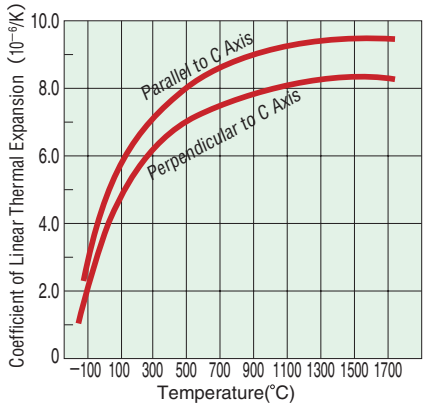


Fig. 1 Thermal Expansion vs. Temperature

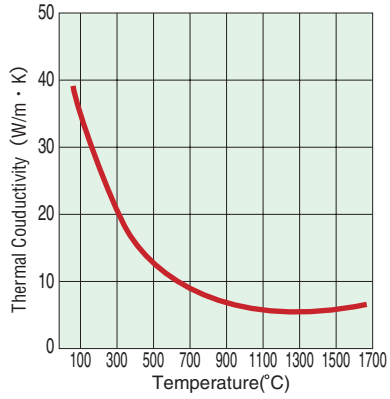


Fig. 2 Thermal Conductivity vs. Temperature

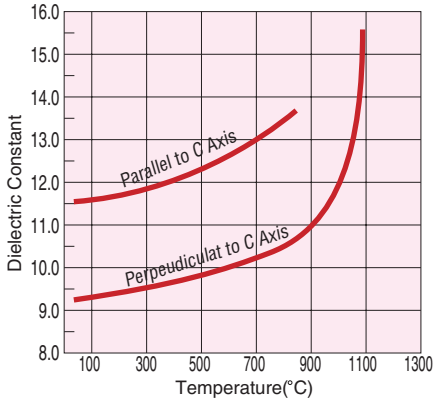


Fig. 3 Dielectric Constant vs. Temperature

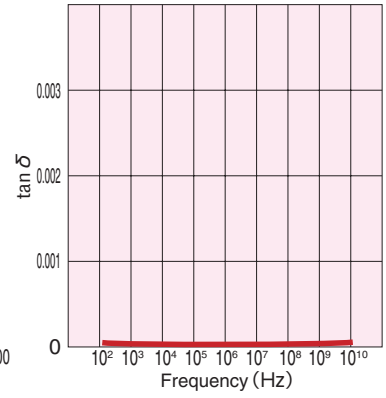


Fig. 4 Dielectric Loss vs. Frequency

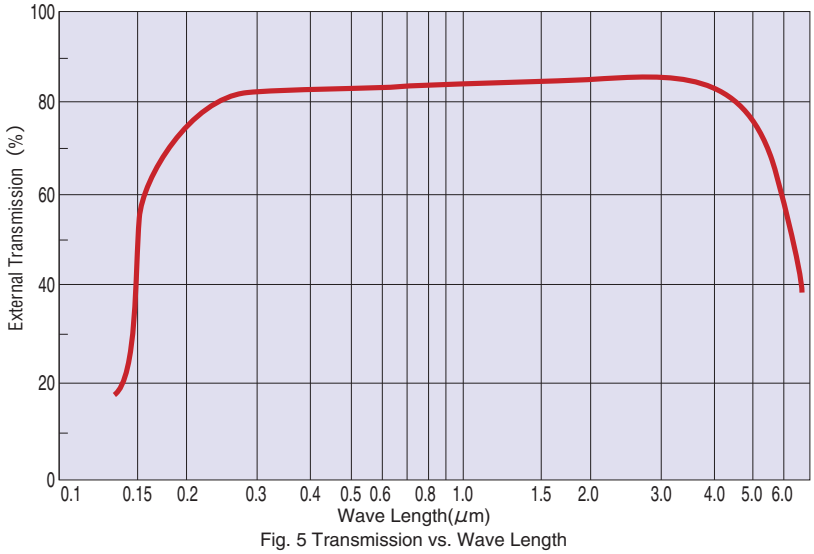


Fig. 5 Transmission vs. Wave Length

NOTE: •Transmittance range varies depending on thickness of Sapphire Products.
•Interfacial Reflection included
•Thickness 1mm.

Standard Dimensional Tolerance

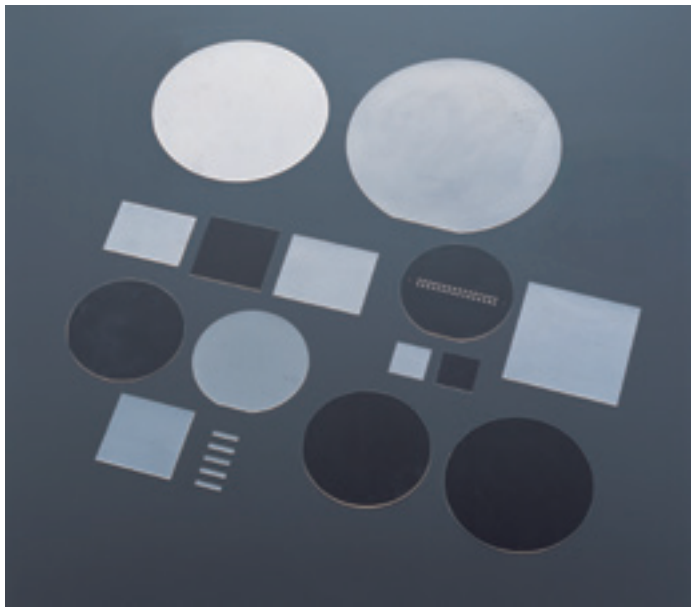
(Unit:mm)

Nominal Dimension : a	1>a	1≦a≦4	4<a≦25	25<a≦102	102<a≦190	190<a
Tolerance (±)	0.05	0.1	0.2	0.25	0.5	1

●Machining accuracy: Tube 1.A.10.A.and standard tube thickness tolerance…±0.25.
Hole diameter and standard pitch tolerance…±0.1

SAPPHIRE PRODUCTS

Substrate

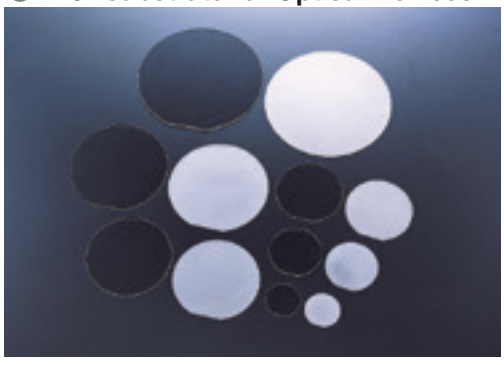


Application

(1)High Brightness LED
(2)HB-LED Semiconductor, Piezoelectric Semiconductor, Superconductor, Thin Film Substrate.
(3)MR Sensor, Precision Resistor
(4)Optical Devices
(5)Thin Film HIC

- Single Crystal Sapphire is widely used substrate material for blue, green, ultraviolet and white LEDs. It has excellent features as a base substrate for GaN deposition and great mass-productivity. In addition, it can meet future larger-size demand.
- Single Crystal Sapphire is used as a base substrate in thin film deposition because of its lattice alignment match with a variety of semiconductor materials combined with excellent thermal and chemical stability.

2"-8" substrate for Optical Devices

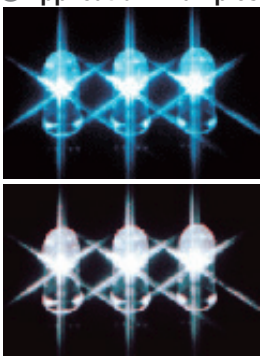


Standard Dimension and Tolerance

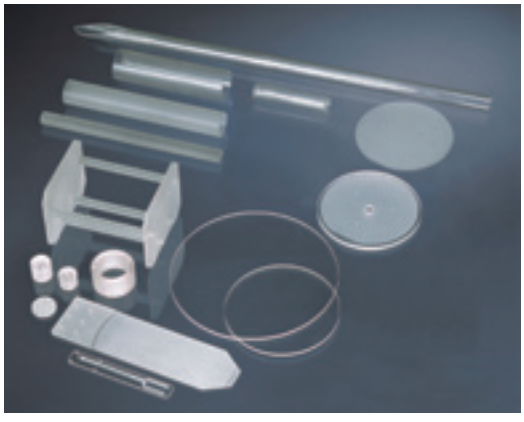
	Size	O.F. Length
8″	ϕ200±0.25×0.725±0.05	55～60
6″	ϕ150±0.25×0.625±0.05	45～50
5″	ϕ125±0.25×0.625±0.05	40～45
4″	ϕ100±0.25×0.53 ±0.05	30～35
3″	ϕ76.2±0.25×0.43 ±0.05	19～25
2″	ϕ50.8±0.25×0.33 ±0.05	13～19

※Specifications other than above are available.
※Available sizes are dependent on a crystal orientation. Sizes and tolerances other than the above table are also available under customer requirements. Please contact or send your requirements to Kyocera.

Application Examples



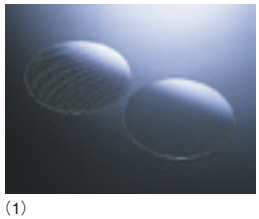
Semiconductor Process Equipment Parts



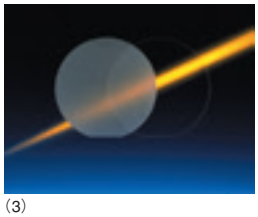
Application

(1)Carrier Plate
(2)Microwave Entrance Tube
(3)Dummy Water
(4)Handling Arm
(5)Vacuum Chuck
(6)Window

- It is used as various Semiconductor Process Equipment due to its high anti-plasma and high anti-heat characteristics.

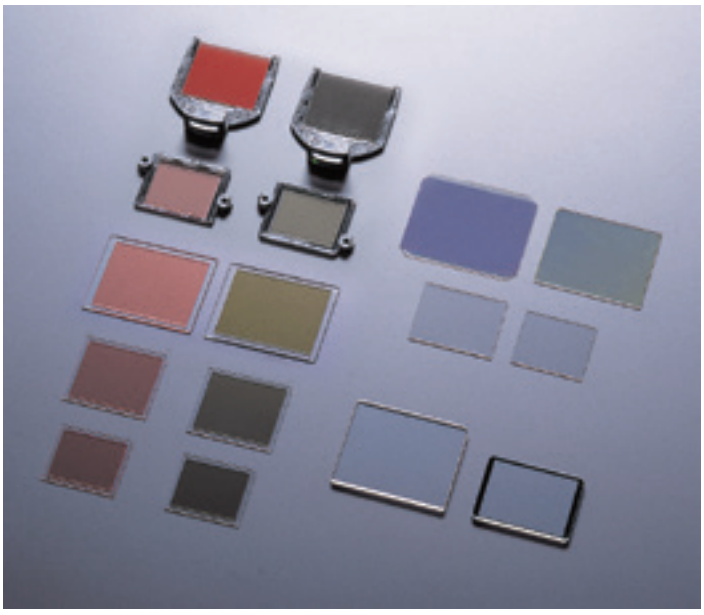

(1)


(2)


(3)


(4)

Optical Products for LCD Projectors



JP Patent No. 3091183, No.3443549
U.S. Patent No. 6577375, No.6642989

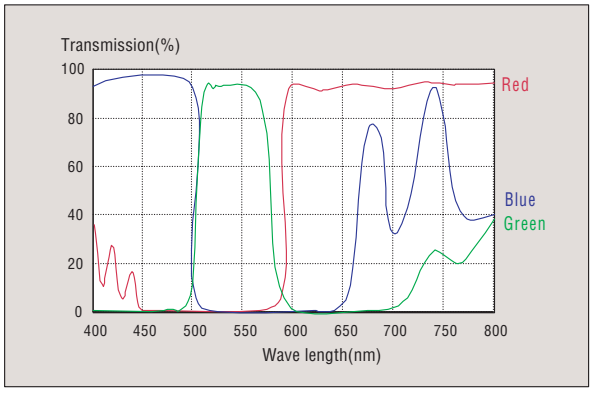
●Application
（1） Sapphire Plate
・Polarizing Film Attached
・Holder Assembled
・Dichroic Filter
（2） LCD Projector
Dust Control Plate

●Sapphire material realizes high brightness and high picture quality for LCD projectors due to its high thermal conductivity and optical properties.

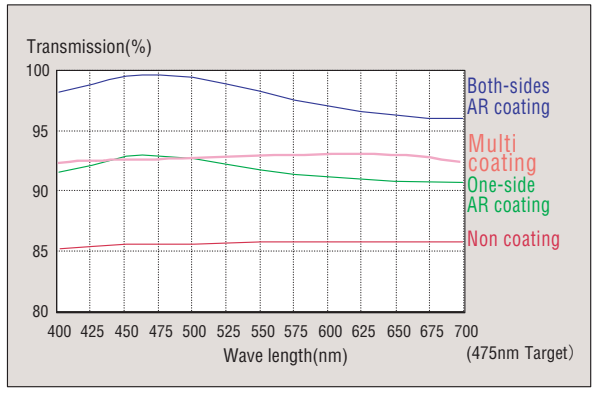
●Coating such as Dichroic Filter, to prevent reflection features is available.

●Standard sizes to fit in various LCD panels are available.

●Selected Transmission Layer for Wave Length Optical Transmission



●AR Coat External Transmission



※Characteristic values are subjected to change due to each specs or conditions.

Optical Products

●Application
(1)POS Scanner Window (SOG)
(2)Window
(3)Cap for Optical Communication
(4)Infrared Measuring Device Window
(5)Coin Sensor
(6)Lamp External Tube
High Pressure Sodium, Xenon, Ultra Pressure mercury
Metallic Halide
(7)Light Receiving Window Accelerating Tube

Others

●Application
(1)Fiber Bar Guide
(2)Insulating Plate and Rod
(3)Single Crystal Material Sheel Holder
(4)Biomaterial (BIOCERAM®)
(5)Watch Window
(6)NMR Protection Tube
(7)Thermocouple Protection Tube
(8)HDC Resonator Rod

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