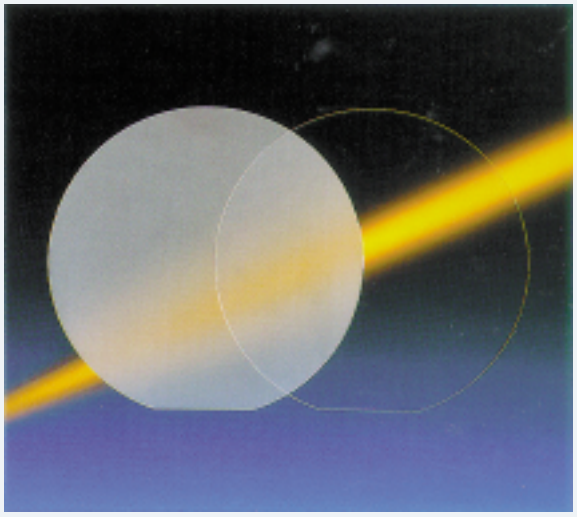
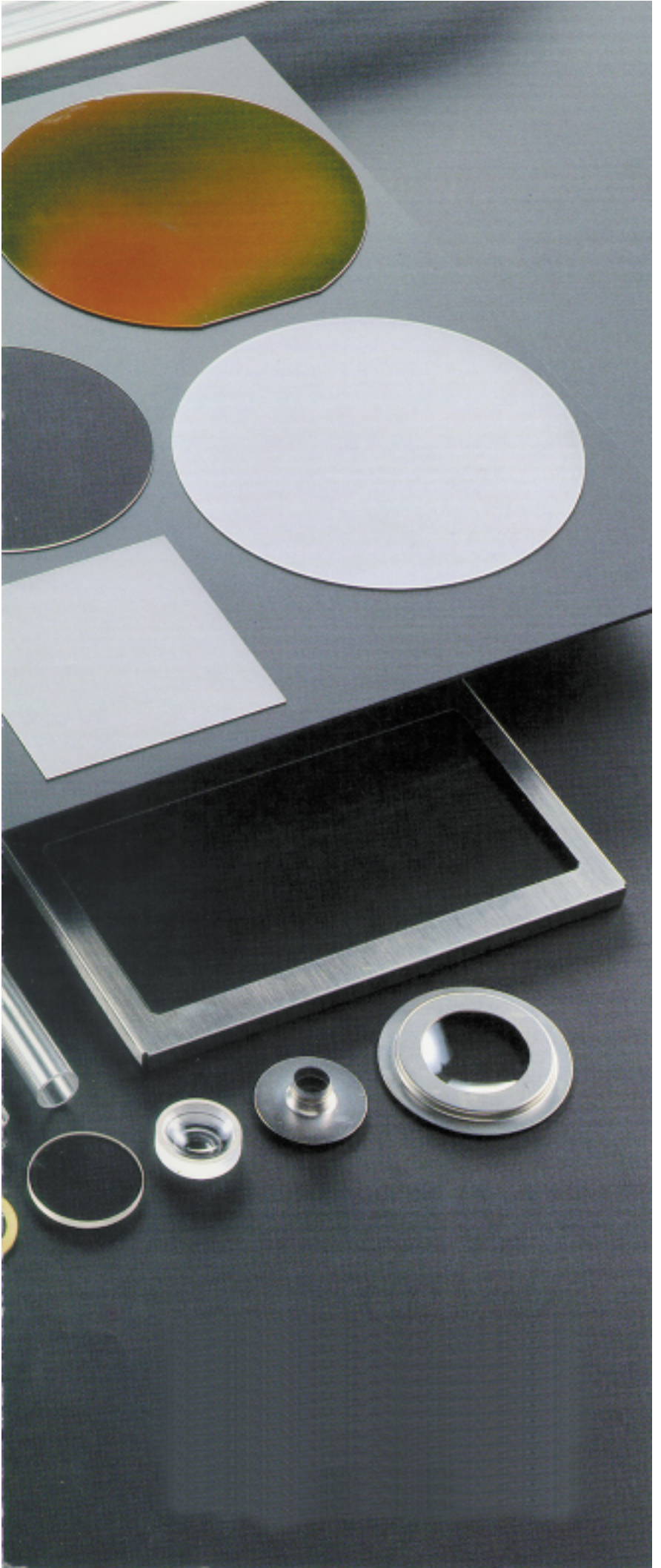
KYOCERA



SINGLE CRYSTAL SAPPHIRE

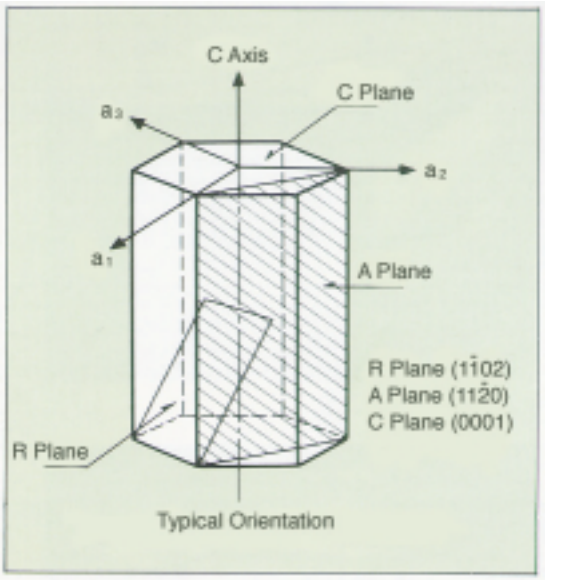
SINGLE CRYSTAL SAPPHIRE



Single Crystal Sapphire plays an ever-increasingly important role as a material for high reliability Opto-Electronics today due to 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 industrial products with large diameters or specific shape requirements.

■Sapphire Unit Call



■Features of Sapphire

- **High Strength, High Rigidity, High Anti-Abrasion, High Anti-Heat, High Anti-Corrosion 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 high-frequency introduction window. Single Crystal Sapphire has become indispensable in the highly advanced communication age.

- **Excellent Light Transmission**

  Single Crystal Sapphire is used for various kinds of vacuum equipment, windows in reaction furnaces, scanner windows and caps for optical communication due to its excellent mechanical characteristics and heat resistance. Single Crystal Sapphire also possesses a wide transmission wavelength region.

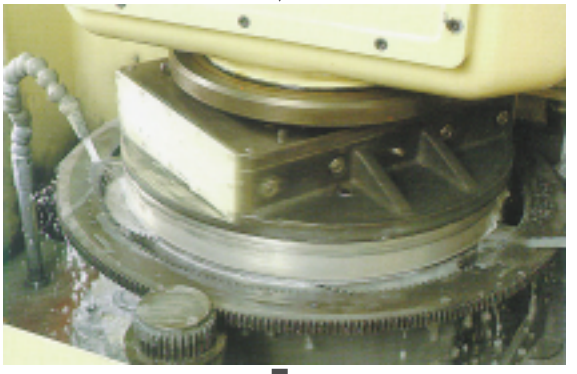
- **Good Thermal Conductivity and High Heat Resistance**

  Excellent thermal conductivity at low temperatures allow Single Crystal Sapphire to be used in many diverse fields requiring thermal conduction and heat radiation.

SAPPHIRE MANUFACTURING PROCESS

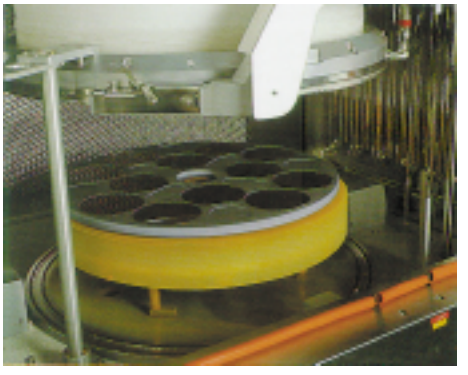
Growth of Raw Material

Grinding

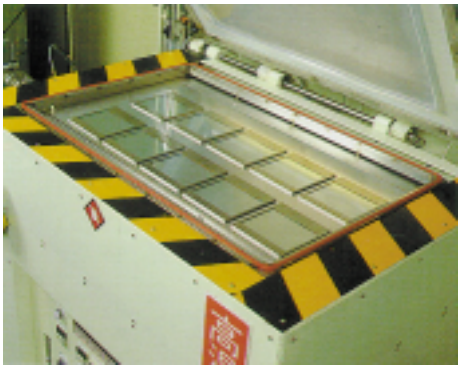


Polishing

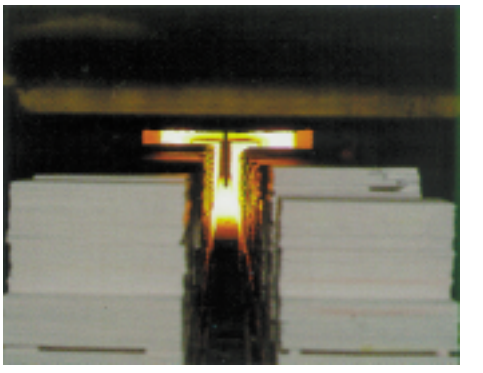
Silicon Epitaxial Growth



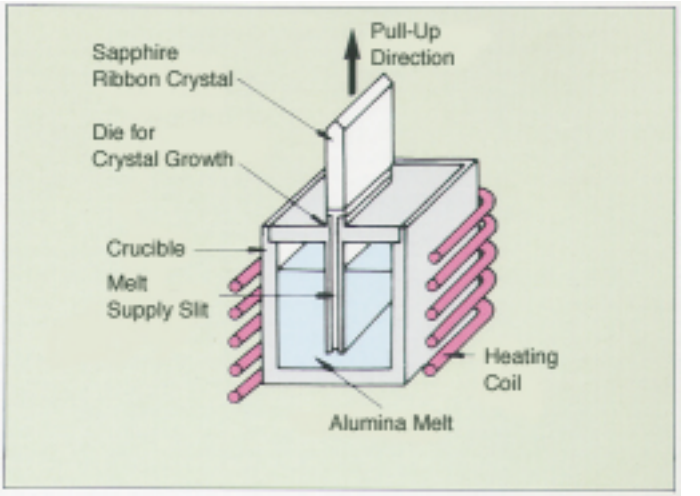
Assembly



Metallization



■EFG Method



■Features

- **Large Size Material**
  Kyocera was Succeeded in pulling up an 8" ribbon. 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.

■Perfect Specular Gloss

Nearly perfect specular gloss can be obtained by means of mechanochmical polishing.

CHARACTERISTICS OF SINGLE CRYSTAL SAPPHIRE

■Characteristics of Kyocera's Single Crystal Sapphire

• Physical Characteristics

Crystallographic structure:

Hexagonal System

(Rhombohedral Single Crystal)

a= 4.763Å

c=13.003Å

Density: 3.97×10^{3}kg/m^{3}

Hardness:

Mohs: 9 (Diamond ···10, Quartz ···7)

Vickers Hardness: 2,300

Tensile Strength:

2250Mpa

(Diameter: 0.25mm, Filament: 25˚C)

Compressive Strength: 2950MPa

Young's Modulus: 4.7×10^{5}MPa

Flexural Strength: 690MPa

• Thermal Characteristics

Melting point: 2,053˚C

Coefficient of Linear Thermal Expansion:

5.3×10^{-6}/K (25˚C) (parallel to C axis)

4.5×10^{-6}/K (25˚C) (perpendicular to C axis)

Thermal Conductivity: 42W/m · k (25˚C)

Specific Heat: 0.75KJ/kg · k (25˚C)

Emittance: 0.02max. (λ=2.6~3.7 μm, 880˚C)

• Electrical Characteristics

Resistivity:

1×10^{14} Ω · m (at ambient temp.)

1×11^{9} Ω · m (at 500˚C)

Dielectric Constant:

11.5 (parallel to C axis) (10^{3}~10^{10}Hz, 25˚C)

9.3 (perpendicular to C axis) (10^{3}~10^{10}Hz, 25˚C)

Dielectric strength: 4.8×10^{4} KV/m (60Hz)

Dielectric Loss Tangent: 10^{-4}max.

• Optical Characteristics

Index of Refraction:

No=1.768

Ne=1.760

Optical Transmission: See Fig. 5.

■Characteristic Values

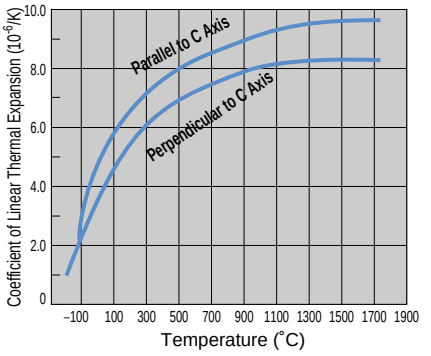


Fig.1 1 Thermal Expansion vs. Temperature

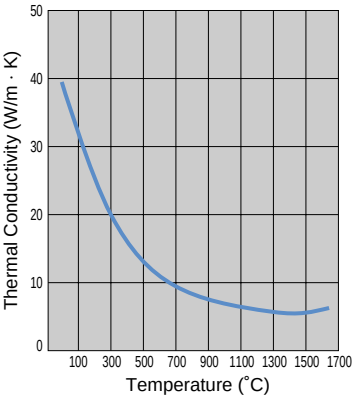


Fig.2 Thermal Conductivity vs. Temperature

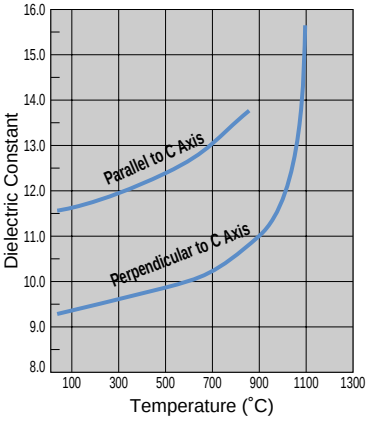


Fig.3 3 Dielectric Constant vs. Temperature

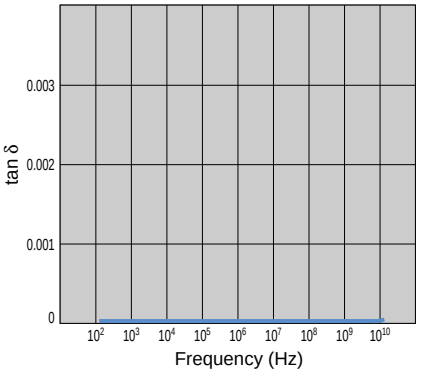


Fig.4 4 Dielectric Loss vs. Frequency

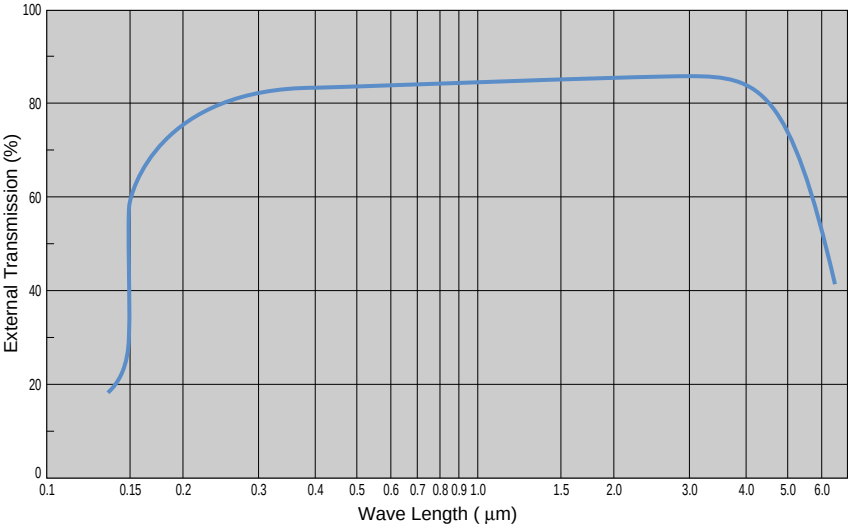
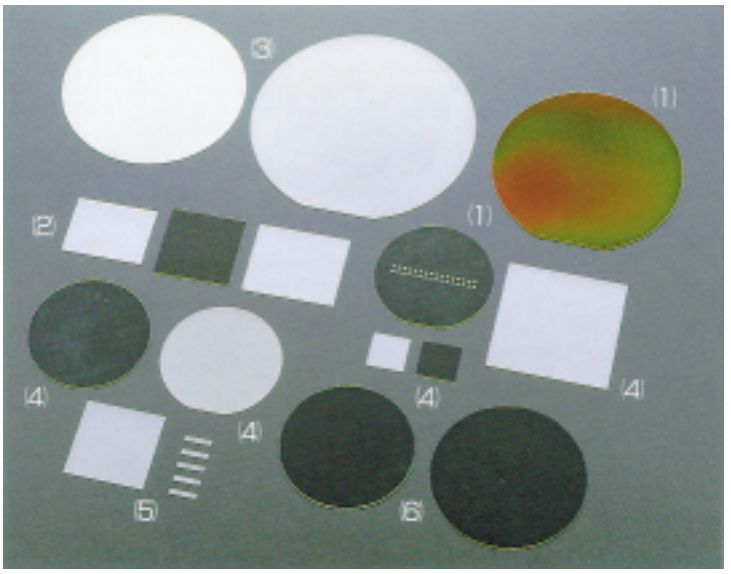


Fig.5 5 Transmission vs. Wave Length

Note: Transmittance range varies depending on thickness of Sapphire.

SAPPHIRE PRODUCTS

■ Substrate



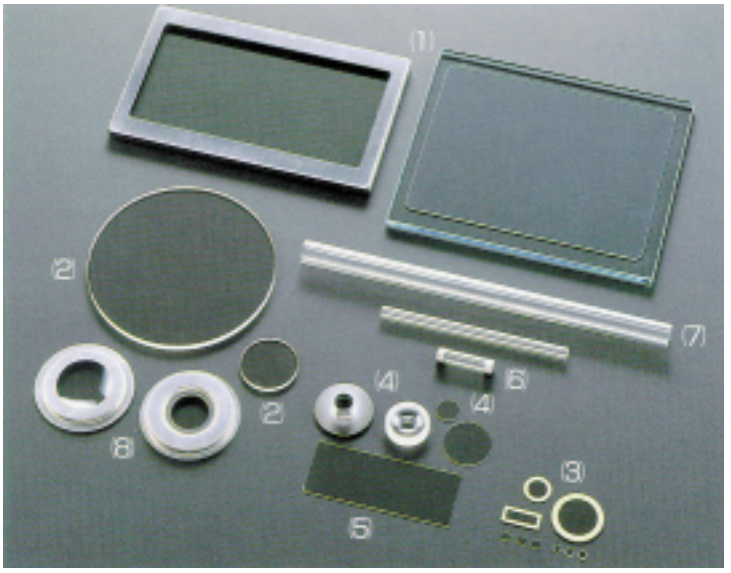
■ Application

(1) SOS
(2) Thin Film HIC Substrate
(3) Semiconductor Monitor Wafer
(4) Semiconductor, Piezoelectric Semiconductor, Superconductor, Thin Film Substrate
(5) MR Sensor, Precision Resistor Substrate
(6) GaAs and other Substrate Holding Plates

■ Standard Specifications

Shape	OF Length
ϕ 200 ±0.25 × 0.725 ±0.05	55 ~ 60
ϕ 150 ±0.25 × 0.625 ±0.05	45 ~ 50
ϕ 125 ±0.25 × 0.625 ±0.05	40 ~ 45
ϕ 100 ±0.25 × 0.53 ±0.05	30 ~ 35
ϕ 76.2 ±0.25 × 0.43 ±0.05	19 ~ 25

■ Optical Products



■ Application

(1) POS Scanner Window (Sapphire On Glass)
(2) Window
Semiconductor Manufacturing Device: Vacuum Equipment, High-Temperature/High-Pressure Container
(3) Cap for Optical Communication
(4) Infrared Measuring Device Window
(5) Coin Sensor
(6) Lamp External Tube
High-Pressure Sodium, Xenon, Metallic Halide
(7) Thermocouple Protection Tube
(8) Light Receiving Window
○ Accelerating Tube
○ High-Temperature Measuring Rod

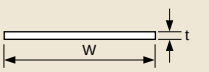
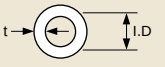
SHAPE AND MACHINING ACCURACY

■Standard Dimensional Tolerance

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

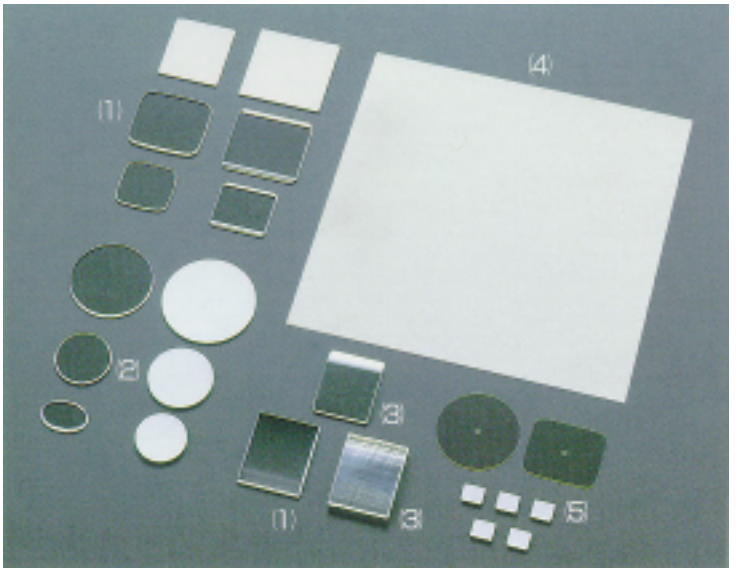
● Machining accuracy: Tube I.A./O.A. and standard tube thickness tolerance···±0.25.
Hole diameter and standard pitch tolerance···±0.1.

■Shape and Specifications

Shape	Example of Section	Dimensions	Crystal Orientation
Plate		Width: 200max. Length: 300max. Thickness: 0.2 ~ 20	R Plane: ±2deg A Plane: ±5deg C Plane: ±2deg
Rod		Diameter: 0.5 ~ 20 Length: 1000max.	C Axis in Longitudinal Direction
Tube		Inside Diameter: 1.3 ~ 50 Tube Thickness: 0.25 ~ 5 Length: 1000max.	C Axis in Longitudinal Direction
Others		To be decided separately	To be decided separately

※Shapes other than shown above are available.

■Watch Window Material



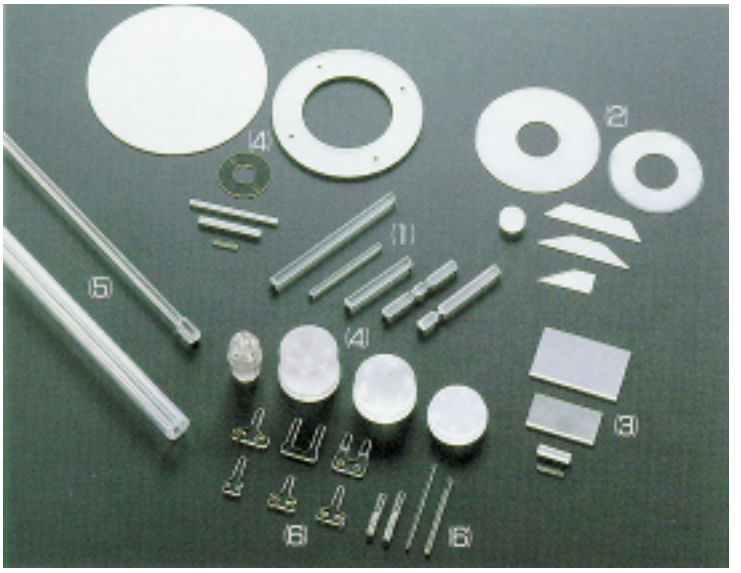
■Use

(1) For Square Model
(2) For Circular Model
(3) For Cylindrical Model
(4) For Large-Size Model
(5) For Bezel and Other Ornaments

■Standard Specifications

Finish: Both-Side Grinding.
Outside edge as cut.
Thickness Tolerance:
For square and circular models: ±0.02
For large-size material: ±0.05

■Sliding Parts. Blade, Structural Material, Others



■Application

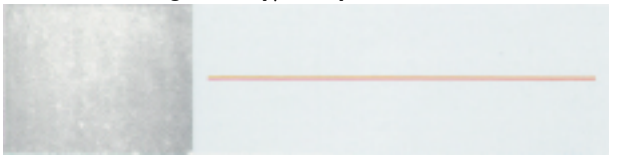
(1) Fiber Bar Guide
(2) Blade (for fiber, razor and office goods)
(3) Tape Cleaner
(4) Insulating Plate and Rod
(5) Single Crystal Material Sheet Holder
(6) Biomaterial (BIOCERAM®)
○ Clamp Ring in Semiconductor Instrument
○ Ultrasonic Microscope Sensor Head

※BIOCERAM® is a registered trademark of KYOCERA.

■ Finish

Finish	AS GROWN	Grinding	Lapping	Polishing
Surface Roughness (μmRa)	———	0.6TYP.	0.2TYP	≦0.01

■ Surface Roughness (μmRa)



※For other special specifications, contact Kyocera.

JUNCTION WITH OTHER MATERIALS

■ Adhesion to Glass

Adhesion to glass is available using EVA sheet adhesive.

■ Brazing to Metal

Same as ceramics, brazing can be done to KOV and other materials through metal-lizing methods.
(Ex.: High Vacuum Container Window, Packing, Cap, etc.)