SINGLE CRYSTAL SAPPHIRE

Single Crystal Sapphire is playing an ever-increasingly important role as a material for high reliability 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

- Any axis and plane can be produced by instituting proper control during crystal growth.
- Control of Crystal Orientation
- Production of Single Crystal Sapphire in Any Desired Sectional Shape
- Sizing-up of materials allows for a broader range of applications and uses.
- Control of Crystal Orientation
- Any axis and plane can be produced by instituting proper control during crystal growth.

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
- 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.

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**SAPPHIRE MANUFACTURING PROCESS**

- **Growth of Raw Material**
- **Grinding**
- **Lapping**
- **Polishing**
- **Substrate**
  - Width: 200mm max.
  - Length: 300mm max.
  - Thickness: 0.1~3
- **Rod**
  - Diameter: 0.5~3
  - Length: 1000mm max.
- **Others**
  - To be Customized
  - C Axis in Longitudinal Direction

**CHARACTERISTICS OF SINGLE CRYSTAL SAPPHIRE**

- **Nominal Dimension**
  - Tube: Length 1,000mm max.
  - Diameter: 0.5
  - Thickness: 0.1

- **Dimensions**
  - Longitudinal C Axis in C plane
  - A plane
  - R plane
  - ± 2deg

- **Others**
  - Customized
  - To be Customized
  - Direction
  - Length 1,000max.
  - Diameter: 0.5

- **Shape and Specifications**

**Electrical Characteristics**

- **Dielectric Constant**
  - Parallel to C Axis
  - Perpendicular to C Axis

- **Volume Resistance**
  - 20°C: 10^14 • cm

- **Dielectric Loss Angle**
  - Parallel to C Axis: 0.3 (1MHz)
  - Perpendicular to C Axis: < 1 (1MHz)

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- **Index of Refraction**
  - Value: 1.768

- **Optical Transmission**
  - Refer to Fig.5

**Mechanical Characteristics**

- **Melting Point**
  - C parallel to C axis: 2,053°C
  - C perpendicular to C axis: 1,014°C

- **Compressive Strength**
  - 2,940MPa

- **Tensile Strength**
  - 2250MPa

- **Young’s Modulus**
  - 470GPa

- **Tangent**
  - 22.5GPa

**Thermal Characteristics**

- **Coefficient of Linear Thermal Expansion**
  - 10^-4 (× 10^-6/℃)

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  - 10^-4 (× 10^-6/℃)

- **Specific Heat Capacity**
  - Internal: 0.75J/g K

- **Thermal Conductivity**
  - 400 W/m K

- **Thermal Emittance**
  - 0.15

- **Flexural Strength**
  - C parallel to C axis: 7.7MPa
  - C perpendicular to C axis: 2,053MPa

**Optical Characteristics**

- **Optical Transmission**
  - 100% (λ = 0.5μm)

**Dielectric Constant**

- **Dielectric Strength**
  - 48 x 10^7V/m

- **Dielectric Constant**
  - Parallel to C axis: 11.5 (1MHz)
  - Perpendicular to C axis: 0.3 (1MHz)

- **Dielectric Loss Angle**
  - Parallel to C axis: < 1 (1MHz)
  - Perpendicular to C axis: < 1 (1MHz)

**Electric Characteristics**

- **Dielectric Strength**
  - 48 x 10^7V/m

- **Volume Resistance**
  - 20°C: > 10^14 • cm

- **Dielectric Constant**
  - Parallel to C axis: 11.5 (1MHz)
  - Perpendicular to C axis: 0.3 (1MHz)

- **Dielectric Loss Angle**
  - Parallel to C axis: < 1 (1MHz)
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  - Refer to Fig.5

**Standard Dimensional Tolerance**

- **Nominal Dimension**
  - 1 > a
  - 1.5 ± a ± 0.5
  - 4 ± a ± 2.5
  - 25 ± a ± 10
  - 102 ± a ± 190
  - 190 ± a

  - Tolerance
    - 0.05
    - 0.1
    - 0.2
    - 0.25
    - 0.5
    - 1

  - Machining accuracy: Tube 1.0.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**

<table>
<thead>
<tr>
<th>Size</th>
<th>O.F. Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot;</td>
<td>Ø200 ± 0.25 x 0.725 ± 0.05</td>
</tr>
<tr>
<td>6&quot;</td>
<td>Ø150 ± 0.25 x 0.625 ± 0.05</td>
</tr>
<tr>
<td>5&quot;</td>
<td>Ø125 ± 0.25 x 0.625 ± 0.05</td>
</tr>
<tr>
<td>4&quot;</td>
<td>Ø100 ± 0.25 x 0.53 ± 0.05</td>
</tr>
<tr>
<td>3&quot;</td>
<td>Ø76.2 ± 0.25 x 0.43 ± 0.05</td>
</tr>
<tr>
<td>2&quot;</td>
<td>Ø50.8 ± 0.25 x 0.33 ± 0.05</td>
</tr>
</tbody>
</table>

*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**

- **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.

**Optical Products for LCD Projectors**

- **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.

**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
  7. Light Receiving Window Accelerating Tube
  8. Fiber Bar Guide
  9. Insulating Plate and Rod
  10. Single Crystal Material Sheel Holder
  11. Biomaterial (BIOCERAM®)
  12. Watch Window
  13. NMR Protection Tube
  14. Thermocouple Protection Tube
  15. HDC Resonator Rod

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