Expanding Applications of Ceramic Components-1

Contributing to Down-sizing & Improved Functionality of Electronics

The electronics industry is continuously making remarkable progress and development. Kyocera, with its Fine Ceramics material and processing technologies developed during its history, supports the increased functionality of equipment used in a wide range of fields such as various electronic components and semiconductor devices along with equipment components required to support manufacturing.

Information-based Society

Down-sizing & Improved Functionality of Electronic Devices

Electronic Components

Components
- Resistors
- Inductors
- RF Components
- Fuses
- Thermostats
- Relays
- SAW Filters
- LEDs
- Oscillators
- Sensors

Manufacturing Equipment

Equipment
- Semiconductor & LCD Processing Equipment
- Electronic Component Processing Equipment
- Chip Mounters
- Inspection Equipment

NEEDS
- Down-sizing
- Heat Resistance
- Low Dielectric Loss
- Thinning
- Heat Dissipation
- Electrical Insulation
- Long-term Reliability
- High Strength
- High Precision
- Low Particle

Electronic Parts

Materials
- Ceramic Substrates
- Structural Parts for Processing Equipment

Various Fine Ceramic Products
Expanding Applications of Ceramic Components-2

Enhancing Automotive Performance

Fine Ceramics provide excellent characteristics in mechanical strength at high temperature and electrical insulation. As automotive electronics evolve to require more robustness for long-term durability and safety to protect drivers and passengers, ceramic components are widely used in hybrid vehicles (HV/PHV) and electric vehicles (EV).

- Ceramic Diaphragms
- Pb-free Piezoelectric Elements
- Ferrites for Automotive Common Mode Noise Filters
- Hydraulic Pressure Sensors
- Combustion Pressure Sensors
- TPMS (Tire Pressure Measurement System)
- Smart Keys
- Water Pumps
- Ferrite Antennas
- Seal Rings

HV, PHV, EV Components

Insulation Plates for Electrical Boosters
Large Current Terminal Parts
Heat Dissipation Substrates for Power Modules
ECU (Engine Control Unit) Substrates

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For product details, please contact webmaster.fc@kyocera.jp
Ceramic Substrates

Stronger
Smoother
Alumina Substrates Matrix
Sapphire Substrate
SA100 Thin Film Printing Substrate
A493H A493 High Strength Substrate
A477A AZ211 Glazed Substrate
A476K Thick Film Printing Substrate
A476 A476T Surface Morphology

3-point Bending Strength
High Reflectivity Substrate
A476A AZ214 Glazing Optional

Ceramic substrates are mainly used as hybrid IC substrates, thin film IC substrates, heat dissipation substrates, and LED sub-mount substrates. Our micro-grain material structure enables substrates which have a smooth surface with less voids, and high flexural strength and electrical insulation under high temperature environments. Upon request, we can also cut through-holes or scribe lines, or form electrode patterns (metallization) by printing or plating the substrates.

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# Material Characteristics of Ceramic Substrates

<table>
<thead>
<tr>
<th>Main Applications</th>
<th>Thick Film Printing</th>
<th>Thin Film Printing</th>
<th>Glazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Material</td>
<td>Alumina Al₂O₃</td>
<td>Alumina Al₂O₃</td>
</tr>
<tr>
<td>Material Code</td>
<td>A476</td>
<td>A476T</td>
<td>A493</td>
</tr>
<tr>
<td>Alumina Content</td>
<td>96%</td>
<td>96%</td>
<td>99.6%</td>
</tr>
<tr>
<td>Density</td>
<td>g/cm³</td>
<td>3.70</td>
<td>3.78</td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Characteristics</td>
<td>Vickers Hardness</td>
<td>GPA</td>
<td>13.7</td>
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<tr>
<td></td>
<td>Flexural Strength</td>
<td>MPa</td>
<td>310</td>
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<tr>
<td></td>
<td>Young’s Modulus</td>
<td>GPa</td>
<td>330</td>
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<tr>
<td></td>
<td>Elasticity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>Coefficient of</td>
<td>×10⁻⁶/K</td>
<td>7.2</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Linear Thermal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expansion (40-400°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal Conductivity</td>
<td>W/m·K</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Dielectric Strength</td>
<td>kV/mm</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Volume Resistivity</td>
<td>Ω·cm</td>
<td>&gt;10¹⁴</td>
</tr>
<tr>
<td></td>
<td>Dielectric Constant</td>
<td>(1MHz)</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>Dielectric Loss</td>
<td>x10⁻⁴</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Angle (1MHz)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflectivity</td>
<td>(Wavelength: 450nm)</td>
<td>%</td>
<td>–</td>
</tr>
<tr>
<td>(Thickness: 1mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>Substrate</td>
<td>mm</td>
<td>0.1~1.0</td>
</tr>
<tr>
<td>Specifications</td>
<td>Thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surface Roughness</td>
<td>Ra0.3</td>
<td>Ra0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>~0.5µm</td>
<td>~0.5µm</td>
</tr>
</tbody>
</table>

* Values are typical properties of each material, and may vary depending on product configurations or manufacturing processes. For more details, please feel free to contact us.

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For product details, please contact webmaster.fc@kyocera.jp
<table>
<thead>
<tr>
<th>Power Module (High Strength)</th>
<th>LED Sub-mount Substrate (High Reflectivity)</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina Al₂O₃</td>
<td>Silicon Nitride Si₃N₄</td>
<td>Alumina Al₂O₃</td>
</tr>
<tr>
<td>AZ211T</td>
<td>SN460 Under Development</td>
<td>A476K</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>96%</td>
</tr>
<tr>
<td>4.01</td>
<td>3.50</td>
<td>3.70</td>
</tr>
<tr>
<td>–</td>
<td>14.0</td>
<td>13.7</td>
</tr>
<tr>
<td>650</td>
<td>750</td>
<td>350</td>
</tr>
<tr>
<td>360</td>
<td>300</td>
<td>330</td>
</tr>
<tr>
<td>7.0</td>
<td>2.7</td>
<td>7.2</td>
</tr>
<tr>
<td>24</td>
<td>55</td>
<td>24</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
</tr>
<tr>
<td>10.8</td>
<td>8.5</td>
<td>9.4</td>
</tr>
<tr>
<td>2.7</td>
<td>10</td>
<td>4.0</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>86.7%</td>
</tr>
<tr>
<td>0.32~1.0</td>
<td>0.25~0.4</td>
<td>0.5~1.0</td>
</tr>
<tr>
<td>Ra0.3 ~0.5μm</td>
<td>Ra3~6μm</td>
<td>Ra0.2 ~0.3μm</td>
</tr>
</tbody>
</table>

*Values are typical properties of each material, and may vary depending on product configurations or manufacturing processes. For more details, please feel free to contact us.
**Features**

- Tight tolerance control
  (Premium: ±0.25%)
- Standard Thickness: 0.1 ~ 2.7mm
- Size flexibility to maximum 12”sq.
  * Scalable up to 1,250mm length
- Small through-hole cutting
  (Ø0.2mm)

**Standard Substrate Size:**

**Outer Dimension:**
- 2”sq. / 3”sq. / 4”sq.
- 4.5”sq. / 5”sq.
- 7.5” × 5.5”

**Thickness (mm):**
- 0.180
- 0.254
- 0.381
- 0.508
- 0.635
- 0.762
- 0.800
- 1.016
- 1.800
**Standard Substrate Specifications**

<table>
<thead>
<tr>
<th>Material</th>
<th>A476</th>
<th>A476T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size Availability (A,B)</strong></td>
<td>12.7mm sq. - 152.4mm sq.</td>
<td>12.7mm sq. - 203.2 × 254.0mm</td>
</tr>
<tr>
<td><strong>Thickness Availability (T)</strong></td>
<td>0.1~1.0mm</td>
<td>0.3~2.7mm</td>
</tr>
<tr>
<td><strong>Thickness Tolerance</strong></td>
<td>Standard</td>
<td>±10% (minimum ±0.05mm)</td>
</tr>
<tr>
<td></td>
<td>Premium</td>
<td>±7% (minimum ±0.05mm)</td>
</tr>
<tr>
<td><strong>As Fired Camber (C)</strong></td>
<td>0.3% of longer side of substrate</td>
<td>0.2% of longer side of substrate</td>
</tr>
<tr>
<td><strong>Surface Roughness</strong></td>
<td></td>
<td>Ra0.3~0.5µm</td>
</tr>
</tbody>
</table>

**Internal Void**

![Internal Void Images]

**Standard Green-punching / Laser-cutting Specifications**

<table>
<thead>
<tr>
<th>Process</th>
<th>Green Punching</th>
<th>Laser Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substrate Dimensional Tolerance (a)</strong></td>
<td>Standard</td>
<td>±0.8% (minimum ±0.1mm)</td>
</tr>
<tr>
<td></td>
<td>Premium</td>
<td>±0.5% (minimum ±0.08mm)</td>
</tr>
<tr>
<td></td>
<td>Super Premium</td>
<td>±0.25% (minimum ±0.05mm)</td>
</tr>
<tr>
<td><strong>Singulation Scoring Tolerance (b)</strong></td>
<td>Standard</td>
<td>±0.8% (minimum ±0.1mm)</td>
</tr>
<tr>
<td></td>
<td>Premium</td>
<td>±0.5% (minimum ±0.08mm)</td>
</tr>
<tr>
<td></td>
<td>Super Premium</td>
<td>±0.25% (minimum ±0.05mm)</td>
</tr>
<tr>
<td><strong>Parallelism (c) / Perpendicularity (d)</strong></td>
<td>Standard</td>
<td>0.5% of outer dimension</td>
</tr>
<tr>
<td></td>
<td>Premium</td>
<td>0.3% of outer dimension</td>
</tr>
<tr>
<td><strong>Corner Radius (e)</strong></td>
<td></td>
<td>0.51mm</td>
</tr>
<tr>
<td><strong>Hole Size</strong></td>
<td>Round Hole: minimum 0.20mm diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Square Hole: minimum 0.38mm square</td>
<td></td>
</tr>
<tr>
<td><strong>Spacing between Holes (f) / Spacing between Edge to Hole (g)</strong></td>
<td>Same tolerance as substrate thickness (minimum ±0.51mm)</td>
<td></td>
</tr>
</tbody>
</table>
Alumina Metallized Substrates

Wide range of applications from circuit boards to power devices

Features

- Available with high adhesion strength Mo-Mn
- Various options for conductive layer (incl. Ag or Cu)
- Customized pattern printing
  (Please consult us in advance regarding design)

Applications

- Circuit Board Substrates
- Power Device Substrates

Long Thick Film Printing Substrates

Maximum 1250mm long substrate, with metallization option for pattern printing

Available Size

- 1250mm max × 125mm max × 0.635mm thick
  (Camber: 0.6mm / 500mm)
Thin Film Printing Substrates
Super smooth substrates used for thin film printed circuit boards

Features

- Excellent smoothness with less voids (Standard: Ra0.05~0.08μm)
- High mechanical strength
- Maximum available size: 165mm sq.

Standard Substrate Size

Outer Dimension:
- 2”sq. / 3”sq. / 4”sq.
- 4.5” × 3.75” / 4.5”sq.
- 5”sq.

Thickness (mm):
- 0.100 / 0.127
- 0.200 / 0.254
- 0.381 / 0.500
- 0.635 / 1.000

For product details, please contact webmaster.fc@kyocera.jp
Polished Thin Film Printing Substrates

Ceramic substrates contribute to the advancement and diversification of thin film technology

### Features

- Dimensional stability at high temperature for multilayer thin film technology (for metal, glass or resin)
- Thin film quality improvement with high level of flatness and smoothness

### Low Voids Alumina Substrate (A493H)

#### Features

- Best-in-class low voids, produced from tight process control
- Excellent surface smoothness
- Mitigation of electrical disconnection in thin film printed circuits

#### Design Guideline

<table>
<thead>
<tr>
<th>Item</th>
<th>A476T</th>
<th>A493</th>
<th>A493H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Thickness (mm)</td>
<td>0.05~2.7</td>
<td>0.05~0.7</td>
<td>0.05~0.7</td>
</tr>
<tr>
<td>Flatness (mm)</td>
<td>0.05~0.6</td>
<td>0.05~0.4</td>
<td>0.05~0.4</td>
</tr>
<tr>
<td>Surface Roughness (Mirror Polish)</td>
<td>&lt;Ra0.05</td>
<td>&lt;Ra0.02</td>
<td>&lt;Ra0.01</td>
</tr>
</tbody>
</table>

* Values may vary depending on the size and thickness of substrates. Please contact us for further information.

For product details, please contact webmaster.fc@kyocera.jp
Single Crystal Sapphire Substrates

Base substrate applications for various epitaxies or depositions

The epitaxial growth of semiconductor film (e.g. Si, GaN, AlN, ZnO, etc.) requires a base substrate with similar lattice constant and no grain boundary. Single crystal sapphire with its smooth surface provides excellent performance, not only as the base substrate for LED, LD, SOS but also as a deposition substrate for super-conductive, metal, oxide, organic, or inorganic films.

**Features**

- Single crystal atomic layout
- Smooth surface finish with no grain boundary
- High electrical insulation with low dielectric loss
- Availability in customized crystal orientation
- High mechanical strength, heat resistance, chemical durability, and plasma resistance properties

**Crystal Orientation / Lattice**

![Crystal Unit Cell Diagram]

**Lattice Constant**

(Reference: for a-axis and c-axis)

<table>
<thead>
<tr>
<th>Reference</th>
<th>a-axis</th>
<th>c-axis</th>
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</thead>
<tbody>
<tr>
<td>Sapphire</td>
<td>4.758</td>
<td>12.991</td>
</tr>
<tr>
<td>GaN</td>
<td>3.189</td>
<td>5.185</td>
</tr>
<tr>
<td>InN</td>
<td>3.548</td>
<td>5.76</td>
</tr>
<tr>
<td>Si</td>
<td>5.43095</td>
<td></td>
</tr>
<tr>
<td>GaAs</td>
<td>5.6533</td>
<td></td>
</tr>
<tr>
<td>ZnO</td>
<td>3.252</td>
<td>5.213</td>
</tr>
<tr>
<td>AlN</td>
<td>3.112</td>
<td>4.982</td>
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</table>

**Surface Roughness**

(Reference AFM)

<table>
<thead>
<tr>
<th>Crystal Orientation / Lattice</th>
<th>Surface Roughness (reference AFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference value</td>
<td>a-axis</td>
</tr>
<tr>
<td>Sapphire</td>
<td>0.086nm</td>
</tr>
<tr>
<td>GaN</td>
<td>0.086nm</td>
</tr>
<tr>
<td>InN</td>
<td>0.086nm</td>
</tr>
<tr>
<td>Si</td>
<td>0.086nm</td>
</tr>
<tr>
<td>GaAs</td>
<td>0.086nm</td>
</tr>
<tr>
<td>ZnO</td>
<td>0.086nm</td>
</tr>
<tr>
<td>AlN</td>
<td>0.086nm</td>
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**Standard Size**

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>Orientation Flat Length</th>
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</thead>
<tbody>
<tr>
<td>Ø 50.8 ±0.25</td>
<td>0.33 or 0.43 ±0.025</td>
<td>16 ±3</td>
</tr>
<tr>
<td>Ø 76.2 ±0.25</td>
<td>(Common for any) ±0.025</td>
<td>22 ±3</td>
</tr>
<tr>
<td>Ø 100 ±0.25</td>
<td>(Common for any) ±0.025</td>
<td>32.5 ±2.5</td>
</tr>
<tr>
<td>Ø 125 ±0.25</td>
<td>(Common for any) ±0.025</td>
<td>42.5 ±2.5</td>
</tr>
<tr>
<td>Ø 150 ±0.25</td>
<td>(Common for any) ±0.025</td>
<td>47.5 ±2.5</td>
</tr>
<tr>
<td>Ø 200 ±0.25</td>
<td>(Common for any) ±0.025</td>
<td>-</td>
</tr>
</tbody>
</table>

*Please contact us for more details. (Unit: mm)*

**Standard Size Availability**

![Standard Size Availability Diagram]

Size is dependent on crystal orientation
High Reflectivity Alumina Substrates

Contributing to improved LED efficiency, with both high reflectivity and high thermal conductivity

**Features**

- White ceramic substrate with both high reflectivity and high thermal conductivity
  - Reflectivity: 95%
  - Thermal Conductivity: 19W/mk
- High level of dimensional accuracy by laser cutting
- Multiple pieces from a larger size substrate

**Applications**

- Base substrate for LED sub-mount assembly for various types of LEDs such as down lights, tube lights, or bulbs
- LED sub-mount substrate for automotive applications

**Reflectivity by Wavelength**

![Reflectivity by Wavelength](image)

**Reflectivity by Substrate Thickness**

![Reflectivity by Substrate Thickness](image)
**Reference**

**Laser Cutting Design Guideline**

**Scribe Line**

![Scribe Line Diagram](image)

**Substrate Edge**

**Standard Depth (Inch (mm))**

<table>
<thead>
<tr>
<th>Substrate Thickness (t)</th>
<th>Scribe Line Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>.015&quot; (0.381)</td>
<td>.0051&quot; (0.13)</td>
</tr>
<tr>
<td>.020&quot; (0.508)</td>
<td>.0067&quot; (0.17)</td>
</tr>
<tr>
<td>.025&quot; (0.635)</td>
<td>.0082&quot; (0.21)</td>
</tr>
<tr>
<td>.030&quot; (0.762)</td>
<td>.0098&quot; (0.25)</td>
</tr>
<tr>
<td>.032&quot; (0.813)</td>
<td>.0102&quot; (0.26)</td>
</tr>
<tr>
<td>.035&quot; (0.889)</td>
<td>.0114&quot; (0.29)</td>
</tr>
<tr>
<td>.040&quot; (1.016)</td>
<td>.0130&quot; (0.33)</td>
</tr>
<tr>
<td>.047&quot; (1.194)</td>
<td>.0157&quot; (0.40)</td>
</tr>
</tbody>
</table>

**Through-Hole**

![Through-Hole Diagram](image)

**Dimensional Tolerance from Scribe Line to Center of Through-hole**

- A, B: ± .002" (±0.050mm)

**Locational Condition of Through-hole**

- a or b > Substrate Thickness
- c > Substrate Thickness

**Contributing to improved LED efficiency, with both high reflectivity and high thermal conductivity**

**High Reflectivity Alumina Substrates**

- Applications:
  - White ceramic substrate with both high reflectivity and high thermal conductivity
  - Reflectivity: 95%
  - Thermal Conductivity: 19W/mk

**Features**

- High level of dimensional accuracy by laser cutting
- Multiple pieces from a larger size substrate

**Reflectivity by Wavelength**

![Reflectivity Graph](image)

**Reflectivity by Substrate Thickness**

![Reflectivity Chart](image)

**For product details, please contact** webmaster.fc@kyocera.jp
Minimized surface defects enable precision thin film printing

- Full Glazing
- Partial Glazing
- Serial Glazing

<table>
<thead>
<tr>
<th>Standard Glazing Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Standard Thickness</td>
</tr>
<tr>
<td>Tolerance</td>
</tr>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>Premium</td>
</tr>
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</table>

Material Characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Condition</th>
<th>GS-5</th>
<th>GS-71</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Transition Temperature</td>
<td>°C</td>
<td>DTA*</td>
<td>670</td>
<td>685</td>
</tr>
<tr>
<td>Glass Softening Temperature</td>
<td>°C</td>
<td>DTA*</td>
<td>865</td>
<td>870</td>
</tr>
<tr>
<td>Coefficient of Linear Thermal Expansion</td>
<td>1/°C</td>
<td>R.T.to 400°C</td>
<td>6.6 × 10⁻⁶</td>
<td>6.8 × 10⁻⁶</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>W/m·k</td>
<td>20°C</td>
<td>0.837</td>
<td>0.754</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20°C</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300°C</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500°C</td>
<td>2.8 × 10⁻⁶</td>
<td>2.1 × 10⁻⁶</td>
</tr>
<tr>
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<td>Ω·cm</td>
<td>20°C</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
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<tr>
<td></td>
<td></td>
<td>300°C</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
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<td>2.8 × 10⁻⁶</td>
<td>2.1 × 10⁻⁶</td>
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<td>Dielectric Constant</td>
<td>–</td>
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<td>7.2</td>
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<tr>
<td>Dielectric Loss Angle</td>
<td>–</td>
<td>1MHz</td>
<td>14.6 × 10⁻⁴</td>
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<td>Surface Roughness</td>
<td>Ra μm</td>
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<td>&lt;0.02</td>
<td>&lt;0.02</td>
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</table>

*Values are typical data from test pieces

*DTA: Differential Thermal Analysis
Heat Dissipation Substrates

Thermal management is increasingly important as electronic devices evolve to realize further downsizing and improved functionality. Kyocera offers heat dissipation substrates to meet customers’ needs by developing high thermal conductive materials, metal jointing technologies, or substrate configurations to improve dissipation efficiency.

- **Surface area increase**
- **Cooling enforcement by coolant**
- **Joining with metal materials**

**Optional**

- Fin Shape
- Flow Channel Structure
- Metallization, Plating, etc.

**Heat Dissipation**

**Plain Ceramic Substrate**

**Alumina Substrate**

**Sapphire Substrate**
Heat Dissipation Structure Ceramic Substrates

Monolithic ceramic structure with no bonding material for long-term reliability

Features

- Cooling or heat exchanging components made of lightweight ceramic with low heat capacity provide a more efficient, energy saving system compared to metal
- Design possibility for thin wall or complex structure
- Long term, efficient cooling and temperature control
- Low maintenance cost due to superior chemical durability
- Applicational exploitation other than cooling or temperature control

Applications

- Heat element coolers / Thermal control components
- Heat exchanger components
- Manifolds
- Micro reactors
- Thermal insulation components

Product Examples

- Heat Element Cooler
- Thermal Control Component

[Images of product examples]

- Ceramic substrate with inner flow channel
- Controlled object
- Heat transfer

For product details, please contact webmaster.fc@kyocera.jp
Design Guideline for Flow Channel Structure

Standard Product Dimensions

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>A Product Thickness</td>
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<tr>
<td>B Channel Height</td>
<td>0.5</td>
<td>10</td>
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<tr>
<td>C Lid Plate Thickness</td>
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<tr>
<td>D Channel Wall Thickness</td>
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<tr>
<td>E Channel Width</td>
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<td>D/E Line &amp; Space</td>
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</tr>
<tr>
<td>B/D Aspect Ratio</td>
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<td>F Maximum Size</td>
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Material Characteristics

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<td>White</td>
<td>White</td>
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<td>Alumina Content</td>
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<td>96</td>
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<td>3.7</td>
<td>3.9</td>
<td>3.1</td>
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<td>Vickers Hardness</td>
<td>GPa</td>
<td>13.9</td>
<td>16.3</td>
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<td>Flexural Strength (3-point Bending)</td>
<td>MPa</td>
<td>380</td>
<td>470</td>
<td>450 (4-point Bending)</td>
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<td>Young’s Modules of Elasticity</td>
<td>GPa</td>
<td>340</td>
<td>380</td>
<td>430</td>
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<tr>
<td>Poisson’s Ratio</td>
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<td>0.23</td>
<td>0.17</td>
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<td>Thermal Conductivity</td>
<td>W/mK</td>
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<td>Specific Heat Capacity</td>
<td>J/(kg·K)</td>
<td>0.78</td>
<td>0.79</td>
<td>0.67</td>
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<td>Coefficient of Linear Thermal Expansion</td>
<td>ppm/K</td>
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<td>7.6</td>
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<td>kV/mm</td>
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<td>18</td>
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<td>Volume Resistivity</td>
<td>RT</td>
<td>&gt;10¹⁴</td>
<td>&gt;10¹⁴</td>
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<tr>
<td></td>
<td>300°C</td>
<td>1.0 x 10¹⁰</td>
<td>4.9 x 10¹⁰</td>
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<tr>
<td></td>
<td>500°C</td>
<td>1.1 x 10⁸</td>
<td>3.5 x 10⁶</td>
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<tr>
<td>Dielectric Loss Angle</td>
<td>1MHz</td>
<td>3.0 x 10⁻⁴</td>
<td>1.0 x 10⁻⁴</td>
<td>–</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>1MHz</td>
<td>9.6</td>
<td>10.2</td>
<td>–</td>
</tr>
</tbody>
</table>

*Other materials can also be considered upon request from prototyping.

*Values are typical data from test pieces.

For product details, please contact webmaster.fc@kyocera.jp
Functional Materials
Dielectric Ceramic Microwave Resonators

Stable temperature property, effective utilization of frequency bands

Features

- High Qf value to realize low dielectric loss of microwave components
- Adjustable $\tau_f$ value
  (from + side to - side, upon request)
- Volume production capability from a few mm to a few hundred-mm sizes
- Design support by providing electromagnetic analysis

Applications

- Filters, duplexers for mobile communication base stations
- LNB (Low Noise Block) for satellite communication
- Band pass filters

Electromagnetic Field Analysis Example
Stable temperature property, effective utilization of frequency bands

**Dielectric Ceramic Microwave Resonators**

- Filters, duplexers for mobile communication base stations
- LNB (Low Noise Block) for satellite communication
- Band pass filters

**Applications**
- High Qf value to realize low dielectric loss of microwave components
- Adjustable $\tau_f$ value (from + side to - side, upon request)
- Volume production capability from a few mm to a few hundred-mm sizes
- Design support by providing electromagnetic analysis

**Features**
- If desired material is not on the list, please feel free to contact us.

### Dielectric Material Characteristics

<table>
<thead>
<tr>
<th>Material Code</th>
<th>A479E</th>
<th>SF210K</th>
<th>SB350</th>
<th>SL390</th>
<th>SV380</th>
<th>SG390</th>
<th>SV440</th>
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<tr>
<td>Dielectric Constant ($\varepsilon$)</td>
<td>9.8</td>
<td>21.5</td>
<td>35</td>
<td>40</td>
<td>39</td>
<td>40</td>
<td>44</td>
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<tr>
<td>Qf Value (GHz)</td>
<td>80,000</td>
<td>70,000</td>
<td>45,000</td>
<td>65,000</td>
<td>40,000</td>
<td>80,000</td>
<td>44,000</td>
</tr>
<tr>
<td>Q Value (1/tan$\delta$) (Measurement frequency)</td>
<td>10,000 (8GHz)</td>
<td>14,000 (5GHz)</td>
<td>11,250 (4GHz)</td>
<td>17,000 (3.8GHz)</td>
<td>10,000 (4GHz)</td>
<td>21,000 (3.8GHz)</td>
<td>12,500 (3.5GHz)</td>
</tr>
<tr>
<td>Temperature Coefficient $\tau_f$ (ppm/°C)</td>
<td>$-3\sim+3$</td>
<td>$0\sim+8$</td>
<td>$-3\sim+8$</td>
<td>$-7\sim+7$</td>
<td>$-3\sim+8$</td>
<td>$-7\sim+8$</td>
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<tr>
<td>Bulk Density (g/cm$^3$)</td>
<td>3.8</td>
<td>3.8</td>
<td>4.8</td>
<td>5.6</td>
<td>5.1</td>
<td>5.6</td>
<td>4.8</td>
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</tbody>
</table>

**Application**
- Resonator 800MHz
- Resonator 1.5-3.5GHz
- Resonator 5-14GHz
- Substrate
- Antenna

*Values are typical data from test pieces.*

* If desired material is not on the list, please feel free to contact us.
Piezoelectric PZT Substrates

PZT: Lead Zirconate Titanate Pb (Zr,Ti) O₃

Piezoelectric ceramic substrate with stable characteristics

Features

• Low voltage actuation with high piezoelectric constant
• High coercive electric field to mitigate piezoelectrical deterioration during high voltage actuation
• Excellent machinability (fine grains / minimal voids)

Applications

• Actuator components (positioning control)
• Various sensors

Design Guideline (mm)

MAX size: 120 × 90
MIN size: 30 × 30
Thickness: 0.1 - 9.0
* Please contact us for more details

Material Characteristics

* Values are typical data from test pieces.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>PZ0750</th>
<th>PZ0801</th>
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<td>Bulk Density</td>
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<td>Piezoelectric Constant (d15)</td>
<td>10⁻¹² m/V</td>
<td>750</td>
<td>900</td>
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<td>Piezoelectric Constant (d31)</td>
<td>10⁻¹² m/V</td>
<td>-230</td>
<td>-190</td>
</tr>
<tr>
<td>Piezoelectric Constant (d33)</td>
<td>10⁻¹² m/V</td>
<td>450</td>
<td>400</td>
</tr>
<tr>
<td>Dielectric Constant (ε₁/ε₀)</td>
<td>–</td>
<td>2400</td>
<td>3000</td>
</tr>
<tr>
<td>Dielectric Constant (ε₃₃/ε₀)</td>
<td>–</td>
<td>1950</td>
<td>2280</td>
</tr>
<tr>
<td>Curie Temperature</td>
<td>°C</td>
<td>310</td>
<td>260</td>
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<tr>
<td>Coercive Electric Field</td>
<td>V/mm</td>
<td>1100</td>
<td>970</td>
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</table>
Pb-free Piezoelectric Elements

Piezoelectric material without lead (Pb) in composition

Features

• Environmentally friendly, lead-free composition
• Stable piezoelectric performance in a wide temperature range due to high Curie temperature
• Significantly smaller hysteresis to control displacement

Applications

• Engine combustion pressure sensors
• High temperature vibration sensors

Available Shapes

• Shapes manufacturable from powder forming process
  ex.: In tablet, cylinder, or cube shapes
  * Values are typical data from test pieces
  Please contact us for detailed specifications such as electrode position.

Material Characteristics

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Typical PZT with Pb</th>
<th>Newly Developed Kyocera Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Characteristics</td>
<td></td>
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</tr>
<tr>
<td>Young's Modulus of Elasticity</td>
<td>GPa</td>
<td>63 - 115</td>
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<tr>
<td>Poisson's Ratio (σₚ)</td>
<td>–</td>
<td>0.30 - 0.37</td>
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<td>Flexural Strength</td>
<td>MPa</td>
<td>85 - 125</td>
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<tr>
<td>Bulk Density</td>
<td>g/cm³</td>
<td>5.6 - 8.0</td>
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<tr>
<td>Electrical Characteristics</td>
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<td></td>
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<tr>
<td>Dielectric Loss Angle @ 1kHz (tanδ)</td>
<td>10⁻³</td>
<td>0.3 - 2.2</td>
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<tr>
<td>Dielectric Constant (ε₃₃/ε₀)</td>
<td>–</td>
<td>800 - 4720</td>
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<tr>
<td>Curie Temperature</td>
<td>°C</td>
<td>150 - 340</td>
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<tr>
<td>Maximum Operational Temperature (Tₘ&gt; )</td>
<td>°C</td>
<td>120 - 230</td>
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<tr>
<td>Piezoelectric Characteristics</td>
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<td>Dynamic d33 (d₃₃)</td>
<td>pC/N</td>
<td>133 - 603</td>
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<tr>
<td>Hysteresis</td>
<td>%</td>
<td>~10</td>
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<tr>
<td>Mechanical Quality Factor (Q₀)</td>
<td>–</td>
<td>80 - 2070</td>
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</table>

** Ball-on-three-balls Test
Inductor Cores

Optimal materials and electrode patterns for customized applications and surface mounting processes

Features

- Core material either in alumina or in ferrite
- Flexible material selections for customized needs (ex. Magnetic permeability, Saturation magnetic flux density, Curie temperature, etc.)
- Accommodation to highly precise, miniaturized designs
- Electrode patterns adjustable to surface mounting process

Electrode Pattern Examples

- Top surface only
- Top + side
- Top + side (tapered)

Material Characteristics

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<thead>
<tr>
<th>Material Code</th>
<th>A476</th>
<th>NZ021A</th>
<th>NZ112H</th>
<th>NZ112A</th>
<th>NZ131A</th>
<th>NZ26C</th>
<th>NZ241A</th>
<th>NZ312B</th>
<th>NZ262B</th>
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<td></td>
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<td></td>
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<tr>
<td>100kHz</td>
<td>1</td>
<td>7</td>
<td>60</td>
<td>65</td>
<td>160</td>
<td>400</td>
<td>490</td>
<td>500</td>
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<td>1MHz</td>
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<td>7</td>
<td>58</td>
<td>65</td>
<td>160</td>
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<tr>
<td>10MHz</td>
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<td>65</td>
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<td>250</td>
<td>300</td>
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<td>Relative Loss Factor (tanδ/μ)</td>
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<td>335</td>
<td>200</td>
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<td>1375</td>
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<td>280</td>
<td>4000</td>
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<td>3200</td>
<td>5000</td>
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<td>Relative Temperature Coefficient (α·μ)</td>
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<td>25-20°C (×10^9)</td>
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<td>–</td>
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<td>380</td>
<td>370</td>
<td>470</td>
<td>250</td>
<td>290</td>
<td>430</td>
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<tr>
<td>–</td>
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<td>230</td>
<td>160</td>
<td>300</td>
<td>120</td>
<td>110</td>
<td>150</td>
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<tr>
<td>Curie Temperature (°C)</td>
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<tr>
<td>–</td>
<td>≥300</td>
<td>≥300</td>
<td>≥300</td>
<td>240</td>
<td>300</td>
<td>150</td>
<td>90</td>
<td>220</td>
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<td>Volume Resistivity (Ω·cm)</td>
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<td>&gt;10^{10}</td>
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<td>10^6</td>
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<td>10^6</td>
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</tr>
</tbody>
</table>

* If desired material is not on the list, please feel free to contact us.
Optimal materials and electrode patterns for customized applications and surface mounting processes.

- Inductor Cores
  - Core material either in alumina or in ferrite
  - Flexible material selections for customized needs (e.g., Magnetic permeability, Saturation magnetic flux density, Curie temperature, etc.)
- Accommodation to highly precise, miniaturized designs
- Electrode patterns adjustable to surface mounting process

**Features**

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Magnetic Permeability</th>
<th>Relative Loss Factor</th>
<th>Saturation Magnetic Flux Density (Bs)</th>
<th>Residual Magnetic Flux Density</th>
<th>Curie Temperature</th>
<th>Volume Resistivity</th>
<th>Relative Temperature Coefficient</th>
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<td>NZ350A</td>
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<td>570</td>
<td>650</td>
<td>860</td>
<td>1100</td>
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<td>1150</td>
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<td>NZ331B</td>
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<td>880</td>
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<td>1500</td>
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<td>NZ421A</td>
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<td>4000</td>
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<td>NZ544A</td>
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<td>20</td>
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<tr>
<td>NZ545A</td>
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<td>20</td>
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<td>NZ546A</td>
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<td>20</td>
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<tr>
<td>NZ547A</td>
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<td>20</td>
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<tr>
<td>NZ548A</td>
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<td>0</td>
<td>20</td>
<td>5</td>
<td>15</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

*Values are typical data from test pieces*
**Inductor Core Shape Examples**

**SQUARE CORE**
- Available in both alumina and ferrite materials
- Suitable for complex shape with tight tolerance
- Edged shape for high speed surface mounting

**CAP CORE**
- Thin wall cap shape suitable for shielded core
- Edged shape for high speed surface mounting
- Low height design possibility together with Push-pin Core
- Please contact us for possible combinations among OD, height, bottom thickness, and wall thickness.

**DR CORE (Edged sleeves & winding core type)**
- Available in both alumina and ferrite materials
- Please contact us for possible combinations among OD, core diameter, height, machinable width, and sleeve thickness.

**PUSHPIN CORE**
- One side sleeve shape suitable for shielded core
- Low height design possibility together with Cap Core

* Tooling structure for volume production may require some design restrictions. Please contact us to finalize feasible dimensions and tolerances.
Device Peripherals

* Tooling structure for volume production may require some design restrictions.

Please contact us to finalize feasible dimensions and tolerances.

**Inductor Core Shape Examples**

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- **PUSHPIN CORE**
  - One side sleeve shape suitable for shielded core
  - Low height design possibility together with Cap Core

For product details, please contact webmaster.fc@kyocera.jp
Sapphire Cover Plates

Surface protection from mechanical stress or friction for display and transparency

The LCD panel or reading indicator of an inspection stage requires a scratch-free protection plate with high optical transparency. Our unique design and polishing capabilities make our single-crystal sapphire into a thin, high-quality cover plate with remarkable hardness and stiffness.

**Features**

- Scratch-free hardness
- Excellent optical transparency
- Bonding technology with glass (sapphire on glass) for large, rigid substrates
- Assembly capability with surface coating or printing

**Scratch Resistance Test**

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubbing each other with pressure</td>
<td>Sapphire No scratch Tempered Glass Scratched</td>
</tr>
</tbody>
</table>

**Optical Transparency**

![Optical Transparency Graph]

**Anti-Reflection Coating (AR Coating)**

![Optical Transparency Chart]

**SOG (Sapphire on Glass)**

Sapphire-on-Glass bonding structure makes the plate both shock-resistant and shatter-resistant.

*Please contact us for available sizes.* *Values are typical properties of each material, and may vary depending on product configurations or manufacturing processes. For more details, please feel to contact us.*
Volume Production Components for Various Electronics

Volume production capability of customized product, in monthly quantity of hundreds of millions per item

Features

- Variety of product configurations
  - Technology to optimize density balance in forming process enables multi-cavity shapes or ultra small components
- Wide selection of ceramics materials
  - Alumina / Silicon Carbide / Ferrite / etc.
- Volume production capability
  - Experience in monthly quantity of hundreds of millions per item
- Please contact us for any specific requirement

Applications

- Insulators for downsized electronic components, or ceramic parts to minimize magnetic / dielectric losses
  (ex.: Used in or as fuses, thermostats, inductor cores, filters for base tranceiver stations, etc.)
Ultra Thin Ceramic Caps

Ultra thin, enabling devices to become smaller in size, lower in height

Features

• Cap in ceramic for smaller size and lower height
• Ultra thin walls, based on Kyocera’s unique material / forming technology

New Ceramic Cap Size

Minimum Wall Thickness Comparison (Compared to our company’s product)

<table>
<thead>
<tr>
<th></th>
<th>Conventional Technology</th>
<th>New Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Wall Thickness</td>
<td>0.24mm</td>
<td>0.12mm</td>
</tr>
<tr>
<td>Top Wall Thickness</td>
<td>0.20mm</td>
<td>0.15mm</td>
</tr>
</tbody>
</table>

* Please contact us for any other sizes.
Ultra thin, enabling devices to become smaller in size, lower in height

**Ultra Thin Ceramic Caps**
- Cap in ceramic for smaller size and lower height
- Ultra thin walls, based on Kyocera’s unique material / forming technology

**Features**
- Side Wall Thickness
- Top Wall Thickness
- Minimum Wall Thickness Comparison (Compared to our company’s product)
  - New Technology: 0.24mm, 0.20mm
  - Conventional Technology: 0.12mm, 0.15mm

**Application Example in Gyro Sensor**
- Miniaturization
- Ultra Thin Ceramic Cap

**Application Example in Crystal Oscillator**
- Lower Height
- Downsizing

**Market for Ultra Thin Ceramic Caps**
- Gyro Sensors
- Accelerometers
- Magnetic Sensors
- Fuses
- Surge Absorbers
- Oscillation Modules
- Crystal Oscillators
- SAW Devices
- Sensors
- Security Parts
- Quartz Components

For product details, please contact webmaster.fc@kyocera.jp
High Voltage-resistant Alumina Ceramic (AH100A)

Possibility of 50% downsizing, with 1.6 times higher voltage resistance than conventional ceramic (based on Kyocera simulation)

Features

- Improvement of dielectric strength / creeping voltage resistance in vacuum atmosphere
- Conditioning time reduction at high voltage operation
- Ripple reduction
- 50% downsizing from conventional alumina (based on Kyocera simulation)

Applications

- High Voltage Accelerators (Analysis Equipment)
- Ultra High Vacuum Feedthroughs (Semiconductor Processing Tools)
- Electron Beam Generators (Medical or Industrial X-ray Tubes)

Conditioning Time

Measuring Conditions: Pressure $\leq 10^{-3}\text{Pa}$
Voltage Increase 1kV/min.
Restarted from 0V every time flashover voltage is observed

Volume: 50% reduction
Weight: 55% reduction
Possibility of 50% downsizing, with 1.6 times higher voltage resistance than conventional ceramic (based on Kyocera simulation)

High Voltage-resistant Alumina Ceramic

Improvement of dielectric strength / creeping voltage resistance in vacuum atmosphere

Conditioning time reduction at high voltage operation

Ripple reduction

50% downsizing from conventional alumina (based on Kyocera simulation)

Features

- Ultimate Field Intensity
- Dielectric Strength
- Volume Resistivity
- Dielectric Constant (1MHz)
- Dielectric Loss Angle (1MHz)
- Average Strength
- ASTM D2442 TYPE3
- Young’s Modulus of Elasticity
- Poisson’s Ratio
- Fracture Toughness
- Thermal Conductivity
- Coefficient of Linear Thermal Expansion (RT-800°C)

Material Characteristics & Measurement Comparison

(Reference Data)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>A479 (Conventional Alumina)</th>
<th>AH100A (High Voltage Resistant Alumina)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Field Intensity</td>
<td>MV/m</td>
<td>8.4 (ave.)</td>
<td>14.1 (ave.)</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>MV/m</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>Volume Resistivity</td>
<td>Ω·cm</td>
<td>≥ 1 × 10¹⁴</td>
<td>≥ 1 × 10¹⁴</td>
</tr>
<tr>
<td>Dielectric Constant (1MHz)</td>
<td>–</td>
<td>9.9</td>
<td>10.2</td>
</tr>
<tr>
<td>Dielectric Loss Angle (1MHz)</td>
<td>–</td>
<td>1 × 10⁴</td>
<td>&lt; 1 × 10⁴</td>
</tr>
<tr>
<td>Average Strength ASTM D2442 TYPE3</td>
<td>MPa</td>
<td>310</td>
<td>330</td>
</tr>
<tr>
<td>Young’s Modulus of Elasticity</td>
<td>GPa</td>
<td>360</td>
<td>380</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>–</td>
<td>0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>Fracture Toughness</td>
<td>MPa·m¹/²</td>
<td>3~4</td>
<td>5</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>W/mK</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>Coefficient of Linear Thermal Expansion</td>
<td>ppm/K</td>
<td>8.0</td>
<td>8.2</td>
</tr>
</tbody>
</table>
# Characteristics of Kyocera’s Fine Ceramics

The term "Fine Ceramics" is interchangeable with "advanced ceramics," "technical ceramics" and "engineered ceramics." Use varies by region and industry.

<table>
<thead>
<tr>
<th>Material</th>
<th>Aluminum Oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Al₂O₃)</td>
</tr>
<tr>
<td>Kyocera No.</td>
<td></td>
</tr>
<tr>
<td>A459</td>
<td>A445</td>
</tr>
<tr>
<td>A473</td>
<td>A476</td>
</tr>
<tr>
<td>A479</td>
<td>A479S</td>
</tr>
<tr>
<td>A479M / A479G</td>
<td>A480S</td>
</tr>
</tbody>
</table>

## Appearance

- **Dense**
- **Strong**
- **Good for Metallizing**
- **High Temperature Strength**
- **High Wear Resistance**
- **High Chemical Resistance**
- **High Fracture Resistance**
- **Good Surface Finish**
- **High Purity**
- **High Strength**
- **Good Anti-Flame**
- **Good Light Shield**
- **High Electrical Insulation**
- **High Conductivity**
- **High Transparency**

## Main Characteristics

- **Good for Metallizing**
- **Light Interceptive**
- **High Heat Dissipation**
- **Display Substrates**
- **Transistor Substrates**
- **Mechanically Strong**
- **Good Surface Smoothness**
- **Good for Printing**
- **Hard**
- **High Chemical Resistance**
- **Wear Resistance**
- **Chemically Resistant Parts**
- **Chemical Processing Equipment Parts**
- **Resistor Cores**
- **Molten Metal Parts**
- **Anti-wear Liners**
- **Wear Resistance**
- **Various Circuit Parts**
- **Resistant Parts**
- **Electron-tube Parts**
- **IC Multilayer Parts**
- **Substrates**
- **IC Packages**
- **Thin Film Substrates**
- **Heat Dissipation Substrates**
- **Functional Materials**
- **Device Peripherals**

## Main Applications

- **Magnetron**
- **IC Packages**
- **IC Multilayer Packages**
- **Electron-tube Housing**
- **Wear Resistant Parts**
- **Chemically Resistant Parts**
- **Chemical Processing Equipment Parts**
- **Resistor Cores**
- **Molten Metal Parts**
- **Anti-wear Liners**
- **Wear Resistance**
- **Various Circuit Parts**
- **Resistant Parts**
- **Electron-tube Parts**
- **IC Multilayer Parts**
- **Substrates**
- **IC Packages**
- **Thin Film Substrates**
- **Heat Dissipation Substrates**
- **Functional Materials**
- **Device Peripherals**

## Material Properties

- **Vickers Hardness**
- **Compressive Strength**
- **Young’s Modulus of Elasticity**
- **Poisson’s Ratio**
- **Fracture Toughness (SEPB)**
- **Coefficient of Linear Thermal Expansion**
- **Thermal Conductivity**
- **Specific Heat Capacity**
- **Thermal Shock Temperature Difference**
- **Dielectric Strength**
- **Volume Resistivity**
- **Dielectric Constant**
- **Dielectric Loss Angle**
- **Loss Factor**
- **Nitric Acid (60%) 90 °C, 1day**
- **Nitric Acid (60%) 90 °C, 1day**
- **Sulphuric Acid (95%) 95 °C, 1day**
- **Caustic Soda (30%) 80 °C, 1day**

*The values are typical material properties and may vary according to products configuration and manufacturing process. For more details, please feel free to contact us.*
<table>
<thead>
<tr>
<th>Ceramic Substrates</th>
<th>Heat Dissipation Substrates</th>
<th>Functional Materials</th>
<th>Device Peripherals</th>
</tr>
</thead>
<tbody>
<tr>
<td>For more details, please feel free to contact us.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mechanical Characteristics
- **Poisson's Ratio**
- **Compressive Strength**
- **Flexural Strength (3 P.B.)**
- **Water Absorption**

### Thermal Characteristics
- **Dielectric Strength**
- **(Put in Water, Relative Method)**
- **Dielectric Loss Angle**
- **Volume Resistivity**
- **(95%) 95 °C,1day**
- **500 °C**
- **300 °C**
- **(1MHz)**

### Electrical Characteristics
- **Wt Loss**
- **KV/mm**
- **mg/cm²**
- **×10⁻⁴**
- **GPa**
- **JIS C2141**
- **JIS R1611**
- **JIS R1618**
- **JIS R1607**
- **JIS R1602**
- **JIS R1608**

### Chemical Characteristics
- **Caustic Soda**
- **Dielectric Loss Angle**
- **Volume Resistivity**
- **(95%) 95 °C,1day**
- **500 °C**
- **300 °C**
- **(1MHz)**

### Functional Materials
- **Metallizing**
- **Russet**
- **Dark Brown**
- **White**
- **Ivory**

### Device Peripherals
- **Windows**
- **High Frequency**
- **Insulator**
- **Heat Uniformity Parts**
- **Molten Metal Parts**
- **High Temperature Strength**

### Ceramic Substrates
- **Sapphire**
  - (Al₂O₃)
- **Steatite**
  - (MgO·SiO₂)
- **Forsterite**
  - (2MgO·SiO₂)
- **Silicon Nitride**
  - (Si₃N₄)
- **Aluminum Nitride**
  - (AIN)
- **Zirconia**
  - (ZrO₂)

### Properties of Kyocera's Fine Ceramics

### For more details, please feel free to contact us.

---

1 kgf/mm² = 9.807 MPa
1 cal/g °C = 4.187 J/g °K = 4.187 x 10³ J/(kg x °K)
Process Flow from Inquiry to Delivery

STEP 1 Inquiry

Please provide as much information as possible about your product and requirements

• Drawing(s) or description of required shape
• Operating Conditions / Application
• Quantity
• Delivery Request
• Other requests or issues

STEP 2 Proposal / Quotation

We will provide you with our proposal for a product that meets your requirements

STEP 3 Purchase Order

Production will begin according to the agreed-upon specifications and terms

STEP 4 Production

STEP 5 Delivery

Even in cases that require special development, we can support your project

E-mail Inquiries
webmaster.fc@kyocera.jp

Telephone / FAX Inquiries
Local contact info on the back page

Please feel free to send us an e-mail in case you cannot find our local contact

global.kyocera.com/prdct/fc/index.html
Corporate Profile

Corporate Summary
(Total companies and employees as of March 31, 2017)

Company name: KYOCERA Corporation
Established: April 1, 1959
Capital: 115,703 million yen
Group companies: 231 (Including KYOCERA Corporation)
Group employees: 70,153

Consolidated Sales by Segment
(Year ended March 31, 2017)

Industrial & Automotive Components 16.2%
Fine Ceramic Components
Automotive Components Displays
Cutting Tools
Optical Components

Semiconductor Components 17.3%
Ceramic Packages & Substrates
Organic Materials
Organic Packages & Printed Wiring Boards

Electronic Devices 16.9%
Capacitors
SAW Devices
Power Devices
Crystal Devices
Connectors
Printing Devices

Communications 17.7%
Smartphones
Feature Phones
Tablets
IoT Modules
Information Systems & Telecommunication Services

Document Solutions 22.8%
Printers & Multifunctional Products
Solutions Busines

Life & Environment 10.5%
Solar Energy
Medical and Dental Products
Jewelry & Kitchen Tools, etc

Total Components Business 50.4%

Total Equipment & Systems Business 51.0%

Others & Adjustments and eliminations △1.4%

Consolidated Sales by Region
(Year ended March 31, 2017)

Europe 235,355 million yen (16.5%)
Asia 304,013 million yen (21.4%)
Japan 598,639 million yen (42.1%)
U.S.A. 228,968 million yen (16.1%)
Others 55,779 million yen (3.9%)