# Ceramic - Chemical Resistance

<table>
<thead>
<tr>
<th></th>
<th>Acids - concentrated</th>
<th>Acids - dilute</th>
<th>Alkalis</th>
<th>Halogens</th>
<th>Metals</th>
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</thead>
<tbody>
<tr>
<td>Alumina/Silica/Boria</td>
<td>Fair</td>
<td>Good</td>
<td>Poor-Fair</td>
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<td>Good</td>
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<tr>
<td>$\text{Al}_2\text{O}_3$ (32)/$\text{SiO}_2$ (24)/$\text{B}_2\text{O}_3$ (14)</td>
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<td>$\text{SiO}_2$ (57)/$\text{Al}_2\text{O}_3$ (36)/$\text{CaO}$/$\text{MgO}$/ $\text{BaO}$</td>
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<tr>
<td>Aluminum Nitride - Machinable</td>
<td>Fair</td>
<td>Poor</td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>AlN / BN</td>
<td></td>
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<tr>
<td>Aluminum Nitride AlN</td>
<td>Poor</td>
<td>Fair</td>
<td>Fair</td>
<td>-</td>
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<tr>
<td>Beryllia BeO 99.5</td>
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<td>Boron Carbide - Hot-pressed $\text{B}_4\text{C}$</td>
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<td>$\text{SiO}_2$ (50)/$\text{ZrSiO}_4$ (40)/$\text{Al}_2\text{O}_3$ (10)</td>
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<td>Magnesium Oxide MgO</td>
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<td>Potassium Aluminosilicate Muscovite Mica</td>
<td>Fair</td>
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<td>Good</td>
<td>-</td>
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<td>Quartz - Fused $\text{SiO}_2$</td>
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<td>Good</td>
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<td>Good</td>
<td>Good</td>
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<td>Sapphire</td>
<td>$\text{Al}_2\text{O}_3$ 99.9</td>
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<td>Silicon Carbide - Hot-pressed $\text{SiC}$</td>
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<td>Good-Poor</td>
<td>Good-Poor</td>
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<td>Good</td>
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<td>Fair</td>
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<td>Good</td>
<td>Good-Poor</td>
<td>Good</td>
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<thead>
<tr>
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<th>Acids - concentrated</th>
<th>Acids - dilute</th>
<th>Alkalis</th>
<th>Halogens</th>
<th>Metals</th>
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<tbody>
<tr>
<td><strong>Silicon Nitride - Reaction Bonded</strong> Si₃N₄</td>
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<td><strong>Silicon Nitride/Aluminum Nitride/Aluminum Oxide Sialon</strong></td>
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<td>Fair</td>
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<tr>
<td><strong>Titanium Diboride</strong> TiB₂</td>
<td>Fair</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
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<td><strong>Titanium Dioxide</strong> TiO₂ 99.6%</td>
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<td>Good</td>
<td>Poor</td>
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<td>Poor</td>
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<tr>
<td><strong>Zirconia - stabilized with Magnesia ZrO₂/MgO</strong></td>
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<td>Good</td>
<td>Good-Poor</td>
<td>Fair</td>
<td>Good-Fair</td>
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<table>
<thead>
<tr>
<th>Material Description</th>
<th>Dielectric constant</th>
<th>Dielectric strength kV mm⁻¹</th>
<th>Volume resistivity Ohmcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina/Silica/Boria</td>
<td>5.2 @ 9.4GHz</td>
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<td>-</td>
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<tr>
<td>Alumina/Silica/Boria</td>
<td>5.7 @ 9.4GHz</td>
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<td>Alumina /SiO₂ 28/B2O₃ 2</td>
<td>9.0-10.1</td>
<td>10-35</td>
<td>&gt;10¹⁴ @25C</td>
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<td>Aluminum Nitride - Machinable (BNP-2) AIN / BN</td>
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<tr>
<td>Aluminum Nitride - Machinable AIN / BN</td>
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<td>40</td>
<td>1.8 x 10¹³ @25C</td>
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<tr>
<td>Aluminum Nitride AIN</td>
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<td>35</td>
<td>&gt;10¹⁴ @25C</td>
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<tr>
<td>Beryllia BeO 99.5</td>
<td>6.5-7.5</td>
<td>10-14</td>
<td>&gt;10¹⁴ @25C</td>
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<tr>
<td>Boron Carbide - Hot-pressed B₄C</td>
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<td>-</td>
<td>0.1-10 @25C</td>
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<tr>
<td>Boron Nitride BN</td>
<td>4.3</td>
<td>40-200</td>
<td>10¹ⁱ-10¹⁰ @25C</td>
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<tr>
<td>Potassium Aluminosilicate Muscovite Mica</td>
<td>6.0-6.6</td>
<td>40-200</td>
<td>10¹⁵ @25C</td>
</tr>
<tr>
<td>Quartz - Fused SiO₂</td>
<td>3.8</td>
<td>25-40</td>
<td>10¹⁴ @25C</td>
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<tr>
<td>Ruby Al₂O₃/Cr₂O₃ /Si₂O₃</td>
<td>7.5-11.5</td>
<td>15-50</td>
<td>10¹⁵ @25C</td>
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<tr>
<td>Sapphire Al₂O₃ 99.9</td>
<td>7.5-11.5</td>
<td>15-50</td>
<td>&gt;10¹⁴ @25C</td>
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<tr>
<td>Silicon Carbide - Hot-pressed SiC</td>
<td>40</td>
<td>-</td>
<td>10⁻¹⁰⁻¹ @25C</td>
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<td>Silicon Carbide - Reaction Bonded SiC</td>
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<td>-</td>
<td>10⁻¹⁰⁻¹ @25C</td>
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<tr>
<td>Silicon Nitride - Hot-pressed Si₃N₄</td>
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<td>10⁻¹⁰⁻¹ @25C</td>
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<td>Silicon Nitride - Reaction Bonded Si₃N₄</td>
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<td>&gt;10⁻¹ @25C</td>
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## Ceramic - Electrical Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Dielectric constant</th>
<th>Dielectric strength kV mm(^{-1})</th>
<th>Volume resistivity Ohmcm</th>
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<tbody>
<tr>
<td>Silicon Nitride/Aluminum Nitride/Aluminum Oxide Sialon</td>
<td>-</td>
<td>-</td>
<td>10(^{15})-10(^{17}) @25C</td>
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<tr>
<td>Titanium Diboride TiB(_2)</td>
<td>-</td>
<td>-</td>
<td>15x10(^{-9}) @25C</td>
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<tr>
<td>Titanium Dioxide TiO(_2) 99.6%</td>
<td>80-100</td>
<td>-</td>
<td>10(^{13})-10(^{15}) @25C</td>
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<tr>
<td>Tungsten Carbide/Cobalt WC 94/Co 6</td>
<td>-</td>
<td>-</td>
<td>2x10(^{-8}) @25C</td>
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<table>
<thead>
<tr>
<th>Material</th>
<th>Compressive strength MPa</th>
<th>Fracture toughness MPam(0.5)</th>
<th>Hardness - Knoop kgf mm²</th>
<th>Hardness - Vickers kgf mm²</th>
<th>Poisson's ratio</th>
<th>Shear strength MPa</th>
<th>Tensile modulus GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina/Silica/Boria Al₂O₃/SiO₂/B₂O₃ 14</td>
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<td>Alumina/Silica/Boria Al₂O₃/SiO₂/B₂O₃ 25</td>
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<td>2100</td>
<td>1500-1650</td>
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<td>300-400</td>
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<td>34.1 (parallel)</td>
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<td>Beryllia BeO 99.5</td>
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<td>1100</td>
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<td>180-250</td>
<td>340-400</td>
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<td>2800-3500</td>
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<td>12-25</td>
<td>20-35</td>
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<td>70</td>
<td>72-74</td>
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<td>2500-3000</td>
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<td>2000</td>
<td>1600-1800</td>
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<td>2400-2800</td>
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<td>210-380</td>
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<td>2500-3500</td>
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<td>Material Description</td>
<td>Compressive strength MPa</td>
<td>Fracture toughness MPa(0.5)</td>
<td>Hardness - Knoop kgf mm⁻²</td>
<td>Hardness - Vickers kgf mm⁻²</td>
<td>Poisson’s ratio</td>
<td>Shear strength MPa</td>
<td>Tensile modulus GPa</td>
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<td>Silicon Nitride - Gas Pressure Sintered Si₃N₄</td>
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<td>800-1000</td>
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<td>190-240</td>
<td>170-220</td>
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<td>Silicon Nitride/Aluminum Nitride/Aluminum Oxide Sialon</td>
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<td>1650-1800</td>
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<td>280-300</td>
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<td>0.18-0.20</td>
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<td>Titanium Dioxide TiO₂ 99.6%</td>
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<td>1250</td>
<td>-</td>
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<td>200</td>
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## Ceramic - Physical Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Apparent porosity</th>
<th>Density g cm⁻³</th>
<th>Refractive index</th>
<th>Useful optical transmission range</th>
<th>Water absorption - saturation %</th>
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<tbody>
<tr>
<td>Alumina/Silica/Boria Al₂O₃ 62/SiO₂ 24/B₂O₃ 14</td>
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<td>1.57</td>
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<td>1.62</td>
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<td>Alumina Al₂O₃ 99.5</td>
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<td>3.89</td>
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<tr>
<td>Alumino-silicate Glass SiO₂ 57/Al₂O₃ 36/CaO/MgO/BaO</td>
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<td>1.54</td>
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<td>500-3000nm</td>
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<td>Leachable Ceramic SiO₂ 50/ZrSiO₀.40/Al₂O₃ 10</td>
<td>25</td>
<td>2.1</td>
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<td>3.40</td>
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<tr>
<td>Potassium Alumino-silicate Muscovite Mica</td>
<td>-</td>
<td>2.6-3.2</td>
<td>1.5-1.6</td>
<td>450-700nm</td>
<td>Very Low</td>
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<tr>
<td>Quartz - Fused SiO₂</td>
<td>0</td>
<td>2.2</td>
<td>1.46</td>
<td>180-2500nm</td>
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<tr>
<td>Ruby Al₂O₃ /Cr₂O₃ /Si₂O₃</td>
<td>0</td>
<td>3.98</td>
<td>-</td>
<td>150-5500nm</td>
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</table>

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<table>
<thead>
<tr>
<th>Material Description</th>
<th>Apparent porosity</th>
<th>Density $g/cm^3$</th>
<th>Refractive index</th>
<th>Useful optical transmission range</th>
<th>Water absorption - saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapphire $Al_2O_3$, 99.9%</td>
<td>0</td>
<td>3.985</td>
<td>1.71-1.79</td>
<td>200-5500nm</td>
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<tr>
<td>Silicon Carbide - Hot-pressed SiC</td>
<td>0</td>
<td>3.15</td>
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<td>Silicon carbide/Silica/Alumina/Magnesia $SiC 90/SiO_2 7/Al_2O_3 1.5/MgO 1.5$</td>
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<td>0.55</td>
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<td>3.2</td>
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<td>-</td>
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</tr>
<tr>
<td>Silicon Nitride - Gas Pressure Sintered $Si_3N_4$</td>
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<td>3.24</td>
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<td>Silicon Nitride - Hot-pressed $Si_3N_4$</td>
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<td>Silicon Nitride - Reaction Bonded $Si_3N_4$</td>
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<td>2.4</td>
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<td>Silicon Nitride/Aluminum Nitride/Aluminum Oxide Sialon</td>
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<td>3.24</td>
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<td>Silicon Nitride $Si_3N_4$</td>
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<td>1.6</td>
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<td>Superwool® Silica/Caia/Magnesia</td>
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<td>0.21</td>
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<td>Titanium Diboride $TiB_2$</td>
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<tr>
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<td>Yttrium Oxide $Y_2O_3$</td>
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<td>5.03</td>
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<td>Zirconia - stabilized with Magnesia $ZrO_2/MgO$</td>
<td>0</td>
<td>5.74</td>
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<table>
<thead>
<tr>
<th></th>
<th>Apparent porosity %</th>
<th>Density g cm⁻³</th>
<th>Refractive index</th>
<th>Useful optical transmission range</th>
<th>Water absorption - saturation %</th>
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</thead>
<tbody>
<tr>
<td>Zirconia - stabilized with Yttria ZrO₂/Y₂O₃</td>
<td>-</td>
<td>5.9</td>
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<td>Zirconia - unstabilized ZrO₂ 99</td>
<td>-</td>
<td>6.1</td>
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### Ceramic - Thermal Properties

<table>
<thead>
<tr>
<th>Ceramic</th>
<th>Coefficient of thermal expansion x10^-6 K</th>
<th>Melting point °C</th>
<th>Specific heat J K^-1 kg^-1</th>
<th>Sublimation point °C</th>
<th>Thermal conductivity W m^-1 K^-1</th>
<th>Upper continuous use temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina/Silica/Boria Al2O3 62/SiO2 24/B2O3 14</td>
<td>3 @20-1000C</td>
<td>-</td>
<td>1100 @25C</td>
<td>1800</td>
<td>-</td>
<td>1200-1400</td>
</tr>
<tr>
<td>Alumina/Silica/Boria Al2O3 70/SiO2 28/B2O3 2</td>
<td>5 @20-1000C</td>
<td>-</td>
<td>1000 @500C</td>
<td>1800</td>
<td>-</td>
<td>1350-1650</td>
</tr>
<tr>
<td>Alumina/Silica Al2O3 80/SiO2 20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1600</td>
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<tr>
<td>Alumina Al2O3</td>
<td>8.0 @20-1000C</td>
<td>2100</td>
<td>850-900 @25C</td>
<td>-</td>
<td>26-35 @20C</td>
<td>1700</td>
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<tr>
<td>Alumina Al2O3</td>
<td>8.3 @20-1000C</td>
<td>-</td>
<td>850 @25C</td>
<td>-</td>
<td>26.0 @20C</td>
<td>1800</td>
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<tr>
<td>Alumino-silicate Glass SiO2 57/Al2O3 36/CaO/MgO/BaO</td>
<td>5 @20-1000C</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>900</td>
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<tr>
<td>Aluminum Nitride - Machinable (BNP-2) AlN / BN</td>
<td>5.1 @23-800C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>92 @25C</td>
<td>1000 (air)</td>
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<tr>
<td>Aluminum Nitride - Machinable AlN / BN</td>
<td>5.2 @20-1000C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100 @20C</td>
<td>1000-1900</td>
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<tr>
<td>Aluminum Nitride AlN</td>
<td>4.4 @20-1000C</td>
<td>2200</td>
<td>800 @25C</td>
<td>2500</td>
<td>175 - 190 @20C</td>
<td>1000-1800</td>
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<tr>
<td>Beryllia BeO 99.5</td>
<td>8.4-9.0 @20-1000C</td>
<td>-</td>
<td>1020-1120 @25C</td>
<td>-</td>
<td>260-300 @20C</td>
<td>1800-1900</td>
</tr>
<tr>
<td>Boron Carbide - Hot-pressed B4C</td>
<td>5.6 @20-1000C</td>
<td>2450</td>
<td>950 @25C</td>
<td>-</td>
<td>30-90 @20C</td>
<td>600-800</td>
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<tr>
<td>Boron Carbide B4C</td>
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<td>2450</td>
<td>-</td>
<td>-</td>
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<td>600-800</td>
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<tr>
<td>Boron Nitride BN</td>
<td>1.0-36 @20-1000C</td>
<td>-</td>
<td>800-2000 @25C</td>
<td>2600-2800</td>
<td>15-50 @20C</td>
<td>950-2500</td>
</tr>
<tr>
<td>Leachable Ceramic SiO2 50/ZrSiO4 40/Al2O3 10</td>
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<tr>
<td>Magnesium Oxide MgO</td>
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<tr>
<td>Potassium Alumino-silicate Muscovite Mica</td>
<td>9.36-20-1000C</td>
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<td>50 @25C</td>
<td>-</td>
<td>0.5-7 @20C</td>
<td>500-600</td>
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<tr>
<td>Quartz - Fused SiO2</td>
<td>0.54 @20-1000C</td>
<td>1715</td>
<td>670-740 @25C</td>
<td>-</td>
<td>1.46 @20C</td>
<td>1100-1400</td>
</tr>
<tr>
<td>Ruby Al2O3/Cr2O3/SiO2</td>
<td>5.8 @20-1000C</td>
<td>2050</td>
<td>750 @25C</td>
<td>-</td>
<td>35-40 @20C</td>
<td>1800-1950</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Material / Composition</th>
<th>Coefficient of thermal expansion x10^{-6} K</th>
<th>Melting point °C</th>
<th>Specific heat J K^{-1} kg^{-1}</th>
<th>Sublimation point °C</th>
<th>Thermal conductivity W m^{-1} K^{-1}</th>
<th>Upper continuous use temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapphire Al₂O₃ 99.9</td>
<td>5.8 @20-1000C</td>
<td>2050</td>
<td>750 @25C</td>
<td>-</td>
<td>35-40 @20C</td>
<td>1800-1950</td>
</tr>
<tr>
<td>Silicon Carbide - Hot-pressed SiC</td>
<td>4.5 @20-1000C</td>
<td>2650-2950</td>
<td>670-710 @25C</td>
<td>-</td>
<td>90-160 @20C</td>
<td>1500-1650</td>
</tr>
<tr>
<td>Silicon Carbide - Reaction Bonded SiC</td>
<td>4.3-4.6 @20-1000C</td>
<td>-</td>
<td>1100 @25C</td>
<td>-</td>
<td>150-200 @20C</td>
<td>1350</td>
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<tr>
<td>Silicon carbide/Silica/Alumina/Magnesia SiC 90/SiO₂/7/Al₂O₃ 1.5/MgO 1.5</td>
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<td>2650-2950</td>
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<tr>
<td>Silicon Nitride - Gas Pressure Sintered Si₃N₄</td>
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<td>-</td>
<td>-</td>
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<td>25</td>
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</tr>
<tr>
<td>Silicon Nitride - Hot-pressed Si₃N₄</td>
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<td>680-800 @25C</td>
<td>1900</td>
<td>15-43 @20C</td>
<td>1100-1650</td>
</tr>
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<td>690 @25C</td>
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<td>10-16 @20C</td>
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<td>620-710 @25C</td>
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<td>20 @20C</td>
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<td>1900</td>
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<td>Titanium Diboride TiB₂</td>
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<td>50-70 @20C</td>
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<td>2.5-5.0 @20C</td>
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<tr>
<td>Tungsten Carbide/Cobalt WC 94/Co 6</td>
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<td>200-480 @25C</td>
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<td>8-12 @20C</td>
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<td>Zirconia - stabilized with Magnesia ZrO₂/MgO</td>
<td>5-10 @20-1000C</td>
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<td>400-500 @25C</td>
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<td>1.5-2.5 @20C</td>
<td>1000</td>
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<tr>
<td>Ceramics</td>
<td>Coefficient of thermal expansion $\times 10^{-6} , \text{K}^{-1}$</td>
<td>Melting Point $^\circ \text{C}$</td>
<td>Specific Heat $\text{J} , \text{K}^{-1} , \text{kg}^{-1}$</td>
<td>Sublimation Point $^\circ \text{C}$</td>
<td>Thermal Conductivity $\text{W} , \text{m}^{-1} , \text{K}^{-1}$</td>
<td>Upper Continuous Use Temperature $^\circ \text{C}$</td>
</tr>
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<td>--------------------------------</td>
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<td>---------------------------------</td>
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<td>Zirconia - stabilized with Yttria $\text{ZrO}_2/\text{Y}_2\text{O}_3$</td>
<td>10 @20-1000°C</td>
<td>2700</td>
<td>400-500 @25°C</td>
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<td>2200</td>
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