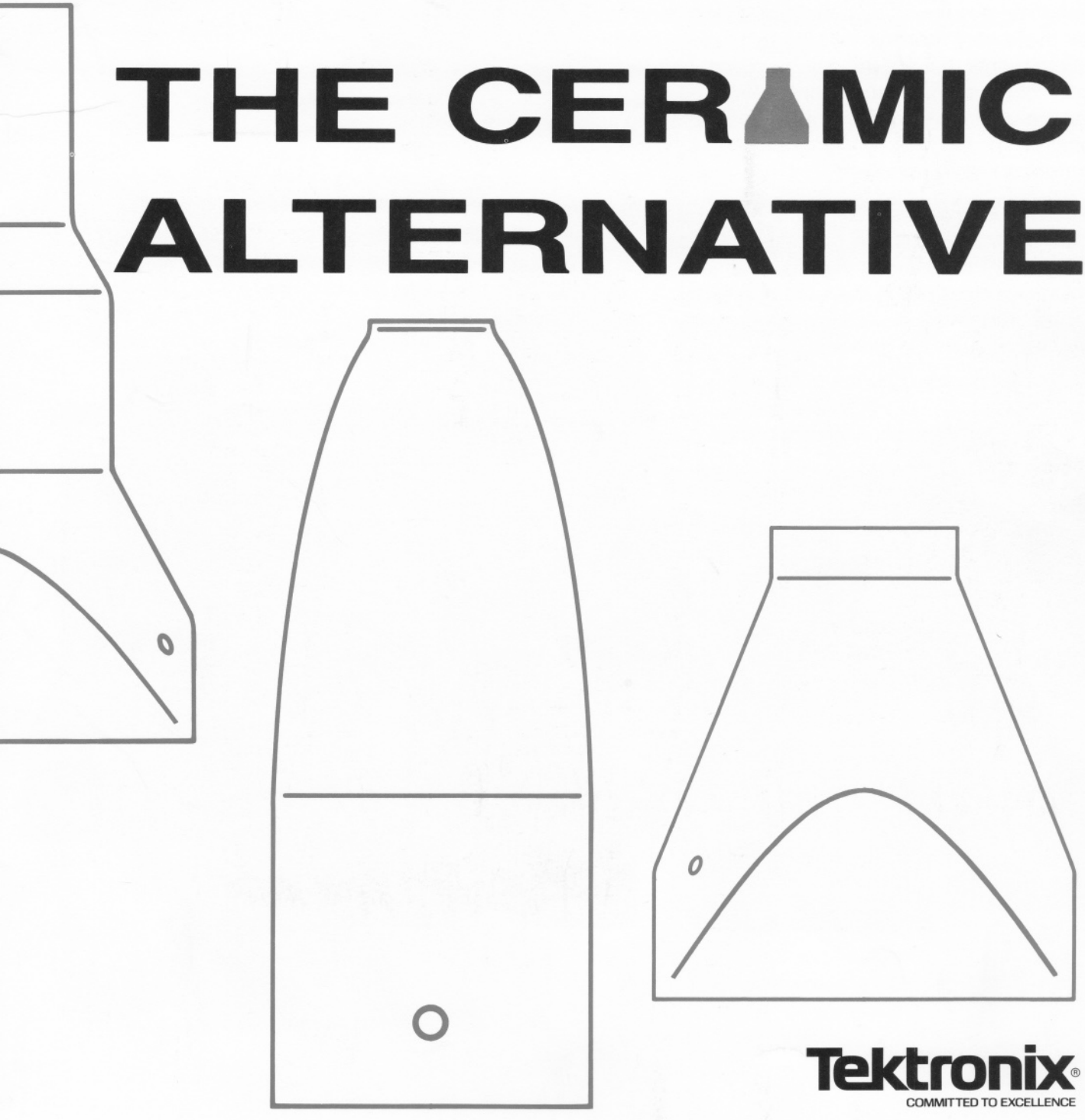
# THE CERAMIC ALTERNATIVE



Tektronix®
COMMITTED TO EXCELLENCE

# Multilayer Ceramic Packaging Material Characteristics

| Item | Units | 96% $AL_2O_3$ (High Fire) | Glass/Ceramic (Low Fire) |
|---|---|---|---|
| Color | | White | White |
| Alumina Content | % | 96 | 25 |
| Specific Gravity | $g/cm^3$ | 3.73 | 2.56 |
| **Electrical** | | | |
| Dielectric Constant (1 MHz) | | 9.6 | ~~5.4~~ 5.8 |
| Dissipation Factor (1 MHz) | ($\times 10^{-4}$) | 15 | 16 |
| Dielectric Strength | Volts/mils | 550 | 808 |
| Volume Resistivity (20°C) | Ohm·cm | $>10^{14}$ | $>10^{14}$ |
| (300°C) | Ohm·cm | $1.4\times10^{11}$ | $1.8\times10^{10}$ |
| (500°C) | Ohm·cm | $7.9\times10^{8}$ | $1.3\times10^{8}$ |
| **Thermal** | | | |
| Coefficient of Thermal Expansion (25–500°C) | ($\times10^{-6}$/°C) | 7.2 | 4.6 |
| Thermal Conductivity (20°C) | Watt/meter·°K | 23 | 2 |
| **Mechanical** | | | |
| Hardness | R45N | 81 | |
| Flexural Strength | PSI | 60,000 | 20,000 |
| Compressive Strength | PSI | 320,000 | |
| Tensile Strength | PSI | 27,000 | |

# Heat Sink Materials Thermal Properties

| Material | Composition by Weight (%) Tungsten | Copper | Nickel | Thermal Coefficient of Expansion 25–400°C (ppm) | Thermal Conductivity (Cal/cm sec·°C) |
|---|---|---|---|---|---|
| Tungsten Copper Nickel | 90 | 8 | 2 | 6.89 | 0.45 |
| Tungsten Copper Nickel | 80 | 18 | 2 | 8.52 | 0.52 |
| Alumina 96% | N/A | N/A | N/A | 7 | 0.05 |
| *BeO (99.5%) | N/A | N/A | N/A | 7.5 | 0.6 |
| *Aluminum | N/A | N/A | N/A | 23 | 0.53 |

* Tektronix does not manufacture BeO or Aluminum (included for reference purposes only).

# Alumina Ceramics
# Physical and Electrical Properties

| Properties | | Units | Alumina | | |
|---|---|---|---|---|---|
| Alumina Content | | % | 90 | 90 | 96 |
| Specific Gravity | | $g/cm^3$ | 3.75 | 3.51 | 3.71 |
| Hardness | Rockwell | R45N | 78 | 76 | 81 |
| Surface Finish | As Fired | Microinches | 26 | 24 | 24 |
| Crystal Size | Average | Micrometers | 3 | 3 | 4 |
| Water Absorption | | | None | None | None |
| Gas Permeability | | | None | None | None |
| Color | | | Black | White | White |
| Compressive Strength | 25°C | KPSI | 340 | 380 | 405 |
| Flexural Strength | 25°C | KPSI | 37 | 37 | 41 |
| Tensile Strength | 25°C | KPSI | 22 | 24 | 25 |
| Modulus of Elasticity | | $10^6$ PSI | 45 | 39 | 48 |
| Shear Modulus | | | 17 | 16 | 20 |
| Poisson's Ratio | | $10^6$ PSI | 0.30 | 0.24 | 0.21 |
| Max. Use Temperature | No Load | °C | 1450 | 1525 | 1610 |
| Coefficient of Linear Thermal Expansion | 25–500°C | $10^{-6}$/°C | 7.4 | 7.1 | 7.2 |
| Thermal Conductivity | 20°C | Cal/cm·sec·°C | 0.04 | 0.04 | 0.06 |
| Specific Heat | | Cal/g·°C | 0.23 | 0.21 | 0.20 |
| Dielectric Strength 0.025 in. Thick | | AC (Volts/mil) | 460 | 620 | 600 |
| Dielectric Constant | 1 kHz | | 24.2 | 8.7 | 9.2 |
| | 1 MHz | | 9.7 | 8.6 | 9.2 |
| | 1 GHz | | 9.5 | 8.5 | 9.2 |
| Dissipation Factor | 1 kHz | | 0.2932 | 0.0036 | 0.0018 |
| | 1 MHz | | 0.0470 | 0.0019 | 0.0008 |
| | 1 GHz | | 0.0030 | 0.0019 | 0.0010 |
| Loss Index | 1 kHz | | 7.095 | 0.031 | 0.016 |
| | 1 MHz | | 0.457 | 0.016 | 0.007 |
| | 1 GHz | | 0.028 | 0.016 | 0.009 |

# Sputtering Target Materials

| | Density | Composition | Purity | Sizes |
|---|---|---|---|---|
| **Indium-Tin Oxide** | >90% of Theoretical | On Demand | 99.8% (Higher Purity Available) | On Demand |
| Conductivity of Target: | $>10^4(\Omega\ cm)^{-1}$ | | | |
| **Titanium-Tungsten** | >90% of Theoretical | On Demand | Mobil Ions (Sodium, Potassium) >1 PPM. Lower mobil ion concentration available. Oxygen Concentration <0.2% (Higher Purity Available) | On Demand |
| CV Shift: <200 mV. Lower shift available with higher purity starting materials. | | | | |
| **Superconducting** | 70 to >90% of Theoretical | $YBa_2Cu_3O_{7-X}$ (1-2-3) | 99.90% (Higher Purity Available) | 1 to 8" |
| **Nichrome** | 60 to >90% of Theoretical | On Demand Al Doping | 99.90% (Higher Purity Available) | On Demand |

# Forsterite Ceramics
# Physical and Electrical Properties

| Properties | | Units | Forsterite | | | |
|---|---|---|---|---|---|---|
| Tektronix Number | | | B3–91 | B3–94 | B3–98 | XR-1 |
| Specific Gravity | | g/cm$^3$ | 2.82 | 2.82 | 2.82 | 3.06 |
| Hardness | Rockwell | R45N | 65 | 60 | 56 | 60 |
| Surface Finish | As Fired | Microinches | 41 | 48 | 42 | 66 |
| Crystal Size | Average | Micrometers | 1 | 1 | 1 | 1 |
| Water Absorption | | | None | None | None | None |
| Gas Permeability | | | None | None | None | None |
| Color | | | Light Pink | Buff | Light Blue | Russet |
| Compressive Strength | 25°C | KPSI | 195 | 170 | 195 | 165 |
| Flexural Strength | 25°C | KPSI | 21 | 21 | 20 | 19 |
| Tensile Strength | 25°C | KPSI | 13 | 13 | 12 | 12 |
| Modulus of Elasticity | | 10$^6$ PSI | 18 | 18 | 19 | 17 |
| Shear Modulus | | | 8 | 7 | 7 | 7 |
| Poisson's Ratio | | 10$^6$ PSI | 0.21 | 0.25 | 0.26 | 0.25 |
| Max. Use Temperature | No Load | °C | 1225 | 1225 | 1225 | 1225 |
| Coefficient of Linear Thermal Expansion | 25–500°C | 10$^{-6}$/°C | 9.3 | 9.6 | 10.0 | 9.6 |
| Thermal Conductivity | 20°C | Cal/cm·sec·°C | 0.008 | 0.008 | 0.008 | 0.008 |
| Specific Heat | | Cal/g·°C | — | — | — | — |
| Dielectric Strength | 0.025 in. Thick | AC (Volts/mil) | 560 | 720 | 560 | — |
| Dielectric Constant | 1 kHz | | 6.3 | 6.3 | 6.3 | — |
| | 1 MHz | | 6.2 | 6.3 | 6.2 | 6.8 |
| | 1 GHz | | 6.2 | 6.1 | 6.2 | — |
| Dissipation Factor | 1 kHz | | 0.0057 | 0.0049 | 0.0047 | — |
| | 1 MHz | | 0.0025 | 0.0020 | 0.0017 | 0.0006 |
| | 1 GHz | | 0.0031 | 0.0029 | 0.0023 | — |
| Loss Index | 1 kHz | | 0.036 | 0.031 | 0.030 | — |
| | 1 MHz | | 0.016 | 0.013 | 0.011 | 0.004 |
| | 1 GHz | | 0.019 | 0.018 | 0.014 | — |
| Volume Resistivity | 25°C | | $4.0\times10^{15}$ | $6.0\times10^{15}$ | $8.0\times10^{15}$ | $2.6\times10$ |
| | 300°C | Ohms·cm$^2$/cm | $1.0\times10^{8}$ | $1.0\times10^{8}$ | $9.0\times10^{7}$ | $3.0\times10$ |
| | 500°C | | $3.0\times10^{6}$ | $3.0\times10^{6}$ | $3.0\times10^{6}$ | $5.0\times10$ |


**For Further Information Contact:**
Tektronix Ceramics Division
P.O. Box 500, Mail Stop 13-835
Beaverton, Oregon 97077
503-627-3993





1/89


Tektronix®
COMMITTED TO EXCELLENCE