Sapphire watch glasses

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# Sapphire ($Al_2O_3$) – datasheet

Sapphire ($Al_2O_3$)

Sapphire optical components

Synthetic **Sapphire** is a single crystal form of corundum, $Al_2O_3$, also known as alpha-alumina, alumina, and single crystal $Al_2O_3$. Sapphire is aluminium oxide in its purest form with no porosity or grain boundaries, making it theoretically dense. The combination of favourable chemical, electrical, mechanical, optical, surface, thermal, and durability properties make sapphire a preferred material for high performance systems and component designs.

Unique properties to be mentioned (among others):

- excellent transmission in a wide range from UV to IR
- chemical inertness and outstanding durability against aggressive media
- extremely good thermal conductivity
- very good resistance against high temperatures and thermal shocks
- unexcelled scratch resistance
- preeminent corrosion- and abrasion resistance
- unique hardness (just beaten by diamond)
- best electrical features (high electric resistance, large dielectric constant)

Those features have made synthetic sapphire the material of choice for demanding applications in semiconductor, aerospace, analytics, medical, optics and watch industries.

| | |
|---|---|
| Chemical formula | $Al_2O_3$ |
| Crystal class | Hexagonal system, rhomboidal class 3m |
| Lattice constants, A | a = 4.785, c =12.991 |
| Density, g/cm³ | 3.98 |
| Melting point, °K | 2303 |
| Hardness | Knoop (daN/mm²): 1800 parallel to C-axis, 2200 perpendicular to C-axis, Mohs: 9 |
| Optical transmission range, µm | 0.17 – 5.5 |
| Refractive index at 0.532 µm | $n_0$ = 1.7717, $n_e$ = 1.76355 |
| Water absorption | nil |
| Young Modulus, Gpa | 345 |
| Shear Modulus, Gpa | 145 |
| Bulk Modulus, Gpa | 240 |
| Bending Modulus (Modulus of Rupture), Mpa | 420 at 20°C, 280 at 500°C |
| Elastic Coefficient | C11 = 496, C12 = 164, C13 = 115, C33 = 498, C44 = 148 |
| Poisson ratio | 0.25 – 0.30 |
| Friction Coefficient | 0.15 on steel, 0.10 on sapphire |
| Tensile strength, MPa | 400 at 25°, 275 at 500°, 345 at 1000° |
| Flexural strength, daN/mm² | 35 to 39 |
| Compressive strength, GPa | 2.0 |
| Young's modulus E, daN/mm² | $3.6 \times 10^4$ to $4.4 \times 10^4$ |
| Specific heat, J/(kg x K) | 105 at 91°K, 761 at 291°K |
| Thermal coefficient of linear expansion, $K^{-1}$, at 323K | $6.66 \times 10^{-6}$ parallel to optical axis, $5 \times 10^{-6}$ perpendicular to optical axis |
| Thermal conductivity, W/(m x K) at 300K | 23.1 parallel to optical axis, 25.2 perpendicular to optical axis |
| Resistivity, Ohm x cm | $10^{16}$ (25°), $10^{11}$ (500°), $10^6$ (1000°) |
| Dielectric constant | 11.5 ($10^3$ – $10^9$ Hz, 25°) parallel to C-axis, 9.3 ($10^3$ – $10^9$ Hz, 25°) perpendicular to C-axis |
| Dielectric strength, V/cm | $4 \times 10^5$ |
| Loss tangent | $1 \times 10^{-4}$ |
| Solubility | |
| – in water | insoluble |
| – in $HNO_3$,$H_2SO_4$, HCl, HF | insoluble to 300°C |
| – in alcalis | insoluble to 800°C |
| – in melts of metals Mg, Al, Cr, Co, Ni, Na, K, Bi, Zn, Cs | insoluble to 800 – 1000°C |
| g-radiation stability | No change in transmission above 2.5 mm after exposure to $10^7$ Rads. No visible coloration after exposure to $10^8$ Rads/hr for 60 minutes at – 195°C |
| Proton radiation stability | No change in transmission below 0.3 µm after exposure to $10^{12}$ proton/cm² total dose |
| Chemical resistance | Sapphire is highly inert and resistant to attack in most process environments including hydrofluoric acid and the fluorine plasma applications commonly found in semiconductor wafer processing (NF3, CF4) |

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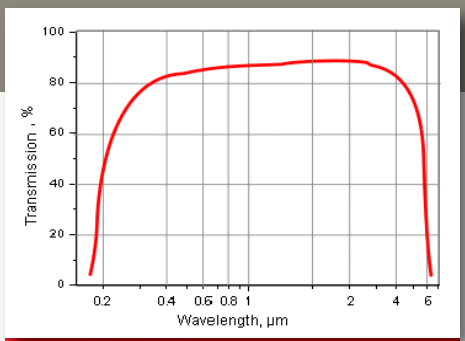
# Sapphire ($Al_2O_3$)

Small groved window and pin

Windows, lenses

Polished sapphire dome

Scanner windows (width 2″–4.1″, length 2″–7″, thickness 0.7–2 mm; surface as grown to 40/20 (S/D)




Transmission spectrum of a 2 mm thick sapphire window

## Why us?

- We do not offer „catalogue“ parts.
- Instead we focus on customer specifications and requirements only.
- „Special features“ such as coatings, engravings, etchings etc. are standard for us.
- We deliver smallest batch sizes (≥1) up to >100k pieces at most economic conditions and with reasonable leadtimes.
- We support customers with cost effective designs (if required).
- We do not have to be the cheapest, but the price worthiest.
- We believe in high level customer service, short response times and long term reliability.
- We measure our success solely in customers‘ satisfaction.

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