

SAPPHIRE REFERENCE TABLE

Synthetic sapphire is a single crystal form of corundum, aka, pure single crystal aluminum oxide, Al₂O₃. The combination of its unique properties make sapphire a preferred material for extreme mechanical, chemical & optical applications. Unlike glass, sapphire cannot be molded. Sapphire can be grown into near net shapes such as tubes and rod, then ground and polished if necessary.

INDUSTRIES SERVED		APPLICATIONS
Aerospace	Windows, ball bearings, sensors	
Medical	Dental tool tips, endoscopy, camera lens cover	
Oil & Gas	Sight window without housing, gauges, diffusion plates	
Military	Windows, viewports, sensors, range finders	
Research	Containment tubes, cuvettes, lenses	
Semiconductor	Plasma tubes, lamps, lasers	
COMMON GRADES		DESCRIPTION & COMMON APPLICATIONS
	There are numerous sapphire growth methods & grades. Generally, the higher the grade the better the transmission in the UV and IR, and the less light scatter and lattice distortion. The best grades, in particular, UV grade will not solarize.	
Verneuil	Original & simplest growth method, lowest cost, excellent for mechanical applications & situations where optical clarity is not critical. Good for lower quality watch crystals & observation ports.	
EFG (Stepanov)	Edge defined growth method (to be exact, Edge-Defined Film-Fed Growth) for near net growth of tubes & large sheets. Better quality than Verneuil, but not as pure & defect free as Kyropoulos or CZ. Excellent for most window applications including scanner windows & viewports and lower cost than Kyropoulos & HEM.	
Kyropoulos & CZ	Excellent optical properties, ideal method for most optical applications except long exposure high UV & extreme power threshold requirements. Also preferred for high purity applications like semiconductor, LED fabrication & high purity chemistry.	
HEM	The best quality sapphire, but difficult to acquire & considerably more costly compared to other grades. Quality compared to Kyropoulos usually not significant enough to justify cost for most applications. Best for extreme power & UV applications & for when zero fluorescence &/or high power threshold is required.	
ORIENTATION		DEFINITION & COMMON APPLICATIONS
C-Axis	Also known as the "optical axis". The only orientation that has almost zero birefringence for signals parallel to the C-axis. Used for optimal optical, mechanical, thermal & electrical performance. In a rod or tube the typical C-axis orientation is along its length, in a window perpendicular to the face.	
Random	Parts are manufactured with no tracking of the crystal orientation. Lower cost & great for applications where orientation will not impact performance.	
Other	90 Degree (to C-axis), M-Plane, A-Plane, R-Plane	
	Click for Orientation Definitions & Drawing	
PROPERTIES		IMPORTANT PROPERTIES OF SAPPHIRE
	Thermal, physical/mechanical, optical, electrical & chemical	
	Click for Sapphire Properties Data Sheet	
TRANSMISSION & OTHER CURVES		DEFINITION
	The overall transmission of sapphire is determined by purity. All quality sapphire materials transmit about the same in the visible wavelengths while higher purity creates better transmission in the UV and IR. For all optical materials, including sapphire, the thinner the material the deeper it transmits into the UV and IR.	
	Click for Sapphire Optical & Thermal Properties Graph	
	Click for Transparent Materials Transmissions Curves Graph	
SURFACE FINISH		DESCRIPTION
Polished	Clear. Has little to no distortion & light scattering (depending on level of polishing). Ideal for optical applications, high purity semiconductor, chemical & vacuum processing.	
Fine Ground	Frosted. Ground surface roughness can be fine tuned for diffuser & low stiction applications. Tends to have micro-cracks that can trap water, gas & other impurities.	
As Grown	Clear but not mechanically polished. Some optical distortion due to growth process but no micro cracks. Excellent for high vacuum systems such as plasma chambers & chemical processing where purity is critical but optical clarity is not.	
	Click for Surface Finish Photos	
SURFACE QUALITY		DEFINITION & RATING
	The scratch-dig rating of surface quality is a qualitative rating based on comparing the actual surface to a scratch-dig standard. Pass or fail is somewhat subjective without clear dimensions to measure.	
80-50	Commercial quality such as car windshield and commercial windows	
60-40	Good polish, good for commercial lenses and optics. Good for optics where light scatter is not a problem.	
40-20	Superior polish, good for higher performance optics and lower powered lasers. Reduced light scatter over 60-40	
20-10	High Precision polish, extreme optics & good laser power threshold for medium powered lasers. Very little light scatter	
10-5	Highest surface quality, highest laser power threshold and lowest vulnerability to solarization. Exceptional optics with near-zero light scatter	
	Click for Quality Scratch-Dig Definitions	
WHY SAPPHIRE?		
	One of the hardest materials available	
	Superior IR & UV transmission compared to other optical materials	
	Highly scratch & abradant resistant	
	Highly chemical resistant	
	Maximum temperature rating of almost 2000C	
	Excellent dielectric & loss tangent performance	
WHY MCDANEL?		
	Onsite engineers & master optician	
	25+ years of expertise in sapphire & exotic materials manufacturing	
	ISO 9001:2008 Certified	
	ITAR Registered	
	State-of-the-art manufacturing equipment & measurement capabilities	
	Cost saving overseas sourcing (for non-ITAR applications only)	
	US Manufacturing at Rayotek's 30,000 SqFt facility + partnerships in the U.S., China, Europe & Russia	
SAPPHIRE SERVICES		
	Annealing, Bonding/Fusing, Coating, Fire Polishing, Grinding, Laser Engraving, Machining & Screen Printing	