

Featured Material - Sapphire

Sapphire (Al_2O_3) has a melting point at 2040 °C, a Knoop hardness of 2000, and a transmission range of ~170-5500 nm. Just these three properties alone, combined with the availability of methods and technology to grow sapphire economically (1, 2), make sapphire an excellent material for a wide range of applications.

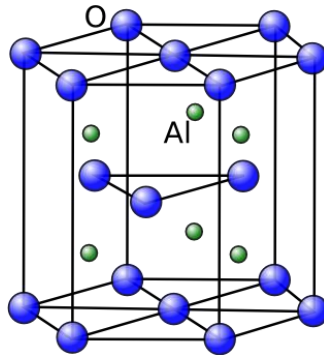


Fig. 1. Crystal structure of sapphire (credit Clipartmax).

IR Windows

Due to the broad-range transmission spectrum of sapphire from UV to mid wave infrared, sapphire windows have been widely used in optical spectroscopy in various fields. They are commonly found in spectroscopy in chemistry, geology, biology, and physics (3-8). Even though many materials have excellent transmission in the mid wave IR region and even long wave region (eg. ZnS, ZnSe, and GeAs), these materials tend to break down at high temperatures. Diamond, the hardest material on earth, suffers oxidation at just 650 °C and begins the process of turning to graphite at higher temperature! Sapphire has none of the aforementioned shortcomings and has found its many uses in mid wave IR applications in the defense industry.

Laser

Single crystal sapphire doped with titanium has been in use in generating laser since 1982. Ti:Sapphire laser are tunable from 660 nm to 1180 nm – the largest tuning range of any laser (9)! The titanium ion also adds another dimension of benefit: large gain bandwidth. Famous examples of the uses of Ti:Sapphire laser include NASA's Lidar Atmospheric Sensing Experiment and gravitational wave detection at LIGO.

Substrate

First and second generation semiconductor materials have low tolerance for temperature. They tend to work only below 200 °C. Third generation semiconductor materials, such as GaN (gallium nitride) and SiC (silicon carbide), are the ideal candidates for today and tomorrow's electronics that work in much more hostile environments such as high temperature, high pressure, high

frequency, and high radiation level. GaN, in particular, because of its wide bandgap, is emerging as the star in electrical and electronic engineering (10). However, growing GaN is no easy feat. CVD and MBE are the two modern methods used, and *c*-plane (0001) sapphire is the preferred substrate for growing GaN. Even though the dislocation density or lattice mismatch between sapphire and GaN is quite high (11), sapphire is still the best substrate for growing GaN due to its many advantageous properties.

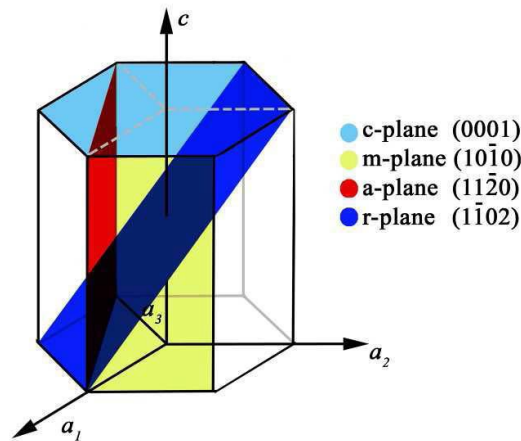


Fig. 2. Planes of sapphire crystal (credit Cuccureddu et al.).

Lapping and Polishing of *c*-plane Sapphire using Qual Diamond Slurries

All sapphire applications often time require some form of planarization (lapping) and polishing. At Qual Diamond, we develop and manufacture nextgen diamond slurries for lapping and polishing a variety of materials ranging from soft materials such as copper, aluminum, stainless steel, ZnSe, ZnS to hard materials such SiC, GaN, sapphire, fused silica - and everything in between.

Here we present data from a 3-step lapping and polishing procedure of a 2-inch in diameter *c*-plane sapphire workpiece using Hydroqual and Dynaqual diamond slurries.

QD Diamond Slurry	QD Hydroqual Mono 10-14 μm	QD Hydroqual Mono 4-6 μm	QD Dynaqual Mono 80 nm
Substrate	Single Crystal Sapphire <i>c</i> -Plane (0001)	Single-Crystal Sapphire <i>c</i> -Plane (0001)	Single-Crystal Sapphire <i>c</i> -Plane (0001)
Plate/Pad Type	Grooved Cast Iron Plate	QDPD	QDMD
Scratch/Artifact (Visual/Microscopy)	Not Visible	No Visible Scratches	No Scratches
Ra (nm)	358	2.4	0.14
Rz (nm)	1601	8.35	0.52
MRR ($\mu\text{m/hr}$)*	76-80	5-6	0.8-1
Slurry Consumption (mL)	10-15	10-15	10-15

*Calculation is based on weight difference/time.

Table 1. Results of sapphire lapping and polishing with Qual Diamond diamond slurries.

Contact sales@qualdiamond.com for a free sample, price quotation, or detail regarding the results.

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