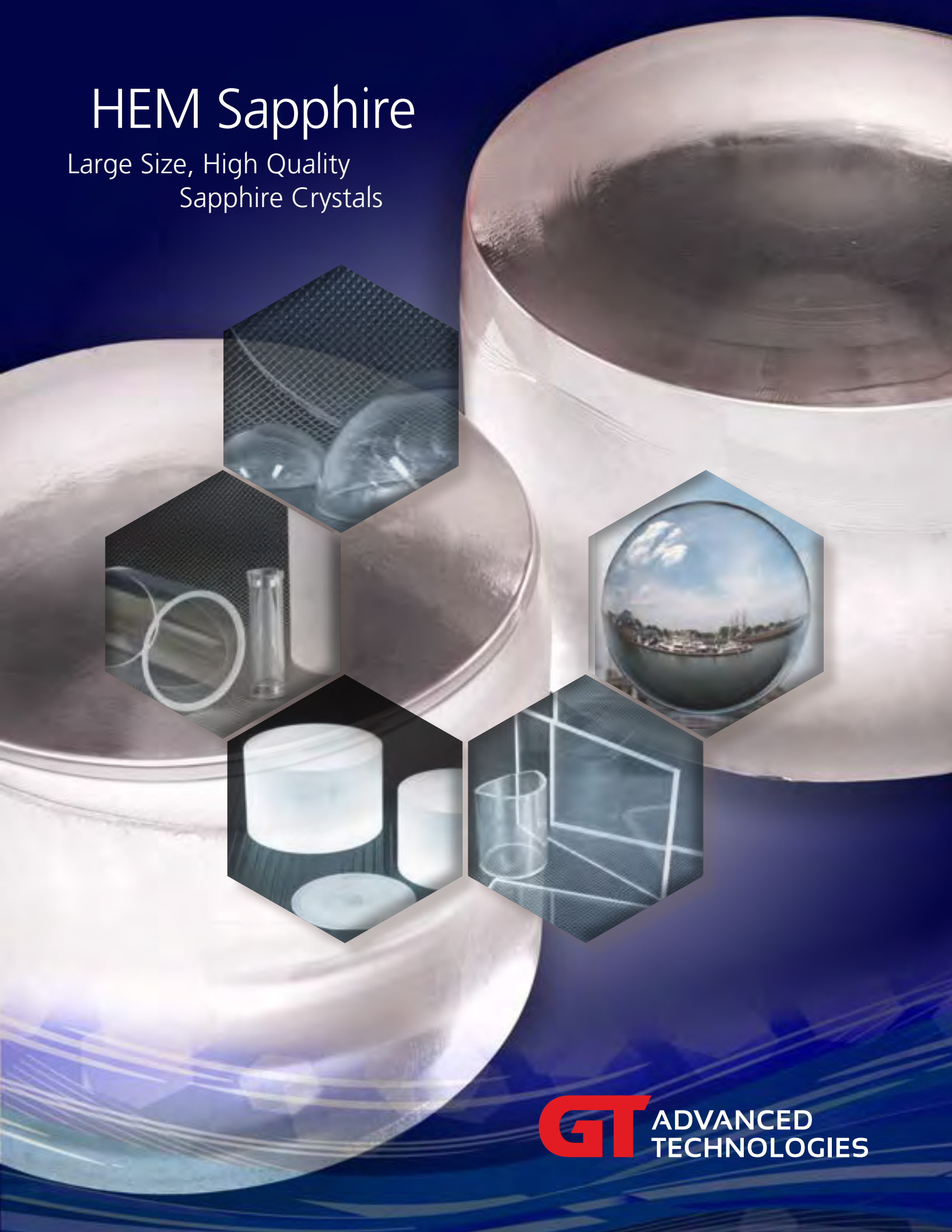
HEM Sapphire

Large Size, High Quality Sapphire Crystals



GT ADVANCED TECHNOLOGIES

Advantages of HEM Sapphire

The HEM technology produces large sized crystals with superior crystalline quality.The combination of high purity level, crystalline perfection, and low light scatter, gives our customers the advantage with their applications. Let our experienced staff, aided by the most advanced manufacturing processes in the world, assist you with your sapphire needs.

World Recognized Crystal Quality

- High purity
- Homogeneity of refractive index as low as 0.022 PV (peak to valley) waves
- Optics can be manufactured to 1/20th wave PV TWE
- Low etch pit density for high quality deposition of GaN
- Low crystalline stress levels allow for better machining
- No detectable light scatter or inclusions
- Lowest absorption coefficients

Manufacturing Technology

- Advanced machining center tolerances to 0.0004"
- Low sub-surface damage machining techniques utilized
- (0001), (1120), (1102), (1010) and other orientations with tolerances to 0.05 degrees
- X-Ray orientation systems
- High volume diamond wire sawing capabilities
- Advanced analytical and test equipment

GT Crystal Systems manufactures products to your specifications and individual needs. We build value and performance into your product by allocating HEM crystals to your job based on your set of criteria including orientation, crystalline structure, purity, geometry and application knowledge. We apply our 40 years of sapphire machining experience and our new machining center to provideexcellence in quality, delivery and value.

HEM Sapphire is the leading material solution for today's demanding technical applications. HEM Sapphire is used by industry leading customers because of its high quality crystalline structure, low stress and consistency. These attributes allow our customers to run HEM sapphire in their production with full confidence of high yields. Today, our 6" and 8" diameter C-plane sapphire is boosting productivity and efficiency in the high-volume LED manufacturing industry.

HEM Sapphire Production Sizes:

- 8" diameter
- 11" diameter
- 13.5" diameter
- 15" diameter

HEM Sapphire Product Offerings:

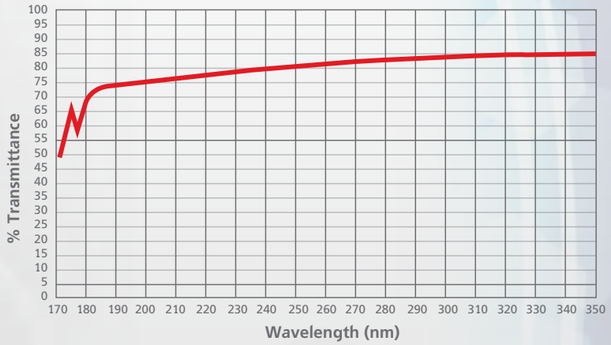
- Windows, blanks, tubes, rods and other product types offered
- Diameters up to 15"
- Part thickness up to 14"
- Surface finishes offered in "as sliced," fine ground or polished
- Polished surfaces from 80-50 scratch dig to Super Polished (surface roughness <5 angstrom PV)
- Annealing treatments available
- Prototype to commercial volume capabilities

Markets Served:

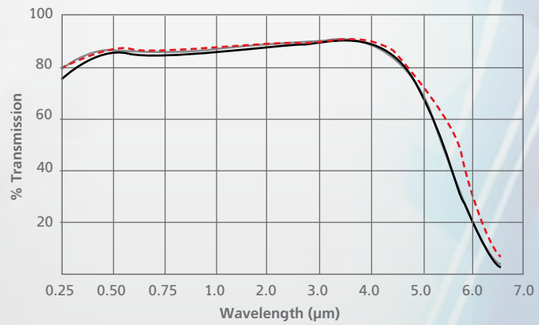
- LED, SOS, Medical, Defense, Research

VUV HEM Sapphire Transmission

(based on measurement of 20 mm diameter x 2 mm product)



Standard HEM Sapphire Transmission



Production Capabilites

GT Crystal Systems has three independent crystal growth facilities located in the USA. These facilities are engineered and designed to incorporate state-of-the-art infrastructure, equipment and tooling to maximize yields and quality.HEM growth technology is the most industrialized crystal growth technology available. The closed-loop-system, advanced software package and user interface help the production facility yield the industry's largest, high quality crystals. GT Crystal Systems has a 40 year reputation of providing quality, consistency and value to its customers.

Once the crystals are grown and characterized, they are transferred to our advanced ceramic machining center. Our experienced engineers and machinists shape, grind and machine to your specifications.

Quality technicians utilize an ISO compliant quality system and specialized measurement tools to verify the fit, form and function of your parts.Your order will be ON-TIME AND READY.

Sapphire Properties

Physical

Chemical Formula	Al_2O_3
Crystal Structure	Hexagonal system (rhombohedral)
Unit cell dimension	a = 4.758 Å , c = 12.991 Å
Density	3.98 g/cm^{-3}
Hardness	9 mohs, 1525-200 Knoop
Melting Point	2040°C (nominal)
Boiling point	2980°C

Mechanical*

Tensile strength	40,000-60,000 psi (design criterion)
Flexural strength	70,000-130,000 psi (design criterion)
Young's modulus	50 x 10^6 psi
Compressive modulus	55 x 10^6 psi
Flexural modulus	52 x 10^6 psi
Rigidity modulus	21.5 x 10^6 psi
Volumetric modulus of elasticity (bulk modulus)	35 x 10^6 psi
Poisson's ratio	0.29

*psi = 6.9 kPa

Thermal

Thermal conductivity	0.065 cal/cm-sec-°C
Thermal expansion coefficient (60° to c-axis) 25 - 800 °C	8.40 x 10^{-6} per °C
Specific heat at 25 °C	0.185 cal/gm
Heat capacity at 25 °C	18.6 cal/°C-mole

Electrical

Volume resistivity	10^{14} Ohm-cm
Dielectric strength	480,000 V/cm
Dielectric constant	
E perpendicular to c-axis	9.4
E parallel to c-axis	11.5
Dissipation factor, tan delta	10^{-4}

Worldwide Headquarters
20 Trafalgar Square
Nashua, NH 03063 USA
Phone: +1 603.883.5200
Fax: +1 603.595.6993
www.gtat.com

Sapphire Material Sales & Services
GT Crystal Systems, LLC
35 Congress Street
Salem, MA 01970 USA
Phone: +1 978.745.0088
Fax: +1 978.745.5059
SapphireSales@gtat.com

GT ADVANCED TECHNOLOGIES