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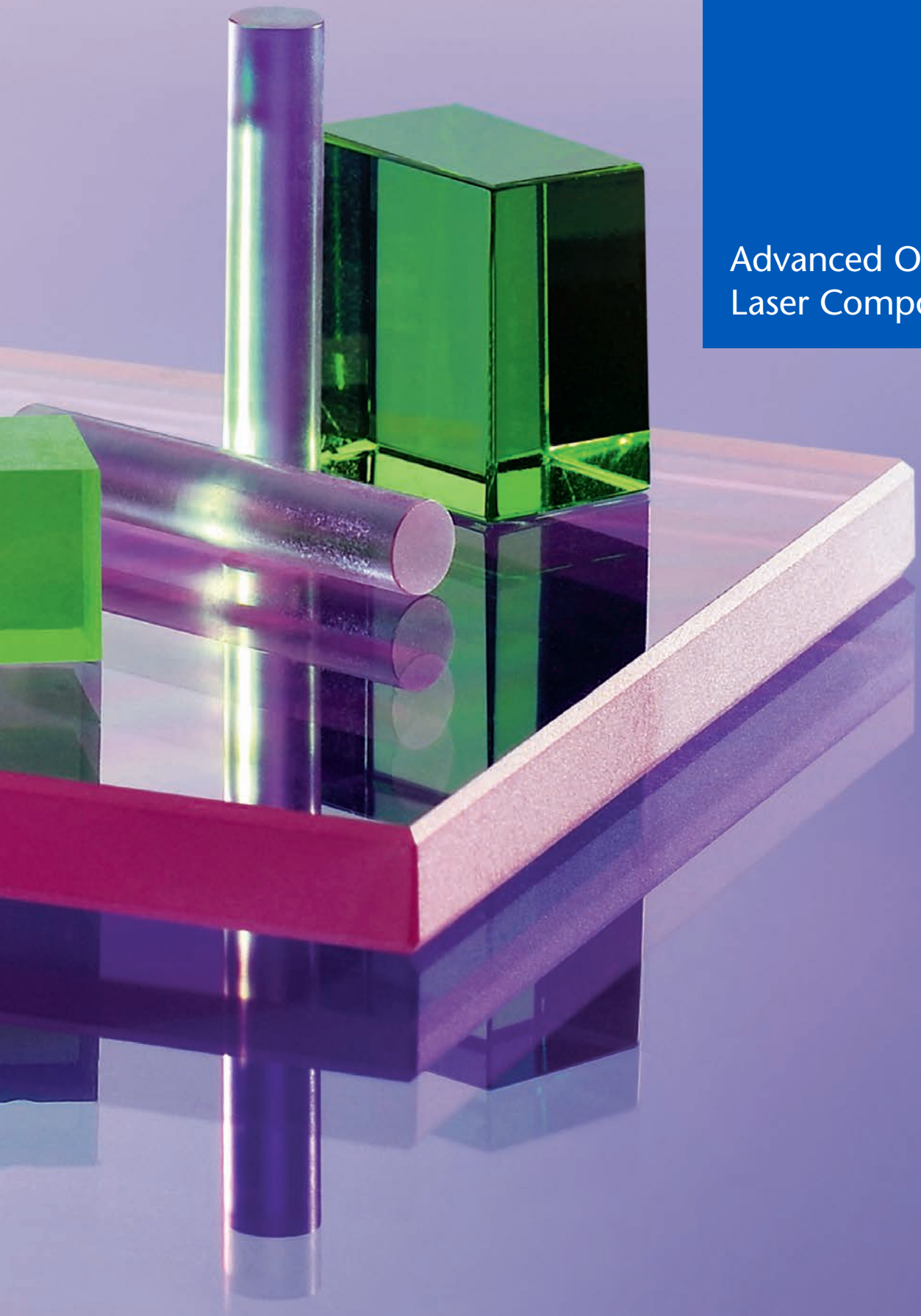
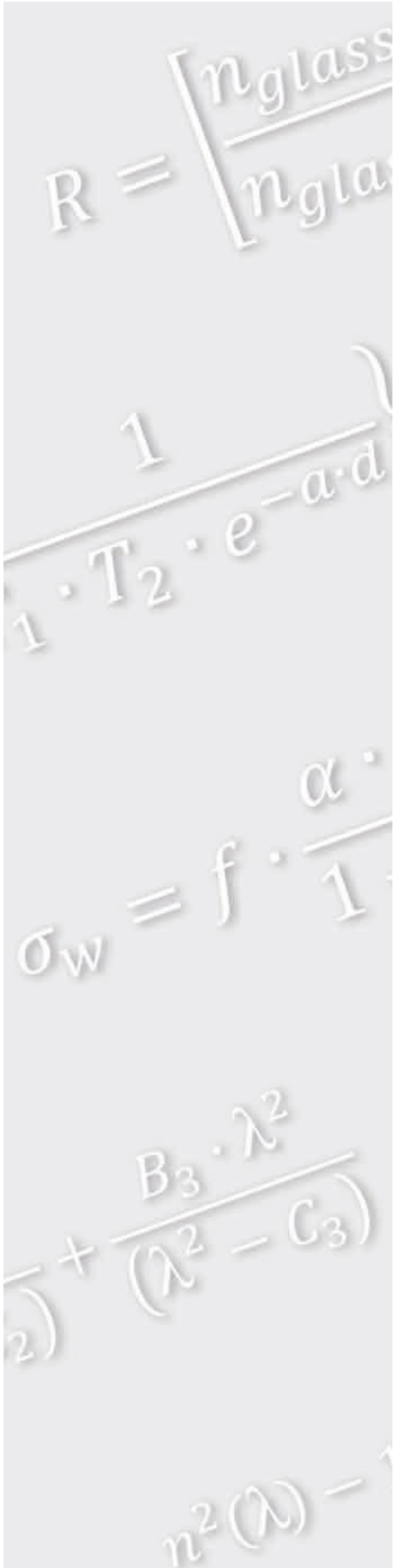
Advanced Optics
Laser Components





…Complete Material and Component Solutions for Laser Applications…

Advanced Thinking for Advanced Laser Technologies

Critical to numerous industrial, scientific, medical, and defense applications, lasers make today's way of life possible. Ranging in type from diode to solid-state and gas, lasers cover a multitude of wavelengths and pulse lengths – from X-ray and IR to power up to Petawatt, and from attosecond to cw, respectively. However, there is a fundamental component that all lasers share and rely on for optimal performance: high-quality optical components.

SCHOTT Advanced Optics is a world leader in end-to-end optical solutions, offering an extensive range of materials and components for state-of-the-art laser applications. From development and manufacturing to final coating and testing, SCHOTT consistently delivers the quality, high-performing optic solutions laser applications demand.

Active Materials

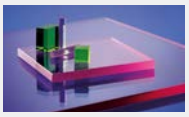
Because of its unique properties, glass is an ideal host material for the rare earth ions that give optically pumped lasers their power. Having long been at the forefront of optical glass manufacturing technology, SCHOTT understands how to successfully blend glass's wide-ranging compositional attributes with desired rare earth properties. The result is active laser glass products that are specifically tailored to your unique application, possessing the characteristics needed to excel in high-energy, high-average power or integrated optics uses.

SCHOTT innovation doesn't stop there. In meeting a wide variety of laser glass challenges, we have successfully developed platinum-particle-free melting. This process allows for significantly more advanced manufacturing options and customization, including:

- High-fluence laser glass components, which operate without laser-induced damage
- Large volume laser slabs, available in apertures to 40 cm and in mass quantities, which enable high-energy storage for inertial confinement fusion programs
- Zig-zag slabs and large diameter laser rods with the highest optical quality and homogeneity possible, which can help make high-output power of materials processing laser systems a reality

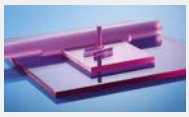
Materials and Components supporting Laser Applications

- Active Laser Glass (neodymium doped, erbium doped) e.g. APG, IOG, LG
- Silicate based glasses
- Phosphate based glasses



Materials Active

- Rods
- Plates



Components Active

Materials Passive

- Passive Laser Glasses e.g. S7010N, S7005, S7000
- Wide range of optical glasses and its special variants (e.g. SCHOTT N-BK7®)
- ZERODUR®

Components Passive

- Aspherical Lenses
- Laser Mirrors & Windows
- Beamsplitter & Polarizers
- Polished prisms
- Optical Filters

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Glass for Laser Applications

SCHOTT offers active and passive laser glasses for high power, ultra-short pulse, laser range finding and medical applications. These materials run the gamut from neodymium-doped laser and special filter glasses for use as active laser medium and diagnostic filters to ultra-stable glass ceramic for laser applications requiring the utmost in precision.

SCHOTT melts these materials at our factory in Duryea, PA in continuous melting tanks and single batch crucibles. SCHOTT also offers custom glass melting services so that you can tailor a glass to a specific application.

Active Glasses

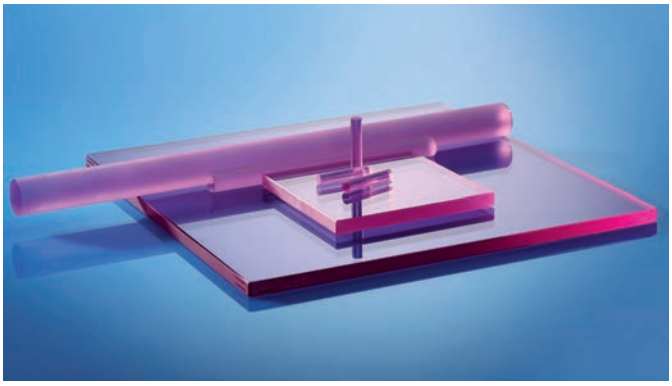
Glass is a uniquely suitable host material for rare earth ions to provide the laser action in optically pumped lasers. SCHOTT has combined wide ranging compositional possibilities of glass with a deep understanding of property control in developing our active laser glass products. The result is a glass tailored to your application, possessing the characteristics needed to excel in high energy, high average power or integrated optics uses.

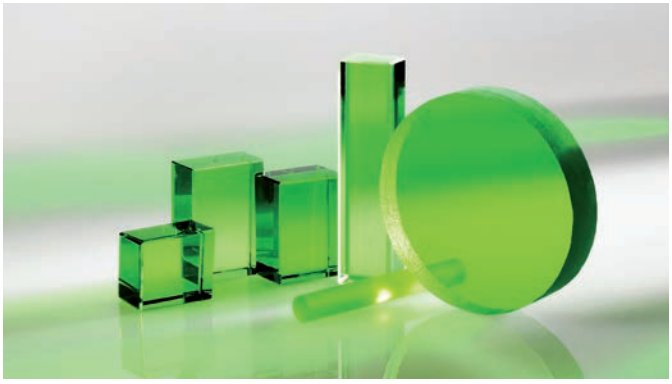
The innovation doesn't stop there. SCHOTT has long been at the forefront of optical glass manufacturing technology and has met a wide variety of challenges especially for the glass laser industry. Platinum-particle-free melting developed at SCHOTT permits high fluence operation of phosphate laser glass components without laser-induced damage; large volume laser slabs in apertures to 40 cm and in mass quantities enable high energy storage for the inertial confinement fusion program; and zig-zag slabs and large diameter laser rods produced in the highest optical quality and homogeneity help to realize high output powers of materials processing laser systems.

SCHOTT Laser Glass Types

Phosphate Based Laser Glass for High Energy Applications

LG-750, LG-760, LG-770 have been developed to meet the needs of the high energy solid state laser community. All three glasses exhibit high laser cross section, low nonlinear refractive index, and athermal characteristics. All are available in a form free of all metallic platinum particles or other inclusions that can exhibit laser damage.





SCHOTT supplies finished components with high-end polish and coating.

Phosphate Based Laser Glass for High Power and Ultra-Short Pulse Applications

APG-1 is a phosphate glass with enhanced thermal mechanical properties desirable in high average power applications. The broad emission bandwidth of this material has been utilized in femtosecond regime laser systems. The lower gain cross section and long low concentration emission lifetime have made this glass of interest in applications limited by amplified stimulated emission and/or intended for excitation by diode lasers.

´Eye-Safe´ Laser Glasses

The **LG-940** is an Erbium – Ytterbium – Chromium – Cerium doped phosphate based laser glass used in flashlamp pumped and diode pumped solid-state laser systems. Phosphate glasses generally offer higher solubility of rare earth dopants, thus the amount of active ions can be significantly increased.

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Silicate Based Laser Glass

LG-680 is the classic laser glass that features a high cross section, high ultraviolet transmission, and high resistance to solarization. This glass is commonly employed in high repetition rate solid state laser systems.

Active Glass for Integrated Optic Applications

IOG-1 and IOG-10 were developed specifically for compatibility with known sodium ion exchange technologies for fabrication of active guided wave structures. These glasses have particularly found applications with such rare earth ions as erbium, ytterbium, praseodymium, and their combinations.

Laser Glass Codes

SCHOTT production laser glass codes indicate the type of host glass and, in the case of neodymium, the active rare earth ion concentration. For example, LG-770-4.2 refers to a phosphate glass doped with 4.2×10^{20} Nd^{3+}ions/cm^3, and LG-770-2 % denotes the same glass doped with 2 wt % Nd_2O_3. The number of ions per cm^3 can easily be converted to the Nd_2O_3 weight percentage (and vice versa) by using the following formulas:

Nd_2O_3 [wt %] = 1/F x Nd^{3+} ion concentration [10^{20} ions/cm^3]
Nd^{3+} ion concentration [10^{20} ions/cm^3] = F x Nd_2O_3 [wt %]

Where the value of F is as follows for the common laser glasses:

Glass Type	Value of F	Glass Type	Value of F
LG-680	0.91	APG-1	0.94
LG-750	1.01	IOG-1	0.98
LG-760	0.93	IOG-10	0.97
LG-770	0.92		

Passive Glasses

Laser Cavity Materials

SCHOTT offers different materials for use as laser pumping cavity filters. They absorb undesired pumping light in the UV and IR, preventing solarization of the laser glass. By absorbing the Nd laser light these filters reduce amplified spontaneous emission and eliminate parasitic oscillation, thereby increasing lasing efficiencies and powers. They are used in many configurations: flat plates, close fitting cylindrical sleeves, cylindrical water jackets, etc. These materials can be chemically strengthened to increase their mechanical strength and thermal shock resistance fourfold.

S7010N and S7005 samarium-doped glasses block the 1.06 (um wavelength and UV pump light from neodymium lasing elements, such as Nd: YAG or Nd:glass rods and slabs. Two samarium-doped silicate glasses are offered. S7010N (10 % doping) is recommended for most applications, while S7005 (5 % doping) is usually reserved for elements thicker than 6 mm.

S7000, a clear, cerium-doped silicate glass, is also available to serve as a UV cut-off material.

ZERODUR®

ZERODUR® is a glass ceramic that was developed by the SCHOTT research laboratories for applications calling for a near-zero coefficient of thermal expansion over a fairly wide temperature range. It is a homogeneous material that exhibits practically no measurable variations in its thermal and mechanical properties. It possesses exceptional long-term dimensional stability. Because ZERODUR® is transparent, its internal quality can be measured to meet your specifications.

Contract Melting

SCHOTT North America recognizes that the needs of laser customers are not limited to available glasses. For this reason we maintain a program of custom test melting on a contract basis. In this way we can provide you with glass samples suitable for characterization of optical, physical, and laser properties, as well as for fabrication of small optics and devices. This allows you to take advantage of our vast glass knowledge, or, if you prefer, to have us melt your glass composition.

High-End Component Manufacture

All components are manufactured per customers' specifications and can be polished up to $\lambda/10$ flatness. SCHOTT also provides an anti-reflection or high-reflection coating with a laser induced damage threshold > 1.5 GW/cm^2.

Quality Assurance

Quality control is based on statistical process control, as well as on rigorous final inspection of the finished component. Glass properties are measured for every melt. Measurement instruments include a broad range of interferometers, spectrophotometers, physical property test systems, vision systems, and a laser test bed.

Version August 2013 | SCHOTT Advanced Optics reserves the right to make specification changes in this product flyer without notice.

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APG-1 Phosphate Laser Glass

For High Power Applications

Neodymium Laser Properties	
Emission Peak, λ [nm]	1053.9
Emission Width, $\Delta\lambda_{em}$ [nm]	27.8
Radiative Lifetime, τ_{Rad} [µs]	361
Emission Cross Section, σ_{em} [10^{-20} cm^2]	3.4
*Quenching Constant-Zero Concentration Lifetime, τ_o [µs]	375
*Quenching Constant-Q Factor, Q [10^{20} cm^{-3}]	6.8

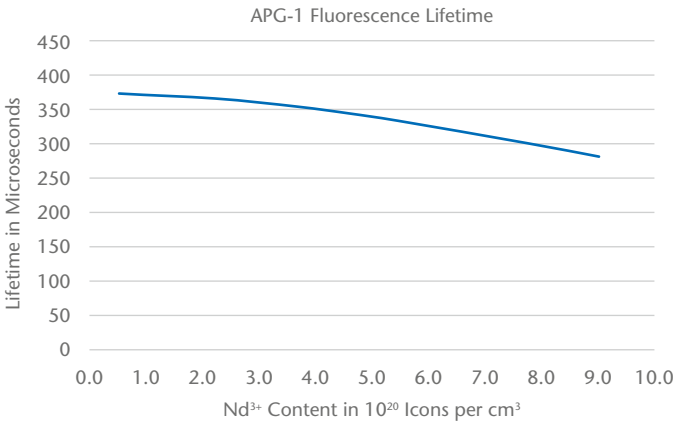
*Lifetime as a function of neodymium content is approximated by: $T = T_o/(1+(Nd/Q)^2)$, Nd = Nd concentration in 10^{20} ions/cm^3

Optical Properties	
n_d	1.5370
v_d	67.70
$n_{633\ nm}$	1.5350
$n_{1054\ nm}$	1.5260
Nonlinear Refractive Index at 1054 nm, n_2 [10^{-20} m^2/W]	3.1
Stress-Optic Coefficient, K (588 nm, 22 °C) [10^{-6} mm^2/N]	2.20
Stress-Optic Coefficient, $-K_{par}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	1.00
Stress-Optic Coefficient, $-K_{per}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	3.10
Temperature Coefficient of Refractive Index, dn/dT_{rel} (1060 nm, 20–40 °C) [10^{-6}/K]	1.2
Temperature Coefficient of Optical Pathlength, $W = \alpha_{+20/+40\,°C}\,(n-1) + dn/dT$ [10^{-6}/K]	5.2

Sellmeier Coefficients			
B1	1.01260752	C1	0.01079807
B2	0.32028946	C2	0.00000000
B3	1.02870062	C3	107.148538

Attenuation Coefficient [cm^{-1}]			
400 nm	≤ 0.20	3000 nm	≤ 0.80
1054 nm	≤ 0.0015	3333 nm	≤ 2.00

APG-1 is an advanced phosphate laser glass developed to offer thermo-mechanical properties desirable in the active material of high repetition rate laser systems. APG-1 is an aluminum-phosphate based glass initially developed for the US DOE High Average Power laser program. The development and the advantages of this glass are discussed in "Advances in glasses for high average power laser systems" Proc SPIE, Vol 1021, 36-41 (1988).



Physical Properties	
Density, ρ [g/cm^3]	2.633
Thermal Conductivity (25 °C), λ [W/m·K]	0.78
Thermal Conductivity (90 °C), λ [W/m·K]	0.83
Young's Modulus, E [10^3 N/mm^2]	70.00
Poisson's Ratio, µ	0.238
Fracture Toughness, K_{1c} [MPa·m$^{1/2}$]	0.61
Knoop Hardness, $HK_{0.1/20}$	450
Heat Capacity (25 °C), C_p [J/g·K]	0.84
Thermal Diffusivity (25 °C), σ [10^{-7} m^2/s]	3.54
Thermal Expansion, $\alpha_{+20/+300\,°C}$ [10^{-6}/K]	9.96
Thermal Expansion, $\alpha_{+20/+40\,°C}$ [10^{-6}/K]	7.60
Transformation Temperature, T_g [°C]	450

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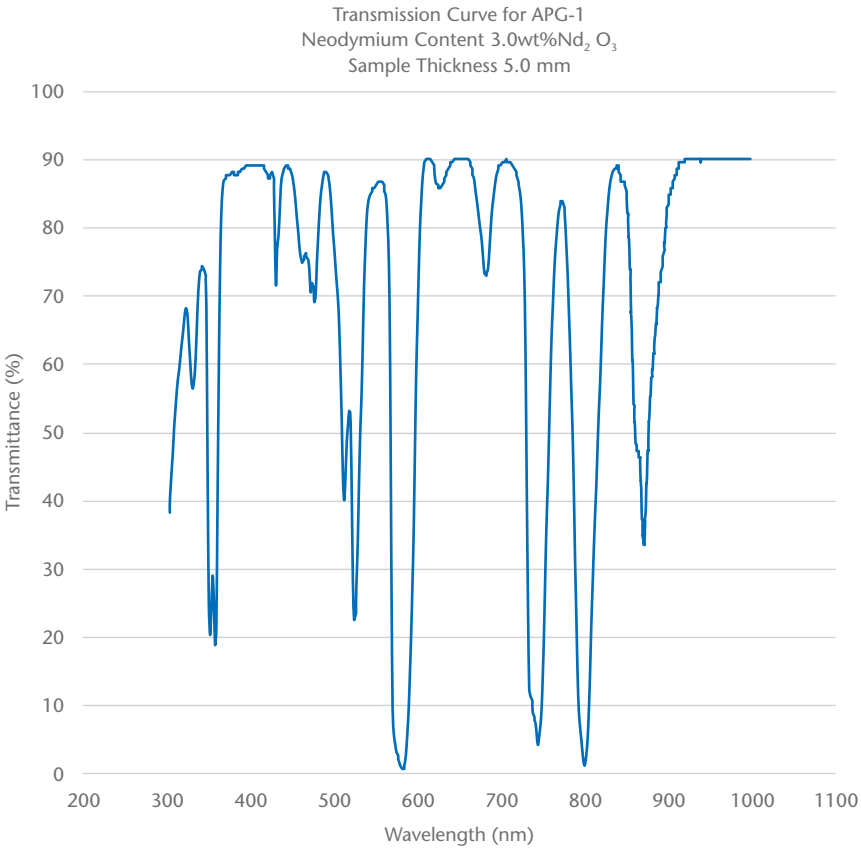
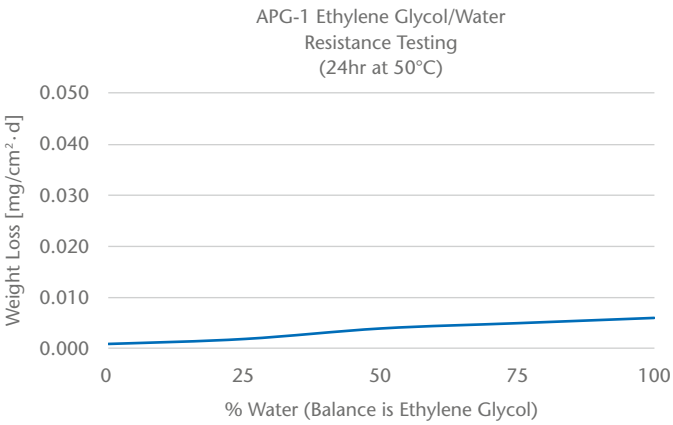
APG-1 Phosphate Laser Glass

For High Power Applications



Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm² · d)]	0.006
SR	3.3
AR	4.0
FR	0
CR	1



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LG-680 Silicate Laser Glass

Neodymium Laser Properties	
Emission Peak, λ [nm]	1059.7
Emission Width, $\Delta\lambda_{em}$ [nm]	35.9
Radiative Lifetime, τ_{Rad} [µs]	361
Emission Cross Section σ_{em} [10^{-20} cm^2]	2.54
*Quenching Constant-Zero Concentration Lifetime, τ_o [µs]	337
*Quenching Constant-Q Factor, Q [10^{20} cm^{-3}]	5.5

*Lifetime as a function of neodymium content is approximated by: $T = T_o/(1+(Nd/Q)^2)$, Nd = Nd concentration in 10^{20} ions/cm^3

Optical Properties	
n_d	1.5705
v_d	57.51
$n_{633\ nm}$	1.5684
$n_{1054\ nm}$	1.5588
Nonlinear Refractive Index at 1054 nm, n_2 [10^{-20} m^2/W]	4.3
Stress-Optic Coefficient, K (588 nm, 22 °C) [10^{-6} mm^2/N]	2.00
Stress-Optic Coefficient, $-K_{par}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	0.36
Stress-Optic Coefficient, $-K_{per}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	2.38
Temperature Coefficient of Refractive Index, dn/dT_{rel} (1060 nm, 20–40 °C) [10^{-6}/K]	2.9
Temperature Coefficient of Optical Pathlength, $W = \alpha_{+20/+40\,°C}\,(n-1) + dn/dT$ [10^{-6}/K]	8.1

Sellmeier Coefficients			
B1	1.08521	C1	0.00626
B2	0.34218	C2	0.02100
B3	1.39921	C3	150.456

Attenuation Coefficient [cm^{-1}]			
400 nm	0.10		
1054 nm	0.0020	3333 nm	2.00

LG-680 is the classic lithium-aluminum based glass with high cross section for stimulated emission, high ultraviolet transmission and high resistance to solarization.

Physical Properties	
Density, ρ [g/cm^3]	2.540
Thermal Conductivity (25 °C), λ [W/m·K]	1.19
Thermal Conductivity (90 °C), λ [W/m·K]	1.35
Young's Modulus, E [10^3 N/mm^2]	90.10
Poisson's Ratio, µ	0.242
Fracture Toughness, K_{1c} [MPa·m$^{1/2}$]	0.86
Knoop Hardness, $HK_{0.1/20}$	620
Heat Capacity (25 °C), C_p [J/g·K]	0.92
Thermal Diffusivity (25 °C), σ [10^{-7} m^2/s]	5.09
Thermal Expansion, $\alpha_{+20/+300\,°C}$ [10^{-6}/K]	10.18
Thermal Expansion, $\alpha_{+20/+40\,°C}$ [10^{-6}/K]	9.3
Transformation Temperature, T_g [°C]	468

Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm^2·d)]	0.050
SR	1.0
AR	1.0
FR	0
CR	4

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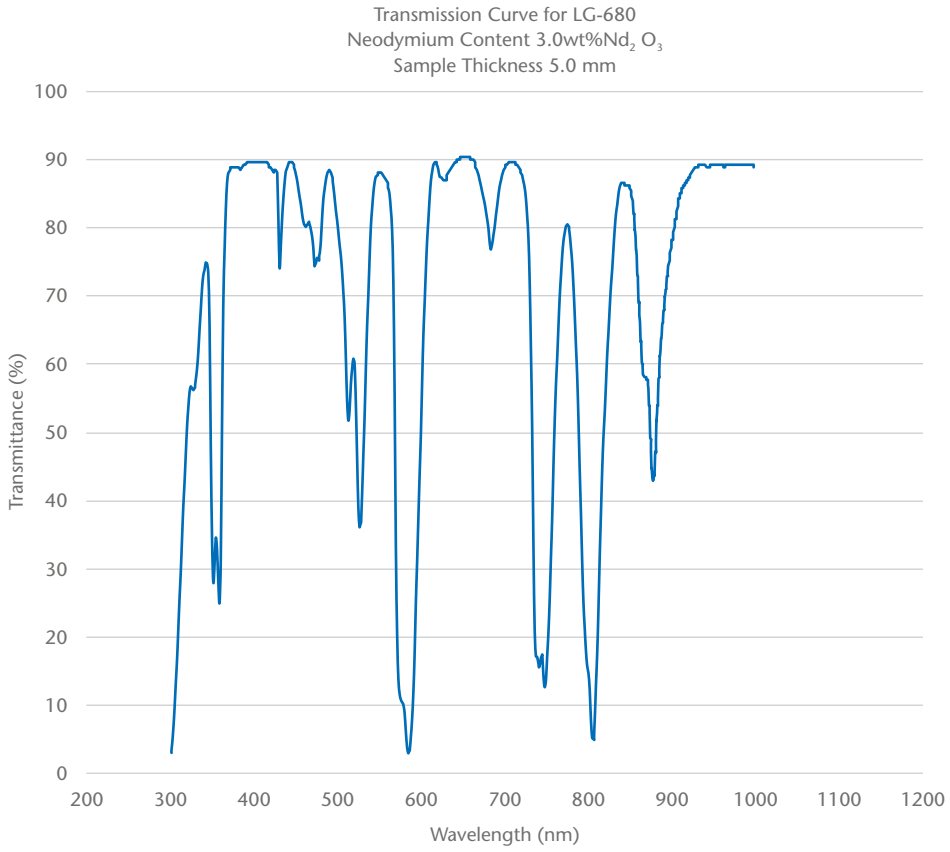
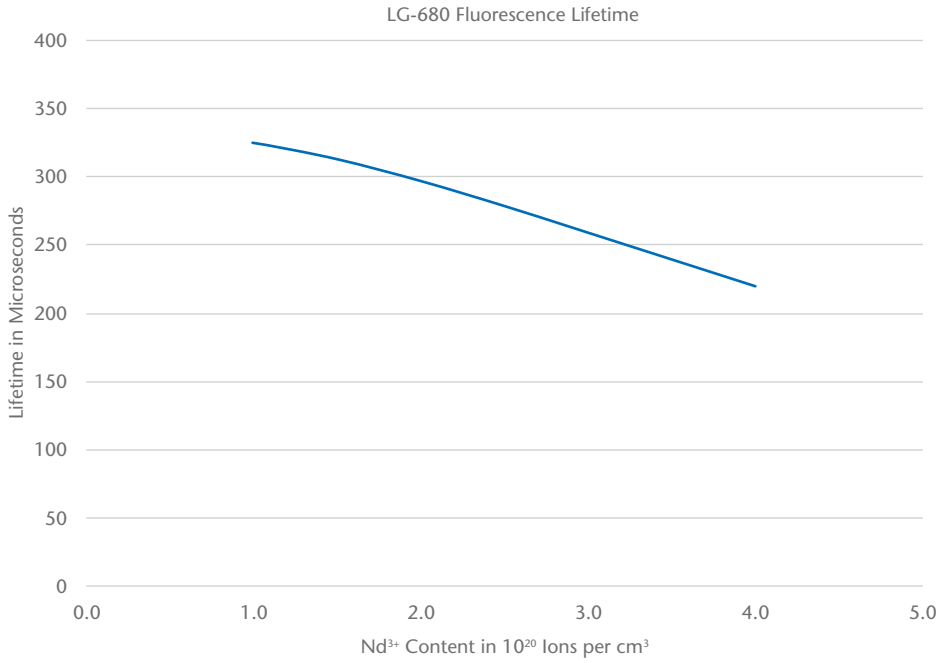
LG-680 Silicate Laser Glass





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LG-750 Phosphate Laser Glass

For High Energy Applications

Neodymium Laser Properties	
Emission Peak, λ [nm]	1053.7
Emission Width, $\Delta\lambda_{em}$ [nm]	26.0
Radiative Lifetime, τ_{Rad} [µs]	347
Emission Cross Section, σ_{em} [10^{-20} cm^2]	3.7
*Quenching Constant-Zero Concentration Lifetime, τ_o [µs]	383
*Quenching Constant-Q Factor, Q [10^{20} cm^{-3}]	7.4

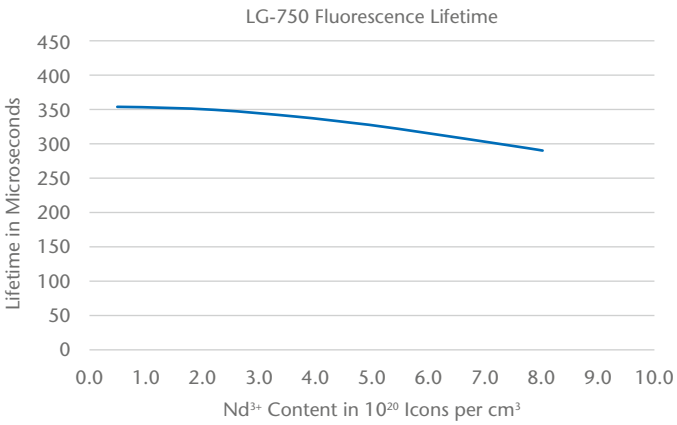
*Lifetime as a function of neodymium content is approximated by: $T = T_o/(1+(Nd/Q)^2)$, Nd = Nd concentration in 10^{20} ions/cm^3

Optical Properties	
n_d	1.5260
v_d	68.20
$n_{633\ nm}$	1.5240
$n_{1054\ nm}$	1.5160
Nonlinear Refractive Index at 1054 nm, n_2 [10^{-20} m^2/W]	3.0
Stress-Optic Coefficient, K (588 nm, 22 °C) [10^{-6} mm^2/N]	1.80
Stress-Optic Coefficient, $-K_{par}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	2.68
Stress-Optic Coefficient, $-K_{per}$ (632.8 nm, 25 °C) [10^{-6} mm^2/N]	4.46
Temperature Coefficient of Refractive Index, dn/dT_{rel} (1060 nm, 20–40 °C) [10^{-6}/K]	–5.1
Temperature Coefficient of Optical Pathlength, $W = \alpha_{+20/+40\,°C}$ (n-1) + dn/dT [10^{-6}/K]	0.8

Sellmeier Coefficients	
B1	C1
B2	C2
B3	C3

Attenuation Coefficient [cm^{-1}]			
400 nm	≤ 0.20	3000 nm	≤ 0.80
1054 nm	≤ 0.0015	3333 nm	≤ 2.00

LG-750 is the potassium-barium-aluminum-phosphate based glass with a high cross section for stimulated emission, low nonlinear refractive index, and good athermal characteristics. This glass was initially developed for the US DOE NOVA Laser Facility. The glass property space of this glass is extensively discussed in "Effect of composition on the thermal, mechanical, and optical properties of phosphate laser glasses" Proc SPIE, Vol 1277, 121-139 (1990).



Physical Properties	
Density, ρ [g/cm^3]	2.830
Thermal Conductivity (25 °C), λ [W/m·K]	0.49
Thermal Conductivity (90 °C), λ [W/m·K]	0.52
Young's Modulus, E [10^3 N/mm^2]	50.10
Poisson's Ratio, µ	0.256
Fracture Toughness, K_{1c} [MPa·m$^{1/2}$]	0.48
Knoop Hardness, $HK_{0.1/20}$	290
Heat Capacity (25 °C), C_p [J/g·K]	0.72
Thermal Diffusivity (25 °C), σ [10^{-7} m^2/s]	2.43
Thermal Expansion, $\alpha_{+20/+300\,°C}$ [10^{-6}/K]	13.01
Thermal Expansion, $\alpha_{+20/+40\,°C}$ [10^{-6}/K]	11.4
Transformation Temperature, T_g [°C]	450

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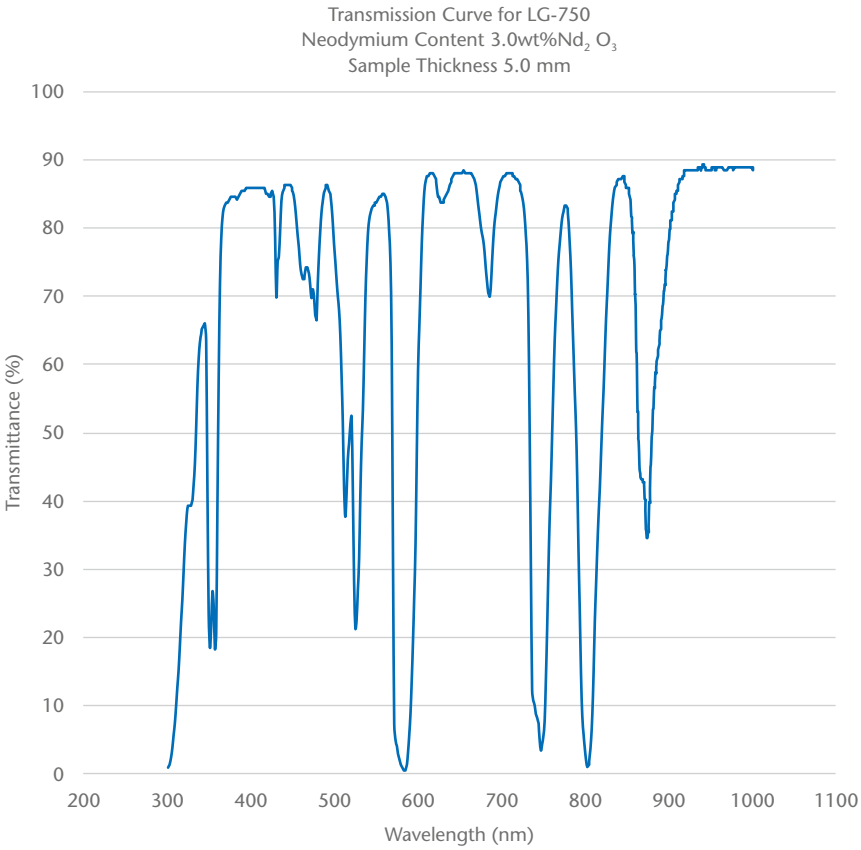
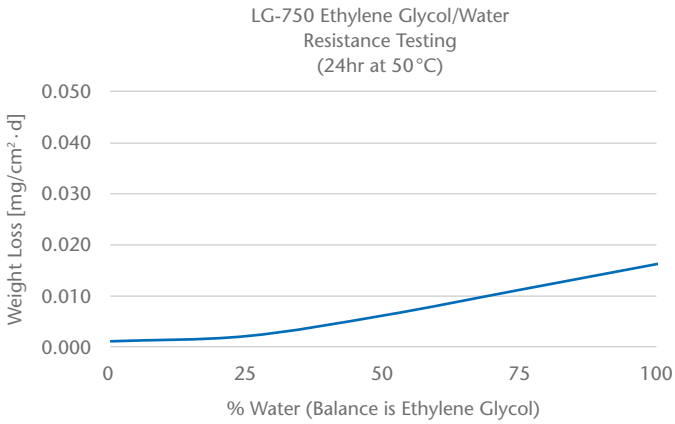
LG-750 Phosphate Laser Glass

For High Energy Applications



Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm² · d)]	0.016
SR	3.0
AR	3.0
FR	1
CR	2



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LG-760 Phosphate Laser Glass

For High Energy Applications

Neodymium Laser Properties	
Emission Peak, λ [nm]	1054
Emission Width, $\Delta\lambda_{em}$ [nm]	24.3
Radiative Lifetime, τ_{Rad} [µs]	323
Emission Cross Section + σ_{em} [10^{-20} cm^2]	4.5
*Quenching Constant-Zero Concentration Lifetime, τ_o [µs]	330
*Quenching Constant-Q Factor, Q [10^{20} cm^{-3}]	10.0

*Lifetime as a function of neodymium content is approximated by: $T=T_o/(1+(Nd/Q)^2)$, Nd = Nd concentration in 10^{20} ions/cm^3

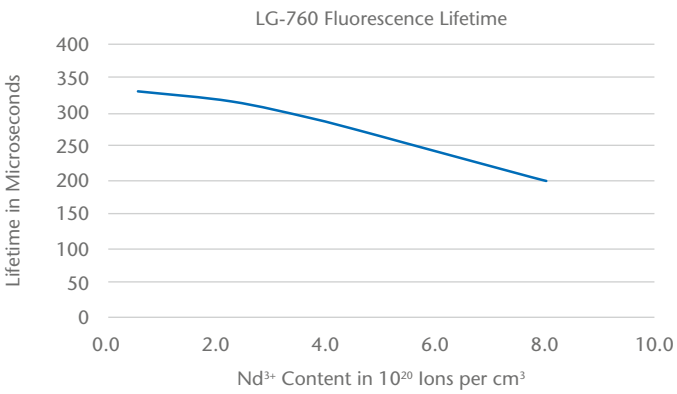
Optical Properties	
n_d	1.5190
v_d	69.20
$n_{633\ nm}$	1.5140
$n_{1054\ nm}$	1.5080
Nonlinear Refractive Index at 1054 nm, n_2 [10^{-20} m^2/W]	2.9
Stress-Optic Coefficient, K (588 nm, 22 °C) [10^{-6} mm^2/N]	2.00
Stress-Optic Coefficient, $-K_{par}$ (632.8 nm, 25°C) [10^{-6} mm^2/N]	2.02
Stress-Optic Coefficient, $-K_{per}$ (632.8 nm, 25°C) [10^{-6} mm^2/N]	4.02
Temperature Coefficient of Refractive Index, dn/dT_{rel} (1060 nm, 20–40° C) [10^{-6}/K]	–6.8
Temperature Coefficient of Optical Pathlength, $W = \alpha_{+20/+40\,°C}$ (n-1) + dn/dT [10^{-6}/K]	–0.4

Sellmeier Coefficients	
B1	C1
B2	C2
B3	C3

Attenuation Coefficient [cm^{-1}]			
400 nm	≤ 0.20	3000 nm	≤ 0.80
1054 nm	≤ 0.0015	3333 nm	≤ 2.00

Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm^2·d)]	0.028
SR	4.0
AR	4.0
FR	1
CR	2

LG-760 is a potassium-barium-aluminum-phosphate based glass with a high cross section for stimulated emission, low nonlinear refractive index, and the best athermal characteristics.



Physical Properties	
Density, ρ [g/cm^3]	2.600
Thermal Conductivity (25 °C), λ [W/m·K]	0.57
Thermal Conductivity (90 °C), λ [W/m·K]	0.60
Young's Modulus, E [10^3 N/mm^2]	53.70
Poisson's Ratio, µ	0.267
Fracture Toughness, K_{1c} [MPa·$m^{1/2}$]	0.47
Knoop Hardness, $HK_{0.1/20}$	340
Heat Capacity (25 °C), C_p [J/g·K]	0.75
Thermal Diffusivity (25 °C), σ [10^{-7} m^2/s]	2.92
Thermal Expansion, $\alpha_{+20/+300\,°C}$ [10^{-6}/K]	15.04
Thermal Expansion, $\alpha_{+20/+40\,°C}$ [10^{-6}/K]	12.5
Transformation Temperature, T_g [°C]	350

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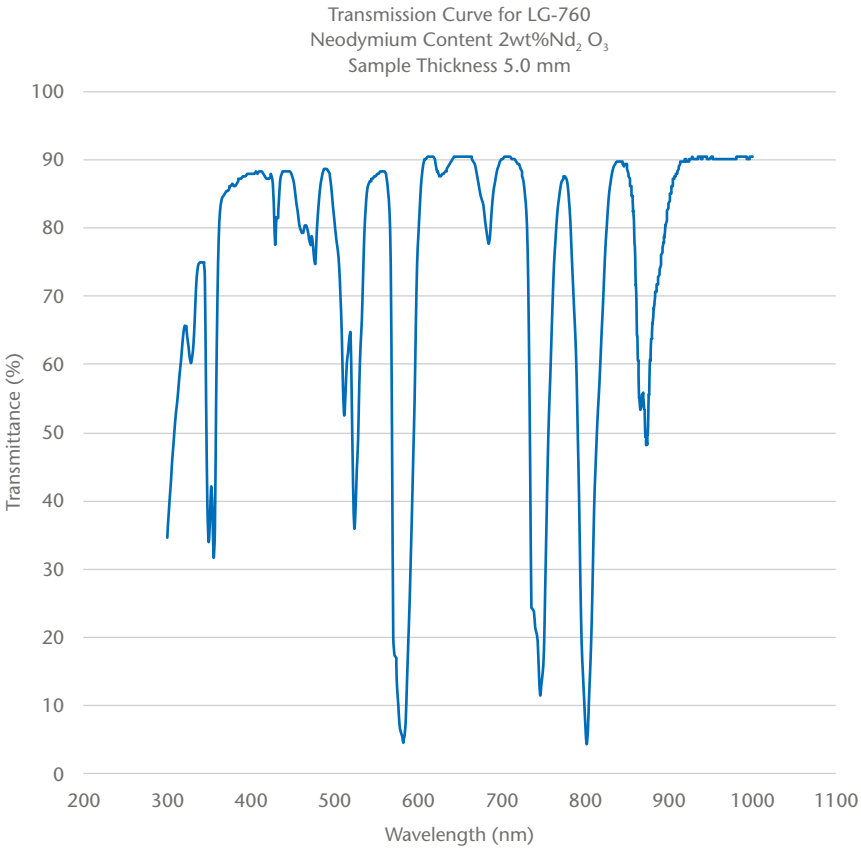
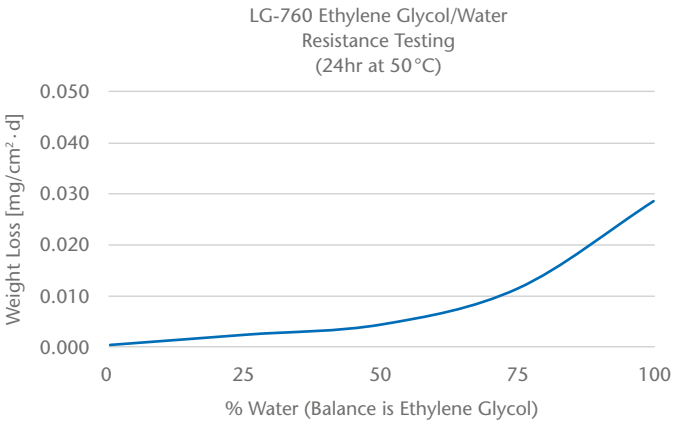
LG-760 Phosphate Laser Glass

For High Energy Applications





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LG-770 Phosphate Laser Glass

For High Energy Applications

Neodymium Laser Properties	
Emission Peak, λ [nm]	1052.7
Emission Width, $\Delta\lambda_{em}$ [nm]	25.4
Radiative Lifetime, τ_{Rad} [µs]	350
Emission Cross Section, σ_{em} [10^{-20} cm^2]	3.9
*Quenching Constant-Zero Concentration Lifetime, τ_o [µs]	372
*Quenching Constant-Q Factor, Q [10^{20} cm^{-3}]	8.8

*Lifetime as a function of neodymium content is approximated by: $T = T_o/(1+(Nd/Q)^2)$, Nd = Nd concentration in 10^{20} ions/cm^3

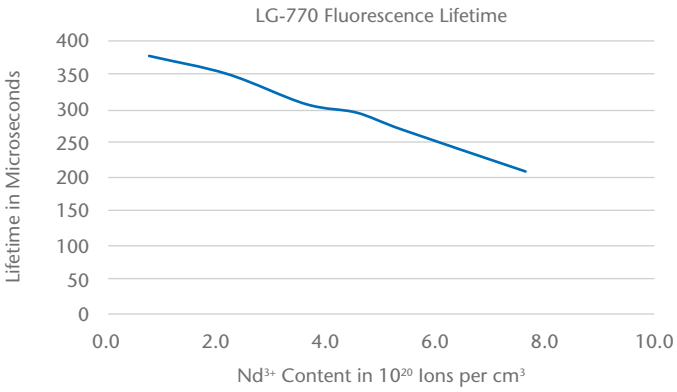
Optical Properties	
n_d	1.5086
v_d	68.40
$n_{633\ nm}$	1.5070
$n_{1054\ nm}$	1.4996
Nonlinear Refractive Index at 1054 nm, n_2 [10^{-20} m^2/W]	2.9
Stress-Optic Coefficient, K (588 nm, 22 °C) [10^{-6} mm^2/N]	2.10
Stress-Optic Coefficient, $-K_{par}$ (632.8 nm, 25°C) [10^{-6} mm^2/N]	2.20
Stress-Optic Coefficient, $-K_{per}$ (632.8 nm, 25°C) [10^{-6} mm^2/N]	3.90
Temperature Coefficient of Refractive Index, dn/dT_{rel} (1060 nm, 20–40 °C) [10^{-6}/K]	–4.7
Temperature Coefficient of Optical Pathlength, $W = \alpha_{+20/+40\,°C}$ (n-1) + dn/dT [10^{-6}/K]	1.1

Sellmeier Coefficients			
B1	1.03692728	C1	0.00577291
B2	0.21105327	C2	0.01976189
B3	0.77362466	C3	101.422203

Attenuation Coefficient [cm^{-1}]			
400 nm	≤ 0.20	3000 nm	≤ 0.80
1054 nm	≤ 0.0015	3333 nm	≤ 2.00

Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm^2·d)]	0.040
SR	3.0
AR	4.0
FR	0
CR	3

LG-770 is an aluminum-phosphate based glass with a high cross section for stimulated emission, extremely low non-linear refractive index, and good athermal characteristics. This glass was initially developed for the US DOE National Ignition Facility and French CEA Project Laser Megajoule. The development and the advantages of this glass are discussed in "Laser and thermo-physical properties of Nd-doped phosphate glasses" Proc SPIE, Vol 1761, 162-173 (1992).



Physical Properties	
Density, ρ [g/cm^3]	2.585
Thermal Conductivity (25 °C), λ [W/m·K]	0.57
Thermal Conductivity (90 °C), λ [W/m·K]	0.63
Young's Modulus, E [10^3 N/mm^2]	47.29
Poisson's Ratio, μ	0.253
Fracture Toughness, K_{1c} [MPa·m$^{1/2}$]	0.48
Knoop Hardness, $HK_{0.1/20}$	330
Heat Capacity (25 °C), C_p [J/g·K]	0.77
Thermal Diffusivity (25 °C), σ [10^{-7} m^2/s]	2.86
Thermal Expansion, $\alpha_{+20/+300\,°C}$ [10^{-6}/K]	13.36
Thermal Expansion, $\alpha_{+20/+40\,°C}$ [10^{-6}/K]	11.61
Transformation Temperature, T_g [°C]	461

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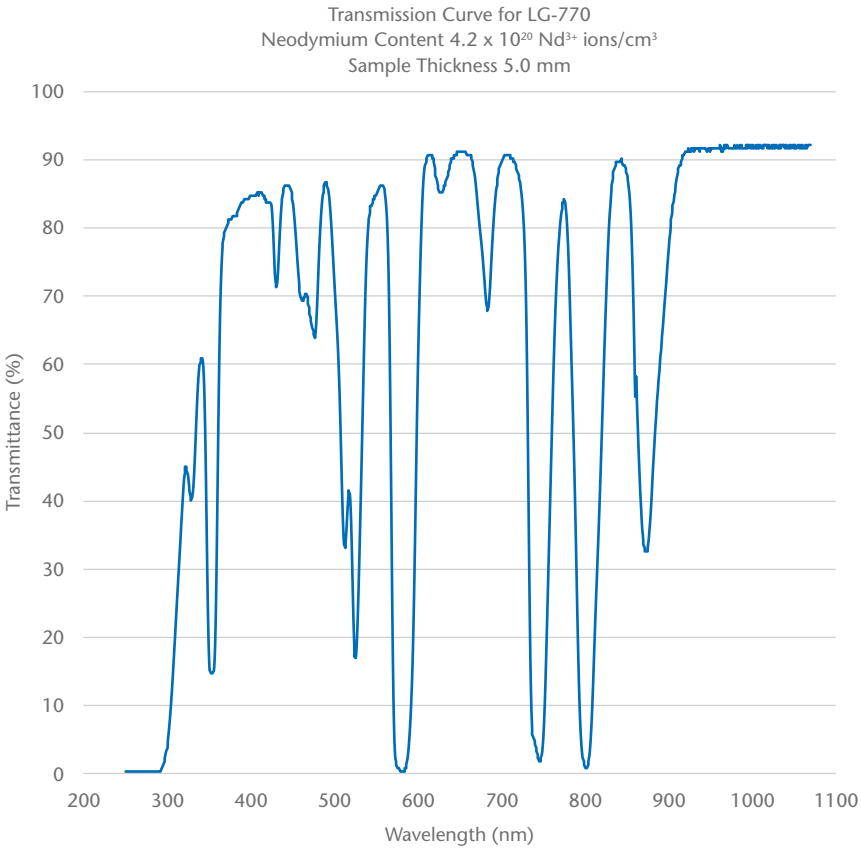
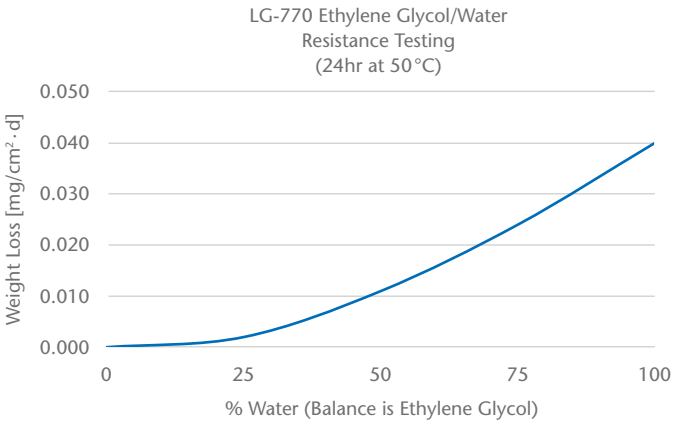
LG-770 Phosphate Laser Glass

For High Energy Applications





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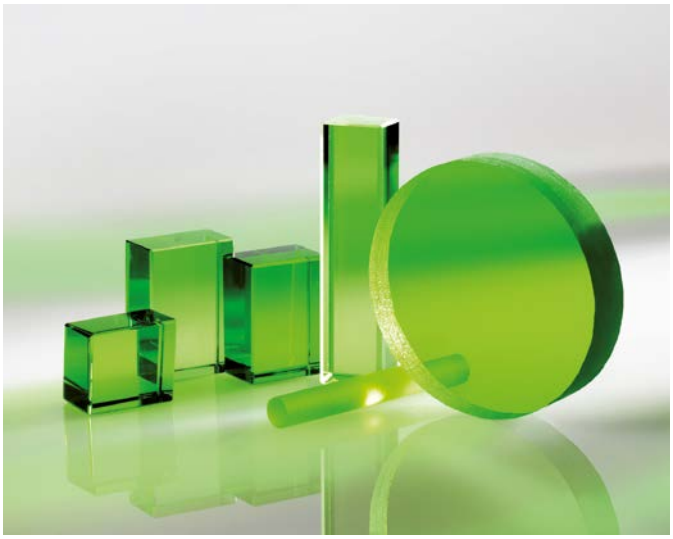
LG-940 'Eye-Safe' Laser Glass

Phosphate laser glass for rangefinding, medical and bio-photonic applications; operation at 1.5 µm

Product Information

The LG-940 is an Erbium – Ytterbium – Chromium – Cerium doped phosphate based laser glass used in flashlamp pumped and diode pumped solid-state laser systems. Phosphate glasses generally offer higher solubility of rare earth dopants, thus the amount of active ions can be significantly increased.



Applications

- Medical lasers for dermatological use
- Analytical instrumentation
- Rangefinders

Advantages

- Good athermal properties
- High transmission at the lasing wavelength
- Consistent quality and high homogeneity

Quality Assurance

Quality control is based on statistical process control, as well as on rigorous final inspection of the finished component. Glass properties are measured for every melt. Measurement instruments include a broad range of interferometers, spectrophotometers, physical property test systems, vision systems, and a laser test bed.

Forms of Supply

We supply fully finished laser components fabricated to customer specifications (e. g. rods, slabs and discs) with high laser damage threshold dielectric coatings.

Application Support

Please contact us with your requested laser glass specifications. Our experienced application team is trained to find the right solution for your application.

Erbium Laser Properties	
Emission Cross Section Maxima, λ [nm]	1532.5
Effective Linewidth [nm]	39.9
Linewidth, FWHM [nm]	25.3
Loss at Lasing Wavelength* [cm^{-1}]	
Radiative Lifetime τ_{Rad} [ms]	11.1
Emission Cross Section, σ_{em} [10^{-20} cm^2]	0.71
Fluorescence Lifetime [ms]	9.4

*Loss at the lasing wavelength is dominated by ground state absorption of erbium and is thus a function of erbium content in the glass. This glass is suitable for "eye-safe" laser devices. Actual safety depends on product configuration.

Erbium has significant absorption at the lasing wavelength.
For further information please contact a sales representative.

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Optical Properties	
n_d	1.533
v_d	62.2
n_2 [10^{-20} m^2/W]	3.5
dn/dT relative at 1.54 µm [10^{-6}/K]	–3.6
$n_{1540\ nm}$	1.522

Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm² · d)]	0.025
SR	4.3
AR	3.3
FR	0
CR	1–2

Physical Properties	
Density, ρ [g/cm³]	3.04
Thermal Conductivity (25 °C), $\lambda_{25\,°C}$ [W/m · K]	0.51
Thermal Conductivity (90 °C), $\lambda_{90\,°C}$ [W/m · K]	0.61
Young's Modulus, E [10^3 N/mm²]	57.6
Poisson's Ratio, µ	0.26
Fracture Toughness, K_{1c} [MPa · $m^{1/2}$]	0.7
Knoop Hardness, $HK_{0.1/20}$	380
Heat Capacity (25 °C), $C_{p25\,°C}$ [J/g · K]	
Thermal Diffusivity (25 °C), $\delta_{25\,°C}$ [10^{-7} m^2/s]	
Thermal Expansion, $\alpha_{20-300\,°C}$ [10^{-6}/K]	11.96
Thermal Expansion, $\alpha_{20-40\,°C}$ [10^{-6}/K]	8.11
Transformation Temperature, T_g [°C]	456

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LG-950 ‘Eye-Safe’ Laser Glass

Phosphate laser glass for range finding and medical applications at 1.5 µm

Product information

LG-950 is an Erbium and Ytterbium doped phosphate laser glass for solid state laser applications usable in diode pumped solid-state laser applications. Besides a good solubility of rare earth ions the phosphate glass offers also a good laser performance. The glass is produced in Europe and is designed for our European customers.

Applications

- Rangefinders
- Medical lasers for dermatological use

Quality assurance

Quality control is carried out under rigorous final inspection of the finished component. Selected glass properties and doping levels are measured for every melt. Measurements include chemical composition control, a range of photometric measurements, physical property test and inspection of inner quality.

Forms of supply

The glass is available as fully finished components, such as rods, slabs and discs, manufactured according to customer specifications including dielectric coatings (AR, HR, etc.) with high laser threshold. Please contact us to find out which of the various doping levels are available from stock according to your needs.

Application support

Please contact us with your laser components specification. Our European expert application team will find the right solution for your application.

Erbium Laser Properties	
Emission Cross Section Maxima λ [nm]	1534.2
Effective Linewidth [nm]	53.4
Linewidth FWHM [nm]	20.4
Radiative Lifetime τ_{Rad} [ms] (calc.)	8.6
Emission Cross Section σ_{em} [10^{-21} cm^2]	7.0
Fluorescence Lifetime [ms]	6.4

Erbium has significant absorption at the lasing wavelength.
For further information please contact a sales representative.

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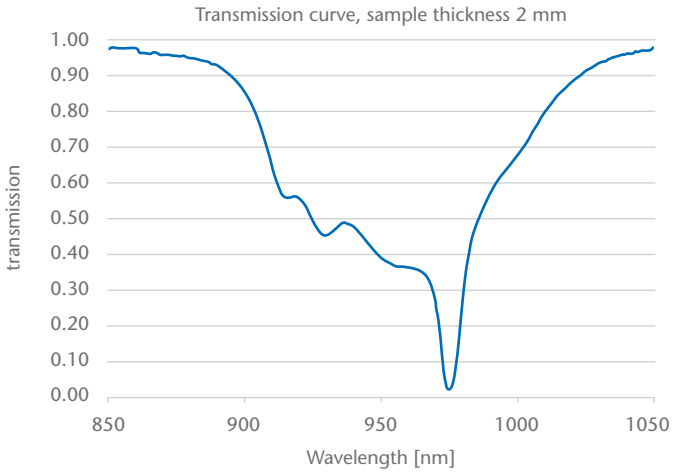
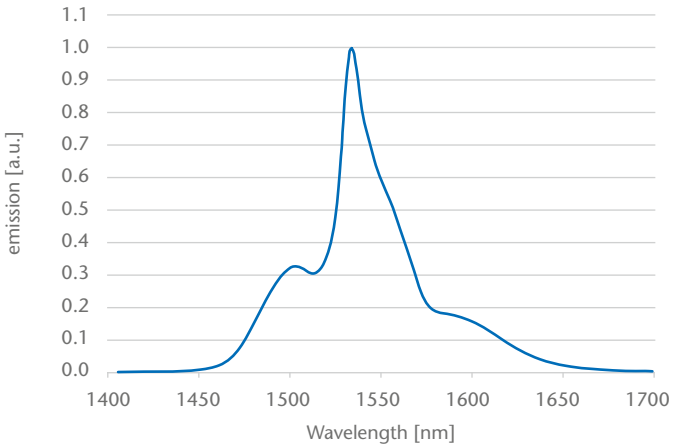
Optical Properties	
n_d	1.5291
ν_d	63.0
n_2 [10^{-20} m^2/W] (calc.)	3.4
dn/dT relative at 1.54 µm [10^{-6}/K]	
$n_{1534\ nm}$ (calc.)	1.5151
Stress Optical Coefficient K [10^{-6} mm^2/K]	2.35

Sellmeier Coefficients			
B1	1.24000	C1	0.00745
B2	0.07010	C2	0.03330
B3	0.81400	C3	100.000

Physical Properties	
Density ρ [g/cm^3]	2.919
Thermal Conductivity $\lambda_{90°C}$ [W/(m·K)]	0.63
Young's Modulus E [10^3 N/mm^2]	56.3
Poisson's Ratio µ	0.249
Knoop Hardness $HK_{0.1/20}$	371
Heat Capacity c_p [J/(g·K)]	0.72
Thermal Expansion $\alpha_{(+20/+300°C)}$ [10^{-6}/K]	12.9
Thermal Expansion $\alpha_{(+20/+40°C)}$ [10^{-6}/K]	10.84
Transformation Temperature T_g [°C]	422

Chemical Properties	
SR	4.0
AR	4.3
FR	0
CR	4





(All properties displayed exemplary for a doping level of $14.7 \cdot 10^{20}$ Yb^{3+} ions/cm^3 and $0.55 \cdot 10^{20}$ Er^{3+} ions/cm^3)

The following doping levels are available:

Yb^{3+} [10^{20} ions/cm^3]	Er^{3+} [10^{20} ions/cm^3]
13.2	0.55
20.0	0.15
all	
±0.3	±0.05

Other doping levels are available for
$12 - 20 \cdot 10^{20}$ Yb^{3+} Ions/cm^3 and $0.13 - 0.70 \cdot 10^{20}$ Er^{3+} Ions/cm^3

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Preliminary

LG-960 'Eye-Safe' Laser Glass

Phosphate laser glass for range finding and medical applications at 1.5 µm

Product information

LG-960 is an Erbium – Yttrium doped phosphate laser glass with improved thermo-mechanical figure of merit usable in flash lamp and diode pumped solid state laser applications. It offers possibilities for increased load and/or repetition rates.

Applications

- Rangefinders
- LIDAR
- Medical lasers for dermatological use

Quality assurance

Quality control is carried out under rigorous final inspection of the finished component. Selected glass properties and doping levels are measured for every melt. Measurements include chemical composition control, a range of photometric measurements, physical property test and inspection of inner quality.

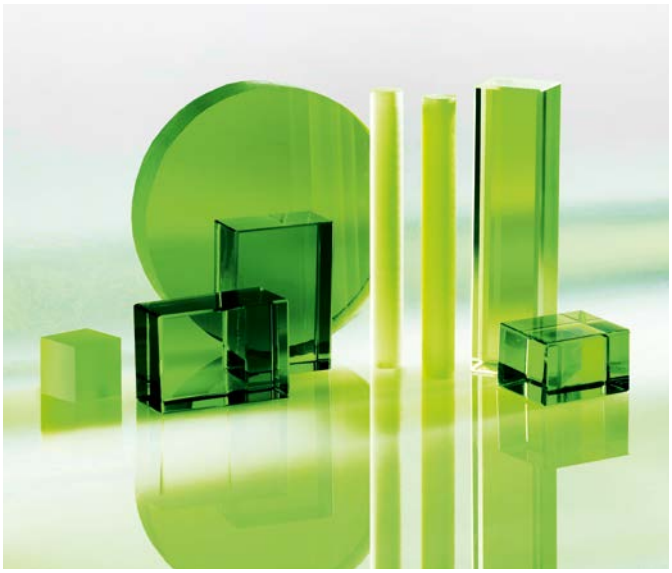
Forms of supply

The glass is available as fully finished components, such as rods, slabs and discs, manufactured according to customer specifications including dielectric coatings (AR, HR, etc.) with high laser damage threshold.

Application support

Please contact us with your laser components specification. Our experienced expert application team will find the right solution for your application.

Erbium has significant absorption at the lasing wavelength.
For further information please contact a sales representative.



Erbium Laser Properties	
Emission Cross Section Maxima λ [nm]	1534.3
Effective Linewidth [nm]	42.9
Linewidth FWHM [nm]	23.0
Radiative Lifetime τ_{Rad} [ms] (calc.)	11.0
Emission Cross Section σ_{em} [10^{-21} cm^2]	6.7
Fluorescence Lifetime [ms]	10.1

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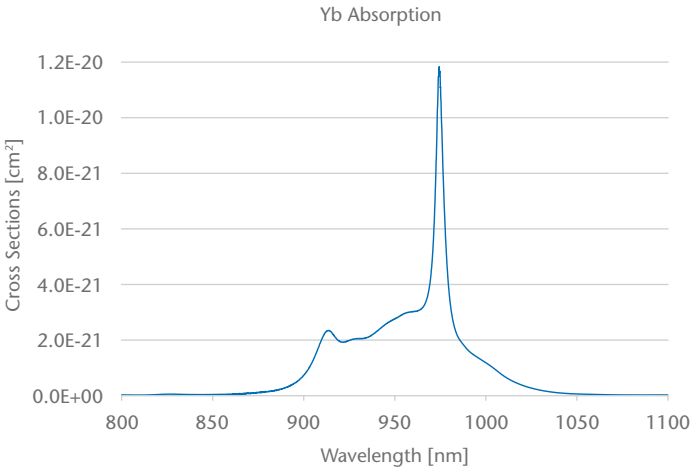
Preliminary

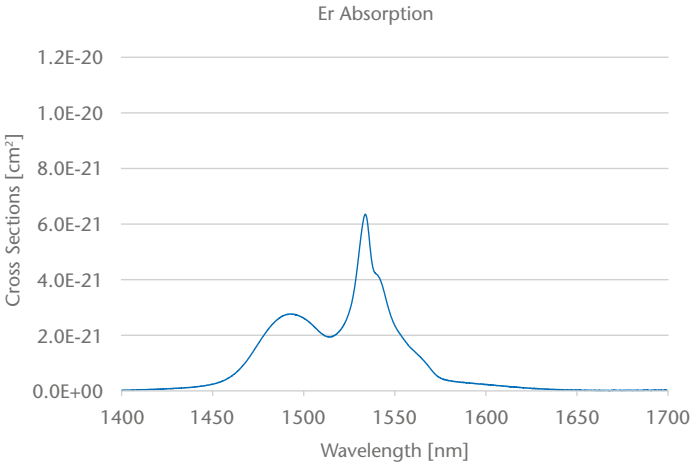
Optical Properties	
n_d	1.545
ν_d	62.5
n_2 [10^{-20} m^2/W] (calc.)	3.6
dn/dT relative at 1.54 µm [10^{-6}/K]	
$n_{1534\ nm}$ (calc. from Sellmeier)	
Stress Optical Coefficient K [10^{-6} mm^2/K]	

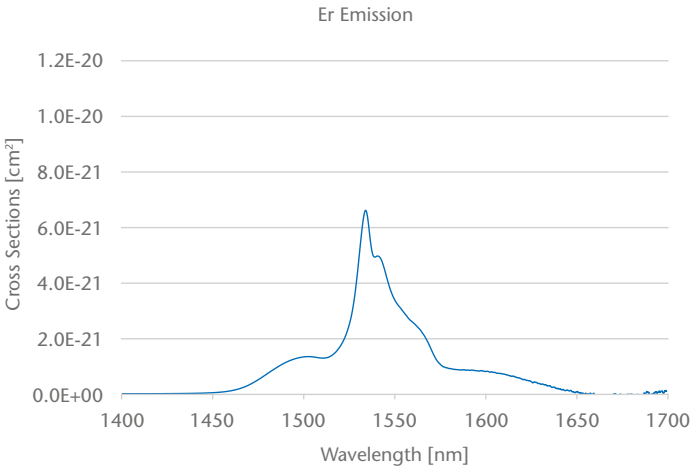
Sellmeier Coefficients	
B1	C1
B2	C2
B3	C3

Physical Properties	
Density ρ [g/cm^3]	3.14
Thermal Conductivity $\lambda_{90\,°C}$ [W/(m·K)]	0.65
Young's Modulus E [10^3 N/mm^2]	66.5
Poisson's Ratio µ	0.25
Fracture Toughness, K_{1C} [MPa·$m^{1/2}$]	0.7
Knoop Hardness $HK_{0.1/20}$	417
Heat Capacity $c_{p,\,25\,°C}$ [J/(g·K)]	
Thermal Expansion $\alpha_{(+20/+300\,°C)}$ [10^{-6}/K]	10.0
Thermal Expansion $\alpha_{(+20/+40\,°C)}$ [10^{-6}/K]	7.8
Transformation Temperature T_g [°C]	489

Chemical Properties
SR
AR
FR
CR







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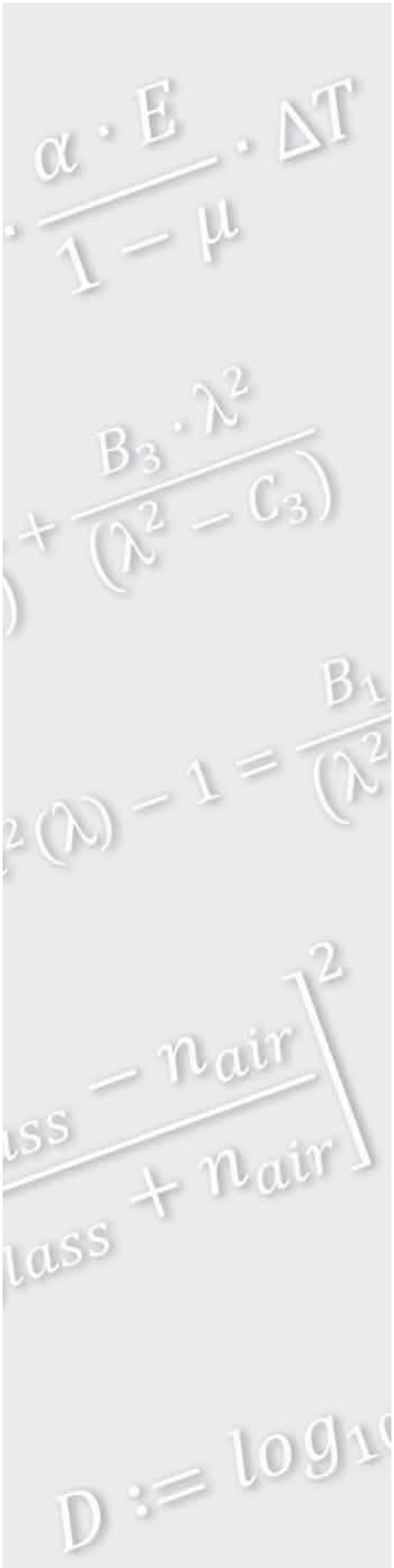


Passive Materials

For more than 125 years, SCHOTT Advanced Optics has worked diligently to meet the ever-changing needs of the optical and industrial markets. As such, we have engineered an extensive portfolio of high-quality optical glasses for numerous applications – from consumer products to those systems required by leading-edge research.

Today we continue this legacy of ingenuity by focusing on new ways to address future market requirements. This includes the development of new optical glasses for rapidly growing, market-oriented innovations and the utilization of new melting processes that ensure economical and timely production. Our exhaustive range of optical glass material offerings includes classical glass types, as well as ZERODUR®, BOROFLOAT®, optical filter glass types and Zinc Sulfide (ZnS).

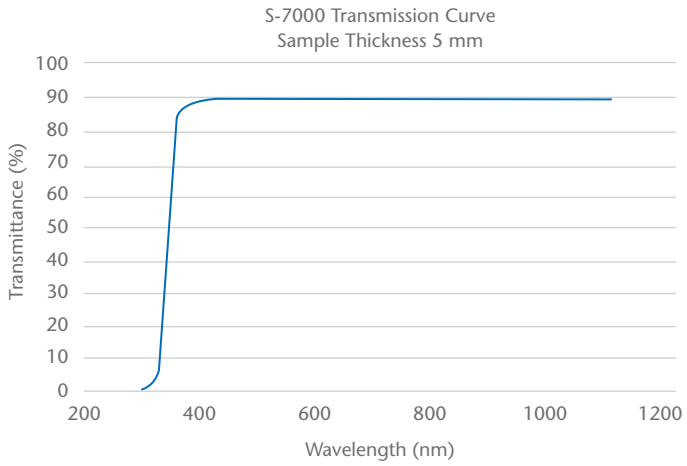
Complementary to our active laser materials portfolio, SCHOTT offers passive laser glasses that address a variety of optical and industrial needs. This can include acting as an absorbing filter to eliminate undesired pumping light or amplified spontaneous emission, inside a laser cavity. SCHOTT can even imbue laser slabs with edge cladding glasses to eliminate parasitic oscillations inside the active materials.

Passive Glasses Laser Cavity Materials S7010N, S7005 and S7000

S7000 is a clear, cerium-doped silicate glass used as a laser cavity material. It is also available to serve as a UV cut-off material. S7005 is a laser cavity material with 5 % doping of samarium oxide. This material is usually thicker than 6 mm. S7010N is a laser cavity material with 10 % doping of samarium oxide. This glass is recommended for most applications. SCHOTT offers a complete line of commercial filter glasses and can produce with a full range of doping levels for specific applications.

Property Sheet for S7000

Optical Properties	
n_d	1.563
v_d	55.7
$n_{1054\ nm}$	1.561
$n_{1054\ nm}$	1.552
UV Cut-off at 10% Transmission, Thickness of 5 mm [nm]	300



Physical Properties	
Density, ρ [g/cm³]	2.83
Thermal Conductivity (25 °C), κ [W/m x K]	0.80
Thermal Conductivity (90 °C), κ [W/m x K]	0.96
Young's Modulus, E [GPa]	78
Poisson's Ratio, ν	0.247
Thermal Expansion, $\alpha_{20-300\,°C}$ [10^{-7}/°C]	111
Transformation Temperature, T_g [°C]	452
Softening Point ($10^{7.6}$ poise) [°C]	598

Chemical Properties	
Weight Loss in 50 °C Water [mg/(cm² x day)]	0.180
Acid Resistance SR pH = 0.3 at 25 °C	1.2
Alkali Resistance AR pH = 12 at 50 °C	1.0
Staining Resistance FR pH = 4.6 100 h at 25 °C	1
Climatic Resistance CR Water Vapor at 40–50 °C for 30 h	1–2
Samarium Content [wt% Sm_2O_3]	0

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SCHOTT N-BK7® – 517642.251

Refractive Indices		
	λ [nm]	
$n_{2325.4}$	2325.4	1.48921
$n_{1970.1}$	1970.1	1.49495
$n_{1529.6}$	1529.6	1.50091
$n_{1060.0}$	1060.0	1.50669
n_t	1014.0	1.50731
n_s	852.1	1.50980
n_r	706.5	1.51289
n_C	656.3	1.51432
$n_{C'}$	643.8	1.51472
$n_{632.8}$	632.8	1.51509
n_D	589.3	1.51673
n_d	587.6	1.51680
n_e	546.1	1.51872
n_F	486.1	1.52238
$n_{F'}$	480.0	1.52283
n_g	435.8	1.52668
n_h	404.7	1.53024
n_i	365.0	1.53627
$n_{334.1}$	334.1	1.54272
$n_{312.6}$	312.6	1.54862
$n_{296.7}$	296.7	
$n_{280.4}$	280.4	
$n_{248.3}$	248.3	

Constants of Dispersion Formula	
B_1	1.03961212
B_2	0.231792344
B_3	1.01046945
C_1	0.00600069867
C_2	0.0200179144
C_3	103.560653

Constants of Dispersion dn/dT	
D_0	$1.86 \cdot 10^{-6}$
D_1	$1.31 \cdot 10^{-8}$
D_2	$-1.37 \cdot 10^{-11}$
E_0	$4.34 \cdot 10^{-7}$
E_1	$6.27 \cdot 10^{-10}$
λ_{TK}[µm]	0.17

Internal Transmittance τ_i		
λ [nm]	τ_i (10mm)	τ_i (25mm)
2500	0.665	0.360
2325	0.793	0.560
1970	0.933	0.840
1530	0.992	0.980
1060	0.999	0.997
700	0.998	0.996
660	0.998	0.994
620	0.998	0.994
580	0.998	0.995
546	0.998	0.996
500	0.998	0.994
460	0.997	0.993
436	0.997	0.992
420	0.997	0.993
405	0.997	0.993
400	0.997	0.992
390	0.996	0.989
380	0.993	0.983
370	0.991	0.977
365	0.988	0.971
350	0.967	0.920
334	0.905	0.780
320	0.770	0.520
310	0.574	0.250
300	0.292	0.050
290	0.063	
280		
270		
260		
250		

Color Code	
λ_{80}/λ_5	33/29
(*= λ_{70}/λ_5)	

Remarks

n_d = 1.51680 **ν_d = 64.17** **$n_F - n_C$ = 0.008054**
n_e = 1.51872 **ν_e = 63.96** **$n_{F'} - n_{C'}$ = 0.008110**

Relative Partial Dispersion	
$P_{s,t}$	0.3098
$P_{C,s}$	0.5612
$P_{d,C}$	0.3076
$P_{e,d}$	0.2386
$P_{g,F}$	0.5349
$P_{i,h}$	0.7483
$P'_{s,t}$	0.3076
$P'_{C',s}$	0.6062
$P'_{d,C'}$	0.2566
$P'_{e,d}$	0.2370
$P'_{g,F'}$	0.4754
$P'_{i,h}$	0.7432

Deviation of Relative Partial Dispersions ΔP from the "Normal Line"	
$\Delta P_{C,t}$	0.0216
$\Delta P_{C,s}$	0.0087
$\Delta P_{F,e}$	-0.0009
$\Delta P_{g,F}$	-0.0009
$\Delta P_{i,g}$	0.0035

Other Properties	
$\alpha_{-30/+70°C}$[10^{-6}/K]	7.1
$\alpha_{+20/+300°C}$[10^{-6}/K]	8.3
T_g[°C]	557
$T_{10^{13.0}}$[°C]	557
$T_{10^{7.6}}$[°C]	719
c_p[J/(g·K)]	0.858
λ [W/(m·K)]	1.114
ρ [g/cm³]	2.51
E[10^3 N/mm²]	82
μ	0.206
K[10^{-6} mm²/N]	2.77
$HK_{0.1/20}$	610
HG	3
B	0
CR	1
FR	0
SR	1
AR	2.3
PR	2.3

Temperature Coefficients of Refractive Index						
	$\Delta n_{rel}/\Delta T$[10^{-6}/K]			$\Delta n_{abs}/\Delta T$[10^{-6}/K]		
[°C]	1060.0	e	g	1060.0	e	g
-40/ -20	2.4	2.9	3.3	0.3	0.8	1.2
+20/ +40	2.4	3.0	3.5	1.1	1.6	2.1
+60/ +80	2.5	3.1	3.7	1.5	2.1	2.7

As of 09/19/2007, Subject to change

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ZERODUR® – Extremely low Expansion Glass Ceramic

Applications

ZERODUR® has become a performance- and quality-benchmark in many spectacular applications within modern technology:

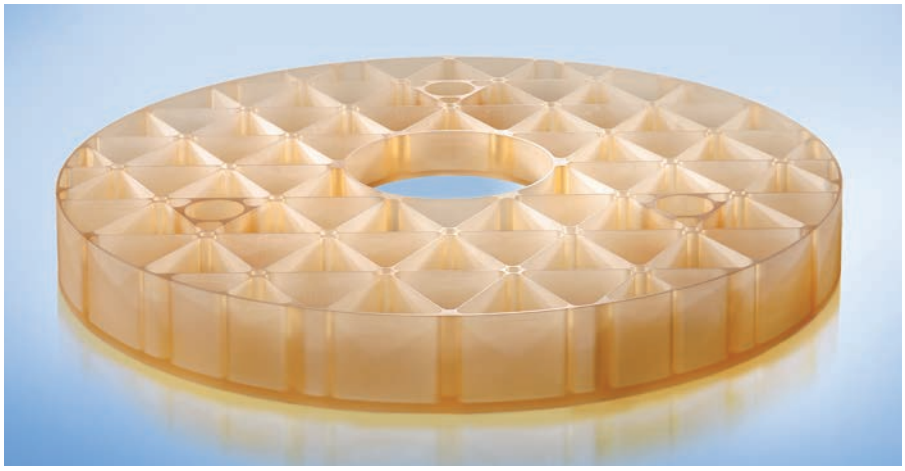
- Stages and mirrors for lithography equipment
- Mirror substrates for segmented and monolithic large astronomical telescopes
- Ultra light weighted mirror blanks
- Standards for precision measurement technology
- High precision mechanical parts, e. g. ring laser gyroscope bodies
- Reference standards for precision measurement technology and comet probes

Properties

ZERODUR® is a glass ceramic with an extremely low thermal expansion for demanding applications in which geometrical shape and distance changes must kept smallest possible under temperature variations.
The key properties of ZERODUR® are:

- Extremely low coefficient of thermal expansion (CTE) for a wide temperature range
- Excellent CTE homogeneity throughout the total volume
- Very low content of imperfections
- Wide range of precise geometrical shapes
- Extremely smooth surface with residual roughness below 1 nm
- Excellent chemical stability

All these properties are realized for small components as well as for astronomy telescope mirror blanks weighting several tons with extraordinary reproducibility.



Extremely low thermal expansion

ZERODUR® is an inorganic glass ceramic with 70 to 78 % of high-quartz micro-crystallites 50 to 80 nm in size, embedded in a remaining glassy phase. The micro-crystals contract when they are subjected to heating, whereas the glass itself expands. Size and number of the micro-crystallites are carefully adjusted to achieve an extremely low thermal expansion. At ambient temperature the net thermal expansion is nearly zero, achieved with an accuracy of down to 0 ± 7 ppb/K. Thanks to the careful temperature processing the thermal expansion of ZERODUR® is extremely homogeneous. About 5 ppb/K CTE homogeneity values have been achieved for 1.5 m class and 4 m class ZERODUR® blanks as well.

Properties	ZERODUR®
Density [g/cm³]	2.53
Young's Modulus E [GPa]	90.3
Poisson's Ratio μ	0.24
Knoop Hardness [HK 0.1/20]	620
Coefficient of thermal expansion α CTE (0 °C; 50 °C) [10^{-6}/K]	0 ± 0.100 (class 2) 0 ± 0.050 (class 1) 0 ± 0.020 (class 0) 0 ± 0.010 (SPECIAL) 0 ± 0.007 (EXTREME)
ZERODUR® TAILORED	TAILORED ± 0.020 ppm/K Optimized for application temperature profile
CTE (0 °C; 50 °C) Homogeneity	< 0.01 – 0.03*10^{-6}/K
Heat Capacity cp (20 °C) [J/(gK)]	0.80
Thermal Conductivity $\lambda_{90°C}$ [W/(mK)]	1.46
Max. Application Temperature [°C]	600

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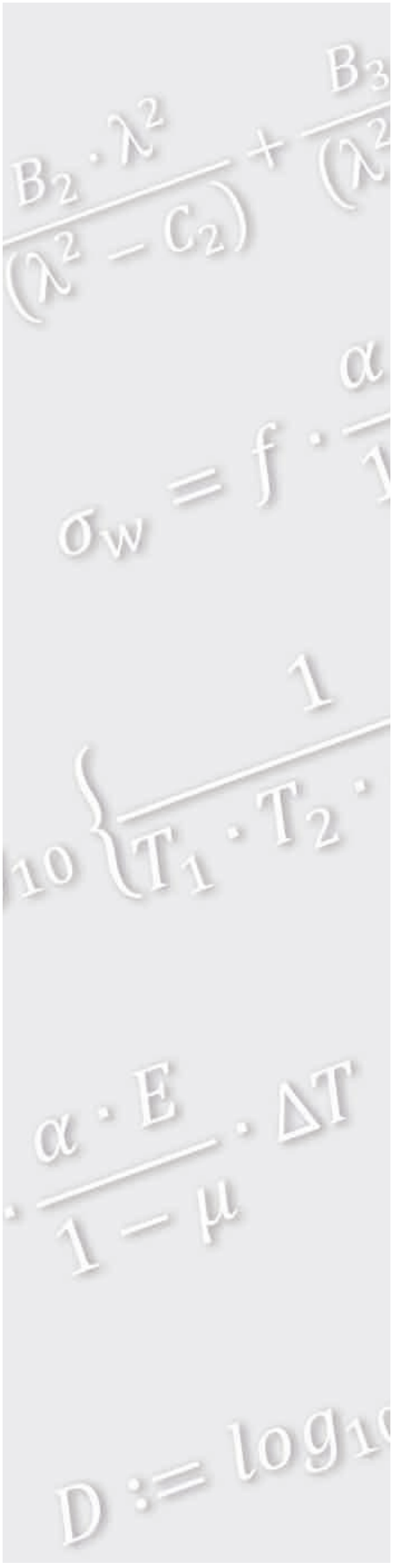
Components

In addition to materials, SCHOTT offers a full range of finished components and advanced coatings for the laser market. This includes precision manufactured spherical and aspherical lenses, mirrors, substrates, wafers, windows, debris shields, and prisms, which are available with or without HR- and AR-coatings.

SCHOTT also has the capacity to design and deliver high-quality, customized components, including beam splitters and polarizers. Our mastery of the entire value chain allows us to optimize our manufacturing process based on your quantity needs, effectively leveraging resources and technology for single component or serial production.



Aspherical Lenses

Product Information

Due to the unique profile, aspherical lenses eliminate monochromatic aberrations (e. g. spherical aberrations) and lead to a better overall image quality. They are increasingly used to replace multi-spherical element assemblies resulting in a weight reduction as well as in a more compact design.

Advantages

- SCHOTT masters the entire value chain from raw glass to aspherical coated lenses
- Custom designed products at competitive prices
- 1 piece to series production levels
- Coating: all lenses can be coated to a specific custom design

Materials

- All types of optical glass
- Fused silica
- Other materials on request

Applications

- High power laser lenses collimation
- Focusing optics for Head Up Displays
- Endoscopy
- Microscopy
- Digital projection, camera, binocular

Attribute	CNC machining and polishing			Molded (Low Tg glasses only)
	Commercial	Precision	High Precision	
Diameter	15 – 180 mm	15 – 160 mm	15 – 140 mm	1.5 – 35 mm
Diameter tolerance*	± 0.1 mm	± 0.05 mm	± 0.02 mm	± 0.05 mm
Center thickness*	3 – 40 mm	3 – 40 mm	5 – 40 mm	0.5 – 10 mm
Radius of curvature convex*	> 10 mm	> 20 mm	> 30 mm	> 3 mm
Radius of curvature concave*	On request	On request	On request	> 5 mm
Tolerance on radius of curvature*	± 0.5 %	± 0.1 %	± 0.05 %	± 0.5 %
Surface flatness (PV, asph. side)*	2 µm	0.5 µm	0.2 µm	< 0.5 µm
Irregularity (PV, spherical side)*	1 µm	0.2 µm	0.1 µm	< 0.5 µm
Tilt from asph. side to other side*	< 6 arc min	< 3 arc min	< 1 arc min	< 1 arc min
Surface roughness – Rq*	< 5 nm	< 3 nm	< 1.5 nm	< 15 nm
Surface quality (scratch & dig) (5/NxA)*	60/40 5/6 x 0.25	40/20 5/3 x 0.25	10/5 5/3 x 0.025	40/20 5/3 x 0.16
Typical volume*	From 1 piece to series production			> 200 pcs

*Depending on customer's specifications. Please call sales representative.

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Beamsplitters and Polarizing Beamsplitters

Product Information

Plano/Plano Beamsplitters are produced by using interference coatings for adjusting the splitting ratio (mostly 50:50). Also polarizing Beamsplitters are used to separate S and P polarization from a laser source.

Applications

Beamsplitters can be used to split the optical path in both directions or to separate S and P polarization of the laser beam in:

- Diode laser
- Gas laser
- YAG medical laser
- Diode pumped Solid-State laser

Advantages

- High quality consistency
- High laser damage threshold
- High accurate shape
- Low Scratch-Dig
- Customized design
- In-house coating capabilities

Materials

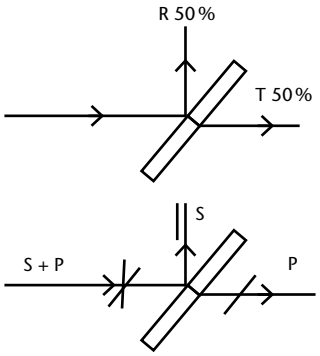
- All types of optical glass
- Fused Silica

Quality Assurance

Our quality control is based on self-checking during production and 100 % final inspection. A coating curve is delivered with the component.

Specifications	
Region for center wavelength	350 – 1600 nm, other wavelengths on demand, bandwidths on demand
Diameter	12.7 – 101.6 mm, other diameters on demand
Surface quality	S-D 10 – 5, depending on dimension
Surface flatness	≤ λ/10, depending on dimension
Roughness	< 1 nm RMS
Parallelism	1 arc minute
Extinction ratio	up to 1000 : 1
Angle of incidence	Standard 45°, other angles on demand
Damage threshold	> 20 J/cm² @ 1064 nm, S-on-1, 10 ns
Coating	Multi-dielectric, AR Coating R < 0.2 %
Splitting ratio	50/50, 70/30, 30/70, other ratios on demand

Beamsplitters



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Debris Shields

Product Information

Debris shields can be used to protect laser optics against dust and pollution. Very high transmission at laser wavelength and low wavefront distortion are key points for Debris shields.

Applications

Debris shields are used especially in high power laser systems to protect the laser optics against dust and fumes from experimental areas.

Advantages

- Customized design
- High quality consistency
- High laser damage threshold
- High transmittance at laser wavelength
- Low wavefront distortion because of high homogeneity
- AR & customized coating possible

Materials

- SCHOTT N-BK7®
- BOROFLOAT®
- Fused Silica
- Other materials on request

Manufacturing Capabilities

	Commercial Quality	Precision Quality	Ultra Precision Quality
Diameter		From 2 mm to 625 mm	
Diameter Tolerance	± 0.25 mm	± 0.050 mm	± 0.005 mm
Thickness Tolerance	± 0.20 mm	± 0.040 mm	± 0.020 mm
Parallelism	< 3 arc minutes	< 1 arc minutes	< 10 arc seconds
Surface Accuracy	2λ	λ/4	λ/20*
Surface Quality (Scratch & Dig)	80/50	60/40	10/5
Surface Roughness	5 nm	2 nm	5Å rms
AR Coating	R_{avg} < 1.5%	R_{avg} < 0.5%	Custom Designed
Order Quantity**		From 1 piece to series production	
Delivery Time**	4 – 6 weeks	4 – 6 weeks	4 – 10 weeks

* Depending on geometry
** Depending on customer specification. Please call your sale representative

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Edge Cladding Glass

Product Information

Edge cladding glass is used for active laser materials to absorb light from spontaneous and amplified spontaneous emission. These effects are reducing laser efficiency and can damage the active materials.

Applications

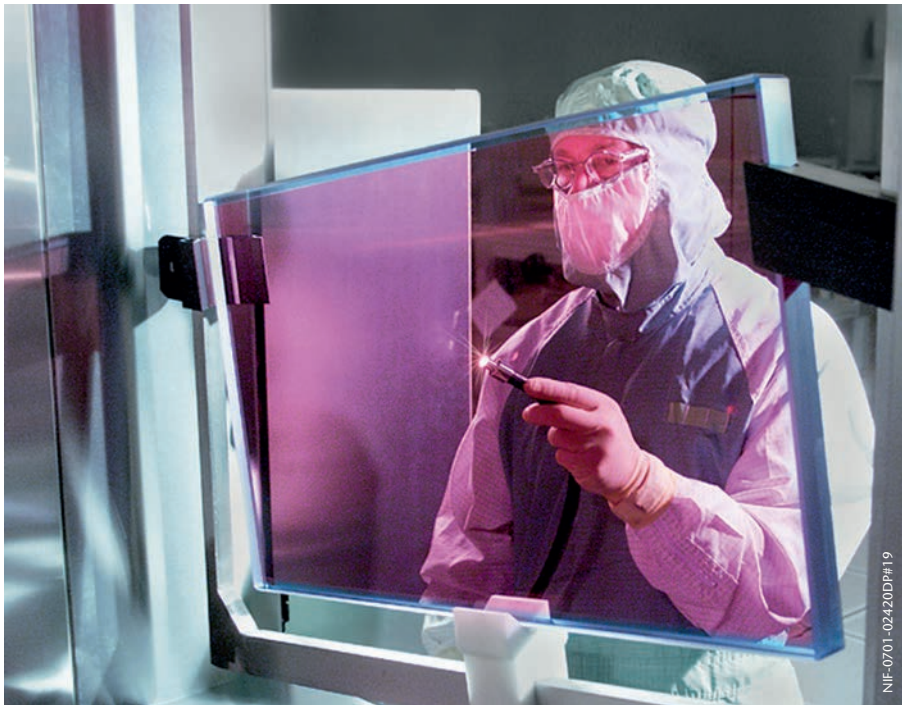
Edge cladding glass can be used for solid state laser and is placed along all of the edges that are not surfaces used for transmitting the amplified laser beam.

Advantages

- Customized design
- High quality consistency
- Good index match to the active laser glass
- High absorption coefficient at laser wavelength

Materials

- Edge cladding glasses for SCHOTT LG laser glasses are available.
- Edge cladding glasses for SCHOTT IOG and SCHOTT APG glasses other solid state laser materials are available upon request.



Lawrence Livermore National lab

Typical Technical Properties (other values are possible)	
Index match to laser glass	+/– 0.003
Absorption coefficient at laser wavelength	0.10 to 0.40 cm^{-1}
Accuracy of absorption coefficient	+/– 0.02 cm^{-1}

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High reflective Laser Mirrors for High Power Laser Applications

SCHOTT's Laser Mirrors with high reflective, broadband coatings especially suitable for high power laser applications

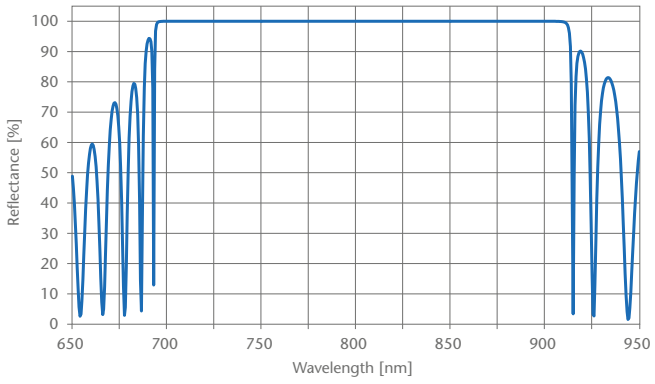
Product Information

Mirror with high reflective broadband coating (700–900 nm) for 45° incidence in S-polarization on SCHOTT N-BK7®, ZERODUR® or fused silica substrates

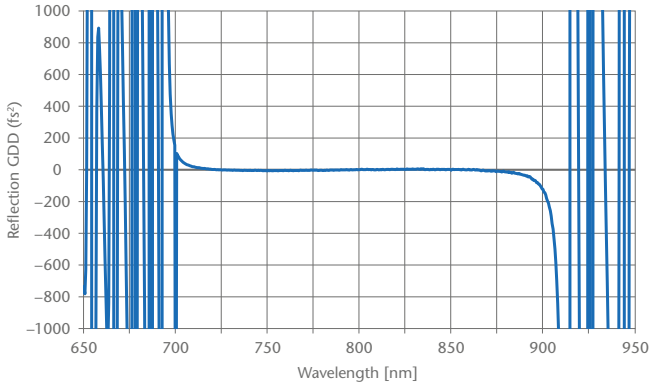
Advantages

- Broad spectral range
- Double sided polished substrates
- High homogeneous SCHOTT N-BK7® for optimum WFE
- High laser damage threshold tested at Lidaris, Lithuania (according DIN EN ISO 21254)

Reflection curve REMAX 785/45° pol. S



Group Delay Dispersion (GDD) curve REMAX 785/45° pol. S



Technical Data

Available dimensions and surface quality	
• Diameter: up to Ø 380 mm • Polishing quality: P4 (R_q = 0.4 – 0.5 nm rms) • Double sided polished	
Spectral range coating	
• R > 99.5 % reflectivity from 700 nm to 900 nm	
Typical Laser Damage Threshold	
10 ns, 10 Hz	155 J/cm²*
200 ps, 1kHz	4.2 J/cm²**
50 fs, 50 Hz	0.5 J/cm²***
Mirror substrates	
• SCHOTT N-BK7® • ZERODUR® • Fused Silica • Custom	

* tested at SPICA, USA
** tested by LOA, France
*** tested at Lidaris, Lithuania

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Laser Windows

Product Information

Windows are used in optical systems to protect lenses from dust or pollution – very high transmission, low absorption material and a low wavefront distortion are the key points for a laser window.

Applications

- Laser windows can be used in a variety of applications, e. g.
- High-Power Laser
- Materials processing (welding)
- Lens protection after the focusing head
- Solid-State Laser (Nd: YAG)

Specifications	
Region for center wavelength	350 – 1600 nm, other wavelengths on demand
Diameter	12.7 – 101.6 mm, other diameters on demand
Surface quality	S-D 10 – 5, depending on dimension
Roughness	< 1 nm RMS
Parallelism	< 1 arc minute
Wavefront distortion	$\leq \lambda / 10$
Damage threshold	> 20 J/cm² @ 1064 nm, S-on-1, 10 ns
Coating	AR coating R < 0.2 %

Advantages

- Customized design
- High quality consistency
- High laser damage threshold
- High accurate shape
- Low Scratch-Dig
- Low roughness

Materials

- All types of optical glass
- Fused silica

Quality Assurance

Our quality control is based on self-checking during production and 100 % final inspection.
A coating curve is delivered with the component.

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Optical Filter Glass

Product Information

SCHOTT offers one of the world's largest portfolios of optical filter glasses for a full spectral solution for your requirements.

SCHOTT's optical filter glasses include the following filter types in the wavelength range above 200 nm:

- Bandpass filters
- Longpass filters
- Shortpass filters
- Neutral density filters
- Contrast enhancement filters
- Night Vision compatible filters
- Multiband filters

Advantages

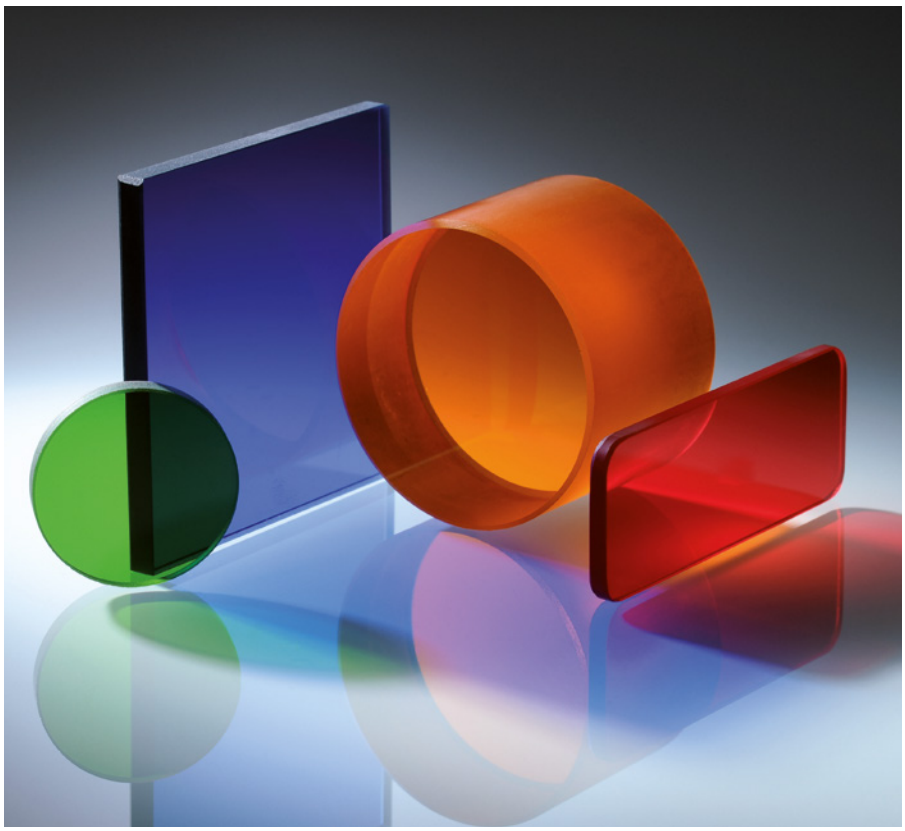
- High transmittance
- High blocking
- Spectral properties are independent on angle of incidence
- Superior quality, reliability and durability

Quality Assurance

Quality control is based on statistical process control as well as on rigorous final inspection. Measurement instruments include a broad range of spectrophotometers, vision systems, etc.

Application Support

SCHOTT is "Your Partner for Excellence in Optics" and a sparing partner to develop, design and choose the right filter for your requirements. Please contact us with your specifications.



Forms of Supply

- Polished plates according to customers request, typically up to 200 mm x 200 mm
- Polished filters also available as coated or framed parts reflecting customer's specifications
- Larger dimensions upon request

Market Segments

Reliable manufacturing with strong technical glass expertise enables SCHOTT to serve the following markets:

Aviation	Homeland Security	Law Enforcement
Medical	Pharmaceutical	Life Science
Automotive	Consumer Optics	Industrial

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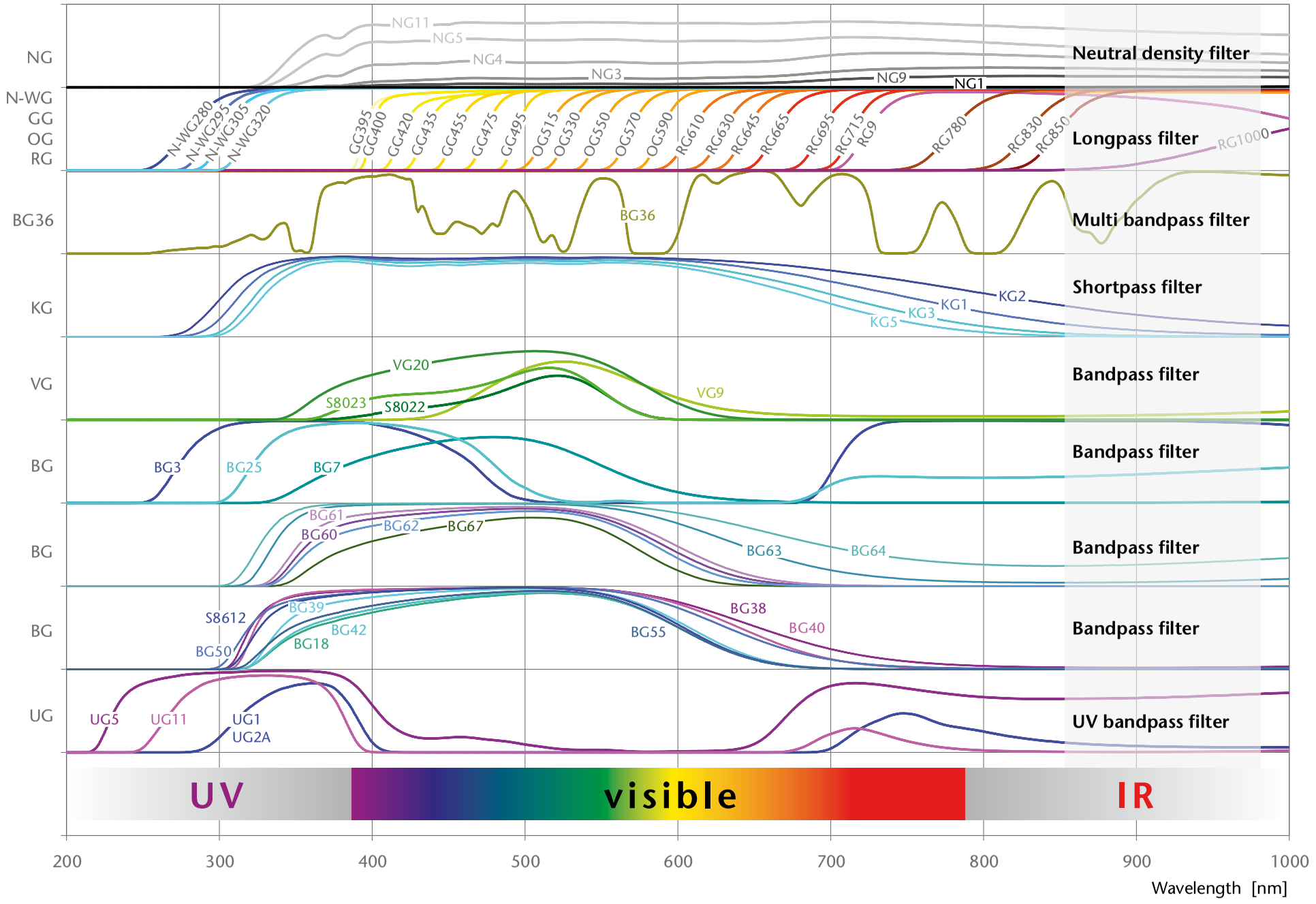
Internal Transmittance of SCHOTT Optical Filter Glass



Optical Components

Product Information

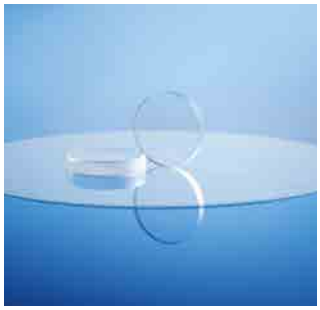
SCHOTT Advanced Optics masters the entire value chain – from material development and its production to the final high precision optical component. Leveraging its extensive portfolio of optical and special materials (optical glass, ZERODUR® zero expansion glass ceramic, IR materials, Sapphire, more), Advanced Optics applies various processing steps – CNC-machining, polishing, coating, assembling, measuring – till providing the custom specific component. The following details describe our manufacturing possibilities and represent our capabilities. Further details can be found at: www.schott.com/advanced_optics/overview-optical-components

Prisms: right angle prisms, rhomboid prisms, penta prisms, light guides, and others

Manufacturing Capabilities

Attribute	Commercial Quality	Precision Quality	Ultra Precision Quality
Size*	10 to 200 mm	10 to 200 mm	10 to 200 mm
Size Tolerance*	± 0.2 mm	± 0.1 mm	± 0.05 mm
Angle Tolerance*	< 1.5 arc minutes	< 1 arc minutes	< 10 arc seconds
Surface Accuracy*	1 λ	λ/4	λ/10
Surface Quality (Scratch & Dig)*	80/50	40/20	20/10

Windows & Substrates: plane parrallel windows, protective windows, laser windows, ultra thin windows, optical flats, substrates for coating, and others



Attribute	Commercial Quality	Precision Quality	Ultra Precision Quality
Diameter*		From 2 mm to 625 mm	
Diameter Tolerance*	± 0.25 mm	± 0.050 mm	± 0.005 mm
Thickness Tolerance*	± 0.20 mm	± 0.040 mm	± 0.020 mm
Parallelism*	< 3 arc minutes	< 1 arc minutes	< 10 arc seconds
Surface Accuracy*	2 λ	λ/4	λ/10
Surface Quality (Scratch & Dig)*	80/50	60/40	10/5
Surface Roughness*	5 nm	2 nm	8Å

Spherical & Achromatic Lenses: singlets, doublets, triplets in different forms: plano-convex, plano-concave, meniscus, and others

Attribute	Commercial Quality	Precision Quality	Ultra Precision Quality
Diameter*	From 3 mm to 150 mm	From 3 mm to 150 mm	From 3 mm to 150 mm
Diameter Tolerance*	+ 0.0/0.25 mm	+ 0.0/0.1 mm	+ 0.0/0.5 mm
Thickness Tolerance*	± 0.20 mm	± 0.040 mm	± 0.020 mm
Centering Tolerance*	< 3 arc minutes	< 1 arc minutes	< 30 arc seconds
Surface Accuracy*	2 λ	λ/4	λ/10
Surface Quality (Scratch & Dig)*	80/50	60/40	10/5

* Depending on geometry. Please call sales representative to discuss your project.

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Aspherical Lenses: 2 technologies are mastered by SCHOTT: CNC-machining and molding; different forms are offered: plano-convex, plano-concave, convex-convex, and others

Attribute	CNC-machining and polishing			Molded (Low Tg glasses only)
	Commercial	Precision	High Precision	
Diameter*	15–180 mm	15 –160 mm	15–140 mm	1.5–35 mm
Diameter tolerance*	± 0.1 mm	± 0.05 mm	± 0.02 mm	± 0.05 mm
Center thickness*	3– 40 mm	3– 40 mm	5– 40 mm	0.5–10 mm
Radius of curvature convex*	> 10 mm	> 20 mm	> 30 mm	> 3 mm
Tolerance on radius of curvature*	± 0.5 %	± 0.1 %	± 0.05 %	± 0.5 %
Surface flatness (PV, asph. side)*	2 µm	0.5 µm	0.2 µm	< 0.5 µm
Tilt from asph. side to other side*	< 6 arc min	< 3 arc min	< 1 arc min	< 1 arc min
Surface roughness*	< 5 nm	< 3 nm	< 1.5 nm	< 15 nm
Surface quality (scratch & dig) (5/NxA)*	60/40 5/6 x 0.25	40/20 5/3 x 0.25	10/5 5/3 x 0.025	40/20 5/3 x 0.16
Typical volume*	From 1 piece to series production			> 200 pcs

Cylindrical Lenses are offered in various shapes: plano-convex, meniscus, bi-convex, rectangular or square, and others

Attribute	Commercial Quality	Precision Quality	Precision Quality
Dimensions*	From 5 mm to 200 mm		
Radius*	From 8 mm to 2000 mm		
Dimensional Tolerance*	+ 0,0/0,25 mm	+ 0,0/0,1 mm	+ 0,0/0,05 mm
Thickness Tolerance*	± 0,20 mm	± 0,10 mm	± 0,05 mm
Centering Tolerance*	< 15 arc minutes	< 6 arc minutes	< 2 arc minutes
Surface Accuracy*	2λ	λ	λ/2
Surface Roughness*	< 25 nm	< 15 nm	< 5 nm
Surface Quality*	80/50	40/20	10/5

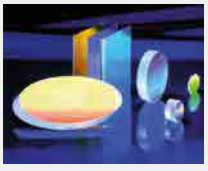
*Depending of geometry. Please call sales representative to discuss your project.

Different technologies used by SCHOTT to serve our customer

Precision CNC-machined parts

High precision polishing

Precision glass molding for aspheres, DOEs, lens arrays



Coatings

Sub-assembly

Measurement systems: Interferometers, profilometers...

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Dielectric Polarizer

Product Information

These kind of polarizers have been developed for demanding lasers separating or blocking S or P polarization.

Applications

- High-Power Laser
- Solid-State Laser
- Gas Laser
- Beam Delivery

Advantages

- Polishing and coating in house
- Extensive expertise in material handling
- Strength in coating
- Very good extinction ratio
- Fine polishing with low roughness
- Low Scratch-Dig

Specifications	
Region for center wavelength	350 – 1600 nm, other wavelenghts on demand
Diameter	12.7 – 101.6 mm, other diameters on demand
Surface quality	S-D 10 – 5, depending on dimension
Roughness	< 1 nm RMS
Surface flatness	≤ λ/10, depending on dimension
Wavefront distortion	λ/10, depending on dimension
Extinction ratio	up to 1000 : 1
Angle of incidence	57°, other angles on demand
Damage threshold	> 20 J/cm²@1064 nm, S-on-1, 10 ns
Coating	Multi-dielectric

Materials

- SCHOTT N-BK7®
- Optical glasses
- Fused silica

Quality Assurance

The following Quality Assurance equipment is used:

- Bench for extinction ratio measurement

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SCHOTT
glass made of ideas

Prisms

Product Information

Prisms are transparent optical elements with flat polished surfaces that refract, reflect or disperse light. They allow easy positioning within an optical system and have excellent thermal stability. A total internal reflection is possible, avoiding light loss in the optical path.

Advantages

- SCHOTT masters the entire value chain from raw glass to coated cemented prisms
- Custom designed products at competitive prices
- 1 piece through series production levels
- Coating: all substrates coated to a specific custom design
- Sub Assembly: extensive expertise in gluing and cementing to integrate prisms in custom designed hardware

Materials

- Optical glasses such as N-BK7HT, N-BAK4HT, N-SK2HT, SF57HTultra, SF6HT
- Fused silica

Examples of Products

- Right angle prisms
- Rhomboid prisms
- Pentaprisms
- TIR prism
- Cube beamsplitter

Manufacturing Capabilities

Attribute	Commercial Quality	Precision Quality	Ultra Precision Quality
Size	10 to 200 mm	10 to 200 mm	10 to 200 mm
Size Tolerance*	± 0.2 mm	± 0.1 mm	± 0.05 mm
Angle Tolerance*	< 1.5 arc minutes	< 1 arc minutes	< 10 arc seconds
Surface Accuracy*	1 λ	λ/4	λ/10
Surface Quality (Scratch & Dig)*	80/50	40/20	20/10
AR Coating*	Ravg < 1.5 %	Ravg < 0.5 %	Custom designed
Order Quantity*	From 1 piece to series production*		
Delivery Time*	6 – 10 weeks	6 – 10 weeks	6 – 10 weeks

*Depending on customer's specification. Please call sales representative.

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