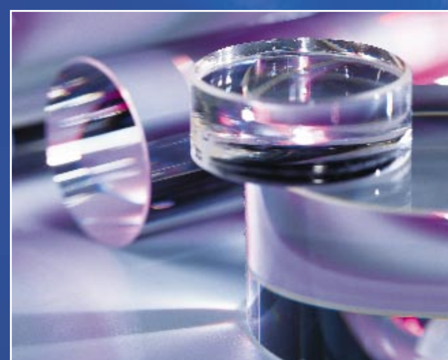
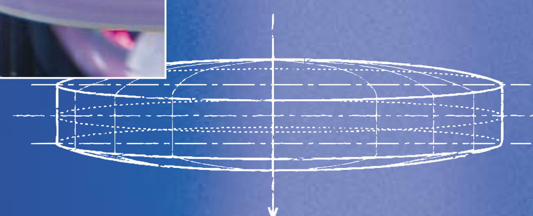
Synthetic Fused Silica

Optical and technical grades





SCHOTT lithotec

Schott Lithotec Fused Silica

Lithosil™Q is available in six different quality grades:

Lithosil™Q0 is characterized by its high three-dimensional optical homogeneity. Free of striations in any spatial direction, it is recommended for high-end resolution requirements in such optical elements as prisms and lenses.

Lithosil™Q1 exhibits high homogeneity and has no striations in one spatial direction. Typical applications are optical elements such as lenses, windows and wafers.

Lithosil™Q2 is not specified concerning homogeneity. This grade is recommended for optics in the visible spectral range or optics in the UV with less stringent demands on transmission.

Lithosil™QT is not specified concerning homogeneity, striae and striations. This grade is recommended for technical applications.

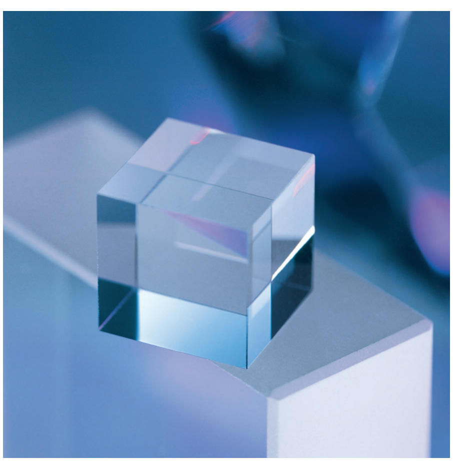
Lithosil™Q0/1-E193
Lithosil™Q0/1-E248
The excimer grade equivalents of Lithosil™Q0 and Lithosil™Q1 for 248 nm (Lithosil™Q0/1-E248) or 193 nm (Lithosil™Q0/1-E193) excimer laser applications present remarkable laser damage resistance, high UV-transmission, extremly low bulk defect level and low fluorescence behavior. These properties make Lithosil™Q-E the first choice material for excimer laser applications and laser machining.

Typical values of internal transmittance at selected wavelengths per 10 mm sample thickness

	Internal transmittance		
	λ = 193 nm	λ = 200 nm	λ = 248 nm
Lithosil™Q0	≥ 0.98	≥ 0.99	≥ 0.995
Lithosil™Q1	≥ 0.98	≥ 0.99	≥ 0.995
Lithosil™Q2	–	≥ 0.85	≥ 0.980
Lithosil™QT	–	–	≥ 0.970
Lithosil™Q0/1-E193	≥ 0.99	–	–
Lithosil™Q0/1-E248	–	–	≥ 0.998

Optical properties of Synthetic Fused Silica

<table>
<tr><th rowspan="3">Grade</th><th colspan="2">Bubbles and inclusions</th><th colspan="4">Homogeneity</th><th>Stress birefringence</th><th>OH content</th></tr>
<tr><th rowspan="2">Bubbles according to bubble class DIN 58927</th><th rowspan="2">Max. bubble diameter [mm]</th><th rowspan="2">Striae[1] according to ISO 10110-4</th><th rowspan="2">Striations[1]</th><th colspan="2">Refractive index change Δn[2]</th><th rowspan="2">5% outer edge exclusion [nm/cm]</th><th rowspan="2">[ppm]</th></tr>
<tr><th>Standard</th><th>Special products</th></tr>
<tr><td>Lithosil™ Q0</td><td rowspan="3">0</td><td rowspan="3">< 0.1</td><td colspan="2">3D none</td><td rowspan="2">H1</td><td rowspan="2">H2–H5</td><td rowspan="2">≤ 5[3]</td><td rowspan="3">appr. 1200</td></tr>
<tr><td>Lithosil™ Q1</td><td rowspan="2">none</td><td rowspan="2">none in functional direction</td></tr>
<tr><td>Lithosil™ Q2</td><td>not specified</td><td>—</td><td>≤ 10[3]</td></tr>
<tr><td>Lithosil™ QT</td><td>0...1</td><td>< 0.6</td><td colspan="3">not specified</td><td>—</td><td>≤ 20</td><td>appr. 1000</td></tr>
<tr><td>Lithosil™ Q0-E193[4]
Lithosil™ Q1-E193[4]</td><td colspan="8">ArF - excimer grade: selected from Lithosil™ Q0 or Q1;
see qualification method on Lithosil™ Q-E</td></tr>
<tr><td>Lithosil™ Q0-E248[4]
Lithosil™ Q1-E248[4]</td><td colspan="8">KrF - excimer grade: selected from Lithosil™ Q0 or Q1;
see qualification method on Lithosil™ Q-E</td></tr>
</table>

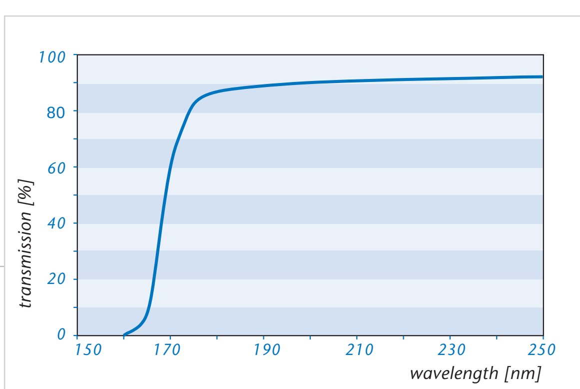


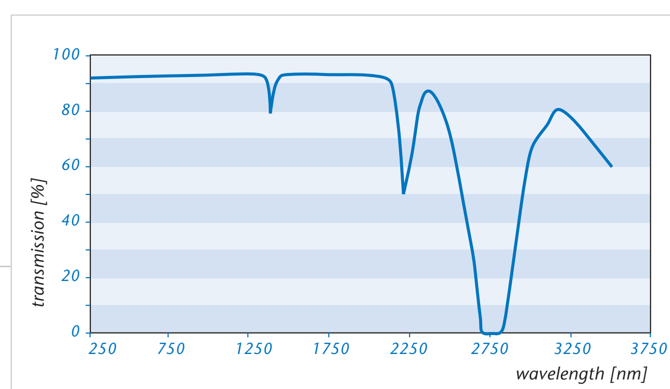
Notes

1) *Shadow method, polarizer and interferometer are used for striae and striation detection.*
2) *Homogeneity Δn is tested interferometrically (5% outer edge exclusion). Classification according to Schott Glas nomenclature.*
3) *Lower values with respect to size and processing available on request.*
4) *Max. LIF factor (fluorescence signal ratio at 650 nm of Lithosil™Q-E to reference) can be individually agreed and guaranteed on request.*

Class	Maximum deviation of refractive index
H1	$\pm 2 \cdot 10^{-5}$
H2	$\pm 5 \cdot 10^{-6}$
H3	$\pm 2 \cdot 10^{-6}$
H4	$\pm 1 \cdot 10^{-6}$
H5	$\pm 5 \cdot 10^{-7}$

Typical Transmission of Lithosil™Q0/Q1 including Fresnel reflection losses (10 mm path length)





n_d = 1.45843 ν_d = 67.87 $n_F - n_C$ = 0.00675
n_e = 1.46004 ν_e = 67.67 $n_{F'} - n_{C'}$ = 0.00680

Refractive Indices (at 20°C and 1013 mbar)	λ [nm] (vacuum wavelength)	n
$n_{2325.6}$	2325.59	1.43290
$n_{1970.6}$	1970.56	1.43849
n_{1530}	1530.00	1.44424
n_{1060}	1060.00	1.44965
n_t	1014.25	1.45021
n_s	852.35	1.45243
n_r	706.71	1.45511
n_C	656.28	1.45634
$n_{C'}$	644.03	1.45667
n_{He-Ne}	632.98	1.45698
n_D	589.46	1.45837
n_d	587.73	1.45843
n_e	546.23	1.46004
n_F	486.27	1.46309
$n_{F'}$	480.13	1.46347
n_g	435.96	1.46666
n_h	404.77	1.46958
n_i	365.12	1.47451
$n_{334.2}$	334.24	1.47973
$n_{312.7}$	312.66	1.48446
$n_{296.8}$	296.82	1.48870
$n_{280.4}$	280.43	1.49401
$n_{248.4}$	248.35	1.50837
n_{KrF}	248.00	1.50856
$n_{194.2}$	194.23	1.55888
n_{ArF}	193.00	1.56080

All refractive indices are interpolated from values measured under dry nitrogen atmosphere

Tolerances of refractive indices ± 2.0 · 10^{-5}

Constants of Dispersion Formula	
B_1	6.69422575 · 10^{-1}
B_2	4.34583937 · 10^{-1}
B_3	8.71694723 · 10^{-1}
C_1	4.48011239 · 10^{-3}
C_2	1.32847049 · 10^{-2}
C_3	9.53414824 · 10^{1}

Typical Trace Contaminants [ppm] Trace elements	Lithosil™ Q0/Q1	Lithosil™ Q2
Al	≤0.05	0.20
Na	≤0.02	0.50
Ca	≤0.02	0.60
K	≤0.01	0.20
Fe	≤0.005	0.10
Ti	≤0.01	0.05
Cu	≤0.005	0.05
Cr	≤0.005	0.01
Mn	≤0.005	0.01

Relative Partial Dispersion	
$P_{s,t}$	0.3290
$P_{C,s}$	0.5780
$P_{d,C}$	0.3097
$P_{e,d}$	0.2390
$P_{g,F}$	0.5280
$P_{i,h}$	0.7288

Deviation of Relative Partial Dispersions from "Normal Line"	
$\Delta P_{C,t}$	0.0401
$\Delta P_{C,s}$	0.0169
$\Delta P_{F,e}$	-0.0014
$\Delta P_{g,F}$	-0.0016
$\Delta P_{i,g}$	0.0066

Temperature Coefficients of relative Refractive Index +20/+40°C Δn/ΔT [10^{-6}/K]	
$n_{C'}$	9.7
n_d	9.8
n_e	9.9
$n_{F'}$	10.1
n_g	10.3
n_h	10.5
n_i	10.9

Thermal Properties	
Strain point $T_{10}^{14.5}$ [°C]	980
Annealing point $T_{10}^{13.0}$ [°C]	1080
Softening point $T_{10}^{7.6}$ [°C]	1600
Mean specific heat c_p (20°–100°C) [J/g · K]	0.79
Heat conductivity λ (32°C) [W/(m · K)]	1.31
Linear thermal expansion coefficient $\alpha_{(25°–100°C)}$ [10^{-6}/K]	0.5

Mechanical Properties	
Young's modulus (25°C) [GPa]	72
Shear modulus (25°C) [GPa]	31
Compressive strength [N/mm²]	1250
Bending strength [N/mm²]	80–100
Poisson's ratio μ	0.17
Knoop HK 0.1/20	580
Mohs	5–6
Density ρ [g/cm³]	2.2
Stress optical coefficient [1/Pa]	3.4 · 10^{-12}
Longitudinal ultrasonic velocity [m/s]	5940
Transversal ultrasonic velocity [m/s]	3770
Internal damping (25°–500°C)	2.0 · 10^{-5}

Constants of Formula for dn/dT +20/+40 [°C]	
D_0	2.06 · 10^{-5}
D_1	2.51 · 10^{-8}
D_2	– 2.47 · 10^{-11}
E_0	3.12 · 10^{-7}
E_1	4.22 · 10^{-10}
λ_{TK} [μm]	0.16

Electrical Properties	
Dielectric constant ε_r	3.8 ± 0.2
Dielectric loss angle φ (25°C/1MHz)	89.92° ± 0.03°
tan δ (δ = 90° – φ) (25°C/1MHz)	(14 ± 5) · 10^{-4}
Electrical resistivity (20°C) [Ω · cm]	1.15 · 10^{18}

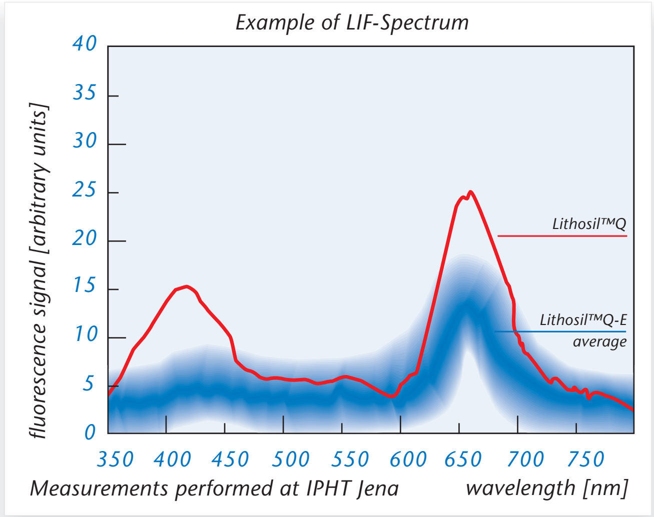
Formula for Dispersion and dn/dT according to Schott Optical Glass catalogue

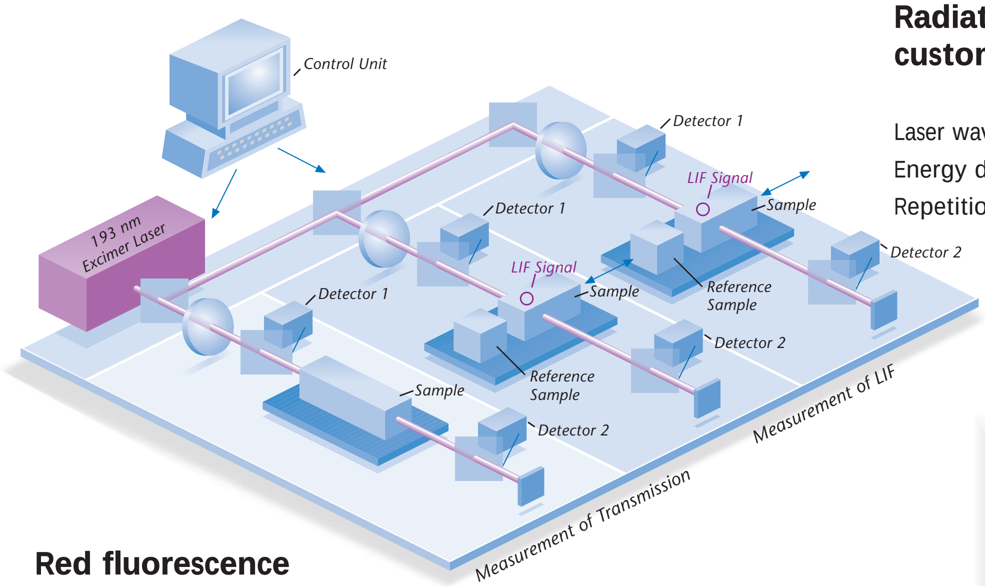
Lithosil™Q-E

Excimer Grade Fused Silica with Low Fluorescence

Inquire for

- Excellent transmission at 193 nm and 248 nm
- Low laser induced fluorescence (LIF)



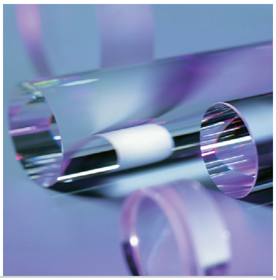


Radiation conditions on customer request:

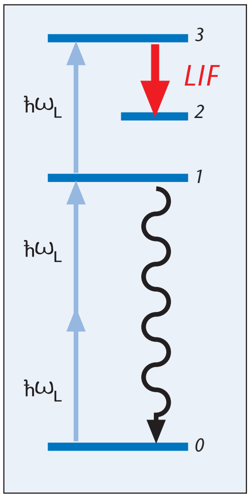
Laser wavelength	193 nm
Energy density	100 - 250 mJ/cm^2
Repetition rate	10 - 300 Hz

Red fluorescence indicates the excimer laser radiation induced defects

- Two-photon absorption bridges the energy gap
- Additional one-photon absorption generates defects like E´ and NBOH centers
- NBOH centers emit red fluorescence (LIF) from the excited state



Energy level diagram



* Glass Science and technology (Glastechnische Berichte) Bd. 71C (1998) 67-72

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