Quartz Glass for Optics
Data and Properties

Quartz Glass for Optics
Data and Properties

3D = 3D material, optically isotropic.
In quartz glass, the homogeneity is typically specified in one direction only. Heraeus manufactures quartz glass grades, which are controlled and specified in all 3 directions regarding striae, homogeneity and stress induced birefringence, for the most demanding applications. These materials are identified by the 3D symbol.

❶ For raw formed ingots the bubble specification is valid for the area defined by the minimum diameter tolerance. For machined parts it is defined as 100 % of the material.

❷ Bubbles or inclusions ≤ 0.08 mm diameter are not counted. For Suprasil® 311/312 and Suprasil® 3001/3002 a specification for bubbles and inclusions of ≤ 10µm is possible on request.

❸ For non-spherical bubbles the diameter is averaged.

❹ The Δn value is the maximum permissible lateral variation in refractive index (measured by interferometer at 632.8 nm after subtraction of tilt and offset) over 90% of the diameter or edge length of a fine ground piece, or 80% of a raw formed ingot.

Grade	Bubbles and Inclusions ❶❷			Homogeneity ❺	
	The bubble grade is given for every 100 cm³. Quartzglass from Heraeus is free of inclusions.			Δn-value ❹	
	DIN 58927	DIN ISO 10110 ❸	Total cross-sections (in mm²) of all bubbles (TBCS value)	Striae class as ❹ per DIN ISO 10110 (per 30 mm thickness)	PV value ❻ (Peak-to-Valley)
Suprasil® 311 3D	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 3 · 10⁻⁶
Suprasil® 312	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 4 · 10⁻⁶
Suprasil® 3001 3D	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 4 · 10⁻⁶
Suprasil® 3002	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 10 · 10⁻⁶
Suprasil® 300	0	1/1*0.08	≤ 0.015	acc. MIL	n. sp.
Suprasil® 1 3D	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 5 · 10⁻⁶
Suprasil® 2 Grade A	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 5 · 10⁻⁶
Suprasil® 2 Grade B	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 10 · 10⁻⁶
Suprasil® CG	0	1/1*0.08	≤ 0.015	acc. MIL	≤ 30 · 10⁻⁶
Suprasil® 1 ArF / KrF 3D	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 5 · 10⁻⁶
Suprasil® 2 ArF / KrF	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 5 · 10⁻⁶
Spectrosil® 2000	0	1/1*0.08	≤ 0.015	2 / -;5	≤ 10 · 10⁻⁶
Homosil® 101 3D	0	1/2*0.10	≤ 0.03	2 / -;5	≤ 3 · 10⁻⁶
Herasil® 102	0	1/1*0.20	≤ 0.1	2 / -;5	≤ 4 · 10⁻⁶
Infrasil® 301 3D	0	1/1*0.16	≤ 0.03	2 / -;5	≤ 5 · 10⁻⁶
Infrasil® 302	0..1	1/1*0.35	≤ 0.1	2 / -;5	≤ 6 · 10⁻⁶
HOQ® 310	2...3	1/1*0.63 ≤ 6 kg 1/2*1.0 > 6 kg	0.5	n. sp.	n. sp.

Synthetic Fused Silica | Cultured Quartz | Natural Quartz | Natural Quartz

The maximum test diameter is 430 mm. Larger pieces are measured using overlapping interferograms.

❺ Does not apply to drawn rods.

❻ Lower values available on request.

❼ The residual strain values refer to the measured phase difference per cm light path. The residual strain value is specified over 90% of the diameter or edge length of a fine ground piece, or 80% of a raw formed ingot.

n. sp. = not specified

Residual Strain ❼	Fluorescence	OH-Content
nm/cm ❻	Excitation by Hg-Lamp@ λ = 254 nm and UG 5-filter; Lamp-power: 8W; Detection: adapted eye	ppm (µg/g)
≤ 5	free	ca. 250
≤ 5	free	ca. 250
≤ 6	slight blue	≤ 1
≤ 6	slight blue	≤ 1
≤ 5	slight blue	≤ 1
≤ 5	free	≤ 1300
≤ 5	free	≤ 1300
≤ 5	free	≤ 1300
≤ 20	free	≤ 1300
≤ 5	free	≤ 1300
≤ 5	free	≤ 1300
≤ 5	free	≤ 1300
≤ 5	blue-violet	ca. 150
≤ 5	blue-violet	ca. 150
≤ 5	blue-violet	≤ 8 ❻
≤ 5	blue-violet	≤ 8 ❻
≤ 10	blue-violet	ca. 30

Refractive index

at 20°C and 1 bar

The given values are interpolated from measured values. More accurate data available upon request.

In contrast to other optical glasses, quartz glass shows very little difference in refractive index from melt to melt.

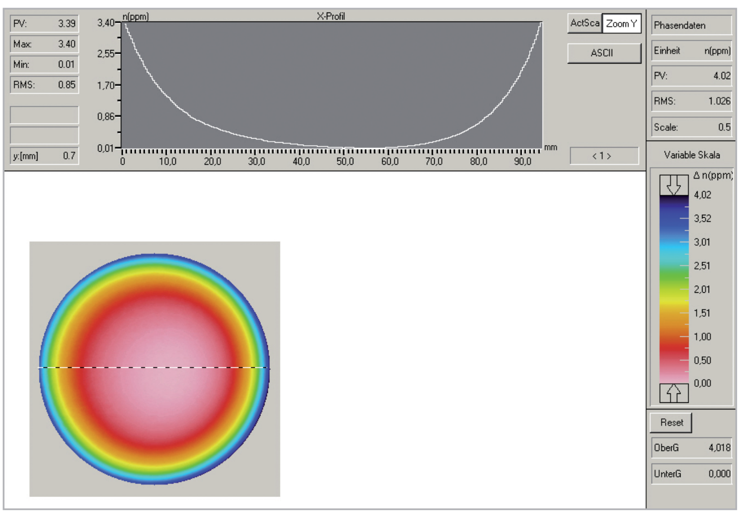
*without Suprasil® 3001, 3002, 300

Wavelength nm		Suprasil-family	Homosil / Herasil / Infrasil / HOQ
	190	1,5657	-
ArF	193,4	1,5601	-
	200	1,5505	-
	202,54	-	1,5473
	220	1,5285	1,5287
	232,94	-	1,5183
	240	1,5133	1,5136
KrF	248,4	1,5083	-
	260	1,5024	1,5026
4 x Nd:YAG	266	1,4997	1,4999
	274,87	1,4961	1,4963
	280	1,4942	1,4944
	300	1,4878	1,4880
XeCl	308	1,4856	1,4858
	320	1,4827	1,4829
HeCd	325	1,4816	1,4818
N2	337	1,4792	1,4794
	340	1,4787	1,4788
	360	1,4753	1,4754
(ni)	365,48	1,4745	1,4746
	380	1,4725	1,4726
	400	1,4701	1,4703
(nh)	404,65	1,4696	1,4698
(ng)	435,83	1,4667	1,4668
HeCd	441,6	1,4662	1,4663
Kr	447,1	1,4658	1,4659
(nF)	486,13	1,4631	1,4632
Ar	488	1,4630	1,4631
Ar	514,5	1,4616	1,4617
2 x Nd:YAG	532	1,4607	1,4608
(ne)	546,07	1,4601	1,4602
(nd)	587,56	1,4585	1,4586
HeNe	632,8	1,4570	1,4571
(nc)	656,27	1,4564	1,4565
Ruby	694,3	1,4554	1,4555
Kr	752,5	1,4542	1,4543
	800	1,4533	1,4534
	850	1,4525	1,4526
	900	1,4518	1,4519
GaAs	905	1,4517	1,4518
	1000	1,4504	1,4505
Nd:YAG	1064	1,4496	1,4497
HeNe	1153	1,4486	1,4487
	1200	1,4481	1,4482
Nd:YAG	1319	1,4467	1,4468
	1400	1,4458	1,4459
	1600	1,4434	1,4435
	1800	1,4409	1,4410
	2000	1,4381	1,4382
	2200	1,4350	1,4352
	2400	1,4316	1,4318
	2600	1,4279	1,4280
	2800	1,4238	1,4239
	3000	1,4193	1,4194
	3200	1,4143	1,4144
	3400	1,4088	1,4090

Optical Homogeneity and Stress Induced Birefringence

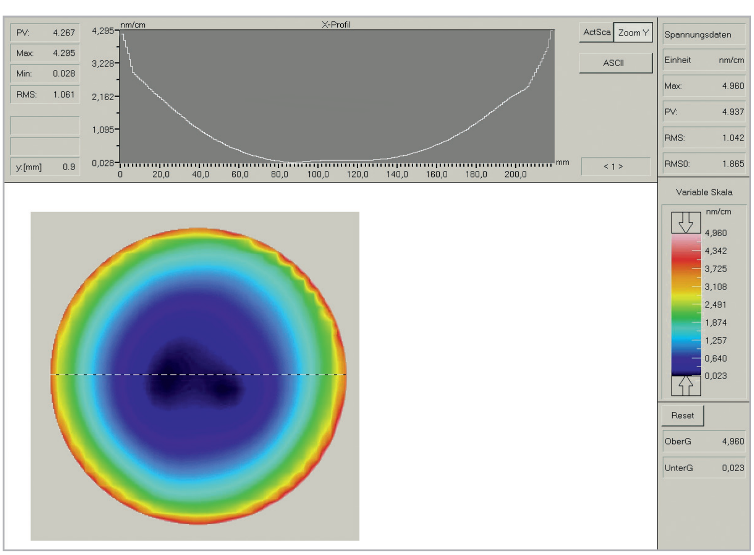
The false colour interferogram below shows the typical two-dimensional refraction-index distribution. The interferogram belongs to a circular blank.

The sectional view along the diameter shows the refraction-index distribution across the blank. One can clearly see the very low value in the center of the plate and the rise close to the edge.



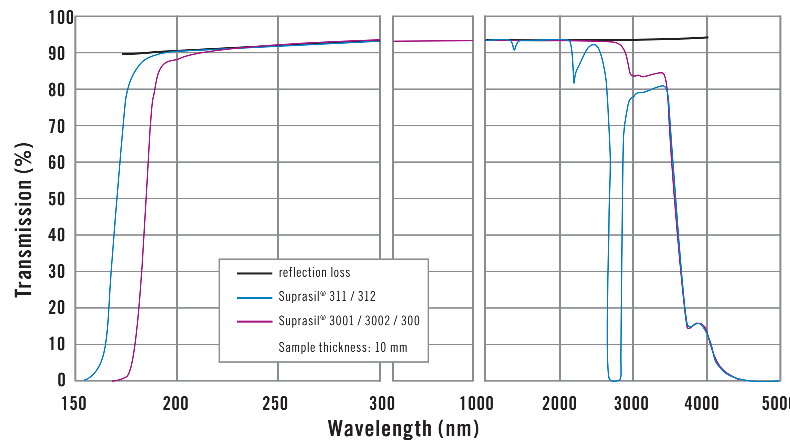
The false colour measurement below shows the typical two-dimensional birefringence distribution.

The sectional view along the diameter shows the birefringence distribution across the plate. One can clearly see the very low value in the center of the plate and the rise close to the edge.

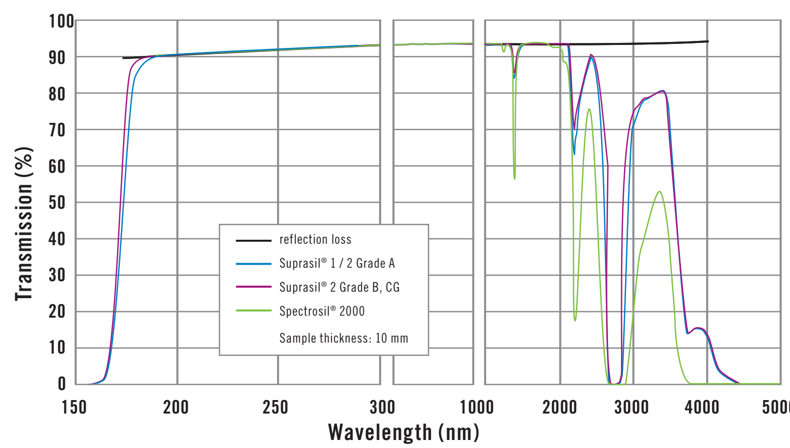


Typical transmission including Fresnel reflection losses (1-R)²

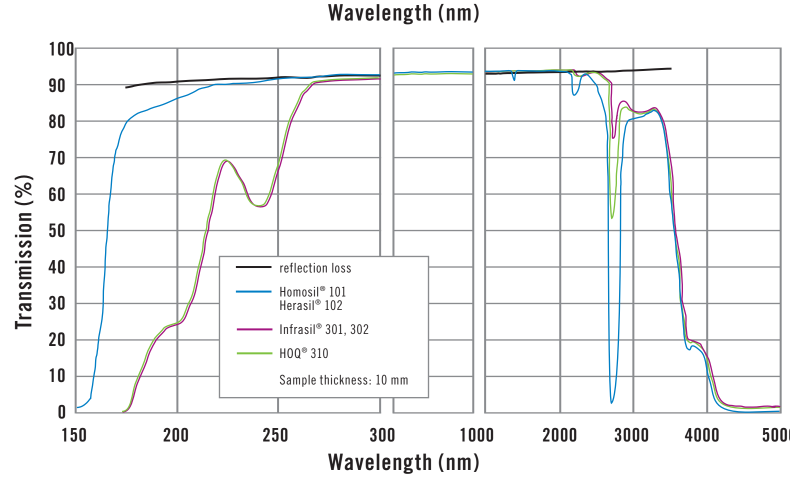
Suprasil® 311, 312
Suprasil® 3001, 3002, 300



Suprasil® 1, 1 ArF / KrF
Suprasil® 2 Grade A, 2 ArF / KrF
Suprasil® 2 Grade B, Suprasil® CG
Spectrosil® 2000



Homosil® 101
Herasil® 102
HOQ® 310
Infrasil® 301, 302



The uppermost curves in the transmission graphs indicate the calculated Fresnel reflection losses for two uncoated surfaces.

Please find our transmission calculator online at www.optics.heraeus-quarzglas.com

Technical Properties

Internal transmission (%)

Values of pure transmissions of a 10 mm thick sample for selected UV-Wavelengths.

Wavelength nm	Suprasil® ArF/ KrF - specified -	Suprasil®-family - typical -	Homosil® 101 Herasil® 102 - typical -
193,4	≥ 99,30	98,50	92,00
248,4	≥ 99,80	99,50	98,00
266	99,90	99,90	99,50

Relative temperature coefficients of the refractive index in 10^{-6} K^{-1}

Wave-length	Suprasil®-family, Spectrosil®		Homosil® / Herasil® / Infrasil® / HOQ®	
nm	0...20°C	20...40°C	0...20°C	20...40°C
237,8	14,6	14,9	15,2	15,3
365	11	11,2	11,5	11,6
546,1	9,9	10,1	10,6	10,7
587,6	9,8	10,0	10,5	10,6
643,8	9,6	9,8	10,4	10,5

Abbe constant

$\nu_d = \frac{n_d - 1}{n_F - n_c}$	67,8 ± 0,5

Birefringence constant @ 633 nm

$\frac{nm}{cm \cdot bar}$	3,54 ± 0,05	3,61 ± 0,05

Refraction index dispersion

Dispersion constants (Sellmeier)

	Suprasil®-family, Spectrosil®	Homosil® / Herasil® / Infrasil® / HOQ®
B1	$4{,}73115591 \cdot 10^{-1}$	$4{,}76523070 \cdot 10^{-1}$
B2	$6{,}31038719 \cdot 10^{-1}$	$6{,}27786368 \cdot 10^{-1}$
B3	$9{,}06404498 \cdot 10^{-1}$	$8{,}72274404 \cdot 10^{-1}$
C1	$1{,}29957170 \cdot 10^{-2}$	$2{,}84888095 \cdot 10^{-3}$
C2	$4{,}12809220 \cdot 10^{-3}$	$1{,}18369052 \cdot 10^{-2}$
C3	$9{,}87685322 \cdot 10^{1}$	$9{,}56856012 \cdot 10^{1}$

Sellmeier Equation:

$n^2 - 1 = B_1\lambda^2/(\lambda^2 - C_1) + B_2\lambda^2/(\lambda^2 - C_2) + B_3\lambda^2/(\lambda^2 - C_3)$

Wavelength λ in µm at 20°C

Typical trace impurities in quartz glass

Impurities	Suprasil®-family, Spectrosil® ppm	Herasil® 102 / Homosil® 101 ppm	Infrasil® / HOQ® ppm
Al = aluminium	≤ 0,010	10	20
Ca = calcium	≤ 0,015	1	1
Cr = chrome	≤ 0,001	0,1	0,1
Cu = copper	≤ 0,003	0,1	0,1
Fe = iron	≤ 0,005	0,2	0,8
K = potassium	≤ 0,010	0,1	0,8
Li = lithium	≤ 0,001	1	1
Mg= magnesium	≤ 0,005	0,1	0,1
Na = sodium	≤ 0,010	1	1
Ti = titanium	≤ 0,005	0,1	1

Mechanical data		Suprasil®-family, Spectrosil® Homosil® / Herasil® / Infrasil® / HOQ®
Density	g/cm^3	2,20
Mohs-hardness		5,5........6,5
Micro-hardness	N/mm^2	8600........9800
Knoop-hardness	N/mm^2	5800........6200
Modulus of elasticity (at 20°C)	N/mm^2	$7{,}0 \cdot 10^4$
Modulus of torsion	N/mm^2	$3 \cdot 10^4$
Poisson´s ratio		0,17
Compressive strength	N/mm^2	1150
Tensile strength	N/mm^2	50
Bending strength	N/mm^2	67
Torsional strength	N/mm^2	30
Sound velocity	m/s	5720

Electrical data	
Resistivity in $\Omega \cdot m$	
20°C	10^{16}
400°C	10^8
800°C	$6{,}3 \cdot 10^4$
1200°C	$1{,}3 \cdot 10^3$
Dielectric strength in kV/mm (Layer thickness ≥ 5 mm)	
20°C	40...50
500°C	4...5
Dielectric loss angle (tg δ)	
1kHz	0,0005
1...1000MHz	< 0,001
$3 \cdot 10^4$MHz	0,0004
Dielectric constant (ε)	
20°C 0...1 MHz	3,7
23°C 0...1000 MHz	3,80
23°C $3 \cdot 10^4$ MHz	3,81

Thermal data		Suprasil®-Family, Spectrosil®	Homosil®/ Herasil®/ Infrasil®/ HOQ®
Softening temperature	°C	~ 1600	~ 1730
Annealing temperature	°C	~ 1120	~ 1180
strain temperature	°C	~ 1025	~ 1075
Max. working temperature			
continuous	°C	~ 950	~ 1150
short-term	°C	~ 1200	~ 1300
Mean specific heat $J/kg \cdot K$			
	0...100°C	772	
	0...500°C	964	
	0...900°C	1052	
Heat conductivity $W/m \cdot K$			
20°C		1,38	
100°C		1,46	
200°C		1,55	
300°C		1,67	
400°C		1,84	
950°C		2,68	
Mean thermal expansion coefficient K^{-1}			
-160...0°C		0	
-50...0°C		$2{,}7 \cdot 10^{-7}$	
0...100°C		$5{,}1 \cdot 10^{-7}$	
0...200°C		$5{,}8 \cdot 10^{-7}$	
0...300°C		$5{,}9 \cdot 10^{-7}$	
0...600°C		$5{,}4 \cdot 10^{-7}$	
0...900°C		$4{,}8 \cdot 10^{-7}$	

Germany

Heraeus Quarzglas
GmbH & Co. KG
Optics
Quarzstr. 8, 63450 Hanau
Phone +49 (6181) 35-62 85
Fax +49 (6181) 35-62 70
sales.hqs.optics.de@
heraeus.com

USA

Heraeus Quartz America, LLC.
Optics
100 Heraeus Blvd.
30518 Buford, Georgia
Phone +1 (678) 714-4350
Fax +1 (678) 714-4355
sales.hqs.optics.us@
heraeus.com

HQS-MO_01.0/E/04.2013

The data given here is correct for April 2013 and is subject to change.

China

Heraeus ShinEtsu Quartz
(China) Inc.
Room 1702, No. 620 Zhangyang Road,
East Tower, Zhongrong Hengrui
International Plaza, Pudong,
Shanghai, 200122
Phone +86 (21) 68672266-809
Fax +86 (21) 68751434
sales.hqs.optics.cn@heraeus.com

UK

Heraeus Quartz UK Ltd.
Neptune Road,
Wallsend,
Tyne & Wear NE28 6DD,
United Kingdom
Phone +44 (191) 2598454
Fax +44 (191) 2638040
sales.hqs.optics.uk@heraeus.com

Korea

HS Advanced Materials Co., Ltd.
149-3, Hoechuk-ri,
Gwanghyewon-myun
Jincheon-gun, Chungbuk, 365-834
Korea
Phone +82 (43) 532 5371
Fax +82 (43) 532 5334
hsam@hs-am.com

www.optics.heraeus-quarzglas.com