



Quartz Glass for Optics Data and Properties

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 = 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.

• 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.

- 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 $\leq 10\mu\text{m}$ is possible on request.
- For non-spherical bubbles the diameter is averaged.
- 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.

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

- Does not apply to drawn rods.
- Lower values available on request.
- 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







Refractive index





at 20°C and 1 bar

The given values are interpolated from measured values having an accuracy of $\pm 3 \cdot 10^{-5}$.

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

*without Suprasil® 3001, 3002, 300

Grade	Bubbles and Inclusions ^{1 2}			Homogeneity ³		Residual Strain ⁷ nm/cm ⁶	Fluorescence Excitation by Hg-Lamp@ $\lambda = 254$ nm and UG 5-filter; Lamp-power: 8W; Detection: adapted eye	OH-Content ppm ($\mu\text{g/g}$)
	The bubble grade is given for every 100 cm ³ . Quartzglass from Heraeus is free of inclusions.			Δn -value ⁴				
	DIN 58927	DIN ISO 10110 ⁵	Total cross-sections (in mm ²) of all bubbles (TBCS value)	Striae class as ⁸ per DIN ISO 10110 (per 30 mm thickness)	PV value ⁹ (Peak-to-Valley)			
Suprasil® 311 	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 3 \cdot 10^{-6}$	≤ 5	free	ca. 250
Suprasil® 312	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 4 \cdot 10^{-6}$	≤ 5	free	ca. 250
Suprasil® 3001 	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 4 \cdot 10^{-6}$	≤ 6	slight blue	≤ 1
Suprasil® 3002	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 10 \cdot 10^{-6}$	≤ 6	slight blue	≤ 1
Suprasil® 300	0	1/1*0.08	≤ 0.015	acc. MIL	n. sp.	≤ 5	slight blue	≤ 1
Suprasil® 1 	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 5 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Suprasil® 2 Grade A	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 5 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Suprasil® 2 Grade B	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 10 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Suprasil® CG	0	1/1*0.08	≤ 0.015	acc. MIL	$\leq 30 \cdot 10^{-6}$	≤ 20	free	≤ 1300
Suprasil® 1 ArF / KrF 	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 5 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Suprasil® 2 ArF / KrF	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 5 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Spectrosil® 2000	0	1/1*0.08	≤ 0.015	2 / -,5	$\leq 10 \cdot 10^{-6}$	≤ 5	free	≤ 1300
Homosil® 101 	0	1/2*0.10	≤ 0.03	2 / -,5	$\leq 3 \cdot 10^{-6}$	≤ 5	blue-violet	ca. 150
Herasil® 102	0	1/1*0.20	≤ 0.1	2 / -,5	$\leq 4 \cdot 10^{-6}$	≤ 5	blue-violet	ca. 150
Infrasil® 301 	0	1/1*0.16	≤ 0.03	2 / -,5	$\leq 5 \cdot 10^{-6}$	≤ 5	blue-violet	≤ 8 ¹⁰
Infrasil® 302	0..1	1/1*0.35	≤ 0.1	2 / -,5	$\leq 6 \cdot 10^{-6}$	≤ 5	blue-violet	≤ 8 ¹⁰
HQ® 310	2...3	1/1*0.63 ≤ 6 kg 1/2*1.0 > 6 kg	0.5	n. sp.	n. sp.	≤ 10	blue-violet	ca. 30

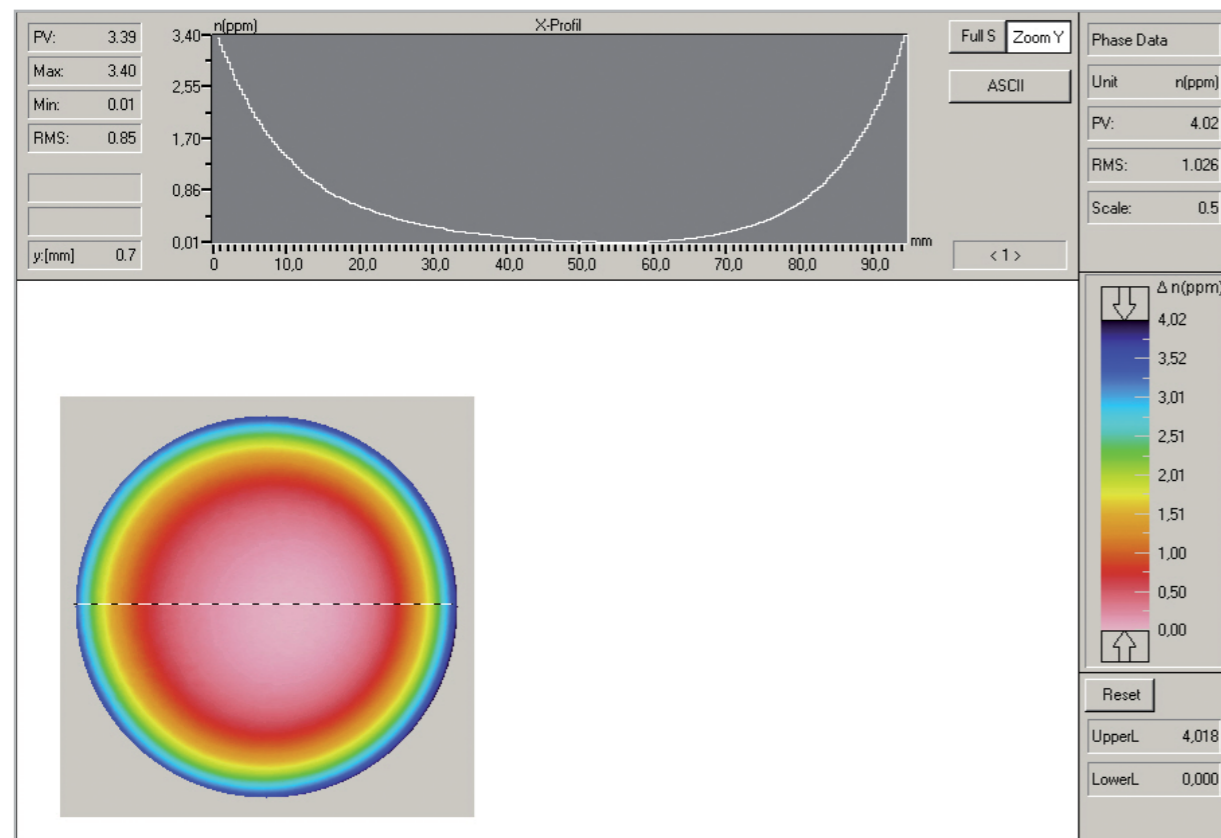
 Synthetic Fused Silica  Cultured Quartz  Natural Quartz  Natural Quartz

Wavelength nm	Suprasil-family	Homosil / Herasil / Infrasil / HQ
190	1.56572	-
193.4	1.56013	-
200	1.55051	-
202.54	-	1.54729
220	1.52845	1.5287
232.94	-	1.51834
240	1.51334	1.51359
248.4	1.50833	-
260	1.50239	1.50264
266	1.49968	1.49993
274.87	1.49607	1.49634
280	1.49416	1.49439
300	1.48779	1.48800
308	1.48564	1.48583
320	1.48274	1.48292
325	1.48164	1.48182
337	1.47921	1.47938
340	1.47865	1.47881
360	1.47529	1.47544
365.48	1.47447	1.47462
380	1.47248	1.47262
400	1.47012	1.47025
404.65	1.46962	1.46975
(nh)	1.46669	1.46681
(ng)	1.46622	1.46634
HeCd	1.46578	1.46591
Kr	1.46301	1.46313
(nF)	1.46156	1.46166
Ar	1.46071	1.46081
2 x Nd:YAG	1.45846	1.45856
(ne)	1.45702	1.45711
(nd)	1.45637	1.45646
HeNe	1.45542	1.45552
(nc)	1.45419	1.45428
Ruby	1.45332	1.45341
Kr	1.45250	1.45259
800	1.45175	1.45185
905	1.45168	1.45177
1000	1.45042	1.45051
Nd:YAG	1.44963	1.44972
HeNe	1.44859	1.44868
1200	1.44805	1.44815
Nd:YAG	1.44670	1.44680
1400	1.44578	1.44589
1600	1.44342	1.44353
1800	1.44087	1.44099
2000	1.43809	1.43821
2200	1.43501	1.43515
2400	1.43163	1.43177
2600	1.42789	1.42804
2800	1.42377	1.42393
3000	1.41925	1.41941
3200	1.41427	1.41444
3400	1.40881	1.40897

Optical Homogeneity

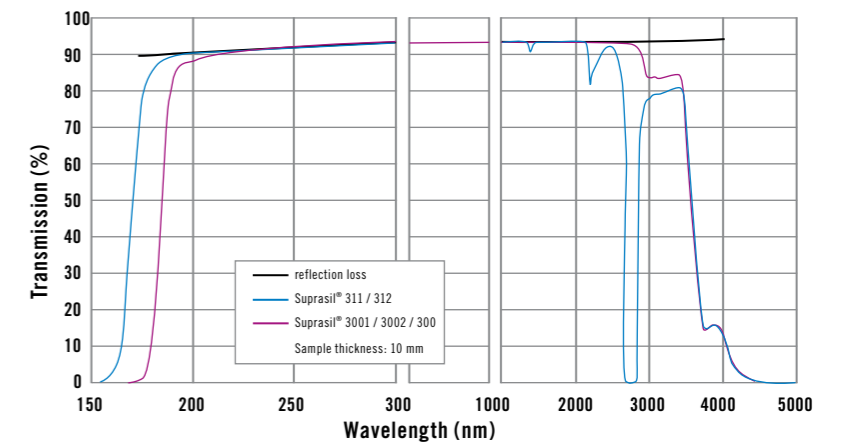
The false colour interferogram below shows the typical two-dimensional refraction-index distribution. The interferogram belongs to a circular blank.

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.

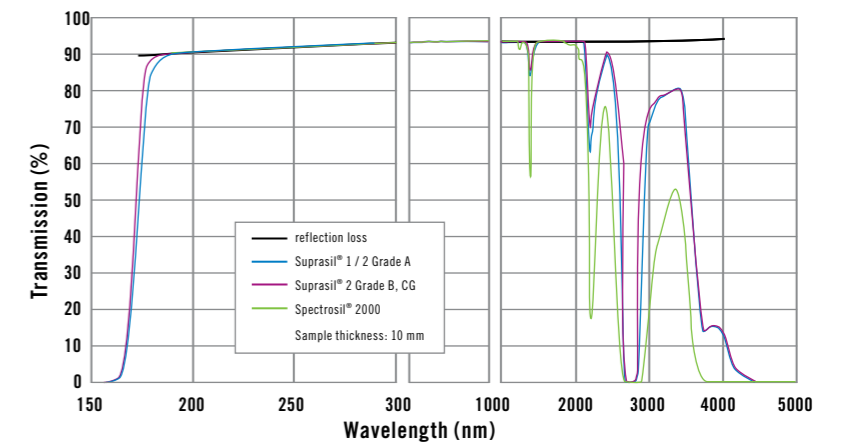


Typical transmission including Fresnel reflection losses $(1-R)^2$

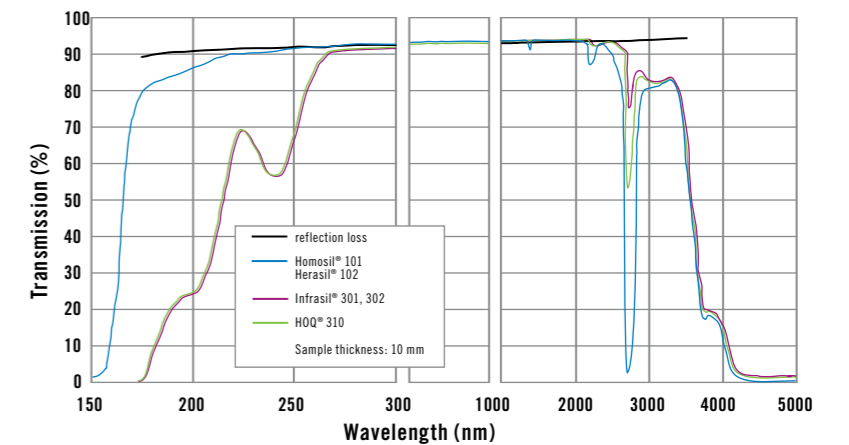
Suprasil® 311, 312
Suprasil® 3001, 3002, 300



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 nm	Suprasil®-family, Spectrosil®		Homosil® / Herasil® / Infrasil® / HOQ®	
	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

$$v_d = \frac{n_d - 1}{n_f - n_c} \quad 67,8 \pm 0,5$$

Birefringence constant @ 633 nm

nm / cm · 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 · 10 ⁻¹	4,76523070 · 10 ⁻¹
B2	6,31038719 · 10 ⁻¹	6,27786368 · 10 ⁻¹
B3	9,06404498 · 10 ⁻¹	8,72274404 · 10 ⁻¹
C1	1,29957170 · 10 ⁻²	2,84888095 · 10 ⁻³
C2	4,12809220 · 10 ⁻³	1,18369052 · 10 ⁻²
C3	9,87685322 · 10 ¹	9,56856012 · 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 · 10 ⁴
Modulus of torsion	N/mm ²	3 · 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 $\Omega \cdot \text{m}$		
20°C	10 ¹⁶	
400°C	10 ⁸	
800°C	6,3 · 10 ⁴	
1200°C	1,3 · 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 · 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 · 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 · K			
	0...100°C	772	
	0...500°C	964	
	0...900°C	1052	
Heat conductivity W/m · 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 · 10 ⁻⁷	
	0...100°C	5,1 · 10 ⁻⁷	
	0...200°C	5,8 · 10 ⁻⁷	
	0...300°C	5,9 · 10 ⁻⁷	
	0...600°C	5,4 · 10 ⁻⁷	
	0...900°C	4,8 · 10 ⁻⁷	

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