# DATA SHEET

# HERAEUS HOQ310

## Quartz Glass for Optics Data and Properties

= 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. Tighter specification for bubbles and inclusions down to ≤ 10µm is possible on request.

❸ For non-spherical bubbles the maximum dimension is used.

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 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 3 \cdot 10^{-6}$ |
| Suprasil® 312 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 4 \cdot 10^{-6}$ |
| Suprasil® 313 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | n. sp. ❽ |
| Suprasil® 3001 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 4 \cdot 10^{-6}$ |
| Suprasil® 3002 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 10 \cdot 10^{-6}$ |
| Suprasil® 300 | 0 | 1/1*0.08 | ≤ 0.015 | acc. MIL | n. sp. |
| Suprasil® 3301 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 2 \cdot 10^{-6}$ |
| Suprasil® 3302 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 3 \cdot 10^{-6}$ |
| Suprasil® 1 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 5 \cdot 10^{-6}$ |
| Suprasil® 2 Grade A | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 5 \cdot 10^{-6}$ |
| Suprasil® 2 Grade B | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 10 \cdot 10^{-6}$ |
| Suprasil® CG | 0 | 1/1*0.08 | ≤ 0.015 | acc. MIL | $\leq 30 \cdot 10^{-6}$ |
| Suprasil® 1 ArF / KrF | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 5 \cdot 10^{-6}$ |
| Suprasil® 2 ArF / KrF | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 5 \cdot 10^{-6}$ |
| Spectrosil® 2000 | 0 | 1/1*0.08 | ≤ 0.015 | 2 / -;5 | $\leq 10 \cdot 10^{-6}$ |
| Infrasil® 301 | 0 | 1/1*0.16 | ≤ 0.03 | 2 / -;5 | $\leq 5 \cdot 10^{-6}$ |
| Infrasil® 302 | 0..1 | 1/1*0.35 | ≤ 0.1 | 2 / -;5 | $\leq 6 \cdot 10^{-6}$ |
| HOQ® 310 | 2...3 | 1/1*0.63 ≤ 6 kg<br>1/2*1.0 > 6 kg | 0.5 | n. sp. | n. sp. |

Synthetic Fused Silica  Natural Quartz ❾  n. sp. = not specified  = 3D material, optically isotropic



**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com
www.uqgoptics.com

# DATA SHEET

# HERAEUS HOQ310

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.

❽ Typically less than $10 \cdot 10^{-6}$.

❾ The chemical composition, and therefore, the optical properties of natural quartz can vary.

| Residual Strain ❼ nm/cm ❻ | Fluorescence Excitation by Hg-Lamp@ λ= 254 nm and UG 5-filter; Lamp-power: 8W; Detection: adapted eye | OH-Content ppm (µg/g) |
|---|---|---|
| ≤ 5 | free | ≤ 300 |
| ≤ 5 | free | ≤ 300 |
| ≤ 5 | free | ≤ 300 |
| ≤ 6 | slight blue | ≤ 1 |
| ≤ 6 | slight blue | ≤ 1 |
| ≤ 5 | slight blue | ≤ 1 |
| ≤ 2 | free | ≤ 20 |
| ≤ 3 | free | ≤ 20 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 20 | free | ≤ 1300 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 5 | free | ≤ 1300 |
| ≤ 5 | blue-violet | ≤ 8 |
| ≤ 5 | blue-violet | ≤ 8 |
| ≤ 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.

| Wavelenght nm | | Suprasil®-family | Suprasil® 3001/3002/300 | 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 | 1,4748 | 1,4746 |
| | 380 | 1,4725 | 1,4728 | 1,4726 |
| | 400 | 1,4701 | 1,4704 | 1,4703 |
| (nh) | 404,65 | 1,4696 | 1,4699 | 1,4698 |
| (ng) | 435,83 | 1,4667 | 1,4670 | 1,4668 |
| HeCd | 441,6 | 1,4662 | 1,4665 | 1,4663 |
| Kr | 447,1 | 1,4658 | 1,4661 | 1,4659 |
| (nF) | 486,13 | 1,4631 | 1,4634 | 1,4632 |
| Ar | 488 | 1,4630 | 1,4633 | 1,4631 |
| Ar | 514,5 | 1,4616 | 1,4619 | 1,4617 |
| 2 x Nd:YAG | 532 | 1,4607 | 1,4610 | 1,4608 |
| (ne) | 546,07 | 1,4601 | 1,4604 | 1,4602 |
| (nd) | 587,56 | 1,4585 | 1,4588 | 1,4586 |
| HeNe | 632,8 | 1,4570 | 1,4573 | 1,4571 |
| (nc) | 656,27 | 1,4564 | 1,4567 | 1,4565 |
| Ruby | 694,3 | 1,4554 | 1,4557 | 1,4555 |
| Kr | 752,5 | 1,4542 | 1,4545 | 1,4543 |
| | 800 | 1,4533 | 1,4536 | 1,4534 |
| | 850 | 1,4525 | 1,4528 | 1,4526 |
| | 900 | 1,4518 | 1,4520 | 1,4519 |
| GaAs | 905 | 1,4517 | 1,4520 | 1,4518 |
| | 1000 | 1,4504 | 1,4507 | 1,4505 |
| Nd:YAG | 1064 | 1,4496 | 1,4499 | 1,4497 |
| HeNe | 1153 | 1,4486 | 1,4489 | 1,4487 |
| | 1200 | 1,4481 | 1,4483 | 1,4482 |
| Nd:YAG | 1319 | 1,4467 | 1,4470 | 1,4468 |
| | 1400 | 1,4458 | 1,4461 | 1,4459 |
| | 1600 | 1,4434 | 1,4437 | 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 |



**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com

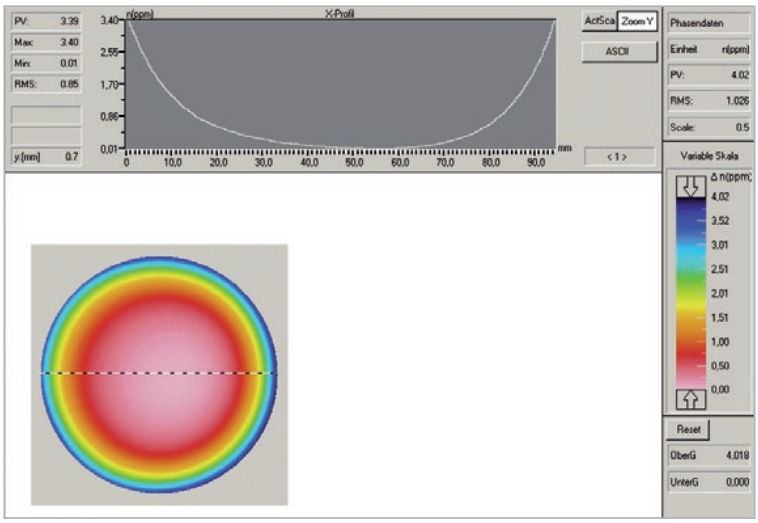
DATA SHEET

HERAEUS HOQ310

# Optical Homogeneity and Stress Induced Birefringence

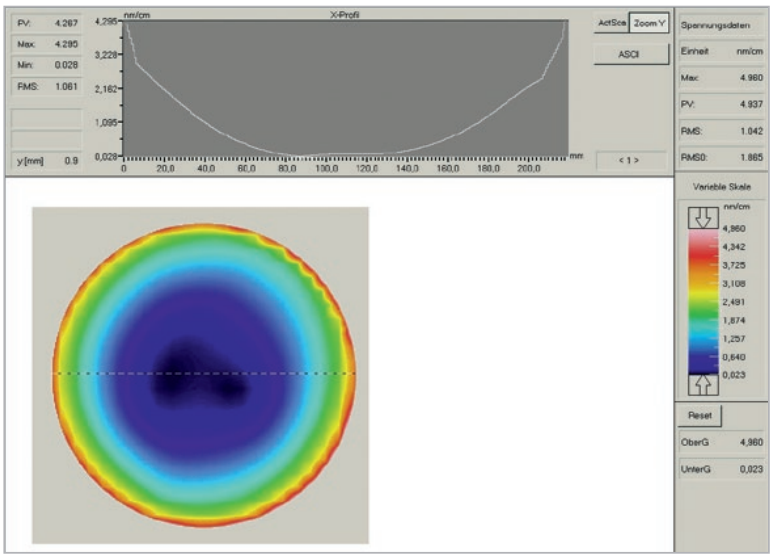
The false colour diagram below shows the typical two-dimensional refraction-index distribution. The interferogram belongs to a circular blank.

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 diagram 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.





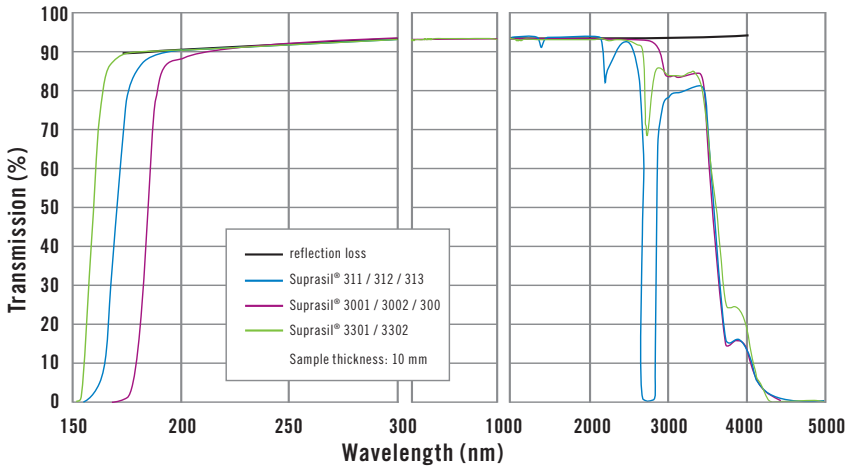

**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com

# DATA SHEET

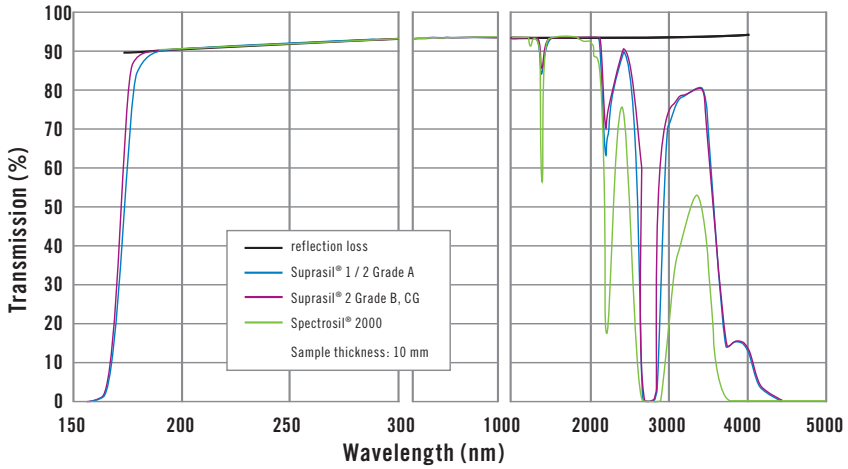
# HERAEUS HOQ310

## Typical transmission including Fresnel reflection losses $(1\text{-}R)^2$

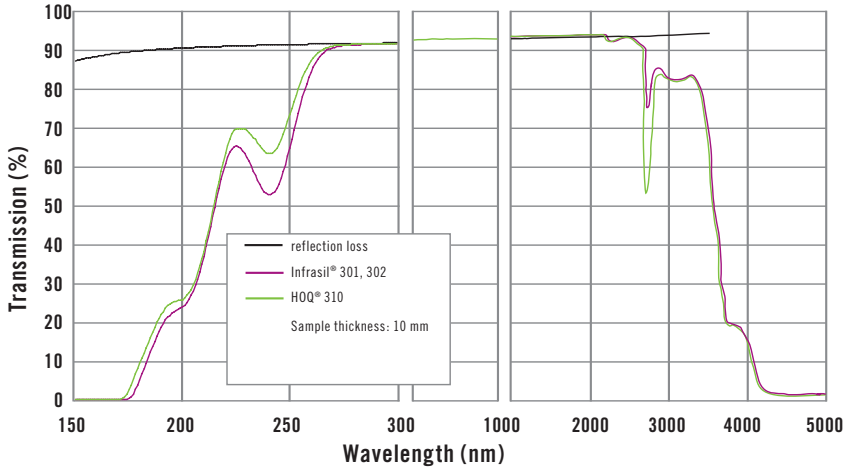
**Suprasil® 311, 312, 313**
**Suprasil® 3001, 3002, 300**
**Suprasil® 3301, 3302**




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




**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.herae.us/transmission-calculator**



**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com

# DATA SHEET

# HERAEUS HOQ310

## 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 - |
|---|---|---|
| 193,4 | ≥ 99,30 | 98,50 |
| 248,4 | ≥ 99,80 | 99,50 |
| 266 | 99,90 | 99,90 |

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

| Wave-length | Suprasil®-family, Spectrosil® | | 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

| | |
|---|---|
| $v_d = \frac{n_d - 1}{n_F - n_c}$ | 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® | 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 | Infrasil® / HOQ® ppm |
|---|---|---|
| Al = aluminium | ≤ 0,010 | 20 |
| Ca = calcium | ≤ 0,015 | 1 |
| Cr = chrome | ≤ 0,001 | 0,1 |
| Cu = copper | ≤ 0,003 | 0,1 |
| Fe = iron | ≤ 0,005 | 0,8 |
| K = potassium | ≤ 0,010 | 0,8 |
| Li = lithium | ≤ 0,001 | 1 |
| Mg= magnesium | ≤ 0,005 | 0,1 |
| Na = sodium | ≤ 0,010 | 1 |
| Ti = titanium | ≤ 0,005 | 1 |



**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com

# DATA SHEET

# HERAEUS HOQ310

| Mechanical data | | Suprasil®-family, Spectrosil® Infrasil® / HOQ® |
|---|---|---|
| Density | g/cm³ | 2,20 |
| Mohs-hardness | | 5,5.....6,5 |
| Micro-hardness | N/mm² | 8600.....9800 |
| Knoop-hardness | N/mm² | 5800.....6200 |
| Modulus of elasticity (at 20°C) | N/mm² | $7{,}0 \cdot 10^4$ |
| Modulus of torsion | N/mm² | $3 \cdot 10^4$ |
| Poisson´s ratio | | 0,17 |
| Compressive strength | N/mm² | 1150 |
| Tensile strength | N/mm² | 50 |
| Bending strength | N/mm² | 67 |
| Torsional strength | N/mm² | 30 |
| Sound velocity | m/s | 5720 |

| Electrical data | | |
|---|---|---|
| **Resistivity in Ω·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® | 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 | | $2{,}7 \cdot 10^{-7}$ | |
| 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 | | $4{,}8 \cdot 10^{-7}$ | |



**UQG (Optics) Ltd.** The Norman Industrial Estate, 99-101 Cambridge Road, Milton, Cambridge CB24 6AT. England.
Tel | **+00 44 (0) 1223 420329** Fax | **+00 44 (0) 1223 420506** Email | info@uqgoptics.com