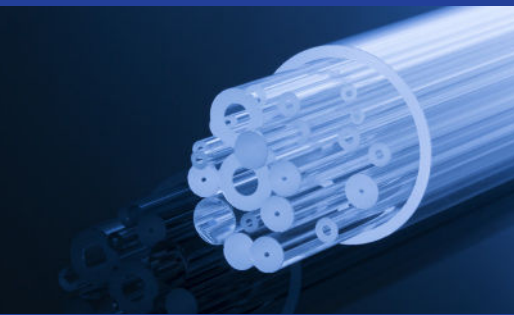




Customized Fused Quartz Products



Materials, Products and Applications

qsil

Expert in advanced materials.

EXPERT IN ADVANCED MATERIALS FOR HIGH TEMPERATURE APPLICATIONS

The QSIL Group is an innovative, internationally active materials specialist for the development and production of sophisticated solutions from a broad portfolio of high-performance materials and proprietary manufacturing technologies. Among other things, QSIL specializes in the production of high-purity quartz glass, specialty glasses, industrial and engineering ceramics, and refractory metals. Key markets include the semiconductor, analytical and diagnostic, traditional and technical light source industries, as well as various applications in mechanical and plant engineering, the chemical industry and fiber optics production. QSIL has a globally diversified customer base. Customers include companies from Europe, Asia and the Americas.

CUSTOMIZED QUARTZ AND SPECIAL GLASS PRODUCTS

QSIL is a leading producer of fused quartz products, which are sold under the trademark ilmasil® and PH quartz and special glass. From the factories in Germany and The Netherlands, its products are widely supplied throughout the global market. The sole focus of QSIL is the manufacture of fused quartz, including the fusion of heavy wall cylinders, small and large diameter tubes, rods, and the fabrication of customized products. Because of its unique plasma fusion process, QSIL is the only company with the ability to manufacture hollow cylinders (billets) in a single production step. The main target of QSIL's quality policy is reliable delivery of products that exactly meet the needs and expectations of our customers. Through the use of statistical process control to monitor the manufacturing process, the measurement and recording of every step in the production process guarantees the complete traceability from the final product back to the raw material.

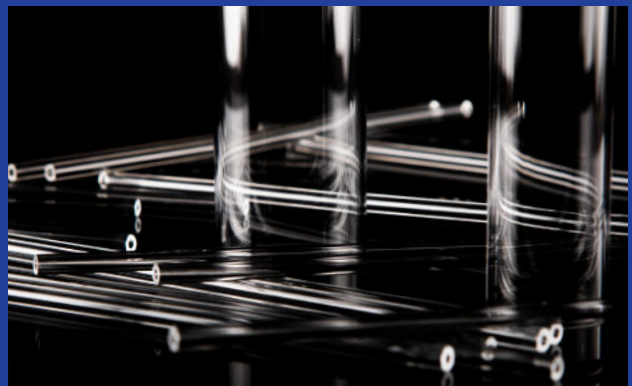
ILMENAU, GERMANY

- Single-stage process for thick-walled hollow cylinders
- Two-stage process tubes
- Manual and mechanical quartz glass hot processing



WINSCHOTEN, NETHERLANDS

- Single-stage process for tubes and rods
- Quartz glass and special glass



Fused Quartz for industrial applications

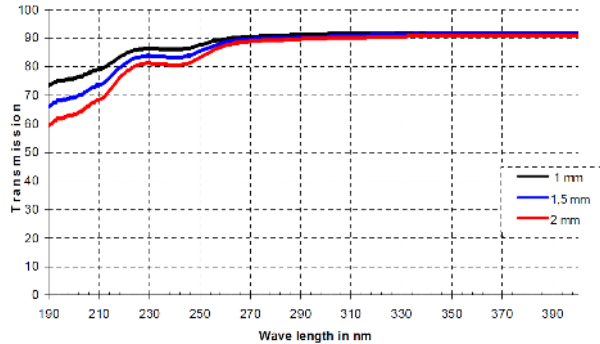
CLEAR FUSED QUARTZ

Typical Trace Element Content in ppm

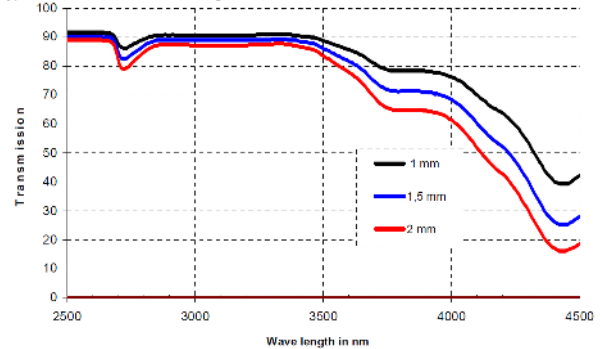
| | Al | Ca | Cr | Cu | Fe | K | Li | Mn | Na | Ti | Ni | Zr | OH |
|--------------------|--------------------------------------|-----|-------|-------|-----|-----|-----|------|-----|-----|-------|-----|------|
| ilmasil® P | Sum of foreign elements max. 250 ppm | | | | | | | | | | | | |
| ilmasil® PN | 15.0 | 0.8 | <0.05 | <0.03 | 0.3 | 0.7 | 0.5 | 0.05 | 1.0 | 1.5 | <0.02 | 1.5 | 30.0 |

Transmission of PN

Typical Transmission in UV-range



Typical Transmission in IR-range



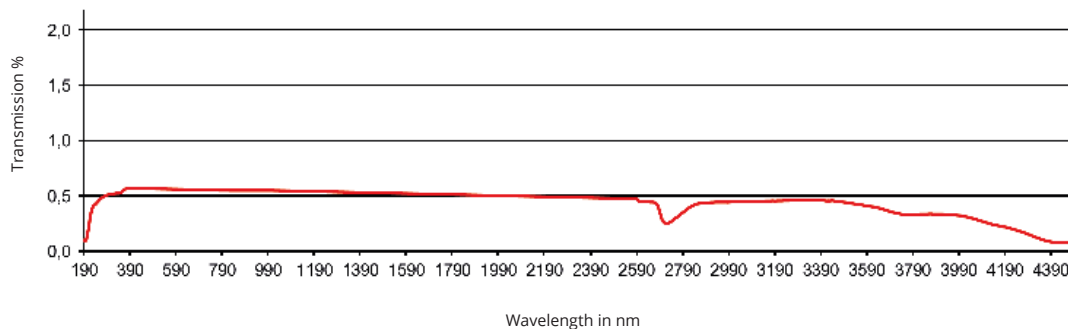
Remark: transmission measured on a plane surface

OPAQUE FUSED QUARTZ

Typical Trace Element Content in ppm

| | Al | Ca | Cr | Cu | Fe | K | Li | Mn | Na | Ti | Ni | Zr | OH |
|----------------------|--------------------------------------|-----|-------|-------|-----|-----|-----|------|-----|-----|-------|-----|--------|
| ilmasil® PO-0 | Sum of foreign elements max. 250 ppm | | | | | | | | | | | | <100.0 |
| ilmasil® PO-1 | 15.0 | 0.8 | <0.05 | <0.03 | 0.3 | 0.7 | 0.5 | 0.05 | 1.0 | 1.5 | <0.02 | 1.5 | <100.0 |

Transmission of ilmasil® PO-1 (Thickness 3 mm)



Clear and opaque fused quartz

COMBINATION OF CLEAR AND OPAQUE FUSED SILICA OF HIGH-PURITY MATERIALS

ilmasil® PN (clear) and ilmasil® PO-1 (opaque)

- Applicable for tube geometries of radial and axial designs
- opaque parts provide thermal isolation



Properties

| THERMAL PROPERTIES | |
|--|--|
| Transformation Range | 1050-1210 °C |
| Annealing Point | |
| ilmasil® PN | 1204 °C |
| ilmasil® PO-1 | 1160 °C |
| Strain Point | appr. 1050 °C |
| Softening Point | appr. 1730 °C |
| Processing Range | 1700-2100 °C |
| Maximum usable temperature | |
| Long term | 1100 °C |
| Short term | 1300 °C |
| Coefficient of thermal expansion (20-300 °C) | appr. 5.5×10^{-7} K ⁻¹ |

| THERMAL CONDUCTIVITY [W/(M*K)] | | |
|--------------------------------|------|------|
| Temperature [°C] | PN | PO-1 |
| 30 | 1,68 | 1,16 |
| 100 | 1,42 | 1,25 |
| 200 | 1,11 | 1,33 |
| 400 | 1,64 | 1,45 |
| 600 | 2,11 | 1,53 |
| 800 | 2,39 | 1,61 |
| 1000 | 2,65 | 1,85 |
| 1200 | 2,73 | 1,92 |
| 1300 | 2,83 | 1,98 |

| SPECIFIC HEAT [J/(G*K)] | | |
|-------------------------|------|------|
| Temperature [°C] | PN | PO-1 |
| 30 | 0,78 | 0,75 |
| 100 | 0,86 | 0,86 |
| 200 | 0,95 | 0,96 |
| 400 | 1,07 | 1,09 |
| 600 | 1,13 | 1,17 |
| 800 | 1,17 | 1,21 |
| 1000 | 1,19 | 1,24 |
| 1200 | 1,21 | 1,26 |
| 1300 | 1,22 | 1,26 |

| THERMAL EXPANSION COEFFICIENT [*10-7/K-1] | | |
|---|------|------|
| Temperature [°C] | PN | PO-1 |
| 20 - 200 | 8,7 | 6,1 |
| 20 - 300 | 9,1 | 7,4 |
| 20 - 400 | 10,4 | 7,5 |
| 20 - 600 | 10,1 | 8,2 |
| 20 - 800 | 9,7 | 8,4 |
| 20 - 1000 | 9,5 | 8,5 |

| MECHANICAL PROPERTIES | ilmasil® PN | ilmasil® PO-1 |
|----------------------------|-------------------------------------|---|
| Density | 2.2 g/cm ³ | 2.05..2.15 g/cm ³ |
| Mohs hardness | 5.5...6.5 | 5.0...7.0 |
| Elasticity modulus (20 °C) | 7.5×10^4 N/mm ² | 6.7×10^4 N/mm ² |
| Compressive Strength | 1150 N/mm ² | 458 N/mm ² |
| Tensile strength | 50 N/mm ² | 50 N/mm ² |
| Bending strength | 68 N/mm ² | 36 N/mm ² |
| Porosity | | 30...70mm ³ /cm ³ |
| Vickers Hardness | | 922 (\pm 9045 N/mm ²) |
| Knoop Hardness | | 614 (\pm 6023 N/mm ²) |

| CHEMICAL PROPERTIES | | |
|---------------------------|-----------------------|-----------------------|
| Hydrolytic resistance per | DIN 12111 (1st class) | DIN 12111 (1st class) |
| Acid resistance per | DIN 12116 (1st class) | DIN 12116 (1st class) |
| Alkaline resistance per | DIN 52322 (1st class) | DIN 52322 (1st class) |

| ELECTRICAL PROPERTIES | | |
|--|---|---|
| Specific electrical resistance (20 °C) | 1018 $\Omega \times m$ | |
| Dielectrical loss factor (7.5 GHz) | $tg \delta \approx 5.0 \times 10^{-4}$ (at 7.5 GHz) | $tg \delta \approx 2.0 \times 10^{-4}$ (at 1 kHz) |
| Dielectrical constant | $\epsilon \approx 3.7$ (20 °C / 7.5 GHz) | $\epsilon \approx 3.3$ (20°C / 1 kHz) |
| Dielectrical strength (20°C) | 25 - 40 kV/mm | |

Fused Quartz Cylinders (Billets)

Heavy wall cylinders (billets) are the perfect base material for manufacturing quartz flanges, rings and similar rotation-symmetric products. Compared to block material there can be large savings in labor and material due to geometric configuration.

CLEAR FUSED QUARTZ BILLETS

AVAILABLE SIZES IN ILMASIL® PN / ILMASIL® P

| OUTER DIAMETER (mm) | MAXIMUM INNER DIAMETER (mm) | MINIMUM INNER DIAMETER (mm) |
|---------------------|-----------------------------|-----------------------------|
| Tolerance: +10/-0 | Tolerance: +10/-0 | Tolerance: +10/-0 |
| 105 | 95 | 90 |
| 120 | 105 | 90 |
| 130 | 117 | 105 |
| 160 | 145 | 90 |
| 180 | 150 | 120 |
| 200 | 170 | 140 |
| 220 | 190 | 140 |
| 240 | 210 | 160 |
| 260 | 230 | 160 |
| 280 | 245 | 170 |
| 300 | 265 | 175 |
| 320 | 280 | 185 |
| 330 | 290 | 200 |
| 350 | 310 | 200 |
| 370 | 330 | 250 |
| 390 | 340 | 260 |
| 410 | 360 | 270 |
| 440 | 390 | 290 |
| 460 | 420 | 300 |
| 500 | 440 | 340 |
| 510 | 440 | 340 |
| 520 | 460 | 340 |
| 540 | 480 | 360 |
| 570 | 510 | 370 |

OPAQUE FUSED QUARTZ BILLETS

ilmasil® PO is a brilliant white opaque fused quartz for industrial applications where, in addition to high purity and thermal Shock resistance, thermal shielding is required. The opacity of this electrically fused material is achieved by controlled distribution of fine microbubbles (typical diameter 10 – 150 nm). There are no additional elements used to achieve opacity. Physical and thermal properties are similar to clear fused quartz. Flame welding can easily be accomplished without shrinkage. Low thermal transmittance and conductivity, together with its high purity and very good processing properties, make ilmasil® PO cylinders a perfect starting material for manufacturing flanges and insulation rings.

AVAILABLE SIZES IN ilmasil® PO-0 / ilmasil® PO-1

| OUTER DIAMETER (mm) | MAXIMUM INNER DIAMETER (mm) | MINIMUM INNER DIAMETER (mm) |
|---------------------|-----------------------------|-----------------------------|
| Tolerance: +10/-0 | Tolerance: +0/-30 | Tolerance: +0/-30 |
| 126 | 113 | 100 |
| 145 | 132 | 90 |
| 160 | 146 | 130 |
| 180 | 166 | 145 |
| 200 | 186 | 165 |
| 205 | 190 | 170 |
| 215 | 199 | 175 |
| 225 | 205 | 185 |
| 240 | 220 | 204 |
| 260 | 240 | 215 |
| 280 | 260 | 220 |
| 300 | 280 | 235 |
| 315 | 295 | 255 |
| 335 | 315 | 270 |
| 360 | 340 | 275 |
| 375 | 355 | 290 |
| 414 | 395 | 315 |
| 420 | 400 | 330 |
| 430 | 400 | 360 |
| 465 | 425 | 385 |
| 475 | 435 | 395 |
| 485 | 445 | 380 |
| 510 | 470 | 365 |
| 520 | 485 | 430 |
| 550 | 490 | 430 |

Fused Quartz Tubing, Rods

ilmasil® fused quartz tubes are manufactured in a tool-free drawing process, providing excellent visual, mechanical, and thermal properties. Contamination from shaping machine tools is not possible. ilmasil® fused quartz tubes are available in a wide geometrical range, also in small and medium batch sizes.

AVAILABLE SIZES ilmasil® PN

| OUTER DIAMETER | TOLERANCE | WALL THICKNESS RANGE | | |
|----------------|-----------|----------------------|----|-----------|
| (mm) | (mm) | MIN. (mm) | | MAX. (mm) |
| 4 | ±0.2 | 0.2 | to | 1.6 |
| 5 | ±0.2 | 0.2 | to | 2.1 |
| 6 | ±0.2 | 0.2 | to | 2.5 |
| 7 | ±0.3 | 0.2 | to | 2.5 |
| 8 | ±0.3 | 0.2 | to | 3.0 |
| 9 | ±0.3 | 0.2 | to | 3.0 |
| 10 | ±0.3 | 0.2 | to | 3.5 |
| 11 | ±0.3 | 0.25 | to | 3.6 |
| 12 | ±0.4 | 0.25 | to | 3.7 |
| 13 | ±0.4 | 0.25 | to | 3.9 |
| 14 | ±0.4 | 0.25 | to | 4.2 |
| 15 | ±0.4 | 0.25 | to | 4.5 |
| 16 | ±0.5 | 0.3 | to | 4.8 |
| 17 | ±0.5 | 0.3 | to | 5.1 |
| 18 | ±0.5 | 0.3 | to | 5.1 |
| 19 | ±0.5 | 0.3 | to | 5.7 |
| 20 | ±0.5 | 0.3 | to | 6.0 |
| 22 | ±0.6 | 0.35 | to | 6.6 |
| 23 | ±0.6 | 0.35 | to | 6.9 |
| 24 | ±0.6 | 0.35 | to | 7.2 |
| 25 | ±0.6 | 0.35 | to | 7.5 |
| 26 | ±0.7 | 0.4 | to | 7.8 |
| 28 | ±0.8 | 0.4 | to | 8.4 |
| 30 | ±0.8 | 0.4 | to | 9.0 |
| 35 | ±0.9 | 0.5 | to | 10.5 |
| 40 | ±1.2 | 0.6 | to | 12.0 |
| 45 | ±1.5 | 0.6 | to | 13.5 |
| 50 | ±2.0 | 0.7 | to | 15.0 |
| 55 | ±2.0 | 0.9 | to | 16.5 |
| 60 | ±2.0 | 1.0 | to | 18.0 |
| 65 | ±2.0 | 1.0 | to | 19.5 |
| 70 | ±2.5 | 1.5 | to | 20.0 |
| 75 | ±2.5 | 2.0 | to | 20.0 |
| 80 | ±3.0 | 2.5 | to | 23.0 |

Other sizes and material grades are available upon request!

LD-Clear Fused Quartz Tubing

Large diameter fused quartz tubes are resized by glassblowinglathe. LD-tubes are custom-made, available in a full range of sizes up to 1000 mm outer diameter.

| OUTER DIAMETER (mm) | WALL THICKNESS RANGE | |
|------------------------|----------------------|-----------|
| | MIN. (mm) | MAX. (mm) |
| 50...59 | 1.5 | 7.0 |
| 60...69 | 2.0 | 7.0 |
| 70...79 | 2.5 | 7.0 |
| 80...99 | 2.5 | 8.0 |
| 100...119 | 2.5 | 10.0 |
| 120...149 | 3.0 | 10.0 |
| 150...179 | 3.5 | 12.0 |
| 180...209 | 4.0 | 12.0 |
| 210...299 | 4.0 | 10.0 |
| 300...799 | 4.0 | 8.0 |
| 800...1000 | 5.0 | 7.0 |

LD-tubes may be doped on the outer surface with a thin layer of Al₂O₃. This layer enables the growth of a cristobalite layer when the tube is exposed to a temperature above 1150 °C, providing better stability (less sagging) and longer lifetime of the process tube at elevated temperatures.

FABRICATION

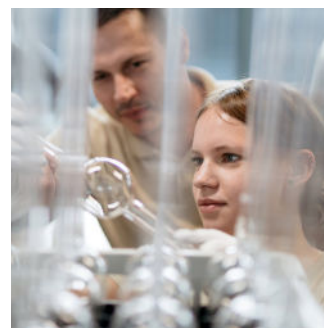
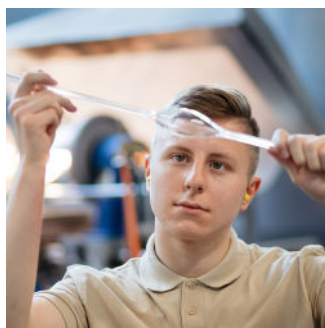
In our experienced glassblowing department, we are able to fabricate custom-made quartzware according to our clients' specifications and drawings. Modern fabrication technologies and strict quality control enable us to supply fabricated items for various applications:

PROCESS TUBES

- for deposition and diffusion
- reactors for fluid bed processes
- muffle tubes
- sleeve and immersion tubes

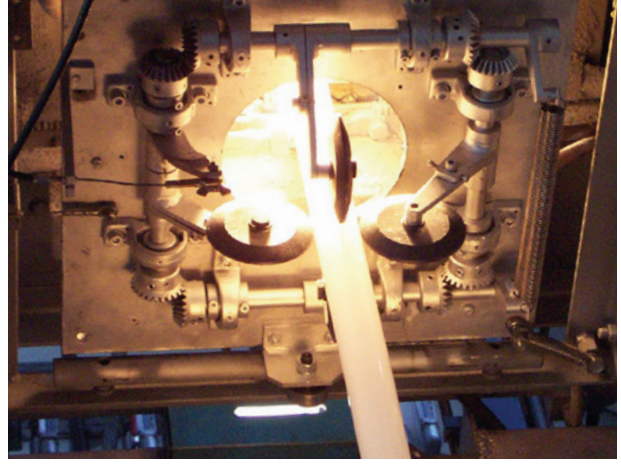
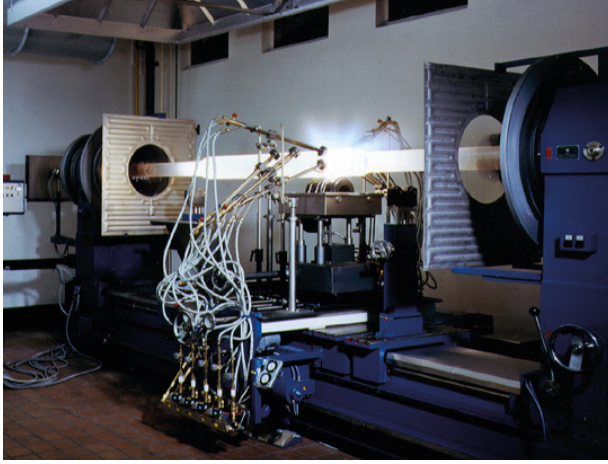
FABRICATED QUARTZWARE FOR LABORATORY AND ANALYTICS

- decomposition tubes
- pressure and vacuum vessels
- coils
- laboratory ware



Technology

QSIL's proprietary technology uses a unique plasma-based fusion process that produces both clear and opaque hollow cylinders (billets) in a single heating step. In a second production step hollow cylinders are drawn into tubing using a vertical drawing tower. This two-stage technology enables QSIL to manufacture tubing in a wide range of sizes with flexibility in small and medium quantities. Modern manufacturing technologies and the finest quality control equipment, together with years of experience in melting and fabricating of fused quartz, forms the foundation for our product quality.



We enable innovation.
www.qsil.com

QSIL GmbH Quarzschmelze Ilmenau
Gewerbering 8
98693 Ilmenau
Germany

Telephone +49 3677 64150
Telefax +49 3677 641511
E-Mail info@qsil.com
Web www.qsil.com

QSIL Nederland B.V.
H.M. Brouwerstraat 1
9672 AG Winschoten
The Netherlands

Telephone +31 597 451 229
E-Mail info.nl@qsil.com
Web www.qsil.com

Follow us on **LinkedIn**

