

# High performance quartz

Customized fused quartz products

Materials, products and applications



SCHOTT

# Expert in advanced materials

## Expert in advanced materials for high temperature applications

SCHOTT Quartz Glass 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.

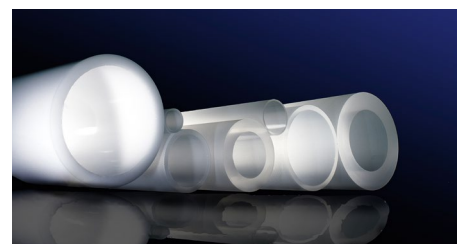
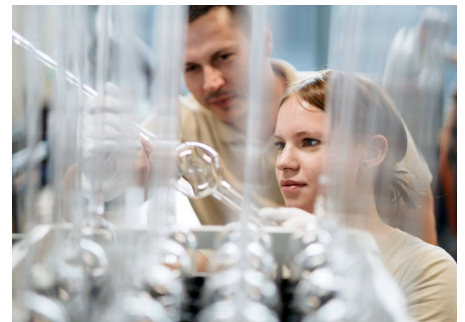
Key markets include the semiconductor, analytical and diagnostic, traditional and technical light source industries, as well as various applications in mechanical and plant engineering, the chemical industry and fiber optics production. SCHOTT Quartz Glass has a globally diversified customer base. Customers include companies from Europe, Asia and the Americas.

## Customized quartz products

SCHOTT Quartz Glass is a leading producer of fused quartz products, which are sold under the trademark Ilmasil™. From the factory in Germany, its products are widely supplied throughout the global market.

The sole focus of SCHOTT Quartz Glass is the manufacture of fused quartz, including the fusion of heavy-walled cylinders, small and large diameter tubes, rods, and the fabrication of customized products. Because of its unique plasma fusion process, SCHOTT Quartz Glass is the only company with the ability to manufacture hollow cylinders (billets) in a single production step. The main target of SCHOTT Quartz Glass' 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.

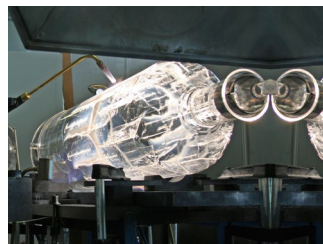
- Single-stage process for heavy-walled hollow cylinders
- Two-stage process tubes
- Manual and mechanical quartz glass hot processing



# Materials, products and applications

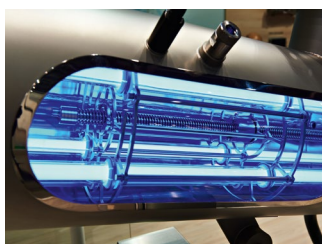
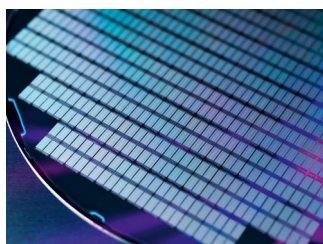
## Materials

Material grade	Properties	Application
Ilmasil™ P	Clear fused quartz	Industrial applications (non-semiconductor)
Ilmasil™ PN	Clear fused quartz	Standard material for semiconductor applications and UV-lamps/sleeves
Ilmasil™ PN-R	Clear fused quartz	UV-lamps/sleeves
Ilmasil™ PI	Clear fused quartz with reduced content of Al, Li and K	Semiconductor applications
Ilmasil™ PL	Clear fused quartz of very high purity	Semiconductor applications
Ilmasil™ PQ	Clear fused quartz of very high purity and low bubble content	Semiconductor applications
Ilmasil™ PO	Opaque fused quartz – available in 3 different purity grades	Semiconductor and other industrial applications
Ilmasil™ PS	Clear fused quartz produced from artificially grown crystal	UV-lamps/sleeves for deep UV applications
Ilmasil™ PN 215/235/240 Ilmasil™ PN 310/350	Doped clear fused quartz with special transmission properties	UV-lamps/sleeves



## Products and applications

Product	Application	Application area
Hollow cylinders (billets), blocks, plates, rods, tubes	Base material for manufacturing of process components	Semiconductor industry
Tubes, rods	Tube bodies for UV-lamps Sleeve tubes and reactors Handling tubes	Lamp industry Water purification Fiberoptics Welding rods
Reactor tubes	Reactor tubes and insulation parts Diffusion and CVD-reactors Process tubes and components	Polysilicon production Solar industry Chemical industry
Custom-made quartzware	Combustion tubes Pressure vessels Ground joints Laboratory ware	Analytical industry  Research & development



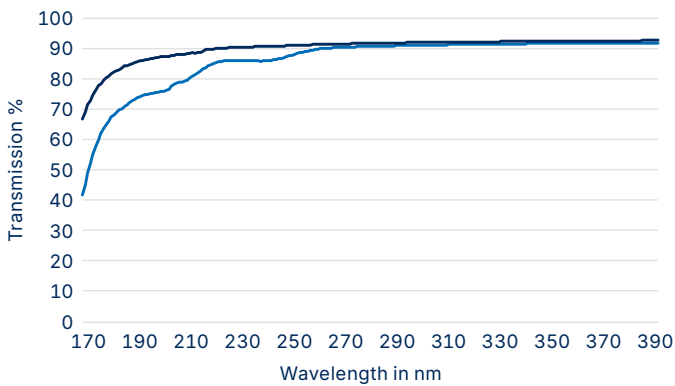
# Fused quartz for semiconductor and industrial applications

## Clear fused quartz

Typical trace element content in ppm

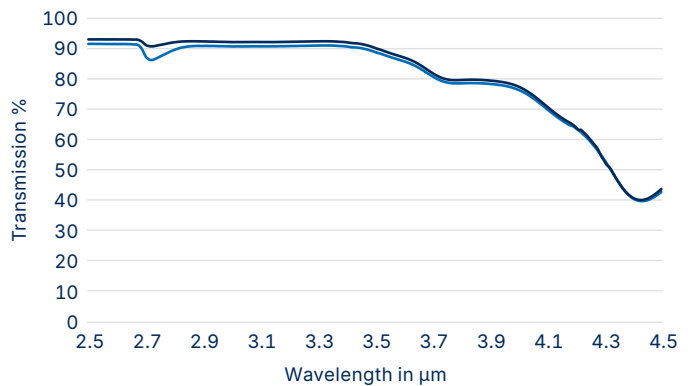
	Al	Ca	Cr	Cu	Fe	K	Li	Mn	Na	Ti	Ni	Zr	OH
Ilmasil™ P	Sum of trace elements maximum 250 ppm												
Ilmasil™ PN	15.0	0.8	<0.05	<0.03	0.3	0.7	0.5	0.05	1.0	1.5	<0.02	1.5	30.0
Ilmasil™ PN-R	15.0	0.8	<0.05	<0.03	0.3	0.7	0.5	0.05	1.0	1.5	<0.02	1.5	15.0
Ilmasil™ PI	8.0	0.8	<0.05	<0.03	0.3	0.4	0.2	<0.01	1.0	1.4	<0.01	1.3	30.0
Ilmasil™ PL	8.0	0.7	<0.05	<0.03	0.2	0.2	0.2	<0.01	0.2	1.4	<0.01	1.0	30.0
Ilmasil™ PQ	4.0	0.1	<0.01	<0.01	0.1	0.05	0.5	<0.01	0.1	0.1	<0.01	<0.02	30.0
Ilmasil™ PS	6.0	0.2	<0.01	<0.01	0.2	0.03	1.5	<0.01	0.1	0.2	<0.01	<0.02	10.0

## Transmission UV-range Ilmasil™ PN / PN-R and PS



Wall thickness 1 mm

## Transmission IR-range



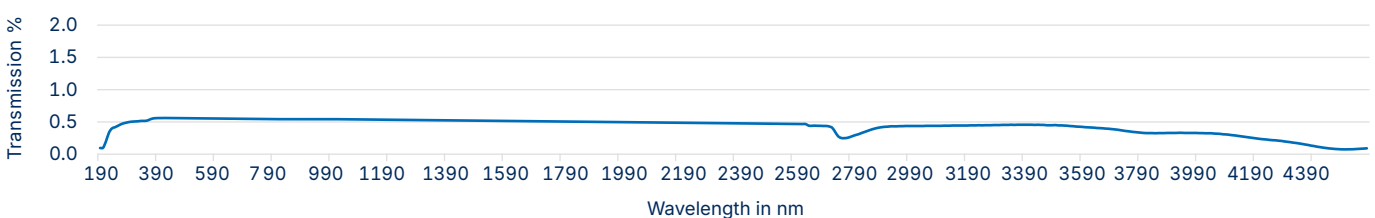
Wall thickness 1 mm

## 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 trace elements maximum 250 ppm												
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
Ilmasil™ PO-2	8.0	0.7	<0.05	<0.03	0.2	0.2	0.2	<0.01	0.2	1.4	<0.01	1.0	<100.0

## Transmission of Ilmasil™ PO-1 / PO-2



Wall thickness 3 mm

# Properties

Thermal properties	
Transformation range	1050 – 1210 °C
Annealing point	
Ilmasil™ PN	1204 °C
Ilmasil™ PI	1180 °C
Ilmasil™ PL	1213 °C
Ilmasil™ PQ	1210 °C
Ilmasil™ PO-1, PO-2	1160 °C
Ilmasil™ PS	1196 °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. $5.5 \times 10^{-7} \text{ K}^{-1}$

Mechanical properties	Ilmasil™ PN/PI/PL	Ilmasil™ PO-1/PO-2
Density	2.2 g/cm <sup>3</sup>	2.05..2.15 g/cm <sup>3</sup>
Mohs hardness	5.5...6.5	5.0...7.0
Elasticity modulus (20 °C)	$7.5 \times 10^4 \text{ N/mm}^2$	$6.7 \times 10^4 \text{ N/mm}^2$
Compressive strength	1150 N/mm <sup>2</sup>	458 N/mm <sup>2</sup>
Tensile strength	50 N/mm <sup>2</sup>	50 N/mm <sup>2</sup>
Bending strength	68 N/mm <sup>2</sup>	36 N/mm <sup>2</sup>
Porosity		30...70 mm <sup>3</sup> /cm <sup>3</sup>
Vickers hardness		922 ( $\Delta 9045 \text{ N/mm}^2$ )
Knoop hardness		614 ( $\Delta 6023 \text{ N/mm}^2$ )

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 $\Omega \times \text{m}$	
Dielectrical loss factor (7.5 GHz)	$\text{tg } \delta \approx 5.0 \times 10^{-4}$ (at 7.5 GHz)	$\text{tg } \delta \approx 2.0 \times 10^{-4}$ (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	

Devitrification	OH-stability
Devitrification is dependent upon surface cleanliness, atmospheric conditions and temperature cycling. At 1265 °C, devitrification takes place at a rate of 0.01 – 1.0 $\mu\text{m/h}$ .	The OH-content for all Ilmasil™ material grades is stable. After thermal treatment, a decrease in OH-content of 3 ppm maximum for clear fused quartz and 5 ppm maximum for opaque fused quartz is obtainable by tempering at 1000 °C under vacuum for a period of 30 hours.

# Clear fused quartz for lamps

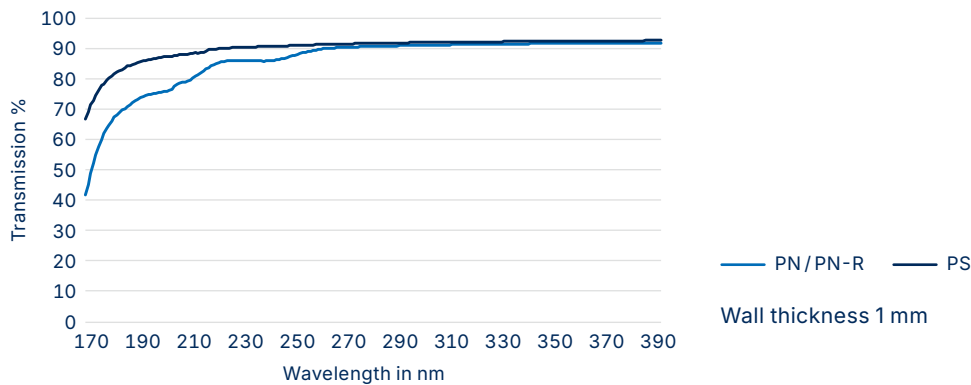
## Two-step technology

Ilmasil™ tubes are manufactured based on a two-step process: heavy-walled cylinders from the plasma fusion process are drawn into tubes from a vertical drawing tower. The cylinders are heated to 2000 °C with the highly viscous fused quartz flowing into the drawing unit that pulls the material down in order to create the tube. This tool-free process provides excellent surface quality and reduces contamination to a minimum. This technology also provides a high degree of flexibility and allows us to easily respond to customer requirements for both specialized sizes and quantities.

## Undoped material

Material grade	Properties	Typical OH-content in ppm	Applications
Ilmasil™ PN	Undoped standard material	30	Low and medium pressure lamps for disinfection and curing, infrared lamps
Ilmasil™ PN-R	Undoped material with reduced OH-content	15	Low and medium pressure lamps for disinfection and curing, infrared lamps
Ilmasil™ PS	Undoped material with high UV-transmission @ 185 nm	10	UV-lamps for ultra pure water disinfection, ozone generation, surface cleaning

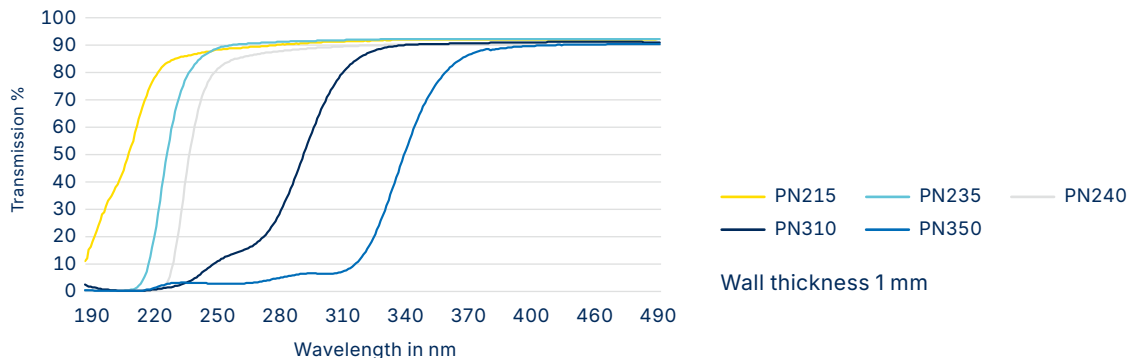
## Transmission UV-range Ilmasil™ PN / PN-R and PS



## Doped material

Material grade	Properties	Typical OH-content in ppm	Applications
Ilmasil™ PN 215 Ilmasil™ PN 235 Ilmasil™ PN 240	Titanium doped materials: eliminate the UV transmission below 200 nm and prevents the formation of ozone when 185 nm wavelength strikes oxygen	35	Ozone-free low and medium pressure lamps for germicidal, reprography, sun tanning
Ilmasil™ PN 310	Vanadium doped material: appears in a blue color	35	Medium pressure lamps for curing and cosmetic applications
Ilmasil™ PN 350	Cerium doped material: is effective in applications where UV radiation is a concern	35	Lamps with reduced UV radiation, sleeve, laser lamps

## Transmission of Ilmasil™ PN 215 / 235 / 240 / 310 / 350



# Fused quartz cylinders (billets)

Heavy-walled 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. Ilmasil™ billets have been certified by leading OEMs for the manufacturing of components for semiconductor applications:

- Wafer carrier parts for etching processes
- Flanges for process tubes
- Components for ring boats

## Clear fused quartz billets

Ilmasil™ clear fused quartz is available in natural fused and synthetic fused quartz grades. All grades are available in custom made near net shapes for ring and flange applications. SCHOTT Quartz Glass' production process of clear fused quartz billets allows a brilliant range of rapid prototyping as well as a high-volume production for mass production. The main usage of Ilmasil™ clear fused quartz billets are rings and flanges for single wafer as well as flanges for batch applications.

### Available sizes in Ilmasil™ PN / Ilmasil™ PI / Ilmasil™ PL / Ilmasil™ PQ

Outer diameter (mm)	Maximum inner diameter (mm)	Minimum inner diameter (mm)
Tolerance: +10/-0	Tolerance: +0/-10	Tolerance: +0/-10
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 µm). 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 / Ilmasil™ PO-2

Outer diameter (mm)	Maximum inner diameter (mm)	Minimum inner diameter (mm)
Tolerance: +10/- 0	Tolerance: +0/- 20	Tolerance: +0/- 20
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

## Thermal reflow

SCHOTT Quartz Glass is able to produce opaque heavy-walled cylinders up to 800 mm outer diameter via thermal reflow. The resulting length of the reflowed material depends on the final size requirements (OD/ID).

# Opaque fused blocks/plates

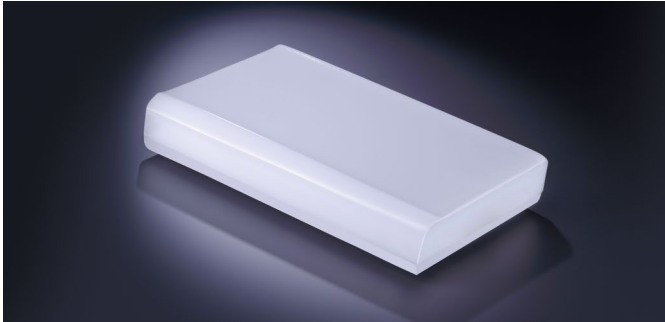
Blocks, plates and discs are available in a wide range of sizes with cut, ground or polished surface

## Plates

- 1000 x 700 x 65 mm
- 400 x 350 x 70 mm
- Near net shape upon request

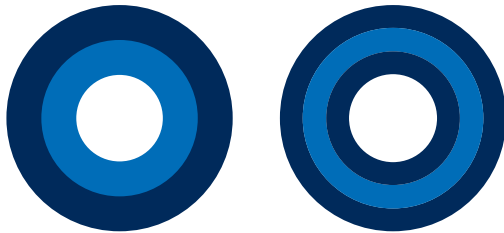
## Ingots

- DIA 300 mm
- DIA 350 mm
- Other diameters upon request



# Multi-layer concept of heavy-walled cylinders, flanges and rings

## Layout examples



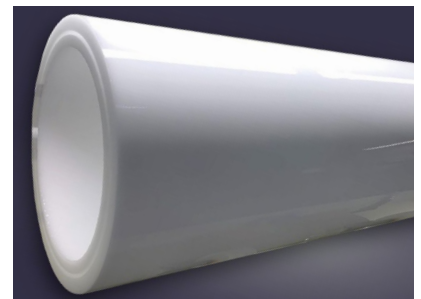
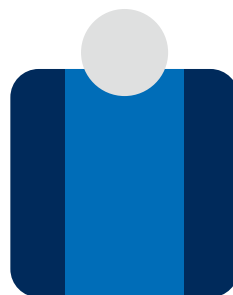
■ Clear ■ Opaque or doped

## Advantages of multi-layer cylinder

- Customized layer configuration.
- Customized wall thickness.
- Solid interface between clear and opaque.
- Excellent chemical resistance.
- Excellent thermal performance.

## Benefits of combination opaque/clear/opaque

- Tight sealing between O-ring and clear fused quartz.
- Clear fused quartz in this area ensures excellent sealing.
- Opaque layers provide IR blocking and thermal properties.
- Longer lifetime due to higher etch resistance of clear fused quartz at the O-Ring seal compared to opaque fused quartz.
- Option for smaller chamfers at the clear fused area.



■ O-Ring ■ Clear ■ Opaque

# Fused quartz tubing

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 (mm)	Tolerance (mm)	Wall thickness range		
		Minimum (mm)		Maximum (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.

# Capillary, Rods, Twin-Tubes

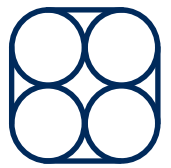
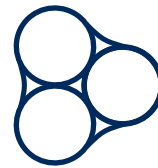
## Capillary

Due to our high precision capillary drawing tower, we are able to offer clear quartz capillaries in most geometric sizes, maintaining tight tolerances.

### Available sizes

Outer diameter (mm)	Minimum wall thickness (mm)	Minimum inner diameter (mm)
0.5...1	0.1	0.1
> 1...2	0.1	0.15
> 2...3	0.1	0.25
> 3...6	0.2	0.3
> 6...7	0.3	0.5
> 7...8	0.3	0.6
> 8...9	0.3	2.0
> 9...10	0.4	2.0

Multi-hole capillaries with 2, 3, 4 and more holes – Inner diameter range 0.4 mm to 2 mm.\*



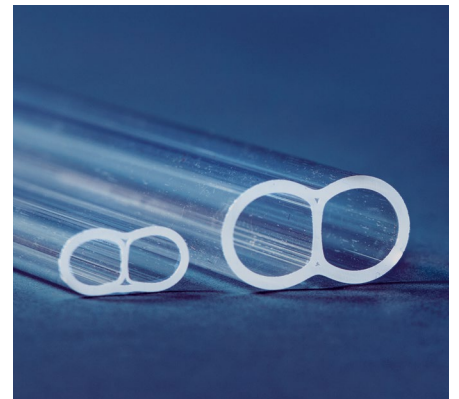
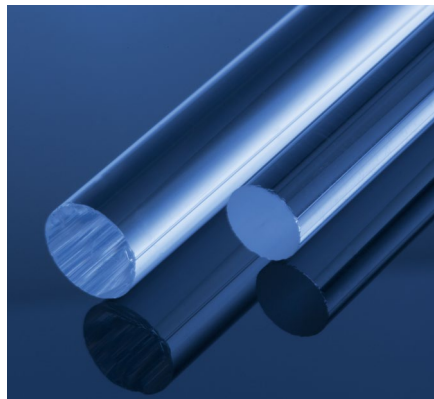
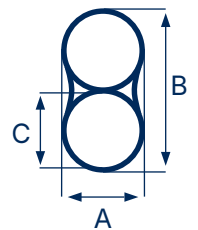
## Welding Rods

Diameter range up to 5 mm.

## Twin-Tubes

Twin Tubes for medium and shortwave infrared heaters are available in Ilmasil™ PN grade. Gold coatings are available.\*

A x B (mm)	C (mm)
8.5 x 17	>5
11 x 22	>7
15 x 30	>10



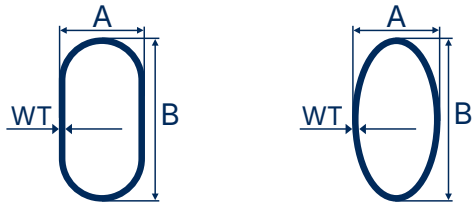
\* Other sizes, tolerances and material grades are available upon request.

# Flat and oval tubing

Flat and oval tubes are available in all Ilmasil™ clear fused quartz grades.

## Production range

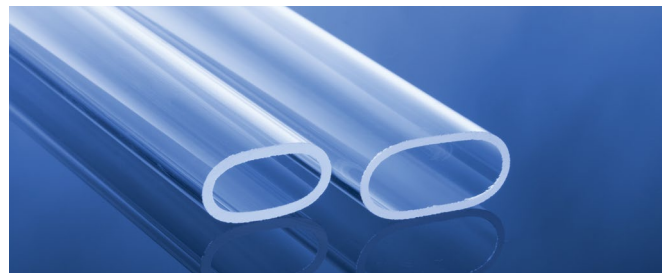
A (mm)	B (mm)	Flat tubes maximum relation B/A	Oval tubes maximum relation B/A
4...15	5...33	2.2	2.0



## Standard sizes

Outer diameter A x B (mm)	Wall thickness range WT (mm)
8 x 16	1.0 to 2.0 ( $\pm 0.2$ )
10 x 20	1.0 to 2.0 ( $\pm 0.2$ )
13 x 29	1.0 to 2.0 ( $\pm 0.2$ )
15 x 33	1.0 to 2.0 ( $\pm 0.2$ )

Other sizes and tolerances are available upon request.

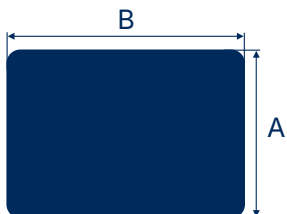


## Profiles and bends

Profiles and bends are available in Ilmasil™ PN grade, manufactured in a tool-free drawing process.

## Production range

$1 \text{ mm} \leq A, B \leq 20 \text{ mm}$  and  $1.0 \leq B/A \leq 10$   
Other sizes are available upon request.



## Examples



# LD-Clear fused quartz tubing

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

Outer diameter (mm)	Wall thickness range		
	Minimum (mm)		Maximum (mm)
50...59	1.5	to	7.0
60...69	2.0	to	7.0
70...79	2.5	to	7.0
80...99	2.5	to	8.0
100...119	2.5	to	10.0
120...149	3.0	to	10.0
150...179	3.5	to	12.0
180...209	4.0	to	12.0
210...299	4.0	to	10.0
300...799	4.0	to	8.0
800...1000	5.0	to	7.0

## Enhanced stability of thermal applications

LD-tubes may be doped on the outer surface with a thin layer of  $\text{Al}_2\text{O}_3$ . 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

- Combustion tubes
- Pressure and vacuum vessels
- Coils
- Laboratory ware



# Components

## 1. Standard taper joints as per DIN 12249 inner and outer joint



5/13	29/32
7/16	34/35
10/19	45/40
12/21	60/46
14/23	71/51
19/26	85/55
24/29	

## 2. Spherical joints as per DIN 12264 ball and socket



S 13
S 19
S 29
S 40
S 51
S 64

## 3. Stopcocks as per DIN 12542 and 12554



Size
2
3
4
6
10

## 4. Iso vacuum flanges



Size
NW 10
NW 16
NW 25
NW 40
NW 50

## 5. GL threaded tubes



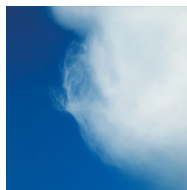
Size
GL 14
GL 18
GL 25
GL 32
GL 45

## 6. Filter discs



Diameter 10 – 120

## 7. Quartz wool



Fiber thickness 9 µm

### ISO 4793-80 International Standard

pore classes		pore size (µm)
Por. 0	P 250	160 – 250
Por. 1	P 160	100 – 160
Por. 2	P 100	40 – 100
Por. 3	P 40	16 – 40

Other pore sizes available on request.

# Handling – Cleaning – Storage

Fused quartz requires care in handling and use to achieve good performance.

Cleanliness will help reduce devitrification and maximize the life of this material. Handle quartz with care to avoid contamination.

## Handling

Handle fused quartz only with clean cotton gloves.

## Cleaning recommendation

1. Clean fused quartz product with non-alkali cleaning agent. Fingerprints can be wiped off with isopropyl alcohol.
2. Acid wash: 5% by wt. hydrofluoric acid (HF) for 2–3 minutes or in a 7% by wt. solution of Ammonium Bifluoride for no more than 10 minutes.
3. Rinse in deionized (distilled) water.
4. Hot air dry.

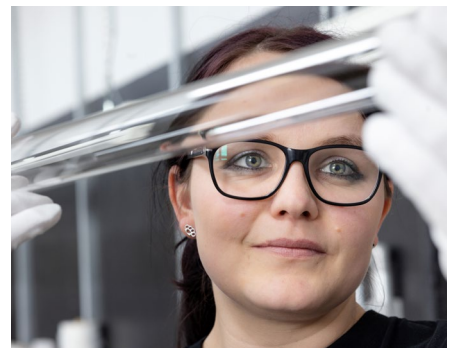
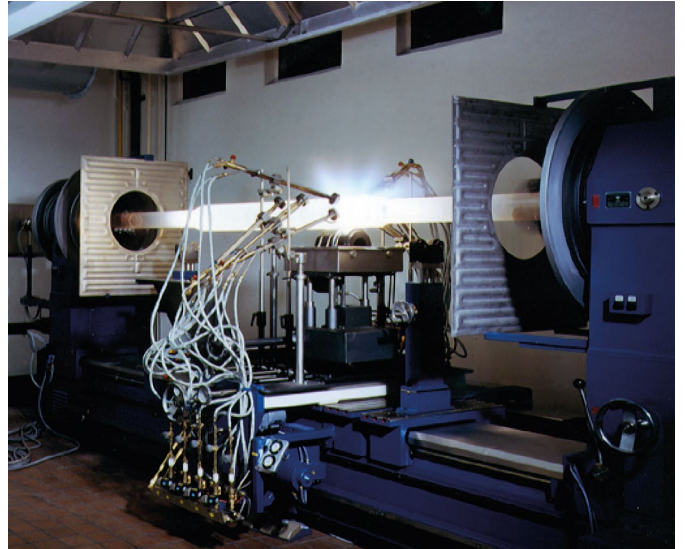
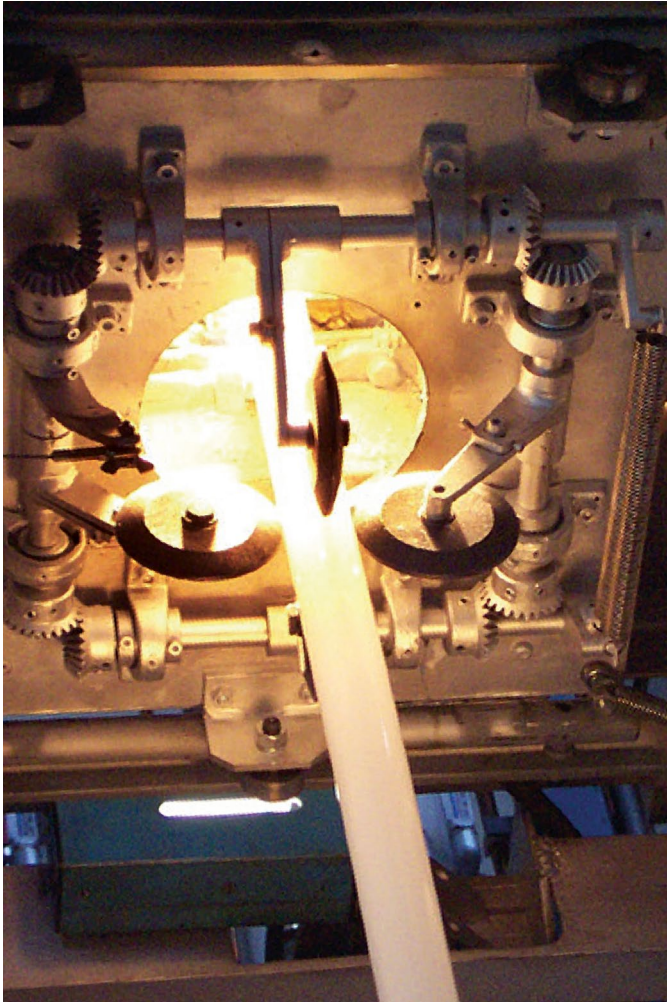
## Storage

Fused quartz products should be stored in its original shipping container. In the case of tubing, the end coverings should be kept in place until the product is used. This protects the ends from chipping and keeps out dirt and moisture, which could compromise the purity and performance of the tubing.

# Technology

SCHOTT Quartz Glass' proprietary technology uses a unique plasma-based fusion process that produces both clear and opaque hollow cylinders (billets) in a single melting step. In a second production step hollow cylinders are drawn into tubing using a vertical drawing tower.

This two-stage technology enables SCHOTT Quartz Glass to manufacture tubes 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.



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