Heraeus

**Basic Materials
Division**

Tomorrow's innovations
spring from 100 years
of experience

Heraeus Quarzglas

Heraeus Quarzglas
A Brief History

Heraeus

Heraeus is a family-held group of companies founded in 1851 with operations all over the world. The 150-year history of success has been marked by innovation and technological breakthroughs.

Wilhelm Carl Heraeus developed the first large-scale platinum melting process and founded the first German platinum smelter. In 1899 the Heraeus company succeeded in fusing rock crystal into a high grade vitreous silica or "quartz glass" using a high temperature oxygen/hydrogen flame. This technology formed the cornerstone of Heraeus Quarzglas.

Heraeus Quarzglas - Hanau / Germany

Heraeus Quarzglas Basic Materials Division - Kleinostheim / Germany

affiliates in the USA and Japan. Production capacities in the basic material division have been greatly expanded worldwide. This reflects a commitment to the ever-increasing demand for quartz glass products in high-tech industries.

Responsiveness and flexibility are the trademarks of Heraeus Quarzglas. Anticipation of the constantly changing demands and expectations of customers is essential. The continuous pursuit of zero defects, controlled processes and improved product reliability is a fundamental aspect of business at Heraeus Quarzglas.

Heraeus Quarzglas

Today Heraeus Quarzglas is a technological and market leader in the production and processing of high-purity quartz glass with the experience of one century.

A number of unique optical, mechanical and thermal properties have made quartz glass an indispensable material in the fabrication of high-tech products.

Heraeus Quarzglas supplies a great variety of industries including semiconductor, fiber optic and chemical processing with a wide range of products made of natural or synthetic raw material.
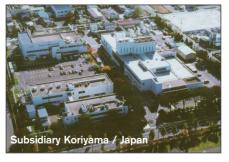
Basic Materials Division

The basic materials division of Heraeus Quarzglas produces and supplies semi-finished quartz glass products. The organization is headed in Kleinostheim (Germany) with subsidiaries and

Subsidiary Buford / USA

Subsidiary Koriyama / Japan

By focusing on customer satisfaction via both experience and technical innovation, Heraeus Quarzglas strives to be a 'company of excellence' emphasizing research and development with great appeal for highly qualified and motivated employees.

Fused Quartz and Fused Silica

Fused quartz and silica are among the most valuable materials available to industry and science.

Semi-finished products made of fused quartz or fused silica possess a unique range of properties:

- High purity level
- Low OH Content
- High homogeneity
- Low thermal expansion
- High chemical resistance
- Excellent thermal shock resistance
- Low dielectric losses
- Low bubble content
- High optical transmission in the IR & UV domain
- Low thermal conductivity
- High use temperatures

Originally the term "fused quartz" was used for transparent quartz glass products manufactured from quartz crystals. "Fused silica" was the name for opaque quartz ware produced from fused sand.

The distinguishing feature today is the derivation of the raw material and not the appearance of the finished product.

- The raw materials for fused quartz - both transparent and opaque - are quartz crystal or quartz sand of natural origin.
- Synthetic fused silica refers to quartz glass prepared from synthetic chemical precursors.

Manufacturing Process

There are three different processes for manufacturing quartz glass:

- Electric Fusion
- Flame Fusion
- Soot Process

Electric Fusion
is the most commonly used melting process for manufacturing quartz glass. Two different methods of electric fusion can be used: continuous and batch (boule) fusion.
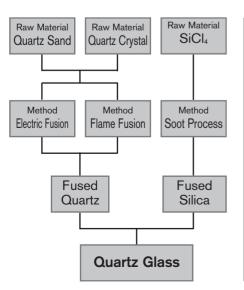
In the continuous method, quartz sand is poured into the top of a vertical melter which consists of a refractory metal crucible surrounded by electric heating elements. The interior of the crucible is maintained in a neutral or slightly reducing atmosphere that keeps the silica from reacting with the refractory metal. The melted material exits the bottom orifice of the crucible which is shaped to produce rods, tubes, plates or other products of various dimensions.

In the batch fusion method, a large quantity of raw material is placed inside a refractory lined vacuum chamber which also contains graphite heating elements. Although this method has historically been used to produce large single boules of material, it can also be adapted to produce much smaller, near-net shapes.
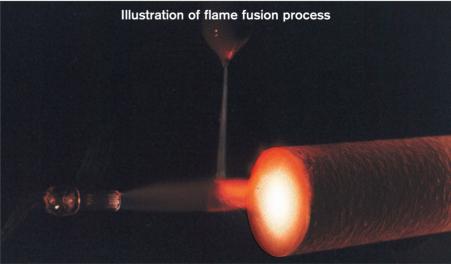
Flame Fusion
was originally known as the Verneuille process.

Heraeus chemist Richard Küch first began fusing quartz rock crystal in an hydrogen/oxygen (H_2/O_2) flame more than 100 years ago. Heraeus has been producing quartz glass on an industrial scale with this process ever since.

The basic process consists of trickling high purity silica sand (made of crushed quartz crystal or natural quartz sand) at a controlled rate into a high temperature H_2/O_2-flame. There it melts and collects on a bait rod that is slowly withdrawn from the flame thus forming a solid round ingot. This ingot can then be shaped into any desired dimension.
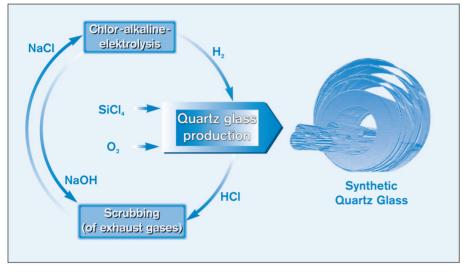
Raw Material Quartz Sand	Raw Material Quartz Crystal	Raw Material SiCl₄
Method Electric Fusion	Method Flame Fusion	Method Soot Process
Fused Quartz		Fused Silica
	Quartz Glass	

Illustration of flame fusion process

Fused Quartz and Fused Silica
Physical Chemistry

Synthetic Fused Silica

is produced by the oxidation/hydrolysis of silicon tetrachloride (SiCl$_4$) vapor in an H$_2$/O$_2$ flame. This process is called the soot process.

$$SiCl_4 \xrightarrow{\;H_2\,/\,O_2\;} SiO_2 + 4HCl$$

Because silicon tetrachloride is a synthetic chemical with exceptional starting purity, alkali and metal contamination in the final product is reduced to ppb levels. To put this in perspective, one part per billion is equivalent to a 40 mm section of the earth´s equator (total length > 40,000 km).

Physical Chemistry

At first glance, quartz glass appears very simple, both chemically and structurally, since it is made from a single oxide component (silicon dioxide – SiO$_2$).

Crystalline SiO$_2$ structure

Silica, as it is also known, is found throughout the earth's crust. However, only a small fraction has sufficient purity (> 99.98 %) to be suitable as raw material for quartz glass.
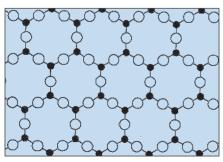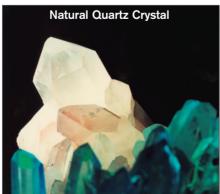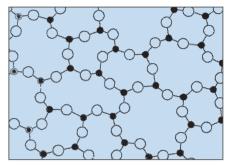
The generalized atomic structure consists of tetrahedral (four-faced) units constructed of four oxygen atoms surrounding a central silicon atom. These tetrahedra link together at the corners to form a three-dimensional network.

Their relative arrangement is very disordered compared to that of crystalline quartz which is melted to form quartz glass. This is what gives the material its glassy nature, which accounts for its melting behavior and formability. Quartz crystal on the other hand cannot withstand being heated more than a few hundred

Natural Quartz Crystal

degrees. This is because abrupt changes occur in the crystal structure and results in cracking. However, the glassy form of silica (fused quartz) stands up to the most extreme temperature shocks.

Glassy SiO$_2$ structure

Note that the structure is completely connected: meaning that all atoms are bonded to at least two others.

This connectivity together with the strength of the silicon-oxygen (Si-O) chemical bond gives quartz glass its high temperature stability and chemical resistance. Note also that the structure is rather open with wide spaces (interstices) between the structural units. This accounts for the higher gas permeability and much lower thermal expansion coefficient of quartz glass relative to other materials.

Quartz Glass

This is because the open spaces, besides allowing gas molecules to diffuse more easily, gives the structure room to expand as its atoms become excited by increasing temperature and oscillate with greater amplitude about their positions.

Chemical Purity

Despite existing at very low levels, contaminants have subtle yet significant effects. Purity is mostly determined by the raw material, the manufacturing method and subsequent handling procedures. Special precautions must be taken at all stages of manufacture to maintain high purity.

The most common impurities are metals (such as Al, Na and Fe among others), water (present as OH groups) and chlorine. These contaminants not only affect the viscosity, optical absorption and electrical properties of the quartz glass; they can also influence the properties of material processed in contact with the quartz glass during the final use application.

The purities of fused quartz and fused silica are outstandingly high. Synthetic fused silica from Heraeus contains total metallic contamination below 1 ppm. For fused quartz the amount is approximately 20 ppm and consists primarily of Al_2O_3 with much smaller amounts of alkalis, Fe_2O_3, TiO_2, MgO and ZrO_2.

Metallic impurities come mostly from natural quartz. Very carefully controlled processes are used to greatly reduce impurities in raw material from 200 ppm to less than 20 ppm (SiO_2-purity of 99.998%).

Aluminum is the most prevalent and little can be done to reduce it beyond the level present in the raw sand. This is because aluminum bonds directly into the quartz glass structure through direct substitution for silicon. Thus it has very low mobility even at high temperature which makes it almost impossible to remove. However, this also prevents migration to materials being processed in contact with the quartz glass (such as semiconductors).

A small amount of aluminum is actually beneficial because it increases quartz glass viscosity, thus raising the maximum use temperature.

Hydroxyl Content

In addition to metallic impurities, fused quartz and fused silica also contain water present as OH units. The approximate values are given in the following table.

Hydroxyl is present in amounts determined by the level of moisture to which the silica is exposed during the forming process. The presence of hydroxyl results in lower viscosity and optical absorption bands in the mid-IR.

Electrically fused quartz has the lowest hydroxyl content (0 - 30 ppm) since it is normally made in vacuum or a dry atmosphere. Hydroxyl content in this range is not fixed in the glass structure. It can go up or down depending on the thermal treatment and amount of moisture to which the quartz glass is exposed at elevated temperature.

Flame fused quartz has significantly more hydroxyl (150 - 200 ppm) since fusion occurs in a hydrogen/oxygen flame.

Typical Trace Elements and OH Content in Quartz Glass (ppm by weight oxide)

Elements	Al	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ti	Zr	OH Content
CFQ 099	15	0.8	< 0.05	< 0.1	0.4	0.8	1.2	0.1	0.1	0.9	1.5	0.8	n.s.*
HSQ 100	15	0.5	< 0.05	< 0.05	0.1	0.4	0.6	0.05	< 0.05	0.3	1.1	0.7	< 30 [1) 2)]
HSQ 300 [3)]	15	0.5	< 0.05	< 0.05	0.1	0.4	0.6	0.05	< 0.05	0.3	1.1	0.7	< 30 [2)]
HSQ 700 [3)]	15	0.5	< 0.05	< 0.05	0.1	0.1	0.05	0.05	< 0.05	0.05	1.1	0.7	< 30 [2)]
HSQ 351 [3)]	15	0.6	< 0.05	0.07	0.2	0.7	0.4	0.1	0.05	0.8	1.1	1.1	175
HSQ 751 [3)]	8	0.5	< 0.05	< 0.06	0.2	< 0.1	0.2	< 0.05	0.05	< 0.05	1.4	0.1	175
HSQ 900 [4)]	< 0.04	< 0.02	< 0.001	< 0.001	< 0.03	< 0.01	< 0.002	< 0.01	< 0.0005	< 0.01	< 0.03	< 0.04	0.2
HSQ 910 [5)]	< 0.04	< 0.02	< 0.001	< 0.001	< 0.03	< 0.01	< 0.002	< 0.01	< 0.0005	< 0.01	< 0.03	< 0.04	250
OM 100	15	1.2	< 0.01	< 0.05	0.2	0.4	0.6	0.05	< 0.03	0.2	1.2	0.8	n.s.*

1) For HSQ 100 rods. OH content of other HSQ 100 semi-finished products on request. *n.s.: not specified

2) The OH Content of HSQ 100, HSQ 300 and HSQ 700 is below 30 ppm. This can be further reduced to below 5 ppm by heat treatment under the right conditions.

3) Tubes made of these materials can be stabilized with a special surface treatment. The outer surface is doped with a nucleating agent to a depth of up to 20 µm.

4) Cl Content: 1500 ppm 5) Cl Content: < 50 ppm

Fused Quartz and Fused Silica
Chemical Behavior / Mechanical Properties

Synthetic quartz prepared by flame hydrolysis of silicon tetrachloride can have high (> 1000 ppm) or very low hydroxyl content depending on whether a hot chlorination step is employed to remove it. The hydroxyl level can be so high because the silica particles that result from the hydrolysis reaction are extremely fine and therefore have tremendous surface area capable of absorbing moisture present in the flame.

Hot chlorination treatment will remove the hydroxyl but results in some residual chlorine in the material. Chlorine behaves much like hydroxyl in that it reduces viscosity by terminating the bridging oxygen bonds that connect the quartz glass structure together.

The main attributes of electrically fused materials are the low hydroxyl content and reduced devitrification rates.

The low hydroxyl content increases infrared transparency and viscosity. The higher viscosity results in an increased maximum use temperature as well as helping to inhibit devitrification. Devitrification is also restrained by the neutral / reducing atmosphere used during melting. This causes the material to be slightly oxygen deficient, which helps to restrain devitrification.

Chemical Behavior of Various Elements and Compounds

Fused quartz is outstandingly resistant to water, salt solutions and acids. It is only attacked by hydrofluoric and phosphoric acid. Metals which are free from oxide, with the exception of alkalis and alkaline-earths, do not react with fused quartz or fused silica.

Quartz glass is sensitive to all alkali and alkaline-earth compounds because even slight traces of them hasten devitrification at high temperatures. It is always advisable to remove fingerprints, which contain traces of alkalis, from quartz glass with alcohol before heating.

The symbols used in the table have the following significance:

○ The element or compound does not react with fused quartz or fused silica

◔ It reacts only above the indicated temperature

◑ Only the melt of the compound reacts with fused quartz or fused silica

● The element or compound reacts with fused quartz or fused silica

Elements

○	Ag	
◔	Al	from 700 to 800 °C rapid reaction
○	Au	
○	Br	
◔	C	only above 1500 °C
◔	Ca	only above 600 °C
○	Cd	
◔	Ce	only above 800 °C
○	Cl	also with heat and humidity no reaction
●	F	only in humid state
○	Hg	
○	J	
●	Li	only above 250 °C
◔	Mg	from 700 to 800 °C rapid reaction
○	Mn	
○	Mo	
○	Na	reacts only in vapor state
●	P	
○	Pb	
○	Pt	
◔	S	above 1000 °C very weak reaction
◑	Si	
○	Sn	
○	Ti	
○	W	
○	Zn	

Acids

○	H_2SO_4	
○	HNO_3	
○	HCl	
●	HF	but weaker than with ordinary glass
●	H_3PO_4	but weaker than with ordinary glass
○	Organic acids	

Gases and Vapors

○	HCl	
○	H_2; N_2; O_2	
○	NO_2; SO_2	
○	CO	

Oxides

◔	Al_2O_3	only above 1200 °C
◔	BaO	only above 900 °C
◔	CaO	only above 1000 °C
◔	CuO	only above 950 °C
◔	Fe-oxides	only above 950 °C
◔	MgO	only above 950 °C
◑	PbO	
◔	ZnO	only above 800 °C
◔	Basic oxides	only above 800 °C acceleration of divitrification

Salts

◑	$BaCl_2$	
◔	$BaSO_4$	only above 700 °C
◑	Borate	
◔	BCl_3	only above 900 °C
◑	KCl	promotes devitrification
◑	KF	
◑	NaCl	
●	Na-metaphosphate	
●	Na-polyphosphate	
○	Na_2SO_4	
●	Na-tungstate	promotes devitrification
◑	Nitrate	
◔	Pt-ammoniumchloride	only above 900 °C
◑	$ZnCl_2$	
◔	Zn-phosphate	slight at 200 °C considerable at 1000 °C
◔	Zn-silicate	only above 1000 °C

Mechanical Properties
Strength and Reliability

The theoretical tensile strength of silica glass is greater than 1 million psi. Unfortunately, the strength observed in practice is always far below this value. The reason is that the practical strength of glass is extrinsically determined rather than being solely a result of chemistry and atomic structure as is an intrinsic property like density. It is the presence of surface flaws that concentrates stress coupled with the chemical effects of atmosphere (water vapor in particular) plus design considerations that ultimately control the strength and reliability of a finished piece of quartz glass. Because of this stress concentration effect, failure most always occurs in tension rather than compression.

In other words: mechanical reliability is proportional to the chance of finding a flaw that will cause failure under the operating conditions.
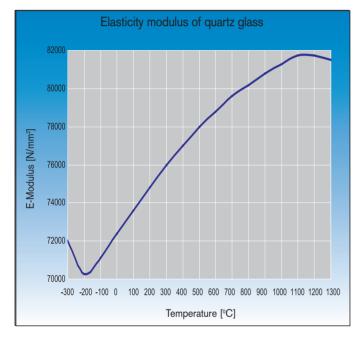
This could also be stated as the probability that the piece will experience a mechanical stress greater than the strength of any existing flaws. As a result of this dependence on probability, reliability decreases as the size of the glass article increases. Similarly, if the number of pieces in service increases, so does the chance of experiencing a failure.
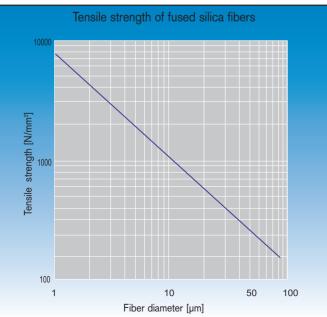
Surface condition is very important. For example, machined surfaces tend to be weaker than fire polished ones. Also, older surfaces are usually weaker than younger ones due to exposure to dust, moisture or general wear and tear. These factors have to be considered thoroughly when comparing the strengths of different „brands" of quartz glass.
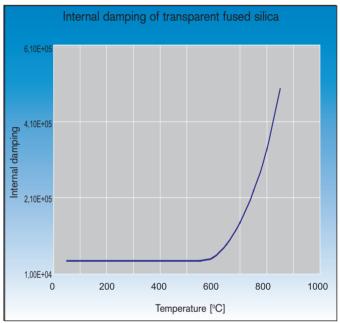
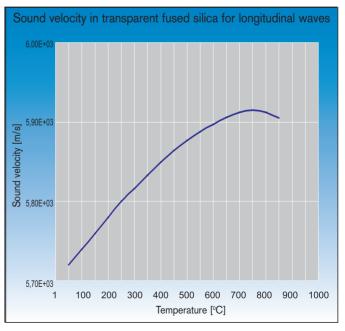| Technical Properties		Electrically Fused Quartz	Flame Fused Quartz	Fused Silica
Mechanical Data				
Density	g/cm³	2.203	2.203	2.201
Mohs Hardness		5.5 ... 6.5	5.5 ... 6.5	5.5 ... 6.5
Micro Hardness	N/mm²	8600 ... 9800	8600 ... 9800	8600 ... 9800
Knoop Hardness	N/mm²	5800 ... 6100	5800 ... 6100	5800 ... 6200
Modulus of elasticitiy (at 20°C)	N/mm²	7.25×10^4	7.25×10^4	7.0×10^4
Modulus of torsion	N/mm²	3.0×10^4	3.1×10^4	3.0×10^4
Poisson´s ratio		0.17	0.17	0.17
Compressive strength (approx.)	N/mm²	1150	1150	1150
Tensile strength (approx.)	N/mm²	50	50	50
Bending strength (approx.)	N/mm²	67	67	67
Torsional strength (approx.)	N/mm²	30	30	30
Sound velocity	m/s	5720	5720	5720
Thermal Data				
Softening temperature	°C	1710	1660	1600
Annealing temperature	°C	1220	1160	1100
Strain temperature	°C	1125	1070	1000
Max. working temperature continuous	°C	1160	1110	950
short-term	°C	1300	1250	1200
Mean specific heat	0...100 °C	772	772	772
J/kg·K	0...500 °C	964	964	964
	0...900 °C	1052	1052	1052
Heat conductivity	20 °C	1.38	1.38	1.38
W/m·K	100 °C	1.47	1.47	1.46
	200 °C	1.55	1.55	1.55
	300 °C	1.67	1.67	1.67
	400 °C	1.84	1.84	1.84
	950 °C	2.68	2.68	2.68
Mean expansion	0...100 °C	5.1×10^{-7}	5.1×10^{-7}	5.1×10^{-7}
coefficient	0...200 °C	5.8×10^{-7}	5.8×10^{-7}	5.8×10^{-7}
K^{-1}	0...300 °C	5.9×10^{-7}	5.9×10^{-7}	5.9×10^{-7}
	0...600 °C	5.4×10^{-7}	5.4×10^{-7}	5.4×10^{-7}
	0...900 °C	4.8×10^{-7}	4.8×10^{-7}	4.8×10^{-7}
	-50...0 °C	2.7×10^{-7}	2.7×10^{-7}	2.7×10^{-7}

Fused Quartz and Fused Silica
Mechanical & Thermal Properties

This is because these tests in reality often turn out to be just comparisons of surface quality resulting from sample preparation, small differences in which easily overwhelm any differences in intrinsic strength.

Because of these considerations, it is important to realize that strength data taken from a small number of similar samples in a laboratory setting is usually not very useful in predicting the observed strength of a large and complex finished piece. Such tests usually give results for

tensile strength in the range of 30 to 60 kpsi but they generally do not test the same flaw size distribution that exists in practice. A very basic rule of thumb that seems to have been proven out in practice is that the design should be such that ordinary tensile stresses do not exceed 1000 psi.
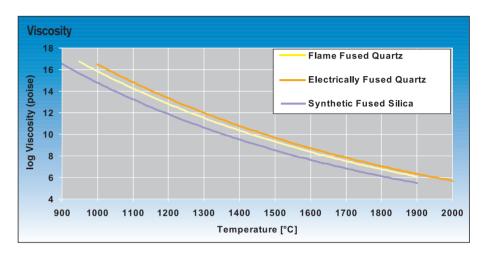

Elasticity modulus of quartz glass

Internal damping of transparent fused silica

Tensile strength of fused silica fibers

Sound velocity in transparent fused silica for longitudinal waves
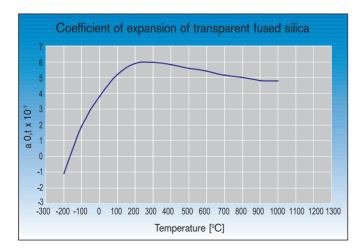
Thermal Properties

One of the most attractive features of quartz glass is its very low thermal coefficient of expansion (TCE). The average TCE value for quartz glass at about $5.0 \times 10^{-7}/°C$ is many times lower than that of other common materials. To put this in perspective, imagine if 1 m³ blocks of stainless steel, borosilicate glass and quartz glass were placed in a furnace and heated by 500°C. The volume of the stainless steel block would increase by more than 28 liters and that of the borosilicate block by 5 liters. The quartz block would expand by less than one liter. Such low expansion makes it possible for the material to withstand very severe thermal shock.
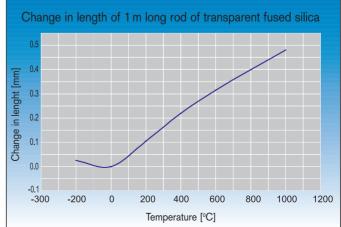
It is possible to rapidly quench thin articles of quartz glass from over 1000°C by plunging them into cold water without breakage. However, it is important to realize that the thermal shock resistance depends on factors other than TCE such as surface condition (which defines strength) and geometry. The various types of fused silica and fused quartz have nearly identical TCE's and thus can be joined together with no added risk of thermally induced breakage.

Viscosity

Viscosity

Somewhere above 1000°C, the time required for quartz glass to change its shape permanently in response to an applied load becomes compatible with the patience of someone trying to measure the deformation. At this temperature and above, the material exists as a super-cooled liquid. The term "super-cooled liquid" is sometimes used to describe quartz glass at lower temperatures but this is not strictly correct. Below 1000°C the material can be regarded as a true solid.

The viscosity has an exponential dependence on inverse temperature and thus decreases rapidly as temperature rises. Despite this fact, quartz glass at 1700°C is still quite thick, having a consistency similar to that of tar on a cold day. The viscosity is significantly affected by trace impurities. The hydroxyl (OH) content lowers the viscosity thus making the method of manufacture an important consideration for defining maximum use temperature. Alkalis and halogens such as sodium and chlorine lower viscosity while small amounts of aluminum and refractory metals like molybdenum increase viscosity.

Coefficient of expansion of transparent fused silica

Change in length of 1 m long rod of transparent fused silica

Fused Quartz and Fused Silica
Electrical & Optical Properties

Devitrification

The term "super-cooled liquid" refers to the fact that, at least from a thermodynamic equilibrium point of view, quartz glass should actually be a crystalline solid rather than a liquid. This fact is the key to understanding why quartz glass devitrifies. Although the thermodynamically preferred state of quartz glass is crystalline, the high viscosity prevents the structural rearrangement necessary to achieve it. In other words the molecules cannot arrange themselves quickly enough compared to the relatively fast rate of cooling that quartz glass normally experiences. However, under certain conditions this constraint can be removed resulting in the glass reverting to a crystalline state. This usually happens at elevated temperature in the presence of a contaminant that drops the viscosity by breaking up the highly connected silicon-oxygen network as well as acting as a nucleating source. Alkalis like sodium or potassium are the most common contaminants that cause devitrification.

Atmospheres high in water vapor or chlorine also exacerbate this process significantly. The growth of the devitrified layer usually starts on the surface and progresses into the material at a rate that depends exponentially on temperature. The crystalline material formed is a high temperature form of silica known as high cristobalite.

High cristobalite has nearly the same density as glassy silica and thus cannot be seen on the surface. However, upon cooling, high cristobalite undergoes a structural change from a cubic to a tetragonal crystal structure at about 275°C. This is accompanied by a large decrease in density that can result in some cracking and spalling. Refractive index differences resulting from the birefringent tetragonal crystal structure also cause the devitrified spots to turn white.

Electrical Properties

Fused quartz and silica are excellent electrical insulators. The large band gap inherent in the electronic structure of the silicon-oxygen bond results in electrical conduction being limited to current carried by mobile ionic impurities. Since the level of these impurities is very low, the electrical resistivity is correspondingly high.

Since ionic conduction is related to the diffusion coefficient of the ionic carriers, the resistivity also has a strong exponential temperature dependence. Hence, unlike typical conductors such as metals, the resistivity decreases with increasing temperature.

The dielectric constant of quartz glass has a value of about 4 which is significantly lower than that of other glasses. This value changes little over a wide range of frequencies. The reason for the low dielectric constant is, once again, the lack of highly charged mobile ions but it also results from the stiffness of the silicon-oxygen network which imparts a very low polarizability to the structure.
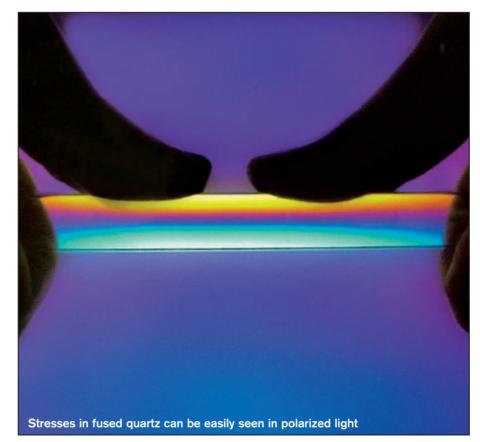
Devitrified Layer

Original Quartz Glass Layer

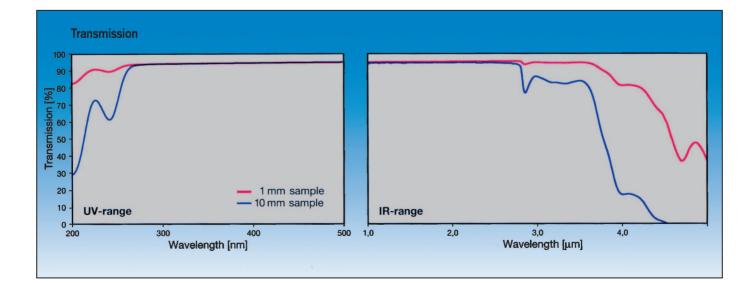| Electrical Data		Electrical Fused Quartz	Flame Fused Quartz	Fused Silica
Electrical resistivity in Ω x m				
20 °C		10^{16}	10^{16}	10^{16}
400 °C		10^{10}	10^{10}	10^{6}
800 °C		6.3×10^{6}	6.3×10^{6}	6.3×10^{4}
1200 °C		1.3×10^{5}	1.3×10^{5}	1.3×10^{3}
Dielectric strength in kV/mm (sample thickness $\geq$ 5 mm)				
20 °C		25 ... 40	25 ... 40	25 ... 40
500 °C		4 ... 5	4 ... 5	4 ... 5
Dielectric loss angle (tg δ)				
	1 kHz	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
	1 MHz	1.0×10^{-4}	1.0×10^{-4}	1.0×10^{-4}
	3×10^{10} Hz	4.0×10^{-4}	4.0×10^{-4}	4.0×10^{-4}
Dielectric constant (ε)				
20 °C	$0...10^{6}$ Hz	3.70	3.70	3.70
23 °C	9×10^{8} Hz	3.77	3.77	3.77
23 °C	3×10^{10} Hz	3.81	3.81	3.81

Optical Properties

The intrinsic UV and IR absorption edges in silica glass are located at roughly 3.5 and 0.180 microns wavelengths, respectively. The intrinsic UV absorption edge results from the onset of electronic transitions within the Si-O network at the point where the photon energy exceeds the network bandgap energy. The intrinsic IR edge arises due to lattice (multi-phonon) vibrations of the Si-O network.

Various overtones of the fundamental SiO_4 tetrahedron vibrational modes are the first to be observed. These intrinsic absorption edges are then further modified by the presence of impurities. Metallic impurities shift the UV edge to higher wavelengths. Water (OH) introduces absorption bands just below the IR edge. The strongest of these is the fundamental O-H stretching band at 2.73 microns.

The transmission versus wavelength spectrum for silica is shown in the figures below. The significant features of the curve are a broad transparent area centered over the visible part of the spectrum that extends partly into the infrared and ultraviolet regions.
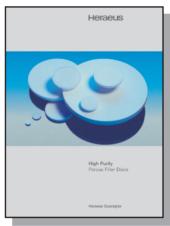

Stresses in fused quartz can be easily seen in polarized light

Transmission [%] — Wavelength [nm] — UV-range — 1 mm sample — 10 mm sample — IR-range — Wavelength [µm]

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HSQ 300 / HSQ 700
Electrically Fused
Quartz Glass

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HSQ 351 / HSQ 751
Flame Fused
Quartz Glass

Heraeus Quarzglas

HSQ 400
Stabilized
Electrically Fused
Quartz Glass

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High Purity
Porous Filter Discs

Heraeus Quarzglas

OM 100
High Purity
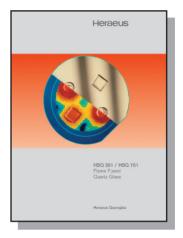Opaque Quartz Glass

Heraeus Quarzglas

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