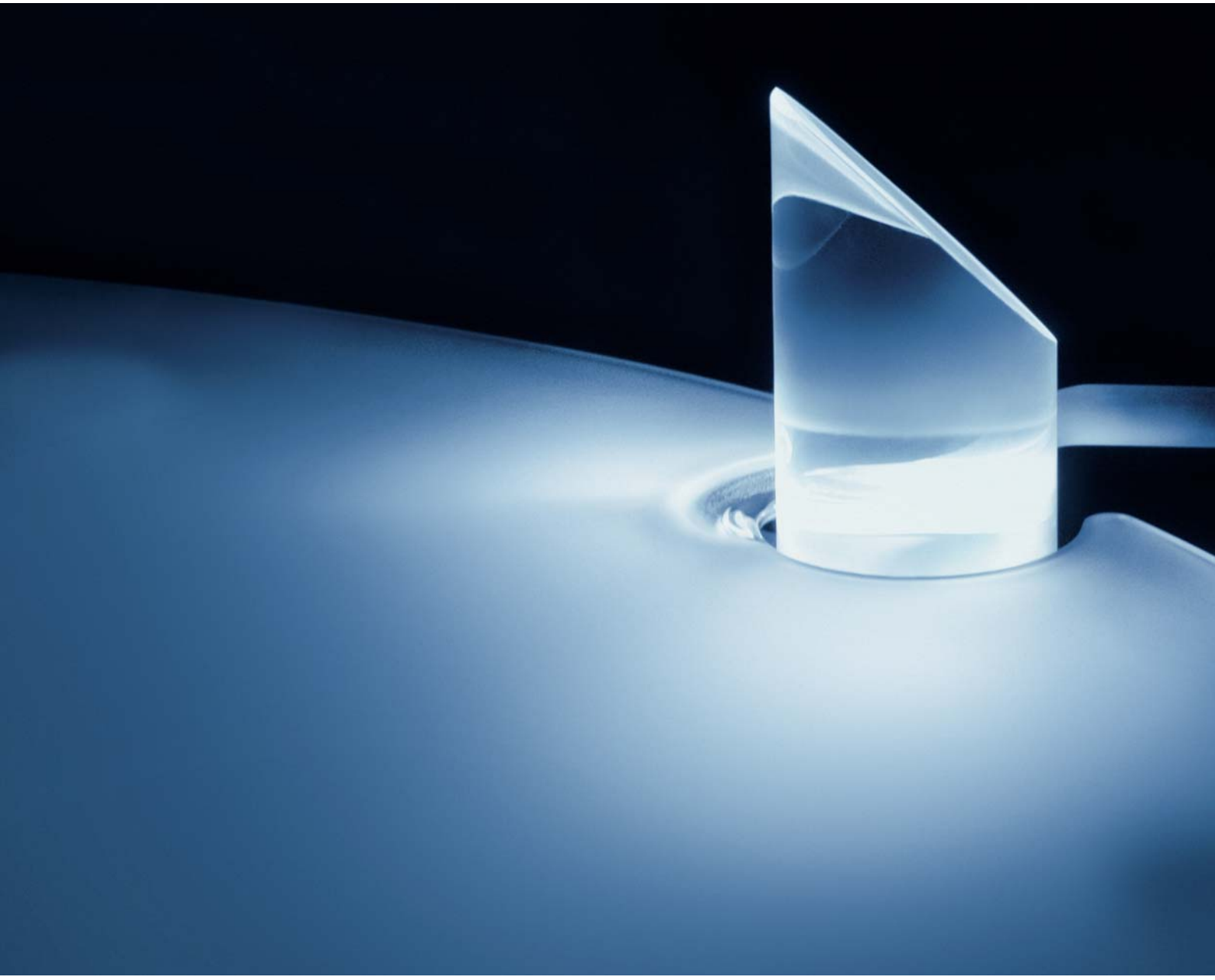
Heraeus



Heraeus Quarzglas

Tailored Solutions for Leading Industries

Quartz Glass –
Explore a Unique Material

For over 100 years, the manufacture and processing of high purity quartz glass is firmly linked to the name Heraeus Quarzglas. Having achieved the position of the world's largest quartz producer, Heraeus Quarzglas can draw on key production and processing technologies as well as innovative products. A standard range of over 5000 products proves its inventiveness and technological diversity. Every product is tailored to the relevant field of application. Heraeus Quarzglas has developed special, proprietary technologies to satisfy our customers' needs. We develop, produce and supply tailor-made solutions from base material to complex system components from one source.

Quartz glass is fascinating: at first glance transparent like normal glass, but capable of transmitting light from deep ultraviolet to far infrared, and 4 times as temperature resistant. Many of these properties are linked to innovative production processes. A low risk of contamination can be achieved by selective reduction of foreign ions, by generating an extremely homogeneous surface, or by synthesis of quartz glass out of highest purity precursors. The options for an application-oriented quartz glass manufacture are virtually unlimited. Heraeus Quarzglas offers competence, experience and advanced manufacturing technologies.

Purity – Light – Temperature

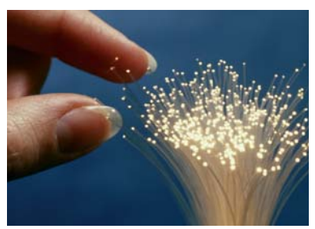
This brochure will give you an overview of the different quartz glass material grades we supply and their unique features. They are assigned to three main characteristics that are crucial for most applications: purity, light and temperature. There are many approaches to vary the profiles individually – by material combinations or processing. We would like to invite you to explore the capabilities of Heraeus Quarzglas.

This brochure will assist you to get an insight in how we can optimize quartz glass even for new applications.

Basic quartz glass features

An extremely small thermal expansion in connection with an outstanding elasticity ensures that quartz glass withstands extreme temperature differences, for example due to spontaneous cooling. High temperature stability up to 1300°C, low heat conductivity and an excellent transparency from ultraviolet to infrared spectral range complement the unique profile.

- chemical purity in the ppb range
- high transparency from UV to IR
- high chemical resistance
- low thermal expansion coefficient
- high temperature and temperature change resistance
- high radiation resistance



Deals with Highly Pure and Aggressive Media

In optimized production processes, highest quartz glass with a purity of 99.99999 % can be achieved.

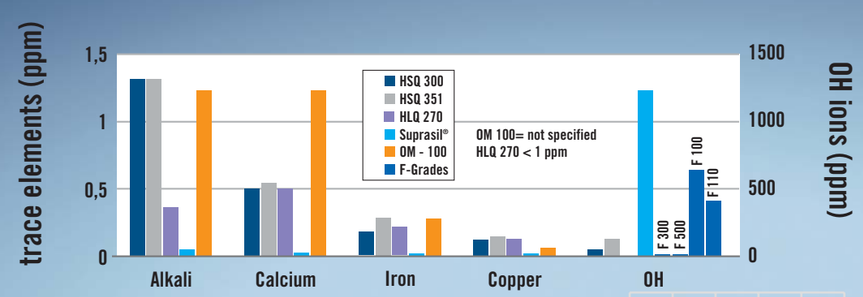
If quartz glass is exposed to environments where it is in contact with fluids and gases, purity and resistance are essential. Generally, impurities are to be strictly avoided. The quartz glass needs to exhibit an inert behaviour and must not spall even under extreme conditions. Typical examples are crucibles used for silicon monocrystal growth. Maximum purity and special coatings ensure that no impurities occur in the semiconductor material even at temperatures over 1300°C. But also for optical fibers it is inevitable to use only the highest purity synthetic fused silica to achieve state of the art attenuation values. Various approaches are available to achieve these features, depending on the requirements of the specific application.

Purity
Maximum purity levels are already influenced by the selection of the manufacturing process. The highest purity is achieved by our synthetic fused silica. Suprasil® and HSQ 900/910 are examples for quartz glass with trace impurities below the detection limit of ICP-MS*. In some applications, the absolute purity is of less importance than the low content of single trace elements. Heraeus Quarzglas offers a number of special materials, such as HSQ 700 or HLQ 270 with low alkali content. In some cases, high instead of extremely low trace element contents may increase the contamination safety or radiation stability. OH groups, for example act as diffusion stoppers and may heal radiation damages. Therefore flame-fused grades such as HSQ 351 and HSQ 751 reduce the contamination risk and high OH synthetic F100 is extremely resistant against UV radiation.

Surface
Special treatment methods of the quartz glass surface may clearly extend lifetime in aggressive environments. Grinding, sandblasting or fire-polishing are some of the standard processes. In addition, Heraeus Quarzglas offers further processes such as the special surface treatment which will optimize the surface to reduce particle generation and to simplify the deposition of layers.

Highest Purity – Content of typical trace elements

* ICP-MS measurement – inductively coupled plasma-mass spectroscopy



Doping
Although purity has to be ensured, doping can improve the strength of quartz glass. Starting from the application in plasma processes, the high resistance to aggressive media such as acids and bases is further increased. Furthermore doping can be used to adjust the refractive index of the material. Metals, chemical compounds, fluorine or hydrogen in the H_2 sintering process are used as dopants. The selection of the optimum process primarily depends on the required additional features of the quartz glass product.

Material	Features	Application Examples
HSQ familiy	Numerous grades with an optimized alkali and OH content depending on the manufacturing process (synthetic, electric, flame-fused)	Processes with varying high purity requirements from room temperature up to high temperatures such as for semiconductor processing, e. g. CVD tubes, diffusion furnaces, epitaxy chambers, etching systems
Suprasil®	Synthetic fused silica of highest purity	Optical applications with maximum purity and homogeneity requirements, e.g. prisms, optics for excimer lasers, microlithography etc.
HSQ 900	Quartz glass of highest purity	Applications in the semiconductor industry with high purity requirements
F 300, F 500	Synthetic fused silica of highest purity with very low OH content (<0.2 ppm / 0.02 ppm)	Optical fibers with lowest attenuation for the telecommunications industry
F 100, F 110	Synthetic fused silica of highest purity with increased OH content	Optical fibers for special applications in the UV range and radiation resistance
HLQ 170, HLQ 270	High purity (alkali content < 0.5 ppm), long lifetime by avoiding recrystallization	Beamer lamps and lamps for rear projection television
OM 100	Opaque quartz glass of high purity with micropores and hence a low conductivity	Numerous application possibilities as thermal insulator in semiconductor production plants, can be employed as a coating in combination with other quartz glass grades

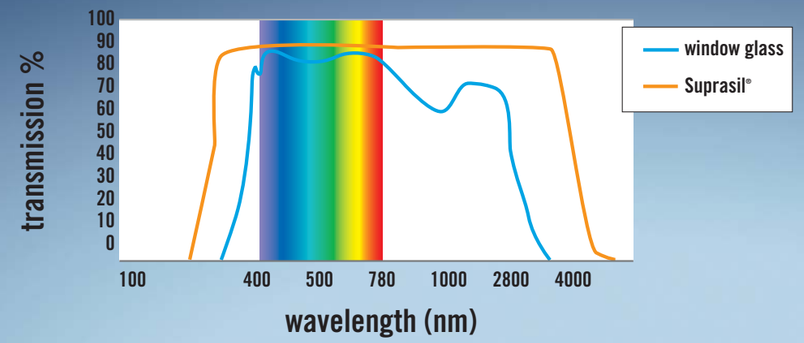
Depending on the application, intelligent process technologies enable transmission adjustment for individual frequency bands – in a range from 160 to 4000 nm!

The optical properties of quartz glass are unique: high transmission of UV up to IR characterizes the material. This is combined with an excellent ageing resistance even under the exposure to high-energy radiation. Working for more than a century with quartz glass is the basis for the well known expertise of Heraeus in processing this exceptional material. As a result, desired optical properties are specifically adjusted. From high transmission over the complete spectral range up to selective screening of certain frequency bands to highest optical homogeneity. The particularly broad range from the low UV up to the IR is achieved by intelligent, mature manufacturing processes. In many cases, other characteristics need to be combined with the optical properties: for example, the excellent temperature and radiation resistance for laser applications or the homogeneity and isotropy in precision lenses. Heraeus Quarzglas has developed special quartz glass grades for many applications, which have proven highly successful. They include material combinations that link significant optical or thermal characteristics in one product. This variety of technologies is the reason why we are able to extend our comprehensive product portfolio to offer tailor-made products.

Transmission
In the range from 160 to 4000 nm, Heraeus Quarzglas can individually adjust the light transparency. Highest, synthetic fused Suprasil® glasses offer maximum UV/IR transmission. Various quartz glass grades such as HLQ 235 and HLQ 382 open different spectral windows. Doping is an elegant process to specifically adjust transmission ranges and the refractive index of our materials. Foreign ions, such as titanium, cerium or vanadium allow a selective absorption of individual wavelength ranges. With Fluosil® we offer multi mode step index preforms where our highly pure synthetic fused silica is combined with a high fluorine doped quartz glass material.

Perfect Material for Optics, Lamps and Optical Fibers

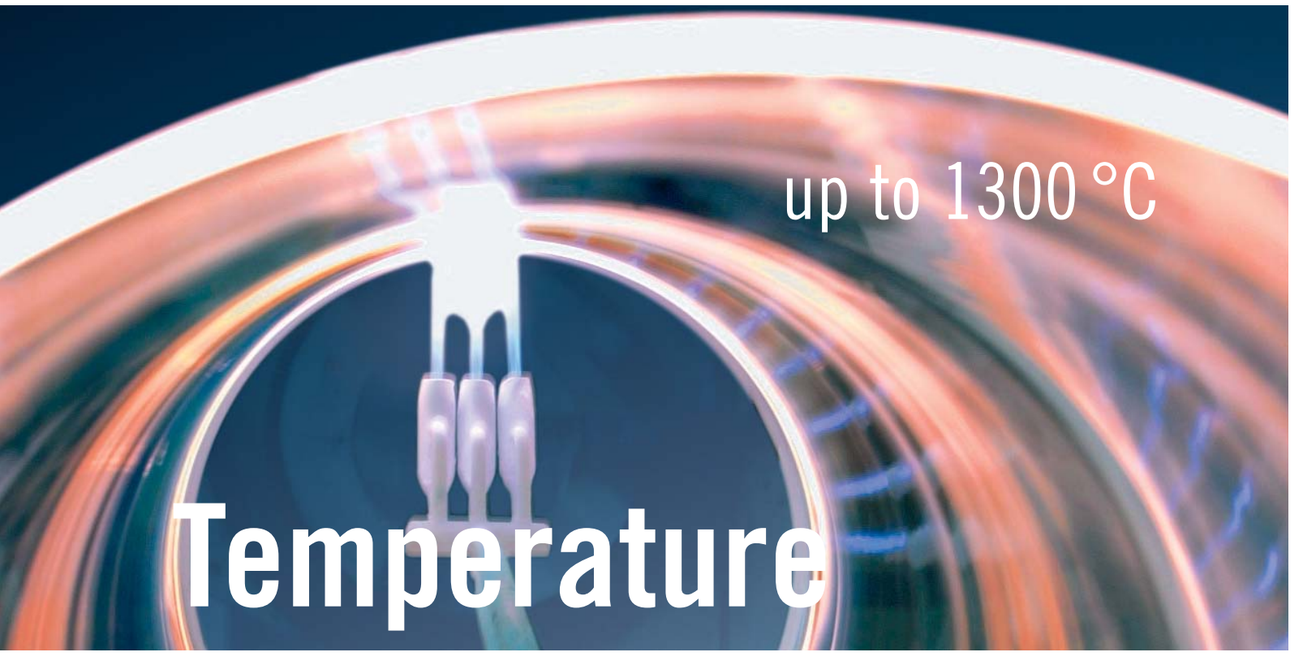
Transmission spectrum of window glass and Suprasil®

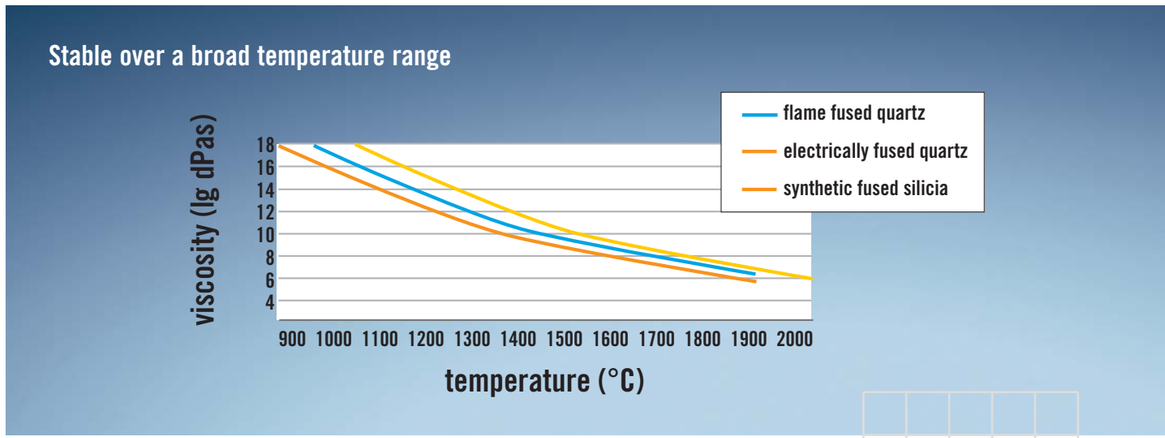


Homogeneity & Isotropy
If light transmits from one medium to another, the beam is bent or reflected. The refraction index is the relevant dimension. For a solid material such as quartz glass, homogeneity and isotropy play a decisive role. Employing special processing methods, Heraeus Quarzglas influences the material specifically, even achieving an optically isotropic material. It is completely free from striae and layers and exhibits an excellent △n in all space directions, which indicates a uniform refraction index.

Resistance
Particularly under exposure to high energy radiation such as laser and UV radiation, quartz glass may loose its transmission characteristics in the UV range. Using special technologies, Heraeus Quarzglas makes sure that flame fused or synthetic fused quartz glass is especially resistant. Doping with rare earth metals such as ytterbium, erbium and neodymium or a high hydroxyl content increases the resistance to high-energy radiation. Depending on application and requirement, a higher ageing strength can be specifically adjusted.

Material	Features	Application Examples
Synthetic fused silica	Highly pure synthetic quartz glass for optical applications of maximum quality requirements from deep UV to visible light. Practically free of bubbles and inclusions	One-dimensional and multi-dimensional optical and UV applications of maximum quality. e.g. lithography, prisms, strongly bent lenses, beam splitters, etalons, retro-reflectors, laser windows, interferometry plates, spectroscopy up to cells and special lamps for analytical purposes, tubes for 172 nm excimer lamps, 185 nm emitters for water treatment and optical fiber manufacturing
Homosil® / Herasil®	From cultured quartz crystals. Meets maximum requirements of optical quality. From UV to near IR. Practically free of bubbles and inclusions	UV windows, interferometry plates, lenses, prisms, beam splitters, suitable for extreme conditions
Infrasil® family	Meets maximum requirements for optical quality, particularly in the infrared and visible range	One-dimensional and multi-dimensional IR applications, such as prisms, lenses, beam splitters, IR laser window, lightguide elements, IR windows etc.
M Family, HLQ family	Extremely low content of trace elements or selective transparency by doping with titanium or cerium	Beamer lamps, IR emitters, infrared lamps for heating and drying, UV hardening for UV disinfection in water purification
OM 100	Diffuse reflection in the IR and optical wavelength range	IR stoppers of semiconductor industry





Temperature-resistant up to 1300 °C, extreme resistance to temperature changes or maximum thermal resistivity – quartz glass offers many heat-relevant features.

Temperatures over 1000°C and pressures above 200 bar prevail in beamer lamps. Despite the high luminous flux, a long lifetime is required. Such complex requirements rather describe the normal application of quartz glass than the exception. But quartz glass offers more: particularly the electrically fused grades even withstand temperatures up to 1300°C. A specific devitrification, induced on the surface with the aid of a special coating, increases the resistance to heat and leads to a higher viscosity. As a result, electrically fused quartz glass grades survive sudden temperature changes of several hundred degrees Celsius in a split second without breaking. The opaque quartz glass grades, offered by Heraeus, exhibit extremely high thermal resistivity in addition to their resistance to heat. In the case of OM 100, this can be utilized for coatings, opening up the possibility to produce completely new material combinations. Crucibles meet highest purity requirements and are hence preferably applied for silicon monocrystal growth from the melt. Depending on the application, the features of quartz glass can be individually tailored in hot processes.

For this purpose, Heraeus Quarzglas uses different technologies:

Screening
If high thermal resistivity is required, Heraeus Quarzglas can offer an ideal material. OM 100 is an opaque quartz glass, with the ability to reduce the temperature over a length of just a few centimetres from 1000°C to less than 100°C. This high thermal resistivity is achieved in a proprietary ceramic production process. This process also allows the application of coatings on transparent quartz glass grades. As a result, very special material combinations can be produced, which combine a high thermal resistivity with other required features.

Stability
In high-temperature applications, stability plays a crucial role in virtually all cases. To ensure a stable shape at high temperatures, it is important to improve the viscosity by the decisive percentages. Furthermore, stability at high temperatures can be improved with the aid of suitable coatings. Special designs such as the so-called back-grinding likewise increase the thermal durability for higher temperature.

Resistance
To increase the resistance to heat, Heraeus Quarzglas uses various processes. For the material HSQ 400, this resistance is generated by means of a coating. The employed aluminum leads to a partial crystallization in a heat treatment and hence improves stability. This effect only occurs on the surface so that the high purity is preserved within the material. Arc-melted quartz glass contains air bubbles and also appears opaque. This likewise improves material durability. OFM-Rotosil® represents the economic variant, if the hot process does not require maximum purity. If a high contamination safety is required in combination with high strength, Heraeus crucibles will be the solution.

Material	Features	Application Examples
HSQ familiy	Thermally stable up to 1160 °C, low heat conductivity between 1.38 and 2.68 W/mK up to highest purities	High-temperature applications in semiconductor production plants with various purity requirements, e.g. CVD tubes, diffusion tubes, epitaxy chambers
Crucibles	Opaque quartz glass with highest temperature stability and purity	Crucible material for silicon monocrystal growth, with natural or synthetic surface coating
HLQ familiy	Quartz glass of high long-term, temperature and devitrification resistance (T > 1000°C)	Beamer lamps and lamps for rear projection television with long lifetimes
M serie, Heralux	Quartz glass of a high resistance against thermal and electrical shocks	Laser flash lamps
Suprasil®	Maximum application temperature, permanent: 950°C, short-term: 1200°C	UV optics, (high-performance) laser optics
Homosil®, Herasil®, HOQ, Infrasil®	Maximum application temperature, permanent: 1150°C, short-term: 1300°C	Optics in the visible and near IR
OM 100	Opaque quartz glass of high purity with micropores	Heat insulator in semiconductor production plants: spacers, flanges, plates

Overview of Heraeus Quartz Material Grades

Quartz Base Material Grades

Materials	Raw Material	Production	Characteristics / Special Features	Products and Applications
CFQ 099	P	E	Standard quartz glass of industry quality	Bar, plate and tube material
HSQ 100	P	E	Quartz glass of semiconductor quality	Bar, plate and tube material
HSQ 300	P	E	Quartz glass of semiconductor quality, thermally stable up to 1160 °C (short-term: 1300 °C), low heat conductivity of 1,38–2,68 W/mK, alkali metal content < 1.5 ppm, OH ppm content < 30	Semiconductor processes with various high purity requirements from room temperature to high temperatures: CVD tubes, diffusion furnaces,epitaxy chambers, etching systems; optical applications; tubes, bars, rods, blocks, plates, discs, flanges
HSQ 330	P	E	Tubes, bars, rods, blocks, plates, discs with guaranteed chemical purity	
HSQ 400	P	E	Temperature resistance by specific recrystallization	Long-term high-temperature processes over 1280 °C
HSQ 700	P	E	Low alkali content by particle size of higher purity, alkali metal/OH content (< 0.05 ppm / < 30 ppm)	Semiconductor processes with very high purity requirements
HSQ 800	P	E	Low alkali content and temperature resistance by specific recrystallization	Long-term high-temperature processes over 1160 °C with maximum purity requirements
HSQ 900	SF	S	Ultra-pure, OH < 0.2 ppm, highest total impurities in the ppb range, minimum number of defect centers	Applications with highest requirements for highest purity, e. g. semiconductor processes
HSQ 910	SF	S	Ultra-pure, OH < 250 ppm, total impurities in the ppb range, minimum number of defect centers	
HSQ 351	P	F	OH content 175 ppm	Diffusion barrier with highest purity requirements and low bubble content
HSQ 751	P	F	OH content 175 ppm, higher purity	Diffusion barrier with highest purity requirements and low bubble content
OM 100	P	C	Opaque material of highest purity with micropores, IR and temperature screening, diffuse reflection in the infrared and optical wavelength range	Thermal insulator, IR stopper with semiconductor purity, spacers, flanges, plates
OFM 70 Rotosil®	P	A	Opaque material, highly resistant to corrosion, high temperatures, thermal shocks and electrical influences, tolerates high concentrations of sulphuric acid and hot chlorination of metal batch mixtures and minerals	Tubes, crucibles, plates, flanges for precious metal recycling, luminescent material industry, high temperature processes electric filter production, chemical technology (container, tubes, dishes etc.), hot chlorination to clean or separate sub stances, calcination and pyrolytic deposition onto substrates
OFM 370	P	A	Like OFM-70, but higher chemical purity	
OFM 970	SF	S	Like OFM-70, but synthetic purity	

Crucibles

Crucible materials with natural coating	P	A	Opaque quartz glass of high temperature stability and purity	Si monocrystal growth with natural coating
Crucible material with synthetic coating	P, SF	A	Opaque quartz glass of high temperature stability and purity	Si monocrystal growth

Lamp Materials

HLQ 200	P	E	Undoped, low OH content < 1 ppm	IR lamps for industrial applications, e.g. for curing and drying, UV hardening (e.g. printing industry), UV disinfection (e. g. water purification)
HLQ 210	P	E	Undoped, low bubble content, high homogeneity	Lamps for laser excitation
HLQ 170, HLQ 270	P	E	Undoped, low alkali content (< 0,5 ppm), high homogeneity, high devitrification (T > 1000 °C), low OH content (< 1 ppm)	Ultra-high-pressure and high-intensity discharge lamps, e. g. for digital projection or car headlamps
HLQ 235, HLQ 250	P	E	Ti-doped, ozone-free*, low OH content (< 1 ppm)	Ozone-free lamps for tanning and UV purification
HLQ 382	P	E	Ce, Ti-doped, uv-free**, low OH content	Lamps for laser excitation and medical application
HERALUX plus VUV	CC	F	Undoped, almost free of bubbles, high purity	UV lamps for heating and drying, UV hardening (e.g. press industry), excimer lamps for surface cleaning, e. g. wafer in semiconductor processes, LCD production
Suprasil® 300	SF	S	Low total impurity and OH content (< 1 ppm), no absorption edges in the visible and infrared spectral range, free of bubbles, highest transparency from UV to IR	Ideal material for broad-band optical applications such as spectroscopy
Suprasil® 310	SF	S	Low total impurity, highest UV transmission, free of bubbles, minimum number of defect centers against damage by short-wave UV radiation	Special lamps for analytical purposes, 172 nm excimer lamps for surface cleaning (e.g. wafer, LCD production), 185 nm lamps
M 235 plus	CC	F	Ti-doped, ozone-free*, high homogeneity, free of striae	Lamps for wafer and LCD stepper, cinema projectors, stage and studio
M 382 plus	CC	F	Ce, Ti-doped, high homogeneity, uv-free**, low bubble content	Lamps for laser excitation

P = pegmatite, NRC = natural rock crystal, CC = cultured crystal, SF = synthetic fused silica, E = electric, F = flame, S = synthetic, C = ceramic, A = arc molten
* (Wavelengths, where ozone forms, are filtered); ** (UV wavelengths are filtered)

Optical Grades

Materials	Raw Material	Production	Characteristics / Special Features	Products and Applications
Suprasil® 1	SF	S	High purity synthetic fused silica. For optical applications with maximum quality requirements, from deep UV to visible. Excellent resistance against high-energy radiation. Practically free of bubbles and inclusions	For use in UV lasers, 3-dimensional optics such as prisms, strongly bent lenses, beam splitters, etalons, retro-reflectors
Suprasil® 2 Grade A	SF	S		2-dimensional optics such as laser windows, interferometry plates, lenses
Suprasil® 2 Grade B	SF	S		2-dimensional optics such as laser windows, interferometry plates, lenses
Suprasil® 1 ArF	SF	S	As Suprasil® 1 and 2, Grade A, but especially optimized, manufactured and inspected for excimer applications (ArF => 193 nm)	Optics for excimer laser applications
Suprasil® 2 ArF	SF	S		
Suprasil® 1 KrF	SF	S	As Suprasil® 1 and 2, Grade A, but especially optimized, produced and inspected for excimer applications (KrF => 193 nm)	Optics for excimer laser applications
Suprasil® 2 KrF	SF	S		
Suprasil® 311	SF	S	High purity synthetic fused silica. For optical applications with highest quality requirements, from deep UV to near IR. Excellent optical homogeneity and high radiation resistance. Practically free from bubbles and inclusions	For use in high-energy lasers, 3-dimensional optics such as prisms, strongly bent lenses, beam splitters, etalons, retro-reflectors
Suprasil® 312	SF	S		2-dimensional optics such as laser windows, interferometry plates, lenses
Suprasil® Standard	SF	S	Most cost effective synthetic material. Good transmission from UV to near IR. Good optical properties.	Commercial optics: simple optical applications, inspection windows, cover plates
Suprasil® 300	SF	S	High purity synthetic fused silica. No absorption bands in the visible and infrared spectral range. OH content < 1 ppm. Ideal for broad-band optical applications	Broad-band optical applications: e. g. spectroscopy cells
Suprasil® 3001 & 3002	SF	S	High purity synthetic fused silica. Very low OH-content. Extremely low absorption in the near IR @ 1.06 µ. No absorption bands from the visible to the IR. Excellent optical homogeneity. Practically free from bubbles and inclusions.	3D / 2D text & high energy lasers with the need for lowest absorption in the range of 900 nm to 1400 nm
Homosil® 101	CC	F	From cultured quartz crystal. Outstanding optical characteristics in 3 dimensions from UV to near IR. Practically free of bubbles and inclusions	3-dimensional optics: prisms, strongly bent lenses, beam splitters, etalons and retro-reflectors
Herasil® 102	CC	F	From cultured quartz crystal. Outstanding optical characteristics in functional direction from UV to near IR. Practically free of bubbles and inclusions	Highly homogeneous UV windows, interferometry plates, lenses
Herasil® 3	NRC	F	Economic quartz glass for simple optical applications	Simple optical components for extreme application conditions such as high-temperature and pressure applications, chemi cally resistant
Infrasil® 301	P	E	Meets demanding requirements for optical applications, particularly in the infrared and visible range. Optically isotropic 3D-material with high homogeneity.	3-dimensional IR optics such as prisms, lenses, beam splitters
Infrasil® 302	P	E	Bubble class 0, practically free from inclusions. Meets demanding requirements for optical applications, particularly in the infrared and visible range, homogeneous and striae-free in functional direction. Meets demanding requirements for optical quality, particularly in the infrared and visible range, homogeneous and striae-free in functional direction.	One-dimensional IR optics such as laser window, lenses
Infrasil® 303	P	E		Commercial optics: optical IR standard applications such as substrates, lightguide elements, IR windows
HOQ 310	P	E	Economic, transparent from IR to UV	Commercial optics: simple optical applications, inspection windows, cover plates, pressure windows

Optical Fiber Grades

F 300	SQ	S	Highly pure synthetic fused silica with low OH Content (< 0.02 ppm) for optical fiber manufacturing	Cladding and substrate tubes for the production of optical fibers, Large cylin-ders for RIC® process, capillaries and rods for microstructured fibers
F 500	SQ	S	Highly pure synthetic fused silica with low OH content (< 0.02 ppm) for optical fiber manufacturing	Substrate tubes with very low OH content for low-water-peak fibers, capillaries and rods for microstructured fibers
F 100 / F 110	SQ	S	Highly pure synthetic fused silica with increased OH content (700 ppm), excellent UV transmission and high radiation resistance at 800 nm	UV grade optical fibers, capillaries and rods for microstructured fibers
Fluosil	SQ	S	All silica step index multimode fiber preform with synthetic fused silica core and highly fluorine doped synthetic fused silica cladding	Medical laser surgery (e.g., ablation of arterial blockage or vaporization of prostate tissue to treat BPH), Automotive applications (laser cutting and welding) Spectroscopy from UV, to VIS, to NIR ranges, Specialty fiber bundles (e.g., beam homogenization for photo lithography and spot curing of UV adhesives)

P = pegmatite, NRC = natural rock crystal, CC = cultured crystal, SF = synthetic fused silica, E = electric, F = flame, S = synthetic, C = ceramic, A = arc molten
* (Wavelengths, where ozone forms, are filtered); ** (UV wavelengths are filtered)

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