Heraeus

Heraeus Quarzglas
Home of Quartz Solutions

Quartz Glass:
A Matter of Competence!

1851

The origin of today's global company was the innovative vision and entrepreneurial spirit of Wilhelm Carl Heraeus, a pharmacist and chemist who took over his father's pharmacy "Einhorn-Apotheke" in Hanau, Germany in 1851. In 1856 he succeeded in melting 2kg of Platinum in an oxy-hydrogen flame and thus laid the basis of today's business of the Heraeus group. In 1899 Dr. Richard Küch followed in the success by fusing rock crystal into a high grade vitreous silica or "quartz glass" by the same method.


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Today

Today, Heraeus Quarzglas routinely manufactures fused quartz and fused silica and has been doing so for over 95 years. The know-how and excellence gained over nearly one century enables Heraeus Quarzglas to manufacture quartz glass solutions to the most demanding applications.

Heraeus Quarzglas, headquartered in Hanau, Germany, is the technology leader in manufacturing high purity quartz materials and advanced quartz components.


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Heraeus Quarzglas supplies not only high quality fused quartz or fused silica but also specific know-how for demanding applications. With over 1,500 employees in 8 production facilities in Europe, Asia, and North America, Heraeus Quarzglas is the world's largest integrated quartz glass producer.

Furthermore, Heraeus Quartz Net incorporates joint venture companies in Japan, Korea, Singapore and Taiwan with more than 750 employees and 7 manufacturing sites.

Wherever quartz glass is required for exceptional applications, in precision optics, in the laser and semiconductor industry, or in communications: You will find Heraeus!

Microlithography and Standard Optics:
2 Business Units for Optics

The optics division of Heraeus Quarzglas includes a team of highly qualified and well trained specialists for optics and materials. Heraeus Quarzglas produces custom-tailored or standardized products for your optical application. If the application is operated in the deep UV or in the Near-Infrared or even over the whole spectral range the optics group of Heraeus Quarzglas has the appropriate material for your application.

If you are, on the other hand, essentially interested in the thermal, chemical or mechanical properties of fused quartz or fused silica Heraeus Quarzglas is your partner as well.

Our team is at your disposal to assist you in the solution of your challenges!

1 "Einhorn" pharmacy, Hanau, Germany
2 Heraeus Quarzglas GmbH & Co. KG, Hanau facility
3 Microlithography lens system of Carl Zeiss SMT AG
4 Selected quartz glass products

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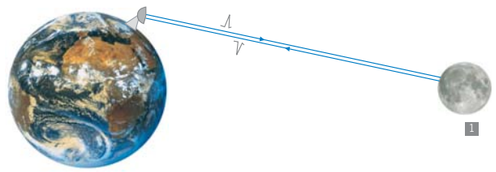
Home of Quartz Solutions

The optics group has delivered solutions made out of fused quartz or fused silica for quite a few demanding projects.

One of the projects was the setting up of retro-reflectors on the moon to determine the distance earth-moon to high accuracy.



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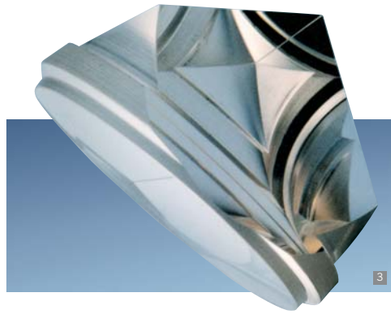
That was achieved by aiming a high intensity laser beam at the retro-reflectors and then measuring the cycle time of the laser beam returning to earth. This demanding application asked for a fused silica with outstanding homogeneity in all three dimensions because the retro-reflectors propagate the light in all three dimensions within the reflector. Because of the long distance between earth and moon the tiniest inhomogeneity in the material would cause an unwanted deflection of the laser beam which in turn would result in a tremendous signal loss. In addition the material had to withstand cosmic radiation and was not allowed to show any signs of solarisation. The proper choice for this challenge was Heraeus' Suprasil® 1. The product is still in use today. Over 35 YEARS!



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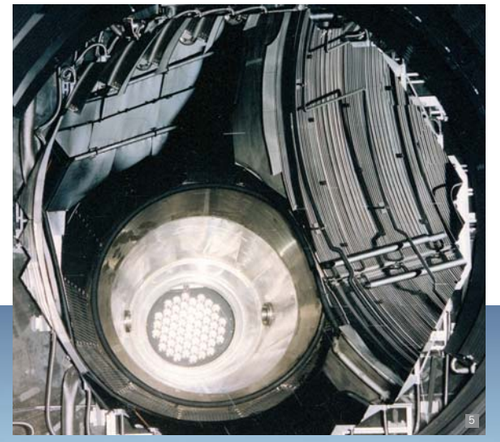
Since then quartz glass from Heraeus was used and is being used in many more projects, e.g. the interior of the Gravity Probe B satellite is made from Herasil®1. This research project has the goal to gather data in space for the evaluation of two effects predicted by Einstein's General Theory of Relativity. One is the geodetic effect the bending of the local space-time by the mass of the earth. The other effect, called Lense-Thirring effect, or frame-dragging, is the amount by which the rotating earth drags local space-time around with it.



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Vacuum windows for space simulation chambers which are used to test space equipment for its suitability or optics for high power lasers that are, amongst others, used for the investigation of laser fusion, are only two more examples where one of the different material grades of Heraeus Quarzglas is used.

A thorough discussion with the customer to understand his or her needs was the first step in the realization of those projects at Heraeus. The innovative R&D team of the Heraeus optics group and their well trained production engineers "translated" the customer's needs into a custom tailored solution.

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1 Light signal travelling from earth to moon and back
2 Heraeus transparent quartz glass in the laser retro-reflector on the moon
3 Precision retro-reflector
4 Understanding the customer's needs
5 Very large fused quartz window – part of the Zeiss sun simulator in the space simulation chamber at ESTEC.

Customer Success with Exceptional Quality

Heraeus Quarzglas holds all relevant production processes for the manufacturing of optical fused quartz and fused silica under one roof: From the raw material production, be it flame fusion, electrical fusion or the synthetic CVD (chemical vapour deposition) to homogenization to hot-forming to annealing and last but not least to the final mechanical shaping.

To secure a high process stability and a high process capability Heraeus Quarzglas uses well defined processes where the process and the resultant product are routinely controlled according to a comprehensive quality plan. To ensure a high quality standard Heraeus Quarzglas encourages a continuous improvement process: All employees, as part of a team or as individuals, strive to improve existing or implement new processes.

The overall process and quality management of Heraeus Quarzglas is based on the Business Excellence model by the European Foundation of Quality Management.

Heraeus Quarzglas is DIN EN ISO 9001:2000 certified and employs well defined guidelines for the environmental / safety control standards following DIN ISO 14001.


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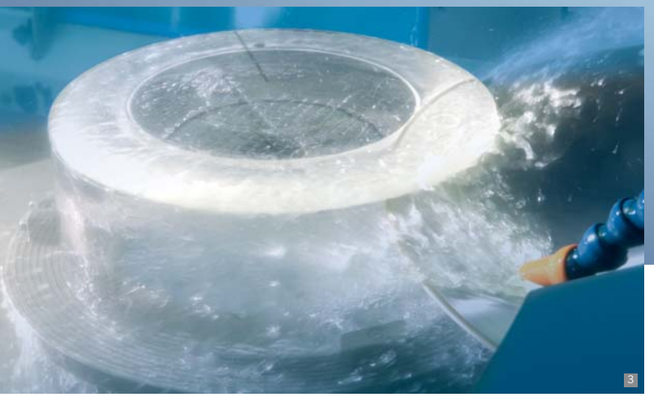
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1 Grain purification systems
2 Annealing furnace
3 Disc saw
4 Band saw

Metrology Services

The last step in the production process is the final inspection of the products. This is the last verification that the products meet the customer's specification. The final inspection ensures that the products meet the optical homogeneity, stress induced birefringence or whatever else the customer has specified.

The know-how Heraeus Quarzglas has gained in metrology over many years is to the benefit of our customer. It enables us to verify the sometimes very demanding specifications needed by our customers. From time to time verifying the specifications requires the development of new inspection methods beyond existing and commercially available solutions.

Our experts from the R&D department will then find the right means in close communication with our customers. The success of our customers is our goal!


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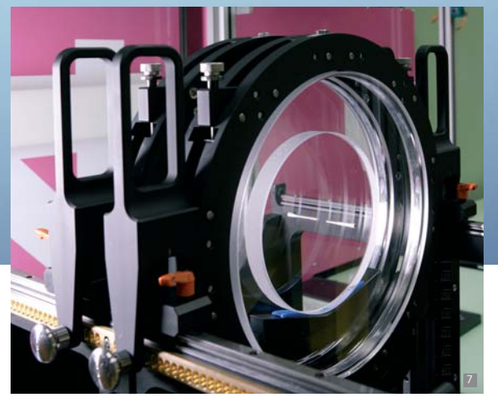
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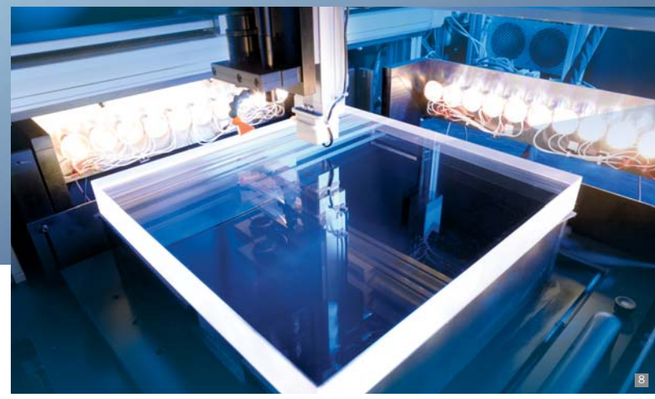
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5 Inspection for stress-induced birefringence
6 Interferometry for large optics blank
7 Interferometry for microlithography
8 Bubble and inclusion inspection, detection limit 10 µm Ø

Quartz Glass –
A very special Material

Quartz Glass – Quartz Crystal

Although crystalline quartz (often referred to as “quartz”) and quartz glass have the same chemical composition, they are structurally very different. Quartz has an ordered, crystalline structure. This means that its optical properties are dependent on the crystal orientation, and that crystalline quartz will not withstand exposure to a sudden increase or decrease in temperature. Quartz glass, however, has a vitreous, thus amorphous, structure.

Quartz Glass – Glass

Quartz Glass is genuine glass – the purest you could imagine. It has only one constituent, i.e. silicon dioxide (SiO_2). Common glasses, on the other hand, usually consist of a mixture of different constituents.

Purity

Heraeus Quarzglas has developed sophisticated methods to keep or even decrease the low impurity level in fused quartz or fused silica. Synthetic quartz glass, i.e. fused silica, shows trace element contents as low as a few ppb and significantly less than 1ppm for all metallic impurities.

Special Properties of Quartz Glass

Due to its composition, structure and purity, quartz glass has a number of most remarkable properties, which are not found in any other material. Amongst these, the following are particularly important where optics and optical applications are concerned.

- Extremely wide spectral range (from deep UV to mid-IR much wider than all other glasses.
- Extremely high optical transmission or, in other words, a very low optical absorption, e.g. quartz glass with a thickness of 100 m would still be as transparent as a window pane.
- Very low variation and disturbance of the refractive index in one solid piece (optical homogeneity), and from one melt to the next (reproducibility), achieved in the advanced Heraeus production processes.
- High resistance to high energy ionizing radiation, e.g. synthetic quartz glass does not discolour (solarisation), even in the case of high radiation doses.
- High resistance to high intensity laser radiation, i.e. from UV to IR radiation (e.g. excimer laser or IR-lasers for material processing).
- High operating temperatures of ~1200°C, approximately four times higher than that of ordinary glass.
- Very low thermal expansion coefficient (approximately 1/20th that of ordinary glass and hence an extremely high temperature shock resistance, which allows rapid heating and cooling.
- Excellent elasticity properties, combined with high geometric stability and fatigue strength.
- Exceptional chemical resistance to most chemicals.

Families of Heraeus Optical Quartz Glass

Heraeus Quarzglas has a complete range of different grades of quartz glass available for applications ranging from simple optical windows to high performance lenses for high power lasers or deep UV microlithography.

The different grades are grouped into “families” in accordance with their basic characteristics. A summary of their main features and preferred applications is given below.

Suprasil® 1 , Suprasil® 2, Suprasil® Standard

Suprasil® 1 and Suprasil® 2 (Grade A & B) are high purity synthetic fused silica materials manufactured by flame hydrolysis of $SiCl_4$. They combine excellent physical properties with outstanding optical characteristics in the deep UV and the visible wavelength range. The index homogeneity is controlled and specified either in one direction (the direction of use or functional direction) or even in all three dimensions. In addition, Suprasil® 1 and Suprasil® 2 (Grade A & B) provide excellent resistance to damage by high energy radiation especially in UV-laser applications. All synthetic fused silica Suprasil® grades are practically free from bubbles and inclusions. The optical homogeneity, which is the main criterion for very low transmitted wave-front distortion, refers to three categories:

Suprasil® 1 is an optically isotropic 3D-material. It is highly homogeneous and has no striations in all three dimensions. These properties are very important for multiple axis optics such as prisms, steep lenses, beam splitters, etalons or retro-reflectors.

Suprasil® 2 Grade A & B are homogeneous in the primary functional direction. Weak striations, if any, are parallel to the major faces and do not affect the optical performance.
Suprasil® 2 Grade A & B are the preferred materials for demanding optics in one directional use such as lenses, UV-laser windows or optical flats.

Suprasil® Standard is a high purity synthetic fused silica material manufactured by flame hydrolysis of $SiCl_4$. It combines excellent physical properties with very good optical characteristics in the UV and the visible wavelength range.

Suprasil® 311 , Suprasil® 312

Suprasil® 311 and 312 are high purity synthetic fused silica materials manufactured by flame hydrolysis of $SiCl_4$. They combine excellent physical properties with outstanding optical characteristics in the deep UV to the near IR. The most prominent property of Suprasil® 311 and 312 is the high degree of index homogeneity which is controlled and specified either in one direction (the direction of use or functional direction) or even in all three dimensions. In addition, Suprasil® 311 and 312 provide a high degree of resistance to radiation damage and are therefore the preferred materials in high energy laser applications.
Suprasil® 311 and 312 are practically free from bubbles and inclusions. The optical homogeneity, which is the main criterion for very low transmitted wave front distortion, refers to two categories:

Suprasil® 3001 , Suprasil® 3002, Suprasil® 300

Suprasil® 3001, 3002 and 300 are high purity synthetic fused silica materials manufactured by flame hydrolysis of $SiCl_4$. They combine excellent physical properties with outstanding optical characteristics from the deep UV to the near IR. During the manufacturing process an intermediate drying step reduces the OH-content of the Suprasil® 300 below 1 ppm. Thus a chlorine content of 1000 ppm – 3000 ppm is material inherent and results in a slight shift of the UV-absorption edge to the longer wavelength region. Therefore the Suprasil® 300x family has no absorption bands from the visible to the IR spectral region. This property makes this material family the ideal choice for any low absorption application in the near-IR.

Suprasil® 3001 is an optically isotropic 3D-material. It is highly homogeneous and has no striations in all three dimensions. These properties are very important for multiple axis optics such as prisms, steep lenses, beam splitters, etalons or retro-reflectors.

Suprasil® 3002 is homogeneous in the primary functional direction. Weak striations, if any, are parallel to the major faces and do not affect the optical performance.
Suprasil® 3002 is the preferred material for demanding optics in one directional use such as laser windows, optical flats or lenses.

Due to their excellent wide transmission region **Suprasil® 3001, 3002 and 300** are the preferred materials for wide band optical applications or low-absorption applications in the near-IR.

Suprasil® 311 is an optically isotropic 3D-material. It is highly homogeneous and has no striations in all three dimensions. These properties are very important for multiple axis optics such as prisms, steep lenses, beam splitters, etalons or retro-reflectors.

Suprasil® 312 is homogeneous in the primary functional direction. Weak striations, if any, are parallel to the major faces and do not affect the optical performance.
Suprasil® 312 is the preferred material for demanding optics in one directional use such as laser windows, optical flats or lenses.

Suprasil® 311 and 312 are the preferred materials for UV-microlithography, interferometry, special laser applications, VUV applications, high quality retro-reflectors and prisms. In the DUV, Suprasil® 311 and 312 show the highest transmission of all Suprasil® grades.

Homosil® 101 , Herasil® 102, Herasil® 3

Homosil® 101 and Herasil® 102 are optical quartz glass grades manufactured by flame fusion of cultured quartz crystals. They combine excellent physical properties with outstanding optical characteristics from the UV to the IR. The index homogeneity is controlled and specified either in one direction (the direction of use or functional direction) or even in all three dimensions.
Homosil® 101 and Herasil® 102 meet the requirements for bubbles class 0 and are practically free of inclusions. The optical homogeneity, which is the main criterion for very low transmitted wave front distortion, refers to two categories:

Homosil® 101 is an optically isotropic 3D-material. It is highly homogeneous and has no striations in all three dimensions. These properties are very important for multiple axis optics such as prisms, steep lenses, beam splitters, etalons or retro-reflectors.

Herasil® 102 is homogeneous in the primary functional direction. Weak striations, if any, are parallel to the major faces and do not affect the optical performance.
Herasil® 102 is the preferred material for demanding optics in one directional use such as lenses, UV-laser windows or optical flats.

Herasil® 3 is a cost effective preferred material for simple technical optics-components having a good homogeneity even under difficult environmental conditions such as high temperatures, temperature-shocks, chemically aggressive media or pressure load.

Infrasil® 301 , Infrasil® 302, Infrasil® 303

Infrasil® 301, 302 and 303 are optical quartz glass grades manufactured by fusion of natural quartz crystals in an electrically heated furnace. They combine excellent physical properties with outstanding optical characteristics especially in the IR and the visible wavelength range. The index homogeneity is controlled and specified either in one direction (the direction of use or functional direction) or even in all three dimensions.

Infrasil® 301 meets the requirements for bubble class 0 and is practically free of inclusions.

Infrasil® 302 and 303 show a low bubble and inclusion content. The optical homogeneity, which is the main criterion for very low transmitted wavefront distortion, refers to three categories:

Infrasil® 301 is an optically isotropic 3D-material. It is highly homogeneous and has no striations in all three dimensions. These properties are very important for multiple axis IR-optics such as prisms, steep lenses, beam splitters, etalons or retro-reflectors.
Infrasil® 302 and 303 are homogeneous in the primary functional direction. Weak striations, if any, are parallel to the major faces and do not affect the optical performance.

Infrasil® 302 is the preferred material for demanding optics in one directional use such as lenses, IR-laser windows or optical flats.

Infrasil® 303 is designed for commercial optical infrared applications such as substrates, lightguide elements, microscope slides and IR-windows.

HOQ 310

HOQ 310 is manufactured by fusion of natural quartz crystals in an electrically heated furnace. HOQ 310 is economically priced and has been developed especially for applications in the technical optics field. Compared with “typical” optical glasses it provides a unique combination of attractive properties:

- Excellent optical transmission from the UV into the IR spectral region
- Outstanding high temperature resistance
- Extremely low coefficient of thermal expansion
- Superior temperature shock resistance
- Excellent chemical resistance
- Outstanding chemical purity

Combined with a low bubble content and an attractive price HOQ 310 is the preferred material for lower precision optical applications such as inspection and/or illumination windows, cover plates, windows for pressurized cabins in a hostile environment, e.g. high temperature and/or thermal shock loads, pressure loads or chemically aggressive atmosphere.

Special Grades of Quartz Glass

For special applications, special grades are available on request, such as:

- Doped quartz glass with modified optical transmission properties (e.g. for use as cut-off filter).
- Quartz glass specially conditioned for a specific customer application.

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