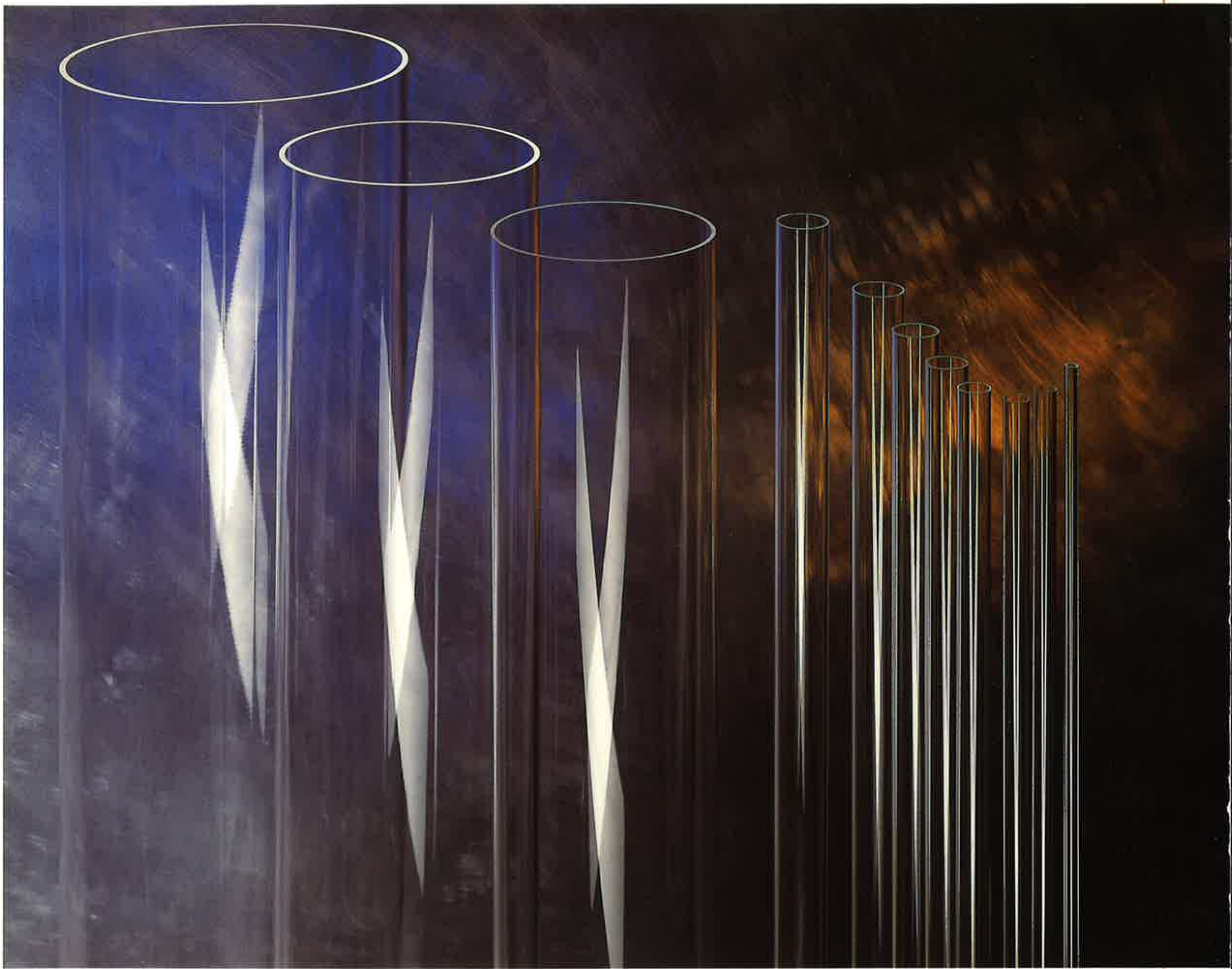
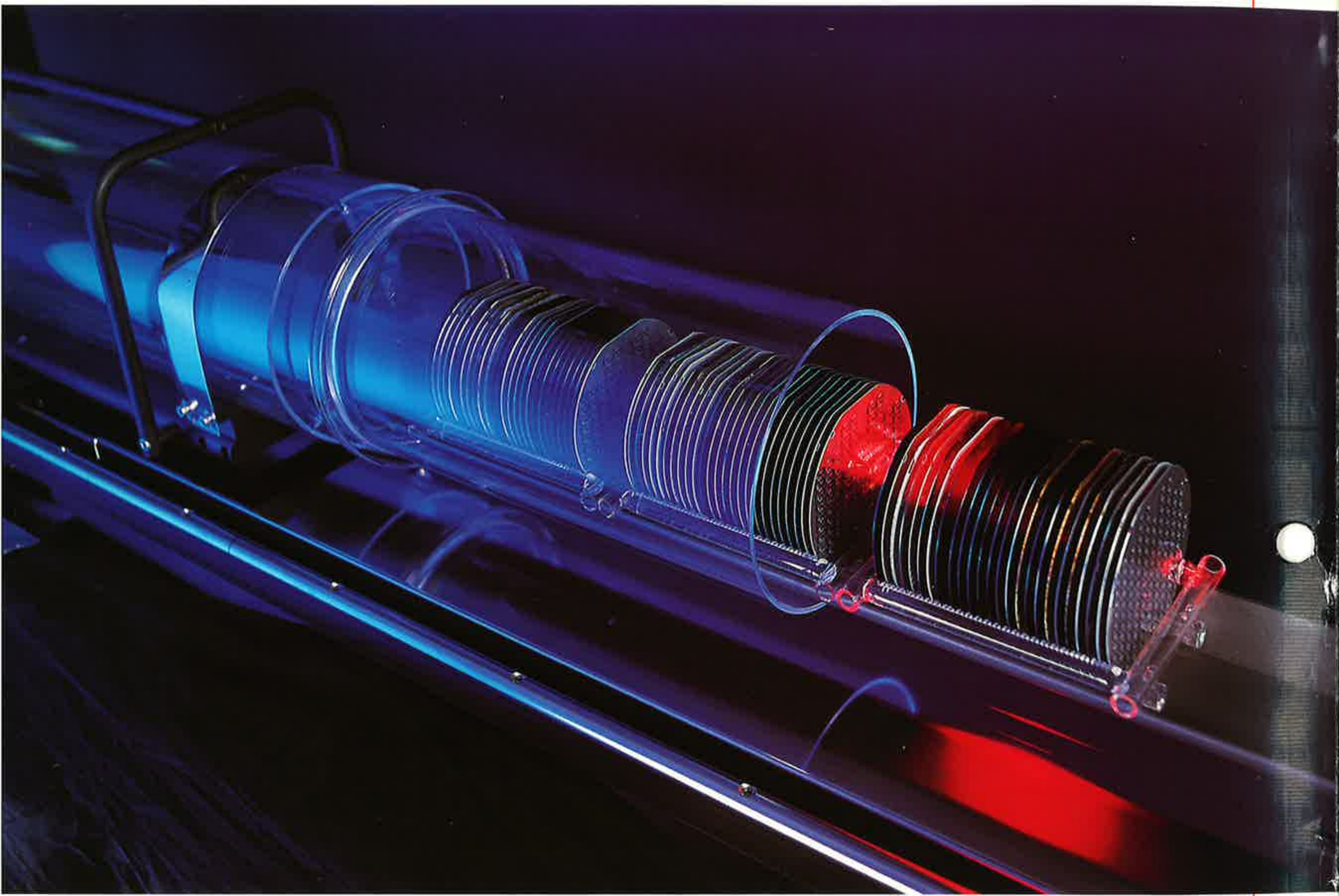
Fused Quartz



OSRAM SYLVANIA

Quality and Service Based on Decades of Fused Quartz Experience

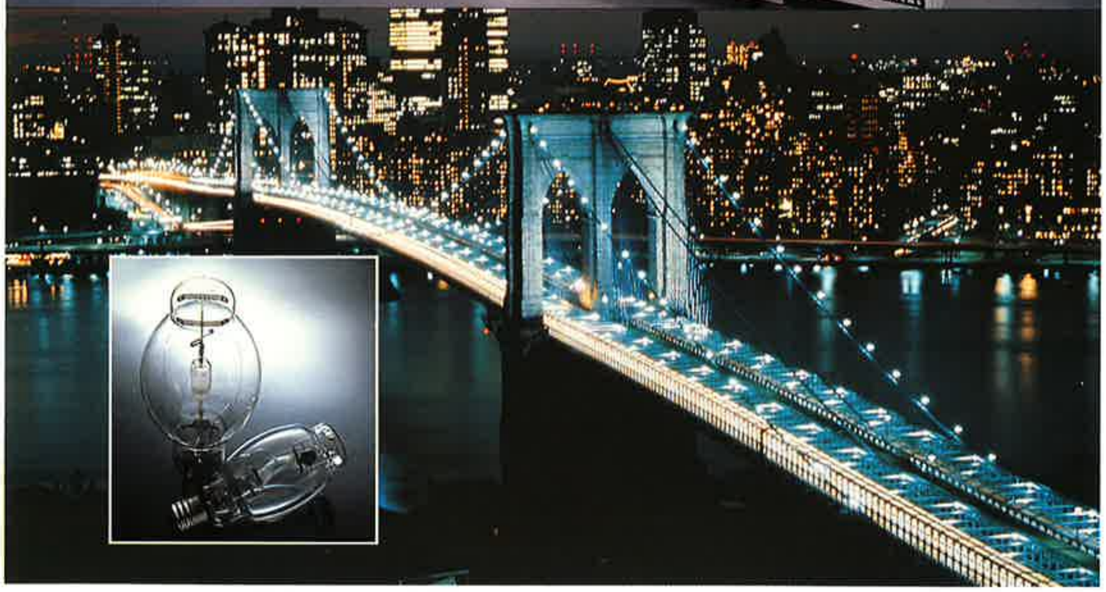


OSRAM SYLVANIA INC., the North American subsidiary of OSRAM GmbH, a Siemens company, manufactures and markets a wide range of engineered materials, parts and components for a broad range of markets including the lighting, aerospace, automotive and computer industries. The Fused Quartz Operation is part of OSRAM SYLVANIA's Precision Materials and Components organization.

Backed by extensive capabilities for research and development, OSRAM SYLVANIA works closely with thousands of customers (including most "Fortune 500" firms) to solve problems and contribute strategically to the development and manufacture of a host of technologically advanced consumer and industrial end products.

OSRAM SYLVANIA has been manufacturing fused quartz products for over 25 years and controls quality through every step of the unique, vertically integrated process. OSRAM SYLVANIA tubing has proven to be performance effective for semiconductor and lighting manufacturers worldwide.

OSRAM SYLVANIA's Concentration on Semiconductor and Lamp Applications



Brooklyn Bridge

Semiconductors: The purest materials for the purest technology

OSRAM SYLVANIA's semiconductor grades of fused quartz tubing are recognized by major semiconductor manufacturers throughout the world for their consistent high chemical purity and high-temperature resistance.

Applications commonly include furnace tubes for oxidation and diffusion processes, end caps, transfer carriers, thermocouple tubes, wafer carriers, end plates, baffles, and bell-jars for epitaxial reactors.

OSRAM SYLVANIA offers high purity grades to meet specific wafer processing needs. Grade SG27SC offers lower aluminum and alkali content. Grade SG28SC provides the lowest alkali and highest thermal resistance. Grade SG29SC has both the lowered aluminum and alkali content.

Grades SG25SCH and SG27SCH, heavy wall fused quartz tubing, are used for the processing of power devices and temperatures to 1250°C.

Wafers 6 inches in diameter and larger are processed in Grades SG25, 27, 28 and 29 SCR resized tubing (available in sizes above 200 mm OD).

Lighting: A focus on the best and the brightest

OSRAM SYLVANIA Grades SG25A and SG25B are widely used in high-temperature arc and filament lamps requiring high purity to minimize devitrification and provide optimum sag resistance. These attributes contribute to the long life of these lamps at high operating temperatures.

Arc Lamp Life Expectancy

Lamp Type	Arc Tube Temp	Expected Life
Mercury	700°C	24,000 hrs.
Metal Halide	850°C	10,000–20,000 hrs.
Tungsten Halogen	350°C to 750°C	50–50,000 hrs.

The outgassing of hydrogen from fused quartz tubing reduces lamp life and results in hard starting for arc lamps. OSRAM SYLVANIA fused quartz is vacuum baked to reduce the residual hydrogen content to very low levels.

The amount of residual hydrogen in fused quartz is related to the optical transmission at 2.73 microns, the hydroxyl (OH) absorption wavelength in fused quartz as compared to the transmission at 2.6 microns.

OSRAM SYLVANIA's Grade SG25BZ "ozone free" and ultra-violet absorbing fused quartz contains titanium dioxide as an additive. The UV transmission below 200 nanometers (nm) is eliminated. This prevents the formation of ozone generated when the 185 nm wavelength strikes oxygen. Since ozone is a lung irritant, Grade SG25BZ is used in arc lamps for reproduction machines that are located in confined spaces.

$$\beta = \frac{1}{t} \operatorname{Log} \frac{T_{2.6}}{T_{2.73}}$$

β = Beta factor, mm^{-1}

t = Wall thickness, mm

$T_{2.6}$ = Transmission at 2.6 Microns

$T_{2.73}$ = Transmission at 2.73 Microns

ppm (OH) $\approx 1{,}000 \times \beta$

Harnessing the Power of the Crystal

OSRAM SYLVANIA fused quartz features low levels of metallic contaminants, low water content, and excellent resistance to high-temperature deformation.

Purified quartz crystal is melted in our high-temperature furnaces at 2000°C. Tubing is formed and drawn continuously to outside diameters of over 200 mm. To produce these larger sizes, OSRAM SYLVANIA has designed and built the largest direct-draw quartz melting furnace in the world.

Grades SG25, 27, 28, and 29 SCR are available in sizes from 200 mm to 450 mm diameter. These larger tubing sizes are produced by a resizing process in which rigid dimensional specifications are met to serve the needs of IC manufacturers using the latest wafer technology.

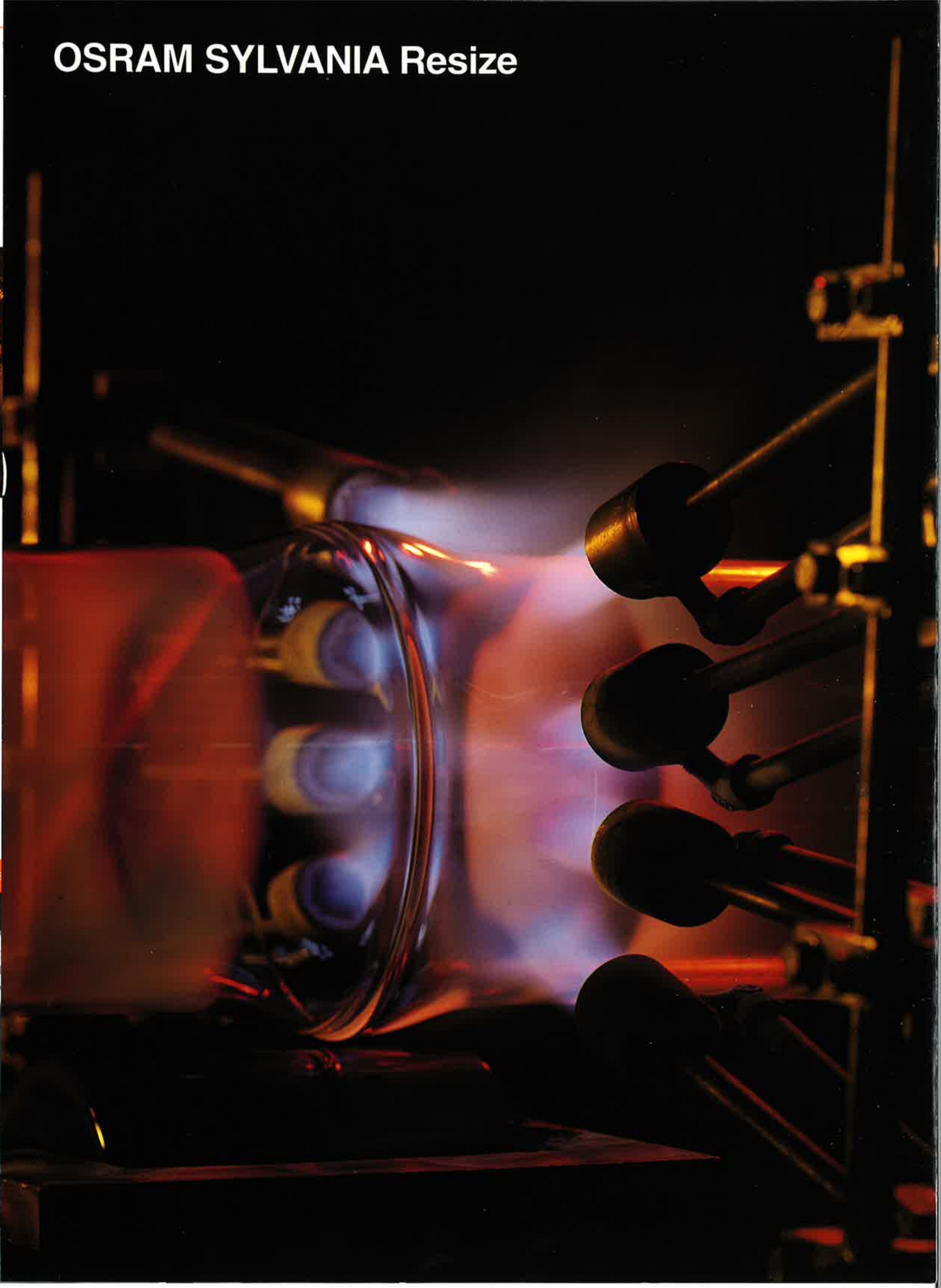
Mining the Quartz Ore

Magnetic Separating

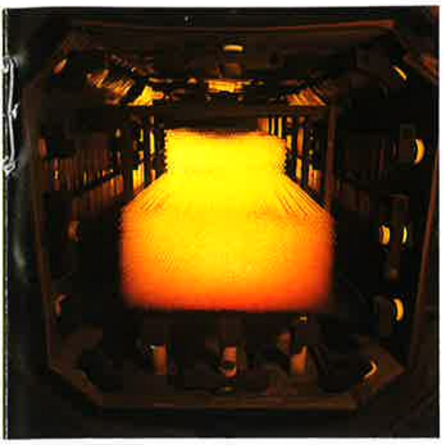
Acid Treating

Calcining

OSRAM SYLVANIA Resize



The Quest for Purity



OSRAM SYLVANIA produces consistently pure fused quartz, starting with an in-house chemical and firing operation for purifying naturally occurring crystalline quartz.

Flame atomic absorption and inductively-coupled plasma analytical methods are routinely used to insure the quality of the starting, in-process, and finished quartz materials.

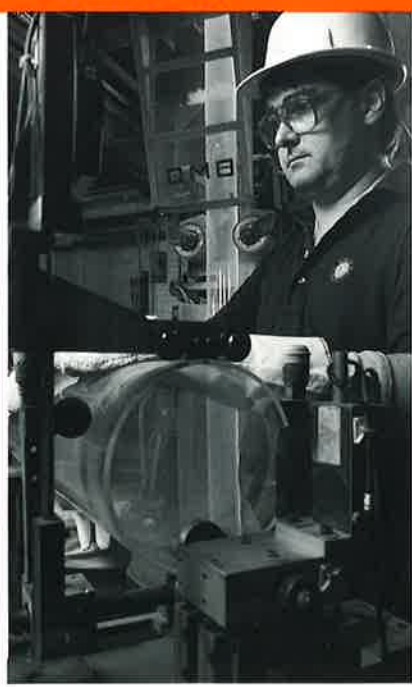
Although the crystalline quartz raw material initially contains 300–600 ppm of elemental contaminants, OSRAM SYLVANIA's purification process reduces total elemental contaminants to less than 20 ppm. This is accomplished by a series of steps that include high intensity magnetic separation to remove iron and iron-bearing minerals, screening to remove contaminated fractions of the raw materials, a strong acid wash to dissolve non-quartz particles, and high-temperature calcining to remove residual organic materials that may exist on the surfaces of the individual quartz crystals.

OSRAM SYLVANIA's rigid process controls assure consistency of processing and the quality of the treated quartz. Quality is monitored by a careful sampling and chemical analysis testing of the purified quartz before it is used in the melting and tube forming process.

Melter Sand Feeding

Tube Drawing

In-Process Quality



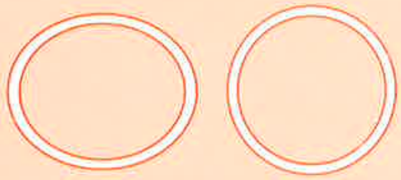
Tube Washing

Va

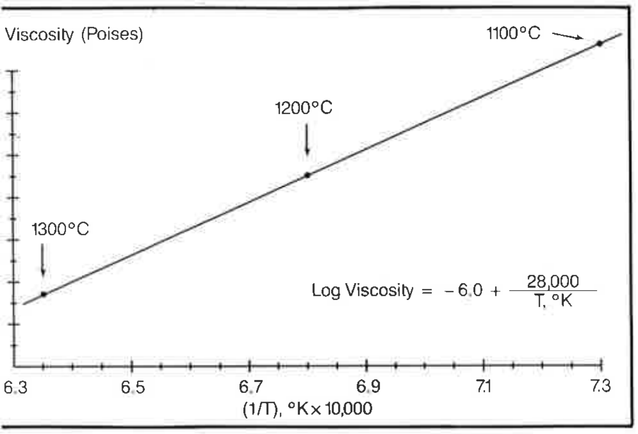
recision Temperature Control
the Key to Quality

AM SYLVANIA melts the alline quartz in furnaces are designed and built in-house resources. se furnaces utilize a ue combination of refrac- metals and oxides which melting and forming peratures up to 2000°C. he high-temperature ing process converts the talline quartz to an amor- phous or glassy structure. Since it is a glass, fused quartz does not have a melt- ing point. It does, however, have a softening or flowability property that is called viscos- ity. A linear relationship exists between the logarithm of vis- cosity (V) and the reciprocal of the absolute temperature (T) as shown.

$$\text{Cross Section Sag Rate} \propto \frac{D^4}{t^2 V}$$



D = mean tube diameter
t = tube wall thickness
V = viscosity



The above relationship is use- ful for evaluating the effect of temperature on the stability of fused quartz. For example, a 10°C temperature increase at 1100°C reduces viscosity and increases the sag rate by about 30%. Temperature sen- sitivity is important in assess- ing the performance of fused quartz at high temperatures.

The tubing is monitored continuously to maintain dimensional control well within specifications. For semiconductor furnace appli- cations, each tube is identi- fied with a tube number. A tube data sheet placed inside each tube provides the tube number and actual dimen- sions. This feature provides the fabricator and the end user a traceability feature.

king

Final Quality Control

Packaging

Semiconductor Application

OSRAM SYLVANIA Quartz Tubing Grow with the Power of Technology

OSRAM SYLVANIA continues to grow in ways that address the specific needs of our semiconductor and lighting customers worldwide:

- Improved dimensional tolerance and enhanced purity to help you better control your processes.
- Statistical process control methods to ensure unrivaled product consistency.
- An expanded regional warehousing network to ensure that OSRAM SYLVANIA quartz tubing is where you want it, when you want it.

OSRAM SYLVANIA is committed to servicing present and future quartz tubing requirements, satisfying growing demands for quality and reliability, and to supporting your developmental efforts.

Call OSRAM SYLVANIA Today

OSRAM SYLVANIA maintains extensive stocks of fused quartz tubing in regional warehouses throughout the world. A phone call or FAX to our Customer Service departments in Exeter, NH will provide availability, delivery, and pricing, as well as any technical assistance that customers may require.

Additional photos, thanks to:

BTU Engineering Corporation
W.R. Grace & Co.-Conn.
Weiss Scientific Glass Blowing Co.

Grades • Sizes • Tolerances • Chemical Analysis

Fused Quartz Tubing Grades

	Type	Grades	Sizes, OD, mm	Type Description
Lighting	A	SG25	4– 40	Mercury, tungsten-halogen
	B	SG25	4– 40	Metal-halide, specialty
	N	SG25	4– 40	High (OH), Unbaked
	BZ	SG26	12– 40	Ozone-free (UV absorbing)
Semiconductor	SC	SG25	4–40	1.0–3.0 Wall
	SC	SG25, SG27	95–216	Direct Draw, 2.5–4.5 Wall
	SCH	SG25, SG27	125–200	Direct Draw, 5.0–6.5 Wall
	SCR	SG25, SG27, SG28, SG29	150–450	Resize, 3.0–7.0 Wall

Dimensional Tolerances (Standard)

Type	Size Range OD, mm	ID ±	OD ±	Oval Max	Wall ±	Siding Max
A, B, BZ, SC	4– 40	2.5%	—	2%	10%	10%
SC, SCH	95–216	—	2 mm	1.0%	10%	15%
SCR(*)	150–450	—	2 mm	0.5%	20%	20%

(*) By Special Request: OD Tolerances to ± 0.5 mm
ID Tolerances to ± 1.0 mm

Chemical Analyses, PPM (Typical)

	Al	Fe	Na	K	Li	Ca	Mg	Cu	Mn	Cr	B	Zr	Ti
SG25	15	0.3	0.7	0.6	0.7	0.6	0.2	<0.2	<0.1	<0.1	<1.0	1.0	0.9
SG26	15	0.3	0.7	0.6	0.7	0.6	0.2	<0.2	<0.1	<0.1	<1.0	<1.0	100.0
SG27	9	0.3	0.2	0.2	0.2	0.5	<0.2	<0.2	<0.1	<0.1	<1.0	0.5	1.2
SG28	15	0.3	0.1	0.6	<0.1	0.6	0.2	<0.2	<0.1	<0.1	<1.0	1.0	0.9
SG29	9	0.3	0.1	0.2	<0.1	0.5	<0.2	<0.2	<0.1	<0.1	<1.0	0.5	1.2

OSRAM SYLVANIA

OSRAM SYLVANIA Quartz Tubing Tolerances

2

ID (mm)	OD (mm)	ID RANGE (mm)	WALL RANGE (mm)	Max. Siding (mm)	Max. Ovality (mm)	Feet Per Pound	KG Per Meter
3.00	5.00	2.92– 3.08	0.90–1.10	0.100	0.10	53.83	0.03
4.00	6.00	3.90– 4.10	0.90–1.10	0.100	0.12	43.06	0.03
5.00	7.00	4.87– 5.13	0.90–1.10	0.100	0.14	35.89	0.04
6.00	8.00	5.85– 6.15	0.90–1.10	0.100	0.16	30.76	0.05
7.00	10.00	6.82– 7.18	1.35–1.65	0.150	0.20	16.89	0.09
8.00	10.00	7.80– 8.20	0.90–1.10	0.100	0.20	23.92	0.06
10.00	12.00	9.75– 10.25	0.90–1.10	0.100	0.23	19.57	0.08
12.00	14.00	11.70– 12.30	0.90–1.10	0.100	0.27	16.56	0.09
15.00	18.00	14.62– 15.38	1.35–1.65	0.150	0.35	8.70	0.17
18.00	20.00	17.55– 18.45	0.90–1.10	0.100	0.39	11.33	0.13
20.00	23.00	19.50– 20.50	1.35–1.65	0.150	0.46	6.67	0.18
22.00	24.50	21.45– 22.55	1.13–1.38	0.125	0.48	7.41	0.20
24.00	26.00	23.40– 24.60	0.90–1.10	0.100	0.51	8.61	0.17
25.00	28.00	24.37– 25.63	1.35–1.65	0.150	0.55	5.42	0.27
26.00	30.00	25.35– 26.65	1.80–2.20	0.200	0.59	3.85	0.39
28.00	31.00	27.30– 28.70	1.35–1.65	0.150	0.60	4.866	0.31
30.00	33.00	29.25– 30.75	1.35–1.65	0.150	0.64	4.557	0.33
32.00	35.00	31.20– 32.80	1.35–1.65	0.150	0.68	4.285	0.35
35.00	38.00	34.12– 35.88	1.35–1.65	0.150	0.74	3.933	0.38
37.00	40.00	36.07– 37.93	1.35–1.65	0.150	0.78	3.729	0.40

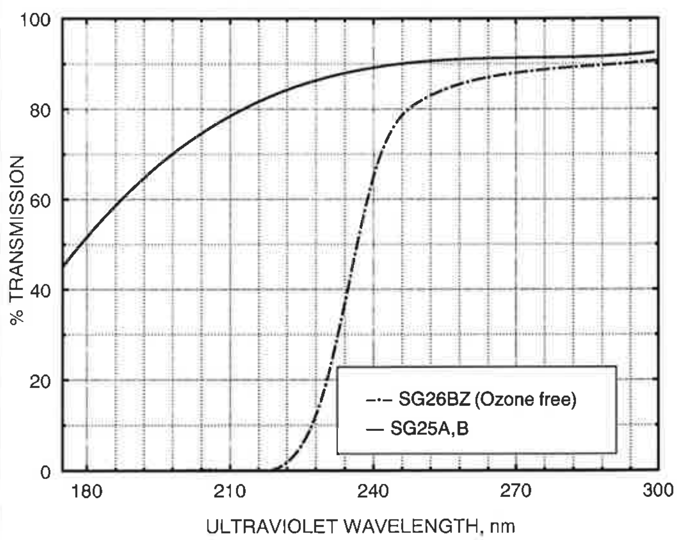
		OD RANGE (mm)				LBS/FT	
101.60	106.60	104.60–108.60	2.25–2.75	0.375	1.07	1.21	1.80
105.00	110.00	108.00–112.00	2.25–2.75	0.375	1.10	1.25	1.86
110.00	115.00	113.00–117.00	2.25–2.75	0.375	1.15	1.31	1.94
115.00	120.00	118.00–122.00	2.25–2.75	0.375	1.20	1.36	2.03
120.00	125.00	123.00–127.00	2.25–2.75	0.375	1.25	1.42	2.11
125.00	130.00	128.00–132.00	2.25–2.75	0.375	1.30	1.48	2.20
130.00	142.70	140.70–144.70	5.71–6.98	0.952	1.43	4.02	5.98
130.00	140.00	138.00–142.00	4.50–5.50	0.750	1.40	3.13	4.66
130.00	135.00	133.00–137.00	2.25–2.75	0.375	1.35	1.54	2.29
135.00	147.70	145.70–149.70	5.71–6.98	0.952	1.48	4.16	6.20
135.00	145.00	143.00–147.00	4.50–5.50	0.750	1.45	3.25	4.83
135.00	141.00	139.00–143.00	2.70–3.30	0.450	1.41	1.92	2.86
140.00	152.70	150.70–154.70	5.71–6.98	0.952	1.53	4.31	6.42
140.00	150.00	148.00–152.00	4.00–6.00	0.400	1.50	3.36	5.01
145.00	151.00	149.00–153.00	2.70–3.30	0.450	1.51	2.06	3.07
150.00	156.00	154.00–158.00	2.70–3.30	0.450	1.56	2.13	3.17
152.00	164.70	162.70–166.70	5.71–6.98	0.952	1.65	4.67	6.94
160.00	170.00	168.00–172.00	4.50–5.50	0.750	1.70	3.83	5.70
160.00	166.00	164.00–168.00	2.70–3.30	0.450	1.66	2.27	3.38
165.00	171.00	169.00–173.00	2.70–3.30	0.450	1.71	2.34	3.48
170.00	182.70	180.70–184.70	5.71–6.98	0.952	1.83	5.20	7.73
170.00	176.00	174.00–178.00	2.70–3.30	0.450	1.76	2.41	3.58
180.00	185.00	183.00–187.00	2.25–2.75	0.375	1.85	2.12	3.15
180.00	190.00	188.00–192.00	4.00–6.00	0.750	1.90	4.29	6.39
184.00	190.00	188.00–192.00	2.70–3.30	0.450	1.90	2.60	3.87
184.00	197.00	195.00–199.00	5.20–7.80	0.975	1.97	5.75	8.55
185.00	197.00	195.00–199.00	4.80–7.20	0.900	1.97	5.32	7.91
187.00	194.00	190.00–196.00	3.15–3.85	0.525	1.94	3.09	4.60
190.00	196.00	194.00–198.00	2.70–3.30	0.450	1.96	2.69	4.00
196.00	202.00	200.00–204.00	2.70–3.30	0.450	2.02	2.77	4.12
200.00	206.00	204.00–208.00	2.40–3.60	0.600	1.03	2.83	4.21
200.00	208.00	206.00–210.00	3.20–4.80	0.800	1.04	3.79	5.63
203.00	211.00	209.00–213.00	3.20–4.80	0.800	1.06	3.84	5.72
208.00	216.00	214.00–218.00	3.20–4.80	0.800	1.08	3.93	5.86
215.00	221.00	219.00–223.00	2.40–3.60	0.600	1.11	3.03	4.52
220.00	230.00	228.00–232.00	4.00–6.00	1.000	1.15	5.22	7.77
225.00	235.00	233.00–237.00	4.00–6.00	1.000	1.18	5.34	7.94
230.00	240.00	238.00–242.00	4.00–6.00	1.000	1.20	5.45	8.11
240.00	250.00	248.00–252.00	4.00–6.00	1.000	1.25	5.68	8.46
240.00	246.00	244.00–248.00	2.40–3.60	0.600	1.23	3.38	5.03
250.00	260.00	258.00–262.00	4.00–6.00	1.000	1.30	5.92	8.80
270.00	280.00	278.00–282.00	4.00–6.00	1.000	1.40	6.38	9.49
290.00	300.00	298.00–302.00	4.00–6.00	1.000	1.50	6.84	10.19
305.00	313.00	311.00–315.00	3.20–4.80	0.800	1.57	5.74	8.53
320.00	330.00	328.00–332.00	4.00–6.00	1.000	1.65	7.54	11.22
340.00	350.00	348.00–352.00	4.00–6.00	1.000	1.75	8.00	11.91

Optical Properties

- For superior discharge lamp performance, the SG25 lighting grades have virtually no hydroxyl content, as shown by the transmission at 2730nm. The maximum hydroxyl contents are 1.0ppm for grades SG25B and SG26BZ, and 5.0ppm for grade SG25A. Hydroxy-containing quartz would show a measurable reduction at 2730nm.
- Grade SG26BZ prevents ozone generation by absorbing the 185nm wave length.
- For germicidal lamps, grades SG25 and SG26 provide excellent transmission at 254nm.
- For fused quartz, the transmission (T2) at other thicknesses is given by:
  $Ln(T2) = (t_2/t_1)Ln(T1/.92) + Ln(.92)$

  Where T1 is the transmission at thickness t1
- Index of refraction 1.4585
  Optical dispersion 67.6

FUSED QUARTZ TRANSMISSION CURVES FOR LIGHTING GRADES
- Sample Thickness 1.5mm
- Includes Surface Reflection Losses



FUSED QUARTZ TRANSMISSION CURVES FOR LIGHTING GRADES
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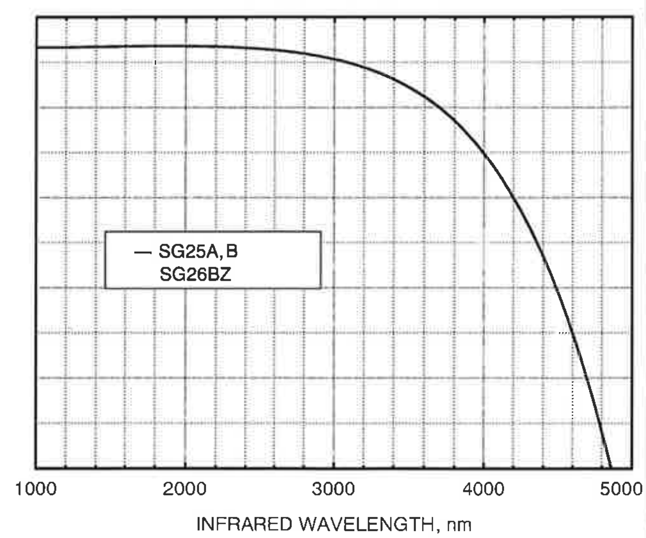
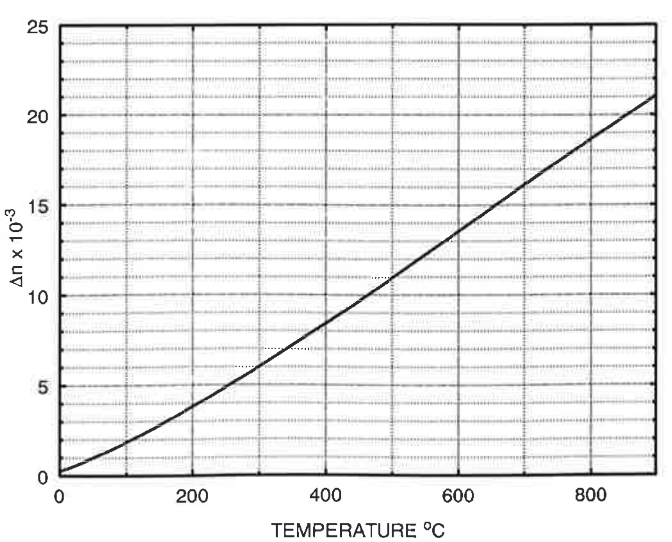
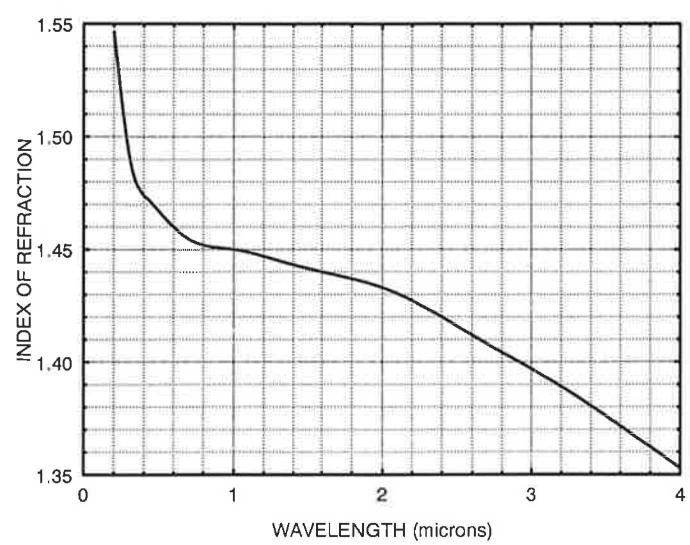


REFRACTIVE INDEX vs TEMPERATURE



REFRACTIVE INDEX vs WAVELENGTH

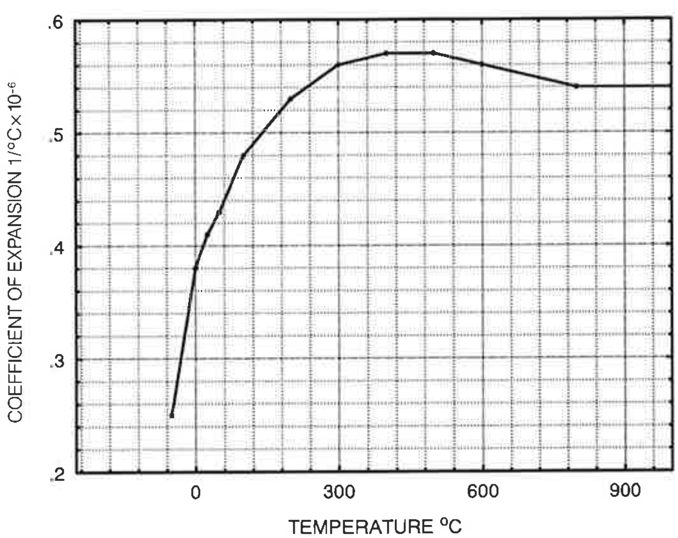


Thermodynamic Properties

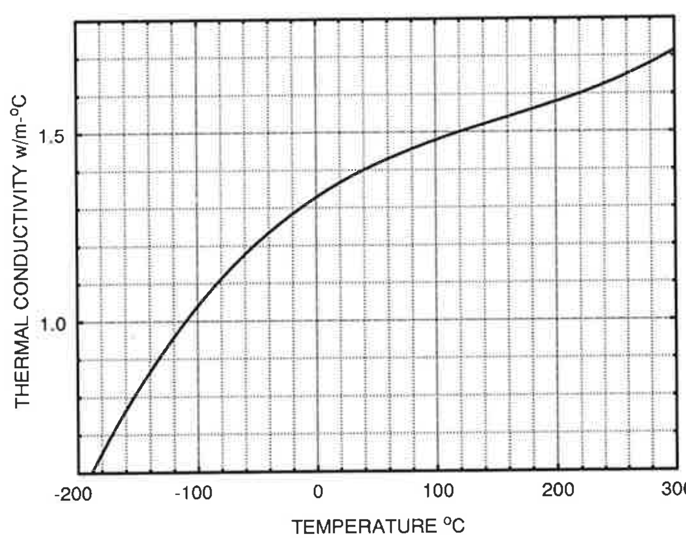
- Fused quartz has a thermal shock resistance that is superior to that of other glasses and most ceramics. This is due to the very low coefficient of thermal expansion. This property is beneficial to applications where rapid heating and cooling occurs, such as fabrication of quartzware for lighting and semiconductor processes.
- The thermal conductivity and heat capacity of fused quartz are temperature dependent, increasing with temperature.
- To optimize useful life at high temperatures, fused quartz should be cleaned just prior to use. Surface contaminants, especially the alkalis, will cause the surface to devitrify, or recrystallize, to cristobalite.
- Coefficient of thermal expansion, Thermal conductivity, Specific heat:

Coefficient of thermal expansion, 20°C–320°C	5.5×10^{-7}	cm/cm–°C
Thermal conductivity, 25°C	.00323	cal/cm-sec-°C
Specific heat, 0°C–100°C	.184	cal/g-°C

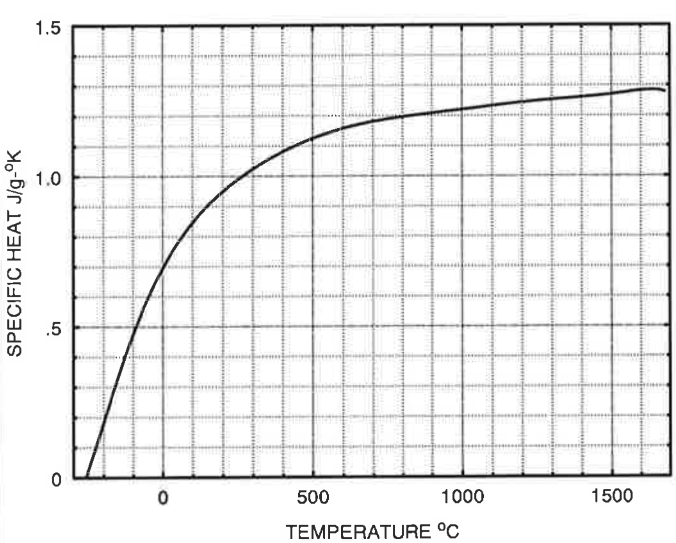
LINEAR COEFFICIENT OF EXPANSION OF FUSED QUARTZ



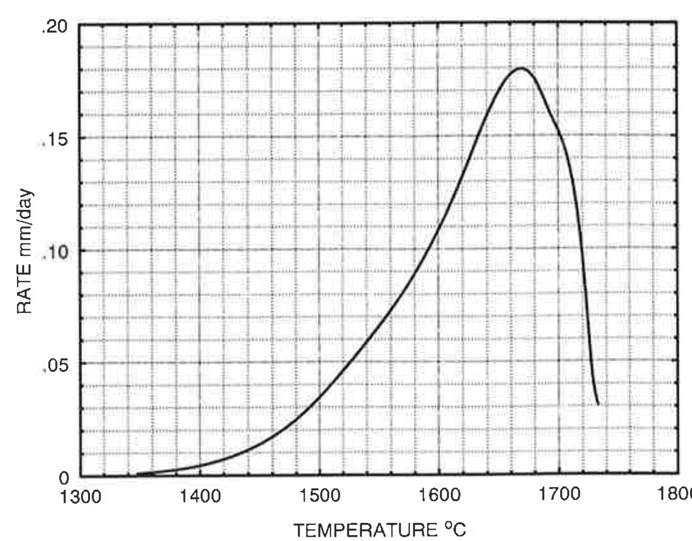
THERMAL CONDUCTIVITY OF FUSED QUARTZ



HEAT CAPACITY OF FUSED QUARTZ



RATE OF FUSED QUARTZ DEVITRIFICATION



Mechanical Properties

- The mechanical properties of fused quartz at low temperatures are similar to that of ordinary glasses.
- Surface flaws such as scuffs and scratches greatly reduce the tensile strength of all glasses, including fused quartz. For this reason, the design tensile strength is usually recommended to be 1000psi. The compressive design strength is 150,000psi.
- Viscosity is a measure of the rate at which a glass will deform or flow at a given temperature and stress. Fused quartz has the highest viscosity of all glasses. This is important to high temperature lighting and semiconductor uses.
- The annealing range for any glass is defined as the temperature range that has a viscosity range of $10^{14.5}$ poises (the strain point) to $10^{13.0}$ poises (the anneal point). For fused quartz, this range typically is 1100°C to 1210°C.

- Density 2.2 g/cc
Hardness (KHN_{50}) 590. kg/sq.mm
Modulus of elasticity 7.2×10^{10} Pa
Modulus of rigidity 3.1×10^{10} Pa
Poisson's ratio .17

Elastic Properties of Fused Quartz with Low Water Content

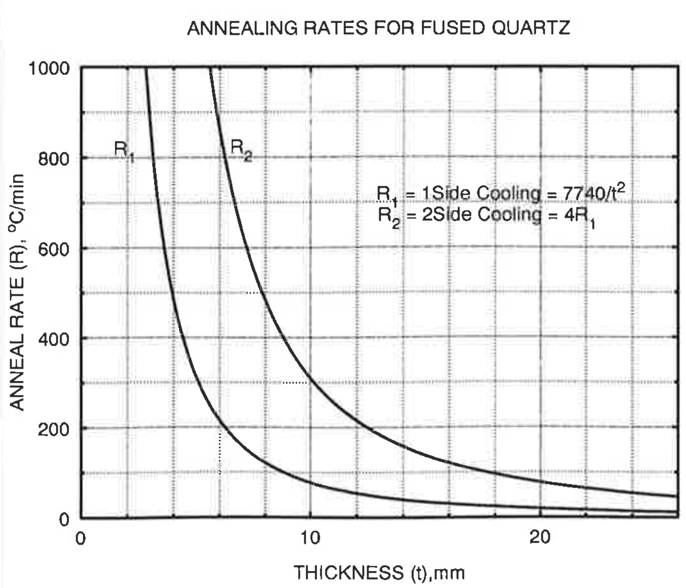
T (°C)	Young's modulus (GPa)	Shear modulus (GPa)	Poisson's ratio
25	72.9	31.3	0.165
100	74.0	31.6	0.171
200	75.1	32.0	0.173
400	77.2	32.8	0.177
600	78.7	33.3	0.182
800	80.0	33.7	0.187
1000	81.1	34.0	0.193
1100	(81.4)	(34.1)	(0.194)
1200	(81.5)	(34.1)	(0.195)
1250	(81.4)	(34.0)	(0.197)

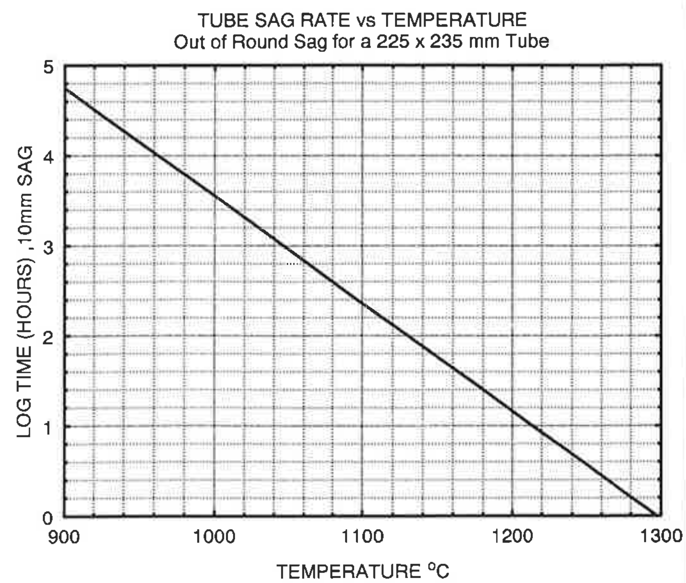
*Parenthesis indicate possible flow contributions to deformations.

Effect of Tube Size on Sag Rate

Tube Size mm	Approximate Time for 10mm OOR* Sag at 1100°C, hrs
320×330	32
190×196	133
225×235	153
184×197	575
135×141	599
160×170	680
101.6×106.6	1523

*OOR = Out-of-Round



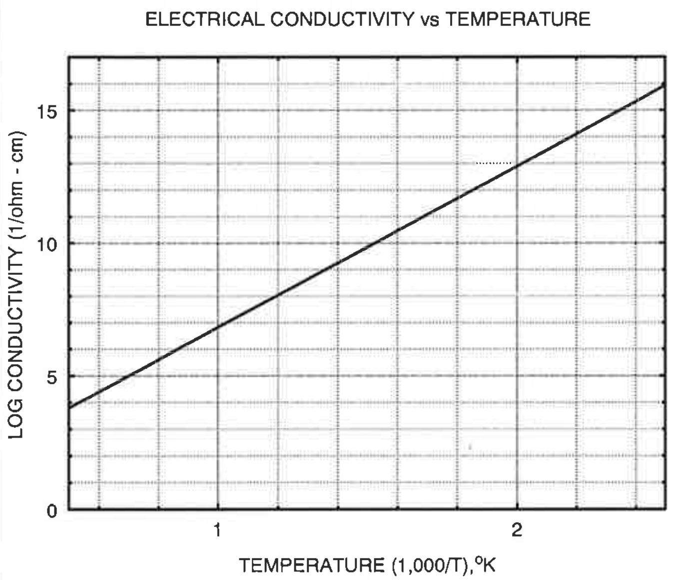


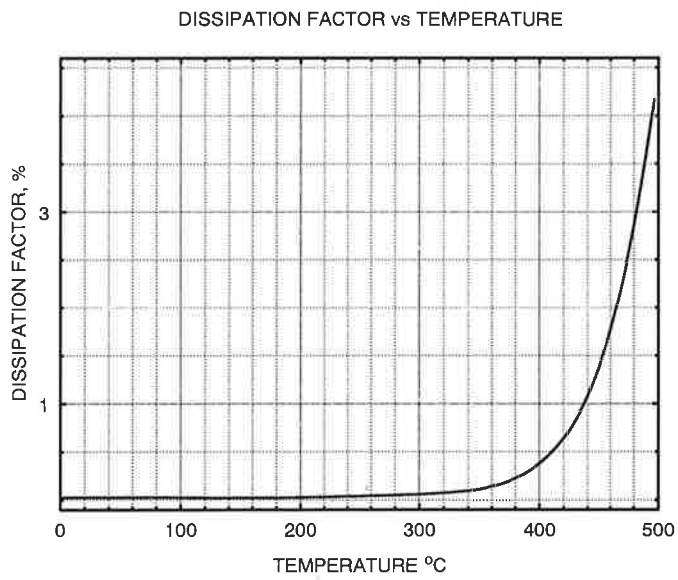
Electrical Properties

- Fused quartz has low electrical conductivity, low dielectric loss and a high dielectric strength, making it ideal for electrical insulation uses.

- Electrical Properties at 20°C, 1 MHz

Electrical resistivity	10^{18} ohm-cm
Dielectric strength	50 k-volts/mm
Dielectric constant	3.75
Dissipation factor	$< 1 \times 10^{-4}$
Dielectric loss factor	$< 1 \times 10^{-4}$





Permeability, Diffusion

- Fused quartz is impermeable to most gases. Ionic and molecular diffusion rates are very low. However, at high temperatures, certain species travel through fused quartz at appreciable rates.
- In semiconductor processes at elevated temperatures, the diffusion of contaminants from the environment outside the quartz tube is an important consideration.
- In lamps, hydrogen diffusion into the lamp atmosphere can cause disruption of the tungsten-halogen cycle, or hard starting and short life in electric discharge lamps.
- Diffusion coefficients at 1000°C, cm.²/sec, $\times 10^6$

Helium	55.
Hydrogen	7.3
Sodium	7.9
Lithium	1.0

Diffusion Coefficients of Sodium in Vitreous Silica

t,°C	D(cm²/s)	t,°C	D(cm²/s)
1000	7.9×10^{-6}	400	1.6×10^{-9}
900	3.8×10^{-6}	300	5.4×10^{-11}
800	1.6×10^{-6}	250	3.5×10^{-12}
700	5.7×10^{-7}	200	2.0×10^{-13}
600	1.3×10^{-7}	170	2.6×10^{-14}
500	1.9×10^{-8}		

Diffusion Coefficients of Various Ions in Vitreous Silica at 1000°C

Ion	D(cm²/s)
Sodium	7.9×10^{-6}
Lithium	1×10^{-6}
Silver	7×10^{-7}
Potassium	1×10^{-8}
Calcium	2×10^{-8}
Aluminum	1×10^{-13}
Phosphorus	8×10^{-14}
Nickel	1×10^{-15}
Arsenic	1×10^{-16}
Boron	1×10^{-17}

Diffusion Coefficients of Helium in Vitreous Silica as a Function of Temperature

t (°C)	D ($10^6\times$cm²/s)	t (°C)	D ($10^6\times$cm²/s)
24	0.024	490	9
78	0.11	605	16
112	0.22	700	24
148	0.37	814	36
191	0.73	860	40
284	2.0	1034	61
380	4.8		

Molecular Diffusion in Fused Silica

Molecule	Diameter (A)	Diffusion Coefficient (cm²/s) 25°C	Diffusion Coefficient (cm²/s) 1000°C	Activation energy Q[1] (kj/mole)
Helium	2.0	2.4×10^{-8}	5.5×10^{-5}	20
Neon	2.4	5×10^{-12}	2.5×10^{-6}	37
Hydrogen (deuterium)	2.5	2.2×10^{-11}	7.3×10^{-6}	36
Argon	3.2		1.4×10^{-9}	111
Oxygen	3.2		6.6×10^{-9}	105
Water	3.3		3×10^{-7}	71
Nitrogen	3.4			110
Krypton	4.2			190
Xenon	4.9			300

Chemical Properties

- Fused quartz has the highest chemical stability of all the glasses. It does not react with most materials, even at temperatures as high as 1000°C. This is important to both lighting and semiconductor applications where many exotic materials are coming in contact with fused quartz. It is reactive with hydrofluoric acid, phosphoric acid, and sodium compounds such as sodium hydroxide and sodium chloride.

Hydrofluoric Acid Dissolving Rates of Silica Phases @ 20°C

	Silica dissolved %	
Silica Phase*	In HF, 5%,½h	In HF, 1%, 1h
Quartz	30.1	5.2
Tridymite	76.3	20.3
Cristobalite	74.3	25.8
Vitreous Silica	96.6	52.9

*Samples of uniform particle size, ca 40 um in dia

Corrosion of Quartz Glass by Phosphoric Acid

Temp (°C)	Loss After 15 Hrs (mg/cm²)	Temp (°C)	Loss After 15 Hrs (mg/cm²)
0	0.0	400	7.3
100	0.0	500	7.9
200	0.0	600	11.3
300	5.8	700	23.0

Corrosion of Quartz Glass by Alkalis

Alkalis (Concentration)		Time (Hr)	Temp (°C)	Loss (mg/cm²)
Ammonium hydroxide	(10%)	100	20	0.019
Sodium hydroxide	(1%)	100	20	0.031
	(10%)	100	20	0.0095
	(5%)	10	100	1.5
Potassium hydroxide	(1%)	100	20	0.019
	(30%)	100	20	0.027
	(10%)	10	100	1.13
Sodium carbonate	(5%)	100	20	0.0015
	(10%)	10	100	0.37

Durability Vitreous Silica at 95°C

Test solution	Duration of test,h	Wt Loss, mg/cm²	Depth of Attack um
5% HCL	24	0.01	0.05
5% NAOH	6	0.7	3.2
0.02N $Na_2 CO_3$	6	0.02	0.09
5% $H_2 SO_4$	24	0.01	0.05
H_2O	24	0.01	0.05

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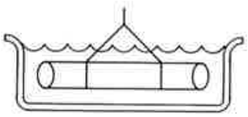
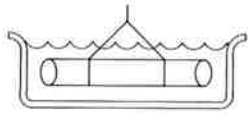
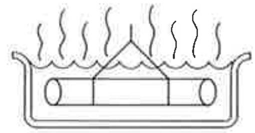
Cleaning



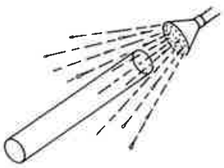
1. DI Water



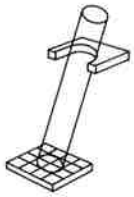
2. Acid Wash



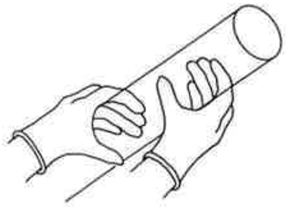
3. Hot DI Water Rinse



4. Hot DI Water Spray



5. Drip Dry



6. Handling

Good cleaning procedures will maximize the life of fused quartz. Clean surfaces will minimize the recrystallization or devitrification of fused quartz caused by non-silica contaminants. A cleaning sequence is shown that is satisfactory for both lighting and semiconductor tubing.

The initial water rinse before the acid wash serves to minimize the preferential etching of any scratches or scuffs.

The acid wash can be:

A. 5% by wt. HF for 2 - 3 minutes;
   or

B. 5% by wt. NH_4F for 10 - 15 minutes.

Other acid strengths and times may be appropriate for special situations.

Rinsing is best accomplished using hot deionized or distilled water.

Drying is best accomplished in a natural manner such as drip drying in a still, clean atmosphere. Methods commonly used to hasten drying such as wiping and/or forced air blowing around the tubes can re-contaminate the surfaces. If compressed air is used, make sure it is both oil- and water-free.

After drying, the clean tube should be:

A. handled with gloves or other equipment that is clean;

B. used in the manufacturing process as soon as possible; or

C. wrapped in clean polyethylene film for storage.

If these precautions are not taken, the maximum performance of the fused quartz will not be accomplished.

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