TOSOH Quartz Materials

Raw material	Product method	Grade
Natural crystal	Flame fused	N,NP
	Flame fused (Opaque)	OP-1,3 (HD)
	Electrically fused	HR,HRP
High pure SiO_2 powder	Flame fused	S
	Electrically fused	S (Dry)
$SiCl_4$	Direct method	ES
		ESL-1, ESL-1000
		ESL-2, ESL-2000
	VAD method	ED-A,ED-B, ED-C,ED-H

TOSOH

Fused Silica Glass (*N,OP,HR Grades*)

- TOSOH fused silica glasses are manufactured from SiO_2 powder in an oxy-hydrogen flame or electric furnace.
- TOSOH fused silica glasses have good heat resistance and are used to produce items for semiconductor manufacturing.
- OP-1 and OP-3 offer excellent heat and UV-IR blocking.

Ultra high purity fused silica glass (*S Grade*)

- S grade is an ultra high purity fused silica glass manufactured from high purity silica powder in an oxy-hydrogen flame or electric furnace.
- S grade has few bubbles and few inclusions and has good UV transparency equivalent to synthetic fused silica glass.
- S grade has no fluorescence when UV irradiated with a low pressure Hg lamp.

Synthetic fused silica glass (*ES,ED Grades*)

- TOSOH synthetic fused silica glasses are manufactured from high purity $SiCl_4$ in an oxy-hydrogen flame.
- TOSOH also uses a VAD process to produce synthetic silica glasses. This then combines high purity and low OH for excellent transmission from the DUV through IR regions.
- ES grade offers excellent laser durability. ED grades offer superior heat resistance and DUV transparency.

TOSOH Quartz Materials

Optical properties

Grade	Bubble class DIN58927	Striae (1)	Homogeneity Δn ppm	Strain nm/cm	Fluorescence λ=254nm $2mW/cm^2$	Laser durability	Radiation durability X or γ -ray	OH content ppm	Available size mm
N	0-4	—	—	<25	blue	—	dark brown	<200	□1200
NP	0-4	—	—	<25	blue	—	dark brown	<200	□1200
S	0-4	—	—	<25	None	—	dark brown	<200	□1200
ES	0	1D	—	<20	None	—	No change	600-1300	□700
ESL-1	0	1D	<20 (ϕ600)	<10	None	—	No change	600-1300	□700
ESL-1000	0	1D	<10 (ϕ350)	<10	None	Guarantee (2)	No change	600-1300	□700
ESL-2	0	3D	<10 (ϕ300)	<10	None	—	No change	600-1300	□700
ESL-2000	0	3D	<10 (ϕ300)	<10	None	Guarantee (2)	No change	600-1300	□700
ED-A	0	3D	—	<10	None	—	No change	<200	□400
ED-B	0	3D	—	<10	None	—	No change	<10	□400
ED-C	0	—	—	<10	None	—	No change	<1	□400
ED-H	0	3D	<10 (ϕ200)	<10	None	—	No change	<100	□400

(1) 1D: 1 direction striae free
3D: 3 direction striae free
(2) Specified with TOSOH own condition of KrF and ArF excimer laser damage tests.

Mechanical , thermal and electrical properties

			Fused quartz						Synthetic fused silica				
			N,NP	S	HR,HRP	OP-1	OP-3	OP-3HD	ES	ED-A	ED-B	ED-C	ED-H
	Density	$g\ cm^{-3}$	2.2	2.2	2.2	2.02	2.02	2.1	2.2	2.2	2.2	2.2	2.2
Mechanical properties	Vickers hardness	MPa	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900
Mechanical properties	Young's modulus	GPa	74	74	74				74	74	74	74	74
Mechanical properties	Shear modulus	GPa	31	31	31				31	31	31	31	31
Mechanical properties	Poisson's ratio		0.17	0.17	0.17				0.18	0.18	0.18	0.18	0.18
Mechanical properties	Bending strength	MPa	94.3	94.3	94.3	60	60	67	94.3	94.3	94.3	94.3	94.3
Mechanical properties	Compressive strength	MPa	1130	1130	1130				1130	1130	1130	1130	1130
Mechanical properties	Tensile strength	MPa	49	49	49				49	49	49	49	49
Mechanical properties	Torsion strength	MPa	29	29	29				29	29	29	29	29
Thermal propeties	Strain point	℃	1,070	1,060	1,120	1,050	1,050	1,050	970	1,060	1,110	970	1,060
Thermal propeties	Annealing point	℃	1,180	1,165	1,220	1,170	1,170	1,170	1,080	1,170	1,200	1,080	1,170
Thermal propeties	Softening point	℃	1,720	1,720	1,720	1,720	1,720	1,720	1,720	1,720	1,720	1,720	1,720
Thermal propeties	Coeffcient of thermal expansion	$\times 10^{-7} ℃^{-1}$	5.9	5.9	5.9	6.9	6.9	6.9	4.7	4.7	4.7	4.7	4.7
Thermal propeties	Specific heat (at 20℃)	$J\ kg^{-1} K^{-1}$	749	749	749	749	749	749	749	749	749	749	749
Thermal propeties	Thermal diffusivity (at 19℃)	$\times 10^{-7} m2s^{-1}$	8.3	8.3	8.3	8.4	8.4	8.5	8.5	8.5	8.5	8.5	8.5
Thermal propeties	Thermal conductivity (at 19℃)	$Wm^{-1}K^{-1}$	1.38	1.38	1.38	1.24	1.24	1.33	1.38	1.38	1.38	1.38	1.38
Thermal propeties	Viscosity (logη,1200℃)	Pa s	11.72	11.10	12.18	11.72	11.72	11.72	10.6	11.61	12.00	10.6	11.37
Electrical propeties	Dielectric constant (ε',500MHz)		3.9	3.9	3.9	3.7	3.7	3.8	3.9	3.9	3.9	3.9	3.9
Electrical propeties	Dielectric loss factor (tanδ,500MHz)	$\times 10^{-3}$	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Electrical propeties	Resistivity (at 25℃)	Ω	3×10^{15}	4×10^{15}	8×10^{15}				5×10^{15}	3×10^{15}	4×10^{15}	8×10^{15}	8×10^{15}
Electrical propeties	Volume resistivity (at 25℃)	Ω·cm	5×10^{16}	7×10^{16}	1×10^{17}				1×10^{17}	5×10^{16}	7×10^{16}	1×10^{17}	5×10^{17}

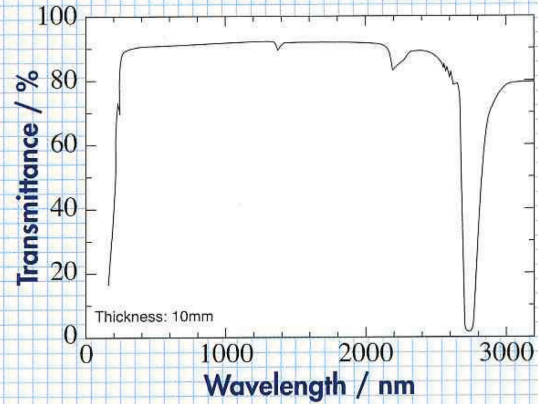
Purity

Unit:ppm

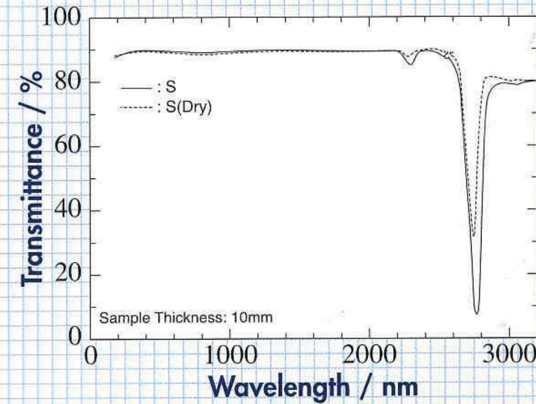
		Al	Ca	Cu	Fe	Na	K	Li	Mg	OH
Fused quartz	N	8	0.6	<0.01	0.2	0.6	0.1	<0.01	0.04	200
Fused quartz	NP	7	0.5	<0.01	0.1	0.1	0.03	<0.01	0.02	200
Fused quartz	S	0.7	<0.01	<0.01	0.05	0.1	<0.01	<0.01	<0.01	160
Fused quartz	S (Dry)	0.04	<0.01	<0.01	0.08	0.02	<0.01	<0.01	<0.01	50
Fused quartz	OP-1	8	0.7	<0.01	0.2	0.5	0.3	0.07	0.04	160
Fused quartz	OP-3 (HD)	7	0.6	<0.01	0.07	0.06	0.03	0.07	0.02	160
Synthetic fused silica	ES	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1000
Synthetic fused silica	ED-A	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<200
Synthetic fused silica	ED-B	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<10
Synthetic fused silica	ED-C	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1
Synthetic fused silica	ED-H	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<100

Spectrum UV-IR,DUV

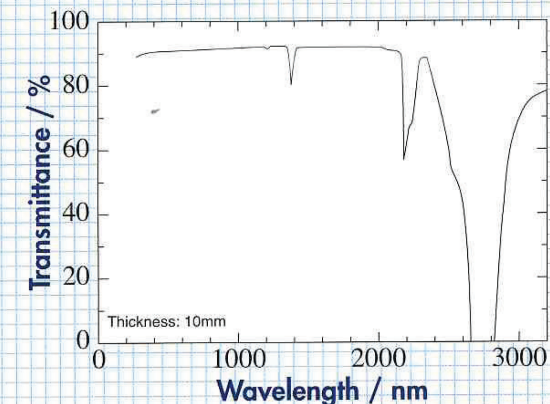
N



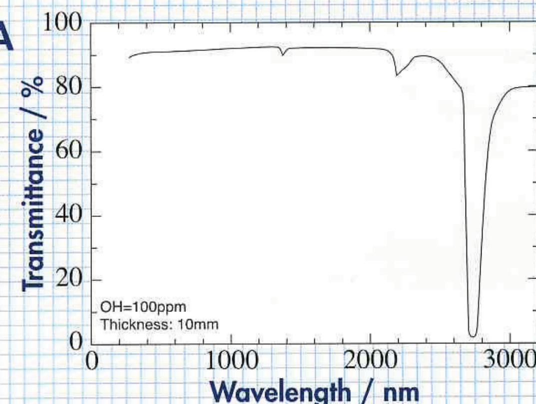
S



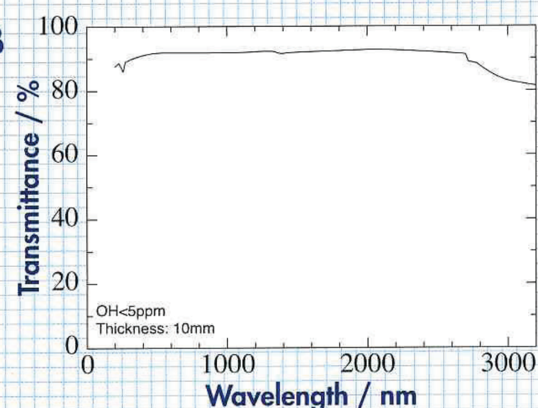
ES



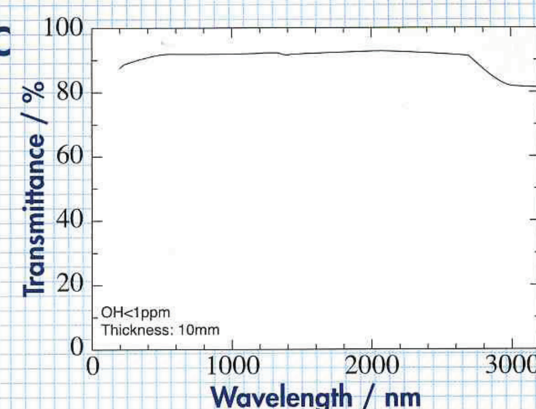
ED-A



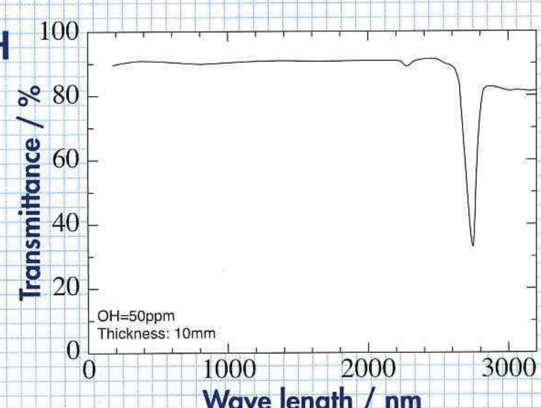
ED-B



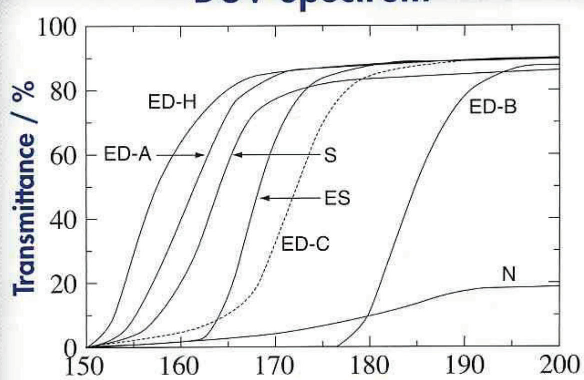
ED-C



ED-H



DUV Spectrum



Handling Precautions

Devitrification

When silica glass is exposed to high temperatures, the pure SiO_2 structure changes from a glass state (amorphous) to a stable crystalline state called cristobalite. This structural change is known as devitrification and generally occurs at temperatures of over 1,150℃ for clean clear fused quartz. Devitrification may also occur at temperatures of less than 1,000℃ if impurity exist, e.g. metal.

The relation between devitrification rate of clear fused quartz and temperatures in various atmospheres is as follows.

Gas composition	Temperature ℃	Time h	Degree of devitrification	Devitrification thickness μm
Air	1,300	72	surface perfectly devitrificated	250
Dried Oxygen	1,300	72	devitrification for 50% of all surface	100～150
Industrial Nitrogen	1,300	72	surface devitrificated	—
Nitrogen (removed O_2 and H_2O)	1,300	72	no devitrification	—
Hydrogen (removed O_2 and H_2O)	1,300	72	no devitrification	—

Handling Precautions

Care must be taken to avoid direct hand contact of fused silica. Skin's natural salts contain alkali metal elements such as sodium, potassium along with other impurities that cause accelerated devitrification. Source of metal contaminants should also be avoided.

For precaution, fused silica should be washed in pure or distilled water, then either air dried in a clean area or wiped dry with an alcohol wetted clean cloth. For more rigorous cleaning, q very thin outer layer of the glass can be removed by etching, prior to water washing, in a 5-10% Hydrofluoric acid solution.

Usage Precautions

- Always clean fused silica prior to use.
- Dry product completely before using at high temperature.
- Pay attention to devitrification due to atmosphere exposure.
- Although fused silica can resist sudden heating and quenching, it does have its limits. Please refer to the thermal properties for your application.
- Fused silica's very low thermal expansion must be considered when the glass is use d with other materials to avoid failure due to the difference in thermal expansion.
- Caution should be taken during prolonged usage at temperature approaching the yield point.
- Gradual structural deformation may occur due to the lower viscosity.

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