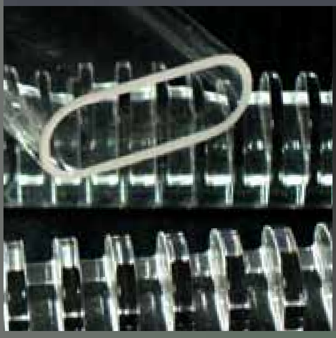
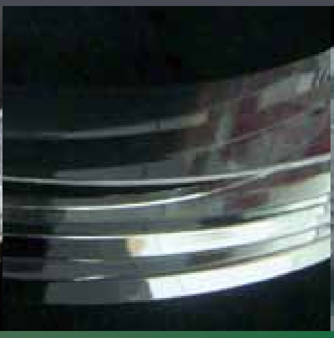
Fused Silica Glass





N Series

Tosoh N and NP materials are manufactured by fusing a high-purity silica powder using Tosoh's proprietary oxy-hydrogen flame fusion process. Thanks to its high purity, low aluminum content, and extremely low level of bubbles and inclusions, N has become the reference material for a broad range of applications:semiconductor manufacturing, metrology, optics, chemical processing, UV and high-temperature windows to name a few.

In particular, N is an enabling material for stringent plasma etch processes used in leading-edge semiconductor manufacturing.

NP is an enhanced version of N material, with further reduced alkali content for use in processes that require extreme contamination control.

Grades	Features
N	Semiconductor standard grade
NP	Semiconductor high-purity grade

Available in up to 1,200mm square ingots, N and NP materials are 450mm wafer ready.

OP Series

Tosoh OP-1 and OP-3 materials are manufactured by fusing a high-purity silica powder using Tosoh's proprietary oxy-hydrogen flame fusion process and a method of generating uniformly dispersed small bubbles inside the material. Thanks to its high purity and excellent infrared blocking properties, OP-1 has become the material of choice as a heat-insulating material for semiconductor and solar manufacturing equipment, such as RTP chambers and oxidation,diffusion, and CVD batch furnaces.

OP-3 is an enhanced version of OP-1 material, with further reduced alkali content for use in processes that require extreme contamination control.

Grades	Features
OP-1	Semiconductor standard grade
OP-3	Semiconductor high-purity grade
OP-3HD	High-density OP-3 grade

OP-3HD is a high-density version of OP-3, with a smaller diameter bubble size distribution that provides enhanced sealing properties and lifetime for advanced batch furnace processes.

Available in up to 1,000mm round and square ingots, OP-1, OP-3,and OP-3HD materials are 450mm wafer ready.

S Grade

Tosoh S material is manufactured by fusing a synthetic super high-purity silica powder using Tosoh's proprietary oxy-hydrogen flame process. Thanks to its extreme purity and complete lack of inclusions, S material is the next generation of material for semiconductor manufacturing.

Available in up to 1,200mm square ingots, S material is 450mm wafer ready.

Available size

Grades	Ingots	Large tubes		Narrow tubes		Rods
	Diameter/Side (mm)	Diameter(mm)	Thickness(mm)	Diameter(mm)	Thickness(mm)	Diameter(mm)
N, NP	□575~□1,200 ○250~○1,000	~480	~6	~35	1~2	~35
OP-1,3,3HD	□600~□1,000	NA	NA	NA	NA	NA
S	□575~□1,200	~480	~6	~35	1~2	~35

※For sizes other than those listed above, please enquire.

Impurity Level (Ave +3σ)

Unit: ppm

Grades	Al	Ca	Cu	Fe	Na	K	Li	Mg	OH
N	8	0.6	—	0.2	0.6	0.1	0	0.04	200
NP	8	0.7	—	0.1	0.1	0.05	0.07	0.04	272
OP-1	9	1.0	—	0.6	0.9	0.4	0.1	0.12	160
OP-3,3HD	9	0.7	—	0.2	0.09	0.06	0.1	0.06	160
S	1.6	0.04	—	0.05	0.18	0	0	0	347

Bubble and Inclusion levels

Unit: Counts/ft^3

Grades	Bubble diameter (mm)			
	<Φ0.3	Φ0.3~0.5	Φ0.5~1	Φ1.0<
N, NP	n.sp.	3	2	0
S	n.sp.	1	0	0

Grades	Inclusion diameter (mm)			
	<Φ0.3	Φ0.3~0.5	Φ0.5~1	Φ1.0<
N, NP	n.sp.	2	1	1
S	n.sp.	0	0	0

Tosoh N, NP, and S materials are fused in a Tosoh proprietary oxy-hydrogen flame fusion process that guarantees a significantly better level of bubbles and inclusions compared with traditional electrically fused quartz.

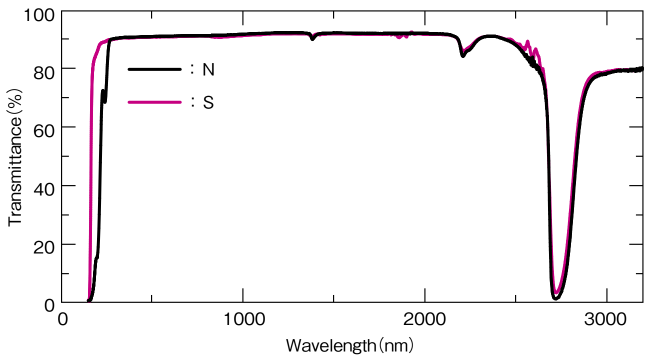
Microscopic image of bubbles and inclusions

S, NP, N

Electrically fused quartz

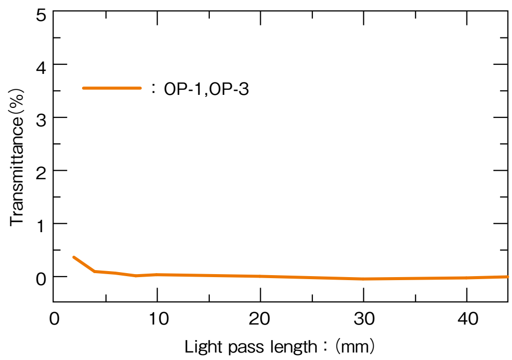
Spectral Transmission of N & S

10mm path length (Typical Data)



Transmission of OP-1 & OP-3

Wavelength:2000nm (Typical Data)



Physical Properties

	Item		Unit	N.NP	S	OP-1	OP-3	OP-3HD
Mechanical properties	Density		g/cm^3	2.2	2.2	2.02	2.02	2.1
	Young's modulus		GPa	74	74	—	—	—
	Shear modulus		GPa	31	31	—	—	—
	Poisson's ratio			0.17	0.17	—	—	—
	Bending strength *1		MPa	65~95	65~95	42~67	42~67	57~87
	Compressive strength		MPa	1,130	1,130	—	—	—
	Tensile strength *1		MPa	49	49	—	—	—
	Torsion strength		MPa	29	29	—	—	—
	Vickers hardness		MPa	8,900	8,900	8,900	8,900	8,900
Thermal properties	Strain point ($\eta=10^{14.5}$)		℃	1,080	1,070	1,070	1,070	1,070
	Annealing point ($\eta=10^{13}$)		℃	1,180	1,170	1,170	1,170	1,170
	Softening point ($\eta=10^{7.6}$)*2		℃	(1,720)	(1,720)	(1,720)	(1,720)	(1,720)
	Coefficient of expansion	30~600℃	x10^{-7}/℃	5.7	5.7	6.4	6.4	6.4
	Specific heat	at 20℃	J/kg·K	749	749	749	749	749
	Thermal diffusivity	at 20℃	x10^{-7}m^2/s	8.3	8.3	8.4	8.4	8.5
	Thermal conductivity	at 20℃	W/mK	1.38	1.38	1.24	1.24	1.33
	Viscosity (logη)	at 1200℃	Poise	12.7	12.5	12.6	12.6	12.6
Electric Prop.	Dielectric constant	500MHz		3.9	3.9	3.7	3.7	3.8
	Dielectric loss factor	500MHz	x10^{-3}	<1	<1	<1	<1	<1
	Resistivity		Ω	3x10^{15}	4x10^{15}	—	—	—
	Volume resistivity		Ω·cm	5x10^{16}	7x10^{16}	—	—	—
	Dielectric breakdown	50Hz, 20℃	V/mm	32,000	32,000	25,500	25,500	—

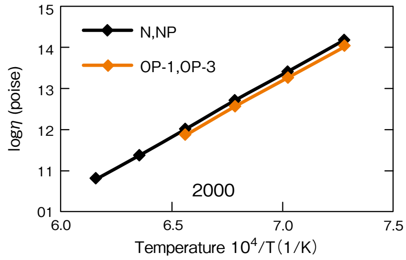
*1 Bending and tensile strengths are affected by surface conditions.

*2 Estimate from extrapolation

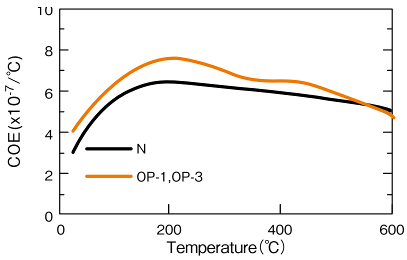
NOTE:Unless otherwise stated, all values prepresent typical data at 25℃

Thermal properties (Typical data)

Viscosity

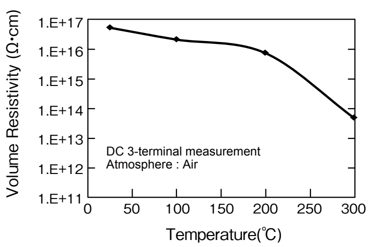


Coefficient of Expansion

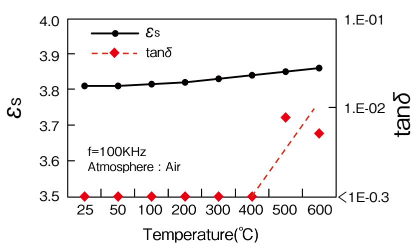


Electric properties (Typical data)

Volume Resistivity of N



Dielectric properties of N



Fused silica glass is a good electrical insulator, retaining high resistivity at elevated temperatures and excellent high-frequency characteristics.

* tanδ Lower measuring limit : 1x10^{-3}

Chemical Properties

Etching rate of fused silica glass by selected acid & alkali

Unit: μm/min. / Unit: μm/h

Grades	Solution : HF 10wt.%, 25℃ *1		Solution : KOH 10wt.%, 25℃ *2	
	F.p. surface*3	Ground surface	F.p. surface*3	Ground surface
N	0.07	0.08	0.001	0.003
S	0.06	0.08	0.001	0.005
OP-3	0.07	0.1	0.002	0.005

Etching rate is affected by solution concentration, temperature, materials, and surface condition.

*1 Etching time : 3 hours
*2 Etching time : 72 hours
*3 F.p. = Fire polished

Chemical reactivity towards other materials

Metals and nonmetals		Gases	
Al, Ag	Rapid reaction at 700-800℃	CO, SO_2	No reaction
Au, Ag, Pt	No reaction	N_2, O_2	No reaction
Zn, Sn, Pb	No reaction	Cl_2	No reaction
Si	Slight reaction when fused	F_2	No reaction with dried gases under 300℃
Ge	No reaction at 900℃	H_2	No reaction
Mo, W	No reaction	HCl	No reaction
Oxides		**Salts**	
Al_2O_3	Gradual reaction over 900℃	$BaCl_2$	Reaction when fused
CaO	Reaction over 900℃	$BaSO_4$	Reaction over 700℃
CuO	Reaction over 800℃	$CaCl_2$	Slight reaction when fused at 800℃
Fe_2O_3	Reaction over 900℃	KCl	Acceleration of devitrification at high temp.
PbO	Intense reaction with fusion	KF	Intense reaction when fused
MgO	Slight reaction at 900℃	NaCl	Reaction visually recognized over 800℃
ZnO	Reaction over 420℃	Na_2SO_4	No reaction

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 over 1,150℃ for clean clear fused quartz. Devitrification may also occur at temperatures below 1,000℃ in the presence of impurities such as metal. The relation between the devitrification rate of clear fused quartz and temperature in various atmospheres is indicated below.

Gas composition	Temp.(℃)	Time(h)	Degree of devitrification	Devitrification thickness(μm)
Air	1,300	72	Surface completely devitrified	250
Dried oxygen	1,300	72	Devitrification of 50% of the surface	100~150
Industrial nitrogen	1,300	72	Surface devitrified	—
Nitrogen (O_2 and H_2O removed)	1,300	72	No devitrification	—
Hydrogen (O_2 and H_2O removed)	1,300	72	No devitrification	—

Handling Precautions

Care must be taken to avoid direct hand contact with silica glass. The skin's natural salts contain alkali such as sodium, potassium, and other impurities that accelerate devitrification. All sources of metal contaminants should be avoided.

As a further 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-soaked clean cloth. For more rigorous cleaning, a very thin surface layer of the glass can be removed by etching, prior to water washing, in a 5% - 10% hydrofluoric acid solution.

Usage Precautions

* Always clean silica glass prior to use.
* Dry product completely before using at high temperature.
* Pay attention to devitrification due to atmospheric exposure.
* Please refer to the thermal properties for your application. Fused silica can resist sudden heating and quenching, but it does have its limits.
* Always consider fused silica's very low thermal expansion when the glass is used with other materials to avoid failure due to the differences in thermal expansion.
* Take caution during prolonged usage at temperatures approaching the annealing point.
* Be aware that slow sagging may occur under high temperature.

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