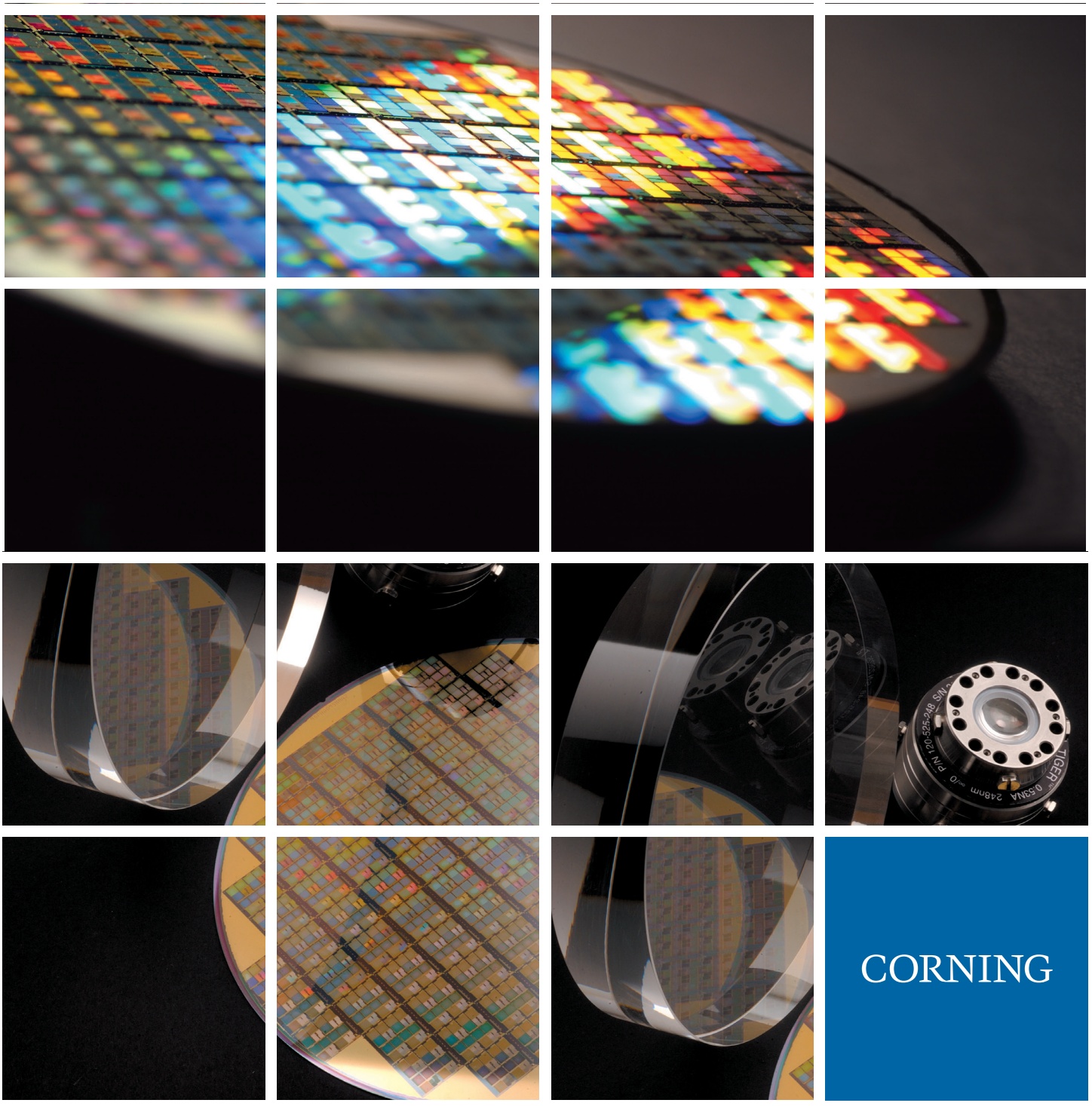
Corning® ULE® 7973 Low Expansion Glass

Optical Materials Product Information
Specialty Materials Division



CORNING

Corning ULE® 7973

7973 is a titania-silicate low expansion glass that has been tailored to meet the needs for mask and optical substrates for EUVL applications. 7973 has a similar composition to ULE® 7972 glass and is made using the same flame deposition process. The lithography transition from 193nm to 13.4nm required a major design shift in stepper optics from refractive to reflective. In reflective optics, substrate materials should be purely passive. The incident light should reflect off of the multilayer coatings of the optics and the photomask without the introduction of any mechanical or optical distortion caused by the underlying substrate. To minimize distortion from the minute temperature changes and meet the stringent EUVL specifications, the substrates must have a near-zero coefficient of thermal expansion (CTE) and tightly controlled zero cross over range. The extremely low CTE requirements are specified in parts per billion per degree Celsius (ppb/C).

Quality Grade Selection Chart
7973 EUV

Grade	Inclusion Quality	Blank Dimensions (Diameter or Diagonal)	
		< 20" (< 508 mm)	20 - 58" (508 - 1473 mm)
EUV Grades	**Critical Zone:** **Total Inclusion Cross Section:** ≤ 0.03 mm **Maximum Inclusion Size:** 0.1 mm		
	Non-Critical Zone: **Total Inclusion Cross Section:** ≤ 2.00 mm **Maximum Inclusion Size:** 1.27 mm		
EUV Mask A Grade	No visible inclusions > 0.05 mm		

Notes:
- Critical Zone — a quality layer typically extending to a depth of 0.200" (5 mm) below the surface specified by the customer for finishing.
- Non-Critical Zone — all glass outside the critical zone
- Inclusions with 0.005" (0.13 mm)or smaller mean diameter are disregarded.
- Mirror and standard grades are available in sizes up to 58" (1473 mm) diameter

7973 Summary of Key Attributes

Attribute	7973 Premium Grade	7973 Mirror Grade	7973 Standard Grade	7973 Tooling Grade	7973 EUV Premium Grade	7973 EUV Standard Grade	7973 EUV Mask A Grade
No visible inclusions > 0.05 mm							■
Low Birefringence	■				■	■	■
Low Radial CTE Range	■				■		■
Low Axial CTE Range	■				■		■
Tzc specified					■	■	■
Low Striae					■	■	■
Low Inclusions in CZ		■			■	■	■
Available in larger sizes (up to 58" diameter)		■	■				
Economical (No certification of any properties)				■			

Quality Grade Selection Chart
7973

Grade	Inclusion Quality	Blank Dimensions (Diameter or Diagonal)	
		< 20" (< 508 mm)	20 - 58" (508 - 1473 mm)
Premium	Max. Mean Diameter	0.040" (1 mm)	N/A
	No./Cu. Inch	4	
	Avg. No./Cu. Inch	0.1	
Mirror	Critical Zone:		
	Max. Mean Diameter	0.040" (1 mm)	0.080" (2 mm)
	No./Cu. Inch (No./mm³)	4 (2.4×10^{-4})	6 (3.7×10^{-4})
	Avg. No./Cu. Inch (Avg. No./mm³)	0.1 (6.1×10^{-6})	0.2 (1.2×10^{-5})
	Non-Critical Zone:		
	Max. Mean Diameter	0.100" (2.5 mm)	0.250" (6.4 mm)
	No./Cu. Inch (No./mm³)	N/S	N/S
	Avg. No./Cu. Inch (Avg. No./mm³)	0.2 (1.2×10^{-5})	0.6 (3.7×10^{-5})
Standard	Max. Mean Diameter	0.100" (2.5 mm)	0.250" (6.4 mm)
	No./Cu. Inch	N/S	N/S
	Avg. No./Cu. Inch (Avg. No./mm³)	0.2 (1.2×10^{-5})	0.6 (3.7×10^{-5})
Tooling	N/A	N/A	N/A

Optical and Thermal Properties

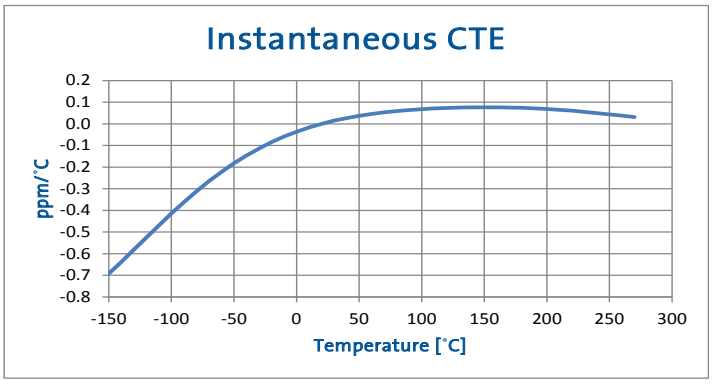
Glass Code	Striae	Optical Retardation	CTE Zero Cross Over Temperature	Coefficient of Thermal Expansion (CTE) Range	
	0 to 400 Scale [%]	Birefringence [nm/cm] maximum	T_{zc} [°C]	Radial [ppb/ °C]	Axial [ppb/ °C]
7973 Premium Grade	100	10	See note below*	≤ 10	≤ 10
7973 Mirror Grade	100	20	See note below*	≤ 15	≤ 15
7973 Standard Grade	100	20	See note below*	≤ 15	≤ 15
7973 Tooling Grade	NS	NS	See note below*	≤ 100	≤ 100
7973 EUV Premium Grade	Critical Zone: 50	10	User defined within 15 °C to 32 °C ± 5 °C	≤ 10	≤ 10
	Non-Critical Zone: 100				
7973 EUV Standard Grade	Critical Zone: 50	20	20 °C ± 10 °C	≤ 15	≤ 15
	Non-Critical Zone: 100				
7973 Mask A Grade	50	NS	20 °C ± 3 °C	≤ 6	N/A

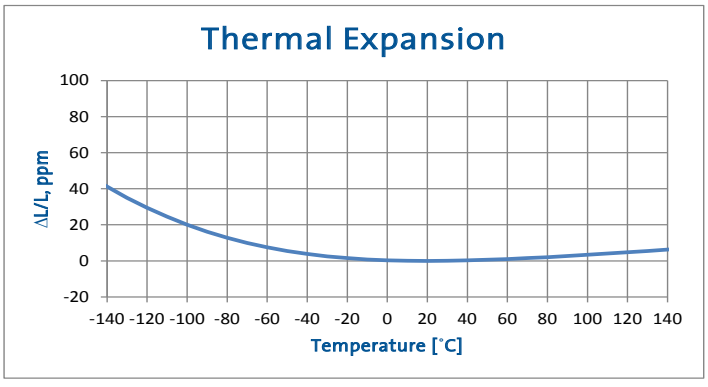
Note:
** Linear Coefficient of Thermal Expansion - The mean CTE shall be 0 ± 30 ppb/°C from 5 °C to 35 °C with a 95% confidence level and 0 ± 100 ppb/°C from 5 °C to 35 °C for Tooling Grade*

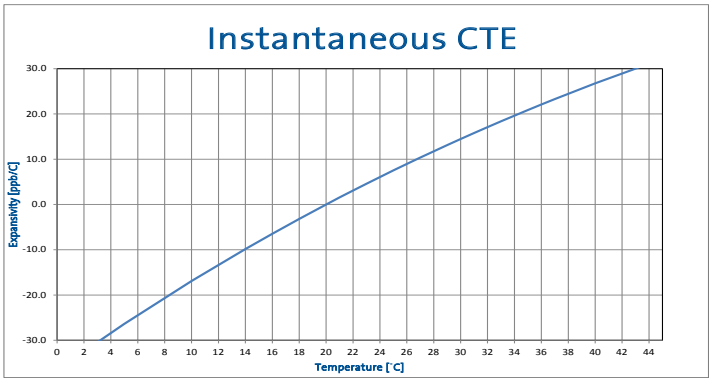
Stress Optical Coefficient	4.15 (nm/cm)/(kg/cm²)
Striae Normal to Blank Faces	None
Abbé Constant	53.1
D.C. Volume Resistivity, 200 °C 100 Hz (R)	$10^{11.6}$ ohm•cm
Thermal Conductivity (K)	1.31 W/(m•K)
Unless otherwise stated, all values above @ 25 °C	

Thermal Diffusivity (D)	0.0079 cm²/s
Mean Specific Heat (C_p)	767 J/(kg•°C)
Strain Point	890 °C
Annealing Point	1000 °C
Softening Point (estimated)	1490 °C
Unless otherwise stated, all values above @ 25 °C	

Expansivity







- CTE verification is achieved through a non-destructive ultrasonic method.
- Stability: Excellent long term dimensional stability at room temperature. No residual figure change when taking a blank from 350 °C to water quench.
- Delayed elastic effect: There has been no measurable delayed elastic effect in Corning 7973. This is an important consideration when large strain is present during fabrication or when environment loading is present, such as during gravity release or dynamic control of active optics.
- No measurable hysteresis results from thermal cycling of Corning 7973.

Chemical Durability

- Excellent resistance to weathering.
- Exhibits virtually no surface clouding or electrical surface leakage when subject to attack by water, sulfur dioxide, and atmosphere gases.
- High Resistance to attack by nearly all chemical agents.

Solution @ 95 °C	Test Duration	Weight Loss
5% HCl	24 hrs	< 0.01 mg/cm²
5% NaOH	6 hrs	0.9 mg/cm²
0.02N Na_2CO_3	6 hrs	0.02 mg/cm²
5% H_2SO_4	24 hrs	< 0.01 mg/cm²
H_2O	24 hrs	< 0.01 mg/cm²

Mechanical Properties

Unless otherwise stated, all values @ 25 °C

Elastic Modulus (E)	67.6 GPa
Shear Modulus	29.0 GPa
Bulk Modulus	34.1 GPa
Poisson's Ratio	0.17
Density	2.21 g/cm^3
Knoop Hardness (200g load)	460 kg/mm^2
Ultimate Tensile Strength	49.8 MPa
Specific Stiffness (E/ρ)	3.12 x 10^6 m

Worldwide Accessibility

We are here to help you specify the best product for your application. For further information, please contact:

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