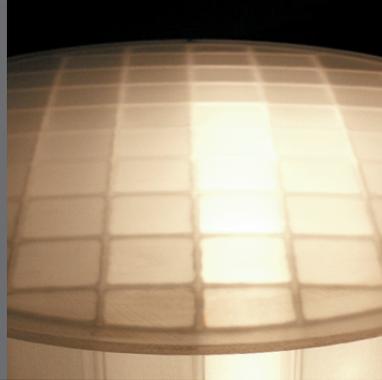


# ULE® Corning Code 7972 Ultra Low Expansion Glass



Advanced Optics  
and Materials

ULE®, Corning Code 7972 Ultra Low Expansion Glass is a titania silicate glass with unique characteristics that has made it the material of choice in applications ranging from machine tool reference blocks to solid and lightweight mirror blanks for larger astronomical telescopes and space satellite applications.

Leading industry experts in the semiconductor integrated circuits manufacturing industry have identified ULE® as a “material of choice” for EUV applications.

## **Linear Coefficient of Thermal Expansion — CTE**

The guaranteed maximum limits for absolute CTE are as follows:

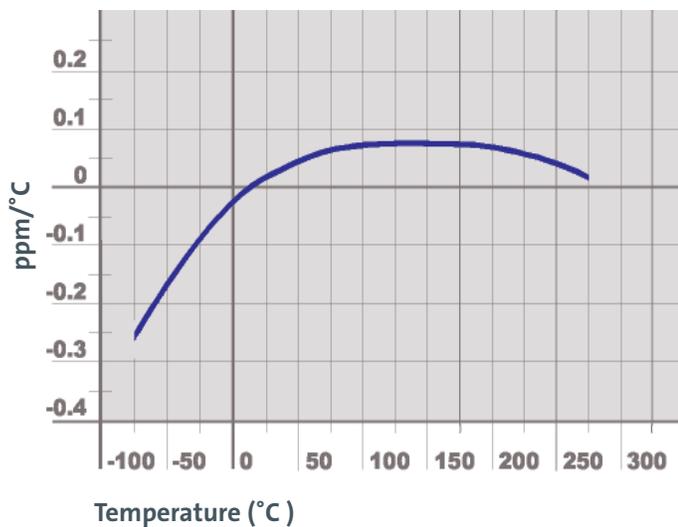
ULE® The mean CTE shall be  $0 \pm 30$  ppb/°C from 5°C to 35°C with a 95% confidence level.

## CTE Variation and Inclusion Quality Grades:

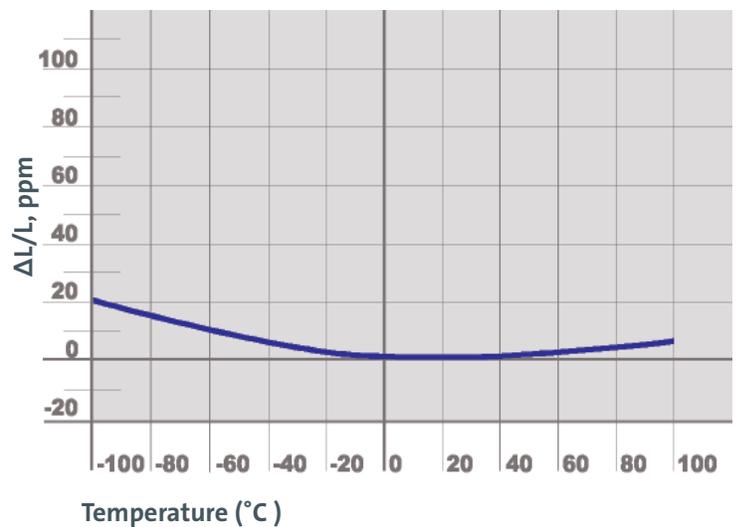
### Quality Grade Selection Chart

Grade	Maximum CTE Variation (ppb/°C)		Optical Retardation	Inclusions		
	Radia Range	Axial Range	Birefringence (nm/cm)	Inclusion Quality	Diameter < 20"	Diameter 20" to 56"
<b>Premium Grade</b>	10	10	10	Inclusion Max Mean Diameter Inclusions per cubic inch Avg. no. of inclusions per cubic inch	0.040" 4 0.1	N/A
<b>Mirror Grade</b>	15	15	20	<b>Critical Zone:</b> Inclusion Max Mean Diameter Inclusions per cubic inch Avg. no. of inclusions per cubic inch  <b>Non-Critical Zone:</b> Inclusion Max Mean Diameter Inclusions per cubic inch Avg. no. of inclusions per cubic inch	0.040" 4 0.1  0.100" N/S 0.2	0.080" 6 0.2  0.250" N/S 0.6
<b>Standard Grade</b>	15	15	20	Inclusion Max Mean Diameter Inclusions per cubic inch Avg. no. of inclusions per cubic inch	0.100" N/S 0.2	0.250" N/S 0.6
<b>Tooling Grade</b>	N/A	N/A	N/A	N/A	N/A	N/A

Instantaneous CTE



Thermal expansion



## Properties:

Unless otherwise stated, all values @ 25 °C

### Thermal Properties:

Mean coefficient of thermal expansion 5°C to 35°C ( $\infty$ )	$0 \pm 30 \times 10^{-9}/K$ [ $0 \pm 30$ ppb/°C]	Mean specific heat ( $C_p$ )	767 J/(kg • °C) [0.183 cal/(g • °C)]
Thermal conductivity (K)	1.31 w/(m • °C) [1.31 kcal/(m • hr • °C)]	Strain point	890 °C [1634 °F]
Thermal diffusivity (D)	0.0079 cm <sup>2</sup> /s	Annealing point	1000 °C [1832 °F]
D.C. volume resistivity, 200°C 100Hz (R)	$10^{11.6}$ ohm • cm	Softening point (estimated)	1490 °C [2714 °F]

### Mechanical Properties:

Poisson's ratio ( $\nu$ )	0.17	Specific stiffness ( $E/\rho$ )	$3.12 \times 10^6$ m [1.23 x 10 <sup>8</sup> in.]
Ultimate tensile stress (MOR)	49.8 MPa [7220 psi]	Shear Modulus (G)	29.0 GPa [4.20 x 10 <sup>6</sup> psi]
Knoop Hardness, 200 g load	460 kg/mm <sup>2</sup>	Bulk Modulus (K)	34.1 GPa [4.95 x 10 <sup>6</sup> psi]
Density ( $\rho$ )	2.21 g/cm <sup>3</sup> [0.079 lbs./in <sup>3</sup> ]	Elastic Modulus(E)	67.6 GPa [9.80 x 10 <sup>6</sup> psi]

### Optical Properties:

Stress Optical Coefficient	4.15 (nm/cm)/(kg/cm <sup>3</sup> ) [0.292(nm/cm)psi]	Abbe' Number ( $v_d$ )	53.1
Refractive index (nominal CTE material)	$n_F$ (486 nm) 1.4892 $n_D$ (589 nm) 1.4828 $n_C$ (656 nm) 1.4801	dn/dt	20-40°C 10.68 x 10 <sup>-6</sup> /°C 40-60°C 11.24 x 10 <sup>-6</sup> /°C

### Chemical durability:

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

Solution @ 95°C	Test duration	Weight loss
5% HCl	24 hrs.	<0.01 mg/cm <sup>2</sup>
5% NaOH	6 hrs.	0.9 mg/cm <sup>2</sup>
.02N Na <sub>2</sub> CO <sub>3</sub>	6 hrs.	0.02 mg/cm <sup>2</sup>
5% H <sub>2</sub> SO <sub>4</sub>	24 hrs.	<0.01 mg/cm <sup>2</sup>
H <sub>2</sub> O	24 hrs.	<0.01 mg/cm <sup>2</sup>

- 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 a water quench.
- Delayed elastic effect —There has been no measurable delayed elastic effect in ULE. This is an important consideration when large strain is present during fabrication or when environmental loading is present, such as during gravity release or dynamic control of active optics.
- No Measurable hysteresis results from thermal cycling of ULE regardless of the rate of temperature change.

## Notes:

- Critical Zone — a quality layer typically extending to a depth of 0.200" below the surface specified by the customer for finishing.
- Non-Critical Zone — all glass outside the critical zone:
  - Inclusions with 0.005" or smaller mean diameter are disregarded.
  - Mirror and standard grades available in sizes up to 58" diameter or diagonal by 5" thick. Corning would be pleased to quote larger sizes to customer specs.
  - Tooling grade available. Please contact Corning for availability.

## Worldwide Accessibility

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

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