

# ZERODUR® – A Zero Expansion Glass Ceramic

## Applications

ZERODUR® has become a performance- and quality-determining factor in many spectacular applications within modern technology:

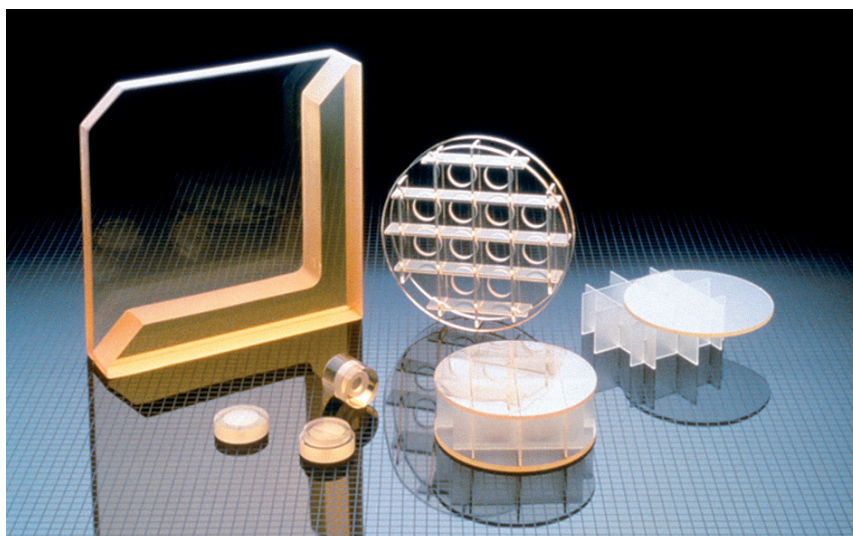
- Optical elements for lithography equipment
- High precision mechanical parts
- Mirror substrates for large astronomical telescopes
- Standards for precision measurement technology
- Mirror substrates for X-ray telescopes, weather satellites and comet probes

## Properties

ZERODUR® is a zero expansion, non-porous glass ceramic with extraordinary properties. It is widely used in applications where unavoidable temperature changes could influence critical size and distance accuracies. The most important properties of ZERODUR® are:

- An extremely low thermal expansion coefficient
- Excellent homogeneity of thermal expansion
- High internal quality
- Good workability
- Polishable to high accuracy
- Excellent chemical stability

All these properties can be realized in small components as well as in parts with weights of several tons with extraordinary reproducibility.



## Zero thermal expansion

ZERODUR® is an inorganic glass ceramic. It owes approximately 70 to 78 percent of its weight to high-quartz micro-crystallites of 30 to 50 nm in size, embedded in a remaining glassy phase. The micro-crystals contract when they are subjected to heating, whereas the glass itself expands. Size and number of the micro-crystallites are adjusted to achieve an extremely low thermal expansion. At ambient temperature the net thermal expansion is nearly zero, achieved with an accuracy of down to  $0 \pm 20$  ppb/K. Thanks to the careful temperature processing the thermal expansion of ZERODUR® is extremely homogeneous. About 4 ppb/K CTE homogeneity values have been achieved for 1 m class ZERODUR® blanks.

Properties	ZERODUR®
Density [g/cm <sup>3</sup> ]	2.53
Young's Modulus E [GPa]	90
Poisson's Ratio $\mu$	0.24
Knoop Hardness [HK 0.1/20]	620
Expansion Coefficient $\alpha$ (0 °C – 50 °C) [10 <sup>-6</sup> /K]	0 ± 0.10 (class 2) 0 ± 0.05 (class 1) 0 ± 0.02 (class 0)
Heat Capacity $c_p$ (20 °C) [J/(gK)]	0.80
Thermal Conductivity $\lambda_{90^\circ\text{C}}$ [W/(mK)]	1.46
Max. Application Temperature [°C]	600

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 glass made of ideas