

Glass Ceramic ZERODUR® for Space Application

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The zero expansion glass ceramic ZERODUR from SCHOTT is widely used for earth bound precision mirror and support structure applications. This poster shows that it is also suited for space applications. Recent developments show that high light weighting degrees are possible saving mass to be launched and that such structures are strong enough to survive launch vibrations. A series of reference applications, where Zerodur has been and is being used (ROSAT, CHANDRA, Meteosat SEVIRI, Hubble Space telescope,...) demonstrate the high and long lasting performance of Zerodur components and thus continuously enlarges the space heritage of the material.

ZERODUR® in Space: List of Successful Applications

SPOT Earth Observation Satellites



Project	Dimensions ø/mm	Weight Reduction	Orbit	Launch/Duration
SPOT 1	735 x 85	70 %	832 km	22.2.1986 – 31.12.1990
SPOT 2	735 x 85	70 %	832 km	22.1.1990 till now
SPOT 3	735 x 85	70 %	832 km	26.9.1993 – 14.11.1997
SPOT 4	735 x 85	70 %	832 km	24.3.1998 till now
SPOT 5	735 x 85	70 %	832 km	4.5.2002 till now

Weather Satellites



Project	Dimensions ø/mm	Weight Reduction	Orbit	Launch/Duration
Meteosat 5	400 x 45	65 %	36.000 km	2.3.1991 – 26.4.2007
Meteosat 6	400 x 45	65 %	36.000 km	20.11.1993 till now
Meteosat 7	400 x 45	65 %	36.000 km	3.9.1997 till now
MSG-1 Meteosat 8	530 x 830 (elliptic)	73*	Geostationary 35600 km	28.8.2002 Till now
MSG-2 Meteosat 9	530 x 830 (elliptic)	73*	Geostationary 35600 km	21.12.2005 Till now

Space Observation Satellites



Project	Dimensions ø/mm	Weight Reduction	Orbit	Launch/Duration
Giotto	250 x 30	-	Comet Halley	2.7.1985 – 23.7.1992
Hipparcos Astrometry	600 x 70	70 %	Elliptic	8.8.1989 – 6.1993
ROSAT	884 x 583 to 470 x 583	8 conic tubes	580 km	1990 - 1999
Hubble M2	300	Solid	569 km	24.4.1990 to now
CHANDRA (AXAF)	1225 x 991 to 632 x 991	12 conic tubes	Elliptical extrentric 63.5 h 10000 – 140000 km	23.7.1999 to now

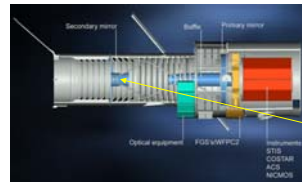
X-Ray Satellite ROSAT



- ZERODUR-Mirrors
- 4 x 2 Mirror Elements 0.85 m wide max x 0.5 m long
- Super polish: 0.2 nm
- Resolution: 2.4 arcsec in 0.1 – 2 keV in 0.04 – 0.2 keV
- In orbit 1.6.1990 to 12.2.1999
- Altitude 580 km almost circular



Hubble Space Telescope

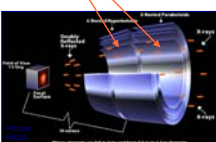


The secondary mirror is a 308 mm x 65 mm ZERODUR Mirror 12.3 kg convex hyperboloid 1.36 m radius

X-Ray Satellite CHANDRA (formerly AXAF)

X-Ray telescope with best image resolution

Key element: Wolter telescope - hollow conical cylinders made from ZERODUR



- ZERODUR-Mirrors
- 4 x 2 Mirror Elements 1.2 m wide max x 1 m long
- Super polish: 0.2 nm
- Resolution: 0.5 arcsec in 0.2 – 10 keV
- In orbit since 1999
- Altitude 10000 – 140000 km



M. Weisskopf, NASA priv. comm.:

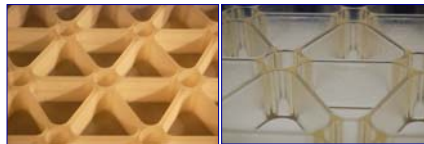
In almost 10 years of on-orbit performance (Launch July 23, 1999), we have seen no degradation in the point source response function.



Significant Progress in Light-Weighting of ZERODUR at SCHOTT

Two different ways lead to light/weighting degrees > 90 %

Grinding and subsequent acid etching



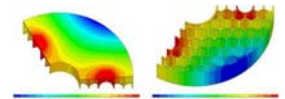
Ground to 2.5 mm thickness Etched to 0.65 mm thickness

Advanced Grinding



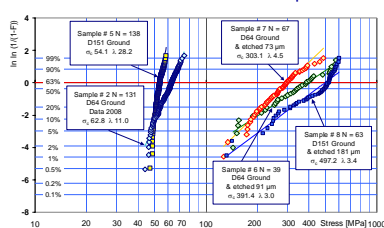
Rib thickness 2 mm
Rib height 190 mm
Curved bottom

Structure Optimization with respect to stiffness and print through via FEA



New Data on the Strength of ZERODUR

D151 / D64 Ground and Etched Samples



Even in ground state Zerodur is comparatively strong With etching the strength can be increased significantly

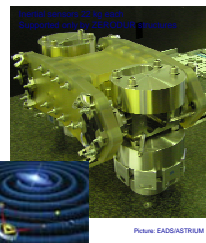
LISA Pathfinder – LISA Technology Package

LISA – The Laser Interferometer Space Antenna Project of NASA / ESA

Assembled system of inertial sensors held by ZERODUR structures

Successfully tested with 15 g sine and 18 g random vibrations

→ Major step forward in the LISA Pathfinder mission



Planned Space Applications

Project	Dimensions ø/mm	Weight Reduction	Orbit	Launch/Duration
SOFIA	2705 x 350	75 %	Jumbo Jet 14 km Stratosphere	2009
SILEX	280 x 400	Special Structure	LEO & GEO	2010
MSG-3/4	530 x 830 (elliptic)	73*	Geostat. 35600 km	2011/2013

SCHOTT
glass made of ideas