

AOX 3D PRINTED CERAPRINT™ SILICON CARBIDE (SiC) High Strength & Ultra-Stable Material Printed to Any Shape

WHAT IS SiC

SiC is a hard ceramic material containing silicon and carbon. SiC is synthesized for a wide use of applications due to its unique characteristics making it ideal for use in harsh environments.

Adaptive Optics Associates –Xinetics (AOX) SiC is a reaction-bonded SiC cermet with a matrix of SiC and silicon.

WHY USE SiC

Due to its material structure SiC is a robust, ultra-stable and non-toxic material. SiC is ideal for use in extreme environments:

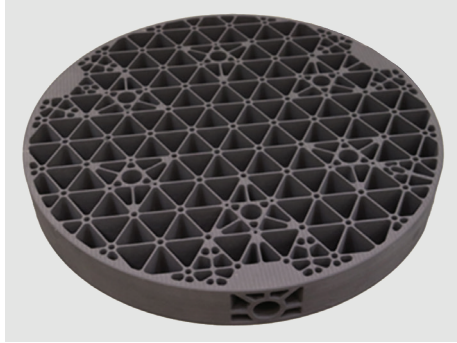
- High stress environments
 - High strength
 - High specific stiffness
 - High and unstable temperature applications
 - Low Coefficient of Thermal Expansion (CTE)
 - Low specific heat capacity
 - High thermal conductivity
 - High thermal diffusivity
 - Charged environments - Low electrical resistivity
- WHY USE AOX CERAPRINT SiC**
AOX has produced reaction-bonded SiC for over twenty years and provides:
- Field and Flight-Proven Capability
 - TRL 9
 - First 3D Printed SiC Optic in Space Mission
 - Additive manufacturing production
 - Infinite design geometries
 - Organic design manufacturability
 - 90% plus lightweighting
 - Rapid prototyping – days vs. weeks or months
 - Optical Grade Performance
 - Direct polishable and cladded super polishable options
 - Predictable uniform and repeatable material
 - Isotropic mechanical/thermal properties
 - Low residual stress
 - Zero porosity
 - Weibull Modulus: 13
 - Proven and controlled manufacturing
 - Certified for US National Security Space missions
 - A/B basis process-based material properties
 - Engineering design expertise for any environment – ground, air, and space flight
 - Design guides available for build to print

AOX 3D PRINTED CERAPRINT SILICON CARBIDE

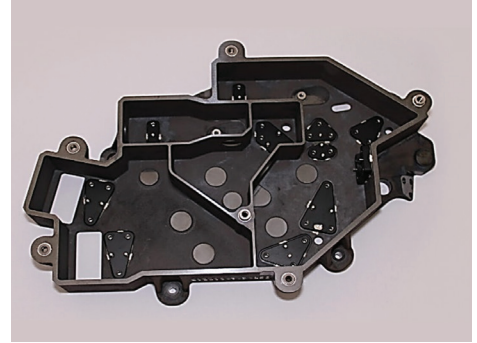
AOX CERAPRINT SiC Solutions



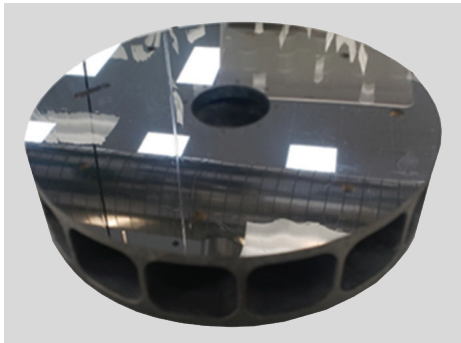
SiC Structures



Lightweight Substrates & Mirrors



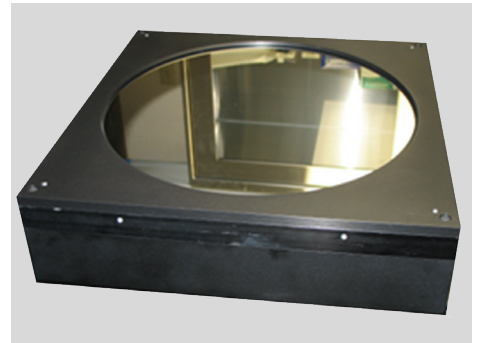
SiC Optical Benches w/ Mounting Inserts



Lightweight Fast Steering Mirrors (FSM)



SiC Systems



SiC Facesheet Deformable Mirrors

AOX CERAPRINT™ SiC VS. ALTERNATIVES

PROPERTY	DEF	UNITS	CERAPRINT SiC	BE ^{3,4}	ULE ⁵	ZERODUR ^{6,7}	AL	Si ⁸	DESIRED VALUE
Modulus of Rupture Ultimate Tensile Strength ¹	σ	MPa	330	309	50	55	276	190	High
Young's Modulus	E	GPa	328	303	68	90.3	68	160	High
Shear Modulus	σ	GPa	136	137	29		26	50	High
Poisson's Ratio	ν	-	0.208	0.07	0.17	0.24	0.33	0.26	Low
Density	ρ	kg/m ³	2900*	1850	2210	2530	2710	2330	High/Low
Coe. Thermal Expansion ^{2,9}	α	ppm/°C	2.43	11.4	0.03	0.05	22.7	2.62	Low
Thermal Conductivity ²	k	W/m°C	173	216	1.3	1.46	159	138	High
Specific Heat Capacity ²	Cp	J/kg°C	670	1820	766	800	879	713	Low
Specific Stiffness	E/ ρ	m ² /s ² x10 ⁶	113	164	31	36	25	69	High
Thermal Diffusivity	k/ ρ Cp	m ² /s x10 ⁻⁵	8.89	6.42	0.08	0.07	6.67	8.31	High
Toxicity			Low	High	Low	Low	Low	High	Low

*SiC high stiffness allows significant lightweighting for total lower weight, achievable areal density of 7 kg/m²

¹Diamond Machined Surface

²@ Room Temperature

³<https://indico.fnal.gov/event/8408/contributions/107329/attachments/70110/84068/MB-001DesigningandFabricatingBeryllium.pdf>

⁴<https://www.azom.com/article.aspx?ArticleID=7646>

⁵<https://www.corning.com/media/worldwide/csm/documents/7972%20ULE%20Product%20Information%20Jan%202016.pdf>

⁶<https://mss-p-009-delivery.stylelabs.cloud/api/public/content/3395a24104204531be2839378a783e3d?v=bca70f55&download=true>

⁷https://www.spiedigitallibrary.org/conference-proceedings-of-spie/9912/991208/ZERODUR-strength-modeling-with-Weibull-statistical-distributions/10.1117/12.2231608.full#_

⁸<https://www.azom.com/properties.aspx?ArticleID=1851>

⁹SiC CTE =0 ppm @ 100k

FOR MORE INFORMATION

Northrop Grumman AOA-Xinetics
115 Jackson Rd.
Devens, MA 01434
(978) 757-9600
aoxinfo@ngc.com