

## ***optoSiC+***

**ULTRA-HIGH PERFORMANCE NON-TOXIC  
& COST-EFFECTIVE OPTICS & STRUCTURES  
FOR THE 21st CENTURY**

# SPACE AGE MATERIAL

Originally developed for the space optics industry, alpha-grain sintered silicon carbide provides a unique combination of key advantages for the production of high performance laser and scanning mirrors, and structures.

With the development of new process production techniques a far superior and cost-effective high-strength grade *optoSiC+* material is now quantified and available with a finer homogenous grain structure, reduced density and improved flexural strength, Poisson ratio and increased mechanical reliability.

The new process produces non-porous near pure *optoSiC+* with no secondary phase, isotropic physical properties, high mechanical strength and stiffness, and is insensitive to mechanical fatigue. It also has high thermal conductivity and low coefficient of thermal expansion for high stability applications in aggressive environments.

Recent developments have also resulted in significant improvements in surface quality with a guaranteed Ra under 2nm.

Sintered SiC is a non-toxic material that has been adapted with bolting, bonding and brazing techniques, allowing the construction of large or small complex systems made entirely of silicon carbide components.

The material is homogeneous with an isotropic microstructure with a very high specific stiffness and a very high stability (low sensitivity to thermal gradients) that allows the ability to obtain very stiff, lightweight and stable structural parts.

The industrial process has been used for more than 20 years of production within the space optics and structures, automotive and chemical engineering industries, and the physical properties are further enhanced by reproducible batch-to-batch reliability.

*optoSiC+* can now be manufactured to ø400mm using the standard CNC-machined green-block and sintering process, or for large volume enquiries with piece sizes up to ø80mm by green injection moulding and sintering.

Furthermore, micro-cooling structures for the laser industry are also easily manufacturable where *optoSiC+* is not degraded by aggressive coolants, thereby collecting nor depositing debris into waterways as fine as ø0.50mm.

This advanced materials technology has been used to manufacture the largest telescope ever to be sent into space to operate in temperatures below -200°C. The European Space Agency's 3.5 metre diameter far-infrared space cassegrain reflector telescope HERSCHEL is launched in 2008 to follow previous space telescope and mirror projects manufactured by sintered SiC processes.

# PRODUCTION PROCESS

Customers may design their own optics, or supply beam footprint diagrams for our design and stress analysis team to create optics maintaining the lowest possible Moment of Inertia, taking into account required dynamic flatness performance in respect to peak acceleration loadings and crash deceleration survivability.

From the approved CAD design, the production team converts the data ready for CNC milling or injection moulding tooling, pre-scaled in preparation for equal material bulk shrinkage during sintering.

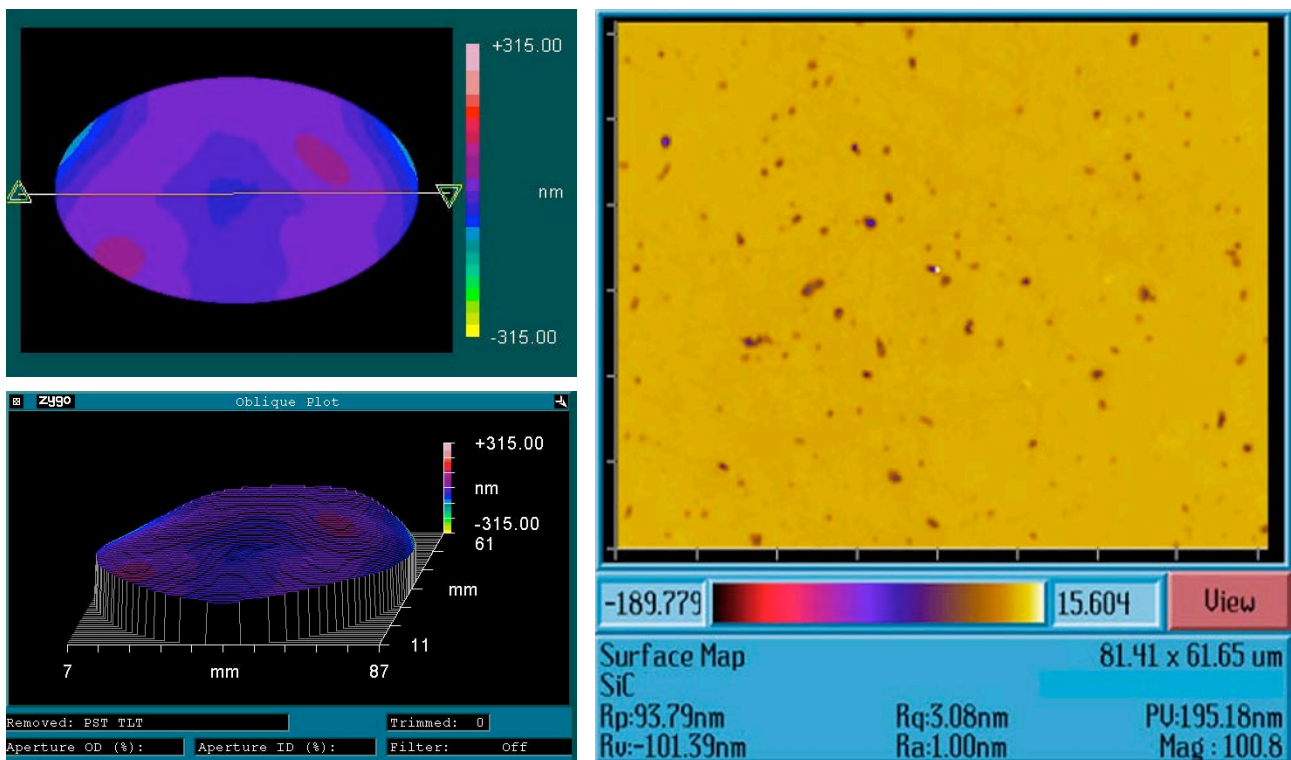
Organic binders and sintering additives are then mixed with powdered silicon carbide and then either isostatically pressed and green machined by high-speed CNC milling, or high-pressure injection moulded to produce near-net shapes.

The material then enters pressureless sintering in a non-oxidizing atmosphere. At this stage the bulk volume of the *optoSiC+* part is controlled with a well mastered technique to achieve a length tolerance  $\pm 0.4\%$ .

The piece is then finished to produce a planarity of a few hundred nanometres before detailed quality assurance tests are then made to confirm each piece is to within stated pre-polished tolerances and without microcracks.

Finally, the optical surface is polished to a Ra roughness of  $<0.002$  microns using a cost-effective, two stage process to achieve up to  $1/20\lambda$  rms flatness at 632.8nm.

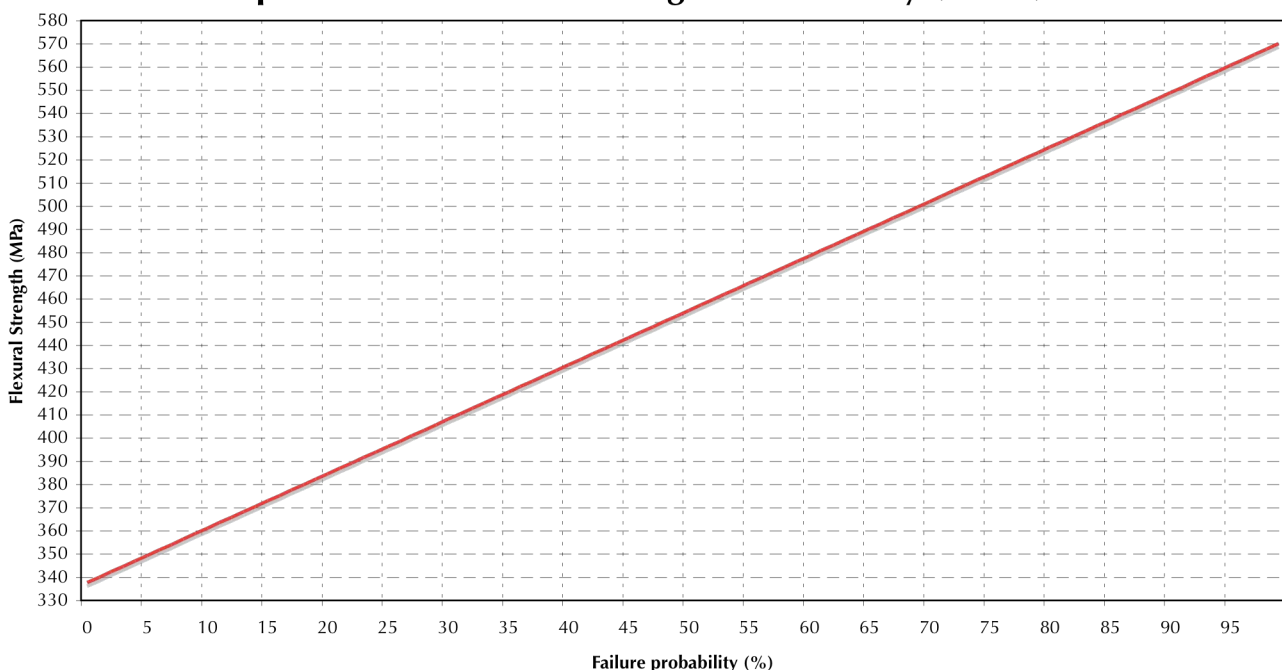
The structure is then ready to commence optical coating. An authenticated CO<sub>2</sub> laser coating is already available. Further wavelength coatings are currently in development.



# optoSiC+ PROPERTIES

Typical Characteristics		Units	Value
Physical	Crystal Structure		$\alpha$ -SiC
	Mean Grain Size	$\mu$	<5
	Density [DIN EN 623-2]	$\rho$ (g/cm <sup>3</sup> )	>3.16
	Porosity [DIN EN 623-2]	P (%)	<1.0
Mechanical	Vickers Hardness [DIN EN 843-4]	HV 1 GPa	25.5
	Knoop Hardness [DIN EN 843-4]	HK 0.1 GPa	24.5
	Flexural Strength (4-pt bending) [DIN EN 843-1]	MPa	510
	Weibull Modulus [DIN EN 843-5]	m	15
	Compressive Strength	MPa	2200
	Young's Modulus [DIN EN 843-2]	GPa	420
	Weibull Modulus [DIN EN 843-5]	m	15
	Poisson's Ratio	$\nu$	0.17
Fracture Toughness (SENB)	$K_{IC}$ [Mpa·m <sup>0.5</sup> ]	25.5	
Optical	Surface Roughness (post-polishing):	Ra	<0.002
	Polished Flatness: Standard RMS	$\lambda$ @632.8nm	1/1
	High RMS (per request)	$\lambda$ @632.8nm	1/20
Thermal	Coefficient of Thermal Expansion: [DIN EN 821-1]		
	20-500°C	$\alpha$ [10 <sup>-6</sup> /°K]	4.1
	500-1000°C	$\alpha$ [10 <sup>-6</sup> /°K]	5.2
	Thermal Conductivity at 20°C [DIN EN 821-2]	$\lambda$ [W/m·K]	125
	Specific Heat at 20°C [DIN EN 821-3]	$C_p$ [J/g·K]	0.6
	Thermal Stress Parameters (calculated):		
$R_1 = \sigma_B \cdot (1-\nu) / (\alpha \cdot E)$	R1 [K]	246	
$R_2 = R_1 \cdot \lambda$	R2 [W/mm]	31	
Electrical	Specific Resistance at 20°C [DIN EN 50359]	$\rho$ [ $\Omega$ cm]	10 <sup>6</sup> - 10 <sup>8</sup>
Chemical	Corrosion Resistance Weight Loss in H <sub>2</sub> SO <sub>4</sub> @100°C	mg/cm <sup>3</sup> year	<10

## optoSiC+ Mechanical Strength & Reliability (m=15)



# optoSiC AG SERVICES

## Design:

From customer supplied beam footprints our team are available to design the mount area, optical face, spine and ribs to produce the optimum balance.

## Stress Analysis:

Our stress analysis designers can then take this data and make further refinements to guarantee dynamic flatness under expected applied loads and optimize the design specific to the required performance.

## *optoSiC+* Production:

The design will then begin CNC design and tooling preparation ready for manufacturing.

## Batch Management:

Because many applications require optics manufactured in specific sets, and because tooling, polishing plate sizes, coating yields and process machine capacities determine run repeat length divisions, optoSiC will advise on the optimum batch quantity to maximize cost-efficiencies and supply times.

## Contact:

optoSiC AG  
Im Rollfeld 6  
D-76532 Baden-Baden  
Germany

Tel: +49 (0) 72 21 97 39 74-0  
email: [info@optosic.com](mailto:info@optosic.com)  
[www.optosic.com](http://www.optosic.com)

