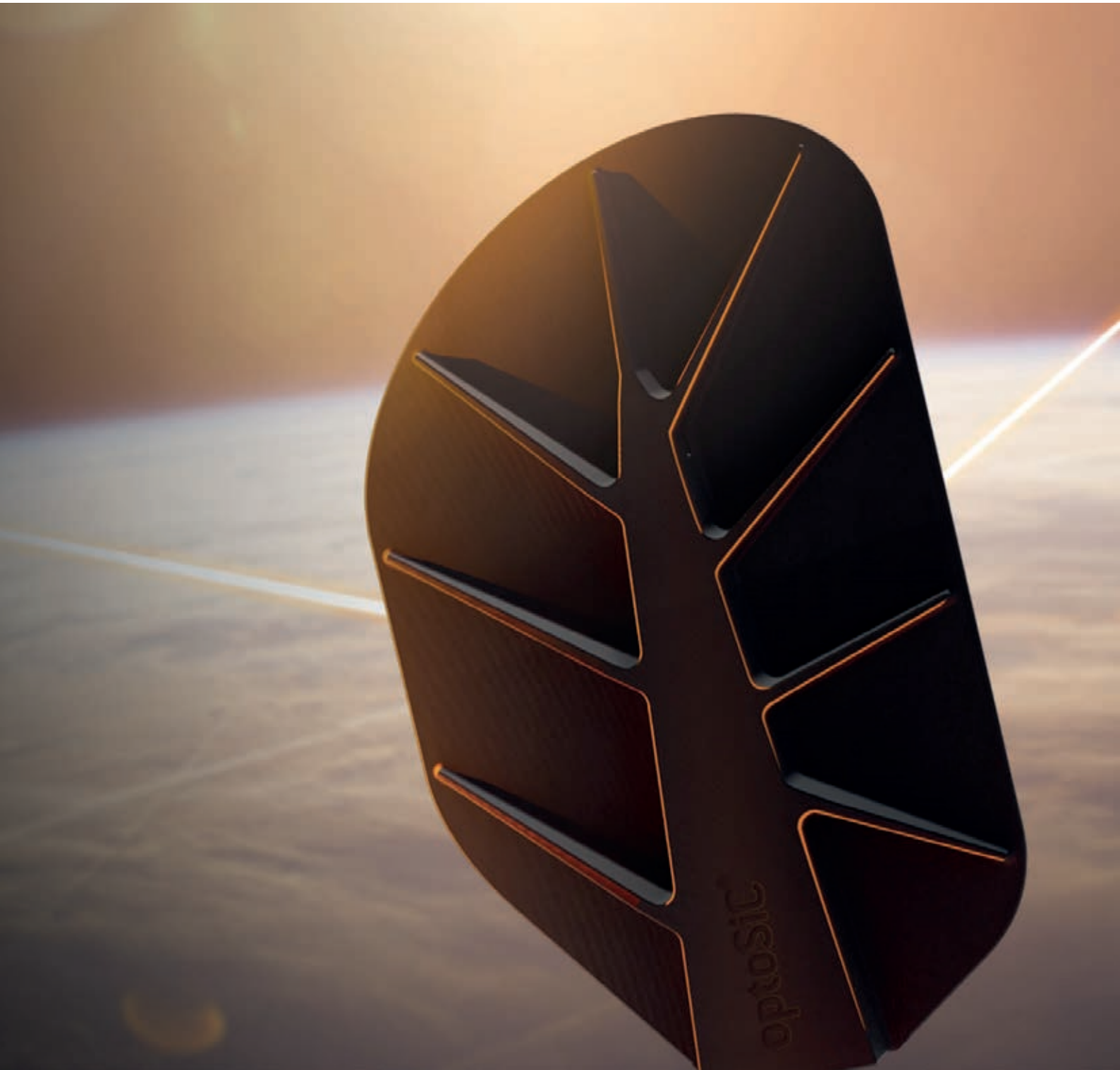




OPTOSIC®  
SIC OPTICS FOR  
HIGH-END LASER  
PROCESSES



# optoSiC<sup>®</sup> optics for high-end laser processes

Mersen develops and produces innovative scanning with galvanometer (galvo-scanning) mirrors in a tailored optoSiC+ ceramic material (SiC = silicon carbide) for today's and future applications.

Mirror products made by optoSiC<sup>®</sup> are the enabling components for the high speed galvo-scanning technology as they are optimized in stiffness, light weight and dynamic performance in order to move the laser-beam in a fast, precise and reliable way.

Our highly qualified team can rely on numerous years of experience within the laser industry from design up to production; thus we are the internationally leading supplier in this technology.

## THE ADVANTAGE OF OPTOSIC<sup>®</sup> MATERIAL

- High stiffness
- High dimensional & thermal stability
- High thermal conductivity, low CTE
- Good radiation hardness
- Low intrinsic stress
- Uniform microstructure, dense
- Geometry near net shape
- Nontoxic (beryllium replacement)
- Vacuum and cryo usage

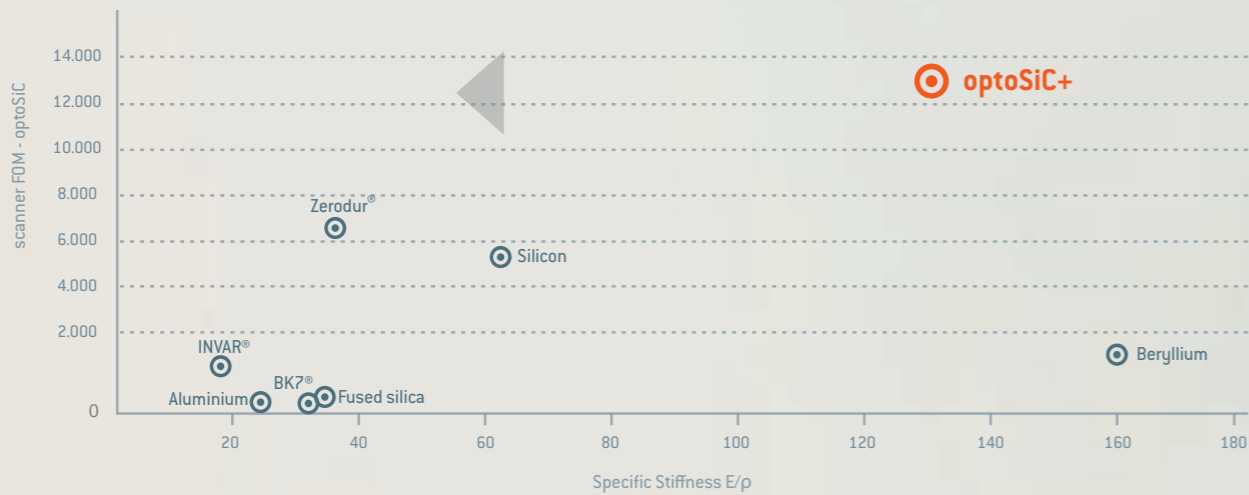
advantage



# Why optoSiC+ in optical systems?

## MATERIAL COMPARISON WITH FOM (figure of merit)

	Diamond	Beryllium S-200FH	Silicon	Aluminium AlZnMg- Cu0,5	INVAR® 6061-T6 32-45Ni	Zerodur® DKO	BK7® -Glas N-BK7	Fused-si- lica FS	optoSiC+ SiC-ceramic	
Bulk Density /	g/cm <sup>3</sup>	3,52	1,85	2,33	2,78	8,00	2,53	2,51	2,20	3,17
Young's Modulus / E	GPa	1141	295	148	70	148	90,3	82	72	420
Fract. Toughness / K <sub>IC</sub>	(MPa·m <sup>1/2</sup> )		12	1,5	20		0,9	1,3	1,2	4
Flexural strength 3pt-bend / σ <sub>b</sub>	MPa	750	261	65	270	455	490		90	510
mean specific heat at 20° C / Cp	J/(g·K)	0,52	1,95	0,685	0,86	0,5	0,8	0,86	0,79	0,6
Thermal conductivity / k	W/m·K	2000	216	150	120	13	1,46	1,11	1,31	150
CTE 2 (25-100°C) /	ppm/K	1	11,4	2,6	27	0,5	0,01	7	0,5	2,5
FOM ( optoSiC) = k * E / (α * ρ * Cp)	Rel units	1,248,495	1,549	5,350	130	962	6,514	6	109	13,249
Specific Stiffness	E / ρ	324,6	159,5	63,5	25,2	18,5	35,7	32,7	32,7	132,5
Thermal Stability	k / α	2000,0	18,9	57,7	4,4	26,0	146,0	0,2	2,6	60,0



## MERSEN QUALITY CONTROL

### Mersen products are quality controlled at three separate stages:

- Post-sintering aspect ratio tolerance and micro-crack inspection. Inspected parts are traceable with unique ID markings for product type and serial number.
- Post-polishing metrology and interferometry
- Post-coating reflection, environmental, abrasion and adhesion tests

We do provide every product with a unique ID number to ensure the traceability in our quality control system.

# optoSiC+ Material Facts

	OPTOSIC+®	BERYLLIUM
HEAT CAPACITY	LOWER	HIGHER
THERMAL EXPANSION	LOWER	HIGHER
DYNAMIC STIFFNESS	HIGHER	LOWER
	FINISHED OPTICAL SURFACES DIRECTLY IN THE BULK MATERIAL	
COATABILITY	MANY LOW STRESS COATING CHOICES VERY GOOD COATABILITY	ADHESION CRITICAL/ PEAL-OFF ISSUE CONTACT LAYER/ REJECTS
POSITIVE TRADEOFFS	MECHANICALLY AND THERMALLY STABLE UNLIMITED AVAILABILITY NO WASTE LOG SAFETY: ROHS CONFORMITY	NOT THERMAL OPTIMUM RESTRICTED AVAILABILITY AND TRACEABILITY OF DISPOSALS TOXIC PARTICLES WHEN PULVERIZED

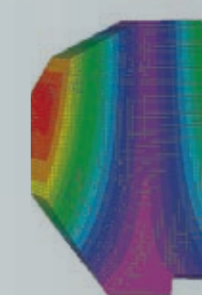
## BEST FIT MIRRORS IN DIFFERENT MATERIALS COMPARED AT STANDARD ANGLE-ACCELERATION RATE (5000 rad/s<sup>2</sup>)



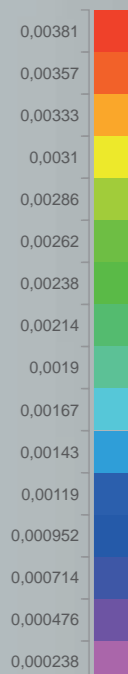
**SiC optoSiC+**  
Deformation  
± 0,32 μm



**Beryllium**  
Deformation  
± 0,51 μm



**Fused silica**  
Deformation  
± 3,79 μm



# GALVO

optoSiC manufactures high-performance laser galvo scanning mirrors from 4mm to 500mm apertures for single pair consumption with a range of high reflective coatings.

## OPTOSIC® MIRRORS FOR STANDARD LASER APPLICATIONS

Mersen manufactures standard Generic “one-size-fits-all” XY laser galvo scanning mirrors from 4mm to 100mm apertures for single pair consumption with a range of high quality reflective coatings. Our customers have the option to get the mirrors with and without a glued mount in all standard shaft sizes. Furthermore, we are able to manufacture in accordance to customer specifications. OEM products in different grades of SiC up to 1000mm and more in geometry are available on request.

### MARKET SEGMENTS FOR OPTOSIC® HIGH-END SCANNING MIRRORS

- High power laser material processing at UV - IR wavelengths
- Directed energy: ultra-high power laser system resonators
- Airborne and space scanning systems, avionic microsatellite mirrors for UAVs
- Bio / medical ophthalmology
- Streak camera-mirrors, targeting application, high-speed photography
- Security, reconnaissance, surveillance
- Sensing applications LIDAR
- Additive Manufacturing
- Kinematic mounts and optical benches

### WHY OPTOSIC+ MATERIAL FOR YOUR APPLICATION?

OptoSiC+ silicon carbide is an advanced ceramic material developed for high end applications in the laser galvo-scanning industry. This unique material has the highest combination of thermal and mechanical stability of any material which can be optically polished making it perfect for high performance lightweight scan mirrors.

Other applications for this ceramic optics mounted on space and airborne systems for imaging like laser targeting and point to point communication.

Application CA mm	Standard polished WF	Standard mount shaft sizes					
		3mm	5mm	6mm	7mm	10mm	12mm
10mm	$\lambda/8$ PV 1064nm $L/2$ PV 10600nm	✓	✓				
15mm	$\lambda/8$ PV 1064nm $L/2$ PV 10600nm		✓	✓	✓		
20mm	$\lambda/8$ PV 1064nm $L/2$ PV 10600nm		✓	✓	✓		
25mm	$\lambda/4$ PV 1064nm $\lambda/2$ PV 10600nm					✓	
30mm	$\lambda/4$ PV 1064nm $\lambda/2$ PV 10600nm					✓	
35mm	$\lambda/4$ PV 1064nm $\lambda/2$ PV 10600nm					✓	
40mm	$\lambda/4$ PV 1064nm $\lambda/2$ PV 10600nm					✓	
45mm	$\lambda/4$ PV 1064nm $\lambda/2$ PV 10600nm						✓
50mm	$\lambda/4$ PV 1064nm 1L PV 10600nm					✓	✓
66mm	$\lambda/2$ PV 1064nm 1 L PV 10600nm						✓
75mm	$\lambda/2$ PV 1064nm 1 $\lambda$ PV 10600nm						✓
100mm	$\lambda/2$ PV 1064nm 1 $\lambda$ PV 10600nm						✓

## REFLECTING PERFORMANCE

We manufacture high-performance fast steering mirrors from 15,5mm to 300mm apertures with a range of high reflective coatings.

### MARKET SEGMENTS FOR OPTOSIC FAST STEERING MIRRORS

- Optical instruments
- Laser Point-to-Point communication
- Laser Scanning
- Cameras
- Laser Beam Stabilization
- Image Stabilization
- Telescopes
- Laser Tracking
- Electro optic systems embedded on airplanes, helicopters, unmanned aerial vehicles (UAV), satellites, spacecrafts, etc...

## OPTOSIC® MIRRORS ULTRA-HIGH PERFORMANCE WITH FAST STEERING MIRRORS IN SiC MATERIAL

Fast Steering Mirrors (FSM) in optoSiC+ compensate for input tilt errors generated in a laser and beam-delivery-system. Due to the stiffness of optoSiC+ material, weight savings and high reflectivity our customers are able to increase the performance of their applications.

We offer standard and customized FSM from 15,5mm to 300 diameter. A wide range of monolithic mount solutions allows the customer to replace standard low performance mirrors with SiC high-end mirrors that best fits their specific application.

### FSM-R

		FSM-R 90	FSM-R 110	FSM-R 130	FSM-R 150
Clear Aperture/Part-Dimension	(mm)	90	110	130	150
FS Thickness	(mm)	2,5	2,5	2,5	2,5
Total Thickness	(mm)	11,5	11,5	11,5	11,5
Mass	(g)	83	110	142	179
Moment of Inertia	(g*cm <sup>2</sup> )	449	793	1367	2268
Optical axis, height above CoG	(mm)	3,49	3,04	2,71	2,46

### FSM-T

		FSM-T 25	FSM-T 31	FSM-T 36	FSM-T 41
Clear Aperture/Part-Dimension	(mm)	25,4	31	36	41
FS Thickness	(mm)	1,5	1,5	1,5	1,5
Total Thickness	(mm)	6,5	6,5	6,5	6,5
Mass	(g)	3,6	4,8	6,0	7,5
Moment of Inertia	(g*cm <sup>2</sup> )	1,31	2,5	4,28	6,95
Optical axis, height above CoG	(mm)	2,07	1,74	1,54	1,38

### FSM-RT

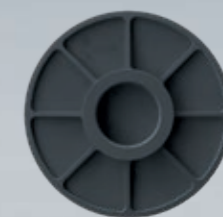
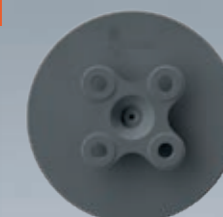
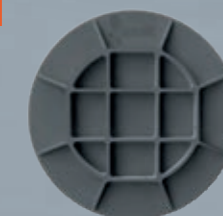
		FSM-RT 31	FSM-RT 65	FSM-RT 165
Clear Aperture/Part-Dimension	(mm)	31	65	165
FS Thickness	(mm)	1,0	2,0	3,8
Total Thickness	(mm)	4,1	9,2	26,5
Mass	(g)	3,5	27	459
Moment of Inertia	(g*cm <sup>2</sup> )	1,78	62,2	6799
Optical axis, height above CoG	(mm)	1,10	2,00	6,53

### FSM-3

		FSM-3_54	FSM-3_62
Clear Aperture/Part-Dimension	(mm)	54*75	62*86
FS Thickness	(mm)	2,5	2,5
Total Thickness	(mm)	8,6	8,6
Mass	(g)	35,6	45,8
Moment of Inertia	(g*cm <sup>2</sup> )	130	231
Optical axis, height above CoG	(mm)	2,08	1,9

### FSM-4

		FSM-3_54	FSM-3_62
Clear Aperture/Part-Dimension	(mm)	54*75	62*86
FS Thickness	(mm)	2,5	2,5
Total Thickness	(mm)	8,6	8,6
Mass	(g)	37,4	47,6
Moment of Inertia	(g*cm <sup>2</sup> )	132	233
Optical axis, height above CoG	(mm)	2,33	2,1



# MINI SiC

## NEW AT OPTOSIC!

We proudly present the newest member of the optoSiC family: our miniSiC - the world's smallest scanning mirror in our unique optoSiC+ material (SiC = Silicon Carbide). Even with sizes of 4 and 5 mm our SiC mirrors provide the material's advantages of a low moment of inertia, high resonance frequency and outstanding optical surface quality. Like for all of our products we will be glad to assist you with flexible designs and customized coating services.



### MARKET SEGMENTS FOR OPTOSIC+ MINISIC:

- High power laser material processing at UV - IR wavelengths
- Bio / medical ophthalmology
- Sensing applications LIDAR
- Microlithography

## OPTOSIC® MIRRORS FOR STANDARD LASER APPLICATIONS

### XY4F

	FS Thickness 0,6mm		FS Thickness 0,8mm		FS Thickness 1,0mm	
	X	Y	X	Y	X	Y
Mass [g]	0,07	0,13	0,09	0,18	0,11	0,22
Moment of inertia [MOI g*cm <sup>2</sup> ]	0,19	0,46	0,34	0,63	0,42	0,8



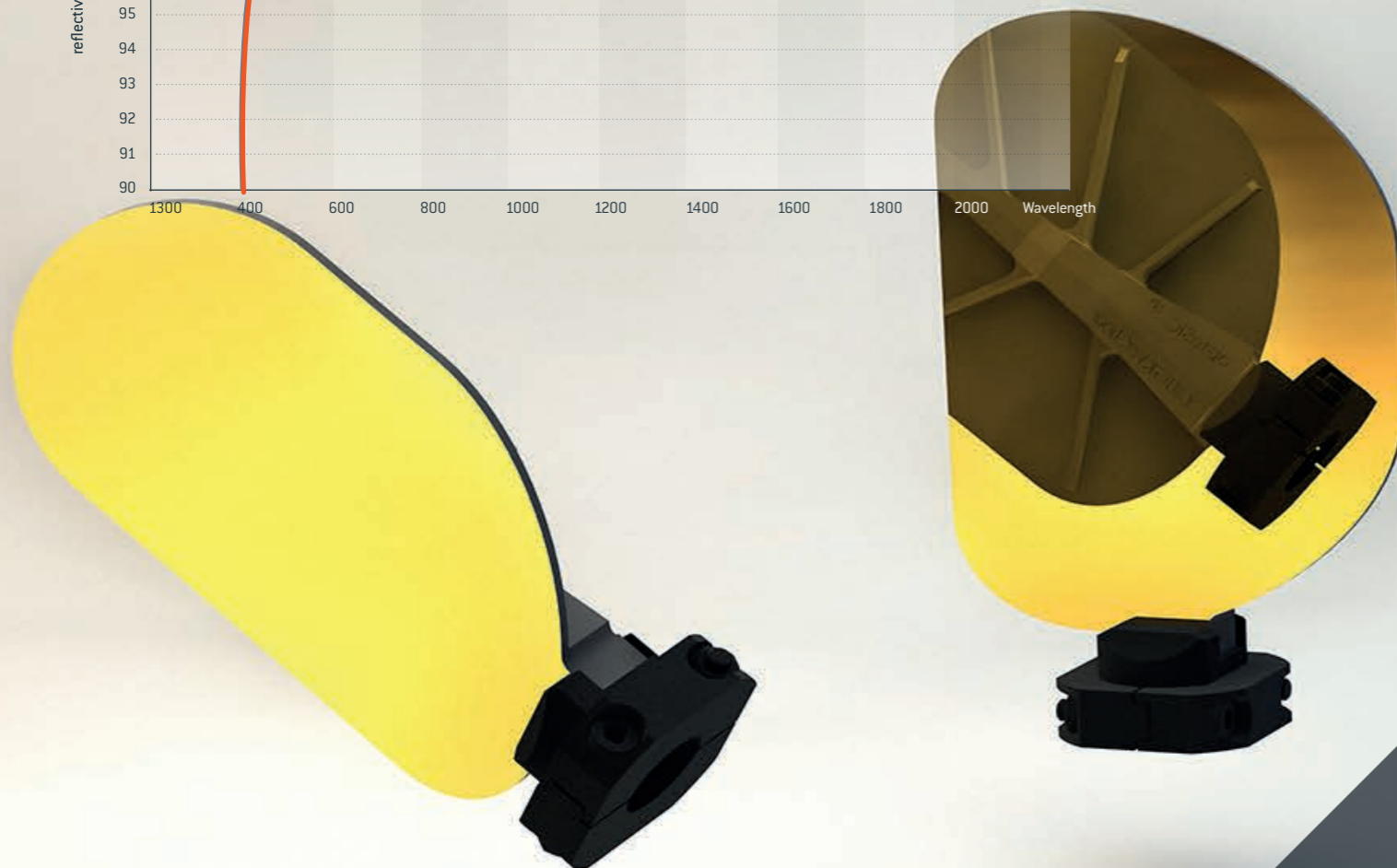
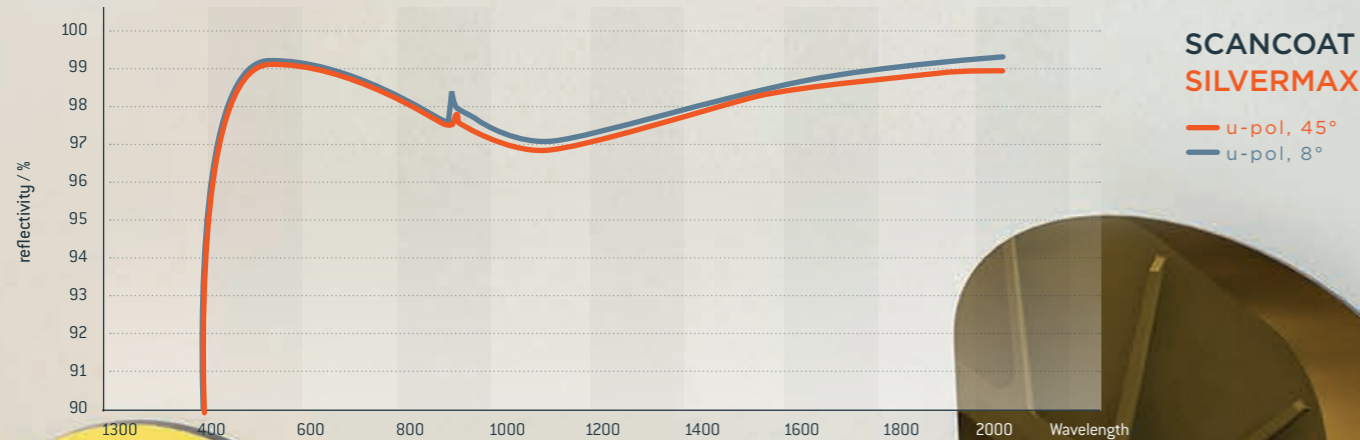
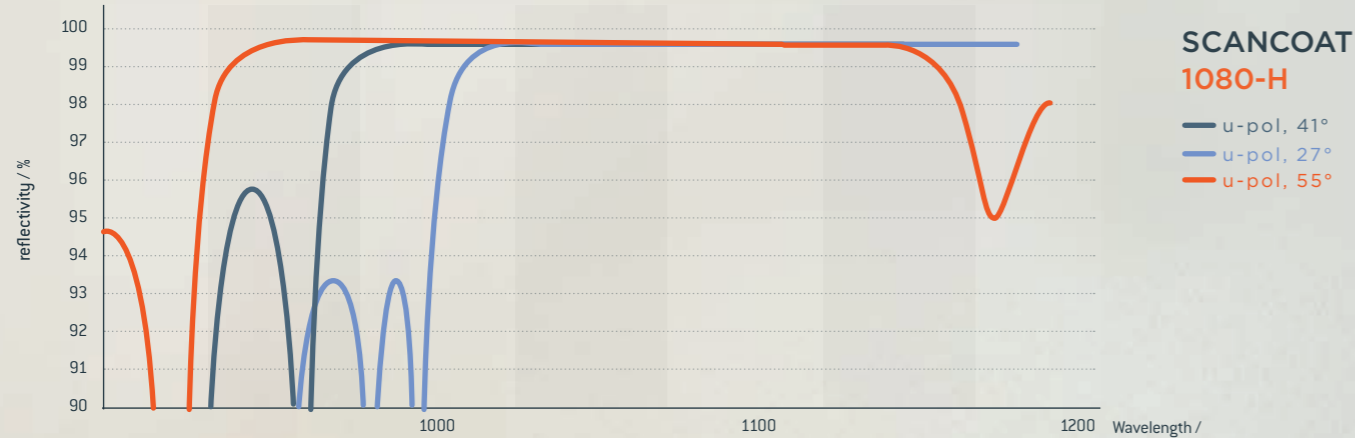
### XY5F

	FS Thickness 0,6mm		FS Thickness 0,8mm		FS Thickness 1,0mm	
	X	Y	X	Y	X	Y
Mass [g]	0,09	0,19	0,13	0,25	0,16	0,32
Moment of inertia [MOI g*cm <sup>2</sup> ]	0,52	1,04	0,7	1,36	0,88	1,71



# Special coatings proven on optoSiC+

Proven SiC standard coating types are available and paired with stock availability from single parts for tests up to large quantities for OEM-supplies



	NOMINAL SPECTRAL RANGE	SCAN ANGLE RANGE <sup>°</sup>	APPLICATIONS
SCANcoat UltraMAX <sup>®</sup> CO2- 10,6μm	10600	45 ± 15	BROADBAND
SCANcoat UltraMAX <sup>®</sup> CO2- HD	10600	45 ± 10	BROADBAND
SCANcoat Au-M wide-IR	2000 - 12000	45 ± 10	BROADBAND
SCANcoat SilverMAX	450 - 2300	45 ± 10	BROADBAND
SCANcoat 1550-H	1530-1580	45 ± 10	LOW STRESS
SCANcoat 1080-H	1030 - 1100	41 ± 13,5	LOW STRESS
SCANcoat 1075-H	1050 - 1100	37,5 / 45 ± 10	LOW STRESS
SCANcoat 1064/532-DB	1064 + 532	37,5 / 45 ± 10,5	HIGH POWER
SCANcoat 1064-D	1064	37,5 / 45 ± 10	HIGH POWER
SCANcoat 1064-H	1020 - 1070	41 ± 13	LOW STRESS
SCANcoat 1030-D	1030 +- 2	38,5 / 45 ± 13,5	HIGH POWER
SCANcoat 990-H	900 - 1080	41 ± 16	LOW STRESS
SCANcoat 532-D	532 +- 2	37,5 / 45 ± 10	HIGH POWER
SCANcoat 532-H	520 - 540	41 ± 13	LOW STRESS
SCANcoat 522-H	510 - 535	41 ± 13,5	LOW STRESS
SCANcoat 355-D	355	37,5 / 45 ± 10	HIGH POWER
SCANcoat 355-H	347 - 367	45 ± 10	LOW STRESS
SCANcoat 343-D	343	37,5 / 45 ± 10	HIGH POWER

## BECAUSE OF

- low surface tension coating type H
- customer specific requirements
- approved package for shipment
- implemented quality assurance



## YOUR BENEFITS

- Minimal surface deformation
- OEM-developed tailored specifications
- optic secured, visible and identifiable
- customer satisfaction

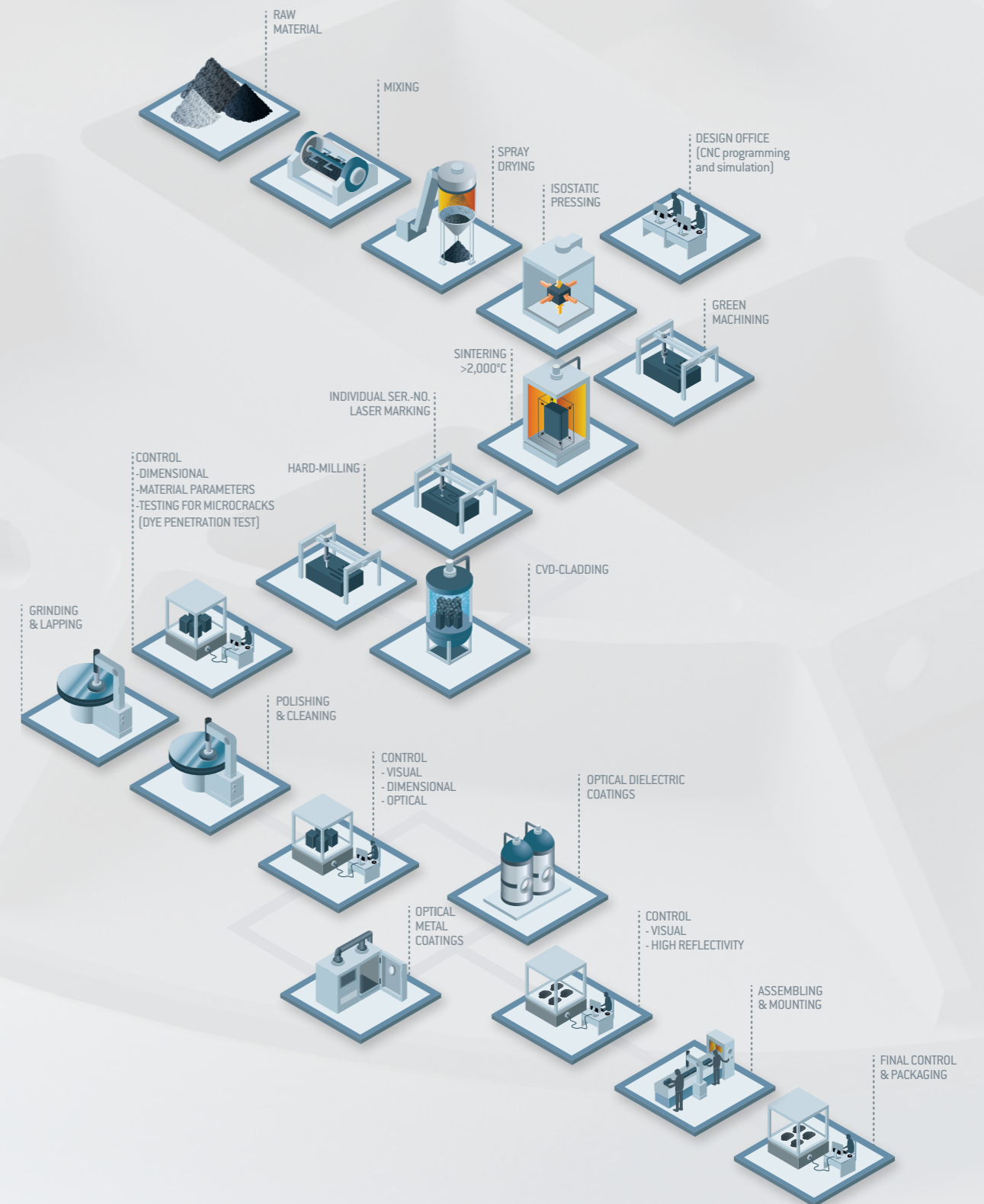
# Properties

## OPTOSiC® SILICON CARBIDE

		Temperature	Typical value	Unit
Theoretical density		20°C	3.21	10 <sup>3</sup> kg/m <sup>3</sup>
Bulk density		20°C	>3.18	10 <sup>3</sup> kg/m <sup>3</sup>
Total porosity (fully closed)		20°C	<1,0	%
Thermal conductivity		20°C	130	W/m.K
Specific heat		20°C	680	J/kg.K
Maximum thermal shock (ΔTc)			325	°C
Maximum temperature of use	In air		1450	°C
	in inert atmosphere		1800	°C
Bending strength (DINEN 2188-1 & 5)	Mechanical strength	20°C	510	MPa
	Weibull modulus	20°C	10	MPa
K <sub>1c</sub> toughness (SENB method)		20°C	4	MN.m <sup>-3/2</sup>
Young's modulus		-200°C to 1 000°C	420	GPa
Shear modulus		-200°C to 1 000°C	180	GPa
Poisson's ratio		-200°C to 1 000°C	0.17	
Electrical resistivity	- 100 V/mm	20°C	10 <sup>5</sup>	Ω.m
Outgassing (ESA ECSS-Q-70-02A)	TML (Total Mass Load)	20°C / 200°C	0.01	%
	CVCM (Collected Volatile Condensable Materials)		0.0	%

# + OPTOSiC

## Manufacturing process







GLOBAL EXPERT IN ELECTRICAL  
POWER AND ADVANCED MATERIALS

**AMERICAS**

**MERSEN USA**  
Bay City, MI  
Greenville, MI  
St Marys, PA  
Columbia, TN

**MERSEN MEXICO**  
Monterrey

**MERSEN ARGENTINA**  
Buenos Aires

**MERSEN CHILE**  
Santiago

**MERSEN COLOMBIA**  
Bogota

**MERSEN BRAZIL**  
Sao Paulo

**EUROPE & AFRICA**

**MERSEN BENELUX**  
Schiedam

**MERSEN GERMANY**  
Suhl & Munich  
**Centre of Expertise**  
Baierbrunner Str. 39 - 81379 Munich  
tel: +49 (0) 89 7807239-0

**MERSEN FRANCE**  
Gennevilliers & Bazet

**MERSEN IBERICA**  
Barcelona

**MERSEN TURKEY**  
Gebze

**MERSEN ITALY**  
Malonno

**MERSEN NORDIC**  
Kista

**MERSEN UK**  
Teesside & Holytown

**MERSEN SOUTH AFRICA**  
Johannesburg

**ASIA & OCEANIA**

**MERSEN CHINA**  
Chongqing,  
Kunshan  
Yantai

**MERSEN INDIA**  
Pune & Bangalore

**MERSEN JAPAN**  
Tokyo

**MERSEN SOUTH KOREA**  
Cheonan

**MERSEN OCEANIA**  
Reservoir Victoria

**MERSEN TAIWAN**  
Taipei