



# SIGRAFINE<sup>®</sup> Advanced SiC

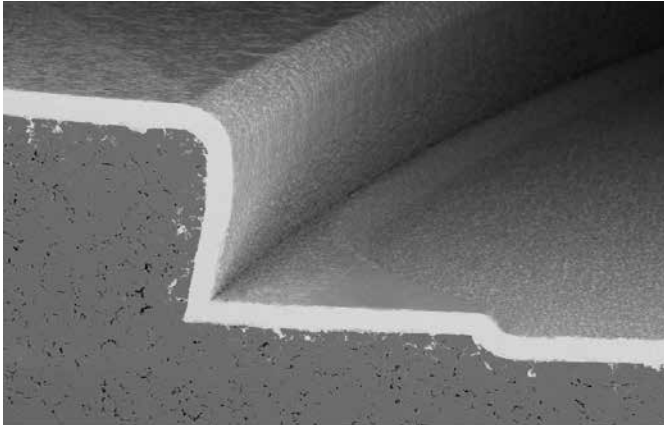


## Powering the next generation of LED

In order to meet the challenges of the next generation of LEDs, SGL Carbon has developed the SIGRAFINE Advanced SiC coating with polycrystal orientation that is produced in our proprietary high temperature process. The Advanced SiC coating offers several advantages over standard coating.

## Improved uniformity

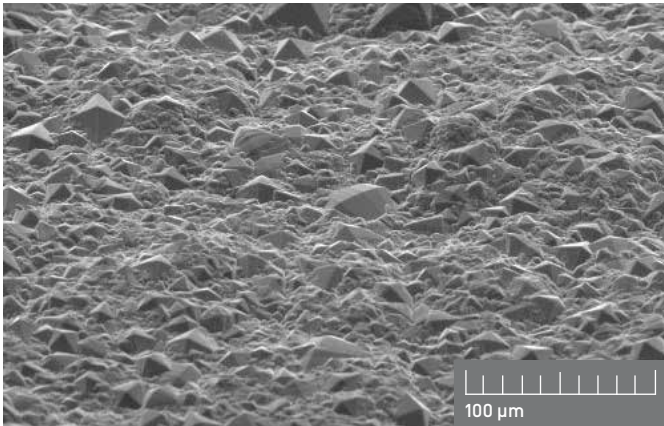
SIGRAFINE Advanced SiC coating has a 50% higher thickness uniformity and offers a deeper SiC penetration inside the graphite surface than the standard SIGRAFINE coating. The improved SiC film uniformity enhances the photoluminescence (PL) uniformity, leading to a higher LED chip yield.



↑ Representative cross-section

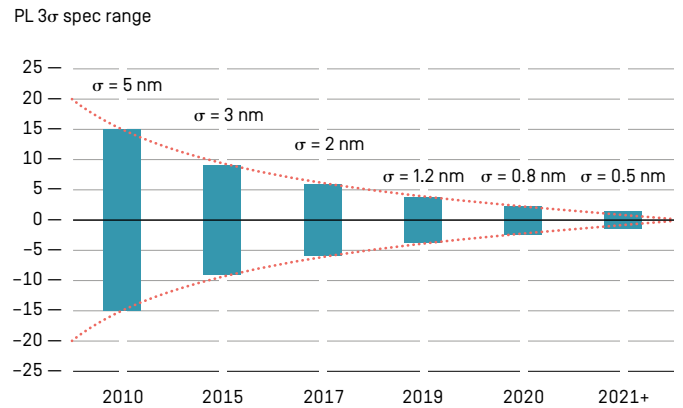
## Improved consistency

The SIGRAFINE Advanced SiC coating, in combination with our own isostatic graphite grade SIGRAFINE R6810 with highest thermal conductivity, best-in-class machining technology for dimensional accuracy, and pocket design features, is a breakthrough in achieving <1nm yield in the production of next generation mini- and micro-LEDs and semiconductor power devices.



↑ Micrograph of SiC surface

## LED customer PL Standard Deviation (StDev) requirements over time



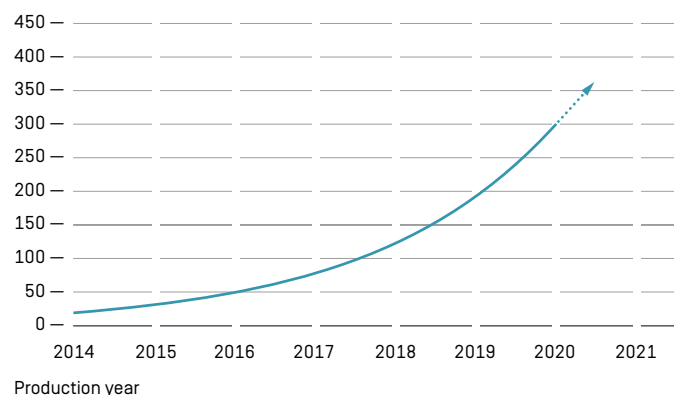
↑ Fully automated inspection

## Improved lifetime

With SIGRAFINE Advanced SiC we are further extending the lifetime of our LED carriers to ensure that our customers get the lowest total cost of ownership. Through decades of research, development and experience, SGL Carbon has harmonized the aspects of material and process to provide this industry leading product with customer value always in mind.

### MOCVD carrier lifetime evolution

Lifetime of top performing carriers each year (# runs)



↑ Quality control of a wafer carrier (© 2018 Ricky Rhodes)

## Material properties

### Material data of our SIGRAFINE® SiC coating

Typical properties	Units	Values*
Structure		beta (cubic) 3C polytype Proprietary blend <311> preferred
Orientation	Fraction [%]	<311> preferred
Bulk density	g/cm <sup>3</sup>	3.2
Stoichiometry		1:1 Si/C
Hardness	GPa	40
Fracture toughness	MPa m <sup>1/2</sup>	3.0
Thermal expansion 100 – 600 °C [212 – 1112 °F]	10 <sup>-6</sup> K <sup>-1</sup>	4.3
E-modulus	GPa	435
Typical film thickness	µm	100 (or customer specific)
Surface roughness	µm	2.5

\* Typical average values. The actual individual values might vary dependent on the product type. For any engineering/design purposes please always contact our technical sales team.

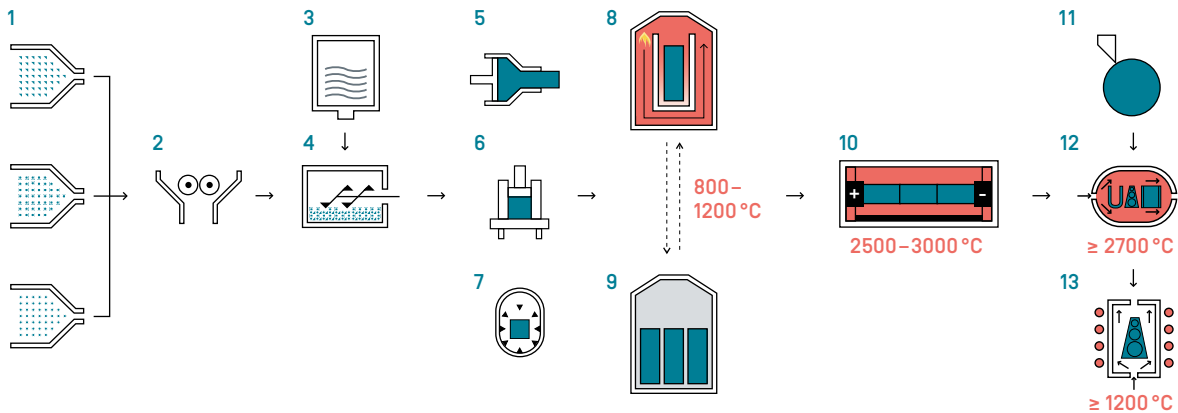
### Purity data of SIGRAFINE® SiC coating [glow discharge mass spectroscopy]

Element	ppm	Element	ppm
Sodium	<0.05	Copper	<0.01
Magnesium	<0.01	Zinc	<0.05
Aluminum	<0.04	Gallium	<0.05
Phosphorus	<0.01	Germanium	<0.05
Sulfur	<0.04	Arsenic	<0.005
Potassium	<0.05	Indium	<0.01
Calcium	<0.05	Tin	<0.01
Titanium	<0.005	Antimony	<0.01
Vanadium	<0.001	Tungsten	<0.01
Chromium	<0.05	Tellurium	<0.01
Manganese	<0.005	Lead	<0.01
Iron	<0.01	Bismuth	<0.01
Nickel	<0.005		

## SiC coating process

SiC is deposited as thin layers on SGL Carbon isostatic graphite by chemical vapor deposition (CVD). Deposition takes typically place at temperatures above 1200 °C (2192 °F). The thermal expansion behavior of the substrate material should be adapted to the SiC coating to minimize thermal stresses.

### Production process for SIGRAFINE® fine-grain graphite with SiC coating



- 1 Coke, graphite
- 2 Grinding
- 3 Binder pitch

- 4 Mixing
- 5 Extruding
- 6 Vibro molding

- 7 Isostatic pressing
- 8 Carbonizing
- 9 Pitch impregnation

- 10 Graphitizing
- 11 Machining
- 12 Purifying
- 13 SiC coating

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