Motivation

Challenge of material degradation

- Inner reactor parts made of graphite and/or SiC which are used in SiC semiconductor processing are highly stressed by high temperatures and corrosive gas environment
- This results in erosion and strong degradation of the reactor parts leading to high maintenance effort, extended reactor down time and considerable spare part costs

→ **High quality SiC coatings** on graphite parts could be a promising approach to

a) effectively protect graphite parts from harsh environments and increase their lifetime

b) be an economic alternative in comparison to cost intensive SiC full-ceramic parts

Potential Application

SiC epitaxy reactors

- SiC coatings **protect graphite hot zone parts** from corrosion by reactive gases like SH_4 or H_2 at high temperatures up to 1600°C. Moreover, SiC epi layer material quality is improved by avoiding loose particle ablation without any additional contamination.

SiC oxidizers

- SiC coated graphite parts **withstand oxidizing atmospheres** and may be used in oxidizers as a cost-effective alternative to bulk SiC material, ensuring a **reliable supply chain** due to readily available raw materials.

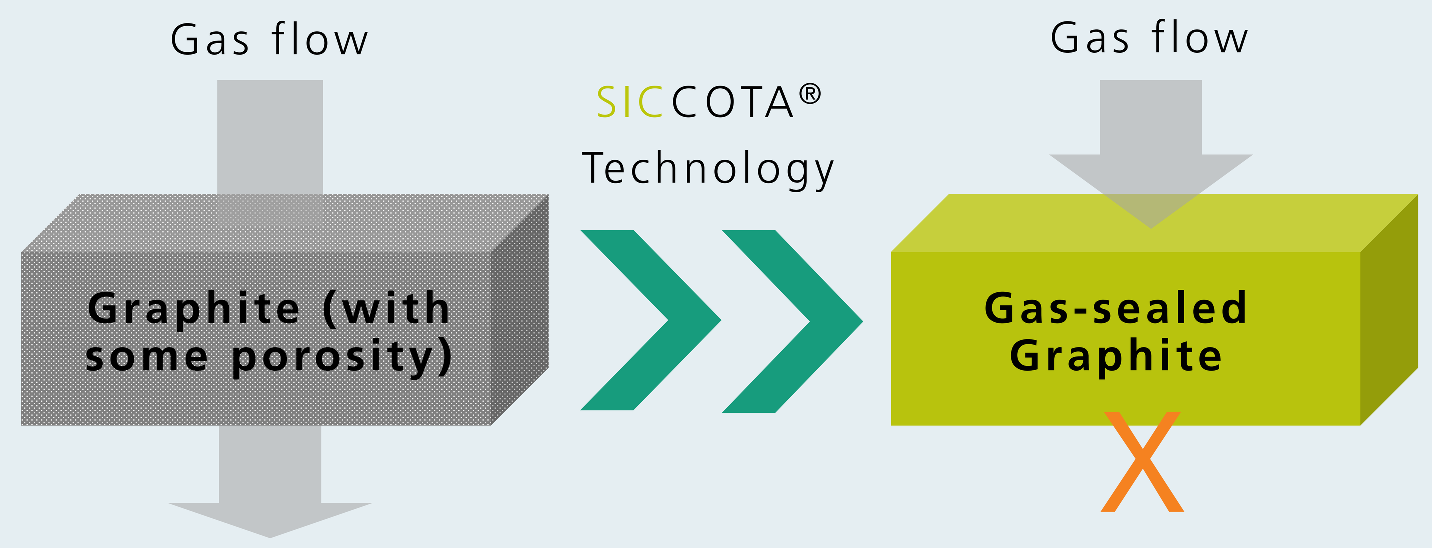
SICCOTA® coating technology and characteristics

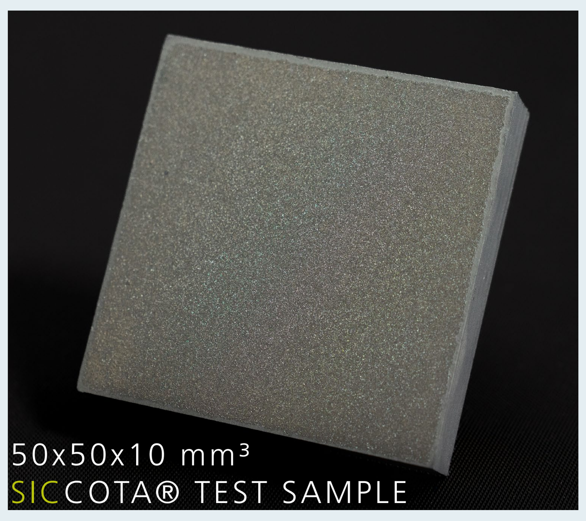
Aim

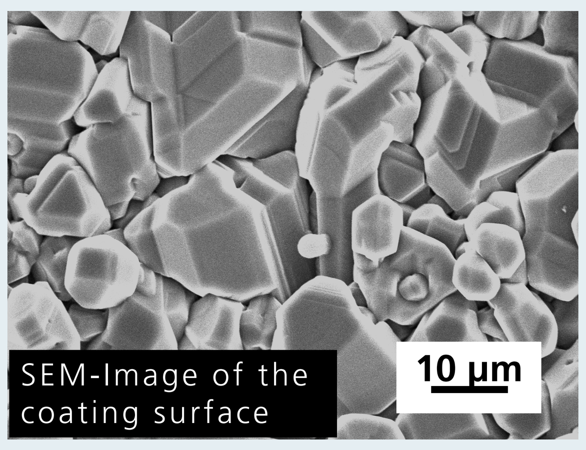
- Reducing stress and avoiding degradation of graphite parts caused by high temperatures and reducing/ oxidizing environments during semiconductor processing

Approach

- Sealing porous graphite by converting its surface into SiC





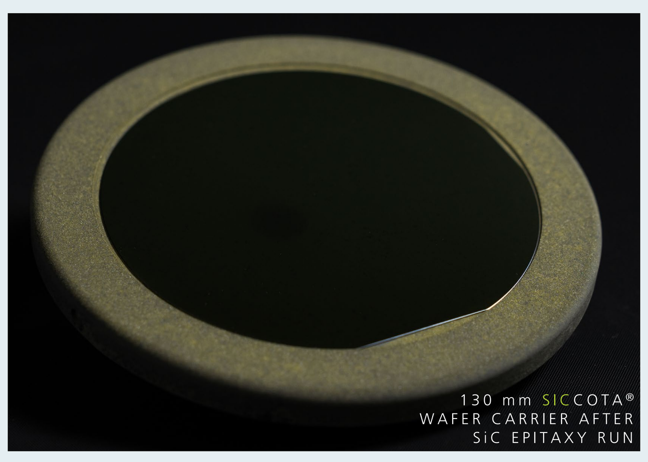


Coating properties

- Polycrystalline SiC consisting of 99.97 % cubic SiC
- Good wear resistance and excellent adhesion to the substrate (> 8 MPa adhesive strength)
- Low gas permeability due to highly dense crystalline SiC-structure
- Resistance against corrosive, reducing (e.g. H_2) and oxidizing (e.g. O_2) gases
- Partial and all around coating possible

→ **Cost-effective and highly flexible technology**

Contamination test in SiC-epitaxy



- Ø100 mm SiC wafer on top of coated wafer carrier
- Growth of ~15 µm SiC Epi-layer in 1h @ 1600°C under SiH_4, C_3H_8, H_2, N_2 atmosphere
- Measuring surface contamination on SiC wafer surface by after Epi-run

Detection limit (dl)	Species	Processed SiC Wafer (Si-plane)	Unprocessed SiC-Wafer (Si-plane)	Industrial epitaxy process
0.031	Li	<dl	<dl	n.m.
0.126	Na	7.157	1.068	n.m.
1.125	Al	1.583	<dl	n.m.
0.115	K	11	0.364	0.053
0.738	Ca	2.641	18.78	<dl (0.05)
0.016	Ti	1.52	<dl	<dl (0.03)
0.063	V	1.58	<dl	<dl (0.02)
0.471	Cr	<dl	<dl	0.105
0.051	Mn	<dl	<dl	0.488
0.270	Fe	0.385	<dl	0.306
0.108	Co	0.412	<dl	<dl (0.02)
0.363	Ni	1.448	<dl	<dl (0.25)
0.618	Cu	<dl	<dl	<dl (0.14)
0.032	Zn	0.3	<dl	<dl (0.05)
0.565	As	<dl	<dl	<dl (0.21)
0.015	Sr	<dl	<dl	<dl (0.003)
0.008	Cd	<dl	<dl	<dl (0.004)
0.010	Ba	0.012	0.051	<dl (0.001)
0.001	Ta	0.077	0.066	0.058
0.012	Pb	<dl	<dl	<dl (0.002)
0.002	Bi	<dl	<dl	<dl (0.001)

Values for surface contamination in 1E10 at/cm², measured by VPD ICP-MS

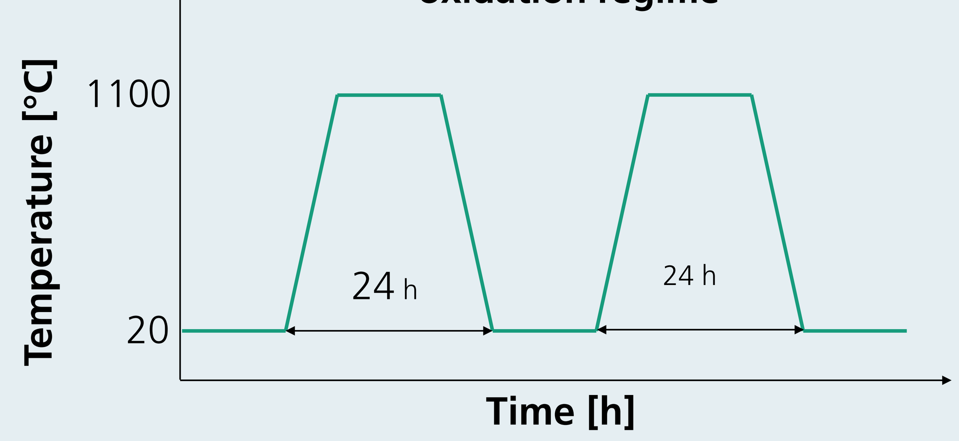
Results

- No ablation or cracking of the **SiCCOTA**® coating after several epitaxy processes
- No significant metal contamination measured by VPD ICP-MS
- No influence of graphite components on contamination behaviour due to complete isolation by the SiC coating from growing atmosphere

Oxidation resistance experiments

- Cyclic oxidation (24 h intervals @ 1100°C)
- Heating rate of 200 K/min
- Continuous air flow (20% O_2)
- Sample size: 50 x 25 x 10 mm³
- Measuring the mass loss of coated samples after each cycle

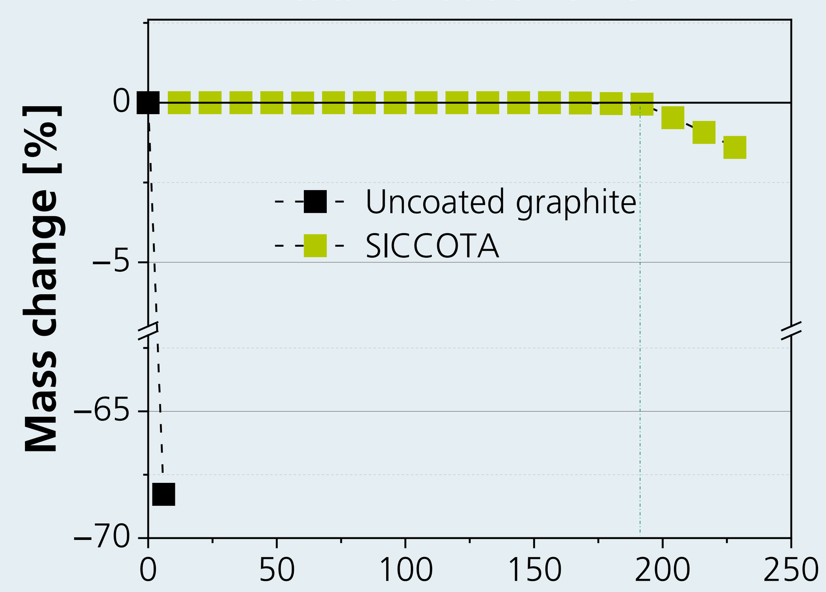
Schematic representation of the cyclic oxidation regime



Results

- Uncoated graphite sample (reference) with massive weight loss already within 1st cycle
- In case of **SiCCOTA**® sample an oxidation resistance (equals to mass loss < 0.1 %) of up to 182 hours could be demonstrated
- SiC coating perfectly withstands cyclic temperature changes due to excellent adhesion to the substrate

Mass change of uncoated and coated graphite samples in dependence on total oxidation time



Conclusion

SiCCOTA®

- Represents a new cost-effective technology for protection of graphite parts vs. extremely high temperatures and corrosive gas atmospheres like silane, hydrogen or oxygen
- Shows no ablation or crack-formation and no significant metal contamination

SiCCOTA®
is a promising alternative to other SiC coating approaches (like CVD) and/or SiC bulk material used in SiC semiconductor processing