Next Generation SiC Cover Rings for SiC Epitaxy

Manny Gonzales, Chatura Patuwathavithane, Tomiko Smith, Laura Dromgoole, Supil Raina

INTRODUCTION

Epitaxy is an important step in the development of high-quality SiC device layer on single crystal SiC substrates/wafers. In addition to key metrics related to EPI film thickness and crystalline defects, doping and wafer shape (bow/warp) are crucial for higher yields requiring implementation of innovative material solutions. Current options for the cover or EPI rings are limited to SiC or TaC coated graphite with their own unique production challenges and performance limitations such as mechanical integrity (warping) and contamination control. Tuning the carrier concentration is critical for reliable device performance, and purity of the EPI rings can have an impact on that. Another important aspect is the structural stability of the EPI rings that allows them to stay flat over multiple cycles, with uniform heat distribution. Entegris has developed the next generation SiC EPI rings (150 mm and 200 mm), that meet and exceed the performance metrics of the current offerings.

SCOPE

Purified graphite rings machined to near-net shape are converted to β-SiC (SUPERSiC®) using a proprietary technology which then undergoes homoepitaxy deposition of CVD SiC up to a thickness of ~75 µm (0.003") to form the final product: SUPERSiC®-3C. Post processing steps ensure a high-quality product with desired purity levels. At the high processing temperatures and aggressive gas chemistries, SUPERSiC-3C provides exceptional thermalmechanical stability that far exceeds the conventional EPI rings with graphite core. Having a monolithic (SiC/SiC) architecture eliminates any risk of structure failure/delamination. Additionally, this materials solution provides lower Cost-of-Ownership as it offers the opportunity to refurbish the original SUPERSiC-3C rings by removing the parasitic SiC deposition during the EPI process, thus extending the life of each ring. Having ISO 9001 and AS 9100 certified production and machining capabilities on-site gives Entegris excellent process control to meet the desired outcomes.

Simplified process flow to produce CVD SiC coated SiC cover rings with different geometries

METHODS

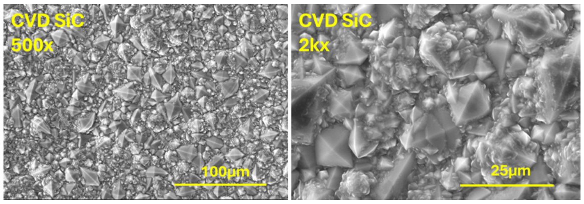
Microstructure/Surface Morphology/Composition- A Thermo Fisher Scientific AXIA Scanning Electron Microscope was used to capture micrographs at different magnifications to examine the typical surface morphology and microstructure. An integrated EDS (Energy Dispersive Spectroscopy) capability was used to determine typical composition of the CVD SiC film, which is ~30wt% of carbon and ~70wt% of silicon.

X-Ray Diffraction Spectroscopy- A SIEMENS Diffraktometer D5000 was used to record the typical spectrum and matched to the β-SiC or the 3C SiC phase from the library. The polycrystalline SiC has (111) and (311) dominant peaks, with the absence of any secondary peaks that can be attributed to the α phase.

Trace Metal Contamination Detection- A Thermo Fisher Scientific iCAP- Laser Ablation ICP-MS tool was optimized to quantify the trace contaminant profiles, especially, boron, aluminum and iron, that can alter the dopant profile and hence the carrier concentrations in the SiC wafers. Additional comparisons were performed using GDMS. These low contamination levels can be attributed to proprietary post-processing steps that further elevate the purity of our products.

Additional thermal and mechanical properties have been derived and tabulated using standard ASTM procedures to provide additional evidence that SUPERSiC-3C provides excellent material compatibility for the SiC EPI process.

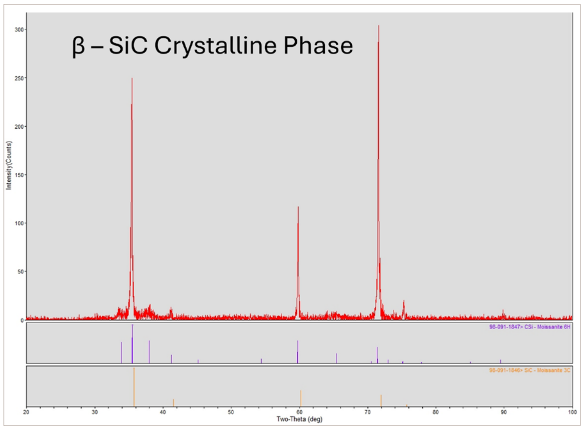
RESULTS



SEM micrographs at 500x and 2000x, showing the polycrystalline surface morphology typical of CVD SiC. The underlying SUPERSiC substrates are ground/polished to achieve the desired flatness and surface finish after the CVD SiC step with a sub-micron surface roughness (Ra).

	Boron (ppm)	Aluminum (ppm)	Iron (ppm)
GDMS (depth profile)	<1.5 ppm	<1.5 ppm	<1 ppm
GDMS (bulk scan)	<1 ppm	<0.5 ppm	<0.5 ppm
LA-ICP-MS	<0.1 ppm	<3 ppm	<0.5 ppm

Comparison of the trace metal profile comparison using GDMS and LA-ICP-MS. These low level can be achieved by proprietary purification processes and a strong adherence to the ISO9001 certified process controls.



Typical XRD spectrum of the CVD SiC coating matched to the β-SiC or the 3C SiC phase from the library. The polycrystalline SiC has (111) and (311) dominant peaks, with the absence of any secondary peaks that can be attributed to the α phase.

PROPERTY	SUPERSiC	SUPERSiC -3C (-3CX)
Apparent density	3.13 g/cm^3 (0.113 lb/in^3)	3.15 g/cm^3 (0.114 lb/in^3)
Bulk density	2.53 g/cm^3 (0.092 lb/in^3)	2.55 g/cm^3 (0.092 lb/in^3)
Total porosity % of volume	20%	20%*
Open porosity % of total	19%	0%**
Total impurity level	<10 ppm	<10 ppm
Flexural strength	155 MPa (22,400 psi)	155 MPa (22,400 psi)
Tensile strength	129 MPa (18,700 psi)	129 MPa (18,700 psi)
Elastic modulus	217 GPa (31 10^6 psi)	217 GPa (31 10^6 psi)
Specific stiffness	86 kN.m/g	85 kN.m/g
Poisson's ratio	0.17	0.17
Dynamic shear modulus	97 GPa (14 10^6 psi)	97 GPa (14 10^6 psi)
Fracture toughness	2.4 MPa.m$^{0.5}$	2.4 MPa.m$^{0.5}$
Hardness knoop	1992 kg/mm^2	N/A
Thermal diffusivity	100 mm^2/s	100 mm^2/s
Thermal conductivity W/m.K (Btu/hr/ft°F)	170 (98)	170 (98)
Instantaneous coefficient of thermal expansion at RT	2.4 10^{-6}/K (1.3 10^{-6}/°F)	2.4 10^{-6}/K (1.3 10^{-6}/°F)

Snapshot of the material properties of the SUPERSiC substrate before and after coating with CVD SiC (SUPERSiC-3C) that highlights the unique benefits of implementing monolithic parts and their compatibility with the SiC EPI process.

SUMMARY

Entegris has already leveraged the excellent material properties of SUPERSiC and SUPERSiC-3C in aerospace and SEMI and now offers a game changing opportunity in SiC EPI application. Complementary solutions from Entegris in the form of slurries and pads for SiC polishing highlight the full spectrum of offerings that enable customers to reach their targets.

FOR MORE INFORMATION

Please call your Regional Customer Service Center today to learn what Entegris can do for you. Visit entegris.com and select the Contact Us link to find the customer service center nearest you.

TERMS AND CONDITIONS OF SALE

All purchases are subject to Entegris' Terms and Conditions of Sale. To view and print this information, visit entegris.com and select the Terms & Conditions link in the footer.

Entegris

Corporate Headquarters
129 Concord Road
Billerica, MA 01821
USA

Customer Service
Tel +1 952 556 4181
Fax +1 952 556 8022
Toll Free 800 394 4083

Entegris®, the Entegris Rings Design®, and other product names are trademarks of Entegris, Inc. as listed on entegris.com/trademarks. All third-party product names, logos, and company names are trademarks or registered trademarks of their respective owners. Use of them does not imply any affiliation, sponsorship, or endorsement by the trademark owner.

©2025 Entegris, Inc. | All rights reserved. | Printed in the USA | 9000-14350ENT-0825