





Silicon carbide industrial newsletter #2



13th European Conference on Silicon Carbide and Related Materials

TOURS (FRANCE) – October 24th to 28th 2021

www.ecscrm-2020.com



Organized whit the support of:







Last September, we should have been all together in Tours (France) for the 13th ECSCRM (European Conference on Silicon Carbide and Related Materials) conference, the yearly event of the whole SiC community. As you already know, the conference has been postponed one-year due to Covid-19 pandemic, shifting consequently the following events in Davos and Napoli. Considering travel restrictions, virus circulation, containing periods, it was the only choice we had.

Unfortunately, due to the conference reschedule, the exhibition part has been also postponed. However, we are sure that the industrial innovations worldwide on silicon carbide are of high interest for each of you. Based on that, the ECSCRM organizing committee decided to highlight the industrial advances thanks to this silicon carbide industrial newsletter.

This event is also a great opportunity to warmly thank our sponsors and exhibitors, that maintained their participation to this conference, despite the Covid-19 pandemic. Without their confidence and support, the 13th ECSCRM conference would probably have been cancelled.

We deeply hope to see you physically next October in Tours to gain knowledge about SiC, of course, but also and above all to enjoy lovely moments all together, hoping that this health crisis will be "only" a sad moment belonging to the past.

Take care.

Daniel ALQUIER
Jean-François MICHAUD
Dominique PLANSON

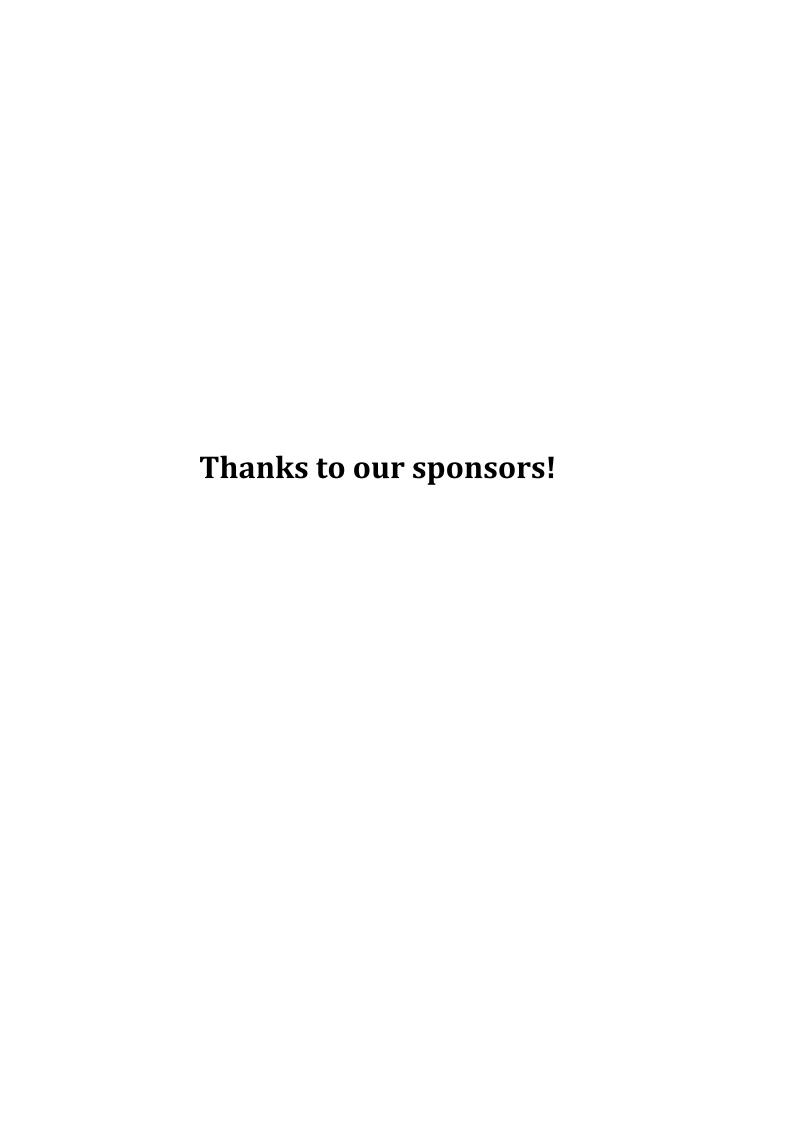


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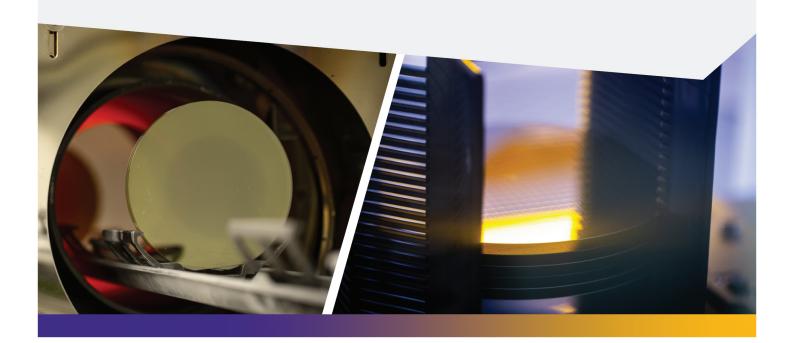




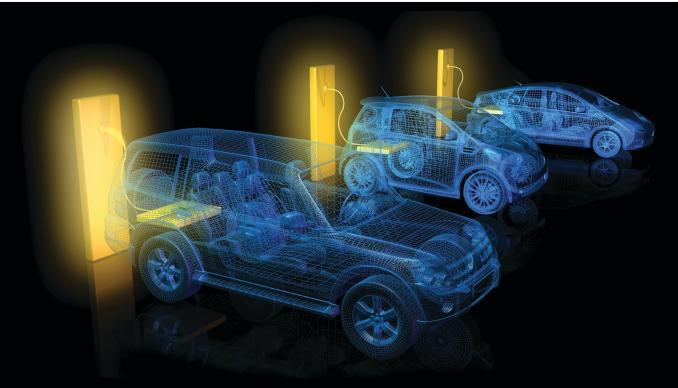
30 YEARS OF SIC INNOVATION FUELING **MORE THAN 30X SIC CAPACITY BY 2024**

Wolfspeed continues to lead the pack with an unprecedented investment in the expansion of SiC and GaN on SiC capacity.

Visit www.wolfspeed.com/materials to learn more.



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- Infrastructure: charging stations
- Renewables: solar and wind
- Industrial: motor drives, power supplies
- Power distribution: HVDC

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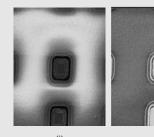


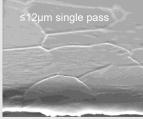
NEXT-LEVEL PRODUCTIVITY for Wide-Bandgap Devices

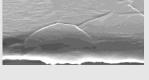
Process capabilities enabling the latest technology inflections in WBG power semiconductors.

SiC and GaN processing on 150/200mm wafers:

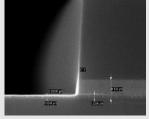
- > DRIE for high aspect ratio, smooth sidewalls, no micro-trenching
- Atomic Layer Etch for highest surface quality and repeatability
- CVD gate oxides for less interface trapping and better mobility
- Thick PVD for frontside and backside metallization.
- Semi-transparent wafer-handling
- Wafer inspection and defect review











SEMVision® SiC Defect Review (i) Standard, (ii) with Anti-Charging

Endura® PVD Thick Aluminum

Centura® DTM SiC Etch

Applied Centura® Etch Using EyeD® End-Point Control

Source: Applied Materials, Inc.



Process Improvements

As part of continuous improvement program, LPE has recently introduced significant innovations that enhance process performance on its Silicon Carbide Epitaxial Reactors.

More specifically, the improvement program has focused on providing our Customer with unmatched thickness and doping concentration uniformity.

After performing a significant number of tests and have therefore a collected solid metrology database we are glad to announce the updated performance:

(i) Thickness Uniformity within wafer:

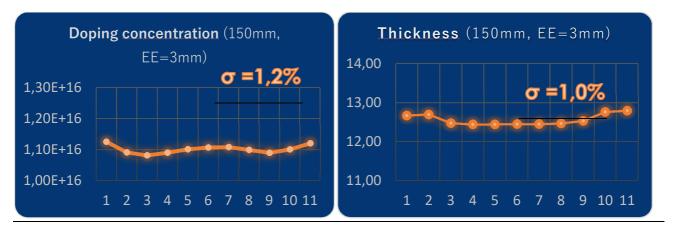
Typical: <1% (σ /mean) (41 points - 3mm EE)

(ii) Doping Uniformity within wafer:

Typical: <2% (σ /mean) (41 points - 3mm EE)

(iii) Doping Uniformity run to run:

Typical: < 2% (average of 41 points)



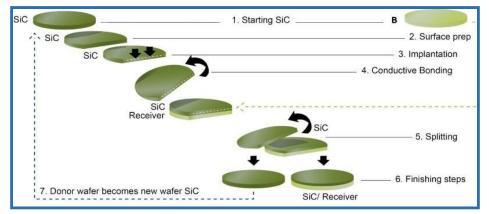
We are looking forward to contributing in delivering superior business results to our Customers thanks to the new \$1 performance.

Please contact us at info@lpe-epi.com for additional information.

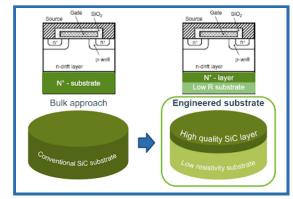


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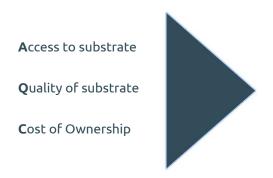


Smart Cut substrate vs Bulk SiC for Power Devices



Picture of an Engineered SiC substrate

Value Proposal vs Bulk SiC



- Use and recycle ~10x of best in class quality SiC layer
 -> supply chain stability
 - 113
- > Significant reduction of defect density
 - -> increase of number of good dies
- > Lower substrate vertical specific on-resistance
 - -> RDSon lowering* (performance improvement)
 - -> die size reduction* (more dies per wafer)
- > Simplification of device manufacturing process
- Strategic partnership with Applied Materials to accelerate Smart Cut[™] SiC time to market
- Pilot line is operational as part of the Soitec and CEA-Leti's Substrate Innovation Center.

Rev. 11-2020 Changes in accordance to technical progress are r

SELECTIVE LASER ANNEALING FOR OHMIC CONTACT FORMATION (OCF)

The formation of ohmic contacts on the back side of SiC power devices plays a key role in defining their electrical characteristics and mechanical strength. Traditionally, thermal annealing has been used for ohmic contact formation on the back side of SiC wafers, but the extremely high temperatures associated with this process can damage structures on the front side of wafers. As the industry migrates to thinner SiC wafers, this problem only worsens. Selective laser annealing provides an attractive alternative due to its high precision and repeatability, and low thermal leakage, which prevent thermal damage to the wafer front side that can negatively affect device performance (Fig 1).

New Challenges

The development and implementation of new technologies typically is associated with new and increasing challenges. The extremely high thermal load within the OCF process thus involves the following problem: The front side of the wafer is already completely structured before the actual OCF process and thus is sensitive to high temperatures. For example, if a silicidation of Nickel (Ni) to nickel silicide (Ni¸Si¸) has to be achieved, then a temperature of about 1,000°C is required in the short term for this purpose. Implementation with a furnace is not possible here, since the heat would have an effect over a long time period. This is why flash lamps are used instead, which with a single flash can transmit a sufficient amount of energy to a defined area. Energy values are typically in the range of 0.5 J/cm² to 4 J/cm². The short flash duration has the advantage that the energy input is stopped before critical temperatures are reached on the front side of the wafer. In addition during silicidation, carbon is produced, which forms so-called carbon clusters directly beneath the nickel silicide layer during the typical exposure time of the flashes. Since these clusters deteriorate the adhesion of the metal layer on the wafer, a fine and uniform (finely dispersed) distribution of the carbon is sought after.



Fig 1: Wafer with laser OCF test fields

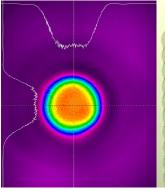
A new challenge for the OCF process is the trend to ever-thinner wafers in order to further reduce the electrical resistance in the component (the current flow is vertical) and to improve the heat conduction. At the same time, the distance between the back side of the wafer to be heated to the thermally sensitive front side decreases. As a result, the energy pulses of a flash lamp may potentially already be too long and the heat may thermally damage the front side of the wafer.

Gentle processing through selective laser annealing

Until now, there used to be only few laser products available on the market that are universally applicable for rapid thermal processes. The universality is gained through extreme complexity and hence they have a too high cost of ownership for the process of silicidation.

The solution: microPRO OCF

With microPRO OCF, 3D-Micromac has developed a tailor-made and cost-efficient laser solution for the OCF process of SiC-power products under volume production conditions. Using a DPSS-UV laser with pulse lengths in the nanosecond range (50 ns to 100 ns) significantly improves the quality of the Ni_xSi_y interface without damaging the front side structures of thinned wafers. With energy density adjustable up to 5 J/cm² and a laser flat top profile (Fig 2), a high throughput of 8 wafers (150 mm) per hour (standard configuration) can be achieved with a very homogenous annealing surface (Fig 3). With this OCF process, the generation of large carbon clusters and heat-induced damage to the front side of the wafer is avoided.





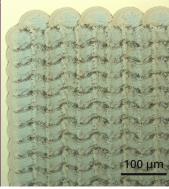


Fig 3: Microscope image of a surface after laser annealing

The DPSS laser used ensures the high availability of the system through a low maintenance effort and generates low operating costs. Important parameters including laser power and the beam profile are recorded by sensors and saved in log files. The system optionally has an interface to the factory IT infrastructure. On customer's request, it is possible to adapt the system with different handling solutions. Furthermore, it is possible to adapt the beam profile e.g. circular or square top hat profile with specific sizes. In addition, the microPRO OCF is designed for the next generation of SiC wafers with a diameter of 200 mm.

More information: https://3d-micromac.com/micropro-xs-ocf/





PRODUCT SPECIFICATIONS

| Polytype | 4H |
|-------------------------------------|---|
| Type (Dopant) | N (Nitrogen) |
| Orientation | 4.0° ±0.5 off axis towards <11-20> direction |
| Diameter (mm) | 150.25 ±0.25 |
| Resistivity (mΩ-cm) | 20 ±5 (Tunable to a 2 m Ω -cm range) * |
| Micropipes (/cm²) | < 0.5 |
| BPD (/cm²) | < 3000 ‡ (lower defect material available upon request) |
| TSD (/cm²) | < 500 ‡ (lower defect material available upon request) |
| Primary flat length (mm) | 47.5 ±2.5 or 57.5 ±2.5 parallel to <11-20> direction (per customer requirement) |
| Usable height @ 150mm diameter (mm) | 20+ |

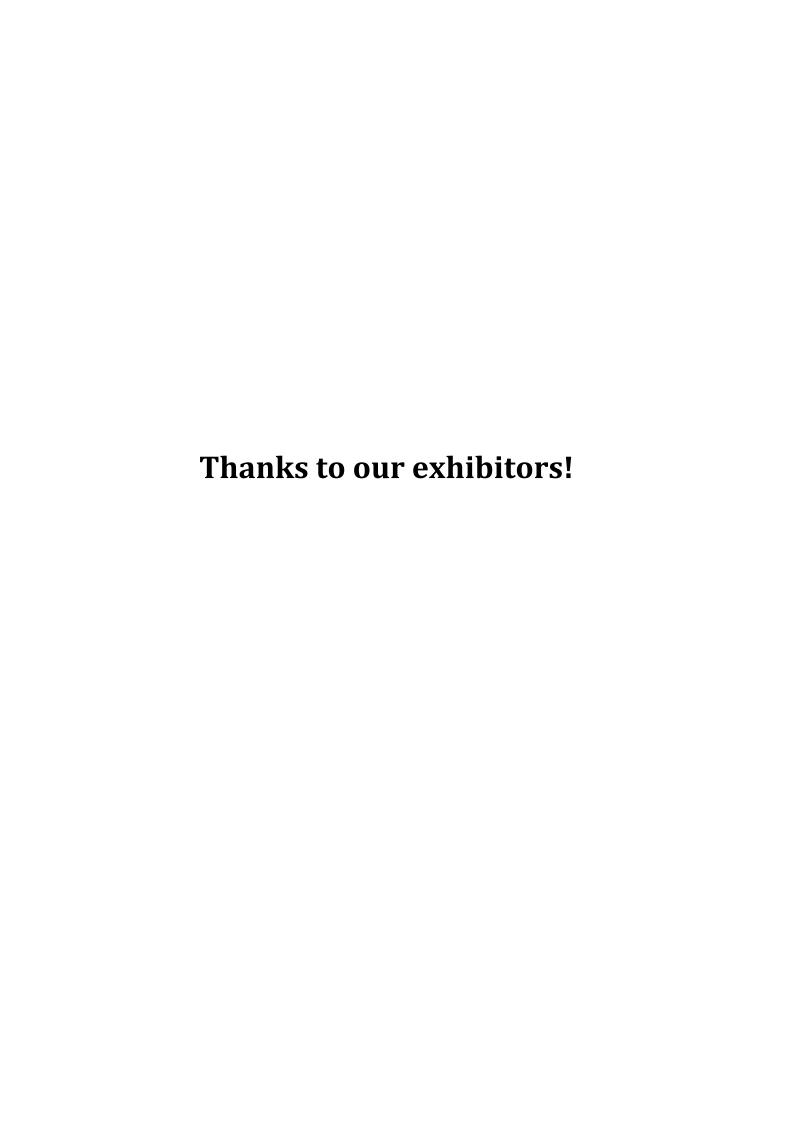
^{*} Upon request; contact GTAT for other custom resistivity specifications

150mm **CrystX**® silicon carbide crystal

GTAT has created a new and affordable source of high-quality silicon carbide crystal. Wafer and epi-substrate producers can now add this high-performance material to their portfolios without crystal-growth capital investment. CrystX® silicon carbide crystal is the smart choice for challenging power electronics applications.



[‡] Semi-automated optical inspection / fully-automated SICA 88 tool analysis using KOH etched wafer.





Rapid Thermal Processing

Rapid Thermal Processing lamp furnaces



- Ohmic contact annealing
- > RTO of silicon carbide
- Up to 1450°C
- Up 200 mm
- Batch process capability



High Temperature Rapid Thermal Processing



Zenith-150

- Silicon carbide wafers implant annealing
- Generation of graphene by sublimation
- Rapid Thermal CVD of graphene
- High temperature annealing processes
- > Up to 2000°C for 1 hour
- ► Up to 4°C/s

TECHNOLOGY UPDATE 200 mm SiC PRODUCTION

centrotherm



G.ACTIVATOR²⁰⁰

SiC/GaN dopant activation, H₂-trench annealing

- Up to 2000°C | Ar, N₂, H₂
- Vacuum processing
- Small footprint

G.OXIDATOR²⁰⁰

SiC GOX growth and POA in NO

- 1500°C | N₂, Ar, O₂, N₂O, NO, DCE, WetOx
- Small footprint

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No. 783158. The JU receives support from the European Union's Horizon 2020 research and

innovation program and Italy, Germany, Belgium, Sweden, Austria, Romania, Slovakia, France, Poland, Spain, Ireland, Switzerland, Israel.







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G.RAPID²⁰⁰

SiC contact annealing, GaN activation annealing, more

• Dual chamber design (NEW



- Box annealing
- Vacuum processing



C.CRYSCOOHTA



Boule & wafer stress annealing, BPD → TED conversion, more

- Up to 2200°C | Ar & H₂
- Vacuum processing

Designed for 200 mm SiC epi



ER3-C

Hot load and controlled wafer cooling

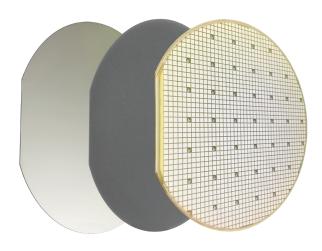
On the fly, you can tune:

- Temperature across the wafer
- Gas concentration across the wafer





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SiC Substrates



iC Epiwafer and Devices

The new carbon insulation for SiC crystal growth by Mersen

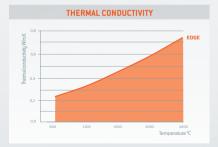
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THE ULTRA
PERFORMER.



Calcarb[®] Edge

Mersen

- Unique Cylinder within Cylinder (CwC) construction gives optimal cost of ownership to the customer
- Our unique process and material combination provides a narrow Standard Deviation on thermal and mechanical properties tolerance.
- Allow precise process control at high temperature (2,400°C)





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High Capacity Single Side Polishing Machine

PR Hoffman Machine Products has expanded the Servo RS machine line to include a ground breaking single side polisher, the SSP-619. This single side polisher offers the first fully automated, cassette-to-cassette, batch processing system available in the single side polisher market

The SSP-619 was specifically designed for SiC wafers to withstand a wide range of slurries at extreme pH levels and temperatures. Exposed surfaces of the machine are chemically resistant to the interactions of slurries, thus improving machine cleanliness, reducing clean up time, and improving wafer quality.

The SSP-619 also brings you innovative features and capabilities that maximize part load size and reduce dedicated operator time. Products, components & systems for Semiconductor Industry up to 1450°C (2642°F) application temperature

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simply high temperature technology

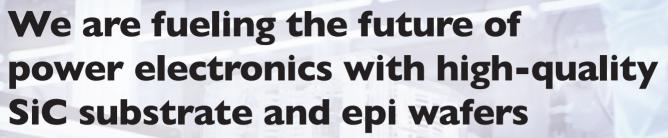
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《Graphite products related to SiC semiconductor manufacturing》



SiC / TaC coated hybrid material equipment Graphite



TaC Coated Graphite Material



SiC single crystal growth