Electrification and Power Semiconductors

A Novel Approach for the Volume Production of Wide-Bandgap Semiconductor

S. Spindler
Process Technology
ELEMENT 3-5 GmbH, Technology Department,
Baesweiler, Germany

Abstract
In this work we describe another epitaxial process. Here we present data of aluminum nitride (AlN), graphene interlayers and of SiC on AlN thin films on sapphire and of epitaxial growth of SiC on SiC grown by Next Level Epitaxy (NLE). The new process is using a surface temperature around 250°C by combining PVD (physical vapor deposition) and CVD (chemical vapor deposition). The growth procedure in NLE is similar to the MOCVD growth process with substrate cleaning, start layer and main layer. Compared to the reactive sputter processes and pulsed sputter epitaxy the NLE uses different plasma sources in various combinations.

The NLE system is a homemade novel deposition system. In the current configuration, it has a capacity of up to 70 x 200 mm wafer at one time. As Al-source pure Al was used. As nitrogen source nitrogen gas, as Si-source silane and as carbon source for graphene and SiC methane which were introduced by a homemade ion gun. Additionally, argon, oxygen and hydrogen were used. During the process the surface temperature of the wafer was kept around 250°C. The used plasma sources are all designed as stripe sources. The wafer is placed on the carrier which is moving front and back in the growth chamber under the stripe sources. First the substrates were cleaned with a mixture of argon and oxygen and after with argon and hydrogen using the plasma. After the in-situ cleaning first a monolayer of aluminum was deposited followed by low plasma power and low growth rate AlN and after higher plasma power and higher growth rate AlN. The graphene layers were used as interlayer sandwiched between AlN and were compared with AlN grown in one step with the same total growth time. The experiments for SiC growth started recently. As seed for the SiC growth NLE-AlN on sapphire was used. Since AlN is counted as 2H-AlN it can act as seed for 2H-SiC and 4H-SiC.

Biography
Dr. Sarah Spindler (Process Technology) joined the technology department in the beginning of 2025 at ELEMENT 3-5 GmbH. Sarah receieved her PhD. at Fraunhofer Institute for Production Technology IPT in 2025. and graduated at RWTH Aachen University 2019.

References

Robust SiC MOSFET Devices for Drive Train Applications

S. Schwaiger
Automotive Electronics
Robert Bosch GmbH, Automotive Electronics,
Reutlingen, Germany

Abstract

SiC technology replaces its silicon competitor in many automotive applications, especially in drive train inverters for high voltage batteries of electric vehicles. Using the higher efficiency in partial load operation, SiC traction inverters outperform Si inverters and allow to extend the range of an electric car. As a result, SiC technology gained market shares and many semiconductor players took significant development efforts to improve the SiC MOSFET performance, i.e. reducing the on-state resistance with the goal to enable smaller and cheaper traction inverters. However, also other improvements, e.g. improvements in switching behavior or the integration of new features like sensing elements improve the applicability on system level.

This talk provides an overview of SiC MOSFET technology for drive train applications. It sums up the key performance indicators for a technology enabling a performant design of a drive train inverter. Furthermore, the talk discusses the advantages of integrating sensing elements on chip level and gives an insight on measures to increase robustness necessary to maintain high quality products with low failure rates. The talk provides an insight into recent advances of Bosch's SiC technology designed for reliable, high performance automotive applications.

Biography

Stephan Schwaiger studied physics at the university of Hamburg and finished with a doctorate degree in 2012. He started in semiconductor industry in Bosch's central research department working power semiconductors. Since 2015 he works on the development of SiC semiconductors for the section Automotive Electronics at Bosch focusing on technology and device development.

References

8” Open Innovation Silicon Carbide Pilot Line and Platform Technologies at A*STAR, Singapore

N. Singh
Deputy Executive Director (Research)
Institute of Microelectronics, Singapore,
Singapore

Abstract

The Institute of Microelectronics, A*STAR, Singapore has established an 8” open innovation silicon carbide pilot line, with specialty in lithography, epitaxy, channeling implant, and MOS interface. The pilot line has been qualified through 1200V class planar and trench gate power MOSFETs. High quality MOS interface with low D_{it}, high channel mobility, low PBTI, and low NBTI, has been achieved and implemented in platform technologies. High aspect ratio trench gate has been characterized with well rounded corners, vertical side, and low surface roughness. Smooth super-junction columns have been achieved using good layer-by-layer alignment.

Key Technologies Covered

Silicon Carbide high voltage MOSFET technology – epitaxy to power module packaging
200 mm SiC specialty process line with high resolution lithography, implanter with integrated XRD and single wafer epitaxy tool.
High growth rate epitaxy with low killer defect counts
Excellent MOS interface with low PBTI and NBTI
High carrier mobility
Well-rounded high aspect ratio trench gate
Excellent column alignment for super junctions

Biography

Dr Navab Singh is the Deputy Executive Director (Research) at the Institute of Microelectronics, A*STAR, Singapore. He started his career in semiconductors as a Lithography Process Engineer in 1996 after graduating with a Master of Technology degree in Solid State Materials from the Indian Institute of Technology Delhi, India. Since then, Dr Singh has worked on advancing specialty technologies to new frontiers in the fields of wide bandgap semiconductors, sensors & actuators, photonics, and heterogeneous integration. He obtained his PhD degree with work in Electrical and Computer Engineering from the National University of Singapore in 2008. He has authored or coauthored about 300 publications and holds an h-index of 49. Dr Singh is a recipient of the George E. Smith Award 2007 and the Singapore National Technology Award 2008, for his pioneer work on nanowire gate-all-around transistors. He was also presented with the TALENT award 2010 by A*STAR for Leading, Educating and Nurturing Talents at IME.

References

Silicon Carbide in AC Motor Drives

J. Puukko
Senior Field Application Engineer
Semikron Danfoss, Helsinki, Finland

Abstract
With recent technological advancements, silicon carbide is becoming the first choice for enabling energy savings and increasing power density. However, motor drives and silicon carbide MOSFETS are two topics that seemed impossible to combine: high costs, fast switching transitions, lack of short circuit capability, and reliability concerns were all persistent roadblocks, preventing a tangible return on investment. But it is time to rethink. By merging state of the art packaging technology with the latest generation of SiC MOSFETs, we provide a totally new degree of design freedom to motor drive design engineers.

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References