Industry Best Practices in Reliability Prediction and Assurance for Power Electronics:
Part 1 - Reliability of Power Electronics Components

NAME AND AFFILIATION OF THE AUTHORS

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SCOPE AND BENEFITS

Reliability of power electronics becomes more and more important. There are several reasons for that:

- Renewable energy generation takes place in harsh environments, like off-shore or in deserts. Maintenance is complicated which means that systems have to operate failure-free for 20 years
- 30 years of failure-free operation is required for avionics and railways
- Advanced power devices like IGBTs and SiC devices can be operated at higher temperatures which means that the temperature swing increases. This creates higher mechanical stresses and fatigue

Based on the physics of failure mechanisms and lifetime prediction will be discussed.

CONTENTS

- 9:30 - 11:00	- Robustness Validation Process - Building-in Reliability into Power Modules -	- E. Wolfgang - - J. Rudzki
- 11:00 - 11:30	- Break	-
- 11:30 - 13:00	- Reliability Testing of Power Devices and Modules - Reliability and Lifetime of Capacitors	- S. Schmitt - E. Wolfgang

i) Robustness Validation Process

The speaker will explain an approach how to secure reliability for power electronics systems and components which is based on the Robustness Validation process (SAE J1211 and AEC-Q101 Rev D1). The new standards will provide the automotive electronics community with a common qualification methodology to demonstrate acceptable reliability. It requires testing the component to failure, or end-of-life (EOL), without introducing invalid failure mechanisms, and evaluation of the Robustness Margin between the outer limits of the customer specification and the actual performance of the component. The reliability tests are based on mission profiles for specific applications, which include all stresses which are applied during operation for the whole specified life. This process is good for all power electronics applications.

ii) Building-in Reliability into Power Modules

- The requirements on today's power electronic modules are getting higher. The need for higher power density results in higher effort for cooling systems and increasing of operating temperature. The challenge now is to match the higher customer requirements with the desired reliability of the power module resulting in higher reliability of the inverter system.
- The key solution is to involve the modern packaging and cooling technology in combination with newest semiconductor devices.
- The tutorial will present new bonding and joining technologies like Ag sintering and Cu wire bonding. New top side contacts for semiconductor devices will be presented. All presented technology improvements increase the reliability of the modern power modules and enable outstanding power density results. The entering of new wide band gap semiconductor devices to the market can utilize the full performance only in combination with the newest packaging and cooling technology.

iii) Reliability Testing of Power Devices and Modules

HALT and HAST are two possible methods to speed up test for development and manufacturing. The advantage to define these methods within a wider range of parameter without special test chambers need knowledge about the failure mechanism of power devices. This will be explained on hand of an example. The same is true for the interfaces inside systems and subsystems to be able to come to a right interpretation of the test result. The differences towards classical qualifications will be the kind of selecting test parameters as well as read outs. Given test parameters by standards look mostly to device parameter, less on systems. Test setups should take this into account.
Reliability tests for industrial power modules in comparison to LV 324 will be shown.

iv) **Reliability and Lifetime of Passives**

Besides the power switches, the DC link capacitor is a key component in drive inverters. In the contribution, different capacitor technologies are presented and compared in terms of their application potential. In contrast to industry inverters, where Al electrolytic capacitors are generally employed, automotive industry focuses on polymer film capacitors. Ensuring the quality and lifetime of those components in the automotive environment is a non-trivial topic.
For power modules, e.g. those of drive inverters, a new automotive qualification scheme has been agreed on (LV324). Similarly, the existing AEC-Q200 standard does not cover the load profiles of an electric vehicle application (e.g. driving and charging), a new set of tests was defined in an ECPE- ZVEI working group which can be used in all other applications as well.

WHO SHOULD ATTEND

Young engineers and scientists who have to deal with reliability.

Technical Level:

Knowledge in electrical engineering, material science, physics, testing and product requirements

ABOUT THE INSTRUCTORS

Prof. Dr. techn. Eckhard Wolfgang

Eckhard Wolfgang studied Mechanical Engineering and Technical Physics at the TU Vienna where he received the Dipl.-Ing. and the PhD degree. From 1970 until December 2006 he was employed by Siemens Corporate Technology at Munich. His main research topics were: Analytics, testing of Mbit DRAMs, power semiconductor devices and power electronics, reliability of electronic components and systems. 1994 he became Honoary Professor at the University of Dortmund, Faculty of Electrical Engineering.
He acted many times as technical chairmen of conferences like ESREF and CIPS. At present he works as a consultant for ECPE, the European Center of Power Electronics.

Dr. Jacek Rudzki

Jacek Rudzki studied Electronics and Semiconductor Technology at the Technical University in Lodz. He received PhD degree at the Technical University in Braunschweig on the field of silver sintering technology in power electronics. He belongs to the Technology Department of Danfoss Silicon Power where he is working on new bonding and joining technologies and advanced reliability concepts. His main research topics are: silver sintering, Cu wire bonding, reliability, power density, top contacts, thermal management. He cooperates close with universities, companies and research institutes in Germany and worldwide. He gives lectures on the University of Applied Sciences in Flensburg and invited lectures at the University of Applied Sciences in Kiel.

Dipl. Ing. Stefan Schmitt

Stefan Schmitt studied Electrical Engineering at TU Erlangen where he received the Dipl.-Ing. degree. Since 1997 he is employed at Semikron Elektronik GmbH&Ko KG. Starting with development of driver electronics and stacks, he went over to field application. Currently he is the head of Semikron's test laboratory.