ESREF 2016 TUTORIALS

Time	Title	Speaker
Tuesday, 2016-09-20, 08:30 - 09:30	Fast Wafer Level Reliability Monitoring as a tool to achieve automotive quality for a wafer process	Andreas Martin
Thursday, 2016-09-22, 08:30 - 09:30	Creeping Corrosion of Copper on Printed Circuit Board Assemblies	Gert Vogel
Tuesday, 2016-09-20, 08:30 - 09:30	10 Years Robustness Validation	Eckhard Wolfgang / W. Kanert
Thursday, 2016-09-22, 08:30 - 09:30	Field- and time-dependent degradation of GaN HEMTs	Enrico Zanoni
Wednesday, 2016-09-21, 08:30 - 09:30	Failure mechanisms and precautions in plug-connectors	Pit Jacob

Fast Wafer Level Reliability Monitoring as a tool to achieve automotive quality for a wafer process
Andreas Martin, Infineon Technologies AG, Munich, Germany

After any process reliability qualification some tool is needed which verifies the stability of the process throughout mass production. A continuous "fast Wafer Level Reliability" (fWLR) Monitoring is essential especially for stringent product reliability specifications of automotive, medical or space applications. "Zero Defect" programs are well known and manifest the implementation of fWLR Monitoring on product wafers. However, often used quarterly reliability re-qualification cannot achieve this quality goal and is inappropriate. Therefore, fWLR Monitoring must be employed, covering reliability topics such as dielectric quality, plasma induced damage, device degradation and metallisation reliability. Additionally, fWLR can support a fast assessment of reliability during process development, split investigations, process tool changes and process qualifications.

In this tutorial an overview will be given on dedicated fWLR test structures, highly accelerated stress measurements, data analysis and sampling. Further, the challenges and limitations of the fWLR methodology will be pointed out as well as benefits will be highlighted. The topics of an out of control action plan, the scrapping of wafers with fWLR and defect density monitoring will be addressed.

This tutorial is suited for engineers and scientists who start in the area of reliability monitoring. But also experts who already work on this topic will benefit since also advanced methods are described. Valuable details and literature citations can be picked up.

Andreas Martin is a process reliability expert in the corporate reliability department of Infineon Technologies AG (IFX) in Munich, Germany. His experience comes from over 23 years in the field of "Wafer Level Reliability" (WLR). He has implemented the methodology of fast WLR Monitoring (fWLR) in all Infineon fabs and foundries worldwide for various process nodes. He is responsible for the IFX process qualification and for the design manual rules on plasma induced damage. He has been tutorial speaker at conferences, such as IEEE IRPS, IEEE IIRW, WoDiM, EurosimE, IEEE ICMTS. He is frequently a tutorial speaker on various reliability topics within the IFX University. He is active in standardization work with JEDEC since 20 years on WLR topics and involved with IEC and ITG. He had chaired IEEE IIRW, WoDiM and ITG-Fachtagung and was additionally involved in committees of IEEE IRPS and ESREF.

Creeping Corrosion of Copper on Printed Circuit Board Assemblies

Gert Vogel, Siemens AG, Digital Factory Division, Control Products, DF CP QM SQA

The mechanism of creeping corrosion of copper will be explained. Creeping corrosion of copper occurs when low concentration of hydrogen sulfide (< 1 ppm H2S) in combination with a relative humidity greater than 60% meets with bare copper on the bottom of a crack or pinhole. The forming copper sulfide is immobile but can be attacked by oxidizing gases and will diffuse as mobile copper oxide out of the pinhole. There it is retransformed by attacking hydrogen sulfide to copper sulfide.

Dr. Gert Vogel studied physics in Stuttgart. He has been with Siemens now for more than 30 years. Seven years he has been a semiconductor technologist in the Siemens DRAM production in Munich and Regensburg. Then he moved to Siemens Amberg where amongst other topics he is a specialist for failure analysis of electronic components on PCBAs (Printed Circuit Board Assemblies). Last year he held a tutorial about "Avoiding Flex Cracks in Ceramic Capacitors" at ESREF 2015 in Toulouse.

10 Years of Robustness Validation

Werner Kanert, Infineon Technologies, Munich
Eckhard Wolfgang, ECPE e.V., Nuremberg

It is a truism that reliability is related to applications requirements. Robustness Validation (RV) is a methodology to provide data demonstrating that a product is "fit for use". The ZVEI working group Robustness Validation was initiated 10 years ago. The concept has received increasing attention over this period, also beyond the automotive qualification procedures it initially originated from. The tutorial gives an overview of the basic concept of RV and experiences made in applying it to development and qualification. Two examples are discussed in detail: qualification of power modules and of thin-film DC-link capacitors. It also discusses difficulties in applying the concept.

Werner Kanert received his Ph.D. in physics from the Technical University Munich in 1986. In 1987 he joined the semiconductor group of Siemens AG, where he worked on silicon technology development, especially on HF-Bipolar, CMOS, smart power and power technologies. Subsequently, he took over responsibility for qualification of smart power and power technologies. Currently he is responsible for qualification strategy and methodology in Infineon's Automotive business division.

Eckhard Wolfgang received his PhD in technical physics from the Technical University Vienna in 1970. In the same year he joined the Siemens Research Center at Munich where he stayed until 2016. His research topics were: magnetooptical memories, analytics, e-beam testing of ICs, characterisation and test of 4 Mbit DRAMs, superconductive passive devices, power devices (light-triggered thyristors, high-voltage IGBTs), packaging and reliability of power devices. In 1994 he became a honoary professor at the University of Dortmund. Since 2017 he is a consultant for ECPE e.V. where he organizing workshops and tutorials as well as conferences (CIPS, ESREF). He has published more than 130 scientific and technical articles.

Field and time-dependent degradation of GaN HEMTs

Enrico Zanoni, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Padova

For both microwave and power switching applications, Gallium Nitride (GaN) devices offer significant advantages with respect to their silicon and GaAs counterparts: high carrier mobility and carrier density, outstanding breakdown fields and the possibility of operating at very high temperature are reflected into the possibility of designing high efficiency and high frequency power amplifiers and power conversion systems. According to the targeted application and market, these devices are epitaxially grown on Si or SiC substrates, the option of GaN bulk substrates being still limited and expensive. Material defectivity, related with lattice mismatch between GaN and substrate, and the extremely high electric field values may cause potential reliability issues which are under intense investigation worldwide. This tutorial will review most recent works concerning the study of defects-related parasitic effects and of physical failure mechanisms of GaN devices.

After a short overview on the reliability of GaN HEMTs for microwave applications, the analysis will focus on the characterization of deep level effects in enhancement- and depletion-mode power GaN devices for switching applications. Threshold voltage instabilities in MISHEMT structures and their dependence on dielectric properties will be reviewed. Subsequently, it will be shown how the extremely high electric field values may lead to time dependent breakdown phenomena, affecting not only dielectric layers but also the GaN semiconductor itself. Recent data on the reliability of p-gate devices will be presented. Finally, breakdown mechanisms limiting the maximum device operating voltages will be reviewed.

Enrico Zanoni is Full Professor of Electronics at the University of Padova (Department of Information Engineering) since 1993; he coordinates a group with >20 members (including professors, researchers, post-docs and PhDs). He made several contributions to the characterization, reliability and modeling of electron devices; on these topics he coauthored more than 600 peer-reviewed papers and five patents. At the date of July 14, 2016, ISI Web of Science reports approx. 420 records, cited 4000 times without self-citations, h-index 34. He is an IEEE Fellow (Electron Devices society). He has been or is coordinator of the "Reliability" section of the European projects: EDA KORRIGAN, "Key Organisation for Research in Integrated Circuits in GaN technology"; EDA MANGA, "Manufacturable GaN"; EDA EUGANIC, "European Gallium Nitride Industry Supply Chain"; HORIZON 2020 ECSEL POWERBASE "Enhanced substrates and GaN pilot lines enabling compact power applications". He is a co-founder of LightCube, a spin-off of the University of Padova developing LED systems for lighting applications, biomedical systems, spectroscopy.#

Failure mechanisms and precautions in plug connectors and relays

Peter Jacob, Empa Dübendorf

Plug connectors are one of the frequent failure causes when regarding at electronic systems. Since connectors had to keep pace with ongoing miniaturization on PCB level, current and voltage capabilities and specifications are frequently sportive or even overestimated. The tutorial focuses on the interfaces between connector and PCB as well as on connector-to cable and the connector contact itself, showing various failure mechanisms and precautions. Environmental conditions may also severely impact the connector reliability. The tutorial sensitizes the failure analyst to this underestimated topic and offers a deeper understanding and precaution measures against connector-related failures. Since many aspects considering plug connectors also apply for relays, the most important relay failure aspects are included in a small chapter of this tutorial.

After his studies in Technical Physics in Munich, **Peter Jacob** worked as a failure analysis expert in IBM Boeblingen 1981-1992. After a short period at Hitachi Scientific Instruments in electron microscopy configurations and customer trainings, he joined ETH Zurich/ Empa as a senior expert for failure analysis on micro- and power-electronics from device to system level. In parallel to this, he joined in 1995 to Swatch Group – EM Microelectronic Marin as a principal F/A engineer. Jacob has authored more than 70 contributed and invited papers including two ESREF Best Papers. He volunteers in the German ESD Forum, EDFAS and EuFANet. In recognition of his lectures in scanning electron microscopy, he was appointed in 2007 to a Honorary Professor of Technical University Munich and in 2010 he received the International Barkhausen Award of Technical University Dresden. In the recent years he focused on system failure analysis including failure anamnesis.