ESREF 2015 TUTORIALS

T1. *Integrated Vehicle Health Management (IVHM) for Aircraft Electronics/Power Electronics* - **Suresh PERINPANAYAGAM**, Cranfield University, Integrated Vehicle Health Management (IVHM) Centre

Integrated Vehicle Health Management (IVHM) is the transformation of system data on a complex vehicle or system (such as a luxury car or a commercial airplane) into information to support operational decisions and optimise maintenance. IVHM is a capability, comprising a number of technologies that can be used across a number of sectors for business benefit. IVHM is becoming increasingly important as OEMs (Original Equipment Manufacturers) move from the traditional sale of a product, in which future income is dependent on spare part revenue, to selling a service in which steady monthly income can be derived in return for the effective maintenance of the asset. IVHM enables this transformation. The IVHM Centre delivers generic IVHM solutions including capability to sense, detect, diagnose, and predict imminent degradations or failures in vehicles, thereby allowing the evaluation of the reliability of the systems under real application environments. This tutorial will focus on investigating the capability of health monitoring techniques to detect degradation of electronic and power electronics in an integrated avionic system.

Dr Suresh Perinpanayagam leads the ePHM Group, part of the Boeing Integrated Vehicle Health Management Research Centre set up by The Boeing Company. Suresh has rapidly established a research group, managing 14 researchers (2 research fellows, 6 full-time PhDs, 2 MSc by research and 4 MSc by taught course students) and has obtained grants amounting to £1.4M in total from industrial, EPSRC, TSB and EU-FP7 projects. Suresh obtained his Master in Engineering and PhD in Engineering at Imperial College, London. Suresh has spent considerable time in industry working on various industrial R&D projects. Suresh's vision is to create every electronic system with its own brain to be self-aware of its own health state and to work effectively with other systems to complete a function even if it is not in an optimal state. To realise this, the group develops tools to detect the inception of failures in electronic components and track them to system failures. They also need to correlate the fundamental physics-of-failure work currently done at material science level (for example, solder joint and wire bond failure) to the electronic system data acquired for system health management from data-centric aircrafts, such as Boeing 787. These intelligent electronic systems will inform and reconfigure its health state at different stages of its life. These new systems will redefine the current Built-In Test (BIT) technology in electronic systems with more user-friendly, reduced no-fault-found rate, reduced repair, reduced cost, predictable failures and greater availability for industry. The ePHM group has links with many of the UK's high value added electronic system manufacturers, including AEC, Thales, Selex, BAE Systems, Meggitt, GE, Honeywell, Cassidian, General Dynamics, UTC, Raytheon and Visteon Corporation. The group uses this forum to connect fundamental research issues in material, design, manufacturing process, testability, system issues and through-life management of these electronic systems.

T2. *Part I: Radiation effects on components at space level* - **Robert ECOFFET** (CNES)

Part II: *Radiation and COTS at ground level* - **Jean-Luc AUTRAN**, **Daniela MUNTEANU**, *Aix-Marseille University, CNRS, IM2NP* (F)

Part I: Radiation effects on components at space level - The space radiation environment is a major constraint in satellite design and a source of many in-flight anomalies. In this communication, we will start with a brief overview of the space radiation environment. Then we will review the state of the art of major effects of radiation on electronic components, as taken into account in space projects today. This part of the talk will be illustrated by examples of radiation-induced spacecraft anomalies. In a third part, we will try to appreciate the possible new challenges brought by technology downscaling and the introduction of new materials and concepts. Finally, we will describe the “radiation hardness assurance” in space projects and highlight the steps where improvements and margin optimization could be made in this engineering process.

Robert Ecoffet was born in Marseille, France, on July 22, 1963. He graduated in 1987 with an engineer degree from the Ecole Supérieure d’Electricité, Gif sur Yvette, France, with a specialization in electronic properties of materials. After serving in the French Marine for his National duties, he joined as an engineer the French Space Agency CNES (Centre National d’Etudes Spatiales). Since 25 years, he has been working for CNES in the field of space environment and radiation effects. He participated extensively in radiation testing and project support in this field, leaded many radiation effects and space environment modeling research activities, was responsible for the development of space environment and technological experiments, and was part of many spacecraft anomalies investigation teams. He co-authored more than 100 papers mainly published in the IEEE Transactions on Nuclear Sciences. He is a member of the RADECS Association (Radiation Effects on Electronic Components and Systems) steering board, and had the honor to serve as General Chairman of the 2014 IEEE Nuclear and Space Radiation Effects Conference. His position in CNES is senior expert in space environment and radiation effects, and responsible for CNES “space environment” R&D axis.

Part II: *Radiation and COTS at ground level* - This tutorial will survey single event effects (SEE) induced by terrestrial cosmic rays on current commercial CMOS technologies. After describing the natural radiation environment at ground and atmospheric levels, the tutorial will describe the physics of SEEs, from the main mechanisms of interaction between atmospheric radiation (neutrons, protons, muons) and circuit materials to the electrical response of transistors, cells and complete circuits. SEE characterization using accelerated and real-time tests will be examined, as well as modeling and numerical simulation issues. Special emphasis will finally concern the radiation response of advanced technologies, including deca-nanometer bulk, FD-SOI and FinFET families.

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Jean-Luc Autran is distinguished professor of physics and electrical engineering at Aix-Marseille University and honorary member of the University Institute of France (IUF). He is also deputy director of the Institute for Materials, Microelectronics, and Nanosciences of Provence (IM2NP, UMR CNRS 7334) and the principal investigator of the Altitude Single-event effects Test European Platform (ASTEP). His current research interests focus on the physics of soft errors, from the characterization of natural radiation to Monte Carlo radiation transport simulation. He is the author or coauthor of more than 300 papers published in international journals and conferences, and has supervised 28 Ph.D theses.

Daniela Munteanu is director of research at the National Center for Scientific Research (CNRS). She is a fellow researcher at the Institute for Materials, Microelectronics, and Nanoscience of Provence (IM2NP, UMR CNRS 7334) and has 15 years of experience in characterization, modeling, and simulation of semiconductor devices. Her current research interests include emerging complementary-metal-oxide-semiconductor (CMOS) devices, compact modeling, numerical simulation in the domains of nanoelectronics, and radiation effects on components and circuits. She is also the author or coauthor of more than 200 papers published in international journals and conferences, and has supervised 12 Ph.D theses.

T3. *FA (=Failure Analysis and Anamnesis) and reliability at system level* - **Peter JACOB**, EMPA Duebendorf (Switzerland)

Most failure analysts are used to do failure analysis on device level but they hardly know about failure analysis and anamnesis on system level. Many device failure analysis wrap up with EOS, which in most cases also means "end of story". However, looking at root cause findings, a majority of device failures result from circuitry transients, environmental conditions or from passive component failures, which produce shorts or lose their protection function. The tutorial shows up systematic approaches on failure anamnesis, which ideally guides towards the failure root cause by a careful application evaluation. Numerous examples illustrate the methodology. In this context, classical device analysis becomes just a supporting function of the anamnesis, which includes statistical and physical failure occurrence, reliability aspects, reverse FMEA and fact sheet analysis. The goal of the tutorial is to open the device-minded view of failure analysts towards the operational environment, mission profiles and system-related physics-of-failure.

After studying Technical Physics in Munich, **Peter Jacob** started his professional work in 1981 as a failure analysis expert in IBM semiconductor plant Boeblingen until 1992. After a short period at Hitachi Scientific Instruments, where he was responsible for 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 work, in 1995 he joined to Swatch Group – EM Microelectronic Marin as a principal F/A engineer. Jacob has authored more than 60 contributed and invited papers including an ESREF Best Paper. He volunteers in the German ESD Forum, EDFAS and EuFANet. In 2007 he was appointed to a Honorary Professor of Technical University Munich and in 2010 he received the International Barkhausen Award of Technical University Dresden.

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T4. *MEMS Failure modes, FA and reliability challenges* – **Jérémie DHENNIN**, Elemca (F)

Challenges in the successful industrialization of MEMS devices are probably now related to their reliability. When lifetime is a first order criterion, reliability should be addressed since the early stages of development. The purpose of the tutorial will be to introduce the methodologies to evaluate the reliability of MEMS devices, as well as the conventional or custom techniques that can be used for that purpose. Indeed, the standard approaches for reliability assessment or qualification of microelectronics devices are insufficient to account for the MEMS peculiarities (multi-physical effects). A case study on RF-MEMS devices will be presented during the tutorial.

Jeremie Dhennin received his master degree in Micro and Nano Physics from the university of Paul Sabatier in Toulouse, France in 2005. He joined NOVAMEMS as a research engineer working on multi-physical characterization and modeling of MEMS switches failure mechanisms. His research activities focused on RF MEMS switches reliability, failure analysis and modeling, especially dealing with micro-contact issues. Since 2012, his technical scope has evolved to more generic reliability issues, dealing with other types of MEMS or electronic components. His managerial experience and broad technical scope has allowed him to take the CEO position at FIALAB – now ELEMCA – at the beginning of 2013.

T5. *Avoiding Flex Cracks in Ceramic Capacitors (CerCaps): Analytical Tool for a Reliable Failure Analysis and Guidance for Positioning CerCaps on PCBs* - **Gert VOGEL**, SIEMENS AG (Germany)

In every electronic assembly line where ceramic capacitors are used and printed circuit boards are de-paneled the quality risk “flex cracks” is known. Unfortunately flex cracks in ceramic capacitors (cercaps) always extend under the metal terminations of the capacitors and electrical tests do only reveal about one percent of the affected parts. With a new method – etch away the terminations and look at the otherwise hidden cracks – it is possible to identify all sources of mechanical bending and warping. In the course of failure analysis is it helpful to know that most times not only the failed ceramic capacitor shows a crack pattern but also all the surrounding cercaps as well. Well-founded knowledge about different crack patterns and failure modes also allows recognizing unsafe bending and warping lines on the PCB. This gives us a guidance to place the ceramic capacitors in optimal orientation not only to de-paneling lines but also in the vicinity of mounting and screw openings. Finally the different kinds of cercaps with internal layouts that prevent boards from failing even if flex cracks should show up are reviewed.

Dr. **Gert Vogel** has been with Siemens 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.

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T6. *Minimizing Defects by Design for Soldering* - **Thomas AHRENS**, TrainAlytics GmbH (Germany)

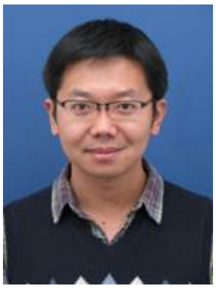
Soldering is by far the most used joining technology for electronic assemblies on printed circuit boards. With small pitch, lead-free soldering and hidden solder joints there are strong challenges and process issues to keep solder defect rates low. Observing certain design rules helps a lot. This tutorial presents key points in geometry of solder lands, material and process tolerances, paste volume vs. solder fillet volume, and needs for process control. You will learn how to classify and count solder defects and be able to sort them according to possible origin. In many cases there are checklists available from various IPC standards, which give a base or a starting point for an appropriate technological approach. Target groups for this tutorial are designers, process and quality specialists and managers. It provides design for manufacturing procedures to enhance the productivity of electronic assemblies, thus reducing the probability of solder defects.

Dr. Thomas Ahrens is active as consultant in the field of quality and reliability, production and repair of electronic assemblies. On a background of materials sciences, he has over 25 years of reputation in trouble shooting and qualification of materials, processes and personnel. His work methods include customized on-site investigation, mediation of seminars, workshops and practical training for industry clients. Dr. Ahrens collects his experiences from a rich fund of public research and development projects, and quality and damage analysis cases. Dr. Ahrens is Master Trainer for IPC-A-610 and J-STD-001 and chairs the DVS thematic group FG 4.11 Education in Solder Process for Electronic Assemblies. Dr. Ahrens is Managing Partner of Trainalytics GmbH, DE-Lippstadt, a company serving electronics industry in employees training, product quality and physical defect analysis.

T7. *Mission profile and reliability on power electronics* - **Prof. Ke Ma and Prof. Huai WANG**, Aalborg University / **Peter de PLACE RIMMEN**, Danfoss Power Electronics

In many mission-critical applications of energy conversions such as renewables, electricity transmission, electric vehicles, and aircrafts, etc, the power electronics should be extremely reliable and robust to avoid high cost of failures. In order to meet this challenging requirement, there is an ongoing paradigm shift in this field from the statistics-based assessment to the physic-of-failures based analysis. In this shift the stress and strength models of the power electronics components need to be accurately built, and both of the factors are closely related to the operating conditions or mission profiles of the whole systems. These mission profiles will involve multi-disciplinary knowledge and new approaches for the design of reliability performances.

In this tutorial an overview of the involved data for specifying reliability for a new product development will be first given, and the importance of mission profiles for the reliability R&D is emphasized from industry perspective. Afterwards a flow and structure, which can translate the mission profiles of applications to the reliability metrics of power electronics, is proposed with practical examples. And some emerging challenges and requirements for the reliability testing/validation are also addressed. Finally the potential methodologies and technology trends involved with mission profiles based reliability analysis are also discussed.



Ke Ma is currently an Assistant Professor at Aalborg University with the Center of Reliable Power Electronics (CORPE), where he is the leader of working package 4 involving reliability modeling and design tools development. His research interests are power electronics technology including reliability in the applications of power generation and consumption systems. In the last 4 years he has contributed more than 50 journal and conference papers including 4 book chapters in the field of power electronics and reliability. He is one of the lecturers for an Industrial/PhD course on "Reliability in Power Electronic Systems" at Aalborg University, and was invited as speaker at two of the European Center for Power Electronics (ECPE) workshops. Dr. Ma received the B.Eng. and M.Sc. degrees from Zhejiang University, China and PhD degree from Aalborg University, Denmark. He was the receiver of the Excellent Young Wind Doctor Award 2014 by European Academy of Wind Energy, as well as a few IEEE prized paper awards. He is now serving as Associate Editor of IEEE Transactions on Industry Applications.

Huai Wang is currently an Assistant Professor with the Center of Reliable Power Electronics (CORPE) in the Department of Energy Technology, Aalborg University, Denmark. His current research interests include the reliability of power electronic systems and reliability of capacitors in power converters. He was one of the lecturers for a PhD course on Reliability in Power Electronic Systems at Aalborg University and was an invited speaker at the ECPE workshop on lifetime modeling and simulation. He has contributed a number of journal papers, including several concept papers on the design for reliability of power electronic systems. Dr. Wang received his PhD degree from the City University of Hong Kong, Hong Kong, in 2012. He is a Visiting Scientist with the ETH Zurich, Zurich, Switzerland, from August to September 2014 and with the Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, from September to November 2013. He was with the ABB Corporate Research Center, Baden, Switzerland, in 2009. He serves as an Associate Editor of IEEE Transactions on Power Electronics, and a Guest Associate Editor of two special issues on topics relevant to reliability in power electronics.

Peter de Place Rimmen is today Reliability Advisor at Danfoss Power Electronics A/S in Denmark. His experience is coming from total 42 years with R&D. Totally 7 years as designer, 9 years with management and during the last 27 years Peter has worked with practical approach implementing Reliability in followed companies: Vestas Wind System R&D form 2004 to 2009, Grundfos Management from 1997 to 2004 and Bang & Olufsen R&D from 1988 to 1997. Before that he had careers at B&O as constructor, Test engineer, Plant manager and Project manager. Peter had for some time participated in IEC dependability group. Peter has together with Nokia trained Nokia R&D and Vestas R&D people around the world in “Design for Quality and Reliability”. Today Peter is participating in “CORPE” Centre of Reliable Power Electronics at Aalborg University, Teaching 2th Master Class at Aalborg University Dep. Energy Technology in modern reliability, participating in ZVEI “Facts Sheets Group”, board member FAST (Danish Society for Applied Statistics) and initiated in 2001 and member of the Danish Six Sigma ERFA-group, subgroup of FAST. Member of the Danish Reliability group (SPM-6) since 1988.