Introduction to Si IGBTs and Fast Diodes: Design Principles, Performance Requirements and Development Trends

Name and Affiliation of the Lecturer:

Dr. Munaf T. A. Rahimo
Consultant
MTAL GmbH
Unterer Schafmattweg 39A
Gänsbrunnen, 4716, Switzerland
Email: munaf.rahimo@mtal.ch
phone: 00 41 79 800 2807

Scope and Benefits:

Over the past four decades, the silicon IGBT and companion Fast Recovery Diode have established themselves as the devices of choice in the vast majority of medium to high voltage power electronics applications. This dominant role has been achieved by the tremendous advancements over the years in Silicon material quality, advanced processing techniques and evolving design concepts. Despite the emergence of high power SiC MOSFETs, the IGBT/Diode prominent position is set to continue for many years to come due to the mature and cost-effective technology platforms and continuous technology advancements for improved overall performance. This tutorial will cover a wide range of IGBT/Diode related topics including basic device principles (structure, operational modes), electrical / reliability performance (Losses, SOA, device stability and failure modes), current and future development trends (advanced trench concepts, RC-IGBTs) and future outlook in relation to SiC MOSFETs.

Contents:

The half-day tutorial will cover first an introduction of power semiconductor devices and power electronics applications. A set of definitions will be presented with respect to the main device sections and associated technology platforms which are common principles for all type of power device structures. This will also include the main power device requirements for mainstream power electronics applications. The target of the above introduction is to aid in gaining a better understanding of the following sections which are dedicated to the silicon IGBT and it`s anti-parallel diode. The following sections will present the basic principles of the IGBT and fast recovery diode structures and electrical performance. This will also include the device static and dynamic behaviour including safe operating area and fault operational conditions such as during short circuit and surge current. The different device design concepts and development trends will be discussed while

outlining the potential impact such advancements will have on the system level performance. A dedicated section will cover the IGBT and diode chip level reliability especially in relation to the device long term stability under challenging environmental conditions such as in humidity or under extreme dynamic avalanche conditions. Finally, the tutorial will attempt to provide an outlook into the future potentials of Silicon IGBTs in particular when compared to the recent advances made for SiC MOSFETs.

Schedule: **Monday, 5 September 2022 - 1st Tutorial Day - Morning**

09:30 – 11:00 Tutorials Morning - Part 1

09:30 – 09:50 Introduction: Power Devices and Power Electronics Applications

- Power Electronics Applications and Power Semiconductors
- Power Semiconductor Boundaries and Limitations

09:50 – 10:15 Power Device Technology Platforms and Device Requirements

- Power Semiconductor Device Sections and Technology Platforms
- Power Semiconductor Performance Requirements
- Technology development drivers (Technology Curve for Bipolar Devices)

10:15 – 11:00 Silicon IGBTs

- Basics and Electrical Characteristics
- Requirements and Structural Evolution
- Safe Operating Area, Short Circuit Instabilities
- Future Development Trends including Advanced Trench and RC-IGBT Concepts

11:00 – 11:30 Coffee break

11:30 – 12:50 Tutorials Morning - Part 2

11:30 – 12:00 Fast Recovery Diodes

- Basics and Electrical Characteristics
- Requirements and Structural Evolution
- Snappy Recovery and Safe Operating Area
- Future Development Trends

12:00 – 12:30 Chip Reliability

- Blocking Stability and Chip Protection
- Dynamic Avalanche Withstand Capability

12:30 – 12:50 Si IGBTs and Fast Diode Outlook (Si versus SiC)

- WBG Power Semiconductors, SiC Power MOSFETs are close to an ideal switch
- Si versus SiC in Future Power Electronics Applications

12:50 – 13:00 Closing Discussion, Lunch break (Optional – if ordered)

Who should attend:

The targeted audience are students, engineers and scientists involved in the field of power semiconductor devices and their applications. The audience will require some basic knowledge of semiconductor device physics and/or power electronics circuits and applications. This presentation is interesting for audience such as:

- Graduate and Post Graduate students in the relevant areas.
- Engineers and scientists working in research institutes or in industry in the relevant areas.

Technical Level:

Technical Level: Beginners, Intermediate and Advanced

About the Lecturer:

Dr. Munaf Rahimo received his BSc from Baghdad University, Iraq in 1991 and his MSc/PhD from Staffordshire University, UK in 1993/1996. He joined GEC Plessey Semiconductors, UK in 1996 and Semelab Plc, UK in 1999. In 2000, he joined ABB Switzerland, Semiconductors. Since 2018, he is general manager of his consulting firm MTAL GmbH and the founder of mqSemi AG which is power device start-up based in Switzerland.

Dr. Rahimo has 30 years of accumulated experience in the field of power semiconductor devices and applications. His industrial experience consists of 25 years of uninterrupted and dedicated work in power device research and development. He pioneered a wide range of breakthrough power device concepts such as the Enhanced Planar IGBT (SPT/SPT+), Bimode IGBT (BIGT) and High-Power Technology IGCT (HPT) to mention a few which are employed globally in mainstream applications such as Grid (HVDC and FACTS), Traction, Renewable and Industrial drives. In 2012, he was awarded ABB`s Corporate Executive Engineer title due to his power device technical achievements which led to clear improvements at system level especially for HVDC applications.

Dr. Rahimo is an IET Fellow and a Senior Member in the IEEE. He > 100 patents families including > 65 families with patent grants and has authored and co-authored > 200 publications and given many invited talks and tutorials.