Discussion Group III at IIRW 2019

Widebandgap Semiconductors in Automotive

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1. Introduction

Widebandgap semiconductor materials, mainly SiC and GaN, are generating interests in more and more segments of the power device market including automotive. This discussion group was set up to screen some of the related topics of this fields. The following questions have been prepared to define the different aspects of this topic:

- What are the typically applications for WBGs in automotive?
- Which are the key reliability aspects/concerns in WBG? Are those topics particular to WBG and why?
- How to assess extrinsic and intrinsic failures effectively?
- Where do we need/want more understanding of the failure mechanism?
- What differences will be needed for qualifying WBGs over Si?
- What additional requirements need to be met for WBGs to appear in automotive?

An introduction to the topic in a broader sense has been given by the two invited talks at this year's IIRW on reliability aspects of GaN high voltage devices [1] and statistical implementations for reliability assessment in automotive manufacturing [2]. Furthermore, a brief introduction has been given on today's perspective of GaN and SiC in the automotive market as well as apparent challenges in reliability [3]. The importance of including application relevant lifetime tests as part the full qualification has been further mentioned [4] and some state-of-the-art results published today were discussed [5,6]. Also a brief overview of key reliability topics in SiC has been presented based on [7].

The discussion was started by an initial introduction round and the collection of most relevant topics among all the present participants.

List of participants:

Clemens Ostermaier, Cristiano Capasso, Armien Hanelli, Vivien Cartailler, Alexander Kotov, Chadwin Young, Gaddi Haase, Jean Yang-Scharlotta, Pat Lenahan, Stanislav Tyaginov, Simon Schlipf, Francesco Maria Puglisi, Talha Chohan, Kin P. Cheung, Alexander Makarov, Shriram Shivaraman, Kin-Leong Pey, Thomas Kauerauf, Michael Waltl

2. Discussion

Out of the initial introduction and brainstorming round two main topics have been elaborated during the time of evening:

1. Which are the key reliability aspects/concerns in WBG?
2. Where do we need/want more understanding of the failure mechanism?

Several other interesting questions arose towards mechanical stress in package, scalable reliability models beyond DC tests in the RF domain and wafer-level reliability testing for GaN. Due to the lack of time those topics could not be continued in the large discussion group.

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2.1 Key reliability aspects/concerns in WBG

The detailed discussion on key reliability concerns of SiC and GaN led to the following comments and concerns

- Screening of extrinsic failures for space applications
- Screening for critical missions, running life tests properly, understanding device drifts
- Effectiveness of screening when intrinsic and extrinsic failures are "merging"
- Not enough extrinsic lifetime models and data available in literature today
- Lifetime modeling for extrinsic fails are perhaps not sufficient
- What is the expected failure rate for these devices?

As the majority of the comments from participants were focusing on the role of extrinsic failures, this particular point has been further elaborated in the discussion with the following statements:

- No difference being made between Si and widebandgap semiconductors when it comes to failures in automotive applications
- Generating screening models and sufficient low failure rates is not a blocking point for WBGs – it just needs to be done.
- Reliability is a value proposition not a cost proposition
- Reliability is an expectation not a value added
- Reliability can be a differentiator

2.2 Where do we need/want more understanding of the failure mechanism?

This particularly interesting question from academia and research institutes has led to the following initial questions and comments:

- Is it possible to use DFT in GaN to get more insight into defects?
- Lateral hard breakdown is not enough understood today!
- Are MIS devices needed in GaN or other wide-bandgap devices
- How would you co-package Si and GaN and SiC devices together in automotive applications?
- Investigate physics of charge-trapping in GaN, and use it to define an acceleration test that covers most of the defects
- How do GaN/SiC devices perform under radiation hard conditions?

After further elaboration on some of those questions the following outgoing statements have been noted down by the participants:

- In GaN the number of potential defects is very high due to the heterogeneity of the material (structure defect e.g. threading dislocations of different types and cores)
- There are also many known defects in SiO_2/Si system - not all are relevant therein too.

- Detailed defect understanding is needed from electrical experience – too much experimental data describe device drifts not defect behavior!
- DFT will be certainly be useful once more detailed physical understanding is available (e.g. see the role of C: point defect or defect band?)
- Use knowledge gained in Si and leverage it for designing good acceleration tests for GaN reliability

In conclusion, among the wide topic of widebandgap semiconductors in automotive, the main focus of the discussion group has been on today's understanding and the future need on extrinsic defects and their physical models.

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References

[1] The role of defects on reliability aspects in GaN power devices, C. Ostermaier et al, IIRW19

[2] Statistical Implementations for Reliability Assessment and Cost Cutting in Automotive Manufacturing, C. Capasso et al., IIRW19

[3] Introduction to Discussion Group III on widebandgap materials, C. Ostermaier, IIRW19

[4] Reliability and qualification of CoolGaN™, Tim McDonald, Infineon 2018 (white paper)

[5] Ming-Cheng Lin et al (TSMC). ISPSD 2019

[6] Ayanori Ikoshi et al. (Panasonic), APEC 2018

[7] Kimoto et al., IRPS 2017, invited talk