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Trip Report on International Symposium on the Physical and Failure Analysis of Integrated Circuits 2018 and NTU-MIT Alliance Labs Visit

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Abstract

Koon Hoo Teo attended the International Symposium on the Physical and Failure Analysis of Integrated Circuits 2018, Singapore, from July 16 -19, 2018. The conference was well attended and there were about 250 attendees with a good mix from both academia and industry. One of the keynote speakers, Prof. Muhammad Ashraf Alam of Purdue University highlighted the followings: The von-Neumann computing architecture itself is expanding to include neural networks, guided by the specialized needs of ecosystem companies, such as Amazon, LinkedIn, and eBay. This sea-change in computing technology must be supported by a corresponding broadening of our focus on multi-component reliability physics. Deep understanding on the reliability physics of logic and power transistors, sensors, solar cells, and batteries is important and create a platform that predicts the integrated, system-level reliability.

Mitsubishi Electric Research Laboratories

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Koon Hoo Teo, Version 1.0, August 19, 2018

Summary

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One of the keynote speakers, Prof. Muhammad Ashraf Alam of Purdue University highlighted the followings: The von-Neumann computing architecture itself is expanding to include neural networks, guided by the specialized needs of ecosystem companies, such as Amazon, LinkedIn, and eBay. This sea-change in computing technology must be supported by a corresponding broadening of our focus on multi-component reliability physics. Deep understanding on the reliability physics of logic and power transistors, sensors, solar cells, and batteries is important and create a platform that predicts the integrated, system-level reliability.
This conference presented many aspects of science of reliability. Some noted conclusions from presentations are as follows:

1 Reliability of bonding due to oxidation of metallization has to be taken seriously to avoid solder void,
2 The use of Auger Electron Spectrum to analyze and monitor surface Fluorine contamination level on a normal Al bondpad is recommended,
3 The origin of Au electrochemical migration that is related to chlorine ions and dominant electrolyte formed in low temperature (-45℃) is alcohol.
4 A proposed Mix-Net offers the best trade-off between minimizing signal loss and improving Electrostatic Defects (ESD) robustness. The proposed ESD networks work well for narrow band mm-wave applications within 7.5 GHz to 62 GHz frequency range.
5 Current distribution was observed to play a large role in electromigration lifetime, in which splitting the current equally between solder balls greatly outlived those configured serially.

Teo also visited NTU-MIT Alliance lab and the SMART Lab in Singapore. The Alliance lab is well equipped to study device reliability due to material defects and they have a number of findings and publications to support their claims. One of which was reported at this conference by Prof Carl. Thompson of MIT and NTU-MIT Alliance (Nanyang Technological University) on GaN device reliability, and in particular due to pit and dislocation formations. He explained how they behaved under mechanical and electrical stress and their impact on device performance. This lab has also experimentally shown that carbon impurities can cause a very high initial leakage current for AlGaN/GaN-on-Si high electron mobility transistors. Its presence in the gate metal can reduce the zero-bias Schottky barrier height. This finding highlights the detrimental effect of carbon to the device fabrication yield.

The SMART lab claimed to be able to design a buffer to reduce dislocation in GaN on Si devices, which is particularly important for GaN and Si circuit integration. As illustrated in experimental results of their fabrication and design capabilities, the density of the V-pits in the initiation layers on 200mm SEMI-spec Si wafers using careful GaN buffer design is $5.5\times^{108}$ cm^{-2}. As a comparison, they are also able to achieve a pit density of 2.7×10^{8} cm^{-2} using thicker 1mm Si substrates.

Details

The following presentations were attended (see http://www.ipfa-ieee.org/2018/):

Failure analysis of multilayer-metal-packaged power devices for abnormal thermal response
1Yulong Zhang*, 2Lulu Wang, 2Bo Gao, 2Lixin Wang, and 1Jiajun Luo 1Key Laboratory of Silicon Device Technology, Institute of Microelectronics of Chinese Academy of Sciences, Beijing, 10002

Case Study and Application on Failure Analysis for Power Device
HE Sheng-zong1, WANG You-liang1, PENG Ze-ya1, ZHANG Yin2, Chen Jin-tao2, ZHU Bin-ruo2, JIANG Jian-Feng2

Can We Use EDS To Determine Fluorine Contamination Level on A Normal Al Bondpad? Hua Younan WinTech Nano-Technology Services Pte. Ltd.

Contaminant and alcohol induced electrochemical migration of Au bond in ICs during low temperature operation test
Xuanlong Chen1,2,3, Lan Chen1,2, Youliang Wang1,2, Daojun Luo1,2, Jintao Chen4, Binruo Zhu4 1. China Electronic Product Reliability and Environmental Testing Research Institute, Guangzhou 510610, China 2. Reliability Research and Analysis Centre, China CEPREI Laboratory, Guangzhou 510610, China 3. School of Electronic and Information Technology, Sun Yat-sen University, Guangzhou 510275, China 4. Electric Power Research Institute, SMEPC, Shanghai 200437, China

Distributed ESD Protection Network for MillimetreWave RF Applications
Aihua Dong1, Srivatsan Parthasarathy2, Javier A. Salcedo2, Hang Li1, Jean-Jacques Hajjar2, Kalpathy Sundaram1, Linfeng He1 and Sirui Luo2
1Electrical and Computer Engineering, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL, United States 32816

Characterization of Dielectric Breakdown and Lifetime Analysis for Silicon Nitride Metal-Insulator Metal Capacitors under Electrostatic Discharge Stresses

Hang Li 1*, Hobie Yun 2, Wei Liang 1, Aihua Dong 1, Meng Miao 1, and Kalpathy B. Sundaram 1
1Department of Electrical and Computer Engineering, University of Central Florida, Orlando, FL 32816, USA. 2Qualcomm Technologies Inc., 5775 Morehouse Dr, San Diego, CA 92121, USA
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Electromigration Reliability of Solder Balls
Christine Hau-Riege1 and YouWen Yau2 Qualcomm Technologies, Inc. Santa Clara1 and San Diego2 USA +1 (408) 533-9647, Email: chaurieg@qti.qualcomm.com

Electrochemical Oxidation, Threading Dislocations and the Reliability of GaN HEMTs
Carl V. Thompson1,3
Dept. of Materials Science and Engineering, M.I.T.
Primary collaborators:
*Wardhana A. Sasangka*1, Govindo Syaranamual1,2,
*Chee Lip Gan*1,2, Tomas Palacios3, Feng Gao3, Jesus Del Alamo3, Jongwoo Joh3, Prashanth Makaram3
1 Singapore-MIT Alliance for Research and Technology

Slides from the meeting with NTU-MIT Alliance lab and the SMART Lab in Singapore are available at
https://www.researchgate.net/publication/330811996_Reliability_of_AlGaNGaN_High_Electron_Mobility_Transistors