CENTER FOR RELIABILITY SCIENCES AND TECHNOLGIES

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Reliability Analysis and Scientific Research Seminar, Tainan, Taiwan

A national seminar on "*Reliability Analysis and Scientific Research Seminar*" was jointly organized by CReST and NRL (National Research Laboratories) labs in National Cheng Kung University, Tainan on 10 September 2019. This seminar was aimed at establishing the correct concept of reliability test and accelerated life assessment, learning how to find appropriate evaluation methods for products, and being able to follow every step of product development, engineering design, manufacturing and sales. This seminar invited experts from industry, academia and research including internal expert, Prof. C.M. Tan, to share how to use reliability analysis and accelerated life analysis technology to effectively shorten the green energy product development verification cycle and quickly improve the reliability of green energy products. Prof. Tan delivered a speech on "Battery and component reliability evaluation method". His talk includes fundamentals of reliability and various reliability evaluation methods used for assessing reliability of battery components. A research member in Prof. Tan's team, Dr. M. K. Loganathan had also

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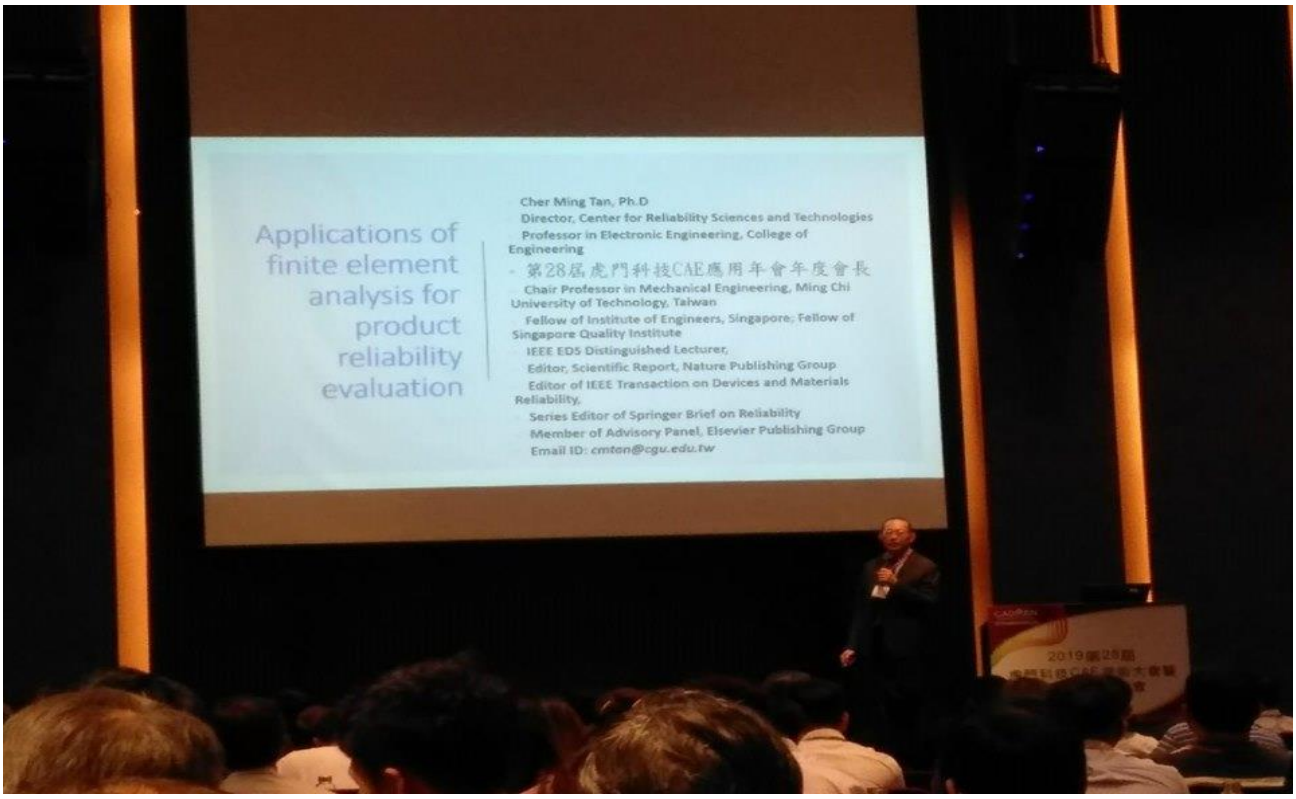
delivered a talk on "System reliability and maintenance strategy", that mainly focused various aspects of reliability and maintenance practices at system level.

Chairman Talk by Prof. C. M. Tan at 28th 2019 Humen Technology CAE Application Annual Meeting and Application Technology Expo., New Taipei, Taiwan

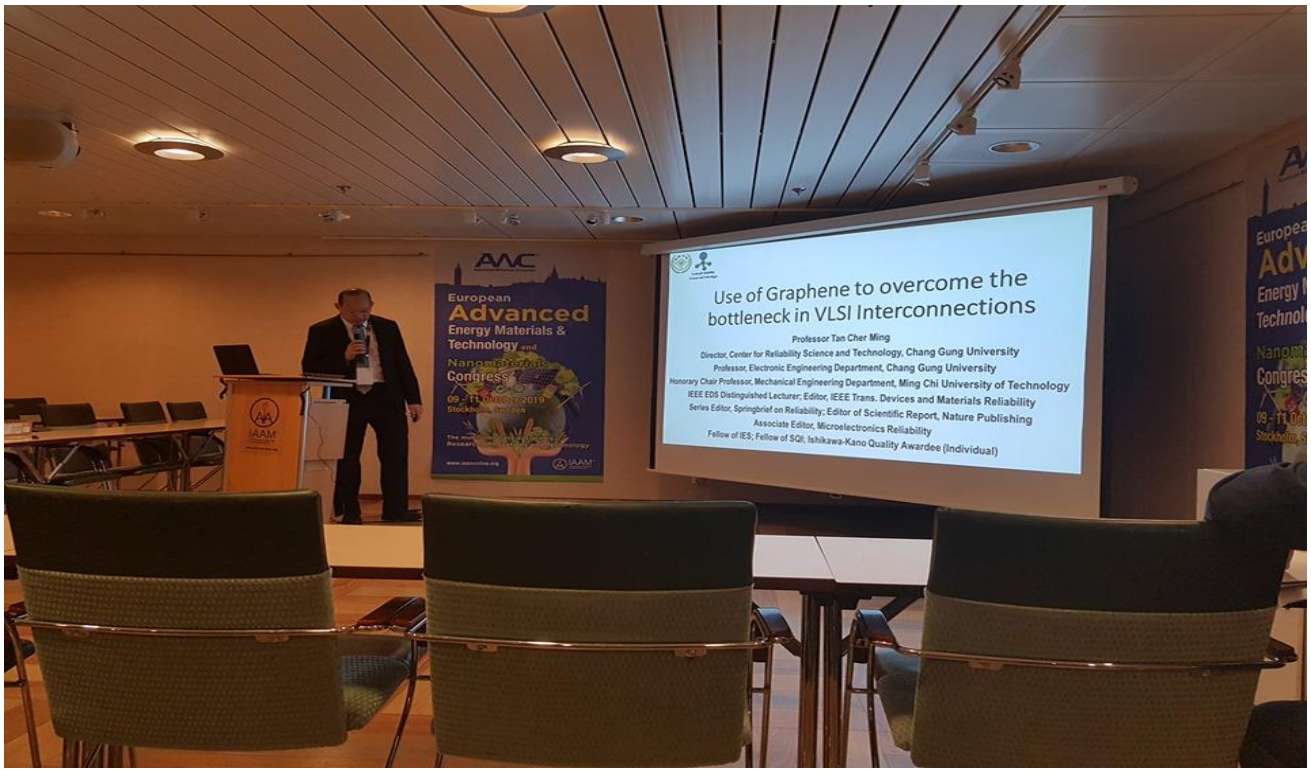
The 28th Humen Technology CAE Application Annual Meeting and Application Technology Expo was organized by CADMEN, Taiwan, at New Taipei City on 04 October 2019. The agenda of the meeting was to create a platform for the industries, research organizations, and academia to have a comprehensive discussion on various issues pertaining to design and development of CAE based products and systems. Various CAE based approaches such as finite element analysis (FEA), computational fluid dynamics (CFD), multibody dynamics (MBD), durability and optimization are effectively used for improving design and development of products and systems. Reliability is a key measure, which is to be evaluated for a product or a system during design stage. Prof. C. M. Tan chaired the event and delivered the Chairman speech on the applications of finite element analysis for product reliability evaluation. He also distributed awards to the winning participants on FEA applications during an award presentation ceremony conducted by CADMEN. The abstract of his talk is as follows;



Smart gadgets require complex structures to be made intelligent. However, complex structures also imply poorer reliability unless highly reliable components are used. But this will increase the cost of the smart gadgets. In today's competitive world and the increasing popularity of smart gadgets, high cost is not acceptable. Thus, a way to ensure high reliability and yet cost effective for these smart gadgets is required. Prof Tan illustrated various examples of such way from his research team in his center, by using finite element method. Some examples were also shared in the ASQ World Congress 2019 and have received very good response.

Keynote Speech by Prof. C. M. Tan at European Advanced Energy Materials and Technology Congress (AEMC 2019), Stockholm, Sweden

The AEMC is an international event organized annually under the banner of Advanced Materials Congress (AMC) to provide a global forum to the researchers, engineers, students, professionals from academia & industries, and business giants to present their research results, breakthrough innovations. The 28th Assembly of AMC was organized in Stockholm, Sweden, during 09 – 11 October 2019. Prof. C. M. Tan presented a keynote address at AEMC 2019. The abstract of the talk is given below;



Electromigration is a key reliability issue for VLSI since the beginning till now. Progress has been made in using better interconnect material, but copper is running out of stream. Many have explored other materials such as carbon nanotube, graphene etc, but the processing steps of these materials are not compatible to the current integrated circuit processing. Prof Tan has invented a method where graphene can be embedded inside copper interconnect, and hence the processing can continue with the current process, but the graphene layer embedded can provide most conduction and also provide uniform temperature along the interconnect, and all these can enhance the electromigration of the composite interconnect. Modeling has shown that such novel interconnect can improve the lifetime of the interconnect by at least 3 times with respect to electromigration. This work has been published in Advanced Interface Materials, 2018.

Visit of NASA Chief Scientist to CReST

The center has witnessed visits of eminent scientists from leading research organization across globe in the past. One such visit was made recently by Dr. Meyya Meyyappan on 22 October 2019, who is the NASA's Chief Scientist for Exploration Technology at the Center for Nanotechnology, NASA Ames Research Center in Moffett Field, CA. He was also serving as the Director of the Center for

Nanotechnology. He is a founding member of the Interagency Working Group on Nanotechnology (IWGN), which was established by the Office of Science and Technology Policy (OSTP). He is a fellow of several organization, and societies including IEEE, ECS, AIChE, and ASME. For his contribution and leadership in nanotechnology, he has received numerous awards including: Presidential award, NASA's outstanding leadership award, Arthur Flemming award, IEEE Judith Resnick award, IEEE-USA Harry Diamond award, AIChE Nanoscale Science and Engineering Forum award, Sir Monty Finniston award, and many more. The purpose of his visit is to discuss collaboration with CReST.

Invited Talk by Prof. C. M. Tan at National University of Kaoushing, Taiwan

An invited talk on "Failure analysis of high frequency and high power electronic devices" was delivered by Prof. Tan to the students of National University of Kaoushing, Taiwan on 23 October 2019. His talk is centered around different types of failures, failure causes, and failure modes and physical failure analysis of electronics devices which are used for high frequency and power applications. In particular, he presented a new failure mechanism that his team discovered on High Electron Mobility Transistor (GaN-HEMT) high frequency power amplifier.

As per their findings, a thick cracked layer was seen over the damaged drain and gate areas. Small granules were also formed due to the cooling down of the melted drain and gate metal in the failure region. The investigations were carried out by using scanning electron microscope, and X-ray spectroscopy. This observed failure mode is very different from the reported failure modes. It is concluded that the failure is related to the strong magnetic field created from the adjacent inductor of the failed transistor. This strong magnetic field induce strong eddy current in the metal layers of the failed transistor. During the operation of the power amplifier, the intensity of the induced eddy current adds on to the operating current on the metal layer, resulting in significant increase in Joule heating that renders a consequent meltdown of the drain and gate gold metal layer. Finite element analysis is employed to verify the mechanism. This study provides new information to the designing of high power and high frequency ICs to guard against Joule heating failure.

Recent patents

The Crest has been granted two patents this year. The details are given below.

No.	Patent Name	Apply Country	Patent No.	Inventor	Applicants	Duration
1.	無電極電鍍金屬的裝置及其方法 Electroless metal plating device and its method	Taiwan	I646215	Cher-Ming Tan (陳始明), Narula udit (那魯拉巫迪)	陳始明 Cher Ming Tan	2019-1-1 – 2037-11-2
2.	Semiconductor structure having multiple-porous graphene layers and the fabrication method thereof	Taiwan/ USA	US20180097066 A1/ 10396160	Chao-Sung Lai(賴朝松), Cher-Ming Tan (陳始明) and Preetpal Singh	長庚大學 Chang Gung University	2018-04-05 - 2038-04-04 2019-08-27 – 2037-01-04

Recent publications

The list of recent publications made by the members of Crest is in the quarter from Jul to Sept;

1. Dipesh Kapoor, Vivek Sangwan, Cher Ming Tan, "Electromagnetic Hotspots Identification in Integrated Circuits", Progress in Electromagnetics Research (PIER) Letters, vol.86, pp. 121-128, 2019.
2. Preetpal Singh, Che Chen, Cher Ming Tan, Shyh-Chin Huang, "Semi-Empirical capacity fading model for SoH estimation of Li-Ion Batteries", Applied Sciences, Vol.9, issue 15, pp. 3012, July 2019.
3. Vivek Sangwan, Cher Ming Tan, Dipesh Kapoor, Hsein-Chin Chiu, "Electromagnetic Induced Failure in GaN-HEMT High Frequency Power Amplifier", IEEE Transactions on Industrial Electronics. (DOI:10.1109/TIE.2019.2931233)
4. M. K. Loganathan, C. M. Tan, B. Mishra, T. A. M. Msagati, and L. W. Snyman "Review and selection of advanced battery technologies for post 2020 era electric vehicles", IEEE-SAE International Transportation Electrification Conference (ITEC 2019), Bangalore, India, 17-19th Dec, 2019.
5. M. K. Loganathan, B. Mishra, and C. M. Tan, "Multi-Criteria Decision Making (MCDM) for the selection of Li-Ion batteries used in Electric Vehicles (EVs)", In Proc.: International Conference on Advances in Minerals, Metals, Materials, Manufacturing and Modelling (ICAM-2019), Warangal, India, 25-27th Sept, 2019.

Achievement

A research article "***Physical Limitations of Phosphor layer thickness and concentration for White LEDs***", Published in ***Scientific Reports volume 8***, authored by ***Cher Ming Tan***, ***Preetpal Singh***, ***Wenyu Zhao*** & ***Hao-Chung Kuo*** received 894 article views in 2018, placing it as one of the top 100 read physics papers for Scientific Reports in 2018. Scientific Reports published more than 1133 physics papers in 2018, and so a position in the top 100 most highly read articles is an extraordinary achievement – the finding of the paper is of real value to the research community, as stated by ***Scientific Reports***.

PhD defense presentation

Vivek Sangwan, a PhD student of Crest, has successfully defended his PhD thesis entitled*: Reliability Study of GaN-HEMT - with the perspective of Electromagnetic Emissions*, on 22 October 2019.

Congratulations to Vivek Sangwan !

The abstract of the thesis is appended below.

Gallium nitride (GaN) high electron mobility transistor (HEMT) comes out to be one of the most appropriate choices for high power and high frequency applications. It is because of GaN-HEMT implausible properties, such as high breakdown field, high saturation velocity, high mobility and withstanding high operating temperatures, etc., which makes it the topic of research in the academics as well as in the industry over the years. However, GaN-HEMT also suffers from many reliability issues such as: high electric field, inverse piezoelectric effect, surface degradation, and thermal stress. In this work, we observed a new failure mechanism for our GaN-HEMT based power amplifier Integrated Circuit (IC) that is different from the aforementioned failure mechanisms.

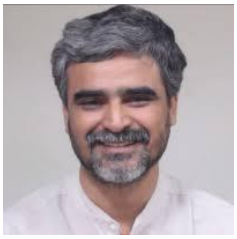
This thesis explores the physics behind this new failure mechanism in this IC. It is found that when the operating frequency of a circuit is equal to or greater than 3 GHz, antenna effect, namely the radiation of electromagnetic waves from the circuit will occur for micrometer scaled devices. Therefore, it is necessary to investigate IC as a source of electromagnetic emissions (EMEs) that is a reason behind this failure. In view of the importance of the EME from IC, this research work also includes developing a methodology to investigate and identify the EMEs from the high power and high frequency IC.

To curb the magnetic field generated from the IC, response surface methodology (RSM) is employed for IC optimization to reduce the maximum magnetic field strength to the minimum possible at the failure site. This helps to build a robust power amplifier IC.

New members

The new research members joined Crest recently are;

1. **Sandeep Sharma, PhD (Electronics)**



Dr Sandeep Sharma has joined Crest on 01 November 2019. He holds B.Sc. and M.Sc. in Electronic Sciences. He received his PhD from Delhi University, India in "*Theoretical Investigation of Transient Analysis of First Order and Second Order Loads powered by PV Generators*". Prior to his joining Crest, he was working with various organizations including Converteam EDC Pvt. Ltd & Saora Informatics India Pvt Ltd, and leading private universities in India. He has numerous research publications to his credit. Crest welcomes Dr. Sandeep to join this vibrant research team.

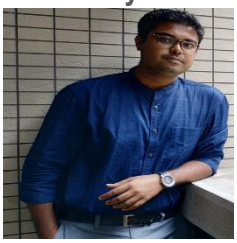
2. **Ashwin Vinod**

Ashwin Vinod has joined on 26 August 2019. He is pursuing Diploma in Electrical Engineering from NGEE ANN Polytechnic, Singapore. Currently, he is undergoing internship at Crest. He is mainly working on PCB testing and degradation analysis. Crest welcomes Ashwin Vinod to be the part this advanced reliability testing lab.

3. **Kelvin Hoi**

Kelvin Hoi has joined on 26 August 2019. He is pursuing Diploma in Electrical Engineering from NGEE ANN Polytechnic, Singapore. Presently, he is under internship programme at Crest. His area of research is in reliability testing and degradation analysis of LEDs. Crest welcomes Kelvin Hoi to be the part this advanced reliability testing lab.

4. **Shubhayan Mukherjee**



Shubhayan Mukherjee has joined Crest on 15 July 2019. He holds B.Sc. in Physics and is pursuing Masters in Electronics from West Bengal State University. Presently, he is doing internship at Crest, and his research work mainly focusses on Electromigration studies to help to evaluate the lifetime distribution of interconnects in electronic devices.

5. **Sreejesh Satheesh**

Sreejesh Satheesh joined Crest on 15 May 2019. He passed B.Sc. and M.Sc. in Physics from Pondicherry University, India. He has just finished his internship and registered for PhD at Crest. His main focus of research is on Quantum Physics and related theories that would be explored in reliability life distribution of an element at atomic level.