CENTER FOR RELIABILITY SCIENCES AND TECHNOLGIES

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Inside this issue

GaN based Circuit Design Capability

With almost negligible side effect, proton beam therapy becomes most common choice for the cancer treatment. But the presence the secondary neutrons during treatment has significant negative effects on the patients as well the electronics present in the treatment room which can not to overlooked. Several researches have been going on to study the effect of the secondary neutrons onto the patients but the study on the electronics is limited. Study shows that these secondary neutrons affects the reliability and performance of the devices implanted into the patients such as pacemakers, implantable cardioverter defibrillators etc. and the semiconductor devices present in the treatment room. Silicon-based semiconductor devices are very vulnerable to the radiations. Hence an alternative material is required which can stand firm in the harsh radiation environments. Gallium Nitride based high electron mobility transistors (GaN-HEMTs) are promising candidate for such harsh radiation environment as compared to the silicon counterpart due to their high mean displacement energy.

We designed GaN based transimpedance amplifier which can be used with position sensitive photo multiplier tube (PSPMT) for processing the prompt gamma signal generated during proton therapy. To verify the operation, we simulated the designed circuit with real time signal obtained from Hamamatsu H8500 PSPMT by storing the signal into a mixed signal oscilloscope which is then imported into the simulation tool LTSpice. Below Figure 1 shows the block diagram of the system where 64 signals from PSPMT are converted into 4 current signals. These current signals are then converted into voltage by proposed transimpedance amplifier. The simulation result is shown in Figure 2, which shows that current is successfully converted into voltage without changing the shape of the signal.

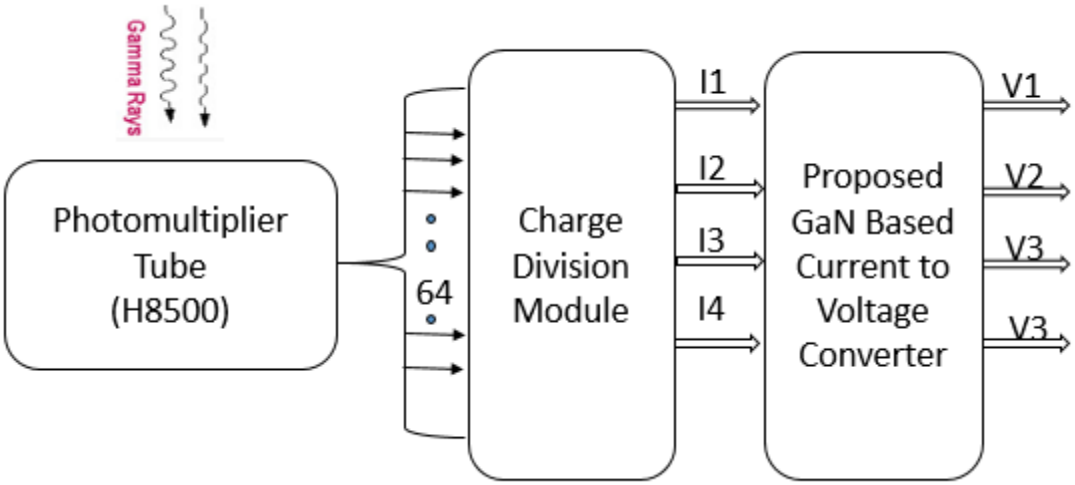


Figure 1 Block diagram

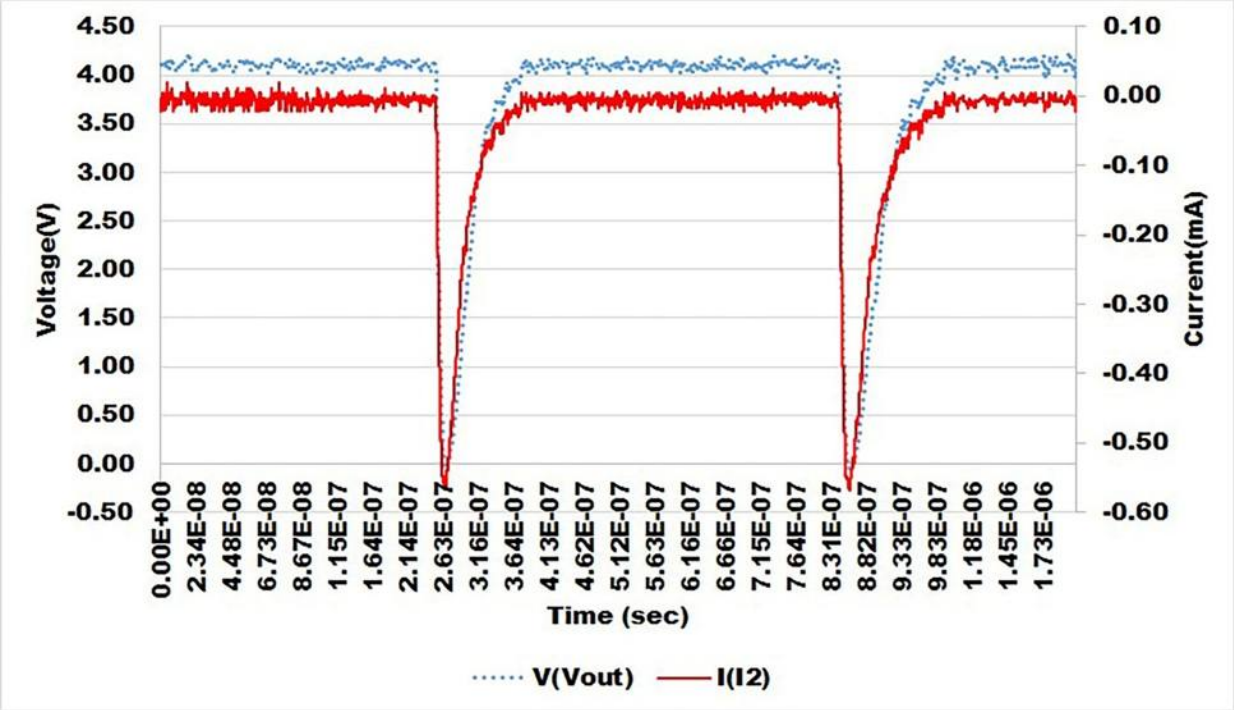


Figure 2 Simulation output

Capabilities for Impact Analysis of Radiation on Microelectronic systems / devices.

The advancement of semiconductor technology in meeting the ever-increasing complex functional requirements of electronics has renders integrated circuits packed with billions of transistors whose scales are in the order of nm. Consequently, these circuits become susceptible to minute radiation even at sea level. With our high dependent on the electronics today, a momentary malfunction of the electronics, even if it is temporary, can have significant impact to our lives. Therefore, the study of the impact of radiation on electronic circuits and devices is becoming necessary. However, combining the radiation physics and electronics is not trivial, and CReST has formulated a team that includes researchers from radiation physics, semiconductor material physics, device physics and circuit design together to address this important issue, with the availability of the proton and other radiation facilities accessible for the team to work on both theoretical and experimentally.

Members in this Radiation on Semiconductor team are:

Tsi-Chian Chao- Radiation physics

Dr Chao is an Associate Professor in the Department of Medical Imaging & Radiological Sciences, Chang Gung University, Taiwan. He obtained his Ph.D in nuclear energy from Rensselaer Polytechnic Institute, USA in 2001. His research interest includes Monte-Carlo Simulation, Image Processing, and Digital Phantom. He published more than 50 research papers in various reputed journals and conferences.

Prof Cher Ming Tan- Material Physics

Dr. Cher Ming Tan is the leader of this team and he will undertake the material simulation, analysis and characterization. He obtained his Ph.D in Applied Science from The University of Toronto, Canada. His research interest includesreliability and failure physics modeling of electronic components and systems, finite element modeling of materials degradation, statistical modeling of engineering systems, nano-materials and devices reliability, and prognosis & health management of engineering system.

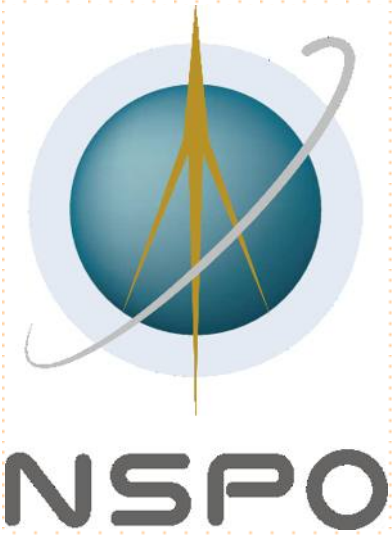
Dr Sandeep Sharma- Device Physics

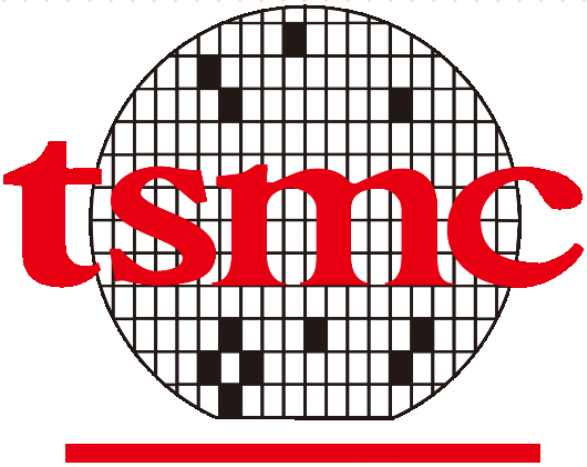
Dr Sandeep is a senior researcher in the Center. He received his Ph D degree from University of Delhi in 2009. His research interest includes Radiation interaction with semiconductor materials and devices, Optical switching devices, semiconductor devices and IoT devices & Systems.

Vimal Kant Pandey- Circuit Design

Mr. Vimal isa Ph.D. student in the Department of Electronics Engineering, Chang Gung University, working in the Center. His research area is circuit design for the radiation environment. He has been working on Cadence from January to June, 2010, and he is now working on the design and implementation of GaN based trans-impedance amplifier that can be used for the proton beam therapy. He is also involved in the radiation testing of devices and circuits.

This team has several collaborations with the following organizations.





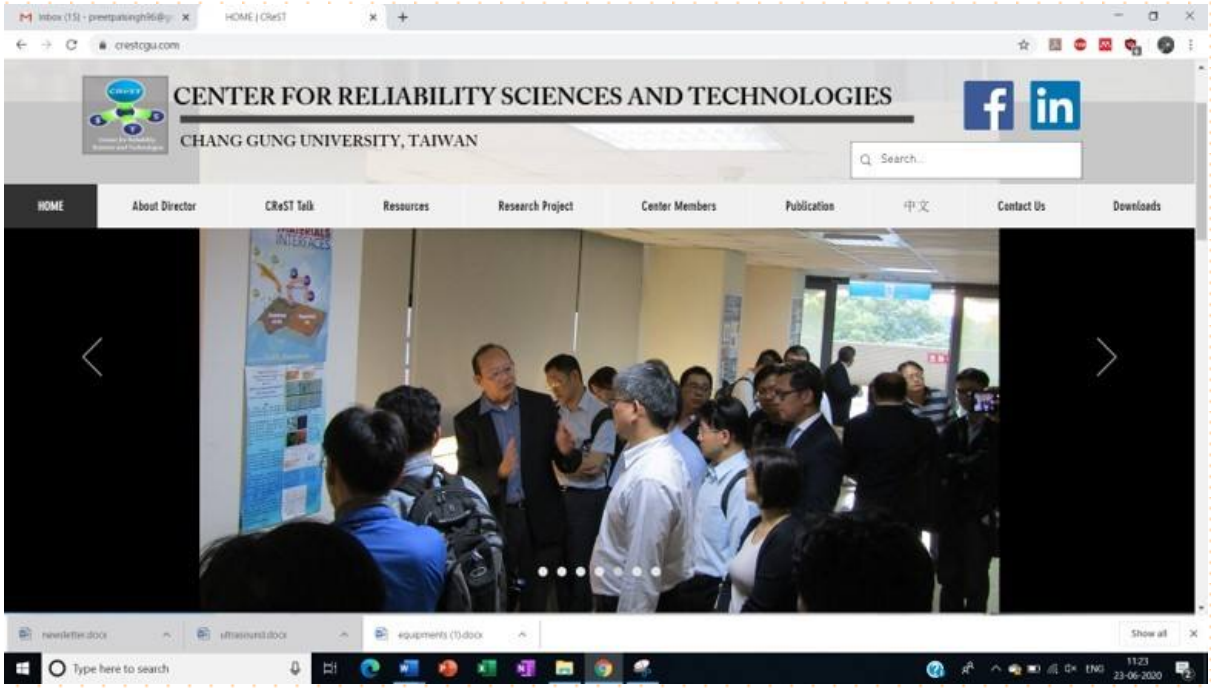
New Appointments

Prof Cher Ming Tan, Director of CReST has accepted the invitations to serve the following new appointment, in addition to his existing Editorial-ship and Committee commitments.

1. Member, EDS Device Reliability Physics Committee, 2020.
2. Member, EDS Master and Ph.D Fellowship, 2020.
3. Organizing Committee Member**,** International Conference on Science Technology and Management (ICSTM-20).
4. Associate Editor of Journal of Functional Materials and Chemical Engineering (JFMCE)- Frontier Scientific and Academic Publishing (FSAPub).
5. Guest Editor of Special Issue of Energies “Battery Storage Technology for a Sustainable Future-MDPI”.
6. Associate Editor of Thin Solid Films (Frontiers in Materials).
7. Guest Editor of International Journal of Nanotechnology.

ANNOUNCING
THE LAUNCH OF OUR NEW WEBSITE

We have been dedicatedly working hard for months to improve your experience related to our website in terms of faster response, ease of navigation, intuitiveness and user friendly, we are delighted to officially announce the launch of our newly designed website. Visit us at https://crest.cgu.edu.tw/. Your valuable inputs / suggestions for improvement are welcome.



New Equipment

CReST announces the expansion of our lab equipment ranging from material analysis to device and products testing. The following are the new added equipment.

Confocal Scanning Acoustic microscope(C-SAM)

PVA TePla AG SAM 301

SAM uses ultrasound waves to detect changes in acoustic impedances in integrated circuits (ICs) and other similar materials

Decapsulation System

Teltec Semiconductor Pacific Limited JetEtch Pro

Latest JetEtch Pro System uses acid corrosion of molding compound to expose die in any kind of IC packages. Acid Decapsulation process is quick, safe, and it produces clean, no corrosion to the die surface.

Scanning Electron Microscope

JSM-IT200 InTouchScope^{TM}

Function- Material Analysis

JSM-IT200 is an easy-to-use SEM focused on cost performance of high functionalities of JSM-IT500 (higher-end model) of InTouchScopeTM, with significantly higher throughput. Specimen Exchange Navi, a beginner-friendly function, offers guided operation from sample loading to area search, and SEM image observation. “Zeromag” for seamless transition from optical to SEM imaging, “Live Analysis”[*2] for real time display of elemental analysis results, SMILE VIEW（TM） Lab for seamless report generation of observation and/or analysis results, etc., provide fast analysis with integrated transition from OM to SEM.

Multiprobe System

CL Technology Co., Ltd.MulitView 4000

Multiple probes/AFMs for advanced experiments such as: nanoscale transport, optical pump-probe, and read-write experiments. The machine is capable of performing Atomic Force Microscope, Electrostatic Force Microscopy, Magnetic Force Microscopy and Thermal Conductivity Microscopy.

Ultimaker S3 3D Printer

The Ultimaker S3 delivers high-quality, composite-ready performance – all efficiently from our desktop. Packed with the latest technology, it is as easy to use as it is powerful, offering the most cost-effective way for disruptive businesses to adopt in-house 3D printing.

Line Impedance Stabilization Network

TBLC08 LISN

The TBLC08 50 µH LISN is a Line Impedance Stabilization Network for the measurement of line-conducted interference within the range of 9kHz to 30MHz, according to the CISPR16 standard. The device is designed for testing single phase, AC-powered equipment with supply voltages up to maximum 240V.

New Publications (March – June, 2020)

1. Optimization of a T-Shaped MIMO Antenna for Reduction of EMI

Kapoor, Dipesh, Vivek Sangwan, Cher Ming Tan, Vani Paliwal, and NirdoshTanwar. "Optimization of a T-Shaped MIMO Antenna for Reduction of EMI." *Applied Sciences* 10, no. 9 (2020): 3117.

In this paper, optimization of a miniaturized multiple-inputs multiple-outputs (MIMO) antenna was performed. This antenna was composed of a T-shape radiating element with stub and reduced ground plane and a compact size of 25 mm × 25 mm × 1.6 mm. The behavior of antenna was evaluated in terms of return loss (S-parameter < −10 dB), electromagnetic interference (EMI), and operation frequency. The antenna design is applicable to many applications. A 2^K factorial design combined with a genetic algorithm (GA) optimization technique were used to identify the key design parameters responsible for affecting the performance quality of the antenna. Optimization of the antenna design for EMI reduction was utilized, and the optimal design showed enhanced bandwidth of the antenna and reduced power consumption.

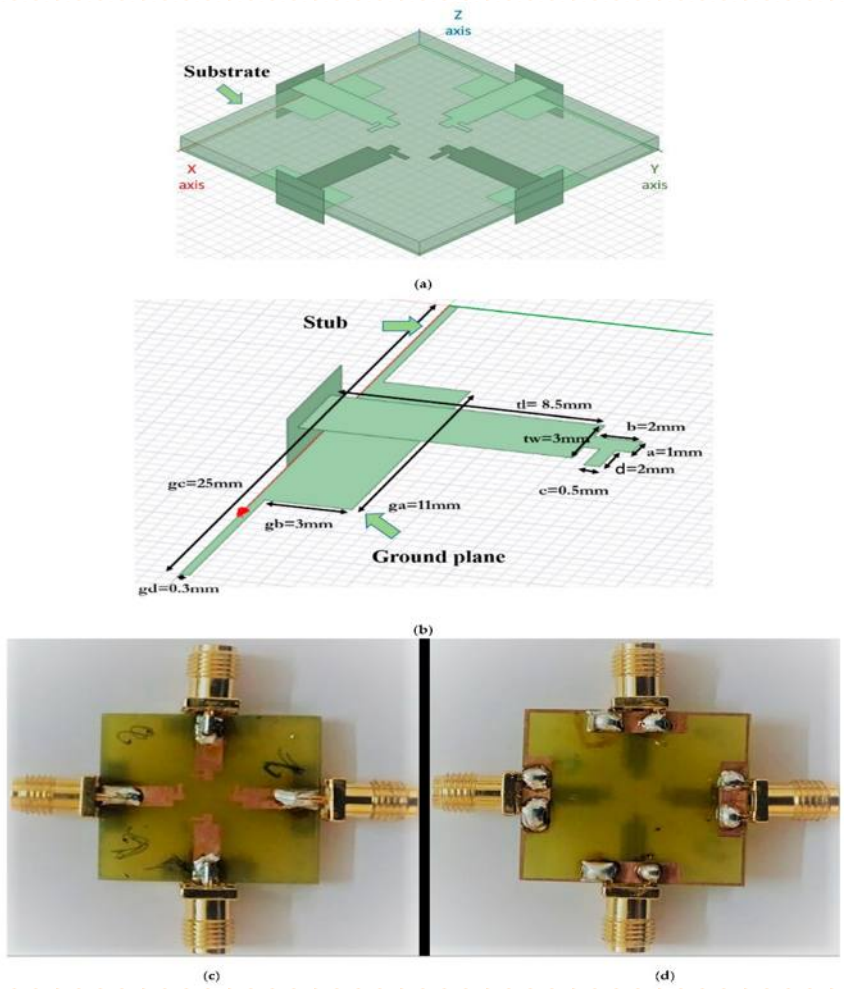


Figure Multiple-input multiple-output MIMO antenna with substrate, (**b**) dimensional geometry of one element in the four-element MIMO antenna, (**c**) top view of the fabricated

antenna, and (**d**) back view of the ground plane. Substrate is absent in (**b**) to highlight the ground plane.

2. **Investigate the Equivalence of Neutrons and Protons in Single Event Effects Testing: A Geant4 Study**

Chiang, Yueh, Cher Ming Tan, Tsi-Chian Chao, Chung-Chi Lee, and Chuan-Jong Tung. "Investigate the Equivalence of Neutrons and Protons in Single Event Effects Testing: A Geant4 Study." *Applied Sciences* 10, no. 9 (2020): 3234.

Neutron radiation on advanced integrated circuits (ICs) is becoming important for their reliable operation. However, a neutron test on ICs is expensive and time-consuming. In this work, we employ Monte Carlo simulation to examine if a proton test can replace or even accelerate the neutron test, and we found that 200 MeV protons are the closest to resembling neutron radiation with five main differences. This 200 MeV concur with the suggestion from National Aeronautics and Space Administration (NASA, Washington, DC, USA). However, the impacts of the five differences on single event effects (SEEs) require future work for examination.

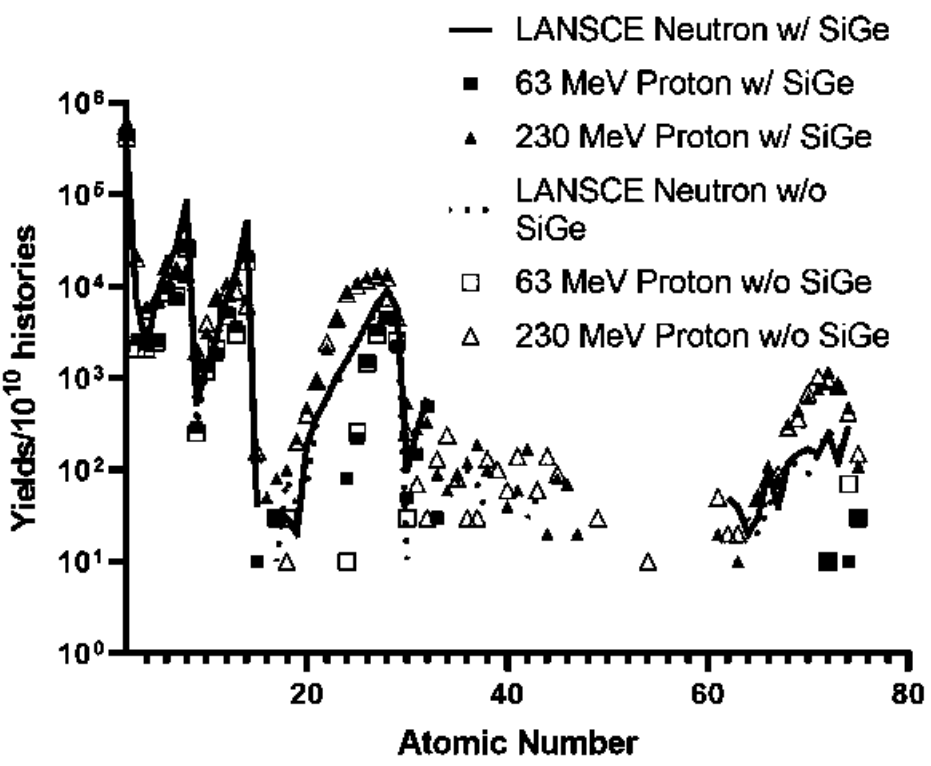
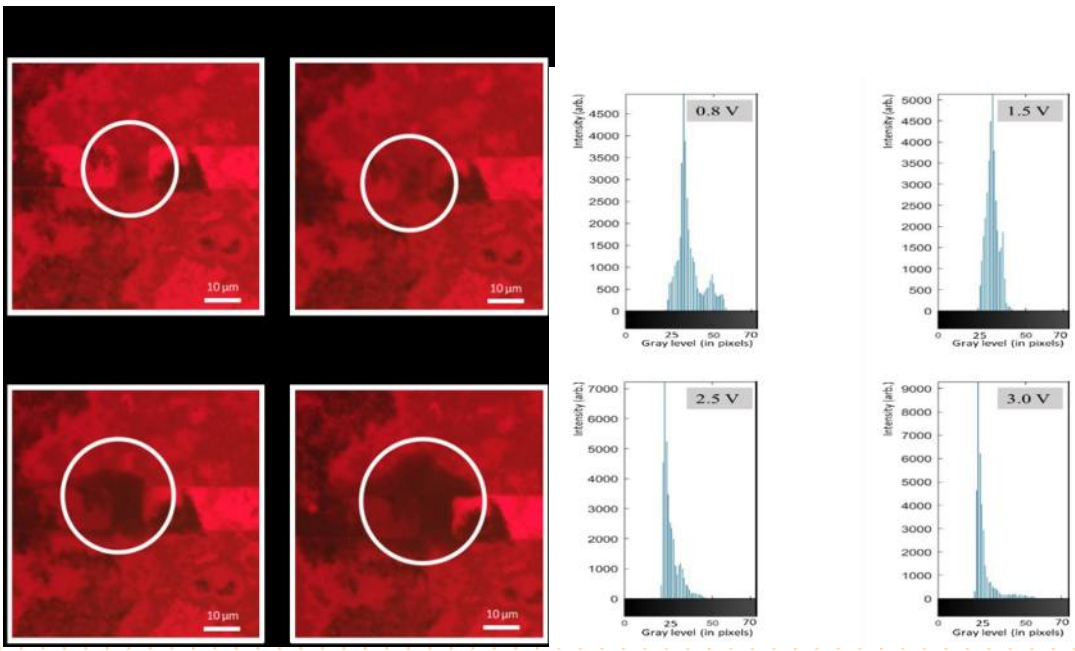


Figure The secondary particle yields in the structure with and without SiGe irradiated by 63 and 230 MeV protons and LANSCE neutron.

3. **In-situ Characterization of the Defect Density in Reduced Graphene Oxide under Electrical Stress Using Fluorescence Microscopy**

Zequn Zeng, Preetpal Singh, Sharon Lim Xiaodai, Cher Ming Tan and ChorngHaur Sow, " In-situ Characterization of the Defect Density in Reduced Graphene Oxide under Electrical Stress Using Fluorescence Microscopy", International Journal of Nanotechnology, Under publication.

A new approach to characterize the defect density in graphene oxide (GO) is presented in this work. Fluorescence microscopy is employed to directly observe changes in defect density on the graphene oxide surface at the macroscopic level. The area under scan becomes darker as the electrical bias is increased from 0.5 V to 3 V. Gray level conversion of the fluorescence images are used to quantify our results. The reduction of graphene oxide as observed under fluorescence microscopy images is also verified using Raman microscopy where ID/IG ratio decreases as the voltage stress is increased. However, defect density increases for the samples from 0 to 0.5 V range and are maintained till 1 V, which shows that this range may not be suitable for electronic applications when graphene oxide is employed as its electronic properties are poor in this range. Thus, this in-situ measurement of defect density on the graphene oxide for large area graphene samples can help in identifying the uniformity of the defect density on GO as well as its defect density changes under electrical bias condition, an information crucial for its electronic applications.



(a) (b)

Figure (a) The fluorescence responses of GO sample at different voltages. (**Yellow-light** excitation source) White-circle domain is where the Raman spectra of GO are measured. (b) The histograms of gray levels of GO fluorescence responses. The horizontal axis refers to the gray levels, and the vertical axis indicates the corresponding intensities.

Conference paper:

1. **Review and selection of advanced battery technologies for post 2020 era electric vehicles**

Loganathan, M. K., Cher Ming Tan, Bikash Mishra, Titus AM Msagati, and Lukas W. Snyman. "Review and selection of advanced battery technologies for post 2020 era electric vehicles." In *2019 IEEE Transportation Electrification Conference (ITEC-India)*, pp. 1-5. IEEE, 2019.

The Lithium-ion batteries, which are currently used in EVs do not sufficiently hold the energy for long driving ranges. Issues related to safety and performance are not totally alleviated. On the other hand, there is a tremendous pressure on the EV manufacturers to reduce the vehicle cost, without compromising the safety, performance and driving range. The EV companies are not able to reduce the vehicle price because of expensive batteries. This necessitated the further development of new battery technologies. There are advanced technologies like graphene, solid-state, and aluminum air batteries, which are being developed by OEMs, and universities across globe. But the challenge for the EV manufacturer is to select the best battery technology to help optimize the vehicle cost. In this work, a short review and a method to select the advanced battery technologies for the post 2020 era electric vehicle are presented. An MCDM (Multi-Criteria Decision Making) based WPM (Weighted Product Model) has been developed for the selection of best battery technology. This work includes review of all these batteries technologies, identifying a list of performance factors the determines the acceptability criteria for the battery selection. Subsequently, WPM is used to obtain the product of normalized weighted parameters that helps to rank the battery technology. The proposed methodology will help the EV OEMs to select best battery while reducing overall vehicle cost.

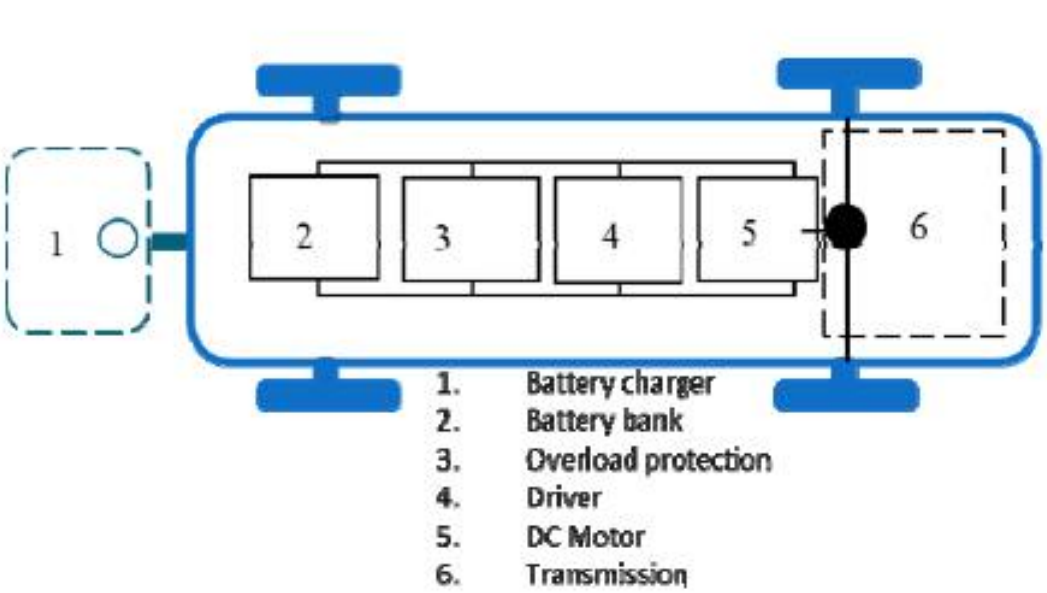
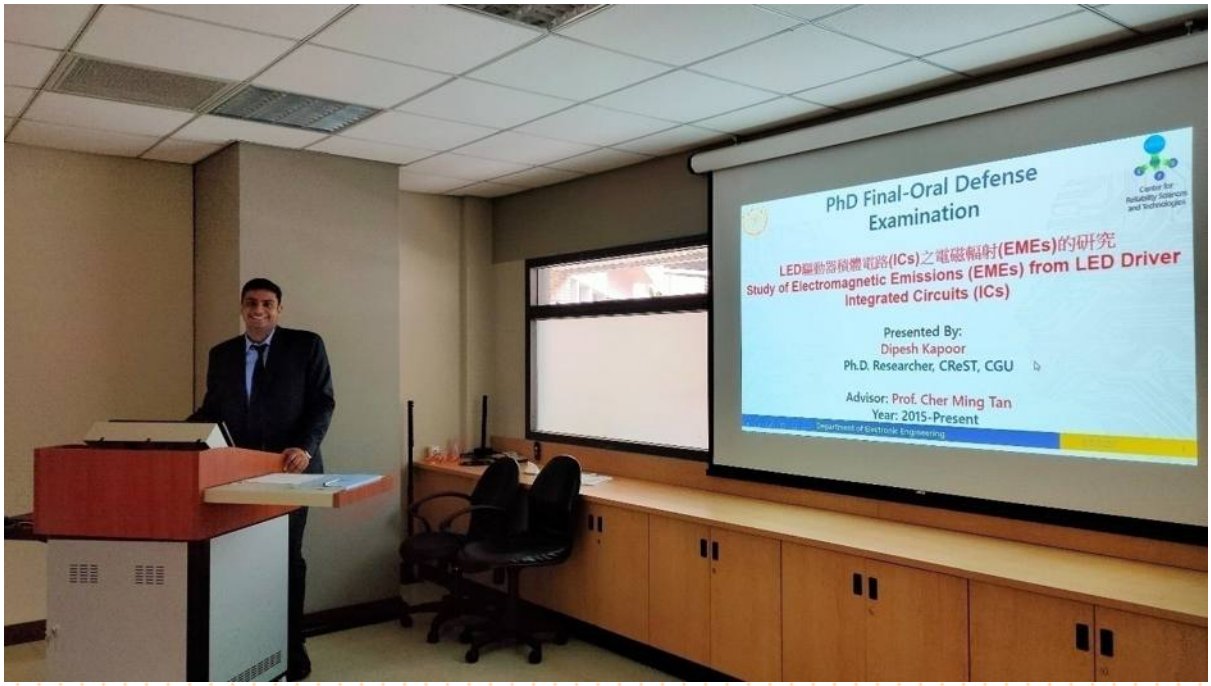


Figure A typical electric vehicle layout

Graduations

Congratulations to Dipesh Kapoor for successfully defending his PhD defence and being awarded PhD degree



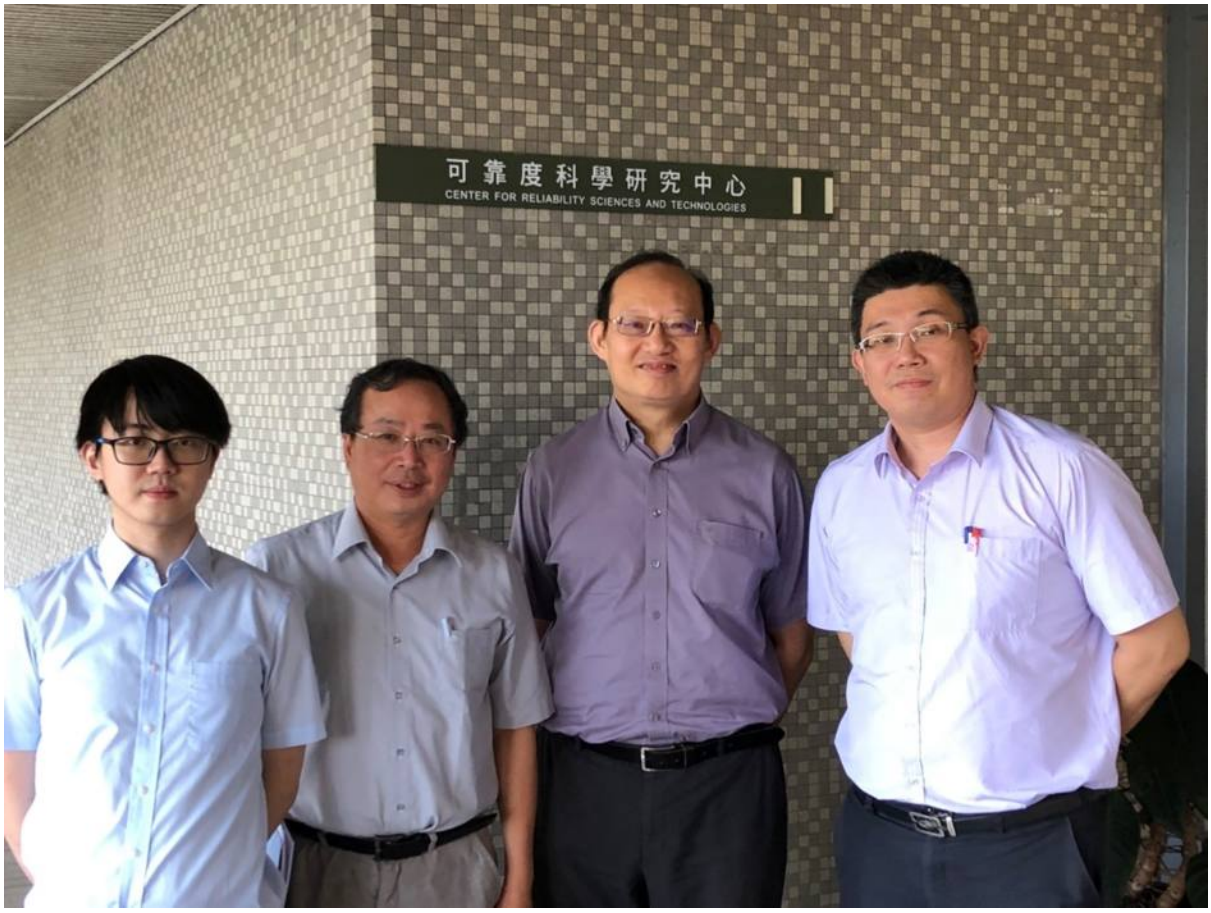
Title: Study of Electromagnetic Emissions (EME) from LED Driver Integrated Circuits (ICs)

Light Emitting Diode (LED) is one of the most widely used lighting source because of its low power consumption, high efficiency, and low maintenance. A LED lighting system consists of LED chip, driver circuit and heat sink. The driver circuit converts the AC power source into constant current for LEDs, as constant current is needed to ensure display color gamut stability from the LED. The linear mode driver has a better accuracy on the output current, and it has smaller dimension due to the absence of inductor. The LED driver studied in this work is a linear mode LED driver.

The constant current from the linear mode LED driver requires Pulse Width Modulator (PWM). The high oscillating frequency of PWM can create Electromagnetic Interference (EMI) when large number of LEDs is switching on simultaneously and can generate a significant current spike on the power supply lines. This increasing switching renders EMI from the LED driver ICs, making them and other neighbouring circuits susceptible to the Electromagnetic Emissions (EMEs).

The main objective of this thesis is to identify the hotspots in ICs with a developed methodology combining measurement and simulation. 3D layout simulation approach provides good precision in the results as compared to the measurement results.

Congratulate Brian XIE for successful completion of Master degree



Title: Application and feasibility of new type pulse oximeter for low SpO_2 detection

Oxygen is an indispensable part of human life. If there is insufficient oxygen supply, it will affect cell metabolism and even death. Therefore, in order to monitor the blood oxygen concentration in the human body, the blood oxygen saturation meter was born. The oximeter has been commercialized and portable after years of research. However, the design of the detection head of most oximeters is to detect the oxygen saturation concentration of superficial tissues. In this research project, a new type of detection head with three-dimensional structure is used to detect the signal of specific tissue depth, and through a special algorithm and discrete time signal processing obtain the blood oxygen saturation concentration in the deep tissue and low oxygen saturation concentration in hypoxic. This article will introduce the architecture and design of the hardware and detection head of the 3D pulse oximeter and show the results of previous experiments to verify and try to optimize and achieve the results of portability.

Congratulate Thurein Aung for successful completion of Master degree in NEEDs (A joint program between SUTD Singapore and CGU)

Title: The Design of Low-power, Triple-Cascode Low Noise Amplifier in 60 GHz Applications

The Low Noise Amplifier (LNA) is the first key component in the receiving end of nearly every communication system in the world. The LNA is responsible for providing enough gain to the signal with the least distortion possible. In this work, a millimetre-wave (MMW) low power, high Gain LNA at center frequency 60 GHz is presented along with the analysis, design and measurement results. A three-transistor stacked cascode technology is adopted to achieve higher gain and improve the reverse isolation. NFET 65nm GF technology has been chosen for the design of the LNA at the transistor level. To reduce overall power consumption, the first and second stages of the amplifier share the same supply voltage and the current. At the input and output of amplifier, a LC load stage is utilized to achieve best input and output matching. The result shows a voltage gain of 20.5 dB, a noise figure is 5.5 dB, input and output return losses better than -22 dB, respectively and it dissipates 7.4 mW from 1.2 V DC supply.

Congratulate Sumit Pandey for successful completion of Master degree

Title: Machine Learning Based Prediction and Analysis Algorithms

Machine Learning (ML) based algorithms have discovered themself in extended application in solving complex problems in engineering because of their accuracy and robustness. This thesis presents the development and implementation of ML based Algorithms in health and industrial sectors. The work reported in this thesis is threefold: 1). Deep Learning based Algorithm to detect the Pneumonia in chest X-rays, 2). Predictive Maintenance strategy to reduce the downtime and maintenance cost of a Haemodialysis machine and 3). ML based Algorithm that estimates health index of the equipment and predicts the maintenance time before failure.

Chest X-ray images are used to produce pictures of chest organs. To analyse and detect the Pneumonia in chest X-rays, a ResNet-50 model is trained and validated over 5000 chest X-ray images. This model results in 97.2% accuracy, 97.7% recall, 98.5% precision, and 98.14 % F1-Score. This model can help doctors to analyse the X-rays and decision making.
Haemodialysis machines are important medical equipment that is used to treat renal failures. To prevent failures in these machines, a Root Cause Analysis Based Maintenance Policy (RCBM) strategy is employed to optimize the maintenance schedules derived from the existing maintenance and failure data. It results in increased availability of Haemodialysis machines by 99.99% and a reduction in maintenance cost by 60%.
In the industrial sector, where machines are utilized for 24*7 (except maintenance days), it is important to keep tracking its health and prevent failure. To meet these objectives, a predictive maintenance Algorithm is developed and implemented. This Algorithm calculates the health index of equipment and tracks it over the time and predicts next maintenance time.

Congratulate Ashwin Vinod for being awarded as the Terasaki Electric Silver Medal & Prize for the second most outstanding graduate in the Diploma in Electrical Engineering course

NGEE ANN
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SINGAPORE

This is to certify that

Ashwin Vinod

was awarded
the Terasaki Electric Silver Medal & Prize
for the second most outstanding graduate
in the Diploma in
Electrical Engineering course

4 May 2020

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Tang Kin Fei
Council Chairman

Ti Boon Wee
Principal

S 20044

Farewell Party for Graduating Students

CReST organized a farewell party for its graduating students Dr. Dipesh, Brian and Sumit Pandey. Prof Tan shared his experience related to working with these students and gave valuable suggestions for their bright future. It was very insightful. These students also shared their thoughts about environment, work culture and their memories at CReST

We wish good luck to the three graduates for bright future and thanks for their support in the last few years.