CENTER FOR RELIABILITY SCIENCES AND TECHNOLGIES

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Inside this issue

CReST Annual Lab meeting 2021

The annual lab meeting of CReST was held on January 2021 where all the Professors and members affiliated to CREST attended the meeting. The agenda for the meeting was to discuss the research strategies and general administration for the year 2021. Various regulations regarding equipment usage and faculty/student collaborations was also discussed.

Prof. Tan presents in the CADMEN conference

Prof. tan was invited as a guest speaker in the annual CADMEN CAE Conference held on 29 January 2021. He discussed about the importance of Density functional theory simulations and their significance in Reliability and Failure analysis. DFT tools Such as MedeA helps provide a platform to compute different aspects of material properties that has vital significance in determining the material failure mechanism of devices under Reliability tests. It also gives great insight by calculating the activation energy of failure mechanisms which are helpful for Reliability modelling.

The work is now accepted in Journal of Applied Physics, “Shabir, Abdul, and Cher Ming Tan. "Impact of visible light and humidity on the stability of high-power light emitting diode packaging material." *Journal of Applied Physics* 130.8 (2021): 083101.”

Prof. Tan Presented to the Taiwan transport safety board

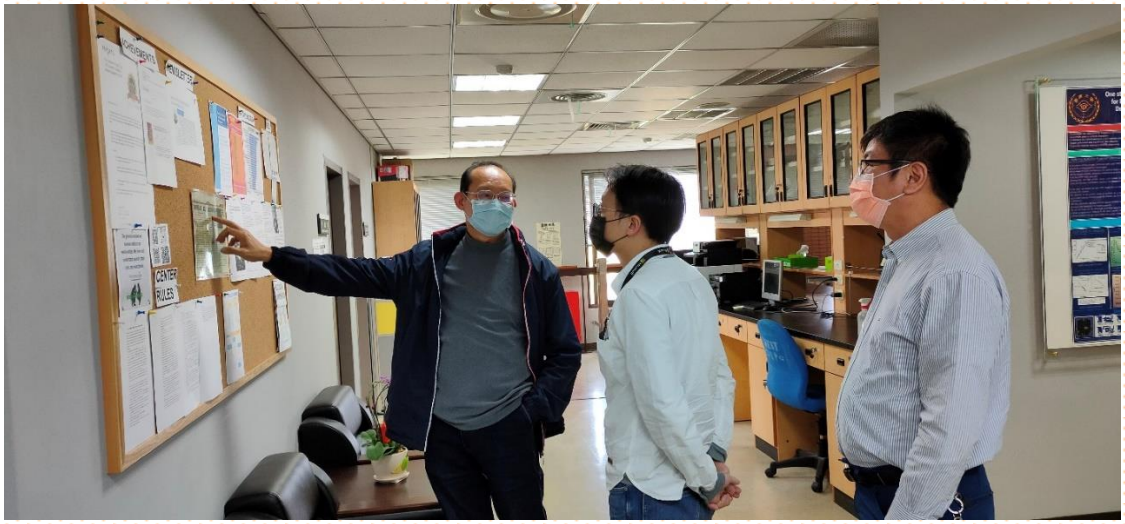
Professor Tan is invited to present his reliability and failure analysis work to the top management of the National body on transportation safety board for future collaboration. The board is set up to manage the transportation occurrences notification, investigation, causes analysis and identification, write investigation reports as well as issue transportation safety recommendations. Analyse the trend of transportation occurrences, monitor the execution of the safety recommendations, and conduct related safety studies. Establishing the comprehensive capabilities and techniques for transportation occurrence investigation, including recorders read-out and engineering analysis. Establish, revise and abolish laws and regulations associated with the transportation occurrence investigation. Coordinate and communicate with transportation occurrence investigation and safety-related organizations nationally and internationally.

MOXA hands on training workshop by CReST

MOXA is a leader in edge connectivity, industrial computing, and network infrastructure solutions for enabling connectivity for the Industrial Internet of Things. With over 30 years of industry experience, Moxa has connected more than 71 million devices worldwide and has a distribution and service network to serve customers in more than 80 countries. On the 7th of April 2021 a hands-on training programme for the Employees of MOXA was provided by CReST in the laboratories in Chang Gung University and Ming Chi university respectively. The employees were trained by the members of CReST on a wide range instruments that are used for Reliability testing and evaluation.

Industry Visits to CReST -

Microsoft



Microsoft USA is seeking possible collaboration with CReST on their data centre reliability. Two of the engineers from the branch office in Taiwan visited the centre on 25th March 2021 to have a detail understanding of the activities and capabilities of the centre. Discussion of the collaboration is undergoing.

Delta Electronics

The CTO of Delta Electronics brought his team to visit CReST for possible future collaborations on 28th April 2021. They were pleased that they can find such centre in Taiwan. Professor Tan is invited to give a seminar to them on 3 September, and they will discuss in detail the collaboration project then.

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. Assessor, Lester B. Pearson International Scholarships, University of Toronto, 2021
2. Member, SQI Advisory Panel, 2021-2022
3. Topic Editor of Electronics (MDPI)

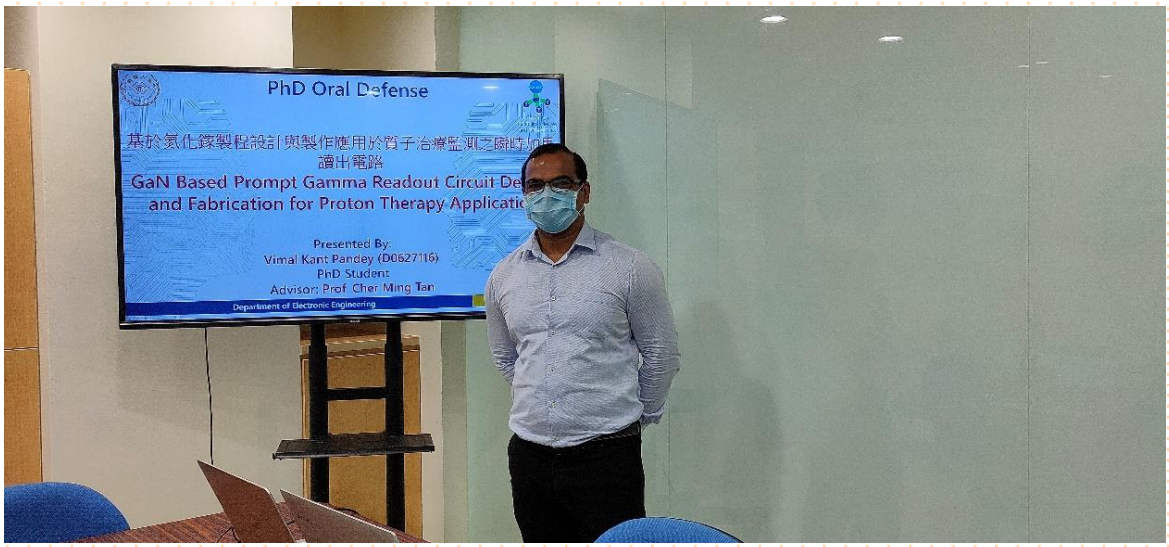
Awards

Prof. Tan awarded by CADMEN (29 Jan 2021)

Prof. Tan awarded by TAAI (8 June 2021)

Graduations

Congratulations to Vimal Kant Pandey for successfully defending his PhD thesis and being awarded the PhD degree on 8th July 2021



Title- GaN Based Prompt Gamma Readout Circuit Design and Fabrication for Proton Therapy Applications

Abstract- Proton beam therapy due to its unique dose distribution characteristic becomes an attractive choice for cancer therapy over conventional radiotherapy. In proton beam therapy, the dose distribution initially remains quasi-constant and rises sharply to the maximum value at the end of the path, known as Bragg's peak. Beyond Bragg's peak, the dose is negligible, hence the side effects are negligible. To fully utilizes the advantages of proton therapy, an accurate invivo range verification technique is required so that the position of Bragg's peak can be measured precisely. Prompt gamma imaging is one of the in-vivo range verification techniques that utilize prompt gamma signals generated due to the nuclear interaction of proton beams with tissues during the therapy. Along with the prompt gamma, secondary neutrons are also generated during the therapy due to the interaction of proton beams with the beam shaping devices and with the patient body. These secondary neutrons will negatively affect the health of the patient and the reliability and performance of the electronic devices present in the treatment room. This thesis aims to develop a high reliability prompt gamma readout circuit. The reliability of the gallium nitride (GaN) high electron mobility transistor (HEMT) is higher than the silicon devices in the neutron ambient. Hence, the readout circuit is designed using GaN HEMT. The prompt gamma signals are detected by radiation detectors and converted into an

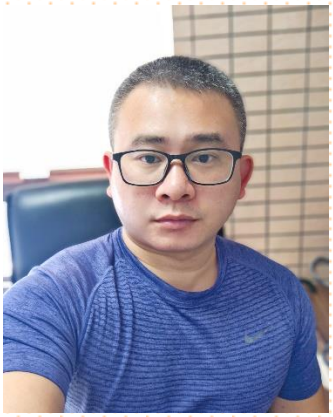
electrical signal using position-sensitive photomultiplier tubes (PSPMT). The PSPMT has 64 channels which are reduced to 4 channels using discretized positioning circuit (DPC) which is further processed by the readout circuit. The DPC circuit is designed using resistive networks and since the tolerance of the resistors is an important parameter for such circuits, thus, design of experiment method is used to study the impact of tolerance on the performance of DPC. The basic building blocks of the readout circuit are a transimpedance amplifier, an adder, an integrator, and a comparator circuit. Thus, each of these circuits is designed individually and after verifying their performances, integrated together to design the readout circuit. The performance of the transimpedance amplifier is also studied, before and after the proton irradiation.

His GaN circuit designs are fabricated and tested under proton radiation with proven success. 2 patents were granted from his work:

1. C.M. Tan, V.K. Pandey, Gallium Nitride Transimpedance Amplifier – (Applied in Taiwan & U.S.)
2. C.M. Tan, V.K. Pandey, Gallium Nitride Operational Amplifier– (Applied in Taiwan)

Dr. Ming-Wei Lee Joined CReST Lab

Ming-Wei Lee received the PhD degree from the Department of Optics and Photonics of National Central University. He has served as a post-doctoral researcher in the DBIRS of NYMU, DRO of Linkou CGMH, IRR of CGMH/CGU. Recently, he works as the post-doctoral researcher in the CReST of CGU. His main research topic is the development of nuclear medicine imaging systems, including the optimal configuration of SPECT system, proton-induced prompt Gamma Compton imaging system and proton-induced PET system.



Ms. Yang Yan Joined CReST Lab

Yang Yan received her Master degree from Sichuan University in 2015 on Probability Theory and Mathematical Statistics. She mainly studied statistical data processing, and generalized linear models. After graduation, she assisted in the establishment and optimization of customer credit scoring models in bank and financial companies. She is now working on the Reliability statistics methods at the Center.

Patents

CReST lab has filed a new patent for their technology which has been stated below:

1. **Gallium nitride operational amplifier**

   The present invention is gallium nitride based operational amplifier because reliability and performance of the gallium nitride is better than the silicon counterpart in radiation environment. The operational amplifier includes four stages, first stage is dual input balanced output differential amplifier, second stage is dual input unbalanced differential amplifier, third stage is buffer stage to couple second and fourth stage, and fourth stage is cascaded common source amplifier with degeneration. A capacitor coupled between second and third stage is to enhance the stability of operational amplifier.

Keynote/Invited talks

1. **Cher Ming Tan** "Understanding and Prediction of failure/degradation of complex system - demonstration of the power of reliability science" ANQ Congress, 2021.

Publications

1. Shabir, Abdul, and **Cher Ming Tan**. "Impact of visible light and humidity on the stability of high-power light emitting diode packaging material." Journal of Applied Physics 130.8 (2021): 083101.

   There are many advantages of LEDs in energy and environmental conservation, but their short life in many outdoor applications prompt a necessity to have a detailed understanding of their degradations to prolong their lifetime, which can also conserve LED material and even expand their applications. Using *ab initio* density functional theory formulation, we identify the detail paths of the LED degradation in outdoor applications. We discovered that the main stressors are humidity and the light that is emitted from the LED chip itself. This is rather ironical. A mathematical model is developed based on the *ab initio* study, and excellent experimental agreements are found. With this model, we can predict the situations where no and slow degradations can be achieved, and these are verified experimentally here. We can also predict quantitatively the time to a specific degradation severity. Quality index of the housing material for LEDs can also be determined.
2. Singh, P., & Tan, **C. M**. (2021). Statistical Method and Non-Destructive Analytical Tools in the Failure Analysis of LED Array. *ECS Journal of Solid State Science and Technology*, *10*(2), 025008.

   When several units failed during operation or reliability test, and their failure modes are the same, it is difficult to examine if there are multiple failure mechanisms unless destructive analysis is performed on every units. However, this can be very time and resource consuming. This work demonstrates a method that combine statistical method and non-destructive analytical tools to determine various failure mechanisms where

their failure modes are the same. The sample examined in this work is an array of LEDs assembly which consists of 20 lED chips. The sample is subjected to a standard 85 °C and 85%RH test for 1000 h, and all of them have the same failure mode of high forward voltage. We determine the number of possible degradation mechanisms using statistical method and find that there are three different mechanisms. Series resistance increase is found to be the dominant mechanism behind this high forward voltage rise. Non-destructive tools are used to confirm the three different mechanisms and identify their underlying physics.

3. Chiang, Y.; **Tan, C.M**.; Tung, C.-J.; Lee, C.-C.; Chao, T.-C. Lineal Energy of Proton in Silicon by a microdosimetry Simulation. Appl. Sci. 2021, 11, 1113. https://doi.org/ 0.3390/app11031113

   Single event upset, or Single Event Effect (SEE) is increasingly important as semiconductor devices are entering into nano-meter scale. The Linear Energy Transfer (LET) concept is commonly used to estimate the rate of SEE. The SEE, however, should be related to energy deposition of each stochastic event, but not LET which is a non-stochastic quantity. Instead, microdosimetry, which uses a lineal calculation of energy lost per step for each specific track, should be used to replace LET to predict microelectronic failure from SEEs. Monte Carlo simulation is used for the demonstration, and there are several parameters needed to optimise for SEE simulation, such as the target size, physical models and scoring techniques. We also show the thickness of the sensitive volume, which also correspond to the size of a device, will change the spectra of lineal energy. With a more comprehensive Monte Carlo simulation performed in this work, we also show and explain the differences in our results and the reported results such as those from Hiemstra et al. which are commonly used in semiconductor industry for the prediction of SEE in devices.

4. Pandey, Vimal Kant, **Cher Ming Tan**, and Sangwan, Vivek. “GaN-Based Readout Circuit System for Reliable Prompt Gam-ma Imaging in Proton Therapy.” Applied Sciences, MDPI

   Prompt gamma imaging is one of the emerging techniques used in proton therapy for in-vivo range verification. Prompt gamma signals are generated during therapy due to the nuclear interaction between beam particles and nuclei of the tissue that is detected and processed in order to obtain the

position and energy of the event so that the benefits of Bragg's peak can be fully utilized. This work aims to develop a gallium nitride (GaN)-based readout system for position-sensitive detectors. An operational amplifier is the module most used in such a system to process the detector signal, and a GaN-based operational amplifier (OPA) is designed and simulated in LTSpice. The designed circuit had an open-loop gain of 70 dB and a unity gain frequency of 34 MHz. The slew rate of OPA was 20 V/µs and common mode rejection ratio was 84.2 dB. A simulation model of the readout circuit system using the GaN-based operational amplifier was also designed, and the result showed that the system can successfully process the prompt gamma signals. Due to the radiation hardness of GaN devices, the readout circuit system is expected to be more reliable than its silicon counterpart.

5. Pandey, Vimal Kant, **Cher Ming Tan**, Sunjin Kim, Preetpal Singh, Vivek Sangwan, Jin-Woo Han, and M. Meyyappan. "Effect of 150 MeV protons on carbon nanotubes for fabrication of a radiation detector." Nanotechnology 32 355501 (2021): 10pp

   High energy and high flux protons are used in proton therapy and the impact of proton radiation is a major reliability concern for electronics and solar cells in low earth orbit as well as in the trapped belts. Carbon nanotubes (CNTs), due to their unique characteristics, have been considered for the construction of proton and other radiation sensors. Here, a single wall CNT based proton sensor was fabricated on FR4 substrate and its response to 150 MeV proton irradiation was studied. The change in the resistance of the nanotubes upon irradiation is exploited as the sensing mechanism and the sensor shows good sensitivity to proton radiation. Proton radiation induces dissociation of ambient oxygen, followed by the adsorption of oxygen species on the nanotube surface, which influences its electrical characteristics. Since the nanotube film is thin and the 150 MeV protons are expected to penetrate into and interact with the substrate, control experiments were conducted to study the impact on FR4 substrate without the nanotubes. The dielectric loss tangent or dissipation factor of FR4 increases after irradiation due to an increase in the cross-linking of the resin arising from the degradation of the polymer network.

6. V. K. Pandey and **C. M. Tan**, "Application of Gallium Nitride Technology in Particle Therapy Imaging," in IEEE Transactions on Nuclear Science, vol. 68, no. 6, pp. 1319-1324, June 2021, doi: 10.1109/TNS.2021.3072654.

   A transimpedance amplifier (TIA) is an essential electronic circuit in prompt gamma detection. To improve the performance and reliability of the electronics, we designed a TIA using GaN high electron mobility transistor (HEMT) as it is more radiation-hardened when compared to its silicon counterpart and it has lower noise. Our circuit is designed using GaN HEMT from efficient power conversion (EPC) and has a 3-dB frequency of 21 MHz and 45 dB Ω of transimpedance gain. Its total output rms noise voltage is 3.1 mV. Its functionality is verified using a Lu-176 radiation source, and experimental result shows that the current generated from the H12700 position-sensitive photomultiplier tube (PSPMT) detector when the gamma radiation hits the scintillator crystal is successfully converted into voltage with the gain in agreement with our simulation result. Comparison of this GaN-based TIA with the reported silicon-based TIA shows superior performances for particle therapy imaging. The circuit is also tested under 100-MeV proton radiation with a fluence of 1.6×1011 cm^{-2} and flux of 1.14×108 cm $-2s^{-1}$, and negligible variations in the linearity and gain in the postradiation measurements are observed.

7. **Li, Chung-Yi**, et al. "Simple and hardware-efficient row-based direct-mapping estimators in fixed-width modified Booth multipliers." *International Journal of Circuit Theory and Applications* 49.4 (2021): 909-920.

   The great demand of high-performance fixed-width two's-complement modified Booth multipliers (FWBM) arises because of the wide applications of approximate computing. In this paper, a row-based direct-mapping (RDM) method for designing error estimators in FWBM is proposed. The proposed closed form is derived from probability summation of each entire row to avoid the long setup time of exhaustive simulations. Consequently, a simple and systematic procedure by the Karnaugh map can be utilized to design low-error and hardware-efficient compensation circuits for various widths of FWBMs. By checking the leading column of the truncation part, the extendable design principle can be easily applied to different lengths and different columns inspected. We use Synopsys Design Compiler and TSMC 90 nm standard cell library to synthesize the register transfer language (RTL)

design of our proposed estimators. In addition, the RDM is synthesized using the Xilinx Vivado tool with Xilinx Kintex-7 XC7K325T-2FFG900C FPGA. Results of software simulation, hardware synthesis, and implementation experiment validate the high accuracy, hardware saving, and power efficiency of the proposed RDM estimators.

8. C.-W. Su, H. Jin, **C.-Y. Li**, Y.-J. Liao, K.-S. Chin, "Pattern-Reconfigurable Dual-Band Dipole Antenna Array with Four Switchable Beams for Full Coverage in Horizontal Plane" IET Microwaves, Antennas & Propagation, Openacess. 2021/1/8

   In this study, we develop a pattern-reconfigurable dual-band 1 x 2 dipole antenna array for operation in 2.45- and 5.5-GHz bands. Parasitic directors are added to the antenna to change the shape of the radiation pattern, and the length of parasitic directors are adjusted using diode switches; therefore, each band can switch four beams in 0° (front broadside), 90° (right endfire), 180° (back broadside), and 270° (left endfire) directions to achieve full coverage in the horizontal plane. For demonstration, one prototype of the proposed pattern-reconfigurable dual-band dipole antenna array was fabricated and measured. Measured results indicated that dual-band operation was achieved with the maximum impedance bandwidths of 30.8% and 46% in 2.45- and 5.5-GHz bands, respectively. Four switchable beams were obtained with a maximum gain of 5.3 dBi and a front-to-back ratio up to 17.3 dB.

9. Chong Rong Huang, Chia-hao Liu, Hsiang-Chun Wang, **Hsuan-Ling Kao**, , Hsien-Chin Chiu, Chih-Tien Chen, Kuo-Jen Chang, "The Characteristics of 6-inch GaN on Si RF HEMT with High Isolation Composited Buffer Layer Design," Electronics, vol. 10, no. 1, 2021, pp.46. 2021/1/1

   In this study, a 50-nm $Al_{0.05}Ga_{0.95}N$ back barrier (BB) layer was used in an AlGaN/GaN high-electron-mobility transistor between the two-dimensional electron gas channel and Fe-doped/C-doped buffer layers. This BB layer can reduce the channel layer. The BB layer is affected by doped carriers in the buffer layer and the conduction energy band between the channel and the buffer layers. The I_{on}/I_{off} ratio of the BB device was 4.66×10^5, and the ratio for the device without BB was 1.91×10^3. Lower leakage currents were obtained in the BB device because of the higher conduction energy band. The 0.25-μm gate length device with the BB exhibited a high current gain cutoff

frequency of 24.4 GHz, and power gain cutoff frequency of 73 GHz.

10. Hsien-Chin Chiu, Chun-Ming Chen, Li-Chun Chang, **Hsuan-Ling Kao*,** "A 5-bit X-band GaN HEMT-Based Phase Shifter," *Electronics*, vol. 10, no. 6, 2021, pp. 658.

    In this study, we propose a 5-bit X-band gallium nitride (GaN) high electron mobility transistor (HEMT)-based phased shifter monolithic microwave integrated circuit for a phased-array technique. The design includes high-pass/low-pass networks for the 180° phase bit, two high-pass/bandpass networks separated for the 45° and 90° phase bits, and two transmission lines based on traveling wave switch and capacitive load networks that are separated for the 11.25° and 22.5° phase bits. The state-to-state variation in the insertion loss is 11.8 ± 3.45 dB, and an input/output return loss of less than 8 dB was obtained in a frequency range of 8–12 GHz. Moreover, the phase shifter achieved a low root mean square (RMS) phase error and RMS amplitude error of 6.23° and 1.15 dB, respectively, under the same frequency range. The measured input-referred P_{1dB} of the five primary phase shift states were larger than 29 dBm at 8 GHz. The RMS phase error and RMS amplitude error slightly increased when the temperature increased from 25 to 100 °C. The on-chip phase shifter exhibited no dc power consumption and occupied an area of 2 × 3 mm^2.

11. Yu Chun Huang, Hsien-Chin Chiu, **Hsuan-Ling Kao,** Hsiang-Chun Wang, Chia-Hao Liu, Chong-Rong Huang, Si-Wen Chen, "High Thermal Dissipation of Normally off p-GaN Gate AlGaN/GaN HEMTs on 6-Inch N-Doped Low-Resistivity SiC Substrate," *micromachines*, vol. 12, no. 5, 2021, pp. 509.

    Efficient heat removal through the substrate is required in high-power operation of AlGaN/GaN high-electron-mobility transistors (HEMTs). Thus, a SiC substrate was used due to its popularity. This article reports the electrical characteristics of normally off p-GaN gate AlGaN/GaN high-electron-mobility transistors (HEMTs) on a low-resistivity SiC substrate compared with the traditional Si substrate. The p-GaN HEMTs on the SiC substrate possess several advantages, including electrical characteristics and good qualities of epitaxial crystals, especially on temperature performance. Additionally, the price of the low-resistivity SiC substrate is three times lower than the ordinary SiC substrate.

12. **Lee, Kun-Mu**, et al. "Reducing Defects in Organic-Lead Halide Perovskite Film by Delayed Thermal Annealing Combined with KI/I2 for Efficient Perovskite Solar Cells." *Nanomaterials* 11.6 (2021): 1607.

    This study improved quality of $CH_3NH_3PbI_3$ ($MAPbI_3$) perovskite films by delaying thermal annealing in the spin coating process and introducing KI and I_2 to prepare $MAPbI_3$ films that were low in defects for high-efficiency perovskite solar cells. The influences of delayed thermal annealing time after coating the $MAPbI_3$ perovskite layer on the crystallized perovskite, the morphology control of $MAPbI_3$ films, and the photoelectric conversion efficiency of solar cells were investigated. The optimal delayed thermal annealing time was found to be 60 min at room temperature. The effect of KI/I_2 additives on the growth of $MAPbI_3$ films and the corresponding optimal delayed thermal annealing time were further investigated. The addition of KI/I_2 can improve perovskite crystallinity, and the conductivity and carrier mobility of $MAPbI_3$ films. Under optimized conditions, the photoelectric conversion efficiency of $MAPbI_3$ perovskite solar cells can reach 19.36% under standard AM1.5G solar illumination of 100 mW/cm^2.

13. CH Hsing, LDH Oanh, **TC Chao**, CC Lee, JH Hong, CC Cheng, CK Tseng, CJ Tung, MOSFET dose measurements for proton SOBP beam. Physica Medica 2021, 81, 185-190

    The aim of this work was to develop a computational scheme for the correction of the LET dependence on the MOSFET response in water phantom dose measurements for a spread-out Bragg peak (SOBP) proton beam. The LET dependence of MOSFET was attributed to the stopping power ratio of SiO_2 to H_2O and to the fractional hole yield in the SiO_2 layer. Using literature values for the stopping powers of the continuous slowing down approximation and measured fractional hole yields vs. electric field and LET, formulas were derived for the computation of a dose-weighted correction factor of a SOBP beam. Dose-weighted correction factors were computed for a clinical 190-MeV proton SOBP beam in a high-density polyethylene phantom. By applying correction factors to the SOBP beam, which consisted of weighted monoenergetic Bragg peaks, the MOSFET outputs were predicted and agreed well with the measured MOSFET responses. By applying LET dependent correction factors to MOSFET data, quality assurance of dose verification based on MOSFET measurements becomes possible for proton therapy.

14. Tan, H.Y.; Lin, S.C.; Wang, J.; Chang, C.J.; Haw, S.C.; Lin, K.H.; Tsai, L.D.; **Chen, H.C.*;** Chen, H.M.* MOF-Templated Sulfurization of Atomically Dispersed Manganese Catalysts Facilitating Electroreduction of CO_2 to CO. ACS Applied Materials & Interfaces, 2021

    To reach a carbon-neutral future, electrochemical CO2 reduction reaction (eCO2RR) has proven to be a strong candidate for the next-generation energy system. Among potential materials, single-atom catalysts (SACs) serve as a model to study the mechanism behind the reduction of CO2 to CO, given their well-defined active metal centers and structural simplicity. Moreover, using metal–organic frameworks (MOFs) as supports to anchor and stabilize central metal atoms, the common concern, metal aggregation, for SACs can be addressed well. Furthermore, with their turnability and designability, MOF-derived SACs can also extend the scope of research on SACs for the eCO2RR. Herein, we synthesize sulfurized MOF-derived Mn SACs to study effects of the S dopant on the eCO2RR. Using complementary characterization techniques, the metal moiety of the sulfurized MOF-derived Mn SACs (MnSA/SNC) is identified as MnN3S1. Compared with its non-sulfur-modified counterpart (MnSA/NC), the MnSA/SNC provides uniformly superior activity to produce CO. Specifically, a nearly 30% enhancement of Faradaic efficiency (F.E.) in CO production is observed, and the highest F.E. of approximately 70% is identified at −0.45 V. Through operando spectroscopic characterization, the probing results reveal that the overall enhancement of CO production on the MnSA/SNC is possibly caused by the S atom in the local MnN3S1 moiety, as the sulfur atom may induce the formation of S–O bonding to stabilize the critical intermediate, *COOH, for CO2-to-CO. Our results provide novel design insights into the field of SACs for the eCO2RR.

15. Tung, C.W.; Tso, C.H.; Chen, B.Y.; Chu, H.; Hou, C.H.; **Chen, H.C**.; Chang, M.C.; Shyue, J.J.; Lin, P.H.; Chen, H.M.* Heterocyclic-additive-activated dinuclear dysprosium electrocatalysts for heterogeneous water oxidation. Inorganic Chemistry, 2021, 60, 6930.

    Heterogeneous catalysis based on air-stable lanthanide complexes is relatively rare, especially for electrochemical water oxidation and reduction. Therefore, it is highly desired to investigate the synergy caused by cocatalysts on the lanthanide complex family for heterogeneous catalysis because of their structural diversity, air/moisture insensitivity, and easy preparation

under an air atmosphere. Two mononuclear and three dinuclear dysprosium complexes containing a series of Schiff-base ligands have been demonstrated as robust electrocatalysts for triggering heterogeneous water oxidation in alkaline solution, in which the complex [Dy2(hmb)2(OAc)4]·MeCN(3) was revealed to have the best activity toward heterogeneous water oxidation among all five complexes in the present study. The molecular activation of dysprosium complexes has also been investigated with a series of N-containing heterocyclic additives [i.e., 4-(dimethylamino)pyridine (DMAP), bis(triphenylphosphine)iminium chloride ([PPN]Cl), indole, and quinoline]. In particular, the corresponding overpotential was effectively enhanced by 211 mV (at a current density of 10 mA cm–2) with the assistance of DMAP. On the basis of electrochemical and ex situ/in situ spectroscopic investigations, the best catalyst, DMAP–complex 3 on a carbon paper electrode, was confirmed with well-maintained molecular identity during heterogeneous water oxidation free of forming any dysprosium oxide and/or undesired products.

16. Lin, J.T.; Chu, T.C.; Chen, D.G.; Huang, Z.X.; **Chen, H.C**.; Li, C.S.; Wu, C.I.; Chou, P.T.*; Chiu, C.W.*; Chen, H.M.* Vertical 2D/3D Heterojunction of Sn Perovskites for Highly Efficient HTM-free Perovskite Solar Cell. ACS Applied Energy Materials, 2021, 4, 2014.

Tin perovskite solar cells (PSCs) have been attracting attention in photovoltaic application, while the performance of Sn PSCs, especially for hole-transporting materials (HTMs)-free configuration, is relatively poor because of short mean-free-path for photogenerated charge carriers. We report a p–n junction with spatially appropriate architecture and energetic alignment in perovskite light-absorbing layer, resulting in an excellent performance of HTM-free Sn PSCs with a power conversion efficiency (PCE) of 5.17%, the highest value reported in HTM-free Sn PSCs. The p–n junction configuration plays a key role in achieving high efficiency and realizing excellent stability for more than 200 h operation.

Social Events

Dinner Party with CReST Members (from left in order): Dr. Vivek Sangwan, Dr. Vimal Kant Pandey, prof. Dr. Cher Ming Tan, L.J.Hung (Bachelor Student), Jason (Bachelor Student), Abdul Shabir (Research Scholar)

Lunch Party hosted by Dr. Vimal in CReST Lab (from left in order): Prof. Dr. Cher Ming Tan (director), Dr. Vimal Kant Pandey, Dr. Vivek Sangwan, Asst. Prof Dr. Hsiao-Chien Chen (CReST member/Professor at CGU), Dr. William (Post-Doctoral Fellow), Abdul Shabir (Research Scholar)