產品可靠性暨系統安全研發中心
CENTRE FOR ADVANCES IN RELIABILITY AND SAFETY

APRIL 2021 ISSUE 3

CAiRS NEWSLETTER

盧家航博士
香港理工大學電子及資訊工程學系副教授
雪菲爾大學哲學博士，電機電子工程師學會會員
Dr Ka Hong Loo
Associate Professor, Electronic and Information Engineering
The Hong Kong Polytechnic University
PhD (Univ. of Sheffield), MIEEE

OPPORTUNITIES IN THIRD-GENERATION SEMICONDUCTOR
第三代半導體的機遇

A Conversation with Dr Ka Hong Loo
與盧家航博士的對話

Centre for Advances in Reliability and Safety (CAiRS) is supported by several professors at The Hong Kong Polytechnic University as the research project leaders. In this issue, we invited one of the project leaders, Dr Ka Hong Loo, Associate Professor, Department of Electronic and Information Engineering at The Hong Kong Polytechnic University who leads our research programs "Use of Failure Models and Bayesian Method for Real Time Failure Prediction and Uncertainty Management" and "Anomaly Detection and Syndromic Surveillances" to share his experiences. Dr Loo's areas of research interest include power electronics, renewable energy systems and solid-state lighting technologies. He has authored or co-authored over 100 peer-reviewed journal and international conference papers in these areas.

產品可靠性暨系統安全研發中心(CAiRS)的研究計劃擁有多位香港理工大學教授作為項目領導提供支持。今期封面訪問，我們邀請了其中一位項目領導，在中心研究有關"異常檢測和症狀監測項目"及"實時故障預測和不確定性管理項目"的電子及資訊工程學系副教授盧家航博士向讀者分享他的經驗。盧博士的研究領域包括電力電子、可再生能源系統和固態照明技術。他在這方面撰寫或合著了100多篇期刊和國際會議論文。

What is your current research interest?
請問你的研究興趣是什麼?

My research focuses on power electronics, which includes power circuits, semiconductor devices and control design. Mainly power electronics is concerned with efficient power conversion and supply of high-quality power to electrical and electronic systems for their proper operations. For example, if LED current is not well regulated, this will cause its light output to flicker. If the supply voltage of CPU is not well regulated, its computational performance will be affected, leading to computation errors. The application domain of power electronics is very large ranging from mega-watt systems such as solar farms to low-power systems such as handheld devices.

我的研究領域主要在電力電子，包括電路、半導體裝置以及控制組件設計。在電力電子的領域，主要關注在於高效的功率轉換以及為電氣和電子系統的正常運作提供高質的電力供應。例如，如果LED電流調節不當，則會導致其光輸出閃爍。如果CPU的電源電壓調節不當，則會影響其計算性能，從而導致計算錯誤。電力電子的應用領域非常廣泛，從兆瓦級系統（例如太陽能發電場）到低功率系統（例如手提設備）。

INTERVIEW

How do you consider the reliability and safety in our daily life?
你對於日常生活中的可靠和安全性有何看法?

As users of electrical and electronic products in our daily life, we often have high expectation for the safety and reliability of these products. From my perspective, one simple way to assess the reliability of a product is to verify whether it can perform its normal functions correctly under the operating conditions that it is designed for. For example, we expect water kettle to stop heating when the water in the kettle reaches a certain temperature, such as 100°C. If the kettle does not stop heating under the prescribed condition, then we will think that the kettle is not reliable because it is not performing its basic functions correctly. Another example is autonomous vehicles. An autonomous vehicle shall be designed to recognize the colors of traffic light and will take appropriate actions corresponding to the colors. For example, slow down when it sees amber color and stop when it sees red color. In addition, the acceleration profile of the vehicle shall make general users feel comfortable. On the safety aspect, the basic requirement is to ensure that a product will cause no harm to its users. Going beyond this basic requirement, it is also important to ensure that users "feel" safe when using a product. For example, when a product gives rise to a high noise level during its operation, users may "feel" unsafe although the noise will not cause any real danger to them.

作為日常生活中電氣和電子產品的用戶，我們經常對這些產品的安全性和可靠性寄予厚望。從我的角度來看，評估產品可靠性的一種簡單方法是驗證產品在設計的工作條件下是否能夠正確執行其正常功能。例如，當水壺中的水達到一定溫度（例如100度）時，我們期望水壺停止加熱。如果水壺在規定條件下沒有停止加熱，那麼我們會認為水壺不可靠因為它沒有正確執行其基本功能。另一個例子是自動駕駛汽車。自動駕駛汽車的設計應能識別交通信號燈的顏色，並將採取與這些顏色相對應的適當措施。例如，看到橙黃色時減慢速度，看到紅色時停止。此外，車輛的加速度曲線應使一般用戶感到舒適。在安全方面，基本要求是確保產品不會對用戶造成傷害。在此基本要求上再加以考量，確保用戶在使用產品時"感到"安全也很重要。例如，當產品在其操作過程中產生高噪音水平時，儘管噪音不會對他們造成任何真正的危險，但用戶可能會"感到"不安全。

What are the opportunities you can see in coming years especially for power electronics?
未來幾年尤其在電力電子領域，你覺得有哪些機遇?

I am interested in studying the reliability of third-generation semiconductor at CAiRS. Silicon Carbide (SiC) and Gallium Nitride (GaN) are third-generation semiconductor that have attracted a lot of interest in the recent years due to their superior switching and temperature characteristics. In general, they enable more efficient and more compact power electronics products to be designed. While their price has decreased significantly over the recent years, the long-term reliability of third-generation semiconductor still causes a major concern before they are widely deployed in manufacturing power electronics products. Here at CAiRS we aim to conduct in-depth reliability-oriented research on third-generation semiconductor and develop innovative solutions for their online health monitoring and lifetime prediction using AI techniques.

在CAiRS研發中心，我對第三代半導體的可靠性研究非常感興趣。碳化矽（SiC）和氮化鎵（GaN）是第三代半導體，由於其出色的開關和溫度特性，近年來引起了人們的極大興趣。它們的出現使人們可設計更高效、更緊密的電力電子產品。儘管它們的價格在最近幾年已大幅下降，但第三代半導體的長期可靠性在將其廣泛用於製造電力電子產品之前仍然引起人們的極大關注。我們的目標是對第三代半導體進行以可靠性為導向的深入研究，並開發使用AI技術對其在線健康監測和壽命預測進行創新的解決方案。

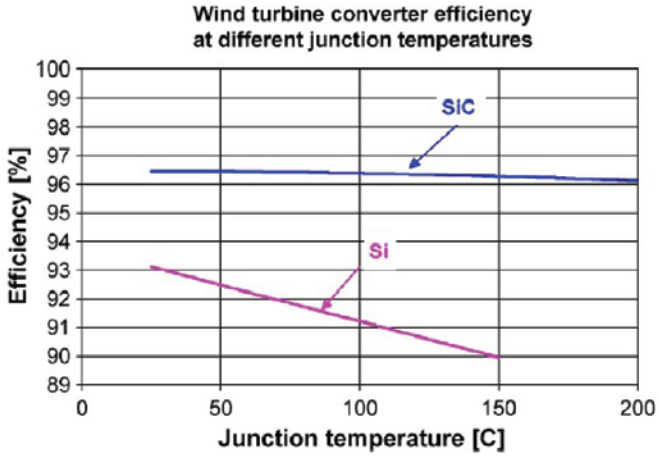


Figure 1: Efficiency of SiC and Si wind turbine converters at full power rating and different temperatures [1]
Figure 1: SiC和Si風力發電機變流器在全功率和不同溫度下的效率 [1]

[1] H. Zhang and L. M. Tolbert, "Efficiency Impact of Silicon Carbide Power Electronics for Modern Wind Turbine Full Scale Frequency Converter," in IEEE Transactions on Industrial Electronics, vol. 58, no. 1, pp. 21-28, Jan. 2011, doi: 10.1109/TIE.2010.2048292

INTERVIEW

What is the challenge on reliability of power electronics?
電力電子的發展在可靠性上面對什麼挑戰?

Temperature fluctuations encountered in semiconductor devices, including third-generation semiconductor, during their operation constitute the major reason for their failures. Post-failure analysis often shows that degradation in packaging materials due to temperature fluctuations is the main reason causing these failures. As different packaging technologies and packaging materials used by different semiconductor manufacturers, it is difficult to generalize the findings obtained from one device to other devices. As a result, a large number of aging tests and post-failure analysis must be conducted which is very time consuming. Moreover, in order to apply AI techniques to the condition monitoring and lifetime prediction of semiconductor devices, a large amount of training data must be collected in advance for mapping different failure causes to failure effects which requires a significant amount of time and manpower.

包括第三代半導體在內的半導體裝置在其工作期間遇到的溫度波動是其引發故障的主要原因之一。故障後分析通常表明溫度波動引起的封裝材料老化是導致這些故障的主要原因。由於不同的半導體製造商使用了不同的封裝技術和材料，因此很難將從一種裝置獲得的發現推廣到另一種裝置。因為以上原因，大量耗時的老化測試和故障後分析必須進行。而且，為了將AI技術應用於半導體裝置的狀態監視和壽命預測，大量的訓練數據必須預先收集以將不同的故障原因對照到故障影響，這也需要大量的時間和人力。

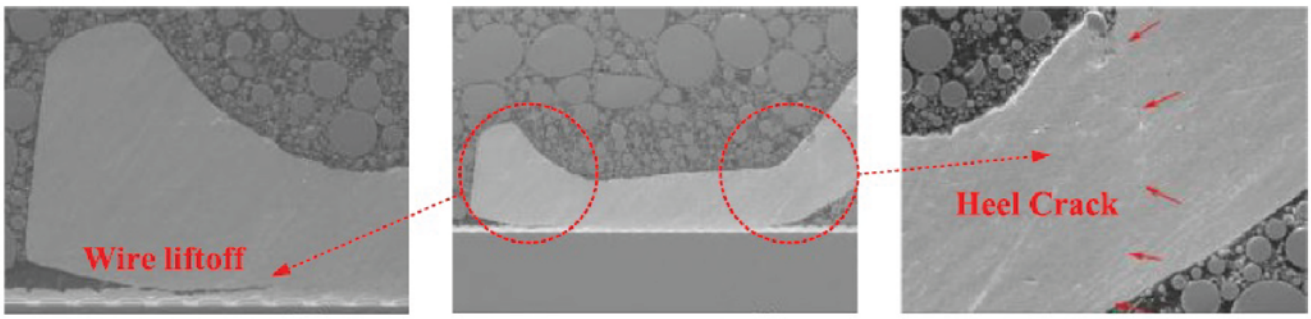


Figure 2: Example of Cross Section SEM image of the aged device [2]
Figure 2: 關於老化電子零件的SEM橫切面圖例子 [2]

Please share the ideas of application on how to consider the reliability for such development.
請分享對如何考慮可靠性的想法。

On feature discovery, it is essential to identify the main aging or failure pre-cursors of third-generation semiconductor by means of accelerated aging tests and device characterization in different aging stages. Knowledge of these pre-cursors and the trends of their variations over the course of aging will provide the basis for developing accurate lifetime model using AI techniques which will enable us to predict the remaining useful lifetime of third-generation semiconductor-based power electronic systems when used in combination with some innovative non-destructive online health monitoring methods. The continuous monitoring of the essential health parameters will also enable us to detect any anomalous conditions accurately and timely and trigger the shutting down of the malfunctioning systems before catastrophic failures occur.

在特徵發現方面，第三代半導體的主要老化或故障先兆必須通過加速老化測試和不同老化階段的裝置表徵來識別。對這些先兆的了解以及它們在老化過程中變化的趨勢將為使用AI技術開發準確的壽命模型提供基礎，使我們能夠結合使用一些創新的無損在線健康監控方法預測第三代半導體的電力電子系統的剩餘使用壽命。對基本健康參數的持續監視還使我們能夠準確、及時地檢測到任何異常情況，並在發生災難性故障之前關閉故障系統。

[2] F. Yang, E. Ugur and B. Akin, "Evaluation of Aging's Effect on Temperature-Sensitive Electrical Parameters in SiC mosfets, " in IEEE Transactions on Power Electronics, vol. 35, no. 6, pp.6315-6331, June 2020, doi: 10.1109/TPEL.2019.2950311

CAiRS HIGHLIGHTS

「提升電子零件、產品及系統的可靠性」網上研討會

WEBINAR ON "RELIABILITY ENHANCEMENT OF ELECTRONIC PARTS, PRODUCTS AND SYSTEMS"

由產品可靠性暨系統安全研發中心(CAiRS)主辦、美國馬利蘭大學Center for Advanced Life Cycle Engineering (CALCE)提供技術指導、香港電子業商會及香港電子業總會協辦、香港工程師學會、香港科技園、國際工程技術學會、英國機械工程師協會、營運工程師學會(香港分會)支持主辦『提升電子零件、產品及系統的可靠性』網上研討會，已於 2021 年 3 月 25 日假「產品可靠性暨系統安全研發中心」舉行。

是次網上研討會邀請到海外及本地著名學者及業界代表出席，包括來自美國CALCE中心的兩位專家，分別是：Dr. Diganta Das, Vice chair of the standards group of IEEE Reliability Society, Sub group leader for the SAE G-19 counterfeit detection standards group, Dr. Michael Osterman of CALCE, Senior member of IEEE, Member of ASME, IMAPS and SMTA，主要為我們分享無監督下的深度學習技術及電器硬件的穩定性預測。本地方面，我們邀請到Dr. Stanislav Markov, Data Scientist of Meridian Innovation Limited及香港先進科技有限公司促成科技開發組副總裁(技術)　吳漢瑜先生為大家分別分享熱影像感測器的可靠性、壽命預測；以及高可靠性電源組件等技術。最後由CAiRS總監及執行董事 - 工程師容錦泉教授為網上研討會作總結。

另外，CAiRS將於2021年5月18日假香港沙田科學園科技大道西12號科學園會展中心三期一樓會議廳舉行首場「人工智能 - 轉化產品及對安全可靠性的影響」技術研討會，當日更安排參觀CAiRS實驗室，機會難得，額滿即止，歡迎大家踴躍參加。歡迎到CAiRS 網站www.cairs.hk登記或留意宣傳刊物。

想了解更多關於CAiRS的最新消息及活動資訊，歡迎大家到CAiRS 網站www.cairs.hk 或關注CAiRS 臉書。

Guest speakers pose a group photo at the webinar.
網上研討會開始前合照

CAIRS HIGHLIGHTS

Organized by "Centre for Advances in Reliability and Safety" (CAiRS), technical supported by Center for Advanced Life Cycle Engineering (CALCE), collaborated by the Hong Kong Electronic Industries Association (HKEIA), Hong Kong Electronics Industry Council (HKEIC) and supported by the Hong Kong Institution of Engineers (HKIE), the Hong Kong Science & Technology Parks (HKSTP), the Institution of Engineering and Technology (IET), Institution of Mechanical Engineers (IMechE) and Society of Operations Engineers (SOE hong kong region), Webinar on "RELIABILITY Enhancement of Electronic Parts, Products and Systems" was successfully organized on 25 March 2021.

In the Webinar, we have invited overseas and local professional experts, and renowned industrialist included Dr. Diganta Das of CALCE, Vice chair of the standards group of IEEE Reliability Society, Sub group leader for the SAE G-19 counterfeit detection standards group who shared about "Unsupervised Machine Learning Techniques in Prognostics of Power Electronics", Dr. Michael Osterman of CALCE, Senior member of IEEE, Member of ASME, IMAPS and SMTA talked about "Reliability Prediction of Electrical Hardware". We have invited Dr. Stanislav Markov, Data Scientist of Meridian Innovation Limited and Mr. Peter Ng, Vice President, Enabling Technology Group, ASM Pacific Technology Ltd. to share "Reliability, Intelligent Performance Monitoring and Lifetime Prediction of Thermal Imaging Sensors" and "Enabling High Reliability Power Module" separately. Ir Prof. Winco Yung, Centre Director of CAiRS delivered closing remarks for the webinar.

Besides, we will organize a Technical Seminar on "Artificial Intelligence – Transforming Products and Impacting Safety & Reliability" at Function Hall, 1/F, 12W, 12 Science Park W. Ave., HKSTP on 18 May 2021. We have invited local professional experts, and renowned industrialist to share their expertise in AI application on transforming products regarding to safety & reliability. Moreover, a private and small group Lab Tour will be offered to our guest.

For more information and details of the Technical Seminar or upcoming activities, please visit our CAiRS website www.cairs.hk or follow our facebook #CAiRS.

(From left) Ir Prof. Winco Yung, Mr. Peter Ng, Dr. Stanislav Markov and Ir Richard Tse pose a group photo.
(左起) 容錦泉教授工程師、吳漢瑜先生、Dr. Stanislav Markov及司儀謝永寧工程師大合照

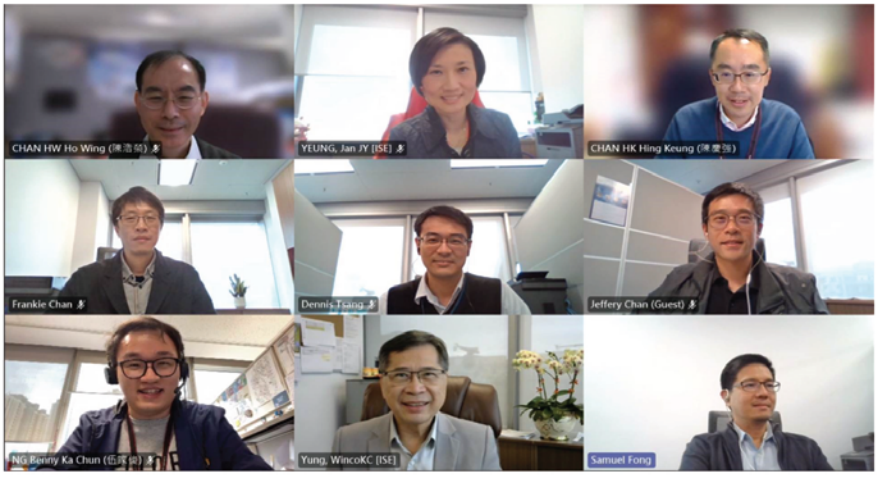
CAiRS HIGHLIGHTS

產品可靠性暨系統安全研發中心(CAiRS)出席港鐵社區聯網網上聚會 分享「智慧出行」和「智慧維修」

CAiRS SHARES "SMART MOBILITY" AND "SMART MAINTENANCE" AT MTR SOCIETY LINK VIRTUAL GATHERING

CAiRS was invited by the MTR to join MTR Society Link Virtual Gathering to share and discuss technical issues and the future development on "Smart Mobility' and "Smart Maintenance" on 20 Feb 2021. Ir Prof. Winco Yung, Centre Director & Executive Director of CAiRS and guest of the Hong Kong Society for Transportation Studies mentioned the Society Link Virtual Gathering which is extremely good and useful for us to have a better understanding on the future development of MTR in smart transportation. He added CAiRS and the research teams are looking forward to future collaboration with MTR as one of the industrial partners of CAiRS's first batch with Hong Kong brands which represent safe and reliable products and systems.

CAiRS應港鐵邀請在2021年2月20日出席港鐵社區聯網網上聚會，並分享「智慧出行」和「智慧維修」等多方面與可靠性及系統安全相關的技術事項，以及討論未來發展方向。香港交通研究學會會員、CAiRS總監及執行董事工程師容錦泉教授表示，希望透過是次的社區聯網聚會，讓我們更瞭解港鐵團隊努力邁向智慧出行的方向。CAiRS和研究團隊對於港鐵積極推動『智慧維修』甚感興趣，並熱切期待稍後與港鐵團隊成為中心首批工商界合作夥伴，共同推動香港安全和優質品牌的產品和系統。



Ir Prof. Winco Yung, Centre Director & Executive Director and teams of CAiRS were invited to join a follow-up meeting chaired by Deputy General Manager - Train Services & System Engineering Mr H K Chan for further discussion on collaboration on 10 March.
3月10日，CAiRS 總監及執行董事工程師容錦泉教授及團隊應邀與港鐵副總經理—車務及系統工程陳慶強先生及團隊會議，討論港鐵與產品可靠性暨系統安全研發中心之間的合作。

UPCOMING NEWS

ARTIFICIAL INTELLIGENCE - TRANSFORMING PRODUCTS AND IMPACTING SAFETY & RELIABILITY

Date: 18 May 2021, Tuesday (10:00-17:00)
Venue: Function Hall, 1/F, 12W, 12 Science Park West Avenue, Hong Kong Science Park
Language: English
Admission Fee: Free of Charge

Certificate for 3 or 6 CPD hours will be issued after attending the Seminar

DR. HAIBO HU
THE HONG KONG POLYTECHNIC UNIVERSITY

PROF. EDWARD CHUNG
THE HONG KONG POLYTECHNIC UNIVERSITY

PROF. JIANNONG CAO
THE HONG KONG POLYTECHNIC UNIVERSITY

MR. TANG CHI WAI, JEFF
ASM PACIFIC TECHNOLOGY LIMITED

MR. HARRIS SUN
RASPECT INTELLIGENCE INSPECTION LTD.

DR. CHARLES CHEUNG
NVIDIA AI TECHNOLOGY CENTER HK | NVIDIA

TIME	TOPICS AND SPEAKERS
10:00-10:05	Welcoming Remarks Prof. H.C. Man, Dean of Faculty of Engineering, The Hong Kong Polytechnic University
10:05-10:35	**Topic: Reliability of Machine Learning Models, How safe is AI?** Dr. Haibo Hu Associate Professor, Department of Electronic and Information Engineering, The Hong Kong Polytechnic University
10:35-11:05	**Topic: Network Wide Traffic Volume Estimation and Prediction** Prof. Edward Chung Associate Dean (Research), Faculty of Engineering, The Hong Kong Polytechnic University
11:05-11:15	Break
11:15-11:45	**Topic: Future Edge Computing: Towards Distributed Intelligence for AIoT applications** Prof. Jiannong Cao Chair Professor of Distributed and Mobile Computing, Associate Director of UBDA, The Hong Kong Polytechnic University
11:45-12:05	Q & A
12:05-12:30	**Showcases & Lab Tour in 19W**
12:30-14:05	Lunch Time
14:05-14:10	Welcoming Remarks Dr. CH Ng, Chairman of the Hong Kong Electronic Industries Association
14:10-14:45	**Topic : Reliability with Predictive Maintenance** Mr. Tang Chi Wai, Jeff R&D Manager, ASM Pacific Technology Limited
14:45-15:20	**Topic: AI-Powered Solutions for Improving Building Safety** Mr. Harris Sun, CEO & Founder, RaSpect Intelligence Inspection Ltd.
15:20-15:30	Break
15:30-16:05	**Topic: NVIDIA GTC 2021 Spotlights of Advanced Manufacturing and Predictive Maintenance** Dr. Charles Cheung Senior Data Scientist and Deputy Director, NVIDIA AI Technology Center HK | NVIDIA
16:05-16:25	Q & A
16:25-16:30	Closing Remarks Prof. Winco Yung, Executive Director & Centre Director of CAiRS
16:30-17:00	**Showcases & Lab Tour in 19W**

REGISTER HERE

CAiRS

產品可靠性暨系統安全研發中心

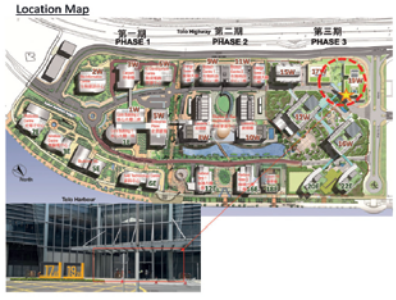
CENTRE FOR ADVANCES IN RELIABILITY AND SAFETY

CAiRSHongKong

cairs.hk

CAiRS

Unit 1212-1213, 12/F, Building 19W, Hong Kong Science Park,
Pak Shek Kok, NT, Hong Kong



+852 2162-5161

info@cairs.hk