4th International Conference on Semiconductor Materials & Technology

(ICoSeMT 2025)

CONCURRENT WITH

3rd International Invention, Innovation and Design Expo

(INoDEx 2025)

29th & 30th September 2025

St. Giles Wembley Penang, Malaysia

ABSTRACT BOOK

Innovation Towards a Sustainable Tomorrow

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TABLE OF CONTENTS

ABOUT THE CONFERENCE

4th International Conference on Semiconductor Materials and Technology (4th ICoSeMT 2025) is a biennial event that is jointly organized by Institute of Nano Optoelectronics Research and Technology (INOR), Universiti Sains Malaysia (USM), Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMCPP), National Nanotechnology Centre (NNC), Ministry of Science, Technology and Innovation of Malaysia (MOSTI), MIMOS Berhad and Collaborative Research in Engineering, Science & Technology (CREST) with the Theme "Innovation Towards A Sustainable Tomorrow". The primary focus of the conference is to create an effective medium for institutions and industries to share ideas, knowledge, and expertise in the fields related to Semiconductor Materials and Technology.

This year, with the aim to promote positive innovation culture and encourage innovation activities and from different walks of life, a sub-event entitled International Invention, Innovation & Design Expo (INoDEx 2025) is going to be held concurrently. This sub-event will be a great platform in creating opportunities for local and international participants to present their innovations and inventions. Eventually, both events will lead to interaction and future collaboration among the local and international participants.

4th ICoSeMT 2025 solicits contributions of abstracts and papers, featuring the theme and four main topics of the conference, encompassing:

Optical and Electronic Materials

- Narrow and Wide Band Gap Semiconductors
- Diamond, Graphene, and Carbon Nanotubes
- Piezoelectric and Ferroelectric Materials
- Electroluminescent Materials
- Colour-Changing Materials
- Energy Storage Materials
- Dielectric Materials
- Porous Structures
- Nanostructures
- Superconductors

Devices

- Optoelectronics
- Sensors and Actuators
- Power Devices
- Novel Devices
- Photovoltaics
- MEMS/NEMS
- Contacts and Interconnects
- Fabrication Processes
- Integrated System Design
- Modelling and Simulation
- IC Design

Organic and Polymeric Materials

- Organic Semiconductors
- Conductive Polymers
- Composite Polymers and Biopolymers

- Polymer Electronics and Coatings
- Polymer Catalysts and Characterization
- Functional Polymers and Polymer Hybrid Materials

Packaging Technology

- Phosphor Technology
- Co-Package Optic
- Lens and Optics
- Thermal Management
- Front End Assembly Processes
- Back End Processes and Applications
- Failure Analysis and Reliability

LIST OF ABSTRACT

KEYNOTE TALK

PLENARY TALK

INVITED TALK

VENDOR TALK

ORAL PRESENTATION

PARALLEL SESSION 1A		
ID	**Presentation Title / Speaker Name**	**Page**
ICO046	"Modelling and Simulation of AlGaN/GaN HEMT with Hybrid Gate-Recessed and AlN/Al_2O_3 Stacked Structure" ***Mr. Muhammad Farizuan Nor Effendy***	38
ICO045	"Water Gated HEMT: A Next Gen Sensor for Glyphosate" ***Mr. Amirul Firdaus***	39
PARALLEL SESSION 1B		
ID	**Presentation Title / Speaker Name**	**Page**
ICO048	"Application of Cu Material & Process in Semiconductor Manufacturing" ***Mr. Wan Tatt Wai***	40
ICO044	"Additive Manufacturing of Printed Electronics Technology for Hybrid Electronic Sensor System" ***Mr. Syed Muhammad Hafiz Syed Mohd Jaafar***	41
PARALLEL SESSION 2A		
ID	**Presentation Title / Speaker Name**	**Page**
ICO036	"Impact of AlN Buffer Layer Thickness on High Temperature Annealed AlGaN:Si for Enhanced UVB LED Performance" ***Ms. Nor Syafiqah Azmi***	42
ICO031	"The Study of Nonlinear Optical Behavior of Gallium Nitride Nanoparticles Synthesized by Laser Ablation in Liquid" ***Ms. Yuganesini Naidu A/P Siva Kumar***	43
ICO023	"Crack-Free Growth of Thick Gallium Nitride on Sapphire for High-Voltage Applications" ***Mr. Mohd Nazri Kasuan***	44

KEYNOTE TALK

K1

RECENT PROGRESS OF 230 nm AlGaN FAR-UVC LED FOR HUMAN HARMLESS DISINFECTION APPLICATIONS

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ABSTRACT – Human harmless short wavelength 230 nm AlGaN far-UVC LED fabricated on sapphire substrate is promising for potential applications of any kind of virus inactivation used in the spaces where people are present. Up to now, the light power of the 230 nm far-UVC LED is lower than those of 265-280 nm LEDs. We demonstrated efficiency increase in 220-230 nm far-UVC LEDs fabricating on AlN/c-sapphire by improving internal quantum efficiency (IQE), injection efficiency (IE), and light-extraction efficiency (LEE). We have demonstrated 0.8-1.5% EQE for 232-236 nm LEDs by introducing polarization doping (PD) layer for transparent p-contact layer. We also challenged short wavelength 219-222 nm LEDs by introducing PD hole injection layer. We also demonstrated efficiency increase by about 4 times in 232 nm LED by introducing photonic crystal (PhC) reflector on p-AlGaN/p-GaN contact layer and obtain single more than 10 mW light power. 80 chips of 230 nm LED with 2.7 mW pulse operation power were integrated to cupper heat sink and we demonstrated 220 mW power far-UVC light module. The 230 nm far-UVC power LED module fabricated on sapphire can be provided in low cost and would be available for virus inactivation applications in human-working space.

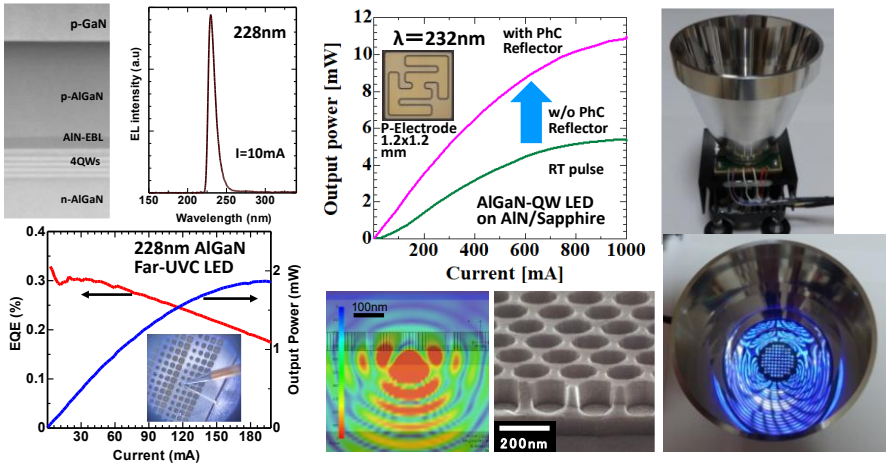

Figure 1. Efficiency increase in 228 nm far-UVC LED, enhancement of output power using refrective photonice crystal, and demonstration of 200 mW class 230 nm LED power modul.

K2

SHIFTING TRENDS IN THE GLOBAL SEMICONDUCTOR LANDSCAPE

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ABSTRACT – The Asia-Pacific (APAC) region produces nearly 70% of the world's semiconductors and hosts the most advanced fabrication capacity, positioning it at the center of global chipmaking. Yet this dominance has also revealed vulnerabilities, amplified by COVID-19, geopolitical tensions, and supply chain fragmentation. Governments are responding with large-scale industrial policies—from the U.S. CHIPS Act and EU Chips Act to China's $150 billion initiative and Japan's subsidies—aimed at reducing dependence and enhancing resilience. Industry strategies, including "China+1" diversification and massive investments in new fabs, are accelerating a regional reconfiguration. At the same time, technological shifts toward AI, electric vehicles, and advanced packaging are driving demand for both cutting-edge and legacy nodes, with heterogeneous integration emerging as a critical paradigm. Demographic factors, especially ASEAN's youthful, digitally savvy, and rapidly urbanizing populations, are further expanding consumer and industrial demand. This presentation examines how these intersecting forces—geopolitics, technology, and demography—are reshaping semiconductor production in the Asia-Pacific, with implications for global innovation and supply chain security.

K3

MATERIAL ASPECTS OF VERTICAL GaN TRANSISTORS

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ABSTRACT – Lateral GaN HFETs have made their way into industrial manufacturing for a variety of applications although they are still subject of research and development also at FBH. For switching of high voltages in power electronics transistors with vertical current flow offer advantages with respect to voltage scaling but also smaller chip area necessary for a given current to be switched. Material issues involved in the development of these devices will be discussed.

Native GaN substrates with low threading dislocation density offer ultimate performance but are not yet economic for many applications due to still too small diameter at too high cost. Heteroepitaxy on sapphire substrate can be scaled to large diameters and offers cost advantages. When transferring the epitaxial layer stack from the insulating sapphire, which only allows for quasi-vertical transport and device design, to a conductive substrate true vertical current flow becomes feasible also on large wafer diameters.

For the GaN drift layer controlled low n-doping with low compensation is required to scale the blocking voltage by increasing layer thickness and decreasing the doping level. Ways how to achieve this and the necessary compromises to be made during growth will be discussed. Also the lateral device layout is important. Different performance is obtained for gates formed on different crystal facets of the etched trenches. Finally, also the choice of the insulator materials as well as their deposition method is important to optimize device performance. The talk will review the current state of vertical GaN transistor technology development at FBH with respect to those different material issues.

K4

ADVANCING THE FUTURE OF POWER ELECTRONICS: INFINEON'S BREAKTHROUGH IN GaN TECHNOLOGY

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ABSTRACT – Around the globe, industries face a common challenge: the rising demand for energy and the urgent need to improve the energy balance to ensure a sustainable future. This challenge also presents one of the greatest opportunities of our time—leveraging advanced technologies to create impactful solutions. Gallium Nitride (GaN) power semiconductors are emerging as a pivotal enabler in this transformation and are reshaping how energy is converted, managed, and consumed. Its unique efficiency and performance characteristics translate into smaller, lighter, faster, and more cost-effective systems while unlocking new possibilities for innovation. As the world accelerates towards a sustainable, interconnected future, GaN is bridging the gap between the need to decarbonize our energy landscape and the opportunity to digitalize our industries. This keynote will explore GaN's current landscape, future potential, and its critical role in enabling the technologies that will define the decade ahead.

Keywords: Gallium Nitride (GaN), Energy, Decarbonization, Digitalization.

PLENARY TALK

P1

STRATEGIC STRATIFICATION OF SEMICONDUCTOR INNOVATIONS: BRIDGING ADVANCED MATERIALS TO ECONOMIC IMPACT

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ABSTRACT – The semiconductor industry is at the heart of the global digital economy, with innovations in III-nitride materials, wide bandgap semiconductors, and optoelectronics driving transformative applications across healthcare, energy, and communication. This plenary talk presents a strategic framework to stratify these technological advancements based on their economic impact, market readiness, and cross-sectoral potential. By aligning scientific innovation with economic imperatives, the talk aims to bridge the gap between research excellence and national development goals. Case studies and strategic models will be shared to illustrate how Malaysia and the region can position themselves competitively in the global semiconductor value chain.

P2

ADVANCES IN COMPOUND SEMICONDUCTOR DEVICE TECHNOLOGIES: PAVING THE WAY FOR SUSTAINABLE AND SMART APPLICATIONS

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ABSTRACT – The presentation will discuss current trends in OptoElectronics including the optimization of cost & performance as technologies mature, the opportunities in the visualization space driven by miniaturization & 2.5D/3D integration, plus some specific focus on semiconductor lasers, high efficiency illumination and the development of Ultra Violet LEDs.

P3

FABRICATION OF AlGaN HETEROSTRUCTURES BY QUASI VAN DER WAALS EPITAXY ON 2D MATERIALS FOR QUANTUM DOTS BASED UV LEDS

Julien Brault[1,*], Sunanda Mitra[1], Sébastien Chenot[1], Maud Nemoz[1], Antoine Reserbat-Plantey[1], Mohamed Al Khalfioui[1], Phuong Vuong[2], Suresh Sundaram[2], Abdallah Ougazzaden[2]

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ABSTRACT – Ultra-violet (UV) light emitting diodes (LEDs), based on aluminium gallium nitride (AlGaN) materials, are showing a rapid development due to numerous strategic applications (i.e. plant growth, disinfection/sterilization, dermatology, etc.) and the necessity to replace widely used mercury lamps (Minamata Convention - https://minamataconvention.org/en). In addition, building a technology that would enable a reduction of the fabrication cost is highly desirable to improve access to this technology. A new approach for the growth of AlGaN is emerging, using materials made of two-dimensional unit layers, such as hexagonal boron nitride (h-BN). Taking advantage of the out-of-plane van der Waals (VDW) bonds, stress-relieved epitaxial growth can be expected on h-BN. Here, we present results on AlGaN/AlN heterostructures grown by quasi VDW epitaxy by molecular beam epitaxy (MBE) on h-BN/sapphire templates fabricated by chemical vapor deposition. The AlGaN layers were characterized by x-ray diffraction and atomic force microscopy. Next, active regions made of AlGaN quantum dots (QDs) were grown and their optical properties investigated by temperature dependent photoluminescence. Finally, QD-based UV LED structures were grown by MBE and LED devices fabricated. Electrical and optical characteristics, investigated by current-voltage, transmission line method and electroluminescence measurements, are presented in this work, supported by ANR funding DOPALGAN <ANR-22-CE51-0035>.

Keywords: AlGaN, Van der Waals Epitaxy, Hexagonal Boron Nitride, Molecular Beam Epitaxy, UV Light Emitting Diodes

P4

STATUS AND CHALLENGES OF EFFICIENT AlGaN FAR-UVC AND UVB LED ON C-PLANE SAPPHIRE FOR MEDICAL AND AGRICULTURAL APPLICATIONS

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ABSTRACT – The increasing resistance of multidrug-resistant organisms (MROs), i.e., methicillin-resistant Staphylococcus aureus (MRSA), Tuberculosis (TB), and Candida auris to antibiotics is a major challenge faced by mankind in the history of medical science [1]. The spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes COVID-19, seriously threatens human health worldwide, and some new pandemics are expected in the future [1-3]. The available Hg-UV lamp sources in the market are hazardous to be used in public spaces, which is prohibited by the Minamata Convention of 2020 [1]. An AlN bulk substrate is preferred for the epitaxial growth of AlGaN-based far ultraviolet-C (far-UVC) light-emitting-diodes (LEDs) [2] due to its low threading dislocations (TDs), however, it is very expensive (8000 USD/2-inch wafer) [1]. Additionally, a relatively less expensive and time-consuming method known as double-growth and double high-temperature annealing (DGA) has been proposed by several researchers for the epitaxial growth of far-UVC LEDs [3]. Using a 2 μm-thick AlN template layer on a re-grown AlN layer, along with a DGA AlN template, resulted in an improved external quantum efficiency (EQE) of 0.24-0.70% for (230-233 nm)-band far-UVC LEDs [3]. In our laboratory, we enhanced the crystal quality of a low-cost AlN template grown on c-plane sapphire substrates (10 USD/2-inch wafer) by employing an ammonia (NH3) pulsed-flow multilayer (ML) growth [1,4,5]. However, we encountered an issue of relaxation ratio (RR) (≥ 35% in the n-AlGaN electron injection layer (EIL) of the LED using ud-AlGaN heteroepitaxy directly on a 4 μm thick AlN layer on c-plane sapphire. The reported EQE was 0.32%, with a light power output of 1.8 mW for a 228 nm far-UVC LED [1]. The low performance observed may be attributed to the high TDs and high RR of 35% in n-AlGaN EIL beneath the multiple-quantum wells (MQWs) using ud-AlGaN heteroepitaxy (transverse magnetic (TM)-mod ≥ transverse electric (TE)-mode). In previous cases involving blue LEDs fabricated on GaN templates, the light output power (Po) was significantly enhanced by introducing a regrowth of the GaN homoepitaxial layer. In this work, we introduced a new method of AlN homoepitaxy instead of heteroepitaxy (ud-AlGaN) on

MOVPE-grown AlN templates, aided by a special thermal cleaning treatment before the growth of the far-UVC LED. As a result, the relaxation ratio in the n-AlGaN EIL beneath the MQWs substantially decreased from 36% [1] to 16-22% (this work). Consequently, the EQE in the 231 nm far-UVC LED improved from 0.32% to 0.44% on the wafer (this work), both under continuous wave (CW)/pulse operation at room temperature (RT). When we increased the number of MQWs from 4-fold to 8-fold in the far-UVC LED, the EQE was remarkably enhanced to 0.5% (CW), and the light output power to 2.6 mW (CW) on the bare wafer. An EQE of more than 1% is expected in far-UVC LED if flip-chip and lens are introduced. Similarly, eco-friendly, smart, and high-power ultraviolet-B (UVB) LED module light sources are demanded for both medical and agricultural applications. Especially, narrow-band (NB) UVB light sources centred on 310 nm can be deployed for: cancer immunotherapy; treating vulgaris, psoriasis, and atopic dermatitis; and plant growth with enriched phytochemicals [4,5]. We found that the nature of relaxation in the n-AlGaN electron-source layer (ESL) strongly influences piezoelectricity, extended defects, point defects, aluminium-alloy fluctuations, and non-radiative recombination centres in the multi-quantum wells (MQWs), which can ultimately degrade the internal quantum efficiency (IQE). We have found at Riken, together with Yamaguchi University, that when we insert a 3.4 μm-thick n-AlGaN buffer layer underneath an n-AlGaN ESL, the relaxation ratio of n-AlGaN ESL reaches 50%, and the total dislocation density is reduced to 7 × 108 cm^{-2} (IQE ~ 54-57%) [4,5]. Recently, after optimization of n-AlGaN buffer layer, quantum well, and final barrier, we further investigated the influence of Al-graded p-type multi-quantum barrier electron-blocking-layer (Al-grad p-MQB EBL) and Al-graded p-AlGaN hole injection layer (HIL) in the context of 3D holes in the active region of LED. As a result, a record external-quantum efficiency (EQE) of 9.6-10% and light power of 42 mW on bar-wafer under CW-operation at RT was achieved, even in the absence of standard package i.e., flip-chip, photonic crystal (PhC) as well as nanoPSS, and resin-like lenses [1,2]. However, there was a very low light-extraction efficiency (LEE) of 8-9%. To improve the LEE, we proposed a simultaneous use of highly reflective Hole-like photonic crystal (HR-PhC) in a p-type AlGaN contact-layer as well as Hole-like nanoPSS in the 304 nm UVB LED. Quite high light extraction of 150% at in UVB LED was also confirmed theoretically.

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P5

SHAPING TOMORROW: WHERE OPTICS, ELECTRONICS AND MECHANICS CONVERGE

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ABSTRACT – The convergence of monolithic CMOS, Silicon Photonics and MEMS foundries is paving the way for the next generation of sensor and communication technologies, particularly in the current medical imaging, datacentres, and artificial intelligence (AI) application.

In this talk, I introduce our MOEMS platform (Micro-Opti- Electro-Mechanics), which integrating mechanical, optical and electronics into a fully integrated system. Through CMOS-compatible processes and deep foundry expertise, we turn your innovations into reality. Proprietary design and manufacturing methods guarantee consistent quality and scalability—making SilTerra a trusted partner for next-generation sensing and photonic applications.

This presentation will explore how this convergence supports the development of cutting-edge technologies especially for the advanced wearables medical devices, high performance datacentres and AI application.

P6

GaN-BASED MICRO-LEDS FOR ADVANCED DISPLAY APPLICATION

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ABSTRACT – GaN based III-Nitride materials have outstanding characters including high electric breakdown field, high-electron saturation velocity, good chemical stability, large thermal conductivity, high mobility and wide adjustable energy bandgap, thus have attracted significant interests in illumination and display society. GaN-based Micro-LEDs have become a research hotspot as a novel display technology due to its numerous unique advantages of high brightness, color saturation, fast response times, and long lifespan. Compared with traditional liquid crystal displays (LCDs) and organic light-emitting diodes (OLEDs), Micro-LEDs have been considered as one of the most ideal choices for a variety of novel display applications in virtual reality (VR), augmented reality (AR), optical communication, biomedical probes and etc. Of course, new applications require new developments, focusing on the following aspects: (1) high efficiency; (2) high luminance; (3) high resolution, which depend on high quality material, well designed quantum structures and advanced integration technique. In this report, recent progress in related area will be demonstrated and discussed.

Keywords: GaN, LED, Micro-LED Display.

P7

BRIDGING THE INNOVATION GAP: ADVANCING THE NATIONAL SEMICONDUCTOR STRATEGY THROUGH EFFECTIVE INDUSTRY-ACADEMIC-GOVERNMENT COLLABORATION IN SEMICONDUCTOR R&D

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ABSTRACT – This plenary highlights CREST's role in shaping Malaysia's E&E and semiconductor future through the triple helix model of collaboration—uniting industry, academia, and government. At the core is CREST's Collaborative R&D Program, such as the GaN-on-GaN initiative, where Nobel laureates, global industry leaders, researchers, and policymakers come together to push the boundaries of semiconductor innovation. These programs tackle long-standing challenges of fragmented priorities, resource gaps, and ecosystem readiness, while building trust and shared progress. Anchored within the National Semiconductor Strategy (NSS), CREST as Secretariat and ecosystem enabler drives capability building, talent growth, and technology transfer. Beyond Return on Investment (ROI), these efforts deliver Return on Value (ROV)—strengthening resilience, innovation, and national competitiveness for Malaysia's semiconductor leadership.

INVITED TALK

I1

NEXT LEVEL EPITAXY FOR SEMICONDUCTOR THIN FILMS

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ABSTRACT – State-of-the-art semiconductor thin films are typically grown by metal-organic chemical vapor deposition (MOCVD) technique. However, this technique has reached their limits. In this study, thin layers of aluminum nitride (AlN), silicon carbide (SiC) and diamond were grown on a variety of substrates including sapphire, SiC, silicon and glass using a special technique, called Next Level Epitaxy (NLE) . This process was carried out at temperatures below 250°C with a combination of multiple plasma sources. Specifically, by using 99.999% pure Al as Al source, nitrogen with a purity of 99.9995% as nitrogen source, silane as silicon and methane as carbon source. All gases were introduced into the NLE reactor by a homemade ion gun. These ion guns, configured as stripe sources, enable uniform deposition on large areas. Strictly speaking, NLE process follows the standard MOCVD growth procedures but utilizes different plasma sources in various combinations at each stage. Initially, the substrates were cleaned with a mixture of argon and oxygen and/or argon and hydrogen using the microwave plasma sources. After cleaning, a few monolayers of aluminum or carbon or silicon were deposited as a nucleation layer. Subsequently, AlN, SiC or diamond were deposited with low plasma power and low growth rate, followed by the layers deposited at higher plasma powers and growth rates. The NLE AlN on sapphire has been demonstrated as a perfect base for MOCVD overgrowth. Meanwhile, the results from XRD, Raman and AFM measurements for the diamond and SiC layers indicate the successful homoepitaxial growth of SiC on 4H-SiC and the formation of diamond islands on AlN-on-sapphire. The results will be presented in detail.

Keywords: AlN, Diamond, SiC, Plasma, Low Temperature.

I2

ADVANCED PACKAGING SUBSTRATES FOR AI CHIPS

Allen Cheah

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ABSTRACT – The emergence of advanced packaging SiP (system-in-package) for heterogeneous integration of multiple chiplets/tiles is taking center stage, right in the middle of the AI, data and digitalization boom. Its applications into HPC, agentic and physical/edge AI and IoT, servers, cloud computing, hardware accelerators, networking, and 5G/5.5G base stations are making advanced packaging SiP a primary economic driver for advanced packaging substrates, OSAT and even automated test and equipment cluster providers. SIP has become key for the Malaysian National Semiconductor Strategy Aspirations as we shift into 2030. Given that advanced packaging substrates are at the heart of advanced packaging SiP, this presentation will address the perennial enablers and importantly, WHY and HOW pertaining to building block solutions for 2.5D embedding and associated technology benefits for AI chips. It is hoped that this information will provide more insights into this agnostic trend and explore technical knowledge to be bolstered for advanced packaging SiP architectures with the E&E ecosystem in Malaysia, ASEAN regions, with vast expansion into the far east regions and globally. After all, ASEAN (Malaysia included) is now the center of semiconductor investments and is the second-largest semiconductor exporter globally at 23% global market share given its strategic location, efficient supply chain and skilled workforce as a key conduit in semiconductor manufacturing.

I3

SOLUTION-PROCESSED FUNCTIONAL NANOSTRUCTURES FOR HIGH-PERFORMANCE NEXT-GENERATION ELECTRONICS

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ABSTRACT – For the past three decades, Nanotechnology has grown at an enormous rate and recent advances in nanostructured materials and nanodevices have opened up new opportunities in a variety of applications, ranging from information and communication technology to healthcare and medicine. The fabrication of modern electronic devices through solution processing enabled us to achieve molecular-level control of material composition and structure that may lead to devices and fabrication strategies not possible with conventional top-down methods.

Resistive random-access memories (RRAM) are promising alternatives to existing computer memories which may offer a potential leap beyond the limits of Flash memories (concerning write speed, write energies) and Dynamic random access memories DRAM (concerning scalability, retention times). A conventional RRAM cell is composed of an insulating/dielectric layer sandwiched between two metallic layers. In this talk, I will highlight some novel ceria-based nanostructures fabricated using solution-processed methods for their applications as RRAMs. The overview of physical and electrochemical processes which may be the origin of the switching phenomenon in these materials will be discussed.

I4

REVOLUTIONIZING ORGANIC DYE MOLECULES IN DSSCS: UNLOCKING HIGHER EFFICIENCY SOLAR HARVESTING THROUGH LOW-COST METAL SALT ADDITIVE

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ABSTRACT – This work presents a speciation-focused strategy for dye–semiconductor integration in dye-sensitized solar cells (DSSCs), utilizing $Al_2(SO_4)_3$-induced acidification to stabilize flavylium-rich anthocyanin structures. By modulating solution pH, the system promotes tautomeric speciation toward the planar, conjugated flavylium cation—enhancing π-electron density, orbital symmetry, and dye–TiO_2 interaction. UV–Vis absorbance spectra confirm intensified π–π* transitions and red-shifted maxima, consistent with flavylium enrichment and improved light harvesting. FTIR analysis reveals strengthened hydrogen bonding and surface activation, supporting robust dye anchoring. Cyclic voltammetry (CV) demonstrates stabilized HOMO levels and favorable LUMO alignment with the TiO_2 conduction band, facilitating efficient electron injection. Open-Circuit Voltage Decay (OCVD) measurements show extended electron lifetimes and reduced recombination rates, indicating improved interfacial charge retention. These electronic refinements are reflected in IV curves, which exhibit enhanced short-circuit current density and fill factor, and in IPCE spectra, which reveal broader spectral response and higher quantum efficiency. By aligning molecular speciation with orbital geometry, the Al^{3+}-treated system offers a scalable, metal-free pathway to photostable, high-efficiency DSSCs. This approach underscores the power of acidification-driven tautomer control in shaping dye behavior at the quantum level, advancing the design of next-generation solar interfaces.

I5

DOPING-ENHANCEMENT HIGH-QUALITY AlN EPITAXY ON SAPPHIRE: GROWTH AND DEFECT MANAGEMENT

Ilkay Demir[1,2]

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ABSTRACT – Aluminum nitride (AlN) is a key wide bandgap semiconductor with strong potential in deep-UV optoelectronics and high-power electronic devices. However, heteroepitaxial growth of high-quality AlN on sapphire still remains challenging due to the large lattice and thermal mismatch, which leads to high dislocation densities, stress, and crack formation. In this talk, recent progress on doping-enhanced epitaxy and defect management in AlN thin films grown by MOCVD will be presented. The use of pulsed atomic layer epitaxy (PALE) has enabled precise control of growth kinetics, improving crystal quality and surface smoothness. Silicon doping strategies were developed to tune electrical properties while minimizing compensation effects. The importance of in-situ thermal cleaning of sapphire substrates for defect reduction and uniform nucleation will be discussed. Furthermore, a sandwich-structured growth method has been demonstrated to relieve strain and achieve crack-free thick AlN layers. Finally, optimization of ammonia flow rates has shown significant influence on dislocation densities and optical quality. Together, these approaches provide a comprehensive framework for realizing high-quality, reproducible AlN epitaxy on sapphire, paving the way toward reliable device platforms in wide bandgap semiconductor technology.

Keywords: AlN, Pulsed Atomic Layer Epitaxy, Doping.

I6

AlGaN MICRORING RESONATORS WITH COMPOSITION-DRIVEN TUNABILITY FOR HIGH-Q PHOTONICS

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ABSTRACT - This study investigates the tunability of aluminum gallium nitride (AlGaN)-based microring resonators (MRRs) as a promising platform for photonic devices operating at wavelengths below silicon's transparency limit (~1.1 μm). AlGaN's wide and tunable direct bandgap enables operation across the visible to near-infrared spectral range. Despite this potential, limited research exists on how varying the Al mole fraction in AlGaN affects the resonance behaviour of MRRs at these shorter wavelengths. This study presents a two-dimensional simulation of an AlxGa1-xN MRR using COMSOL Multiphysics, highlighting its material-based optical tunability. By systematically varying the Al composition from 0 to 100%, the resonant wavelength exhibits a nearly linear shift over a broad range of 73.59 nm, from 750.11 nm to 676.52 nm. Notably, this tuning is achieved without altering the ring radius; instead, the optimal waveguide-to-ring gap adjusts almost linearly, facilitating simpler fabrication. Throughout the compositional variation, the free spectral range remains highly stable with minimal variation, while the resonator maintains high quality factors (10^4–10^5), strong extinction ratios (46.4–57.0 dB), and effective modal confinement (Γ = 0.667–0.723). These findings demonstrate the potential of AlGaN as a versatile platform for compact, high-Q, broadband, wavelength-tunable photonic devices operating below silicon's transparency limit, enabling advances in both linear and nonlinear visible to near-infrared integrated photonics.

Keywords: GaN, Second Order Nonlinearity, Nonlinear Photonics, MOCVD, Sellmeier Equation, COMSOL Multiphysics.

VENDOR TALK

V1

KIRANA SEMIKONDUKTOR SDN BHD AS A SPIN-OFF OF INOR

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ABSTRACT – The global semiconductor industry is increasingly turning to gallium nitride (GaN) material as a key enabler for next-generation electronic and optoelectronic devices. At the Institute of Nano Optoelectronics Research and Technology (INOR), Universiti Sains Malaysia, various innovations in GaN technology have been successfully demonstrated. To bridge the gap between academic research and industrial applications, Kirana Semikonduktor - a newly spin-off company from INOR, is established to advance GaN research to the next level and accelerate its integration into commercial and industrial platforms. By leveraging world-class facilities and technical expertise at INOR, Kirana Semikonduktor has developed high-quality, highly uniform GaN templates which an essential building-block for devices fabrication. These templates offer a promising solution to one of the semiconductor industry's longstanding challenges in achieving consistent material quality for scalable devices production. Additionally, Kirana Semikonduktor offers a range of services to support industry and research partners, including customized processes for device development, device design, and technical consultation. These services are tailored to meet specific requirements, ensuring flexibility, innovation, and practical solutions for advancing semiconductor technologies.

Keywords: Gallium nitride (GaN) Technology, GaN Templates, GaN-Based Devices.

V2

SYNERGISTIC INSIGHTS FROM RAMAN SPECTROSCOPY AND PHOTOLUMINESCENCE

Andrew King

Crest Analytic Sdn. Bhd.

ABSTRACT – Raman spectroscopy and photoluminescence (PL) are two powerful, complementary techniques for probing the structural, electronic, and optical properties of materials at the micro- and nanoscale. In this presentation, we explore the principles and practical applications of Raman and PL measurements, highlighting their combined potential for comprehensive materials characterisation in the semiconductor industry. Raman spectroscopy provides detailed information on molecular structure, crystallinity, and stress, while PL reveals electronic band structure, defect states, and recombination dynamics. The integration of Raman and PL techniques offers unique insights into material quality, enabling rapid, non-destructive analysis for research and industrial applications, accelerating innovation in semiconductor materials and device engineering.

V3

STRUCTURE CHARACTERIZATION OF THIN-FILM SEMICONDUCTORS WITH STATE-OF-ART X-RAY DIFFRACTION TECHNIQUES

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ABSTRACT – As we are moving into the advanced technology nodes and enabling of the 2nd and 3rd generation semiconductor materials, X-ray diffraction becomes more important due to the complexity of the material structures. In this talk, we will introduce Bruker's state-of-art XRD solution for semiconductor material characterization. It will cover various X-ray technologies and the key features to make these technologies successful.

ORAL PRESENTATION (PARALLEL SESSION)

PARALLEL SESSION 1A

ICO046

MODELLING AND SIMULATION OF AlGaN/GaN HEMT WITH HYBRID GATE-RECESSED AND AlN/Al_2O_3 STACKED STRUCTURE

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ABSTRACT – Gallium nitride (GaN) high-electron-mobility transistors (HEMTs) are increasingly important in power electronics, but device performance is strongly affected by gate architecture and dielectric engineering. A hybrid approach integrating gate recessing with AlN/Al_2O_3 stacked dielectrics is investigated using the Silvaco TCAD simulation. Three dielectric ratios (1:2, 1:1, and 2:1) are examined across recess depths ranging from 10% to 90%, with focus on electric field response, electron concentration, and conduction band modulation. Results indicate that Al_2O_3-rich stacks provide strong leakage suppression but suffer from interface trap effects, while AlN-rich stacks enhance interface quality and mobility at the expense of off-state leakage. The 1:1 configuration demonstrates the most balanced behaviour, combining uniform electric field distribution with stable threshold control and efficient charge modulation. Gate recessing further improves threshold tuning, although excessive depth reduces channel conduction and increases peak electric fields. These findings underscore the effectiveness of dielectric stack optimization and recess geometry engineering in advancing GaN HEMT performance.

Keywords: GaN HEMT, Simulation, Gate-Recessed, Dielectric Layers.

ICO045

WATER GATED HEMT: A NEXT GEN SENSOR FOR GLYPHOSATE

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ABSTRACT – High-electron mobility transistor (HEMT)-based sensors hold great promise for rapid, label-free, and real-time detection of chemical contaminants. Leveraging the unique characteristics of the two-dimensional electron gas (2DEG), such devices amplify current responses to surface potential shifts induced by molecular adsorption, thereby enabling high sensitivity to charge variations. In this work, a water-gated HEMT (WGHEMT) was developed for glyphosate detection. The sensor demonstrated a voltage response of 63.52 $\mu V/mgmL^{-1}$, exhibiting strong linearity with an R^2 value of 0.94276 across the tested concentration range. The incorporation of an ion-selective membrane enhanced selectivity, while the device's reliable hysteresis performance confirms its potential for practical environmental monitoring.

Keywords: AlGaN/GaN, HEMT, WGHEMT, Sensor, Glyphosate.

PARALLEL SESSION 1B

ICO048

APPLICATION OF Cu MATERIAL & PROCESS IN SEMICONDUCTOR MANUFACTURING

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ABSTRACT – Cu has been a critical material not only for front end semicondcutor fabrication but also for back end assembly process. Cu material has been used as substitution to Al (aluminium) for chip interconnect when the size of the chip is shrinking, due to the superior low K resistivity of Cu. Electrolytic Cu plating process has thus become one of the key process where a variety of organic additives system is used to enhance its platability in narrow trench. It exhibit superior performance compared to conventional physical vapor deposition process using Al & W (tungsten), when come to high aspect ratio (in nm level) trench filling. Cu is also used for chip front side pad metallization for wire bonding. Cu pillar (in μm level) can be fabricated on the wafer as an interface of the chipvto package interface. Wafer back side metallization with Cu is also applied to improve thermal management, electrical performance & mechanical stress of the chip package. At back end packaging level, Cu material is used in through silicon via (TSV) or as EMI shield on packaging material. However, for packaging materials that are not conductive, electroless Cu plating should apply over conventional electrolytic Cu plating. In this case, catalytic system on the material must be established to enable selective electroless plating. Finally, both physical & chemical characterization methods can be used to characterize the properties of Cu material. In physical methods, EBSD (electron bean scattering diffraction), XRD (X-ray diffraction), nanoindentation, AFM (atomic force spectroscopy) can be used to evaluate the Cu grain size, grain orientation, hardness-Young Modulus & roughness respectively. The physical properties of Cu material on wafer is critical for material's machanical mismatch that will lead wafer's bow. In chemical methods, SIMS (secondary ion mass spectroscopy) is effective in analyzing the trace element in the Cu layer especially for sulfur & carbon element, as the Cu plating process always involve sulfuric acid & organic additives.

Keywords: Cu, Electrolytic Plating, Interconnect, Trench, Front Side Metallization, Back Side Metallization, Through Silicon Via, Cu Pillar, Characterization.

ICO044

ADDITIVE MANUFACTURING OF PRINTED ELECTRONICS TECHNOLOGY FOR HYBRID ELECTRONIC SENSOR SYSTEM

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ABSTRACT – The convergence of additive manufacturing and printed electronics offers a transformative pathway for the development of hybrid electronic sensor systems. In this work, we present the design and fabrication of printed pressure sensors utilising inkjet-based additive manufacturing. Conductive and functional inks were precisely deposited to form multilayer architectures, enabling high-resolution patterning without the need for conventional photolithography. The resulting sensors demonstrate excellent sensitivity, mechanical flexibility, and reproducibility, making them suitable for integration into next-generation hybrid systems. Beyond the technical advances, this work also aligns with global sustainability goals by promoting resource efficiency, reducing fabrication complexity, and enabling environmentally friendly manufacturing practices. Additive manufacturing of printed electronics therefore provides not only a scalable and cost-effective route to innovation but also a meaningful contribution toward sustainable technological development.

Keywords: Additive Manufacturing; Printed Electronics; Pressure Sensors; Piezoresistive.

PARALLEL SESSION 2A

ICO036

IMPACT OF AlN BUFFER LAYER THICKNESS ON HIGH TEMPERATURE ANNEALED AlGaN:Si FOR ENHANCED UVB LED PERFORMANCE

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ABSTRACT – Efforts in improving the performance of AlGaN-based UVB LEDs are ongoing, as the LEDs offer significant values for a wide range of applications. One approach to achieving this goal is to grow the LEDs on high material quality AlGaN layers. This study investigated the impact of AlN buffer layer thickness on improving material quality of high temperature annealed Si-doped AlGaN (HTA-AlGaN:Si). Here, AlN buffer layers with thicknesses of 700 nm and 1.4 µm were grown on sapphire substrates, and subsequently overgrown with AlGaN:Si layers of 700 nm thickness. In comparison to as-grown AlGaN:Si layers (before HTA), the threading dislocation density (TDD) for the HTA-AlGaN:Si reduced threefold with 700 nm thick AlN buffer layer and twofold, with 1.4 µm thick AlN buffer layer. However, pits were observed on the surface of the annealed samples. The surface degradation was mitigated by subjecting the annealed samples to a series of annealing steps and etching, including the deposition of a thin pseudomorpic AlN layer. The potential of the HTA-AlGaN:Si layers treated in this way as a template for AlGaN based UVB LED heterostructure growth was assessed. The results of this study provide valuable insights into the significance of the optimized AlN buffer layer for improving the material quality of HTA-AlGaN:Si to enhance AlGaN UVB LED performance.

Keywords: Si-doped AlGaN or AlGaN:Si, AlN Buffer Layer, High Temperature Annealing, AlGaN UVB LED Heterostructure.

ICO031

THE STUDY OF NONLINEAR OPTICAL BEHAVIOR OF GALIUM NITRIDE NANOPARTICLES SYNTHESIZED BY LASER ABLATION IN LIQUID

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ABSTRACT – Exploring the nonlinear optical behavior of gallium nitride (GaN) nanoparticles is proving to be a promising direction for pushing wide bandgap semiconductors into more versatile photonic applications. In this research, bulk GaN was transformed into nanoparticles using laser ablation in liquid (LAL), a surfactant-free and straightforward technique that yields clean colloidal dispersions ready for optical analysis. The structural and morphological properties were thoroughly characterized using transmission electron microscopy (TEM) and X-ray diffraction (XRD) to probe their size distribution, morphology, and crystal quality. Ultraviolet-Visible (UV–Vis) absorption and photoluminescence (PL) spectroscopy were employed to study bandgap shifts and emission characteristics at the nanoscale. The third-order nonlinear optics response was measured using open and closed aperture Z-scan techniques with a Continuous Wave (CW) laser at 637 nm wavelength via the single beam Z-scan method. The results show pronounced nonlinear absorption and self-focusing effects of GaN nanoparticles, highlighting the influence of quantum confinement and intrinsic defects in shaping their optical response. This study reveals that LAL-synthesized GaN nanoparticles can be tailored for practical photonic applications, including optical limiters, ultrafast switches, and integrated photonic circuits. Collectively, this work has demonstrated a definitive connection between nanoscale structural tuning and nonlinear optical performance, offering new perspectives for extending GaN's capabilities beyond its traditional uses in solid-state lighting and power electronics.

Keywords: Nonlinear Optical Properties, Laser Ablation, Nanoparticles, Z-Scan Method, Band Gap.

ICO023

CRACK-FREE GROWTH OF THICK GALLIUM NITRIDE ON SAPPHIRE FOR HIGH-VOLTAGE APPLICATIONS

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ABSTRACT – We report the successful growth of a ~10 µm crack-free gallium nitride (GaN) epitaxial structure on sapphire using a Taiyo Nippon Sanso SR-2000 metal-organic chemical vapor deposition (MOCVD) system. The structure comprises a 3 µm unintentionally doped GaN base layer on a low-temperature base layer, followed by a 2 µm n-doped GaN drain contact layer, a 5 µm thick drift layer, a 700 nm Mg-doped GaN (p-GaN) layer, and a 200 nm n-GaN source contact layer. The Mg-GaN was grown at 950°C to enhance Mg incorporation, while the other main epitaxial layers were deposited at 1150°C. X-ray diffraction (XRD) analysis confirmed high crystalline quality, with full width at half maximum (FWHM) values of 213 arcsec for the (102) plane and 356 arcsec for the (002) plane. Field emission scanning electron microscopy (FESEM) verified the layer thickness and confirmed a crack-free surface, demonstrating the feasibility of thick GaN growth on sapphire for high-voltage applications.

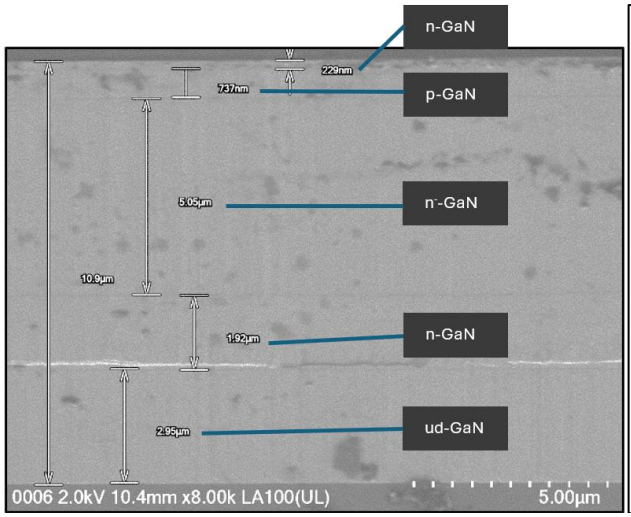

Figure 1: FESEM image of the crosscut from the sample.

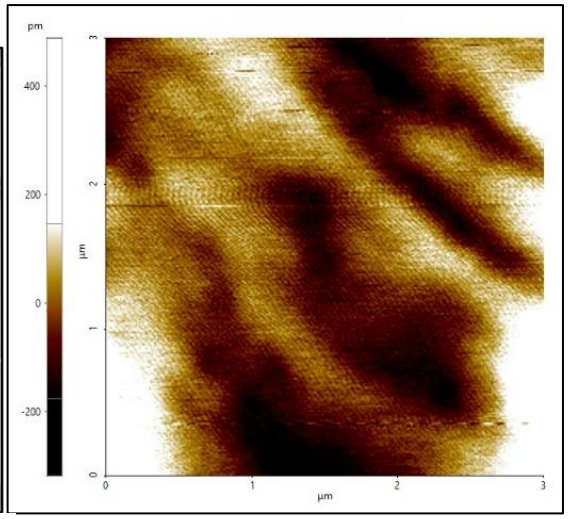

Figure 2: Atomic force microscopy of the surface. Rms surface roughness is 0.104 nm.

ICO028

MACHINE LEARNING FOR DATA-DRIVEN OPTIMIZATION OF 2D hBN GROWTH BY CVD

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ABSTRACT – Optimizing chemical vapor deposition (CVD) for high-quality hexagonal boron nitride (hBN) films is challenging due to complex parameter interactions. This study employs machine learning (ML) to predict hBN film quality, Raman full-width at half-maximum (FWHM), and thickness based on gas flow rates in a four-step CVD process on Ni foil. Using 7 experimental and 993 synthetic datasets, we trained Random Forest (RF), Gradient Boosting Machine (GBM), and Deep Neural Network (DNN) models for classification (quality: high, medium, low) and regression (Raman FWHM, thickness). With 6 independent variables (gas flow rates) and an 80/20 train-test split, GBM excelled in quality classification (F1-score = 0.85, ROC-AUC = 0.94), while RF outperformed in regression (Raman FWHM: RMSE = 3.00, R^2 = 0.96; thickness: RMSE = 2.16, R^2 = 0.92). DNN underperformed (F1-score = 0.80, RMSE = 4.34). NH_3 and B_2H_6 flow rates were critical for quality and thickness, respectively. These ML models enable precise CVD control, enhancing hBN synthesis for industrial scalability.

Keywords: Machine Learning, CVD Process, hBN, Classification, Regression.

PARALLEL SESSION 2B

ICO024

THE EFFECTS OF PDINN AS ELECTRON EXTRACTION LAYER IN ORGANIC SOLAR CELL

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ABSTRACT – Organic photovoltaic is one of the promising alternatives to silicon-based solar cells towards sustainable energy conversion as it is lightweight, cost-effective, flexible and customizable. However, the potential of organic solar cell is yet to be fully unleashed to achieve the desired efficiency and stability. Charge transport at each functional layer and the molecular interface remain the crucial factors that control the electrical and optical characteristics, and thus the performance of the device. Here we investigated the role of the electron extraction layer, PDINN in the performance of PM6:Y6 bulk heterojunction organic solar cell. The introduction of PDINN offers the advantage toward the fabrication of organic photovoltaic with consistent efficiency and scalability.

Keywords: Organic Photovoltaic, Organic Solar Cell, Electron Extraction Layer, Charge Transport, Power Conversion Efficiency.

ICO029

EFFECTS OF NITROUS OXIDE FLOW RATE ON STRUCTURAL, SURFACE MORPHOLOGICAL AND OPTICAL PROPERTIES OF COPPER OXIDE THIN FILMS

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ABSTRACT – Copper oxide (CuO) thin films are a promising candidate for solar cell applications, owing to copper's natural abundance and CuO's favorable optoelectronic properties, such as a bandgap energy within the solar spectrum's most intense range and a high absorption coefficient. In this work, CuO thin films were prepared by electron beam evaporation and then annealed at 400°C and duration of 30 minutes under nitrous oxide (N_2O) ambient with varying flow rates of 100, 200, 300, and 400 sccm. Subsequently, the effects of the N_2O flow rate on the structural, surface morphological, and optical properties of the CuO thin films were investigated. X-ray diffraction analysis confirmed the formation of polycrystalline monoclinic CuO, with the highest crystallinity observed at 100 sccm. Atomic force microscopy results showed that the smoothest surface with the lowest roughness was achieved at 200 sccm. Ultraviolet-visible (UV-Vis) transmission measurements revealed bandgap energies between 1.77 and 1.93 eV, as determined by Tauc plot analysis. The lowest bandgap (1.77 eV) was observed at 200 sccm, indicating a reduction in defect density. Among all the conditions studied, the 200 sccm flow rate stood out as the most promising for producing high-quality CuO thin films.

Keywords: Copper Oxide, Nitrous Oxide, Electron Beam Evaporation, Thin Films, Solar Cells.

ICO032

EFFECTS OF THERMAL ANNEALING IN NITROUS OXIDE AMBIENT ON STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF P-TYPE InGaN FILMS

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ABSTRACT – Thermal annealing in a nitrous oxide (N_2O) environment was conducted to study its effects on the structural, optical, and electrical properties of a p-type InGaN thin film grown by the metalorganic chemical vapour deposition technique. The objective was to assess whether this oxidizing atmosphere could enhance magnesium (Mg) acceptor activation, maintain indium stability, and reduce defect levels. A single p-type InGaN sample (CH0711) was annealed at 650 °C for 15 minutes under N_2O gas flow rates of 100, 200, 300, and 400 sccm. After annealing, the film's characteristics were analyzed using X-ray diffraction, atomic force microscopy, ultraviolet-visible transmission spectroscopy, and Hall effect measurements. The N_2O ambient showed some positive influence on electrical performance but also caused visible surface etching and increased roughness, especially at higher flow rates. These observations suggest that while the strong oxidizing nature of N_2O may support dopant activation, it can also compromise surface quality. Overall, the findings highlight the need to balance electrical activation with structural preservation when using oxidizing gases for the thermal annealing of InGaN materials.

Keywords: P-type InGaN, Nitrous Oxide, Mg Activation, Thermal Annealing, Optoelectronic Materials.

ICO034

Multi-Objective Optimization of InGaN-Si Tandem Solar Cells: Integrating Lion and SCAPS-1D for Enhanced Power Conversion Efficiency

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ABSTRACT – Indium gallium nitride (InGaN)-silicon (Si) tandem solar cells offer a compelling avenue for high-efficiency, affordable photovoltaics by synergizing the bandgap tunability of InGaN with the mature technology of Si. Conventional single-objective optimization often overlooks critical trade-offs, resulting in sub-optimal device performance. This study introduces an advanced multi-objective optimization framework that combines Lion Optimization Algorithm with SCAPS-1D simulations to maximize the power conversion efficiency (PCE) of InGaN-Si tandem solar cells. Key parameters were systematically optimized, including thickness, doping concentration, and indium (In) content for the InGaN absorber layer, as well as thickness and doping for the Si and silicon carbide (SiC) layers. These optimizations targeted improvements in short-circuit current density (J_{sc}), open-circuit voltage (V_{oc}), fill factor (FF), and PCE, yielding an optimal configuration with J_{sc} of 36.15 mA/cm², V_{oc} of 0.85 V, FF of 86.7% and PCE of 26.64%. The results emphasize the value of realistic, multi-parameter tuning in achieving superior tandem cells performance and affirm the efficacy of hybrid meta-heuristic strategies for advancing photovoltaic device engineering.

Keywords: InGaN-Si; Tandem Solar Cell; SCAPS-1D; Lion Optimizer.

PARALLEL SESSION 3A

ICO041

EFFECT OF INDIUM SURFACTANT ON P-TYPE LAYERS OF InGaN/GaN LEDS

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ABSTRACT – In this study, Indium (In) was introduced as a surfactant during the growth of the p-GaN layer and AlGaN blocking layer (EBL) of InGaN/GaN LEDs at concentrations of 13, 22, and 32 µmol/min. Results revealed that 22 µmol/min of In concentration improved the layer's morphology based on the evidence of step-flow growth, resulting in a smoother surface with roughness of 0.86 nm, with the hole concentration reaching 5×10^{17} cm^{-3}, five times higher than in the sample without In. Meanwhile, the resistivity does not show significant changes across different In concentrations. The introduction of In significantly enhances radiative recombination, with a stronger carrier confinement (E_a) observed in the sample with an In concentration of 22 µmol/min. suggesting that this concentration is the optimum. The emission wavelength of the LED with optimum In concentration shifted to a shorter wavelength compared to the reference LED, and the output power was measured at 5.17 mW at 100 mA, which is three times greater than that of the reference LED. This study suggests that applying In as a surfactant may serve as an ideal approach to improve the performance of InGaN/GaN LEDs.

Keywords: Indium Surfactant, P-GaN, Light-Emitting Diodes, MOCVD.

ICO027

OPTICAL CLASSIFICATION OF AMORPHOUS CARBON FILMS DEPOSITED BY PLASMA-ENHANCED CHEMICAL VAPOR DEPOSITION

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ABSTRACT – Amorphous carbon (a-C) in the forms of diamond-like carbon (DLC), graphite-like carbon (GLC), and polymer-like carbon (PLC) serves many purposes in a broad range of applications. In this article, experiments are conducted to understand and optimize the deposition of a-C films using a radio-frequency (RF) plasma-enhanced chemical vapor deposition (PECVD) system. The characterization using spectroscopic ellipsometry and Raman spectroscopy enables fast and non-destructive identification of the material. This study found that low pressure (150 mTorr), low-medium RF power (100 and 200 W), and low-medium temperature (100 and 200 °C) for the methane precursor will always result in PLC film. The GLC film can only be obtained by medium pressure (300 mTorr), high RF power (300 W), high temperature (300 °C), and only on oxide-removed Si substrate as an a-$Si_{1-x}C_x$ needs to be deposited on the Si surface before it is converted into GLC film. The optical characterizations of a-C however cannot specifically tell the portion of DLC in the deposited GLC since they cannot count the number of carbons sp^2 and sp^3 in the samples.

Keywords: a-C Film, PECVD Optimization, PLC Film, GLC Film, Optical Characterization.

ICO026

GROWTH OF CRACK-FREE GaN ON Si (111) EMPLOYING PULSE ATOMIC LAYER EPITAXY AlN BUFFER LAYER

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ABSTRACT – GaN-on-Si has become a cornerstone heterostructures for high-power electronics and optoelectronics due to its numerous advantages. GaN-on-Si epitaxy remains challenging due to large lattice and thermal expansion mismatch, which often results in cracks formation and high threading dislocation densities. Development of suitable buffer layer to compensate for the mismatches is essential. In this study, crack-free GaN epilayer was successfully grown on Si (111) substrate using metal organic chemical vapor deposition (MOCVD), employing pulse atomic layer epitaxy (PALE) AlN buffer layer. The optimization of AlN PALE pulse cycle number, growth temperature and ammonia flow rate, was found to have a significant impact on the surface morphology, crystalline quality and strain state of the GaN epilayers. Atomic force microscopy (AFM) revealed the formation of smooth terraces with a reduced root-mean square (RMS) roughness, indicating smoother surfaces. Detailed XRC measurement reveals a reduction in FWHM values for GaN (0002) and GaN (10-12), indicating a reduction in both screw and mixed-edge type threading dislocations. RSM analysis demonstrated a reduction of tensile strain in the epilayers. These findings show that optimization of AlN PALE growth parameters significantly improve GaN-on-Si epitaxy, offering a promising approach for the GaN-on-Si based devices.

Keywords: Gallium Nitride, Aluminium Nitride, Pulse Atomic Layer Epitaxy, MOCVD.

ICO040

GROWTH OF ALUMINUM NITRIDE (AlN) AT 1175°C

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ABSTRACT – Aluminum nitride (AlN) has been regarded as an indispensable material for ultraviolet light emitting diodes (UV-LEDs), which offers advancement in various area of applications, especially virus disinfection and water purification. High material quality AlN is typically obtained at high temperatures of above 1200 °C. However, ramping up the growth temperature from the low-temperature AlN buffer layer to ≥1200 °C for subsequent AlN growth prolongs the overall growth process. Moreover, without a proper condition, parasitic reactions which result in unwanted AlN particles can be introduced at high temperatures, lowering growth efficiency and uniformity. In fact, the AlN particles can serve as nucleation sites for dislocations. Meanwhile, growing AlN at low temperatures may inspire further explorations in AlN epitaxy, even with the use of standard epitaxy reactors. This present study demonstrates the growth of AlN layers using metal-organics chemical vapor deposition (MOCVD) technique at 1175°C. The growth conditions were varied as an attempt to improve the AlN growth. In particular, the AlN was grown with both nitridation and trimethylaluminum (TMAl) prelow, with nitridation without TMAl preflow, without nitridation and with TMAl preflow, and without both nitridation and TMAl preflow. Without nitridation, threading dislocation density can be reduced, while the transparency and surface are improved. The results are further optimized with TMAl preflow. Overall, this study proposes the possibility of growing AlN at low temperatures without significantly compromising the material properties of the AlN.

Keywords: AlN Layer, Epitaxy, Low Temperature, Nitridation, TMAl Preflow.

PARALLEL SESSION 3B

ICO030

NUMERICAL INVESTIGATION OF GAN WAVEGUIDE GRATING COUPLERS WITH DEPTH GRADIENTS USING COMSOL FOR MODE CONTROLLED LIGHT COUPLING

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ABSTRACT – We propose and investigate a gradient-etched grating coupler integrated into a gallium nitride (GaN) planar waveguide where the groove depth increases progressively along the grating length. This structural variation is expected to tailor the local scattering strength, enabling improved light coupling efficiency and controlled excitation of specific waveguide modes. Unlike uniform-depth gratings, the gradient profile introduces a gradual mode-matching mechanism which may reduce back-reflection and broaden the operational bandwidth. The design is compatible with standard GaN fabrication techniques and its performance will be evaluated through numerical simulations to quantify coupling efficiency, spectral response and mode selectivity.

ICO017

EFFECTS OF MOCVD GROWTH PARAMETERS ON m-PLANE GaN EPITAXY ON SAPPHIRE SUBSTRATE

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ABSTRACT – This study presents the growth of nonpolar m-plane gallium nitride (GaN) on m-plane sapphire substrates via a three-step Metal-Organic Chemical Vapor Deposition (MOCVD) process, systematically optimized under significantly reduced V/III ratios. This three-step process consists of a low-temperature aluminum nitride (AlN) nucleation layer, an intermediate m-GaN buffer layer, and a high-temperature m-GaN (HT-mGaN) layer. Structural and morphological characteristics of each layer were comprehensively examined using high-resolution X-ray diffraction (XRD), including phi scans and rocking curve analysis, as well as atomic force microscopy (AFM) and field emission scanning electron microscopy (FESEM). To further assess the HT-mGaN layer, reciprocal space mapping (RSM) was employed to evaluate strain states, and photoluminescence (PL) spectroscopy was conducted to investigate optical quality. The experimental results indicate that the application of lower V/III ratios within this three-step growth approach contributes to smoother surface morphology, enhanced crystal quality, and a reduction in extended defects. These findings underscore the viability of low V/III ratio processes for the efficient growth of high-quality nonpolar GaN layers.

Keywords: Nonpolar, m-GaN, Three-Step, MOCVD.

ICO013

REVOLUTIONIZING PRECISION AGRICULTURE: NEXT-GEN NANOSENSORS FOR INTELLIGENT CROP MONITORING AND SMART PREDICTION

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ABSTRACT – Nanomaterials are transforming sensor technology by offering enhanced sensitivity, mechanical flexibility, and material tunability - features that align with the performance demands of modern precision agriculture. This work presents an industry-driven exploration of graphene-based nanomaterials for the development of next-generation agricultural sensors, with a focus on leaf wetness monitoring. Graphene's adjustable electrical conductivity and tunable hydrophobicity are utilized to overcome the common drawbacks of conventional sensors, such as rigidity and limited adaptability across various crop species. A case study illustrates the integration of graphene-based sensors into smart farming systems, highlighting scalable and cost-efficient fabrication methods alongside strategies for optimizing performance under operational conditions. Field-relevant testing demonstrates that the sensors effectively replicate natural leaf surface behavior while enabling real-time, high-resolution crop health monitoring. Furthermore, this work investigates the synergy between nanotechnology and machine learning (ML) in the development of intelligent leaf wetness monitoring systems and explores their broader implications for precision agriculture. Overall, this paper demonstrates how cutting-edge materials and digital intelligence are coming together to reshape the future of precision agriculture.

Keywords: Agriculture Sensor, Precision Farming, Nanomaterials, Graphene.

ICO021

PERFORMANCE ENHANCEMENT OF β-Ga_2O_3 NRs/p-GaN MSM UV PHOTODETECTOR VIA THERMAL ANNEALING

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ABSTRACT – Wide bandgap semiconductors such as gallium oxide (Ga_2O_3) have garnered significant attention due to their exceptional properties, particularly for ultraviolet (UV) detection applications. In this study, we report the fabrication of metal-semiconductor-metal (MSM) UV photodetectors based on β-Ga_2O_3 NRs grown on a p-type gallium nitride (p-GaN) via a simple hydrothermal method. The synthesis was conducted at a growth temperature of 150 ºC for 7 hours. The impact of the thermal treatment on the device performance was investigated by comparing as-grown and annealed samples. The annealed MSM pt/β-Ga_2O_3 NRs/p-GaN/pt UV-PD exhibited a significant performance metric enhancement compared to their as-grown device. Field emission scanning electron microscopy (FESEM), energy dispersive X-ray (EDX), atomic force microscopy (AFM), X-ray diffraction (XRD), ultraviolet visible spectrometer (UV-VIS), current-voltage (I-V), and current-time (I-t) were employed to characterise the surface morphology, thickness, atomic percentage of elements, surface topography, structural optical and electrical analysis of the studied β-Ga_2O_3 NRs/p-GaN/sapphire substrate, respectively.

Keywords: β-Ga_2O_3 Nanorods, Wide Bandgap, Semiconductor, UV Photodetector, Metal-Semiconductor-Metal (MSM).

PARALLEL SESSION 4A

ICO018

ENHANCEMENT OF GALLIUM NITRIDE ON SILICON (111) USING PULSE ATOMIC-LAYER EPITAXY (PALE) AlN WITH COMPOSITION-GRADED AlGaN BUFFER

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ABSTRACT – This study investigates how varying aluminum composition (20%, 40%, 60%, 80%) in AlGaN influences the properties of GaN-on-Si heterostructure. Firstly, $Al_xGa_{1-x}N$ (x = 0.2–0.8) buffer layers will be grown on AlN/Si(111) substrates and characterized using photoluminescence (PL) mapping, X-ray reflectivity (XRR), Field Emission Scanning Electron Microscopy (FESEM) to assess Al composition accuracy, accurate thickness. Then, 2 sets of epitaxial growth were performed, 1st set was without GaN uppermost layer, 2nd set was with GaN uppermost layer (550 nm). The 1st set was then characterized using X-Ray Rocking Curve, Phase Analysis, Reciprocal Space Mapping (RSM) and Atomic Force Microscope (AFM) to determine the threading dislocations, strain state and surface roughness. Subsequently, for the 2nd set, it was fabricated using E-Beam Evaporation where Ti/Al/Ni/Au were deposited on the structure and Rapid Thermal Annealing were performed for Hall Effect measurement. This study clarified the impact of aluminum composition in AlGaN acting as the buffer layer on the structural and electronic properties of GaN-on-Si devices, providing valuable insights for optimizing buffer layer design in power electronics applications.

Keywords: AlGaN, E-Beam Evaporation, Rapid Thermal Annealing, Hall Effect Measurement.

ICO022

INFLUENCE OF PECVD PROCESS PARAMETERS ON THE SURFACE MORPHOLOGY AND WETTABILITY OF SILICON NITRIDE FILMS

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ABSTRACT – This research investigates the influence of process parameters in Plasma-Enhanced Chemical Vapor Deposition (PECVD) on the surface properties of Silicon Nitride films. Through an existing production chamber setup, key variables including Silane, Ammonia, Inert Gas flow, Electrode spacing, RF power, and chamber pressure, were systematically varied to examine their influence on the film surface structure. Surface characterisation focused on two key parameters, surface roughness and wettability, which were analysed via Atomic Force Microscopy (AFM) and assessed through contact angle measurements, respectively. The results reveal that surface roughness, ranging from 0.331 nm to 1.417 nm, is closely associated with the optical properties of the film and is significantly influenced by electrode spacing and chamber pressure, as confirmed through the Design of Experiments (DOE) analysis. Surface wettability, with contact angles ranging from 8° to 15°, was predominantly affected by electrode spacing, while other process parameters had a minimal impact on both roughness and wettability. Further surface chemical analysis using X-ray Photoelectron Spectroscopy (XPS) is recommended to elucidate the molecular bonding mechanisms underlying the observed trends.

Keywords: PECVD, Silicon Nitride, Surface Roughness, Contact Angle, Wettability.

ICO015

INVESTIGATION ON 2D LEAD-FREE $Cs_3Sb_2Cl_xI_{9-x}$ PEROVSKITE THIN FILMS ON PLANAR AND BLACK SILICON

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ABSTRACT – Silicon (Si) solar cells dominate photovoltaic (PV) industry due to their high efficiency and proven reliability. However, their limited absorption in the visible wavelength region restricts their performance. While black silicon (b-Si) reduces broadband reflection and enhances light absorption within 300-1200 nm wavelength region, it does not fully address the Si's fundamental limitation. Tandem solar cell configuration which integrates wide-bandgap perovskites on Si enables efficient PV conversion of broader solar spectrum. Among the perovskite materials, two-dimensional (2D) lead-free halide perovskites, particularly $Cs_3Sb_2Cl_xI_{9-x}$, offer advantages including tunable bandgap, strong visible light absorption, high stability and low toxicity. In this study, we investigated the integration of 2D $Cs_3Sb_2Cl_xI_{9-x}$ films on planar Si (p-Si) and b-Si substrates. B-Si was fabricated using aluminium-assisted chemical etching (AACE) process, while perovskite films were deposited via a one-step spin-coating method coupled with SbI_3 vapor post-annealing. Structural, surface morphological and optical characterizations confirmed high crystallinity, dense morphology, and pinhole-free $Cs_3Sb_2Cl_xI_{9-x}$ thin films with well-defined grains on both substrates. The films on the b-Si exhibited suppressed broadband reflection and demonstrated enhanced light-trapping when compared to the p-Si. The combination of the 2D $Cs_3Sb_2Cl_xI_{9-x}$ films on the b-Si highlights their potential towards high-efficiency lead-free perovskite-Si tandem solar cells.

Keywords: Lead-Free, Perovskites, $Cs_3Sb_2Cl_xI_{9-x}$, Black Silicon, Tandem Solar Cells.

PARALLEL SESSION 4B

ICO039

COLORIMETRIC VARIABILITY ANALYSIS OF POST-HARVEST HARUM MANIS MANGOES USING TRISTIMULUS MEASUREMENT

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ABSTRACT – Ripening and storage conditions can influence the optical properties of fruit surfaces, which are critical parameters for non-destructive quality evaluation. Unlike many tropical fruits, *Harum Manis* mangoes exhibit minimal spectral and colorimetric variation during ripening, posing a challenge for conventional visual assessment. In this work, surface color parameters L, a, and b were quantitatively measured using a handheld tristimulus colorimeter at two time points. The dataset was analyzed using multiple visualization techniques: box plots to assess distribution spread, Gaussian (bell) curves to characterize statistical variance, and 3D Euclidean distance plots to compute overall colorimetric displacement in (L,a,b) space. Significant parameter shifts were detected between acquisition dates and between opposing fruit surfaces, indicating spatially non-uniform optical changes during ripening. The results demonstrate the applicability of quantitative colorimetry and multivariate visualization in detecting subtle surface changes in low-contrast produce, enabling more objective post-harvest quality evaluation.

Keywords: Colorimetry, CIELab, Harum Manis Mango.

ICO016

OPTIMISATION OF LASER SOLDERING PARAMETERS IN PTH ASSEMBLIES: EFFECT OF LEAD ANGLE, PAD DESIGN, AND SAC ALLOY TYPE

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ABSTRACT – Laser soldering is a highly precise and efficient method for assembling electronic components, particularly pin-through-hole (PTH) capacitors on printed circuit boards (PCBs). This research investigates the effects of three critical parameters: lead angle, pad design, and solder alloy type on the quality of solder joints formed using laser soldering. Using a combination of validated numerical simulations via ANSYS Fluent, Taguchi-based design of experiments (DoE), and selected experimental benchmarks, the study quantifies solder joint characteristics such as void ratio, filling time, and wetting performance. The results indicate that lead angle has the most significant influence on joint quality, followed by solder alloy type and pad design. An optimal combination of 84° lead angle, circular pad design, and SAC396 alloy delivers the best performance, achieving low void formation and fast filling time. These findings provide practical guidance for optimising laser soldering processes in high-density electronic assembly.

Keywords: Laser Soldering, Pin-Through-Hole (PTH), Lead Angle, Pad Design & SAC Alloy.

ICO038

pH MEASUREMENT IN HARUM MANIS MANGO USING AN 18-CHANNEL MULTISPECTRAL REFLECTANCE SENSOR

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ABSTRACT – This research evaluates the performance of the AMS AS7265x 18-channel multispectral sensor for reflectance spectroscopy, with the QE65000 spectrometer serving as a reference standard. The study specifically examines the sensor's capability to generate reflectance profiles and its effectiveness in determining Harum Manis mango pH levels through spectral analysis. Comparative fruit surface reflectance patterns between both instruments showed that while the AS7265x could capture the overall spectral curve shape in the visible range, its reduced spectral resolution and susceptibility to glare effects, particularly on glossy, curved fruit surfaces produced less precise and noisier data compared to the QE65000. PLSR modeling of the spectral data for pH prediction revealed that the AS7265x's full 18-wavelength model achieved an R-value of 0.72 with a pH RMSE of 0.49, whereas the QE65000's identical wavelength set performed better (R=0.82, RMSE=0.42). Subsequent optimization through wavelength selection and NIR range analysis enhanced prediction accuracy, highlighting the significance of NIR bands in acidity assessment. Despite its current limitations, with improvement in optical alignment between the light source and the sensor, the AS7265x certainly will emerges as a promising, cost-effective portable solution for fundamental reflectance measurements, with potential for enhancement in agricultural quality monitoring applications.

Keywords: Reflectance Spectroscopy, Spectral Sensor, pH, Harum Manis Mango.

PARALLEL SESSION 5A

ICO025

PRELIMINARY STUDY OF DISSOLUTION OF RECYCLED TEXTILE USING DIMETHYL SULFOXIDE: EFFECTS OF TEMPERATURE

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ABSTRACT – The global textile industry had produce over 124 million tonnes waste generation of textile annually, raising the urgent environmental and resource sustainability concerns. Among various textile recycling strategies, chemical recycling has come out as a promising approach, particularly for blended fabrics that are incompatible with conventional mechanical recycling. Cotton-polyester blends represent a dominant composition in global textile consumption, yet their recycling remains technically challenging due to the heterogeneous nature of the fibers. The intrinsic structural disparity between hydrophilic cotton and hydrophobic polyester complicates their simultaneous dissolution and separation. Dimethyl Sulfoxide (DMSO) is a versatile and relatively green solvent that offers potential advantages in terms of solubility control, reduced environmental impact, and scalability. This preliminary study the influence of a single time dependent variable which are temperature (50, 100, 150℃) and contact time (1, 4, 8, 12 hours) on the dissolution behavior of decolorized 100% cotton and 100% polyester in pure DMSO. Results showed that both recycled textiles having a maximum dissolution at 150℃. Cotton achieved the highest dissolution rate of 60.00% at 150℃ for 12 Hours, attributed to its polar nature and strong interaction with DMSO. Meanwhile, polyester exhibited limited solubility, with a maximum dissolution rate of 5.33% for 4 Hours, due to its hydrophobicity and lack of polar functional groups. Viscometry was performed to assess the rheological behavior of the dissolved polymer solutions. However, due to the small quantity of solubilized material and the resulting low solution viscosity, the instrument registered minimal or unstable readings. The SEM images show the transition from a smooth to a rough, porous morphology in both cotton and polyester, supporting the observed dissolution behavior. Meanwhile, DSC results further validated the reduction in thermal stability for cotton, indicating effective solvent-polymer interaction, whereas polyester exhibited negligible thermal shifts, confirming its resistance to DMSO dissolution.

Keywords: Dissolution, DMSO, Cotton, Polyester, Recycle Textile.

PARALLEL SESSION 5B

ICO014

ENHANCED THERMAL MANAGEMENT: COPPER- AND SILVER-COATED HEAT SPREADERS ON ALUMINUM NITRIDE/SILICON WAFERS

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ABSTRACT – Different materials and stacked wafer layers can accumulate heat during operation, which must be dissipated efficiently to avoid thermal failure. As efforts to enhance heat dissipation progress, we investigated the impact of silver (Ag) and copper (Cu) coating layers on heat spreader performance for aluminum nitride/silicon (AlN/Si) wafers. AlN on Si wafers is widely used in high-frequency electronics, microelectromechanical systems, optoelectronics, and high-power applications. In this study, the top and bottom of the AlN/Si wafer were coated separately with two different thicknesses of Ag and Cu, which are 350 nm and 1000 nm. The heater, FLIR camera, and FLIR software were used as tools to analyze five thermal points at different positions, namely Sp1 to Sp5, for each sample. For reference, when the heater was set at 150 °C, the bare AlN/Si wafer showed a high-temperature distribution exceeding 90 °C at five thermal points. Regardless of the type of metal used, the coatings on the top AlN/Si showed a significant temperature drop compared to those on the bottom, which was approximately half the drop. Comparing Ag and Cu as the top coating, Ag with a 350 nm thickness (A-350T) demonstrates the best heat dissipation, with the lowest temperature drop. The good results are followed by A-1000T, C-350T, and C-1000T, which show that thicker top coatings do not enhance heat dissipation. Meanwhile, the results are opposite when the bottom of the AlN/Si coated, where Cu at 350 nm (C-350B) provides the best heat spreader. The other three samples, which had approximately the same results as each other, showed a slight temperature decrease compared to AlN/Si. In conclusion, the Ag with higher thermal

conductivity results in the best heat dissipation at the top coating layer, allowing heat to spread more significantly through the AlN/Si wafer.

Keywords: Thermal Management, Heat Spreader, AlN/Si Wafer, Silver-Coated, Copper-Coated.

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