

# NEWSLETTER

January – June 2023 ISSUE NO.41





## Asia Nanotechnology Leaders

Shaping the Future of Science & Technology for Socio-Economic Well-Being

#### Asia Nano Forum (ANF)

is a **network organization**, founded in May 2004 and now a registered society in Singapore, known as Asia Nano Forum Society, since October 2007.

#### **ANF** mission

To promote responsible development of nanotechnology that educationally, socially, environmentally, and economically benefits each economy by fostering international network collaboration.

#### **ANF** objectives

- Foster nanotechnology in the region by creating mechanisms to share information, human and physical resources, and expertise
- Support regional economic and environmental development through joint projects addressing major regional issues, with an emphasis on support of developing and emerging economies
- Coordinate joint investment in and mutual access to major infrastructure by member economies
- Promote and coordinate standardization and safety of nanotechnology concepts and measurements
- Act as an advocacy group for nanotechnology in the region and for adequate regional representation of nanotechnology at global forums
- Initiate, promote, and manage cooperative scientific and technology research projects within the member economies
- Enhance public awareness and education of nanotechnology and associated social, environmental, health and economic issues

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## **Overview**

In our continuous commitment to promote nanotechnology among peers and having the challenges of the ongoing global pandemic, the Asia Nano Forum (ANF) has remained steadfast in fostering collaboration and partnerships in the field of nanotechnology. As we embark on the year 2023, we are excited to share with you an overview of our activities during the first half of the year which consists of the ANF ExCo Meeting and ANF Workshop on Commercialization on 1 February 2023, ANF Symposium on User-Facility Network in Asia on 2 February 2023, and the 6<sup>th</sup> EU-Asia Dialogue on Nanosafety on 21 June 2023. All activities were held on-site.

In this September issue, we take great pleasure in showcasing the prevailing trends and dynamic activities within the realm of advanced nanotechnology, as contributed by the member economies of the Asia Nano Forum (ANF). Our sincere appreciation goes to the esteemed ANF members for their invaluable support in generously sharing the latest updates and insights for this newsletter.

As we reflected on our activities during the first half of 2023, we remained deeply grateful for the unwavering support of our members and partners. The dedication of our ANF Office Bearers, including Vice Presidents (Dr. Rezal Khairi Ahmad and Dr. Annabelle V. Briones), Secretaries (Dr. Jason Chang, and Dr. Pavadee Aungkavattana), and Treasurer (Dr. Shuhei Numazawa), have been instrumental in keeping ANF on track for 2 years.

With kind continued support and collaboration from every sector, we are confident that we can expand our networks and achieve significant advancements in the development of nanotechnology. We eagerly anticipate the opportunity to meet and collaborate further during the upcoming ANF Summit. Until then, I extend my best wishes to you all and hope that you remain safe and well.

Wannee Chinsirikul
President,
Asia Nano Forum



# **Activities from IRAN**



### **Activities from Member Countries**

IRAN

## 1. A Solution for Construction of a New Generation of Silicon Nanostructure Anodes in Lithium Batteries

A faculty member of Sharif University of Technology in cooperation with a group of researchers from Shanghai University succeeded in introducing a hybrid structure of carbon nanotubes and silicon nanoparticles as the anode of a lithium battery.



Dr. Esfandiar, assistant professor of the Faculty of Physics, Sharif University of Technology, in cooperation with a group of international researchers, indicated by laboratory and numerical simulation that suitable functional groups on carbon nanotubes cause better contact with surface of silicon nanoparticles.

The huge volume change and unstable interface of the silicon anode usually result in the fracture of the active material and the disconnection with conducting current collector, which would highly hinder the application of silicon in powering battery. Thus, developing a stable interface with good mechanical stability to tolerate huge volume change of the silicon, and keep the robust adhesive property is one of the effective methods.

In their publication, a molecular zipper fastened strategy is designed to provide a dynamic stable interface for fast transportation of both ions and electrons, which can also provide a destroy-rebuilt interface for silicon. Through crosslinking of the binary polymer and lithiated nafion (Linafion), the dynamic stable interface was constructed between nano-silicon and carbon nanotubes, leading to long cycling stability at room/freezing temperature as well as high-rate performance. Finite element simulation results also confirm that the uniform electric distributed interface was constructed. The line contact model could minimize the stress caused by deformation during the fast lithiation/delithiation process. This approach offers an effective strategy for the next-generation high capacity, high rate, long lifespan and wide climate range ion battery.

The results of their research were published in Energy Storage Materials entitled "Dynamic stable interface between CNT and nano-silicon for robust anode with large capacity and high rate performance."



## 2. Investigation of Fluorinated Metal-organic Frameworks for Gas Separation by Iranian Researchers

Iranian researchers from Arak University in collaboration with Spanish and American universities, published an article on the effects of fluorinated metal-organic frameworks for gas separation in the journal of "Chemical Society Reviews".

Fluorinated metal—organic frameworks (F-MOFs) have revolutionized the field of gas separation because of their tunable pore apertures, chemical features, as well as excellent stability. A deep understanding of their structure—performance relationships is critical for the synthesis and development of new F-MOFs. This critical review has focused on several strategies for the precise design and synthesis of new F-MOFs with structures tuned for specific gas separation purposes. First, the basic principles and concepts of F-MOFs as well as their structure, synthesis and modification and their structure to property relationships are studied. Then, applications of F-MOFs in adsorption and membrane gas separation are discussed. A detailed account of the design and capabilities of F-MOFs for the absorption of various gases and the governing principles is provided this article. Also, surprising features of stable F-MOFs with engineered pore size and structures are considered to develop selective membranes. Analysis of the position of F-MOFs in gas separation indicated that F-MOFs are good candidates for most of the challenging gas separations.

The future of the science and engineering of F-MOFs and their challenges are also mentioned to tackle the issues of overcoming the trade-off between capacity/permeability and selectivity for a serious move towards industrialization. This research group includes Dr. Ebadi and Dr. Sanaeepour (faculty members of chemical engineering department of Arak University), as well as Rafael Luque, Hermenegildo Garcia, and Banglin Chen from Spanish and American universities. This article was published in Chemical Society Reviews.

#### 3. A Research on Obtaining Hydrogen from Persian Gulf Seawater

A research group including Iranian, Chinese and Italian researchers introduced a highly efficient electrocatalyst for electrochemical reaction of hydrogen production from sea water.



The limitations of common energy sources, such as oil and natural gas have increased the demand for clean energy sources. Hydrogen is a good candidate for a high-density energy carrier. Among various strategies for producing hydrogen, electrochemical water electrolysis



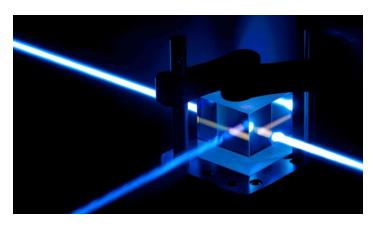
powered by electricity produced from renewable sources is noteworthy. Seawater electrolysis has several key advantages over freshwater electrolysis. These advantages include seawater's abundance, ease of integration with emerging ocean technologies, collaboration in the production of safe drinking water, and the ability of its dissolved salts for promoting the ionic conductivity. For seawater electrolysis to be an efficient and economical method of hydrogen production, highly active electrocatalysts made of non-precious metals are required for hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER).

Hydrogen production employing seawater electrolysis is considered as a sustainable strategy for energy prospects. This study reported high-performance bifunctional water electrocatalyst by designing 3-D heterostructured MnCo/NiSe/NF. DFT based modeling rationalized their experiments and indicated the synergistic effects between MnCo and NiSe in their complex.

This project was conducted as a result of an international joint collaboration of researchers from Tarbiat Modares and Ferdowsi Universities (Iran), Southwest Jiaotong University (China), and Padova University (Italy). This research article was published in "Applied Catalysis B: Environmental" in Elsevier Publications in December 2022.

#### 4. New Generation of Nanophotonic Oxygen Sensors

Researchers from Kharazmi University successfully developed a new generation of nanophotonic oxygen sensors using a type of nanoemitter.



Nanophotonic biosensors capable of being excited in the NIR spectrum have applications in various sectors. In the research which was conducted by researchers from Kharazmi university, a 980 nm-excitable nanophotonic sensor for real-time oxygen detection in both water and air by analyzing the photoluminescence lifetime and intensity using a nanocomposite of lanthanide-doped NaYF4:Yb3+,Tm3+ upconversion nanoparticles and a PtTFPP platinum porphyrin complex in a polystyrene matrix was developed. Acceptable overlap between the emission of the upconversion nanoparticles and the excitation band of the PtTFPP guarantees 68% efficient excitation of the PtTFPP molecules with a 980 nm NIR laser. For the first time, the oxygen sensitivity of the upconversion nanoparticles alone was reported, and it was demonstrated that the PL lifetime-based sensitivity slope was boosted more than 10 times by adding PtTFPP oxygen-sensitive molecules due to the energy transfer from the upconversion nano-emitters. "The functionality of the upconversion-based sensor was investigated by analyzing its sensitivity, stability, reversibility, and temperature-dependent lifetime in both water and air, and



its performance was compared with that of the sensor exposed to direct excitation at 410 nm" Dr. Heidari, faculty member of Kharazmi University said, "more importantly, the sensor was implanted under the skin of a chicken, and it was demonstrated that the PL intensity was amplified more than 12 times by employing the 980 nm excitation laser instead of 410 nm laser light." Therefore, excellent emission of the sensor under the skin paves the way for the development of implantable oxygen sensor platforms.

This research was carried out in the laboratory of nanophotonic and optofluidic sensors of the Physics Department of Kharazmi University. Javad Amir Ahmadi, M.Sc. student of Kharazmi University, and faculty members of this university including Dr. Heidari and Dr. Majlesara, conducted this research in a collaboration with researchers from universities of Glasgow, Scotland and Jiliang, China. The results of this collaboration were published in an article entitled "Dual mode nanophotonic upconversion oxygen sensors" in Nanoscale magazine.

#### 5. Winter Issue of Nanomedicine Journal Published

NANOMEDICINE JOURNAL, a peer-reviewed quarterly publication by the Nanotechnology Research Center of Mashhad University of Medical Sciences published its winter issue in January 2023.



NANOMEDICINE JOURNAL (NMJ), Abbreviated as NANOMED J, is a LIBRE open access peer-reviewed quarterly publication by the Nanotechnology Research Center of Mashhad University of Medical Sciences (MUMS). Authorized by the Iranian Ministry of Science, Research and Technology as a scientific-research publication, NMJ publishes original research papers, review articles, short communications as well as letters to the editor on empirical and laboratory results, preclinical studies and clinical trials related to the applications of nanotechnology to medical sciences.

#### 6. ISC23 Event Will Be Held in Cooperation with K.N. Toosi University of Technology

Afyon Kocatepe University in cooperation with Iranian K.N. Toosi University of Technology and a number of Turkish scientific research centers held the ISC23 International Event on 4-6 September 2023, in Istanbul, Turkiye.





The third International Symposium on Characterization (ISC23) is organized by academics and researchers from different scientific areas of K.N. Toosi University of Technology, the University of Afyon Kocatepe, University of Giresun, NED University of Engineering and Technology, Sabancı University Nanotechnology Research and Application Center (SUNUM) and TUBİTAK Marmara Research Center.

This event aims to create an international forum for academics, researchers and scientists to discuss various issues related to Applied Life Sciences, Medical, Chemistry, Earth and Environmental Sciences, Engineering, Materials Science and Physics. It fosters sound scientific discovery to solve challenges.

In this symposium, an exhibition will also be considered for companies and institutions to present their products, services, and innovations.

#### 7. Considerable Energy Saving Using Nanotechnology-based Insulators.

Sazeh Paidar Elahieh Company successfully produces nanotechnology-based insulators which can reduce energy consumption of heating & utility rooms of building by half.



An Iranian company has successfully produced and marketed an insulator. This product can be used in various construction and industrial projects.

Elastomeric nanocomposite insulators are based on polymers including Nitrile Butadiene Rubber/Polyvinyl Chloride (NBR/PVC) and they are foam-like elastomeric insulators. Sazeh Paidar Elahieh Company utilizes nanotechnology to improve significant properties of the insulator. The



insulator can be used in utility rooms of major buildings, towers, factories, hotels, hospitals, petrochemicals, and refineries. Addition of nanoparticles to insulators leads to improvement of their mechanical properties.

These sound and thermal insulators can reduce energy consumption of utility rooms to a large extent. Thus, optimized values would be obtained for energy consumption. They are a considerably suitable choice for insulating heating and cooling pipes, channels, air conditioning systems, and utility rooms.

Standard tests were conducted on closed cell elastomeric nanocomposite foam produced by this company. Also, the results were compared with the ones obtained from simple closed cell elastomeric insulator. The comparison indicated that the nanotechnology-based product does not provide a suitable environment for growth and reproduction of microorganisms. Also, thermal conductivity coefficient is less than those of glass and wool. Closed-cell elastomeric nanocomposite foam has significantly high resistance coefficient against vapor penetration, which is higher than mineral wool insulator. Therefore, it can perform more efficiently for corrosion inhibition of insulated metal surface.

#### 8. Development of A Nanotechnology-based Thermal Belt by An Iranian Company

RTP Company released a flexible nanotechnology-based thermal belt that starts heating quickly after connecting to a power bank.



An Iranian company produces heating sheets with nanometric coatings for various applications. As an example, the bathroom mirror heating sheet prevents the formation of steam on mirrors with nanometric coatings. The flexible heating belt can be used in various applications including medicine, personal care, etc.

The raw materials of this heater contain nanoparticles that can control the temperature without necessarily using other controllers. The company's thermal belt is hypoallergenic and washable. This product is flexible due to the absence of wire elements. It can be used for more than 5 hours using a 10,000-mA standard power bank.



### 9. Training of trainers (TOT) event in Philippine

Iranian scientists provided a one-month length training program for academics in two Philippine universities.

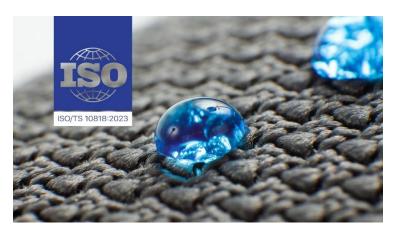
The Training of Trainers (TOT) program in the field of Nanotechnology and Nanomaterials for academic staff of the Philippines was held on 26 June to 10 August (a one-month intensive program) via the online lecturer series and specialized hands-on sessions. The practical part was held at the Materials Science Division, Industrial Technology Development Institute, DOST Compound, Manilla, Philippines.

This program focuses on enhancing the academic faculty members' understanding of the principles, applications, and potential impacts of Nanotechnology and Nanomaterials. Through a combination of lectures, workshops, and hands-on training, participants were equipped with a comprehensive understanding of the latest advancements in this field.



### 10. The 11th Iranian-led International Nanotechnology Standard was published

An international standard in the field of nanotechnology was developed under the leadership of Iran, titled "Nanotechnologies — Textiles containing nanomaterials and nanostructures — Superhydrophobic characteristics and durability assessment". This standard (ISO/TS 10818:2023), has been developed by a specialized group including experts from industry, university and laboratories with the support of Iran Nanotechnology Innovation Council.





One of the main obstacles affecting the growth of the market for water-repellent textiles containing nanomaterials is their durability in different environmental and usage conditions. From a consumer perspective, the durability of water-repellent and superhydrophobic textiles is of utmost importance. If the superhydrophobic properties are not durable, they will lose their efficacy in long-term applications. Generally, there has been no international standard method for assessing the durability of superhydrophobic textiles and classifying these properties.

The international standard ISO/TS 10818:2023 assesses the properties, performance, and durability of nano-enhanced textiles based on usage conditions (washing, drying, ironing, exposure to light sources, and mechanical abrasion). Superhydrophobic textiles are significant due to their applications for protective clothing, in healthcare, and different industries.



# **Activities from JAPAN**



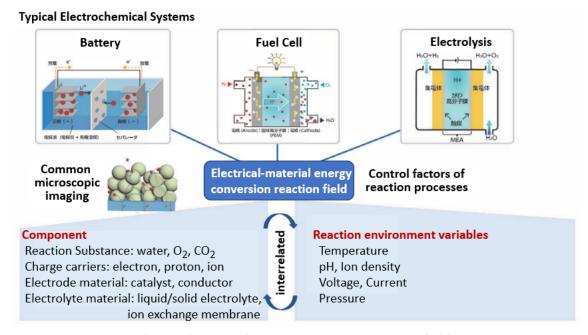
### **Activities from Member Countries**

JAPAN

### Strategic Proposals on Materials/Nanotechnology in CRDS of JST

Since its establishment in 2003, the Center for Research and Development Strategy (CRDS) who is an affiliated institution of Japan Science and Technology Agency (JST) has made a significant contribution nationally as a public think tank by independently carrying out the investigation and analysis and by making proposals on science, technology, and innovation policy and/or research and development strategy. CRDS issues Strategic Proposals in the field of Materials and Nanotechnology every year, which are utilized by the Japanese government for consideration as potential national projects. In 2023, two Strategic Proposals titled "Innovation in the electricity-material energy conversion technology" and "Material development strategy towards innovations in semiconductor devices" were issued. Those executive summaries are provided below. (Available in Japanese Language at https://www.jst.go.jp/crds/report/by-category/03/index.html).

1. Innovation in Electricity-Material Energy Conversion Technologies, -Realization of diverse reaction fields towards massive adoption of renewable energies- (CRDS-FY2022-SP-09, issued in March 2023)



Electrical-material energy conversion reaction field

This proposal discusses how to innovate "electricity-material energy conversion technologies" that can generate, convert, and store electrical energy using interconversion with material energy. The sophistication and diversification of this technology will solve the problems of supply-demand gap due to spatio-temporal variability and localization of suitable locations for renewable energy, and lead to the effective use of renewable energy. The massive adoption of renewable energy will require the massive deployment of devices that enable efficient electrical-material energy conversion, such as storage batteries, fuel cells, and electrolysis. In this proposal,



we focus on the reaction field that governs device characteristics and suggest directions for the development of materials and devices that realize a wider operating environment as an energy infrastructure and a more ideal reaction environment in terms of energy efficiency and reaction rate. Here, we introduce the concept of "electrical-material energy conversion reaction field". This represents the controlling factors that govern device characteristics, including not only the components such as reaction substances, charge carriers (electrons and ions), electrode materials, and electrolyte materials, but also the reaction environment variables such as temperature, pH, and voltage. By establishing a cross-device science of reaction fields, it is expected to accelerate the creation of new technologies for electrochemical materials and devices. We propose the following strategies:

- 1) Promotion of R&D projects that contribute to the circulation of knowledge among researchers in different fields
- 2) Development of research infrastructure to encourage new entrants from different fields
- 3) Promotion of materials and device development using informatics and establishment of R&D eco-system

In order to realize a carbon-neutral society, renewable energies with low environmental impact must be introduced in large quantities as an alternative energy source to fossil resources. Renewable energies have the disadvantages of mismatches between supply and demand due to their time difference and the suitable geographical difference for supply and utilization. To overcome these problems, electrical energy storage systems and the conversion of renewable energy into material energy as energy carriers have to be introduced on a large scale. However, simple implementation of existing technologies is far from enough to realize these requirements. For example, electrochemical systems such as energy storage batteries, hydrogen fuel cells, and water electrolysis (hydrogen production) often require the use of scarce natural resources when operated in the reaction environments currently in use. It raises concerns about natural resource constraints. To address this problem, it is desirable to make a reaction environment milder and more resource-efficient, and the creation of innovative material and device technologies is inevitable for this end. In addition, from the perspective of massive adoption of renewable energy, a technical requirement is raised for materials and devices that can absorb sudden environmental changes as infrastructure to follow the variability of renewable energy.

Requirements to expand the reaction field are raised in the electrochemical devices to solve the natural resource constraint issues and to meet increasing system demands. For a long time, research and development of electrochemical devices has progressed by increasing the functionality and sophistication of individual devices, but such a conventional approach is becoming less effective, and new ideas to control electrochemical reactions are desired. For example, in high-speed water electrolysis and fuel cells, it is known that the bubbles generated by electrodes determine the performance, but even in such systems, no methodology has been established to understand the complex reaction field from material conversion to mass transfer. We propose to establish a cross-device science for those common technical issues and to promote the creation of new methods for material design and the integration of technologies accumulated in each device. Specifically, the following four R&D approaches should be addressed.



# (1) Development of fundamental science for a cross-sectional understanding of the electricity/material-energy conversion reaction field

Electrochemical devices contain many common factors even among devices with different purposes. Currently, materials and devices are being developed that are specialized and subdivided into individual systems. By constructing a science of the reaction field across devices, it is expected to create material design concepts that cross over between devices and to create new methods for materials and device development. Specifically, understanding of interfacial phenomena consisting of heterogeneous materials, understanding of material states placed in various environment of the reaction field (temperature, potential, pH), elucidation of electronic and ionic conduction mechanisms, and search for new conduction mechanisms, should be addressed. Understanding reaction fields confined to the nanoscale, such as near electrode surfaces with complex nanostructures, is essential for the advancement of electrochemical devices. It is also necessary to develop operando measurement techniques, first-principles calculations, multi-scale simulation methods, and data science methodologies to support the understanding of the reaction field. The methodologies constructed here will also contribute to the promotion of R&D in the following.

## (2) Development of materials that contribute to expanding the operating environment for electrochemical devices.

Research and development of new materials that realize a completely different operating environment from that of conventional devices or that are adaptable to a wider range of operating environments than conventional devices is required. Another challenge is to control not only electrochemical properties but also mechanical properties, typically as in the case of all solid-state batteries.

#### (3) Creation of innovative electrochemical devices using novel materials

The realization of a carbon-neutral society requires large-scale deployment of electrochemical devices and their capabilities to respond to diversification of application areas. Energy applications using energy storage and electrolysis devices with low natural resource constraints, electrolytic synthesis of chemical products using CO<sub>2</sub>, alcohol synthesis for applications in the chemical and food products, and development in emerging areas such as materials production like steel and cement, are also expected.

#### (4) Development of electrochemical materials and device informatics

With the diversification of electrochemical devices in the future, it will be necessary to establish technologies to optimize materials, device structures, and operating parameters as early as possible for each application. The electrical-material energy conversion process has a very high degree of freedom in terms of components such as reaction substances/carriers, electrode materials, and electrolyte materials. Informatics approach is effective for rapid research and development of materials and device structures with such a complex reaction field.

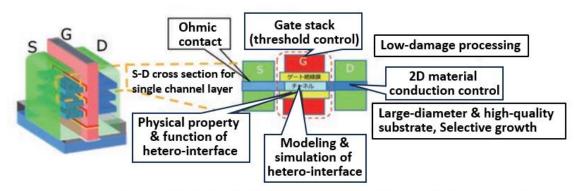
In the short term, data-driven materials development method (materials informatics) for electrochemical materials by utilizing large-scale data obtained through high-throughput calculations, high-throughput experiments, and advanced measurements should be established. In the mid- to long-



term, it is desirable to develop device informatics method, in which the combination of heterogeneous materials and device design are conducted by utilizing big data, with the aid of the cross-device science obtained in the research approach shown in 1. For this purpose, it is necessary to make more data accumulation and utilization possible, and to construct a cross-device data utilization method for heterogeneous materials and devices.

The following promotion measures are proposed to effectively address the above R&D issues. Promote projects that address the pursuit of fundamental science across devices, materials exploration, and device development, and encourage new entrants from different fields. Strengthen the research support system to facilitate proof-of-concept of innovative materials and devices and establishment of standard evaluation technologies as an approach to lower the barriers to entry for newcomers from different fields. It is also necessary to establish a research center for the electrochemical material and device informatics method, and to establish a consortium to promote social implementation of innovative electrochemical devices.

# 2. Material Development Strategy Towards Innovations in Semiconductor Devices, -Utilization of 2D materials as semiconductor channels- (CRDS-FY2022-SP-06, issued in March 2023)



Major R&D tasks for fabrication of transistors with 2D materials

The proposal, entitled "Material Development Strategy Toward Innovations in Semiconductor Devices -Utilization of Two-Dimensional Materials as Semiconductor Channels-, is a research and development strategy designed to develop fundamental technologies required to use twodimensional materials, such as the evaluation of interfacial characteristics with different types of materials, thin film formation of two-dimensional materials at wafer-scale, device structure production and integration, in preparation for the next generation of semiconductors in which transistor channel materials and manufacturing processes are expected to change dramatically at the level of 1-nm feature size and below. In order to achieve higher performance and lower power consumption of semiconductor integrated circuits, innovations in transistor channel materials, which are the basic component of such circuits, as well as device structures are required in addition to device miniaturization. For this reason, we focus our attention on twodimensional materials that can form ultrathin channels of less than 5 nm and propose the promotion of research and development subjects on fundamental technologies such as thin film formation technology of two-dimensional materials at wafer-scale with 200mm or 300mm diameters, and evaluation technologies, where Japanese companies can leverage their strengths. To promote such research and development, we also propose measures for enhancing research and development programs, including funding programs that help develop shared facilities where



material and device researchers can collaborate closely, thin films made of two-dimensional materials at wafer-scale can be produced, and semiconductor device structures can be prototyped and evaluated for their characteristics and also help link industrial strategies to research and development strategies in the facility.

Semiconductor integrated circuits, which are important fundamental technologies that support the digitization of the society, are now expected to continue to achieve improved performance and lower power consumption based on miniaturization and enhanced integration in order to meet requirements such as higher speed and lower power consumption in computer operations and AI processing, higher speed, larger capacity and smaller delay in communications as well as higher sensitivity and lower power consumption in IoT devices. On the other hand, miniaturization technologies have already reached the level of 10 nm, which is very close to the limit of planar miniaturization, and it is becoming more difficult to improve performance based on the conventional two-dimensional miniaturization and enhanced integration. To overcome such an issue, it is necessary to reduce the effectively occupied area in wafers and chips by changing the structure of transistors, which are the basic component of circuits, from two-dimensional to three-dimensional. Lamination of transistor channels and vertical stacking of type-p and type-n transistors are believed to be important. The recent trend is the promotion of research and development of transistors in the Gate-All-Around (GAA) structure, using nanosheet channels made of silicon (Si) or silicon-germanium (SiGe). In a further generation, the use of twodimensional materials made of ultrathin nanosheets (5 nm or less), two-dimensional substances (e.g., transition metal dichalcogenide: TMDC) and multiple one-dimensional substances arranged in two dimensions (e.g., carbon nanotube: CNT) is expected to appear and research and development designed to examine such possibilities are increasing worldwide.

On the other hand, what has been recognized strongly in the midst of the recent decoupling of the world economy and a global shortage of semiconductors is the importance of securing a semiconductor supply chain and retaining semiconductor production facilities and production capabilities in one's own country in terms of economic security. While Japan is internationally in an advantageous position for its materials industry, and process and measurement equipment industries, the country does not have production technologies or production facilities for advanced high-performance semiconductor logic chips of the 40-nm generation and later. In the future, it will become increasingly important for computers, telecommunication, IoT, automobile and other industries to retain cutting-edge semiconductor technologies domestically. Currently, however, the Japanese domestic industry is in a rather difficult situation in its semiconductor business and largely behind its counterparts in Taiwan, Korea and other leading countries in terms of the research and development of advanced semiconductor devices in which twodimensional materials are strongly expected to be introduced. Since the generation in which channel materials and manufacturing processes change dramatically can also be seen as a great opportunity for the resurgence of the Japanese advanced semiconductor technology and industry, it is important for Japan to develop a successful research and development strategy on science and technology that is related to the use of transistor channels based on two-dimensional materials.

The academic research on two-dimensional materials conducted in Japan includes "Science of Atomic Layers" (2013-2017), a new academic field in Grants-in-Aid for Scientific Research (KAKENHI), and "Development of Atomic or Molecular Two-Dimensional Functional Films



and Creation of Fundamental Technologies for Their Applications" (2014-2021), and a JST CREST research. These research programs covered investigation from the characteristics and functionality of two-dimensional substances to device structure production, accumulated knowledge in thin film formation and characteristic control of two-dimensional materials, and identified issues on device development. Recently, Grant-in-Aid for Transformative Research Areas (A) "Science of 2.5 Dimensional Materials: Paradigm Shift of Materials Science Toward Future Social Innovation" (2021-2025) has been launched to research new physical properties, functions and other aspects of laminated two-dimensional substances. In coming years, it will be necessary to strategically promote, from a long-term perspective, the research and development of fundamental technologies such as thin film formation technology of two-dimensional materials, evaluation technology for interfacial characteristics, interfacial control technology and higher carrier mobility technology in order to apply them to new functional devices and integrated circuits.

The research and development issues that should be examined in the future include the identification and modeling of interfacial physical properties and functions of two-dimensional materials, high-quality thin film formation of two-dimensional materials at wafer-scale as well as device production and integration, which require various fundamental technologies as shown in the following.

#### (1) Identification and modeling of interfacial physical properties and functions of twodimensional materials

Although the physical properties of two-dimensional substances such as graphene and TMDC, multiple one-dimensional substances arranged in two-dimensions such as CNT, and ultrathin silicon of less than 5 nm have been mainly studied as two-dimensional materials for semiconductors, their physical properties and functions including the heterointerfaces with insulators, metals and other substances are not fully understood yet. For this reason, it is necessary to develop analysis and evaluation methods that can characterize the physical, chemical, stress, electrical and other characteristics of hetero-interfaces with two-dimensional materials and also develop models and theories that help understand the obtained measurement results. It is important to form highly functional and high-quality hetero-interfaces, based on these findings. It is also desirable to search new two-dimensional materials with new compositions and crystal structures that exhibit better characteristics.

#### (2) High-quality film formation at wafer-scale

In order to use two-dimensional materials in the channels of fine transistors for an integrated circuit, it becomes critical to develop the technology for forming a high-quality thin film made of two-dimensional materials with a large area on a silicon wafer. The thickness of the two-dimensional materials has to be controlled with an atomic layer precision over 200mm or 300 mm silicon wafers by using chemical vapor deposition (CVD) methods or spattering methods. It is also important to develop a method for transferring a high-quality crystal layer of two-dimensional materials produced on a different substrate onto a silicon wafer, while controlling the surface orientation.



#### (3) Device structure production and integration.

The transistors with the two-dimensional materials as semiconductor channels are expected to make possible devices that are difficult to produce with a conventional silicon technology, such as a transistor with an ultra-thin high-mobility channel, terahertz (THz) active devices, and sensors with molecular-level sensitivity. To this end, not only film formation and n/p doping technology of two-dimensional materials but also various process technologies, particularly gate stack structure and low-resistant ohmic contact formation technologies are highly required to be developed. It is also necessary to prototype new device structures using transistors with two-dimensional materials as semiconductor channels and verify their performance and functionality. Moreover, it is important to develop a device simulation technology that models characteristics specific to two-dimensional materials and characteristics of their hetero-interfaces in order to advance the design and integration of high-performance devices.

The efficient promotion of the above research and development efforts will need the establishment of new research and development programs. In addition to leveraging the knowledge obtained in past efforts and projects on two-dimensional materials to the maximum level, coordination and collaboration among different research fields such as material science, theoretical science, process science, data science, device physics and simulation should be promoted. The development of shared facilities where substrates can be produced with two-dimensional materials and devices can be prototyped and evaluated will be required. It is also desirable to develop a new community for device research using two-dimensional materials and promote collaboration between the academia and industry in device development projects. Furthermore, it is important to leverage Japan's technological strengths in materials, crystal growth and device fabrication to acquire the knowledge and technology of advanced semiconductor integration processes through enhanced collaboration with research institutions in overseas that have strengths in process technology and integration technology. Particularly interaction with young human resources in overseas organizations is desired to develop and train young semiconductor experts in Japan, with knowledge and skills ranging from materials to devices and processes.



# **Activities from KOREA**



## **Activities from Member Countries**

KOREA

#### Nano Young Challenge 2023

The 'Nano Young Challenge,' a competition focused on fostering the development of nanotechnology and nurturing the next generation researchers, has reached its 7<sup>th</sup> iteration this year since that was held first in 2017.

This aims to discover and reward those who present creative ideas with the potential for societal impact in various fields of nanotechnology, such as Nano-energy, environment, bio, manufacturing, devices, and information electronics for undergraduate and graduate students in Korea.

It is hosted and organized by the Ministry of Science and ICT and Korea Nanotechnology Research Society (KoNTRS) to facilitate the expansion of nanotechnology awareness by offering the high-quality participatory platform for to researchers in relevant fields. It encourages the exchange of excellent technologies, fosters young professionals, and promotes the advancement of nanotechnology.





From February to April, a total of 120 teams (9 individual teams, 111 groups) applied nationwide, reaffirming the competition's recognition. The expert committee reviewed the proposals, focusing on the feasibility of the ideas, technical difficulty, societal value creation, differentiation strategy and etc.

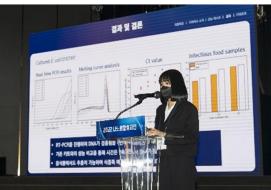
The first and second rounds of evaluation took place until June, resulting in the selection of 10 outstanding nanotechnology-based ideas, including wearable micro-vibration sensors, nanofilters of titanium dioxide zeolite, eco-friendly nanocellulose-based 3D printer materials, embedded hydrogel, and hybrid energy harvesting smart white canes, and etc.

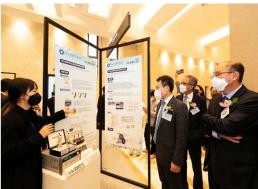
The chosen teams receive activity support funds, and they are given an opportunity to display their ideas at the Poster Session of the NANO KOREA 2023 Symposium in July. In September, the third round of evaluation will focus on the validation of prototype created based on the proposed ideas to determine the final winners.











KoNTRS plans to hold the Nano Young Challenge awards ceremony at the "2023 Korea Science and Technology Competition" to be held in November. The prestigious Minister of Science and ICT Award will be presented to the top winner at this ceremony.



# **Activities from MALAYSIA**



### **Activities from Member Countries**

## MALAYSIA

#### 1. Integrity, Governance, and Anti-Corruption Award (AIGA2022) - 17 JAN 2023

NanoMalaysia Berhad (NMB) received the Anugerah Gangsa at the Integrity, Governance, and Anti-Corruption Award (AIGA2022) under the work culture and practice of integrity in the workplace category.

The Integrity, Governance, and Anti-Corruption Award (AIGA2022) is an award handed out by Institut Integriti Malaysia (IIM) that recognises and appreciates the public and private sectors who show commitment to the culture and practice of integrity and best governance, as well as anti-corruption initiatives in their organisations.

AIGA2022 is also one of the benchmarking mechanisms for public and private organisations in cultivating integrity, best governance, and anti-corruption, especially in their organisations. In addition, it is also a space to discover the capabilities, capabilities, commitment, and seriousness of the private and public sectors in implementing the internal control system of integrity management and corruption prevention. A total of 110 government agencies and private companies participated in AIGA 2022.

The award was accepted by Dr. Rezal Khairi Ahmad, CEO of NanoMalaysia, during a ceremony at Institut Integrity Malaysia, Kuala Lumpur. The award follows the launch of NanoMalaysia's Organisational Anti-Corruption Plan (OACP) in February 2022. The OACP is designed as a guideline to management and employees towards ensuring an efficient, transparent, integrity, clean and implementable delivery system and service.



#### 2. NANOTECH JAPAN 2023 - 2 FEB 2023

NanoMalaysia Berhad continues to revitalise industries and drive innovation through the successful development and commercialisation of nanotechnology in Malaysia by presenting Malaysian nanotech companies at Nanotech 2023.

The pavilion was officiated by the ambassador of Malaysia (Tokyo, Japan), H.E. Dato' Shahril Effendi Abd Ghany, at Tokyo Big Sight.



The pavilion featured companies offering nanotechnology products commercially developed by NanoMalaysia or certified by NanoVerify, a subsidiary of NanoMalaysia. Participating companies included Blue Snow Engineering Sdn Bhd, iDeria Sdn Bhd, Alnair Photonics and Alnair Labs. The Malaysian Investment Development Authority was also present. H.E. Dato' Shahril was joined by Prof. Emeritus Dato' Ir. Dr. Mohamad Zawawi Bin Ismail, Chairman of NanoMalaysia, Dr. Rezal Khairi Ahmad, CEO of NanoMalaysia, Dr. Ruslinda A. Rahim, Director, National Nanotechnology Centre, and Mr. Shamsul Amir Azman, Deputy Director at MIDA Tokyo.



#### 3. MOU NANO4SOCIETY - 3 FEB 2023

NanoMalaysia moved forward with its partnership with Nano4Society with an MOU signed in Tokyo following the exchanges of an LOI in Amsterdam in 2022. Nano4Society, a successor to NanoNextNL, is a nanotechnology ecosystem in The Netherlands.

In 2019, NanoMalaysia signed an MOU with NanoNEXTNL to cooperate in several areas of nanotechnology innovation, including facilitating the networking of Malaysian and Dutch nanotechnology research institutions and companies, exploring collaborative joint development or investment, as well as sharing best practices and knowledge in platform technology and intellectual property on nanotechnology.

The updated MOU focuses on SMEs & Startup's B2B Interface, Joint IP Development, and NanoSafety and Product Certification (NANOVerify), especially in the areas of Energy and Renewables, Electric Vehicle (EV), Hydrogen Economy and Food Security (Urban/Smart/Precision Farming).

NanoMalaysia was represented by its Chairman, Prof. Emeritus Dato' Ir. Dr. Mohamad Zawawi bin Ismail, and Dr. Rezal Khairi Ahmad, CEO of NanoMalaysia, while Raoul A. Oostenbrink and Prof Dr. Ir Wilfred G Van Der Wiel represented Nano4Society.





#### 4. MOU NMB x XIAMEN UNIVERSITY ON BICEP - 16 FEB 2023

NanoMalaysia Berhad and Nanoquartz signs Memorandum of Understanding (MoU) With XMU Jiageng Education Development for cooperation in Biomass Innovation Circular Economy Programme (Bicep) at Xiamen University Malaysia on 16 February 2023.

Witnessing by YB Tuan Chang Lih Kang, the Minister of Science, Technology and Innovation of Malaysia (MOSTI), Datuk Ts. Ir. Dr. Hj Aminuddin Bin Hassim, Secretary General of MOSTI, Prof. Emeritus Dato' Ir. Dr. Mohamad Zawawi bin Ismail, Chairman of NanoMalaysia Berhad (NMB) while the MoU was signed by Dr. Rezal Khairi Ahmad, Chief Executive Officer of NanoMalaysia Berhad, Dr. Daniel Bien, Director of NanoQuartz Sdn. Bhd. and Professor Dr. Wang Ruifang, the President of Xiamen University Malaysia. Dignitaries present for the occasion included Datuk Ts, Dr. Mohd Nor Azman bin Hassan, Deputy Secretary General of MOSTI (Technology Development), Dr. Ruslinda A. Rahim, Director, National Nanotechnology Centre, Associate Professor Dr. Zhang Ying, the Vice-President of Xiamen University Malaysia, Associate Professor Dr. Ong Wee Jun, the Director of the Center of Excellence for NaNo Energy & Catalysis Technology (CONNECT), and Professor Dr. Chen Binghui, the Dean of School of Energy and Chemical Engineering of Xiamen University Malaysia.

The objective of the MoU is to strengthen the progressive trilateral relationships and cooperation in the Biomass Innovation Circular Economy Programme (BICEP) between the Ministry of Science, Technology and Innovation (MOSTI), NanoMalaysia Berhad - as the leading agency for the commercialisation of nanotechnology and advanced solutions - and Xiamen University Malaysia - as a university dedicated to providing world-class research and teaching towards a new era of high value of biomass industry in the country.





#### 5. MOU NMB x BIFORST BHD - 19 MAC 2023

The Ministry of Science, Technology and Innovation (MOSTI) through its agency for electric vehicle (EV) technology development, NanoMalaysia Bhd (NMB), has signed a collaboration agreement with Biforst Bhd to adapt the Hydrogen Hybrid Energy Storage System (H2SS) for carbon-free transportation.

The collaboration will enable the development, testing, deployment, and commercialisation of a hybrid hydrogen-based power system based on H2SS as an additional power source on top of EV components, which will replace the internal combustion engine (ICE).

The collaboration agreement was signed by NMB chief executive officer Dr. Rezal Khairi Ahmad and Biforst group managing director Datuk Hamie Appala Nakkiah, witnessed by the Science, Technology and Innovation Minister Chang Lih Kang, NMB chairman, Prof. Emeritus Dato' Ir Dr. Mohamad Zawawi bin Ismail and Biforst chairman, YTM Dato' Muhammad Hj Abdullah during the Malaysia Technology Expo 2023 (MTE 2023) at the World Trade Centre.





## 6. MOU NMB x SBC x NCSTT x TESTA x EVAP x NBRI x ABEVTC IN BALI INDONESIA - 10 MAY 2023

NanoMalaysia Berhad has signed MoU between Singapore Battery Consortium (SBC), National Center for Sustainable Transportation Technology (NCSTT) from Indonesia, Thailand Energy Storage Technology Association (TESTA), Electric Vehicle Association of the Philippines (EVAP) and National Battery Research Institute (NBRI) during the first ASEAN Battery & Electric Vehicle Technology Conference (ABEVTC) in Bali, Indonesia.

With focus on manufacturing and production sectors, the event strives to bring opportunities & exchange of knowledge amongst the mid-level professionals in the field of EV and Battery technology and nourish relationships among industry players to build an ASEAN community for future collaboration. NanoMalaysia Berhad was represented by Dr. Rezal Khairi Ahmad, CEO of NanoMalaysia Berhad.



# 7. INTERNATIONAL INVENTION, INNOVATION, AND TECHNOLOGY EXHIBITION (ITEX 2023) - 12 MAY 2023

NanoMalaysia Berhad recently participated in the 34<sup>th</sup> International Invention, Innovation, and Technology Exhibition (ITEX) 2023, held at the Kuala Lumpur Convention Centre. They showcased two groundbreaking inventions that garnered significant recognition. The first invention, called Graphene Pre-Cured Tread Liner, received a gold medal in the Automotive, Aerospace, Aviation, and Transportation Category. This innovative rubber compound incorporates a small amount of graphene M-15 and was developed in collaboration with GIIB Rubber Compound Sdn Bhd.

The second invention, AQUENE, a graphene-based nanofluid, which solely nominated under Environment & Enegy category for the Malaysia Innovative Product Award. AQUENE is designed to enhance heat transfer at various heat exchange interfaces and rapidly dissipate heat from conditioned spaces.

Apart from these inventions, NanoMalaysia Berhad also engaged in important collaborations. They exchanged documents with Universiti Malaysia Perlis (UniMAP) and its spinoff, Ideria Sdn Bhd. A Contract Research Agreement (CRA) was signed between NanoMalaysia Berhad



and UniMAP for the project titled "Scale Up of Reduced Graphene Oxide (RGO) from Oil Palm Trunk (OPT)." This project focuses on a sustainable method of converting oil palm trunks into reduced graphene oxide, which has applications in sensors, composite materials, nanofluids, energy storage, and more. The project received a gold medal in the Agriculture Category.



#### 8. LAUNCH OF NANOTRUST AND GRAPHENEVERIFY PROGRAMME - 15 MAY 2023

NanoMalaysia Berhad (NMB) launched two groundbreaking product certification schemes, NANOTrust and GRAPHENEVerify on 15 May 2023. These schemes, part of the NANOVerify Programme, enhance consumer trust in nanotechnology products, promoting the growth of nanotechnology in Malaysia.

The event was officiated by Datuk Arthur Joseph Kurup, Deputy Minister of Science, Technology, and Innovation (MOSTI) in which The NANOTrust and GRAPHENEVerify Product Certification Schemes provide SMEs with nano- based products an opportunity to secure a credible seal of trust. This enables wider market penetration both locally and abroad and contributes to the dynamic nanotechnology ecosystem envisioned in the National Nanotechnology Policy and Strategy 2021-2030 (DSNN).

#### 9. ASEAN GREEN HYDROGEN CONFERENCE 2023 - 23-24 MAY 2023

This year, RoomOfLeaders is proudly taking initiative to organise the ASEAN GREEN HYDROGEN CONFERENCE 2023 in Kuala Lumpur, Malaysia with the main theme 'Stimulating Regional's Green Hydrogen Economy'.

This private and exclusive conference will act as a regional roadmap and aim as the catalyst for the regional's green hydrogen developments, assisting governments, leading energy companies, academics and service providers within the Hydrogen domain across Southeast Asian countries.

Among the conference highlights for this edition include Green Hydrogen Policy and Regulations, Green Hydrogen Ecosystem & Value Chain, Technologies, Research and Developments and Green Hydrogen Financing.





NanoMalaysia Berhad represented by Dr. Rezal Khairi Ahmad, CEO of NMB as one of the panelists just concluded two session titled "Policies, Strategies & Innovation Ecosystems For Future Energy" and "Accelerating Green Hydrogen Production At Low Cost".



# 10. 2023 LANGKAWI INTERNATIONAL MARITIME AND AEROSPACE EXHIBITION (LIMA2023) - 24 MAY 2023

NanoMalaysia Berhad proudly participated in the 2023 Langkawi International Maritime and Aerospace Exhibition (LIMA2023) at Mahsuri International Exhibition Centre in Langkawi, Kedah. Our booth was in the Ministry of Transportation Pavilion from May 23<sup>rd</sup> to May 27<sup>th</sup>, 2023.

NanoMalaysia Berhad's representative presented NMB's innovative Hydrogen-paired Electric Race Car and Nanomaterial-based Multispectral Camouflage to YAB Dato' Seri Anwar bin Ibrahim, the Prime Minister of Malaysia. This event occurred at the NMB Booth, under the Ministry of Transport Pavillion, located at the Mahsuri International Exhibition Centre in



Langkawi, Kedah. Accompanying the Prime Minister were YB Anthony Loke, the Minister of Transport, as well as YB Tuan Chang Lih Kang and YB Datuk Arthur Joseph Kurup, the Minister and Deputy Minister from the Ministry of Science, Technology, and Innovation.



#### 11. MOU NIG INDONESIA - 6 JUNE 2023

NanoMalaysia Berhad (NMB) is pleased to announce that their subsidiary, NanoVerify Sdn Bhd (NVSB), has signed a strategic agreement with PT Nanotech Indonesia Global (NIG) to collaborate and shape the nanotechnology business in the region. The aim of this collaboration is to establish a regional "Gold Standard" in nanotechnology certification. The signing ceremony, which took place in Kuala Lumpur, is a significant milestone in the commercialization of nanotechnology in Malaysia and Indonesia.

NVSB will lead the regional commercialization of nanotechnology through its NANOVerify Certification Programme. This program will set a regional standard for nano product certifications in the ASEAN region. The signing ceremony is a major step towards NVSB's goal of becoming a leading authority for nanotechnology certification and consultation in Asia by 2025.

The partnership between NVSB and NIG has the potential to shape the nanotechnology business in the region. By sharing infrastructure and expertise in nanotechnology product certification, the collaboration aims to explore and leverage the regional potential of nanotechnology products. This initiative is aligned with the Malaysia MADANI framework, which promotes trust, prosperity, and technological advancement to drive socioeconomic growth in communities in Malaysia and Indonesia.

#### 12. 19 JUNE 2023 - LAUNCH OF EZYCART

The Minister of Science, Technology, and Innovation (MOSTI), YB Chang Lih Kang, launched the ezyCart, a smart shopping cart which is projected to be a game-changer in the retail industry at the Redtick Supermarket in Putrajaya. The high-tech trolley is an example of local innovative output in the era of the 4<sup>th</sup> Industrial Revolution.





EzyCart is a technology developed by NanoMalaysia Berhad, an agency under the Ministry of Science, Technology, and Innovation (MOSTI), in collaboration with Retailetics Sdn Bhd, a company providing artificial intelligence-based retail automation solutions. EzyCart offers a personalised shopping experience and was developed based on feedback from shoppers and retailers. Following the successful launch of the prototype in 2022, the smart shopping cart EzyCart has now been equipped with software optimised for seamless data collection and analysis, and is entering the trial phase in several supermarkets, including Redtick Supermarket in Shaftsbury Putrajaya. The development of AI technology in EzyCart utilises advanced nano technology features, such as those found in the semiconductor sector, enabling faster processing. NanoMalaysia guarantees optimal cleanliness of the ezyCart trolleys by integrating nano-based antibacterial technology on the surrounding surfaces, ensuring they remain impeccably clean at all times.

#### 13. ESG POSITIVE IMPACT AWARDS 2022 - 23 JUNE 2023

NanoMalaysia Berhad was honored with a "Gold" award at the ESG Positive Impact Awards 2022 organized by Star Media Group. They received this recognition in the Innovative Partnership category under the SMEs to Mid Tier Company section. The award acknowledges NanoMalaysia Berhad's commitment to sustainability and their ability to foster effective partnerships. It highlights their dedication to driving positive change through collaborations and showcases their leadership in promoting innovative and responsible business practices. This achievement will inspire NanoMalaysia Berhad to continue excelling in their pursuit of sustainability and making a positive social impact.

NanoMalaysia Berhad has announced its commitment to adopting the United Nation's Sustainable Development Goals (SDGs) as guiding principles in its corporate strategy, culture, and day-to-day operations.

NanoMalaysia Chief Executive Officer Dr. Rezal Khairi Ahmad said: "As a business entity that energizes industries and the national economy, we aim to contribute to all 17 goals by realigning our existing sustainability strategies to meet SDGs and green corporate goals. We will take a focused, strategic and robust approach to address local and global issues, which will help attract



future investments and funding. We are already operating on a quadruple helix-based Venture Builder model to support the government, research institutes, industry, and communities to deliver our mandate towards commercializing and developing sector and people-centric nanotechnology solutions, local EV and hydrogen technology for the nation's sustainable economic growth".





# **Activities from TAIWAN**



### **Activities from Member Countries**

TAIWAN

## 1. The 2<sup>nd</sup> Annual Program Review for the USAF/Taiwan-NSTC Topological and Nanostructured Materials Program

The joint program "USAF/Taiwan-NSTC Topological and Nanostructured Materials Program" was initiated by Taiwan National Science and Technology Council (NSTC) and US Air Force Office of Scientific Research (AFOSR) from 2021. The 2<sup>nd</sup> Annual Program Review was held in Dayton, Ohio, USA, from 19-21 July, 2023.

This program announced and call for proposals every 3 years, with the Technology Readiness Level (TRL) between 1 and 1.5. It mainly focuses on materials research:

- Topological and Qubit Materials
- Novel Multifunctional Materials
- Biocompatible Nanomaterials
- Machine Learning Guided Materials Research

Cooperation between Taiwan and USAF could be traced back to 2004. There are 10 ongoing projects from 2021.



AFOSR held annual review meeting this year.



The participants also take a tour of AFRL labs inside Wright-Patterson Air Force Base.



### 2. Nanomaterials Registration Management

 Regulations of New and Existing Chemical Substances Registration Issued by Taiwan EPA on 23 Nov. 2021

#### Article 8

For a new chemical substance meeting the circumstances of being a substance used for the purposes of "Scientific Research and Development" (SRD) or "Product and Process Orientated Research and Development" (PPORD); or having other special forms, in addition to registering the new chemical substance in accordance with the required information items of the Regulations, the registrant shall fill in and submit the following documents to the central competent authority:

- I. Registration form for SRD and PPORD
- II. Registration form for nanoscale chemical substances
- Guidance for New and Existing Chemical Substances Phase 1 Registration (Draft) Issued date: September 2022

Nanomaterial: Clause 3.2.6; Appendix 5

Registration types based on estimated annual manufactured or imported quantity.

Small Quantity Registration (<100 kg/y, Level 1)

Simplified Registration (<1000 kg/y, Level 1)

Standard Registration (>1000kg/y, Level 1 to 4, submit hazard and exposure assessment)

### 3. Occupational safety

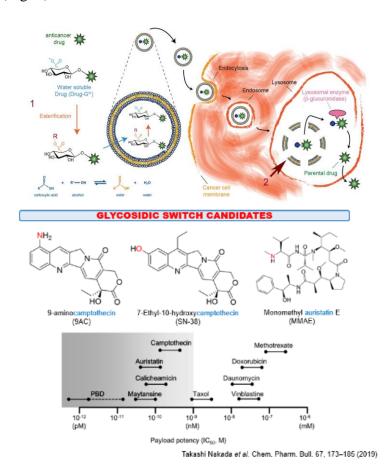
Many chemical fume hoods are used for controlling nanoparticle emission during nanomaterial handling processes. To protect nanopowder handling workers, Taiwan ILOSH (Institute of Labor Occupational Safety and Health) and National Yang Ming Chiao Tung University have been investigating the leakage control efficiency and its relationship with different operation conditions for 3 different fume hoods: constant air volume (CAV), air curtain (AC), and constant air volume (CAV) hoods.

The nanoparticle souce (nano-titanium dioxide TiO<sub>2</sub> or sodium chloride NaCl) was released from inside of the fume hood to simulate the nanoparticle handling operations. For the CAV hood, the leakage percentage of nanoparticles is 13.76% when the sash is fully open. The leakage percentage decreases to 0.34% when the sash is changed to half open. In comparison, the leakage percentage of the VAV hood is lower than that of the CAV hood which is just 0.37% when the sash is fully open. The leakage percentage is further decreased to 0.10% when the sash is half open. Similarly, the air curtain (AC) hood also has less leakage percentage of about 0.18% and 0.17% when the sash is fully open and half open, respectively. The results show that the leakage of nanoparticle is higher for the CAV hood when the sash is fully open since the face velocity of 0.3 m/s which is lower than the recommend value of 0.5 m/s. In comparison, the VAV hood can maintain a constant face velocity of 0.5 m/s when the sash is open at any height. It is worth noting that the leakage percentage is below 0.2% for all three types of fume hoods when the sash is half open indicating good nanoparticle leakage efficiency. In summary, the VAV and AC fume hoods control nanoparticle emission effectively compared to the CAV hood.



### 4. Glycosidic switch liposomes

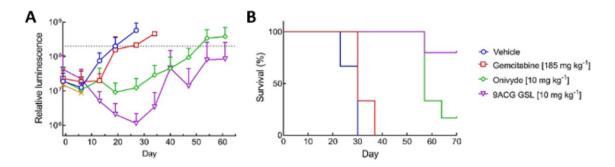
Liposomes are an established nanotechnology for cancer therapy. Although liposomal nanocarriers are increasingly impacting the clinical treatment of cancers, progress is limited by the lack of a general platform to load and retain anticancer agents in liposomes. We overcome this limitation by chemically incorporating a "glycosidic switch" into anticancer drugs. The glycosidic switch can be controllably interconverted between a lipid-soluble ester form for loading and a watersoluble glucuronide form for stable drug retention in the aqueous core to create glycosidic switch liposomes (GSL, Fig. 1). Our first GSL which encapsulated with 9ACG, that displays promising anti-tumor efficacy compared to the clinical-used drugs for pancreatic cancer, gemcitabine and Onivyde® (Liposomal CPT-11 injection) (Fig. 2). SN-38 is an attractive candidate for glycosidic switch strategy, that is an activated metabolite of CPT-11 in the treatment of various malignancies, that also be glucuronidated via an extensive conjugation with D-glucuronic acid through the UDP-glucuronosyltransferase 1A1/9. However, the synthesis of this natural SN-38G is challenging, regardless of chemical route or animal, the production yield is lower than 5%. Currently, we developed a new synthesizing strategy for SN-38G with a superior yield of over 70%. Moreover, we obtained liposomal SN-38G through the GSL strategy with high loading efficiency (80%) and nearly 100% retention stability (Table. 1). Besides camptothecin derivatives, we also developed MMAE, an auristatin analog that displays higher potency, to seek an appropriate candidate for GSL. The V.5 shows promising loading efficiency (38%) and 98% retention stability (Fig. 3).



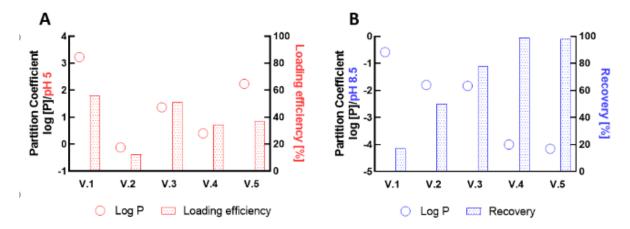


**Fig. 1** Schematic diagram of glycosidic switch strategy for drug loading in liposomes and intracellular drug regeneration: A water-soluble glycosidic switch (GW) is attached to a hydrophobic drug to generate a water-soluble drug (Drug-GW). The glycosidic switch can be esterified to produce a lipid-soluble form (Drug-GL) to facilitate active loading in liposomes. At a high internal pH in the aqueous lumen of the liposomes, the glycosidic switch is spontaneously saponified to the water-soluble form, resulting in strong retention of Drug-GW. Drug-GW liposomes are stable in circulation and can be safely delivered to tumors for cellular uptake. The glycosidic switch on Drug-GW is enzymatically removed by the lysosomal enzyme beta-glucuronidase to regenerate the parental drug inside cancer cells. Some GS drug targets are shown on the right.

#### Resutls:



**Fig. 2** 9ACG GSL displays antitumor activity against human pancreatic cancer. Groups of three NOD-SCID mice were orthotopically injected with CFPAC-1/Luc human pancreatic cancer cells. After 12 days, mice received the vehicle, 185 mg/kg gemcitabine, 10 mg/kg Onivyde<sup>®</sup>, or 10 mg/kg 9ACG GSL via i.v. injections every week for 5 weeks. (A) Bioluminescence image, and (B) mean *in vivo* luminescence signals from cancer cells measured on an IVIS imaging system. (C) Mice survival rate.



**Fig. 3** Effects of modulated MMAE-G derivatives. **A.** The <u>logP</u> of the lipid-soluble form at pH 5, higher values demonstrate its hydrophobicity which facilitates the loading efficiency of GSL. B. The <u>logP</u> of the water-soluble at pH8.5, lower values demonstrate its hydrophilicity, which stabilized the drug's retention inside the liposome.



Table 1. Partition Coefficient and Relevant GSL Parameters of SN-38G Derivatives

	pH 5, loading efficiency of drug		pH 8.5, stability of drug <sup>W</sup> retained	
SN-38G	Log P of drug	Loading efficiency (%)	Log P of drug <sup>w</sup>	Recovery after dialysis(%)
R1*	0.36	80	-3.7	100**
R2	0.85	67	-3.4	100**
R3	1.3	59	-3.2	100**

<sup>\*</sup>R1, shows the best loading.

**Table 2.** Partition Coefficient and Relevant GSL Parameters of MMAE-G Derivatives

	pH 5, loading efficiency of drug		pH 8.5, stability of <u>drug<sup>W</sup></u> retained	
MMAE-G	Log P of drug	Loading efficiency (%)	Log P of <u>drug</u> W	Recovery after dialysis(%)
V.1	3.2	56	-0.58	17
V.2	-0.12	13	-1.8	50
V.3	1.4	51	-1.8(OMe <sup>1/2</sup> )	78
V.4	0.4	35	Est4	100
V.5*	2.4	37	-4.2	98

<sup>\*</sup> V.5 possesses rational hydrophobicity for GSL loading and extreme hydrophilicity for stabilizing the drug's retention inside the liposome.

Sources: Yu-Lin Leu, Department of Pharmacy, Chia Nan University; Chun-Hung Lin, Institute of Biological Chemistry, Academia Sinica; Steve Roffler, Institute of Biomedical Sciences, Academia Sinica, from 2023 奈米科技創新應用計畫研究成果交流會暨審查會議

<sup>\*\*</sup>Loaded SN-38G is stable inside the liposome.



# **Activities from THAILAND**



### **Activities from Member Countries**

### THAILAND

The National Nanotechnology Center (NANOTEC) is the leading agency on nanotechnology development in Thailand. Established on 13 August 2003, NANOTEC is one of four research agencies operating under the jurisdiction of the National Science and Technology Development Agency (NSTDA) and the Ministry of Higher Education, Science, Research, and Innovation (MHESI). NANOTEC has participated and conducted various nanotechnology activities under ANF Nano Safety and Risk Management working group as following:

#### 1. NANOTEC - KMITL Nanosafety online workshop

On 28 February 2023, NANOTEC and the College of Nanotechnology at King Mongkut's Institute of Technology Ladkrabang (KMITL) organized Nanosafety workshops to help build students and faculty understand issues related to nanotechnology. This year the workshop is arranged in a physical setting under the precaution. The workshop goal is to introduce Nanosafety not only in the laboratory or research setting but also about the manufacture process the environmental concern, the related guidelines and Thailand national standard as well as the good governance on nanotechnology. To develop safe and sustainable nanotechnology Nanosafety topics need to be include at the beginning of the research as well as the future advance materials related with Nanotechnology. At the end of the seminar students were very active participating in the question, and answer session.





Nanosafety workshop at KMITL

## 2. NSTDA Annual Conference (NAC 2023) Seminar Session on Nanosafety: legislation on submicron particles

On 30 March 2023, NANOTEC (Thailand) a member of National Science and Technology Development Agency (NSTDA) organizer the webinar Under the NSTDA Annual Conference (NAC 2022). The topic of the seminar was focused on 4 topics as follows.

- 1. Measurement and analysis method of submicron particles in the air.
- 2. Combustible Dusts: Law and Regulation.
- 3. Managing Chemical Hazards in the workplace.
- 4. Health and safety practices occupational settings relevant to nanomaterials



NANOTEC speakers together with the speaker from Department of Industrial Works and Department of Labour protection and welfare also answer the questions from the participants. The objective of this seminar is to share information about submicron particles in the out-door environment and workplace including the law regulation and related guideline to all stakeholders. The participants are including but not limited to the nine Nanosafety Network for Industry partners, academia, research agencies, and private sectors.



NSTDA Annual Conference (NAC 2023) Seminar on Nanosafety: legislation on submicron particles

## 3. MOU Ceremony between NANOTEC and 10 partner organizations on Nanosafety Network for Industry phase 2.

On 25 April NANOTEC and 10 partner organizations cerebrate MOU on Nanosafety Network for Industry phase 2. Due to the first phase of the Nanosafety Network, which ends in December 2022, being successful. In the initial stage, nine organizations—NANOTEC, Thailand Food and Drug Administration, Thai Industrial Standards Institute, Office of the Consumer Protection Board, Department of Industrial Work, National Institute of Metrology, Federation of Thai Industries, Council of Scientific and Technological Associations of Thailand, and Nanotechnology Association of Thailand—worked together to establish various activities related to nanosafety. Phase 2 of the collaboration was approved by all alliance groups, and two additional agencies—the departments of labour safety and welfare and pollution control—joined in this phase. The "The Nanosafety and Ethics Strategic Plan of Thailand" will unite all organizations in phase 2 to establish nanosafety knowledge for all stakeholders for the sustainability of nanotechnology development in Thailand. The honorable guests during the ceremony including the representatives from Secretary of Ministry of Higher Education, Science, Research and Innovation, Dr. Junpen Meka-apiruk and President of National Science and Technology Development Agency, Prof. Dr. Sukit Limpijumnong.











MOU ceremony on Nanosafety Network for Industry phase 2

## 4. PROPAK Asia Seminar on "Technology and biological processes for food and food packaging"

On 15 June 2023, NANOTEC and Council of Scientific and Technological Associations of Thailand (COSTAT) joined the 30<sup>th</sup> International Processing and Packaging Exhibition for Asia (PROPAK Asia) to organize a seminar on "Technology and biological processes for food and food packaging".

Maj. Gen. Dr. Chainarong Cherdchu, President of COSTAT and Chairman of Nanosafety Network for Industry, NANOTEC gave the opening remarks. The seminar topics included the following:

- "Bioprocessing: From Thai Bioresources to Application"
   by Dr. Kobkul Laoteng, Director of Functional Ingredients and Food Innovation Research Group, BIOTEC/NSTDA Core Business Director, Service Platform for Food and Functional Ingredients (FoodSERP).
- "Nanomaterials and Nanoplastics: Perspectives on Food Safety and Environment" by Dr. Sasitorn Aueviriyavit, Researcher, NANOTEC
- "Zero food waste" by Mr. Wattanapong Petcharat, Wiangsra Industrial and Community Education College, Surat Thani.





ProPak Seminar on "Technology and biological processes for food and food packaging"

#### 5. Standard Developing Organization 2023

NANOTEC acting as a Standards Developing Organization (SDOs), has collaborated with the Thailand Industrial Standard Institute (TISI) to develop new Thailand National Standards Guidelines. On 9 June the SDOs committee started the 1st meeting on the National Industrial standard draft of Emblica Extract and Pueraria Extract Nano-Encapsulated Particles.

### 6. The 6th Eu-Asia dialogue

On 21 June 2023, the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and BioNanoNet Forschungsgesellschaft mbH (BNN) organized the 6<sup>th</sup> EU-Asia Dialogue on Nanosafety entitled "The role of characterisation and how it is addressed in International Network Initiative on Safe and Sustainable Nanotechnology (INISS-nano)" Dr. Waluree Thongkam was invited as a chair of the break-out session of "Societal and Ethical Considerations – Policy Framework for Characterization" supported by ANF Nanosafety & Risk Management Working Group. In this session, Dr. Waluree shared her idea on the safety and sustainability of nanomaterials and advanced materials. The result of the discussion is that there will be collaboration work between Pillar 1 "Characterization Items in Standardization" and Pillar 4 "Societal and Ethical Considerations – Policy Framework for Characterization" of INISS-nano and the webinar between EU and ANF will be planned and hosted by NANOTEC, Thailand in the future. In addition, they discussed that the key for driving the societal and ethical consideration on policy framework for characterization are language barrier solution, two-way communication, and mutual learning.









The  $6^{th}$  EU-Asia Dialogue on Nanosafety entitled "The role of characterisation and how it is addressed in International Network Initiative on Safe and Sustainable Nanotechnology (INISS-nano)



### **Upcoming Events**

### • nano tech 2024 nano tech

Date: 31 January – 2 February 2024

Venue: East Halls, Tokyo Big Sight, Tokyo, Japan

### • ANF ExCo Meeting 2024

Date: 31 January – 2 February 2024

Venue: The Iris 1/3 room of Tokyo Bay Ariane Washington Hotel, Tokyo, Japan

### • 7th EU-ASIA dialogue on Nanosafety

Date/Venue: To be confirmed.



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National Nanotechnology Center (NANOTEC), Thailand