'17 '18

2017/2018

NATIONAL TSING HUA UNIVERSITY

R&D REPORT

'17 '18 NATIONAL TSING HUA UNIVERSITY R&D REPORT

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Message from the President

National Tsing Hua University (NTHU) is a research university with a long and proud tradition. Since the reestablishment in Hsinchu in 1956, NTHU has been known for excellent academic programs as well as outstanding alumni. Over the last sixty years, NTHU has transformed herself into a comprehensive university and is recognized in all disciplines.

NTHU provides a stimulating and nurturing environment within which our faculty can offer quality teaching and conduct innovative research. Regarded as one of the toptier research universities, our research and development activities across the university emphasize fundamental discoveries at the forefronts of basic sciences and exploration of breakthrough technologies with a high potential for applications. These can be reflected from our publications in the world's preeminent journals, awarded international patents, and technology transfer cases. In the 2017-2018 R&D annual report, we highlight several important breakthroughts of five fields and also provide the facts and figures related to other important R&D activities. This volume is undoubtedly too limited to give the full scope of R&D at NTHU, but a glimpse into our recent achievements. Hopefully, this can serve as a catalyst for further interactions, exchange of ideas, and establishment of collaborations.

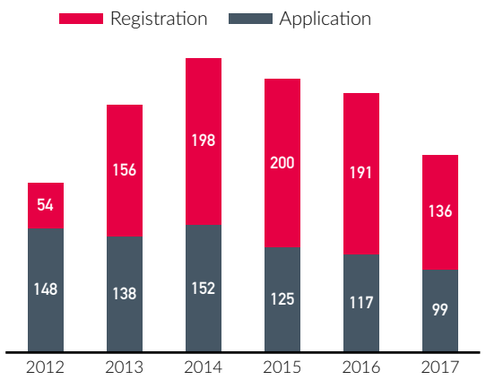
Built on our proud heritage, NTHU will continue to promote excellent teaching and innovative research with the goal of ascending the university into the cradle of human accomplishments, important scientific discoveries and innovative technologies. I hope that you will find this R&D annual report useful and give us your precious opinions and suggestions.

President *Dr. Hong Hocheng*

National Tsing Hua University
Hsinchu, Taiwan
November 2018

R&D Facts and Figures

Taiwan Patent Application and Registration(2012-2017)

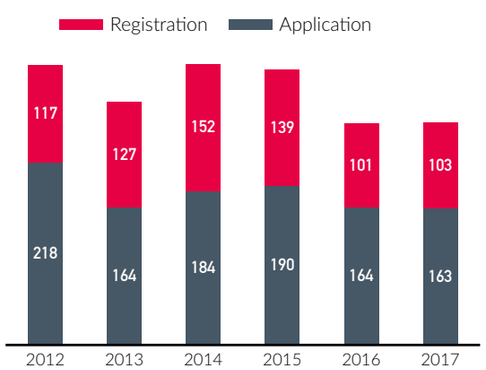


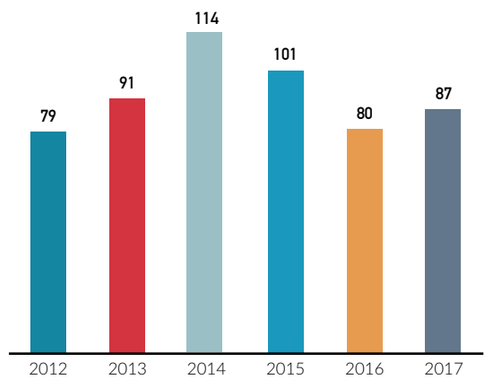
Number of Awarded US Patents

Taiwan Ranking **No.1** 2014-2017

2012	2013	2014	2015	2016	2017
World Ranking					
15	15	11	15	25	23
Taiwan Ranking					
2	2	No.1			

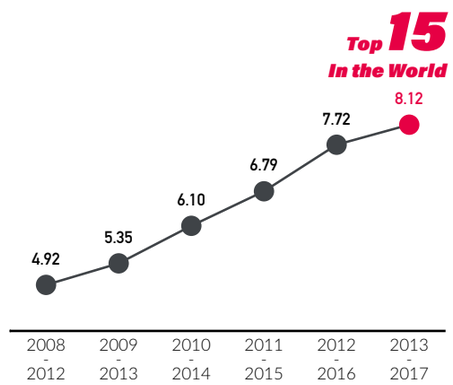
International Patent Application and Registration (2012-2017)





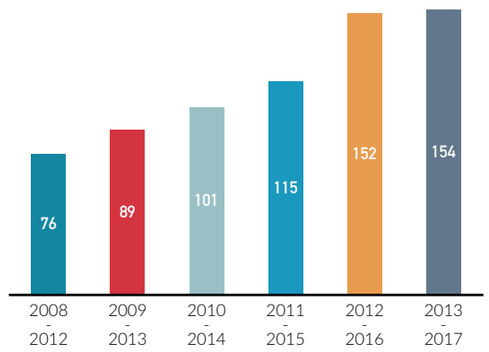
Citations Per Faculty

Top 15 In the World



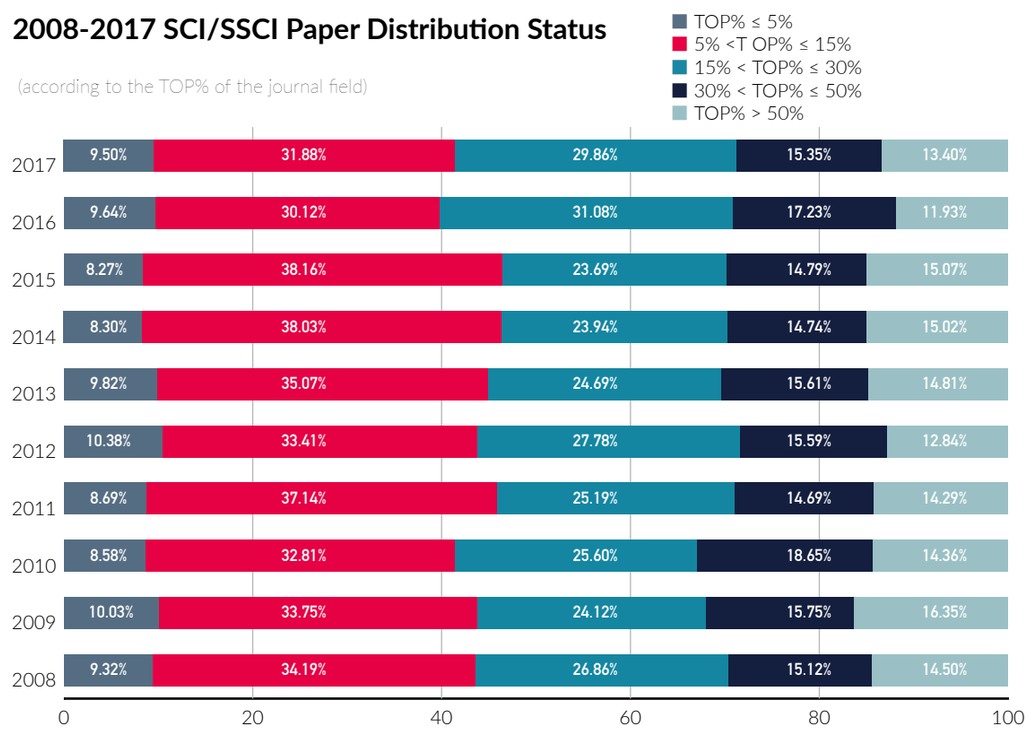
Highly Cited Paper

Data source: ESI; Year range: 2008-2017



2008-2017 SCI/SSCI Paper Distribution Status

(according to the TOP% of the journal field)



Natural Science

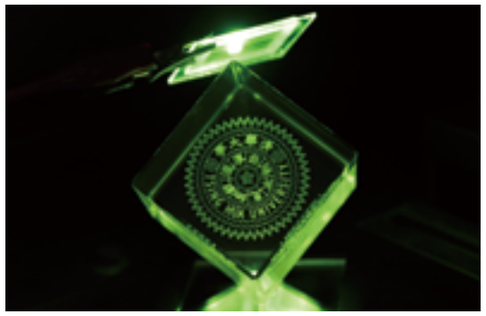
- Diboron Compound-Based Organic Light-Emitting Diodes with High Efficiency and Reduced Efficiency Roll-Off
- Quantum Optics in Artificial Lattice of Monolayer Semiconductor
- Protein Has An Intrinsic Dynamic Component, Not Slaved by Solvent Motions
- A Green Chemistry Approach and Circular Economy Guide Vision Turning e-Waste Oils into Green Gold

Professor Chien-Hong Cheng/chcheng@mx.nthu.edu.tw

Diboron Compound-Based Organic Light-Emitting Diodes with High Efficiency and Reduced Efficiency Roll-Off

Organic light emitting diodes (OLEDs) are the flat and solid-state light emitting technology, composed of several organic thin layers that are between the two electrodes, the anode and cathode. When an electrical source is applied to the device, the holes and electrons recombine to generate excitons in the emitting layer and then light emission occurs.

OLED displays have been adopted for various mobile devices and high-resolution TVs for several years. Compared to LCD displays, OLEDs become more and more popular due to the advantages, such as display with wide color gamut, high-contrast, fast response and the screen can be transparent, light-weighted, thinner and flexible. OLED can also be applied to lighting, virtual reality (VR) and augmented reality (AR) applications in the future, and represents a dream display technology!



The photo displays the lighting of a NTHU logo by the diboron-based green OLED (top), which achieves a record-high performance with external quantum efficiency of 37.8%.

The research team by Prof. Chien-Hong Cheng, Prof. Rai-Shung Liu from Department of Chemistry and Prof. Hao-Wu Lin from Department of Materials Science and Engineering designed and synthesized a series of new diboron-based emitters. The new materials are excellent thermally activated delayed fluorescence (TADF) materials and show outstanding device performance when used as the new OLED emitters. This outstanding result was reported in Nature Photonics, a top journal in the field of photonics.

The 1st generation fluorescent materials and the 2nd generation phosphorescent materials are widely used in the commercial OLEDs, nowadays. The conventional fluorescence OLED suffers from the low efficiency issue, due to the theoretical limit of external quantum efficiency (EQE) is around 5%. The phosphorescence OLED can achieve highly efficient device, but the main materials consisting of heavy or noble metal might increase the production cost and cause environmental pollution.

Therefore, TADF materials have attracted great attention. TADF materials have become the 3rd generation emitter in OLEDs, because they are able to harvest triplet excitons by up-conversion to singlets and then fluorescence. Moreover, they are pure-organic materials, metal-free, low cost and eco-friendly compared to the 2nd generation phosphorescence emitters. The theoretical value of exciton utilization is 100% for TADF emitters, and the EQE of the OLED device could approach EQE around 20 to 30%. However, TADF-based OLEDs often suffer from high efficiency roll-off and low light intensity problems.

In this work, two rod-like diboron derivatives bearing carbazole groups, CzDBA and tBuCzDBA, have been designed and prepared. They exhibit excellent photoluminescence quantum yields (PLQYs) and TADF properties including small ΔE_{ST}, short delayed fluorescence lifetime and high horizontal emission dipole orientations. It worth noting that a green OLED by using CzDBA as dopant material shows a high external quantum efficiency (EQE) of 37.8 ± 0.6% with a low efficiency roll-off of 0.3% at 1,000 cd m^{-2}. The outstanding performance makes it attractive for color-display applications.

The domestic panel industry in Taiwan has been seriously behind Japan and South Korea, and even China in the development of OLED display technology. The diboron-based materials consist of common elements C, H, N and B without any precious metal. The synthesis steps are simple, convenient, and a larger than gram-scale preparation of these materials can be achieved in the laboratory, and are expected to greatly reduce the cost of emitting materials. Hopefully, the success of these diboron materials can promote and upgrade our ability in the OLED panel and lighting industry in Taiwan.

The NTHU group has been developing OLED materials for more than 15 years. This work combined the expertise of three laboratories, including material design, synthesis, device fabrication and advanced measurement technology. The emissive diboron materials and efficient OLEDs can be described as "The Light of Tsing Hua".

The NTHU research group in a press conference in the Ministry of Science and Technology. From the left, Professor Rai-Shung Liu, Vice President Sinn-wen Chen, Postdoctoral Researcher Tien-Lin Wu, Professor Chien-Hong Cheng, and Professor Hao-Wu Lin.

Research Highlights

- Two highly efficient diboron-based TADF molecules, CzDBA and tBuCzDBA, were designed and synthesized for the first time.
- These TADF molecule-based OLEDs achieved a record-high device performance in the world, showing an excellent device efficiency and very low efficiency roll-off.

Research Output

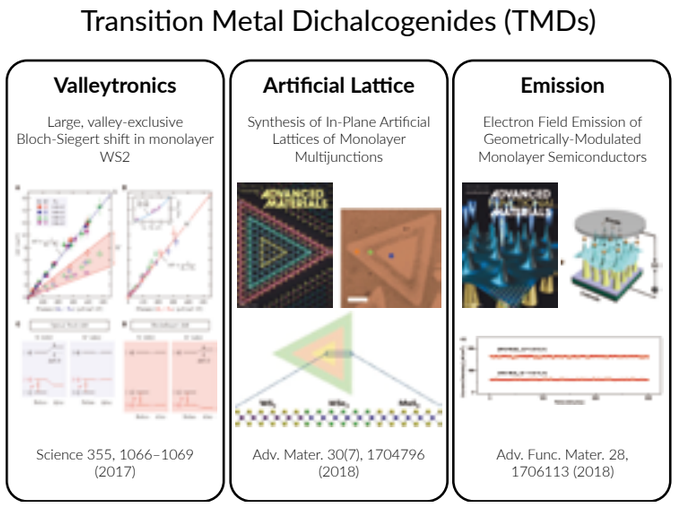
- Tien-Lin Wu, Min-Jie Huang, Chih-Chun Lin, Pei-Yun Huang, Tsu-Yu Chou, Ren-Wu Chen-Cheng, Hao-Wu Lin*, Rai-Shung Liu* and Chien-Hong Cheng* Nat. Photon. 12, 235–240 (2018).
- Boron-containing compound, emitting layer of organic light emitting diode and organic light emitting diode device, R.O.C. Patent I613205.

Professor Yi-Hsien Lee / yhlee.mse@mx.nthu.edu.tw

Quantum Optics in Artificial Lattice of Monolayer Semiconductor

Monolayer two-dimensional (2D) materials are of high potential for nonlinear optics, nanoelectronics and fundamental physics. Among the material family of 2D lattices, semiconducting transition-metal dichalcogenides (TMDs) possess a suitable bandgap to enable a robust platform for tailoring the light-matter interaction. Recently, monolayer TMDs grown by chemical vapor deposition (CVD) offer a scalable capability over the convention mechanical exfoliated sample and are regarded as a promising material candidate for next generation of low-dimensional optoelectronics.

ANGEL lab that is started in NTHU in 2013 with the research focus on science and related techniques of 2D materials. In 2015, significant demonstration on valley selective optical Stark effect is presented and selected as cover of the journal of Nature Materials with the collaboration of MIT team led with Prof. Nuh Gedik. With on-going collaborations with the MIT team, Bloch-Siegert shift in condensed matter is demonstrated for the first time in Science in 2017 and it shed a light on valley-related physics in 2D materials. Optical stark effect and Bloch-Siegert shift is effectively driven at specific valley by controlling the helicity of incident light and related parameters. Monolayer WS2 sample is pumped by intense infrared pulses and probed by broad band pulses in the visible region. Since only the lowest energy exciton state (1s) is probed, which possess similar behavior as hydrogen atoms, a simple two-level framework is applicable for sufficiently describe the measured peak shifts. By solving the interaction Hamiltonian with circularly polarized pump beam, the induced valley-selective Stark shift and Bloch-Siegert shift can be evaluated as $\Delta E_k = \frac{\mu^2 \varepsilon_0^2}{2} \frac{1}{E_g - \hbar\omega}$ and $\Delta E_k = \frac{\mu^2 \varepsilon_0^2}{2} \frac{1}{E_g - \hbar\omega}$, respectively. Form the different energy dependency, Stark shift and Bloch-Siegert shift can be clearly identified. Interestingly, the Bloch-Siegert shift and optical Stark effect possess opposite valley selection rules so that we are able to well separate the two effects. These result provide a new window to coherently control the valley degree of freedom of 2D TMDs and corresponding valley-selective physics.



Valleytronics, Monolayer multi-junctions , emission of monolayer semiconductors

In 2018, the ANGEL lab further demonstrated artificial 2D lattice of multi-junctions of more than two different monolayer TMDs in the journal of Advanced Materials. The unique synthesis on in-plane hetero-epitaxial growth of monolayer TMDs has been achieved using sequential CVD growth of diverse 2D materials. In-plane multi-junctions of the WS2/WSe2/MoS2 is realized with atomically sharp interface and the interface can be clearly revealed by the mapping of photoluminescence, Raman, and SHG microscopy. Atomically sharp interface of the 2D multi-junctions is significant to further fundamental sciences.

ANGEL lab also develop controlled emission in monolayer 2D lattice because the optical absorption and emission in the monolayer of van der Wall materials is limited with low efficiency. With theoretical predictions and experimental demonstrations on band structure engineering through stain control, surface geometry of the monolayer TMD is controlled by using ZnO nanowire arrays to artificially tune the emission properties of the monolayer semiconductor. Field emission of the as-grown monolayer TMDs is significantly enhanced with the structural suspension and surface geometry tuning. The geometrically modulated monolayers on the ZnO nano arrays realize a highly efficient field electron emission with superior emission stability, furthermore, the scalable property of CVD-grown TMDs promise great potential on diverse industrial-level applications.

(from left) Yu-Ming Li, Zhe-Hong Yang, Yu-Ting Lin, Yong-Jie Wu, Meng-His Chuang, Xin-Quan Zhang, Chun-An Chen, Dr. Ying-Yu Lai, Jian-Guo Rong, Prof. Yi-Hsien Lee, Erh-Chen Lin, Yi-Cheng Chiang, I-Tung Chen, Po-Yen Chen, Kai-Jie Hsu

Research Highlights

- Research award from US Navy and US Airforce. (2016~2018, Grant No. FA2386-16-1-4009)
- TW-Airforce collaboration (2018~2020)
- Y. Z. Hsu Scientific Paper Award 2015

Research Output

- Edbert J. Sie, Chun Hung Lui, Yi-Hsien Lee, Liang Fu, Jing Kong, Nuh Gedik, “Large, valley-exclusive Bloch-Siegert shift in monolayer WS2,” Science 355, 1066–1069 (2017).
- Kuan-Chang Chiu, K.H. Huang, C.A. Chen, Y.Y. Lai, X.Q. Zhang, E.C. Lin, M.H. Chuang, J.M. Wu, Yi-Hsien Lee, “Synthesis of In-plane Artificial Lattices of Monolayer Multi-junctions,” Adv. Mater. 30(7), 1704796 (2018).
- Tung-Han Yang, K. Chiu, Y. Harn, H. Chen, R. Cai, J. Shyue, S. Lo, J. M. Wu, Yi-Hsien Lee, "Electron Field Emission of Geometrically-Modulated Monolayer Semiconductors," Adv. Func. Mater. 28(7), 1706113 (2018).

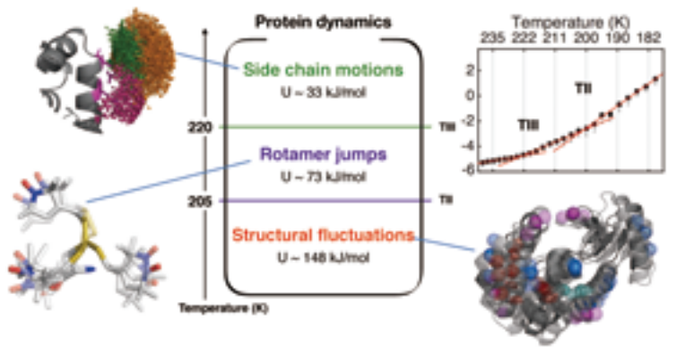
Professor Yun-Wei Chiang / ywchiang@gapp.nthu.edu.tw

Protein Has an Intrinsic Dynamic Component, Not Slaved by Solvent Motions

Protein structures are dynamic rather than static. They fluctuate on many different time scales and continually switch among conformational states to execute a variety of functions. Protein dynamics can span over a wide time range from shorter than nanoseconds to longer than milliseconds even at subfreezing temperatures. It is well-accepted that protein functions are governed by their dynamic motions. However, the role of solvent dynamics in the protein structure dynamics function relationship remains unclear. While solvent is essential for protein dynamics and function, its role in regulating the dynamics remains highly debated. This study aims to explore, in a fully hydrated condition, the connection between the protein dynamics and the dynamics of the surrounding solvent.

This study employs saturation transfer electron spin resonance (ST-ESR) to explore the issue and maps out the variation in protein local dynamics in the time range from microseconds to seconds, hence providing new insights into the dynamics on a longer time scale than has been extensively explored. We first demonstrate the reliability of ST-ESR by showing that the dynamical transition reported in the spectra coincides with liquid-liquid transition (LLT) in bulk solvents, accordingly establishing the connection between the dynamical changeover and the LLT of bulk solvent.

To investigate protein dynamics, site-directed spin labeling (SDSL) in combination with ST-ESR is introduced to explore the slow dynamics on the time range from microsecond to seconds in a fully hydrated protein over the temperature range 180 240 K. ST-ESR is developed to study the rotational dynamics on the very slow time scale (> μ s), where conventional ESR is not sensitive. The basic principle of ST-ESR is to collect the spectra under saturation conditions and high modulation amplitudes to observe the response of the spin system on spectral diffusion of saturation by molecular motions. SDSL in combination with



Spin-label ESR reveals the hierarchy of protein dynamics from μs to s. This study identifies the slow and collective dynamic component, intrinsic to protein and not slaved by solvent.

ESR techniques is a powerful tool to explore local information on dynamics of molecular structure in an ensemble system. Basically, change in the dynamic structure of solvent can be probed by a nitroxide radical doped in the solvent. As opposed to other techniques detecting the overall dynamic motions in the ensemble, the SDSL-ESR provides local information on the dynamics of spin probes and the corresponding potential energy associated with the local environment in the solvent. When the spin-label side chain is incorporated into a protein by the SDSL methods, the tethered probe is also sensitive to various dynamic components related to the protein, such as dynamics of the side chain, backbone fluctuations, and interactions between tertiary structures. In this regard, the local environment reported on the ESR spectra of spin- labeled proteins is a composite of information from protein and nearby solvent molecules.

We show that the bulk solvent (10 mol % glycerol/ water) dynamics can only dominate the dynamics of the highly exposed sites in T4L below transition TI (～ 190 K) in liquid II state. For other sites that are relatively less exposed, protein maintains control over the dynamics itself throughout the temperature range studied. The temperature-dependent behaviors of the protein-related dynamic components are not dominated by the solvent dynamics. The dynamics of spin labels is shown to reflect the overall structural dynamics in T4L (180 205 K), the dynamics of rotamer clusters (205 220 K), and the internal side-chain dynamics (220 240 K). The overall structural dynamics is collective and independent of protein structural segments, providing information for understanding the fundamental dynamic component of a protein that has not been reported. More than one protein-related dynamical transition is revealed. However, these dynamic components are arrested in the dehydration state. This study not only reveals the hierarchy of the protein dynamics associated with side-chain motions, but also provides quantitative descriptions for the dynamic components observed in the ST-ESR results of the fully hydrated T4L. The presence of hydration is required for protein to exhibit its dynamics, whereas it does not dominate the protein dynamics. The studies presented here support that bulk solvent plasticizes protein and facilitates rather than slaves protein dynamics.

(from left) Dr. Y.H. Kou, Dr. T.C. Sung, Professor Y.W. Chiang.

Research Highlights

- (2016) Ta-You Wu Memorial Award of Ministry of Science and Technology (MOST) of Taiwan
- (2013-2019) MOST Grant for Outstanding Early-career Researcher
- (2015) Outstanding Young Investigator Award of Taiwan Chemical Society

Research Output

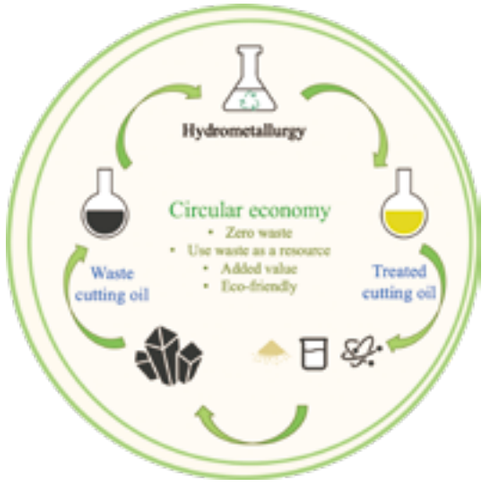
- Y.H. Kuo, Y.W. Chiang*, Slow Dynamics around a Protein and Its Coupling to Solvent, ACS Central Science, 4 (2018) 645-655.
- T.Y. Kao, C.J. Tsai, Y.J. Lan, Y.W. Chiang*, Role of Conformational Heterogeneity in Regulating the Apoptotic Activity of BAX Protein, Physical Chemistry Chemical Physics, 19 (2017) 9584-9591.
- C.C. Wang, H.C. Chang, Y.C. Lai, H. Fang, C.C. Li, H.K. Hsu, Z.Y. Li, T.S. Lin, T.S. Kuo, F. Neese, S. Ye*, Y.W. Chiang*, M.L. Tsai*, W.F. Liaw*, W.Z. Lee*, A Structurally Characterized Nonheme Cobalt-Hydroperoxo Complex Derived from its Superoxo Intermediate via Hydrogen Atom Abstraction, Journal of the American Chemical Society, 138 (2016) 14186-14189.

Professor Yong-Chien Ling / ycling@mx.nthu.edu.tw

A Green Chemistry Approach and Circular Economy Guide Vision Turning e-Waste Oils into Green Gold

Taiwan is an international leader in semiconductor processes with a globally leading semiconductor IC industry. Nine-tenths of the IC manufacturers are located in the Hsinchu Science Park near-by NTHU. The industry continues to invest in R&D to enable advanced process, shorten mass production lead-time, and introduce sustainable manufacturing technology. The successful reclaim of copper, ammonium sulfate, tetramethylammonium hydroxide, and ammonia nitrogen from the aqueous waste stream and downgrade use of them in other industries discloses the opportunity of simultaneous improving performance and reducing disposal cost. The United Nations' Sustainable Development Goals (SDG) number 12 is "Ensure sustainable consumption and production patterns". More specifically, SDG 12.4 refers "By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment", setting an immediate and urgent challenge of "virtually zero" waste and hazard challenges by 2020 for all responsible enterprises.

Herein, we report our effort to achieve this goal. It is through green chemistry approach to recycle in-process formed e-waste oils and guided by circular economy vision to turn them into green gold with added-values. The e-waste oils refer to cutting oils and vacuum pump oils after extensive use for slicing arsenide-containing GaAs or n-type Si ingots into thin wafers. These accumulated arsenide determined by Toxicity Characteristic Leaching Procedure (TCLP) usually exceed the 5.0 ppm regulatory level. The e-waste oils are therefore judged as a hazardous waste. In comparison to the disposal of general waste, the enterprise has to pay four times higher disposal cost and also bears the producer responsibility. Even so, in Taiwan the increasing shortage of disposal capacity and landfill sites as well as the concern of harmful air pollution after incineration, enterprises inevitably face the dilemma of not being able to deal with e-waste oils in a timely manner, often leading to reduce production capacity and temporarily shut down the production line.



Schematic for green chemistry approach and circular economy guide vision turning e-waste oils into green gold

Our invented process as illustrated in Figure 1 uses an about 400 ppm arsenide-containing waste cutting oil as the test sample. A chemistry-based hydrometallurgy process applies used sulfuric acid and nitric acid mixture to dissolve Ga^{3+} and form As_2O_3 under low temperature in a short time. An organophosphorus compound is subsequently applied to function as a chelating agent for extracting Ga^{3+} under sonication assist. Chelated Ga^{3+} was recovered later and for use in elsewhere. The residual arsenide in the oil is reverse extracted using a used hydrochloric acid and selectively precipitated out. The resultant arsenide free water stream flows through an oil-adsorption foam to remove any residual trace oil before running to the in-plant water treatment unit. The resultant treated cutting oil contains 0.02 ppm arsenide and can be disposed of as a general waste, solving the most headache problem for the enterprise at a much lower cost. In brief, the green chemistry approach offers eco-friendly and zero waste outcome.

Even so, the circular economy vision guides us to further cut the cost down by not to send out for paid disposal but instead using these detoxify cutting oil to prepare high-quality carbon quantum dots (CQDs) with our invented solid phase extraction and purification process for quantum dots. The thus prepared CQDs show high selectivity in the quantitative determination of aqueous Fe^{3+} down to 0.1 ppm using a fluorescence spectrometer. The unit price of the CQDs is hundred times higher than the cutting oils, turning e-waste oils into green gold, referring the approach of inventing a green process to empower sustainable production leading to greener and higher profit. The enterprise not only earns a green image but also earns more profit. The process has been successfully tested on higher level arsenide-containing e-waste vacuum oils as well as scaled up to the plant scale without compromising the overall performance. In brief, the circular economy vision leads to use waste as a resource and creates added value.

(from left) Professor Yong-Chien Ling, Deputy Director General Huang, Yun-Hsuan Tsai, Yu-Hsuan Shih, Chia-Liang Yen, Chi-Chen Wu

Research Highlights

- Taiwan EPA - Academic Second Class Environmental Protection Professional Medal
- Chinese Chemical Society (Taipei) Chemistry Technology Award
- Chinese Environmental Analysis Society Award

Research Output

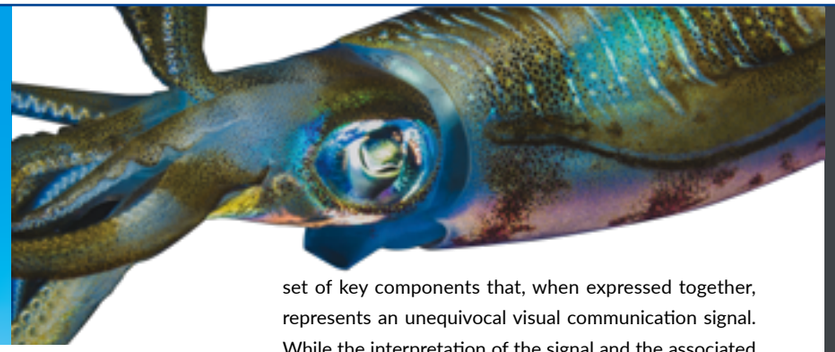
- Wu MC, Deokar AR, Liao JH, Shih PY, Ling YC. Graphene-Based Photothermal Agent for Rapid and Effective Killing of Bacteria. 2013. ACS Nano 7(2), 1281-1290.
- Liu JY, Garg B, Ling YC. CuxAgyInzZnkSm solid solutions customized with RuO_2 or $Rh_{1.32}Cr_{0.66}O_3$ co-catalyst display visible light-driven catalytic activity for CO_2 reduction to CH_3OH, Green Chem 2011, 13(1-2), 2029-2031.
- Graphene based antibacterial therapy and using the same. US 9345797 B2. Ling, Yong-Chien; Ramchandra-Deokar, Archana; Wu, Meng-Chin; Liao, Chan-Hung. 2016-2027

Biomedical Technology

- Visual Signal in Oval Squids
- Studying The Spatial Orientation Circuits in The Fruit Fly Brain

Professor Chuan-Chin Chiao/ccchiao@life.nthu.edu.tw

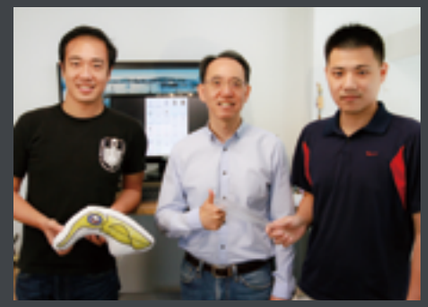
Visual Signal in Oval Squids



Cephalopods use a diverse range of body patterns for visual communication. Each pattern is composed of several distinct chromatic components that are under neural control and are expressed dynamically. In the oval squid Sepioteuthis lessoniana, males use distinct body patterns to interact with females and other males at the spawning site. To systematically examine their visual signals during reproductive behavior, an ethogram of 27 body pattern components produced by S. lessoniana was observed in both the wild and captivity; these were then characterized. Five behaviors were commonly seen among these reproductively active squids, namely parallel swimming, male guarding, male-male fighting, male-parallel mating, and male-upturn mating. Each behavior was found to be composed of the expression in a temporal sequence of different chromatic components. By analyzing the dynamic body patterning time series associated with each behavior, it was found that a certain subset of components was expressed simultaneously or sequentially in response to conspecifics. Importantly, the results not only revealed that each behavior is composed of multiple chromatic components, but the findings also showed that each component is often associated with multiple behaviors. To gain insight into the visual communication associated with each behavior in terms of the body patterning' s key components, the co-expression frequencies of two or more components at any moment in time were calculated in order to assess uniqueness when distinguishing one behavior from another. This approach identified the minimum set of key components that, when expressed together, represents an unequivocal visual communication signal. While the interpretation of the signal and the associated response of the receiver during visual communication are difficult to determine, the concept of the component assembly is similar to a typical language within which individual words often have multiple meanings, but when they appeared together with other words, the message becomes unequivocal. The present study thus demonstrates that dynamic body pattering, by expressing unique sets of key components acutely, is an efficient way of communicating behavioral information between oval squids.

The larger male oval squid and the smaller female in a "parallel swimming" display. Communication is done by body position and by changing their skins' markings. Image by Mr. Chun-Yen Lin.

"William Shakespeare wrote with a quill, Helen Keller liked her typewriter, and the oval squid prefers to use its body, when it comes to expressing love. But unlike these famous authors, the romanticisms of Sepioteuthis lessoniana were unknown. Until now. Recent research out of the National Tsing Hua University (Taiwan), and published in Frontiers in Ecology and Evolution, has finally deciphered the previously unknown symbols and shapes the oval squid decorates itself in, and how they are used." (adapted from the Frontiers Blog on May 9, 2017, The courting cephalopods of the East China Sea)



(from left) Mr. C.-Y. Lin, Professor C.-C. Chiao, Mr. Y.-C. Tsai.

Research Highlights

- Reported by the Frontiers Blog
- Media coverage by Science Daily, Punjab Times, Pinterest.
- TV and news coverage in Taiwan

Research Output

- Lin C.-Y., Tsai Y.-C., and Chiao C.-C. (2017) Quantitative analysis of dynamic body patterning reveals the grammar of visual signals during the reproductive behavior of the oval squid Sepioteuthis lessoniana. Frontiers in Ecology and Evolution 5:30.

Professor Chung-Chuan Lo / cclo@mx.nthu.edu.tw

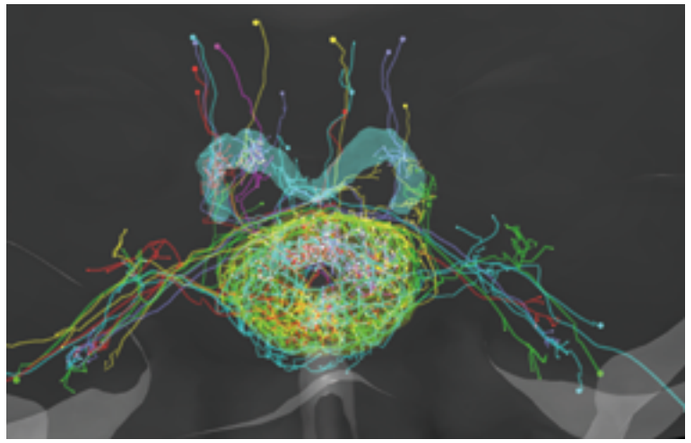
Studying The Spatial Orientation Circuits in The Fruit Fly Brain

Our lab is specialized in constructing computational models that elucidate the neural circuit mechanisms underlying cognitive functions. We have published several papers on connectome analysis and neural circuit models of the fruit fly brain. In a recent paper, we proposed a mechanism of spatial orientation, a critical brain function that enables animals to navigate.

Theories suggest that path integration and angular integration are the two key underlying processes necessary for animal navigation. However, scientists are still not entirely clear about how the associated neural computation is carried out at the circuit level. A recent breakthrough came from several studies which discovered that the ellipsoid body (EB) encodes orientation of a fruit fly's heading by maintaining localized neural activity that shifts according to body rotation. The finding implies that the ellipsoid body performs angular integration.

To understand the neural mechanisms that underlie the observed neural activities, we first constructed a detailed neural circuit involving EB and the protocerebral bridge (PB) based on recently published connectomic data. We found that the complex EB-PB network can be described by simple mathematical equations related to translation invariance. The finding suggests a possible role of this circuit in processing the spatial aspect of the sensory signals.

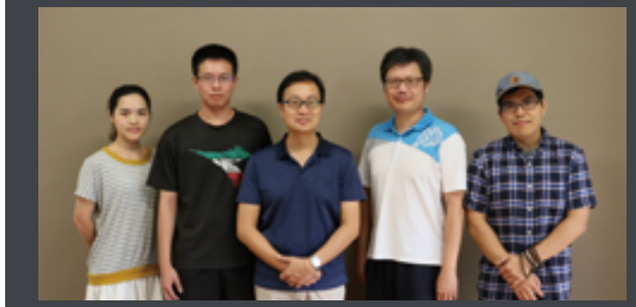
Next, our circuit analysis revealed that the EB-PB circuit can be separated into two coupled sub-circuits: one symmetric ring and one asymmetric ring. The result confirmed that, from a network architecture perspective, the EB–PB circuit is capable of maintaining localized neural activity and performing angular pathway integration.



The complex neural circuits in the fruit fly central complex is responsible for encoding spatial orientation memory

We further constructed a computational model of the EB–PB circuitry and demonstrated that the simulated neural activity reflected several key features of empirically observed neural activities. The model also makes several specific predictions and some of them have been verified experimentally.

Our work is significant in several aspects. First, the study is one of the few examples of neural circuit models built upon detailed connectome analysis down to the single-neuron level. Typical neural network models are based on hypothetical network structures and are very difficult to be verified experimentally. Second, the neural circuits presented in this work support the notion of asymmetric rings proposed in early theoretical studies. These theories have been proposed for the head-direction system found in rodents, although the actual circuits have not yet been observed due to technical limitation. Third, with highly detailed neural circuits, the proposed model is able to make experimentally testable predictions at the level of single neurons, and bring new ideas to neural functional experiments.



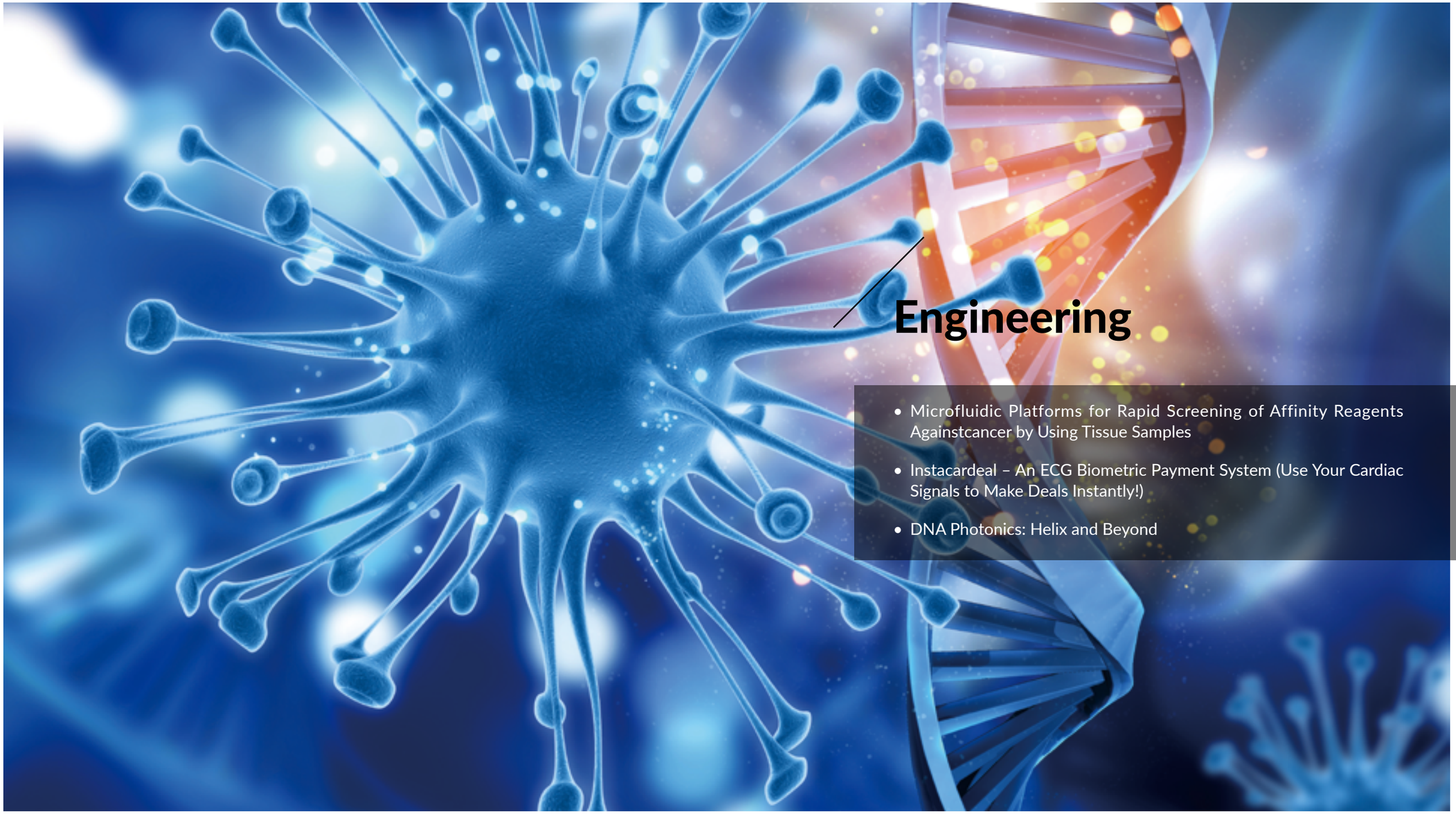
(from left) Wan-Ju Lee, Ta-Shun Su, Chung-Chuan Lo, Yu-Chi Huang, and Cheng-Te Wang.

Research Highlights

- The studies led to new ideas about how to make neuromorphic AI chips that process visual signals. The ideas have helped our lab to win a large-scale research grant, the "moonshot" project for building next-generation semiconductor devices, from the Ministry of Science and Technology.
- Our lab, together with Brain Research Center in NTHU and other labs around the world, formed an international team led by Columbia University. The team built an online application, the "Fruit-Fly Brain Observatory." The project won the first phase of the Open Science Prize in 2016 and became one of the six finalists among 96 competing international projects.

Research Output

- Ta-Shun Su, Wan-Ju Lee, Yu-Chi Huang, Cheng-Te Wang and Chung-Chuan Lo* (2017). Coupled symmetric and asymmetric circuits underlying spatial orientation in fruit flies. Nature Communications 8:139.
- Po-Yen Chang, Ta-Shun Su, Chi-Tin Shih* and Chung-Chuan Lo* (2017). The Topographical Mapping in Drosophila Central Complex Network and its Signal Routing. Frontiers in Neuroinformatics 11:26.
- Chung-Chuan Lo* and Ann-Shyn Chiang* (2016). Toward Whole-Body Connectomics Journal of Neuroscience 36:45.



Engineering

- Microfluidic Platforms for Rapid Screening of Affinity Reagents Againstcancer by Using Tissue Samples
- Instacardeal – An ECG Biometric Payment System (Use Your Cardiac Signals to Make Deals Instantly!)
- DNA Photonics: Helix and Beyond

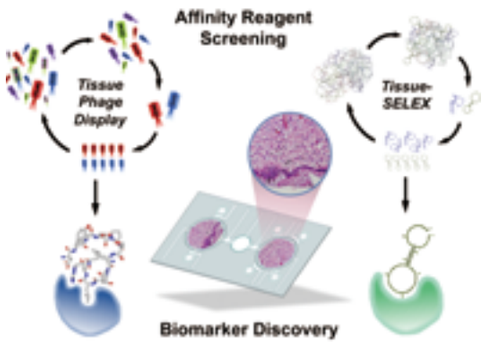
Professor Gwo-Bin "Vincent" Lee/gwobin@pme.nthu.edu.tw

Microfluidic Platforms for Rapid Screening of Affinity Reagents Against Cancer by Using Tissue Samples

Cancer is the most serious disease worldwide and ovarian cancer (OvCa) is the second most common type of gynecological cancer. There is consequently an urgent need for the early-stage detection of OvCa, which requires affinity reagent biomarkers for OvCa. Systematic Evolution of Ligands by Exponential Enrichment (SELEX) and phage display, are two powerful technologies for identifying affinity reagents against biomarkers. The SELEX process identifies target-specific single-stranded DNA (ssDNA) aptamers from a very large oligonucleotide pool through repeated incubation, isolation and amplification procedures. On the other hand, phage display, is a powerful technology to identify peptides or single chain antibodies (scFvs) against target molecules by iterative rounds of in vitro panning and amplification, followed by DNA sequencing. The screened peptides and aptamers (also referred as "artificial antibodies") may likely replace conventional antibodies with comparable or even superior affinity and specificity. However, the benchtop protocols for both screening technologies are relatively lengthy and require well-trained personnel. Recently, microfluidic technologies which are miniaturized biomedical systems with several significant advantages over their large-scale counterparts, have been used for automating labor-intensive and time-consuming in-vitro screening processes, whereby affinity reagents, including aptamers (nucleic acid) and peptides, could be used as probes to recognize molecular biomarkers for a variety of biomedical applications. In comparison to conventional methods, the microfluidic approaches are faster, more compact, require considerably smaller quantities of samples and reagents, and can be automated with less human intervention. Furthermore, they allow for more precise control of reaction conditions (e.g., pH, temperature, and shear forces) such that more efficient screening could be performed.

In our group, we have developed a novel, integrated microfluidic system capable of automating tissue slide-based SELEX (tissue-SELEX) and phage display (tissue phage display) technology. Not only did this microfluidic chip carry out all transportation and reaction steps without major human intervention but it also reduced the time required for screening; furthermore, it also reduced the likelihood of human error. Moreover, it was first of a kind in employing tissue slides as target instead of cell lines. Tissue slides present themselves as complicated targets and, as a result, affinity reagents may uncover valuable information. This allows for the identification of aptamers and peptide probes specific to OvCa cells and tissues. Furthermore, this developed system could be readily modified to uncover affinity reagents for diagnostics or even target therapy of other cancers in the future. After several rounds of automated on-chip tissue-SELEX and phage display, we have identified two aptamer and two peptide probes highly specific to OvCa tissues. By using liquid chromatography–mass spectrometry, bioinformatics, confocal microscopic imaging, and blotting-based analyses, the putative binding targets of aptamers/peptides have also been discovered. It is worth noting that this chip could be readily modified to identify biomarker probes specific to other cancer cells and not limited to use in OvCa.

In conclusion, we have developed a novel microfluidic platform capable of automated screening of two different types of affinity regents (aptamers and peptides) with the future prospective of applications in the field of biomarker discovery using clinical tissue slides.



Prof. Lee and his group have developed a novel microfluidic platform capable of automated screening of two different types of affinity regents (aptamers and peptides) with the future prospective of applications in the field of biomarker discovery using clinical tissue slides.

Microfluidic Biochips Laboratory

Research Highlights

2011 Outstanding Inventor Life-time Award
2013 Fellow, American Society of Mechanical Engineering, USA
2013 Excellent Research Award from Ministry of Science and Technology, Taiwan (the 3rd time)
2014 Fellow, Royal Society of Chemistry, England
2015 Fellow, Institute of Engineering Technology (IET), England
2015 Fellow, School of Engineering, U. Tokyo, Japan
2016 Fellow, Institute of Electrical and Electronics Engineers
2016 National Innovation Award (The 5th time)
2017 Ministry of Education Academic Award (one of the most prestigious awards in Taiwan)
2018 Fellow, American Institute for Medical and Biological Engineering, USA
2018 Corresponding member, International Academy of Engineering

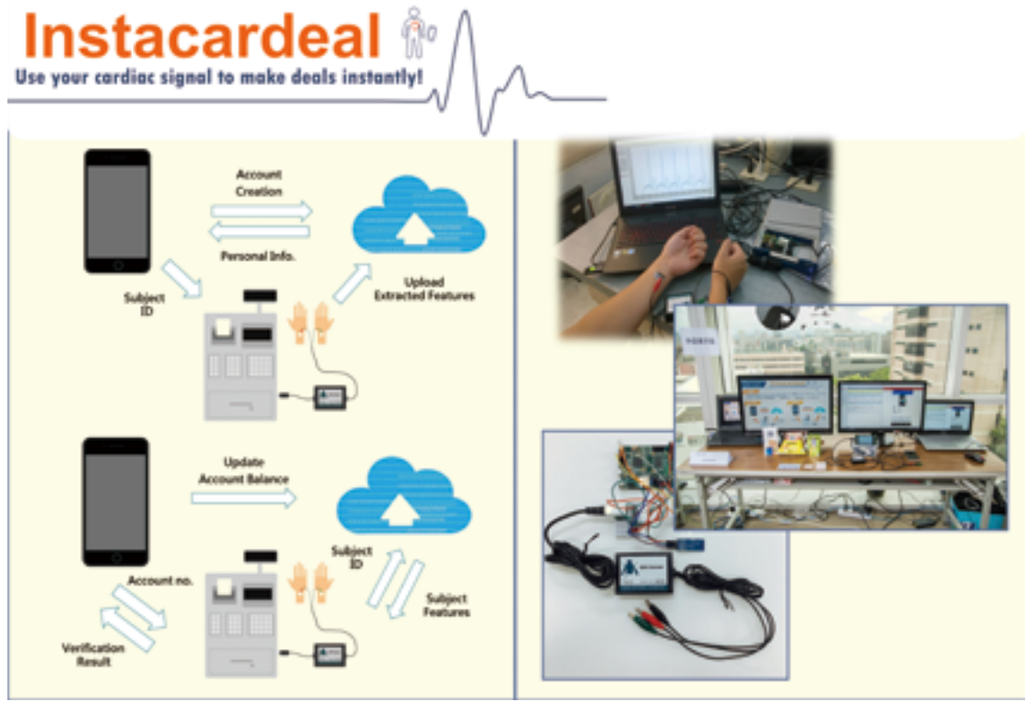
Research Output

- Anirban Sinha, Priya Gopinathan, Yi-Da Chung, Hsin-Ying Lin, Kuang-Hsien Li, Hsi-Pin Ma, Po-Chiun Huang, Shu-Chu Shieh* and Gwo-Bin Lee*, "An integrated microfluidic platform to perform continuous SELEX process to screen affinity reagents specific to cardiovascular biomarkers," Biosensors and Bioelectronics (2018).
- Hong-Lin Cheng, Chien-Yu Fu, Wen-Che Kuo, Yen-Wen Chen, Yi-Shin Chen, Yung-Mao Lee, Kuang-Hsien Li, , Chih-Chen Chen, Hsi-Pin Ma, Po-Chiun Huang, Yu-Lin Wang*, and Gwo-Bin Lee*, Detecting miRNA Biomarkers from Extracellular Vesicles for Cardiovascular Disease with a Microfluidic System," Lab on a chip (2018) (front cover paper).
- Wen-Yen Huang, Shang-Ta Chou, Chia-Hui Chen, Shan-Ying Chou, Jia-Han Wu, Yu-Chen Chen, and Gwo-Bin Lee*, "An Automatic Integrated Microfluidic System for Allergy Microarray Chips," Analyst (2018).
- Yu-Dong Ma, Kang Luo, Wen-Hsin Chang and Gwo-Bin Lee*, "A microfluidic chip capable of generating and trapping emulsion droplets for digital loop-mediated isothermal amplification analysis, "Lab on a chip (2018) (cover paper).
- Yu-Dong Ma, Wen-Hsin Chang, Kang Luo, Chih-Hung Wang, Shih-Yuan Liu, Wen-Hsiang Yen and Gwo-Bin Lee*, "Digitized quantification of DNA through Isothermal Amplification on a Self-driven Microfluidic Chip through a Rapid Surface Modification on Polydimethylsiloxane Channels," Biosensors and Bioelectronics (2018).

Professor Shun-Chi Wu / shunchi.nthu @mx.nthu.edu.tw

Instacardeal – An ECG Biometric Payment System (Use Your Cardiac Signals to Make Deals Instantly!)

With the continuous efforts made to the infrastructure of mobile payment, the sales efficiency in-store, after-sales service and the overall customer satisfaction are highly improved. Despite the convenience offered by this novel payment mechanism as compared to the traditional approaches like cash, its application is also accompanied by security concerns. Relying on the physiological or behavioral traits that are unique to individuals for identity recognition, biometric technologies are now commonly seen in applications such as access control. Recently, the use of electrocardiograms (ECGs) as biometrics for recognition is gaining increasing interest. ECGs are the recordings of the cardiac electrical activity generated by repeated depolarization and repolarization of the heart's atria and ventricles. Because every individual has his/her own internal physical geometry between the pericardium and torso surface, the conductivity distribution therein will be unique and thus will provide morphological dissimilarity in the ECG data. This makes the use of ECGs as a biometric modality possible.



An ECG biometric payment system, named Instacardeal, is realized by Peng-Tzu Chen, Nai-Jun Shao, and Shi-Ying Wei, Jing-Wen Zheng, Jia-Ying Lin and Yen-Ming Shang under the guidance of Prof. Shun-Chi Wu (refer to the above figure on the right). Instacardeal won the top prize of 2017 ARM Design Contest. Lying in the core of this system is an algorithm to convert the ECGs into an abstract representation, referred to as a biometric template, during enrollment. This template is then stored in a cloud database for further applications. The payment process is initialized by the Instacardeal App that commands the specially designed cashier to acquire the ECGs from a user, to retrieve his/her stored template, and to perform identity verification via template matching. The authorized user is then allowed to make the payment. One thing to emphasize is that all the personal information in the cloud database can only be accessed by the Instacardeal cashier; the mobile phone does not have this information at any time and thus eliminates the system security threat caused by the loss of the phone (refer to the above figure on the left).

Despite the convenience offered by biometric technologies in identity recognition, their applications are accompanied by security and privacy concerns. Our effort toward the advancement of the authentication algorithm is to include the concept of cancelable biometrics. The idea involves enabling a biometric template to be revocable like a password. Distinct templates associated with the same biometrics are generated by distorting them differently. Recovering the original biometric from its template is infeasible so that the private information therein can be protected. We currently have an industry-university cooperative research project to enable this advancement.

(from right) Professor S.-C. Wu, P.-T Chen, N.-J. Shao and S.-Y. Wei

Research Highlights

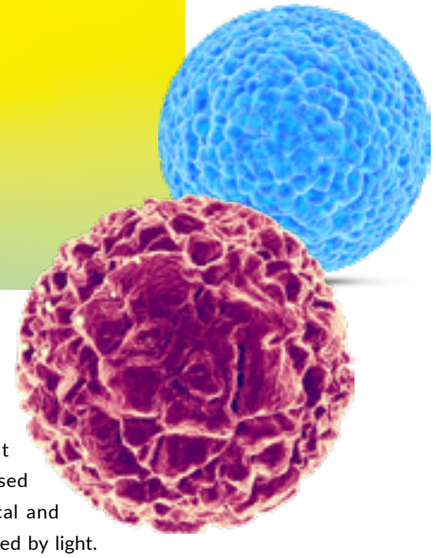
- The First Prize of ARM Design Contest 2017

Research Output

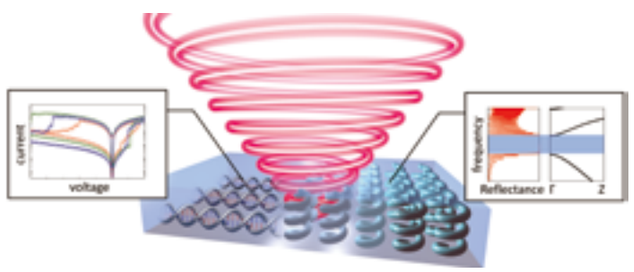
- Shun-Chi Wu*, Peng-Tzu Chen and Jui-Hsuan Hsieh, "Spatiotemporal features of electrocardiogram for biometric recognition," Multidim Syst Sign Process (2018). https://doi.org/10.1007/s11045-018-0593-1.

Professor Yu-Chueh Hung/ychung@ee.nthu.edu.tw

DNA Photonics: Helix and Beyond



DNA is a well-known biomolecule that carries genetic information in organisms and is also broadly employed in nanotechnology as a building block for complex nanostructures. As one kind of biopolymers, DNA has also emerged as an attractive biomaterial for applications in photonics and electronics. In the past years, Prof. Yu-Chueh Hung has conducted interdisciplinary research on developing key technologies in advancing the field of DNA biopolymer photonics, exploring the fascinating DNA biomaterial from different perspetives. By virtue of the unique features of DNA biomaterial, Prof. Hung's research group has demonstrated several DNA biopolymer-based devices for applications in lasers, light-emitting devices, nanofabrication, and light-harvesting devices. Combining the DNA-templating feature and the photochemical synthesis, Prof. Hung also developed a photo-triggered approach to fabricate DNA biopolymer-based nanocomposites. By this technique, Prof. Hung's group has demonstrated the fabrication of composites and complex metallic nanostructures by light irradiation. This technique also facilitates the development of versatile DNA biopolymer-based nanocomposites, where electrical and optical properties can be controlled by light. Based on this platform, optically-controlled DNA nanocomposites are used in resistive switching devices for data storage, where various switching scenarios can be achieved by tuning the durations of light irradiation. The unique approach to demonstrate DNA biopolymer for data storage applications has been previously highlighted in international journals and media. In recent years, Prof. Hung's efforts are devoted to the development of simple and robust platforms for DNA biopolymer devices and the exploration of physics of DNA biopolymer devices.



Another research effort, inspired by the helical structure of DNA molecule, has been devoted to the physics and applications of helix media. The interaction between electromagnetic waves and a helical medium gives rise to various interesting effects for circularly polarized light, originating from the chirality of the helical structure. Rigorous electromagnetic analysis based on numerical method is carried out to examine the complex responses of helix nanostructures. It is meant to develop full capability to manipulate electromagnetic responses of the materials for achieving desired optical properties for photonics applications. In the past years, Prof. Hung's group has presented a simple dipolar interaction model to explain the complex coupling of electromagnetic field and mode splitting behaviors in 3D helix metamaterials. Compared to the single helix, her group shows that DNA-like double helix structures exhibit enhanced coupling effects in dipolar interaction, leading to an even broader band with a high level of circular dichroism. The analysis provides a physical understanding of the resonant behaviors that can guide the design of metallic helix metamaterials and tailor the resonant properties. Another work is the demonstration of a gold helix photonic metamaterial that can achieve broadband, high transmission, large optical activity, and low dispersion in one structure at optical frequencies. Such broadband dispersion-free optical rotation at the telecommunication wavelength is of great interest for high-performance polarization manipulation. Prof. Hung's group also carried out in-depth studies on dielectric helix nanostructures. Compared to the planar chiral configuration, the unique 3D helical arrangement provides another degree of freedom in the manipulation of chiro-optical properties. As opposed to the conventional dielectric helical structure, like cholesteric liquid crystals, her group presented many optical properties that have not been observed in other chiral media counterparts. For example, dual circular polarization gaps are demonstrated in the helix structure consisting of helices with only single handedness. The response of the opposite handedness has been attributed to the emerge of the opposite chiral motifs in the 3D helical arrangement. Furthermore, circular polarization gaps originating from other mechanism, besides the well-known Bragg condition, have been revealed. The interplay of circular polarization gaps with different origins provides versatile scenarios of circular polarization-dependent optical properties. The investigation enables the realization of novel and functional nanostructures for photonic devices that will pave the way towards new photonics technologies.

Prof. Y. C. Hung (middle row, 2nd from the right) and students

Research Highlights

- Wu Ta-You Memorial Award, Ministry of Science and Technology, 2017

Research Output

- H. T. Tung, Y. K. Chen, P. L. Jheng, and Y. C. Hung, Origin and manipulation of band gaps in three-dimensional dielectric helix structures. Optics Express, 25(15), 17627-17638, 2017.
- H. Y. Jeng, T. C. Yang, L. Yang, J. Grote, H. L. Chen, and Y. C. Hung, Non-volatile resistive memory devices based on solution-processed natural DNA biomaterial Organic Electronics, 54, 216-221, 2018.

Humanities and Social Sciences

- Explorations of the Sangleys' Manuscript of Herzog August Bibliothek

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Explorations of the Sangleys' Manuscript of Herzog August Bibliothek

Our cooperative research project aims at probing the early modern Hokkienese manuscript dubbed 佛郎機化人話簿 Hut-long-ki hua-lang ua phoo (The Sangleys' Spanish Learner), lying dormant in the archives of Herzog August Bibliothek for centuries, which can be construed as a pen-recorder or a time capsule that helps us travel backwards to the seventeenth century. It captures in long hand fresh daily used lexical items and conversations in permanent records.

There are four aspects attesting to its significance: First, the exchange between the Spaniards and Hokkiense (the Sangleys) are truly mutual rather than unidirectional. Not only were the Spanish preachers of Dominican order earnest in seeking methods of learning Hokkienese, the Hokkiense were also equally enthusiastic about and took the initiative to devise ingenious ways of learning Spanish. Second, demotic characters current in various genres of written documents represent the much-neglected vibrant legacy of early modern popular (as opposed to elite) culture. The widespread prevalence is attested by local rime books, theoretical scripts and local classified books. The unearthed manual preserved abroad, a thesaurus-like source of knowledge, features a wide range of basic lexical items classified in terms of semantic fields, and simple sentences used in daily conversations.

Third, we will tackle a whole range of linguistic issues pertaining to phonology, morphology and syntax of Southern Min in the seventeenth century. It aims at shedding light on the linguistic situation of early modern Hokkienese Southern Min. Fourth, this historical document goes a long way of deepening our understanding of the important role of Hokkienese sea-faring explorations in the great era of voyage. The Hokkienese diaspora extends beyond the Philippines (formerly Luzon) to areas as far as Kepulauan Maluku, spice islands. It provides unmistakable evidence that Hokkienese had long begun the south-bound commercial foray in the south pacific, independently and without any official support, in the seventeenth century when Spain witnessed its golden age as a maritime power. Their prowess and accomplishments were never be eclipsed by the westerners.

The Sangleys' Spanish Learner

(from left) Professor Yuchung Lee, Professor Chinfa Lien, Professor Ying Cheng.

Research Highlights

- Chinfa Lien, 2017-2018. President of International Association of Chinese Linguistics.

Research Output

- Lee, Fabio Yu-chung & José Luis Caño Ortigosa (chief editors). 2017. Studies on the Map Ku Chin Hsing Sheng Chih Tu, (Hsin-chu, Research Center for Humanities and Social Sciences, National Tsing Hua University)
- 李毓中、張巍譯，〈洋「老爺」的一天：從《拜客訓示》看明末耶穌會士在中國〉，《清華學報》第 46 卷 1 期 (2016,03)，頁 77-119(THCI Core)。
- 李毓中，〈Antonio Perez：一個華人雇傭兵與十六世紀末西班牙人在東亞的拓展〉，《漢學研究》第 34 卷 1 期 (2016,03)，頁 123-152(THCI Core)。
- Lee, Fabio Yu-Chung. 2014. "Fetching Human Galls as an Offering For the King: Customs of Champa in late 16th century as depicted in Spanish documents", Temas Americanistas no. 32.06, pp. 279-302. (SCOPUS).
- 鄭縈、曹逢甫 2012 《華語句法新論下》，董鵬程策劃、柯華葳主編《對外華語文教學研究叢書》，正中書局。
- 鄭縈、鄭思婷 2015〈閩南語體標記「過」篇章語法初探〉，《臺灣語文研究》第十卷第一期，頁 99-118。
- 鄭縈 2014 日常敘事中台灣閩南語短時義時段詞的用法，《台灣學誌》第 10 期，頁 27-59。
- Lien, Chinfa. 2017a. The Emergence of E5 khuan2 个款 as a Sensory Evidential Marker in TSM. International Journal of Chinese Linguistics 4,2,. 173–190. December.
- Lien, Chinfa. 2017b. Human-denoting Interrogative Words in Early Southern Min : Coexistence and evolution. In Peng Gang and Wang Feng (eds.) New Horizons in Evolutionary Linguistics, Monograph Series Number 27. 130-158. April. The Chinese Uniersity Press of Hong Kong.
- Tsai, Chenghung and Chinfa Lien.2018. second author. On How to Defend or Disprove the Universality Thesis. In Stephen Stich, Masaharu Mizumoto, and Eric McCready (eds.) Epistemology for the Rest of the World. 267-278. Oxford: Oxford University Press.
- 連金發 2018. 早期閩南語戲文中「句」的語意詮釋：語意延伸和語用推論 . 清華學報 48.1. : 113-141.

Digital Art

- Tsing Hua Effects 2018 – IoT Technology and Art Exhibition

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Tsing Hua Effects 2018 – IoT Technology and Art Exhibition

After a year of planning by myself (Su-Chu Hsu), the Tsing Hua Effects 2018 – IoT Technology and Art Festival in conjunction with university anniversary events was finally kicked off on April 28 for a two-month duration. I acted as the exhibition curator, Shih-Ta Liu as the technical director, and Chi-Hung Tsai as the design director. This was the first large-scale outdoor technology and art exhibition in Taiwan that combined big data with the Internet of Things (IoT), marking the beginning of the interdisciplinary integration of technology and art at National Tsing Hua University (NTHU).

The festival featured 10 beautiful interactive pieces of light and shadow at the campus lawn, Cheng Kung Lake, Pigeon Square, and snack bar, including Window by Trio Rice Balls; Needle Work by Shu-Chao Hou-Wang; Planting Light by Chi-Hung Tsai; Mushroom Story by Su-Chu Hsu, Shih-Ta Liu, and Po-Yao Wu; Prismatic Color by Yi-Ting Tsai; Geometric Interspace by Wei-Yu Chen; Pressure Effects by Ching-You Lin; English 8-2 by Shih-Ta Liu, Su-Chu Hsu, and Che-Yu Wu; Prairie Coordinates by Te-Liang Kao; and WINDIODE by Wi-Chieh Shih. In addition to reflecting the authors' creative ideas, these works allowed Tsing Hua to "feed" data to scientific and artistic works at designated places and times, such as college learning data, important digital memory of school founding, vocabulary of Tsing Hua impression, interactive behavior data, numbers of people entering the library, outdoor pleasure index, achievements in English, South Gate flow, and Hsinchu wind. Viewers could interact with the pieces or appreciate the content of the data, which was different from the past when people only passively accepted what the artist wanted to display, thus giving viewers new experience and surprise that the whole campus seemed to come alive.

Installed on the North Gate lawn, the work Window set a window on the grass in the daytime as an outlet, which reflected the real figure of the scene behind. When night was beginning to fall, the lights were turned on and the window lost its penetrating feature. It shined through the eight panes for different colleges, allowing the enrollment data and learning data of each college at NTHU to be presented in the form of light. For example, for the top three NTHU colleges with the largest number of students, the light was given out from the panes of the College of Engineering, the College of Electrical Engineering and Computer Science, and the College of Science. For the top three NTHU colleges with students' performance in school and extramural activities, the light was on from the panes of the College of Engineering, the College of Nuclear Science, and the College of Technology Management. As for the NTHU colleges with female students with excellent academic performance, it turned out that all the panes were lit up, meaning that all colleges' female students were doing better than male students.

By Cheng Kung Lake, mushrooms from Mushroom Story would change with what visitors said to them. The 10 mushrooms beside the lake were divided into the "music mode" and "vocabulary mode." When the viewer stood next to the mushrooms in music mode, the mushrooms would play the theme music and even accompany each other if other people touched several other ones, just like a small orchestra on the lawn. The mushrooms in vocabulary mode allowed people to record or write down what they wanted to say about NTHU through the App. These voice and text materials would be "fed" to the mushrooms, turning them into a recorder, so that the public's impression of NTHU could be heard by teachers and students passing by.

During the exhibition, six pyramidal luminaries from Prismatic Color were floating on Cheng Kung Lake frequented by many people. The six luminous objects representing six buildings of the school were lighted up at 6 pm sharp every evening, at which, as long as people used their mobile phones to scan the QR Code on the piece's description board, the mobile phone would become a remote control immediately, with which people could change the lighting colors at any time as one pleased.

Prismatic Color makes Cheng Kung Lake colorful and beautiful at night

Sitting opposite the auditorium was the artwork Planting Light, which set up a Möbius strip on a big tree symbolizing infinite circulation, connecting two-dimensional curvature on both sides. Under the harmonious halo of gradual evolution, electric lights and plants depended on each other, opening up a discussion of how natural life could be deconstructed to find a way out. The time of 6 pm sharp reflected the

People listen to the talking mushrooms about every one's impression of NTHU.

Planting Light uses the bright and dark tubes in the form of a bar code to present NTHU history

important number in NTHU history. The bright and dark tubes in the form of a bar code were used to present the number, just like the memory marked by light password.

Located on the South Gate lawn, Prairie Coordinates inserted horizontal laser beams into the lawn, cutting through the horizontal light in the grassland growing vertically, forming "coordinates," so that the space was rearranged. Laser light hit the light-producing worms climbing on the grass branches on the grassland, where the beams and the projected grassland formed an interdependent relationship, thus creating a confused visual space caused by clear light scanning, like in the world of the movie Avatar. Moreover, the data at 6pm sharp was about the traffic flow at NTHU South Gate—the heavier the traffic flow, the more active and alive light worms.

Prairie Coordinates creates a world like the movie Avatar

Installed at the door of the TSMC Building, WINDIODE would swing and flicker with the strength of the wind detected on the scene. Each carbon fiber rod was equipped with a simple balance instrument and an LED, which would flash when the wind tilted the carbon fiber rod. The 500 replicates produced a Windiode swaying in the wind. The wind force and the resilience of the carbon fiber rods created a sequence of flickers for the Windiode, from which a beauty of rhythm built on randomness could be observed.

WINDIODE is swinging and flickering in the wind in front of the TSMC Building

The purpose of Tsing Hua Effects 2018 was to (1) create a form combining public art and data works, through which the concept of data sculpture at Tsing Hua Effects could be demonstrated; (2) enable teachers and students understand the infinite possibilities from technology combined with art on campus, and stimulate more interdisciplinary cooperation; and (3) let teachers and students interact with the public directly on campus, so that art could be appreciated easily and technology could be understood by the people.

President Hong Hocheng said that the IoT Technology and Art Festival was a special event, and that through interaction, people became creators in the viewing process, a new scene after merging National Hsinchu University of Education

President Hong Hocheng, Honorary Dean Shu-Chao Hou-Wang of the College of Arts, and Dean Su-Chu Hsu officiate the light-up ceremony

Research Output

Academic Bibliographies in the Past Three Years

Journal Papers

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Note

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