

National Tsing Hua University

2013-2014

R&D

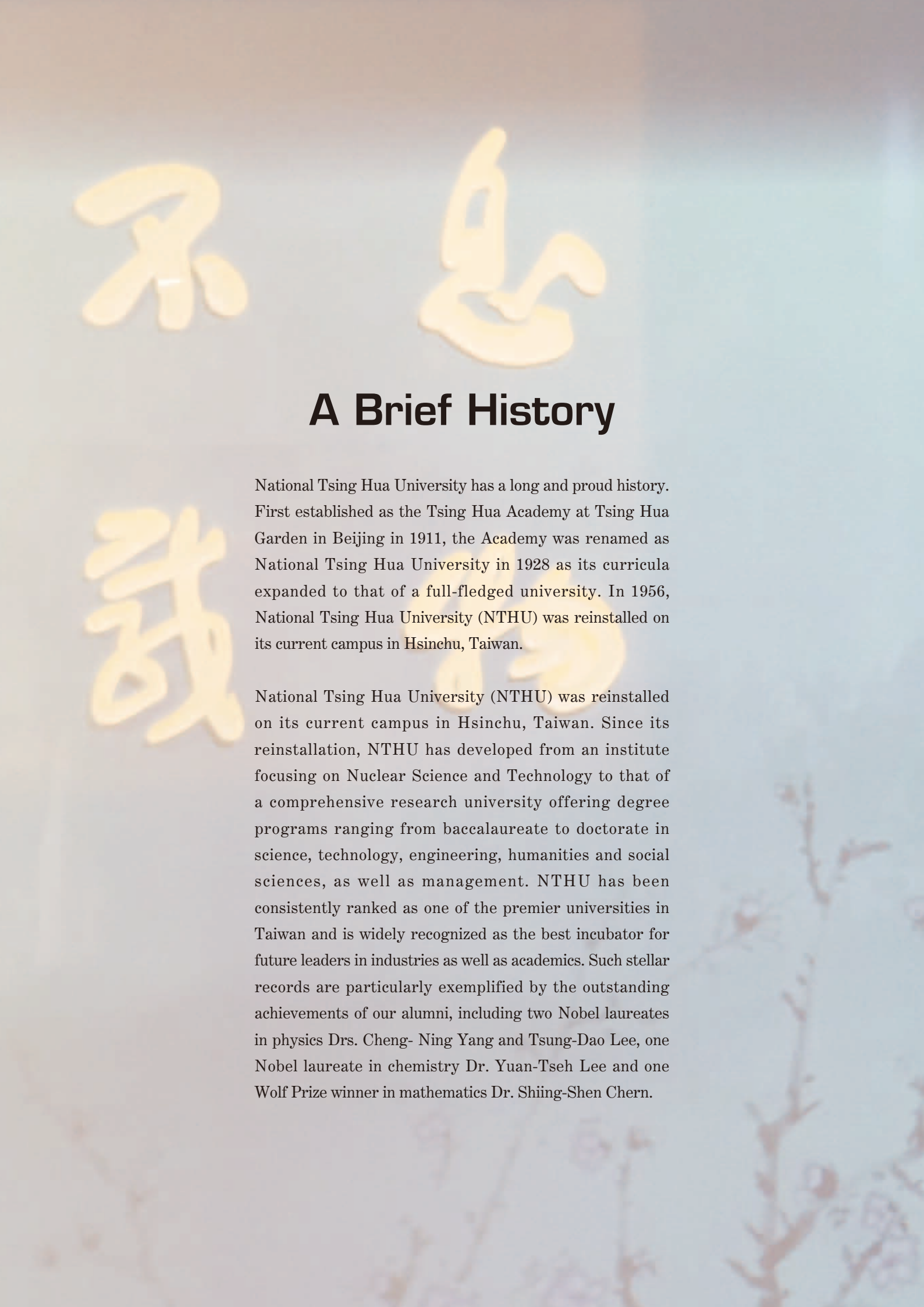
REPORT



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A Brief History

National Tsing Hua University has a long and proud history. First established as the Tsing Hua Academy at Tsing Hua Garden in Beijing in 1911, the Academy was renamed as National Tsing Hua University in 1928 as its curricula expanded to that of a full-fledged university. In 1956, National Tsing Hua University (NTHU) was reinstalled on its current campus in Hsinchu, Taiwan.

National Tsing Hua University (NTHU) was reinstalled on its current campus in Hsinchu, Taiwan. Since its reinstallation, NTHU has developed from an institute focusing on Nuclear Science and Technology to that of a comprehensive research university offering degree programs ranging from baccalaureate to doctorate in science, technology, engineering, humanities and social sciences, as well as management. NTHU has been consistently ranked as one of the premier universities in Taiwan and is widely recognized as the best incubator for future leaders in industries as well as academics. Such stellar records are particularly exemplified by the outstanding achievements of our alumni, including two Nobel laureates in physics Drs. Cheng- Ning Yang and Tsung-Dao Lee, one Nobel laureate in chemistry Dr. Yuan-Tseh Lee and one Wolf Prize winner in mathematics Dr. Shiing-Shen Chern.

Message from the President

National Tsing Hua University (NTHU) is a top-tier research university with a long and proud tradition. Since the re-establishment in Hsinchu in 1956, NTHU has been known for excellent academic programs as well as outstanding alumni. Over the last fifty-eight years, NTHU has transformed herself into a comprehensive university and is highly regarded in all of our academic programs.

To date, NTHU provides a stimulating and nurturing environment within which our faculty can offer quality teaching and conduct innovative research. Our research and development activities emphasize fundamental discoveries at the forefronts of basic sciences and exploration of disruptive technologies with a high potential for real applications. These are reflected from our publications in the world's preeminent journals, awarded international patents, and technology transfer cases. In the 2013-2014 R&D annual report, we highlight several key scientific breakthroughs, discoveries that have significant technological impacts and exemplary publication in diverse fields covering all academic units of the university. Also, we provide facts and figures related to other important R&D activities. The volume is undoubtedly too limited to give the full scope of R&D at NTHU, just a glimpse into our recent achievements. Hopefully, this can serve as a catalyst for further interactions, exchange of ideas, and establishment of collaborations, with our global partners.

Built on our proud heritage, NTHU will continue to pursue excellence in teaching and research with the goal of ascending the University into the class of world-leading top academic institutions. I hope that you will find this R&D annual report useful. Your comments and suggestions would be greatly appreciated.

President Hong Hocheng

National Tsing Hua University
Hsinchu, Taiwan
November 2014





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NTHU Today

Location

National Tsing Hua University is located in Hsinchu, a city 72 kilometers south of Taipei. The campus covers an area of over 105 hectares (260 of acres) of scenic land with lakes and trees. The campus is conveniently located, neighboring research institutes and universities such as the Hsinchu Science Park (HSP), the Industrial Technology Research Institute (ITRI), National Synchrotron Radiation Research Center (NSRRC), National Center for High-Performance Computing (NCHC), Food Industry Research and Development Institute (FIRDI), National Chiao Tung University (NCTU), Chung Hua University (CHU), and National Hsinchu University of Education (NHCUE). These establishments have made Hsinchu known as 'the Science City of Taiwan'.

Academics

(7 Colleges, 1 Commission, 17 Departments, and 24 Institutes)

-  COLLEGE OF SCIENCE
-  COLLEGE OF ENGINEERING
-  COLLEGE OF NUCLEAR SCIENCE
-  COLLEGE OF HUMANITIES AND SOCIAL SCIENCES
-  COLLEGE OF LIFE SCIENCE
-  COLLEGE OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
-  COLLEGE OF TECHNOLOGY MANAGEMENT
-  COMMISSON OF GENERAL EDUCATION



B:Baccalaureate / M:Master / D:Doctorate

COLLEGE OF SCIENCE	DEGREE PROGRAM OFFER
Department of Mathematics	B / M / D
Department of Physics	B / M / D
Department of Chemistry	B / M / D
Institute of Statistics	M / D
Institute of Astronomy	M / D
Interdisciplinary Program of Sciences	B
Graduate Program in Science and Technology of Synchrotron Light Source	M / D
COLLEGE OF ENGINEERING	DEGREE PROGRAM OFFER
Department of Chemical Engineering	B / M / D
Department of Materials Science and Engineering	B / M / D
Department of Power Mechanical Engineering	B / M / D
Department of Industrial Engineering and Engineering Management	B / M / D
Interdisciplinary Program of Engineering	B
Institute of NanoEngineering and MicroSystems	M / D
Industrial Engineering and Engineering Management Master Program	M
Institute of Biomedical Engineering	M
Program of Advanced Energy	D
COLLEGE OF NUCLEAR SCIENCE	DEGREE PROGRAM OFFER
Department of Engineering and System Science	B / M / D
Department of Biomedical Engineering and Environmental Sciences	B / M / D
Interdisciplinary Program of Nuclear Science	B
Institute of Nuclear Engineering and Science	M / D
Graduate Program in Science and Technology of Synchrotron Light Source	M / D
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES	DEGREE PROGRAM OFFER
Department of Chinese Literature	B / M / D
Department of Foreign Languages and Literature	B / M
Interdisciplinary Program of Humanities and Social Sciences	B
Institute of History	M / D
Institute of Linguistics	M / D
Institute of Anthropology	M / D
Institute of Sociology	M / D
Institute of Philosophy	M
Institute of Taiwan Literature	M / D
Graduate Program on Taiwan Studies	M
International Master's Program in Inter-Asia Cultural Studies (University System of Taiwan)	M
COLLEGE OF LIFE SCIENCE	DEGREE PROGRAM OFFER
Department of Life Science	B
Department of Medical Science	B
Interdisciplinary Program of Life Science	B
Institute of Molecular and Cellular Biology	M / D
Institute of Molecular Medicine	M / D
Institute of Bioinformatics and Structural Biology	M / D
Institute of Biotechnology	M / D
Institute of Systems Neuroscience	M
Medicine Biotechnology Program	M / D
Structural Biology Program	D
COLLEGE OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE	DEGREE PROGRAM OFFER
Department of Electrical Engineering	B / M / D
Department of Computer Science	B / M / D
Interdisciplinary Program of Electrical Engineering and Computer Science	B
Institute of Electronics Engineering	M / D
Institute of Communications Engineering	M / D
Institute of Information Systems and Applications	M / D
Institute of Photonics Technologies	M / D
Communications Engineering and Biology Information Program	D
COLLEGE OF TECHNOLOGY MANAGEMENT	DEGREE PROGRAM OFFER
Department of Quantitative Finance	B / M
Department of Economics	B / M / D
Double Specialty Program of Management and Technology	B
Institute of Technology Management	M / D
MBA	M
Institute of Law for Science and Technology	M
EMBA	M
IMBA	M
Institute of Service Science	M
COMMISSION OF GENERAL EDUCATION	DEGREE PROGRAM OFFER
Institute of Learning Sciences	M

Personnel

Academic	Title	Total	Staff	Total
Full-Time(644)	Professor	343	Regular	213
	Associate Professor	167	Campus Police	26
	Assistant Professor	122	Term Appointment	464
	Instructor	7	Research Staff (Funded by projects)	432
	Military Instructor	5		
Research Fellow		257		
Faculty Term Appointment		25		
Adjunct Professor		298		

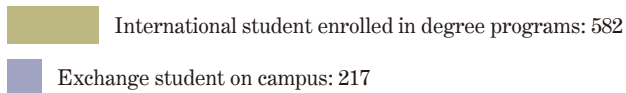
Number of domestic students, as of 2014

Total: 12,291



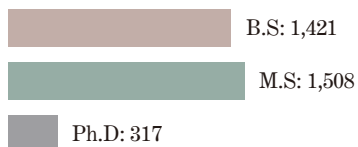
Number of international students, as of 2013

Total: 799



Number of graduates, as of 2013

Total: 3,246

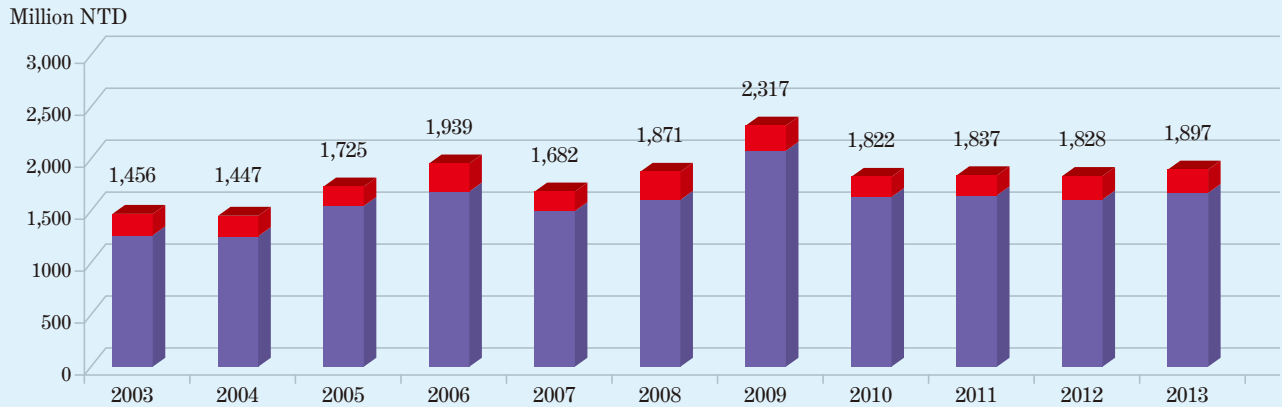


R&D Facts and Figures

Research Fund (2003-2013)

■ Industry & Others ■ Government

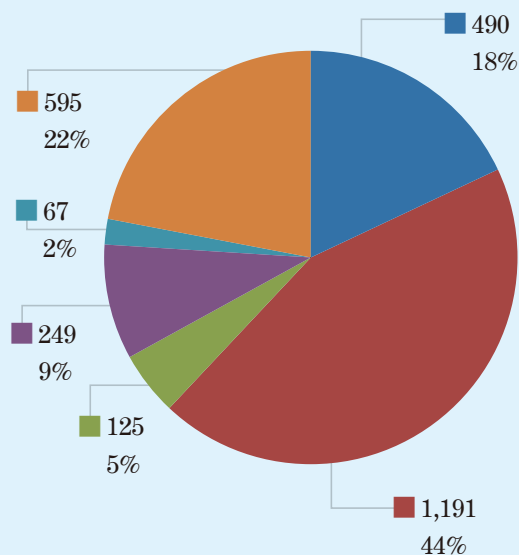
Unit: Million NTD
30 NTD ≈ 1 USD



Funding Distribution by Discipline (2013)

- Physical Sciences
- Engineering
- Social Sciences
- Life Sciences
- Arts & Humanities
- Clinical, Pre-Clinical & Health

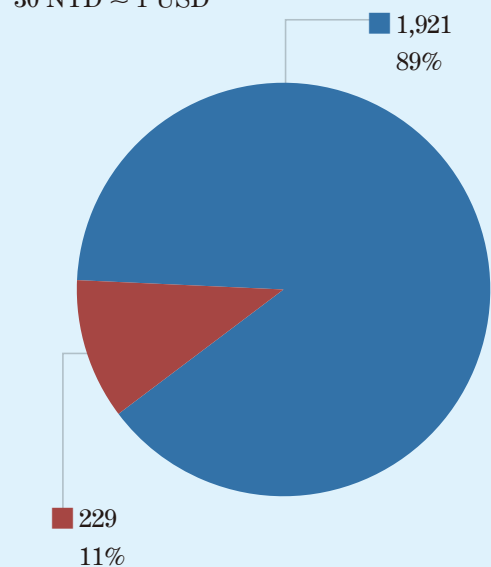
Unit: Million NTD
30 NTD ≈ 1 USD



Sponsored Research Fund (2013)

- Research grant income from public sources and charities
- Research contract income from industry and commerce

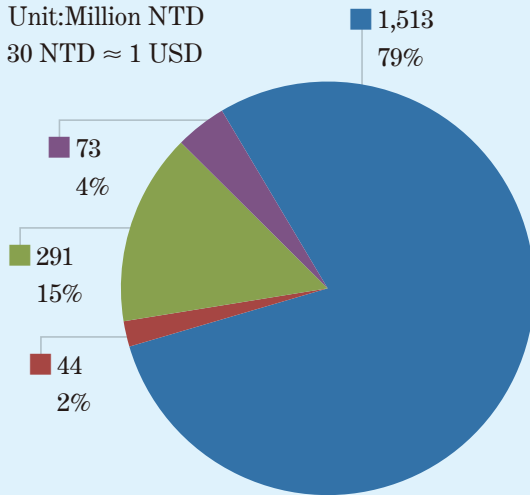
Unit: Million NTD
30 NTD ≈ 1 USD



Government-Sponsored Research Fund (2013)

- National Science Council
- Ministry of Economy
- Ministry of Education
- Others

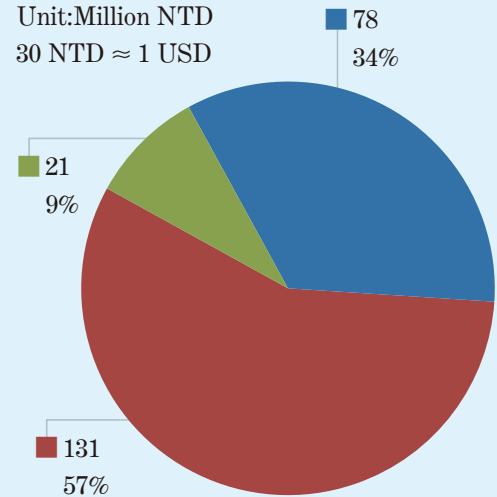
Unit: Million NTD
30 NTD ≈ 1 USD



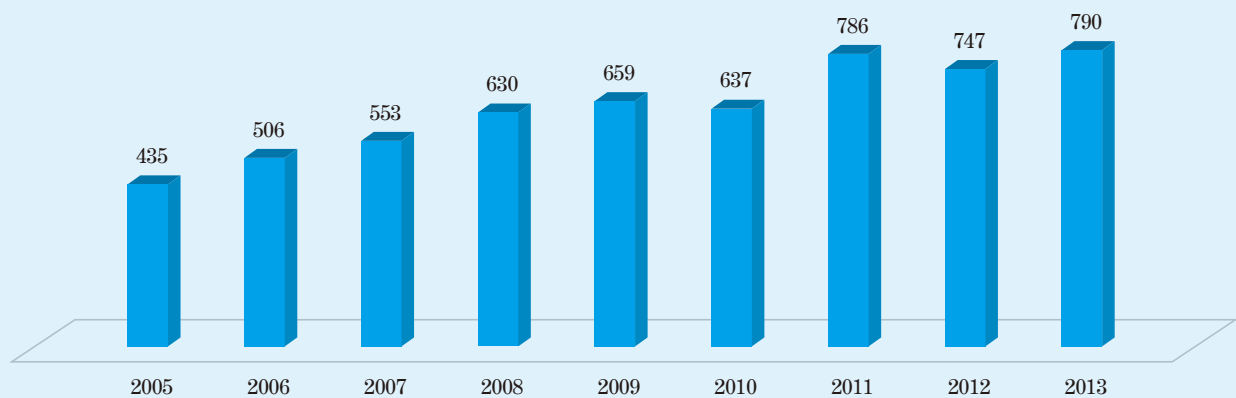
Non-Government Sponsored Research Fund (2013)

- Non-Profit Organization
- Industry
- Overseas

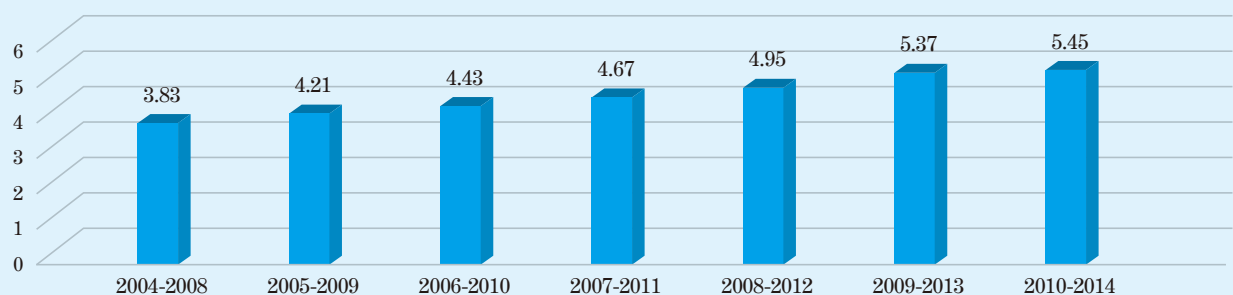
Unit: Million NTD
30 NTD ≈ 1 USD



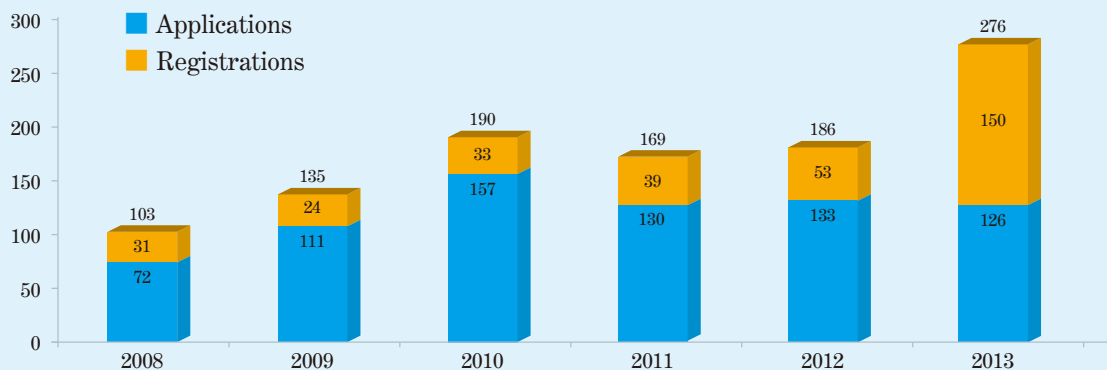
Number of SCI/SSCI Papers Published in Journals with Impact Factors Ranked in Top 15% Of Category (2005-2013)



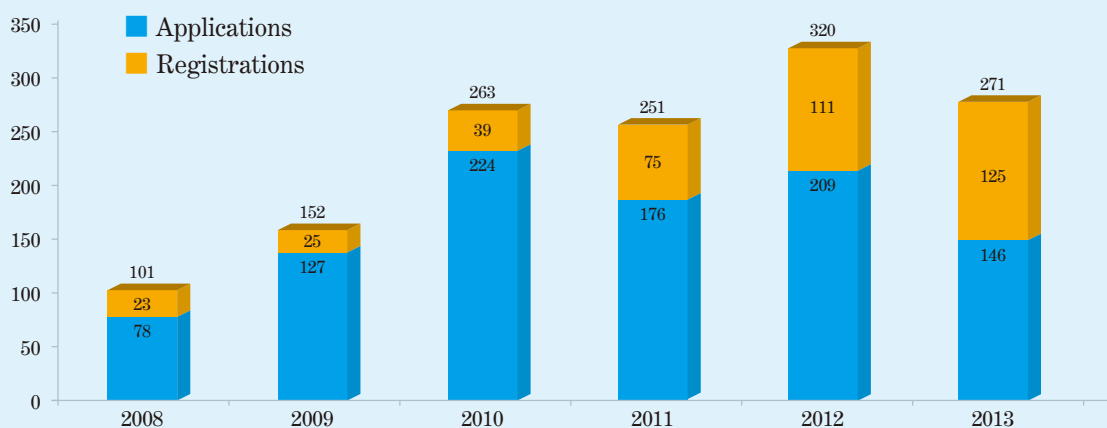
Citations per Paper (2004-2014)



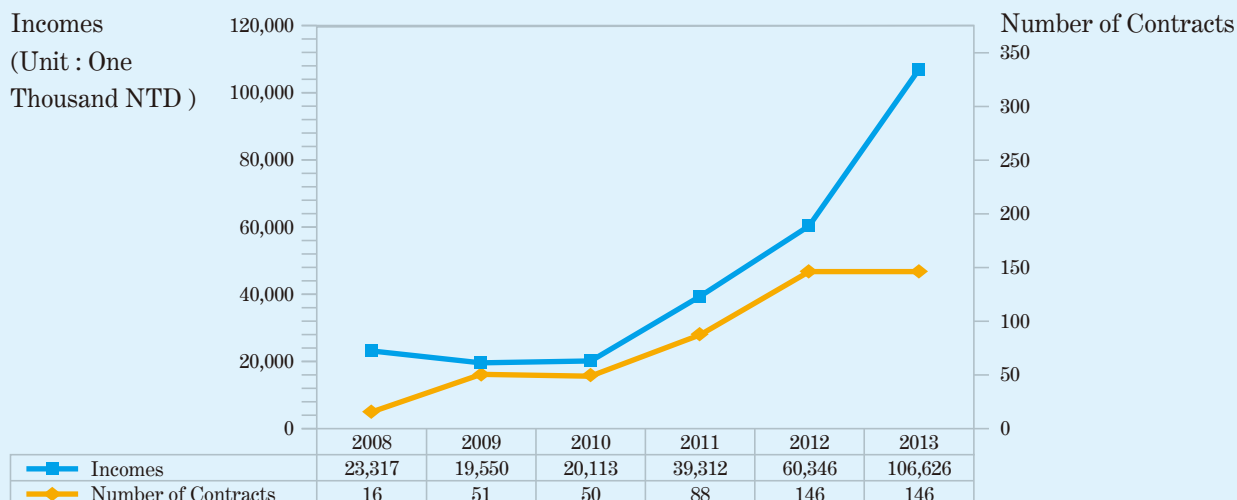
Taiwan Patent Applications and Registrations (2008-2013)



International Patent Applications and Registrations (2008-2013)



Technology Transfer Incomes (2008-2013)



Scientific Breakthroughs

Crystalline Inorganic Frameworks with 56-Ring, 64-Ring, and 72-Ring Channels

Prof. Sue-Lein Wang

Proton Structure from the Measurement of 2S-2P Transition Frequencies of Muonic Hydrogen

Prof. Yi-Wei Liu

Structural Biological Materials: Critical Mechanics-Materials Connections

Prof. Po-Yu Chen

Parallel Neural Pathways Mediate CO₂ Avoidance Responses in *Drosophila*

Prof. Ann-Shyn Chiang

Direct observation of the transition from indirect to direct band gap in atomically thin epitaxial MoSe₂

Prof. Horng-Tay Jeng

In situ observation of step-edge in-plane growth of graphene in a STEM

Prof. Po-Wen Chiu

Optogenetic control of selective neural activity in multiple freely moving *Drosophila* adults

Prof. Ann-Shyn Chiang, Prof. Chien-Chung Fu

Modern Recipe for Preserving Ancient Chinese Scrolls

Prof. Tzay-Ming Hong



Crystalline Inorganic Frameworks with 56-Ring, 64-Ring, and 72-Ring Channels

Prof. Sue-Lein Wang

Science, vol. 339, pp. 811–813 (2013)

The development of zeolite-like structures with extra-large pores (>12-membered rings, 12R) has been sporadic and is currently at 30R. In general, templating via molecules leads to crystalline frameworks, whereas the use of organized assemblies that permit much larger pores produces noncrystalline frameworks. Synthetic methods that generate crystallinity from both discrete templates and organized assemblies represent a viable design strategy for developing crystalline porous inorganic frameworks spanning the micro and meso regimes. We show that by integrating templating mechanisms for both zeolites and mesoporous silica in a single system, the channel size for gallium zincophosphites can be systematically tuned from 24R and 28R to 40R, 48R, 56R, 64R, and 72R. Although the materials have low thermal stability and retain their templating agents, single-activator doping of Mn^{2+} can create white-light photoluminescence.

Zeolite-like structures with extra-large pores (>12-membered rings, 12R) are always the focus of attention as they may promise new properties and applications.

Relative to the more recent metal-organic frameworks, progress in the expansion of inorganic channels has tended to be slow, sporadic, and is currently at 30R, without any way to predict the next channel-ring size. This difficulty could be attributed to the lack of tunable spacer units (e.g., organic linkers) and an inability to control the linkages of the inorganic units. In addition, limitations in channel or pore size may result from the fact that organized assemblies such as surfactant-based templates, while capable of creating large pore sizes, generally lead to disordered wall structures as exemplified by the mesoporous silicates. Thus far, the rational design of microporous and mesoporous inorganic frameworks with ordered wall structures has not been reported.

Synthetic methods that generate crystallinity from both discrete templates and organized assemblies represent a viable design strategy for developing crystalline porous inorganic frameworks spanning the micro and meso regimes. We show that by integrating templating mechanisms for both zeolites and mesoporous silica in a single system, the channel size for gallium zincophosphites (referred to as NTHU-13 family) can be systematically tuned from 24R and 28R to 40R, 48R, 56R, 64R, and 72R (Figure 1).

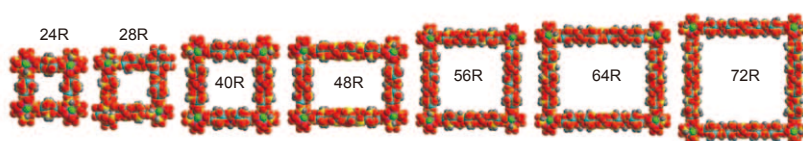


Fig 1. Systematic expansion of structures with extra-large channels with ring size ranging from 24R to 72R.

Previous efforts that used monoamines with long straight carbon chains (>8C) in microporous material synthesis often led to lamellar-phased products. We found that we could increase the likelihood of larger channels by using heterometal centers. In single-metal systems, an increase in template size led to different structures rather than the expansion of ring sizes in the channels. In this study, we used the zinc-gallium bimetallic system and found that increasing the template from 4C-containing (4C') butylamine to 6C' hexylamine was sufficient to enlarge the channel sizes from 24R to 28R, creating 28R-NTHU-13 with a channel diameter exceeding 1 nm. In subsequent reactions, the use of longer amine (8C' octylamine, 10C' decylamine, or 12C' dodecylamine) created the larger ring products 40R- and 48R-NTHU-13, respectively. The use of 14C' tetradecylamine, 16C' hexadecylamine, and 18C' octadecylamine led to the synthesis of 56R-NTHU-13, 64R-NTHU-13, and 72R-NTHU-13 in which pore sizes were as large as 3.5 nm.

We used single-crystal x-ray diffraction to characterize all six structures in the NTHU-13 family. Four channels were determined in the unit cells for 40R-, 48R-, 56R-, 64R-, and 72R-NTHU-13, and eight channels were found in the orthorhombic cell for 28R-NTHU-13. Except for the latter, the channel walls were constructed exclusively from the following three building blocks: anionic chains of $\infty [\text{GaF}(\text{HPO}_3)_2]^{2-}$ (block A), neutral chains of $\infty [\text{Zn}(\text{HPO}_3)]$ (block B), and an anionic trimeric cluster of $[\text{Zn}(\text{HPO}_3)_2(\text{H}_2\text{O})_4]^{2-}$ (block C) (Figure 2). Block A was located at the four corners of the square-shaped channels both A and C were linked only to B and they were never adjacent. A generalized formula of $[\text{A}(\text{BC})_n\text{BA}]$ describes the stoichiometry and connectivity of the four faces or edges of the inorganic walls: $n = 1$ for each face or edge of the 40R channel, $n = 2$ for the 56R channel, and $n = 3$ for the 72R channel. When $n = 0$, the corresponding channel face is ABA and is observed to form 24R channels. Hence, the 40R, 56R, and 72R square-windowed channels can be viewed as the systematic expansion of the 24R channel by inserting one or more BC pairs as the proliferation unit. The rectangular-windowed 48R and 64R channels contain two mixed n values (n and $n + 1$) to describe the shorter and longer window edges. An increase of one BC pair would add four polyhedra to each channel edge, leading to an expansion by 16 rings for square-windowed channels (24R to 40R; 40R to 56R; 56R to 72R) and 8 rings for rectangular-windowed channels (40R to 48R; 48R to 56R; 56R to 64R; 64R to 72R).

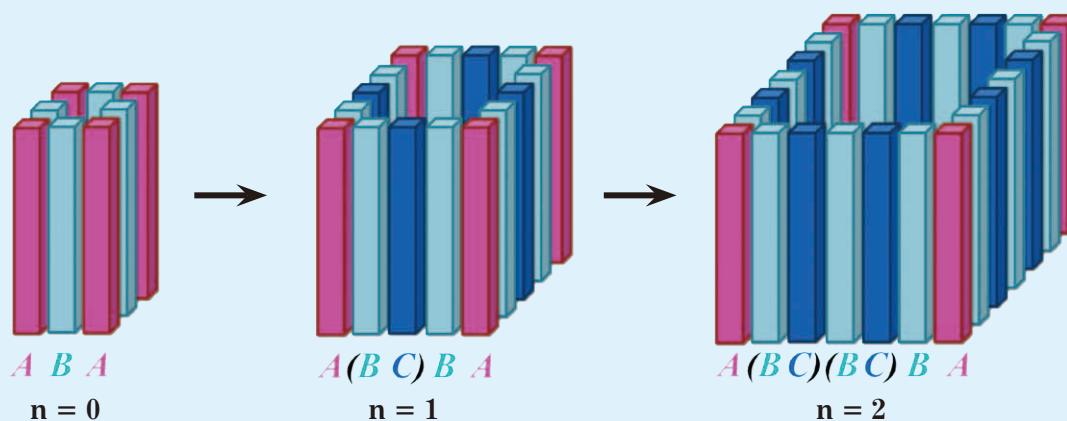


Fig 2. An increase of **one BC pair** would add four polyhedral to each channel edge, leading to an **expansion by 16 rings** for square-windowed channels; for the 16-ring expansion, there was an approximate **0.8-nm increase** in the channel diameter.

Authors

Hsin-Yau Lin (林新堯), Chih-Yuan Chin (秦志遠), Hui-Lin Huang (黃惠琳), Wen-Yen Huang (黃文彥), Ming-Jhe Sie (謝明哲), Li-Hsun Huang (黃莉勛), Yuan-Han Lee (李元翰), Chia-Her Lin (林嘉和), Kwang-Hwa Lii (李光華), Xianhui Bu, Sue-Lein Wang (王素蘭)*

Proton Structure from the Measurement of 2S-2P Transition Frequencies of Muonic Hydrogen

Prof. Yi-Wei Liu

Science, vol. 339, pp. 417–420 (2013)

Accurate knowledge of the charge and Zemach radii of the proton is essential, not only for understanding its structure but also as input for tests of bound-state quantum electrodynamics and its predictions for the energy levels of hydrogen. These radii may be extracted from the laser spectroscopy of muonic hydrogen (μp , that is, a proton orbited by a muon).

We measured the $2S_{\frac{F=0}{1/2}} - 2P_{\frac{F=1}{3/2}}$ transition frequency in μp to be 54611.16(1.05) gigahertz (numbers in parentheses indicate one standard deviation of uncertainty) and reevaluated the $2S_{\frac{F=1}{1/2}} - 2P_{\frac{F=2}{3/2}}$ transition frequency, yielding 49881.35(65) gigahertz. From the measurements, we determined the Zemach radius, $r_Z = 1.082(37)$ femtometers, and the magnetic radius, $r_M = 0.87(6)$ femtometer, of the proton. We also extracted the charge radius, $r_E = 0.84087(39)$ femtometer, with an order of magnitude more precision than the 2010-CODATA value and at 7σ variance with respect to it, thus reinforcing the proton radius puzzle.

Proton size puzzle reinforced

Taiwanese Physicists and their International collaborators confirm surprisingly small proton radius with laser spectroscopy of exotic hydrogen.

The hydrogen atom has played a key role in the investigation of the fundamental laws of physics. Its nucleus consists of a single positively charged proton orbited by a negatively charged electron. The energy levels of this most simple atom can be predicted with excellent precision from the theory of quantum electrodynamics. However, the calculations have to take into account that – in contrast to the point-like electron – the proton is an extended object, made of three quarks bound by so-called ‘gluons’. Therefore the electric charge as well as the magnetism of the proton is distributed over a certain area. The extension of the proton causes a shift of the energy levels in hydrogen. Hence the electric and the magnetic charge radii can be deduced from a measurement of the level shifts.

In 2010, the first results on the spectroscopic determination of the shift of the so-called 2S energy level in muonic hydrogen were published. The exotic atoms were generated by bombarding a target of regular hydrogen with muons from an accelerator at the PSI. Muons behave a lot like electrons, except for their mass: muons are 200 times heavier than electrons. The atomic orbit of the muon is therefore much closer to the proton than the electron’s orbit in a regular hydrogen atom. This results in a much larger sensitivity of the muon’s energy level to the proton size and hence to a stronger shift of the energy levels. Measuring the level shifts is very demanding for technology: muonic hydrogen is very short-lived (muons decay after about two millionths of a second), so the

light pulses for the excitation of the resonance have to be fired onto the hydrogen target only nanoseconds after the detection of a muon.

In the experiment described in the newly published Science article, the energy shift was determined for another transition. This leads to a new measurement of the electric charge radius of the proton. Its value of 0.84087(39) femtometres (1 fm = 0.000 000 000 001 metre) is in good agreement with the group published in 2010, but 1.7 times as precise. The discrepancy to measurements in regular hydrogen or to electron-proton-scattering has thus been reinforced. In addition, the new measurement allows a determination of the magnetic radius of the proton for the first time by laser spectroscopy of muonic hydrogen. A value of 0.87(6) femtometres is determined, which is in agreement with previous measurements. Though the precision is, at present, of the same order as in other experiments, laser spectroscopy of muonic hydrogen has the potential of achieving a much better accuracy in the determination of the magnetic proton radius in the future.

Physicists around the world are seeking a solution to the proton puzzle. Previous measurements in regular hydrogen or electron-proton-scattering are reanalyzed or even repeated. Theorists of various disciplines suggested ways to explain the discrepancy. Very interesting proposals explain the discrepancies by physics beyond the standard model. Other explanations suggest a proton structure of higher complexity than assumed today. The complex structure is expected to reveal itself under the influence of the heavy muon. New measurements are needed to confirm these speculations. Muon-proton-scattering experiments are being developed at PSI. Meanwhile, new precision measurements at the electron accelerator in Mainz are also being considered. The PSI team plans to apply for the first time ever laser spectroscopy to muonic helium in the course of this year as well.

The Taiwan team from National Tsing Hua University (Yi-Wei Liu, professor of physics) participates this experiment for over ten years, with close collaboration with all the international teams. They contributed in various aspects of the experiment, especially the laser system and the precision measurement technique. Under the support from National Science, Taiwan and National Tsing Hua University, They are looking forward to unveiling the secret of proton size and exploring the possibility of the “New Physics”.

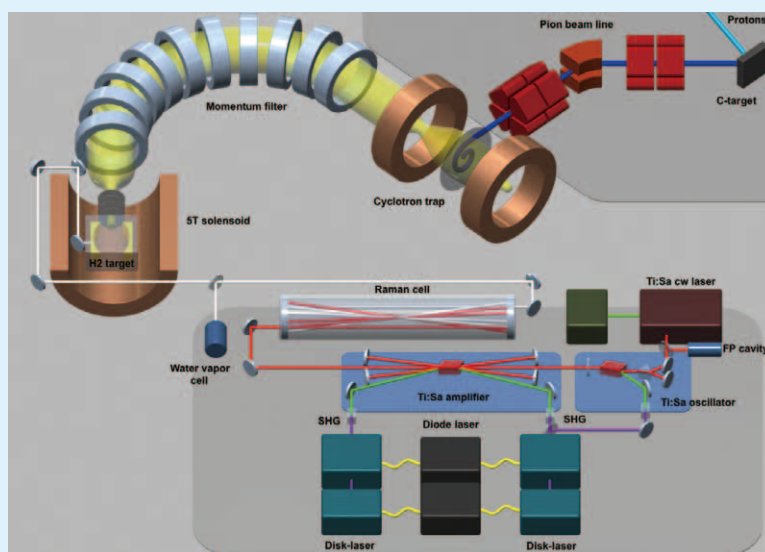


Fig 1.

The experimental setup for the laser spectroscopy of muonic hydrogen. Slow muon beam from PSI accelerator interacting with hydrogen atoms form metastable muonic hydrogens. The laser system is composed of a Ti:Sapphire pulse laser and a Raman cell to excite the 2S-2P transition.

Authors

Aldo Antognini, François Nez, Karsten Schuhmann, Fernando D. Amaro, François Biraben, João M. R. Cardoso, Daniel S. Covita, Andreas Dax, Satish Dhawan, Marc Diepold, Luis M. P. Fernandes, Adolf Giesen, Andrea L. Gouvea, Thomas Graf, Theodor W. Hänsch, Paul Indelicato, Lucile Julien, Cheng-Yang Kao (高政揚), Paul Knowles, Franz Kottmann, Eric-Olivier Le Bigot, Yi-Wei Liu (劉怡維), José A. M. Lopes, Livia Ludhova, Cristina M. B. Monteiro, Françoise Mulhauser, Tobias Nebel, Paul Rabinowitz, Joaquim M. F. dos Santos, Lukas A. Schaller, Catherine Schwob, David Taqqu, João F. C. A. Veloso, Jan Vogelsang, Randolph Pohl

Structural Biological Materials: Critical Mechanics-Materials Connections

Prof. Po-Yu Chen

Science, vol. 339, pp. 773-779 (2013)

Spider silk is extraordinarily strong, mollusk shells and bone are tough, and porcupine quills and feathers resist buckling. How are these notable properties achieved? The building blocks of the materials listed above are primarily minerals and biopolymers, mostly in combination; the first weak in tension and the second weak in compression. The intricate and ingenious hierarchical structures are responsible for the outstanding performance of each material. Toughness is conferred by the presence of controlled interfacial features (friction, hydrogen bonds, chain straightening and stretching); buckling resistance can be achieved by filling a slender column with a lightweight foam. Here, we present and interpret selected examples of these and other biological materials. Structural bio-inspired materials design makes use of the biological structures by inserting synthetic materials and processes that augment the structures' capability while retaining their essential features. In this Review, we explain this idea through some unusual concepts.

Most biological (natural) materials are composites whose mechanical properties are often outstanding, considering the weak constituents from which they are assembled. These biological composites, which have risen from hundreds of millions years of evolution, are inspiring scientists and engineers in the design of novel materials. In this invited review, these three authors presented and interpreted selected examples using Materials Science and Engineering approaches, focusing on the structure-mechanical property relationships. Three bio-inspired concepts are discussed in this review:

1. Structures in Tension: Importance of Biopolymers

Spider silk is a fascinating material with high tensile strength and extensibility. The ability to sustain tensile forces requires a specific set of molecular and configurational conformations. It is composed of beta-sheet nano-crystals embedded in a disordered matrix. Under tensile stress, several deformation mechanisms take place: the low-stress region corresponds to uncoiling and straightening of the protein strands, followed by entropic unfolding of the amorphous strands and then stiffening due to load transfer to the crystalline beta-sheets. This type of deformation mechanism is also utilized by other biological soft materials such as wool, whelk eggs, and other silks.

2. Imparting Toughness: Importance of Interfaces

Ceramics are hard yet brittle. Surprisingly, ceramic-based composites found in nature are usually tough and can sustain high compressive strength without fracture. This is due to their sophisticated hierarchical structure and the presence of interfaces. As a crack impinges on an interface or discontinuity in the biological material, it can be deflected around the interface, requiring more energy to propagate than a straight crack and enhancing toughness or fracture resistance. Examples are the brick-and-mortar microstructure of abalone shell, twisted plywood structure of crustacean exoskeleton and concentric layered structure of sponge spicules.

3. Lightweight Structures Resistant to Buckling—Shells and Foams

Bird feathers, toucan beaks, porcupine quills need to be lightweight and stiff, and able to resist bending, torsion and buckling. This is achieved by filling a slender columnar shell with lightweight foam. This sandwich structure demonstrates a synergistic effect on mechanical properties and may inspire future design in aircraft and aerospace vehicles.

The application of the mechanics and materials science methodologies is promoting a new understanding of biological materials and guiding the design of biologically inspired materials, which will extend to sustainable development by employing more energy efficient and “greener” designs.

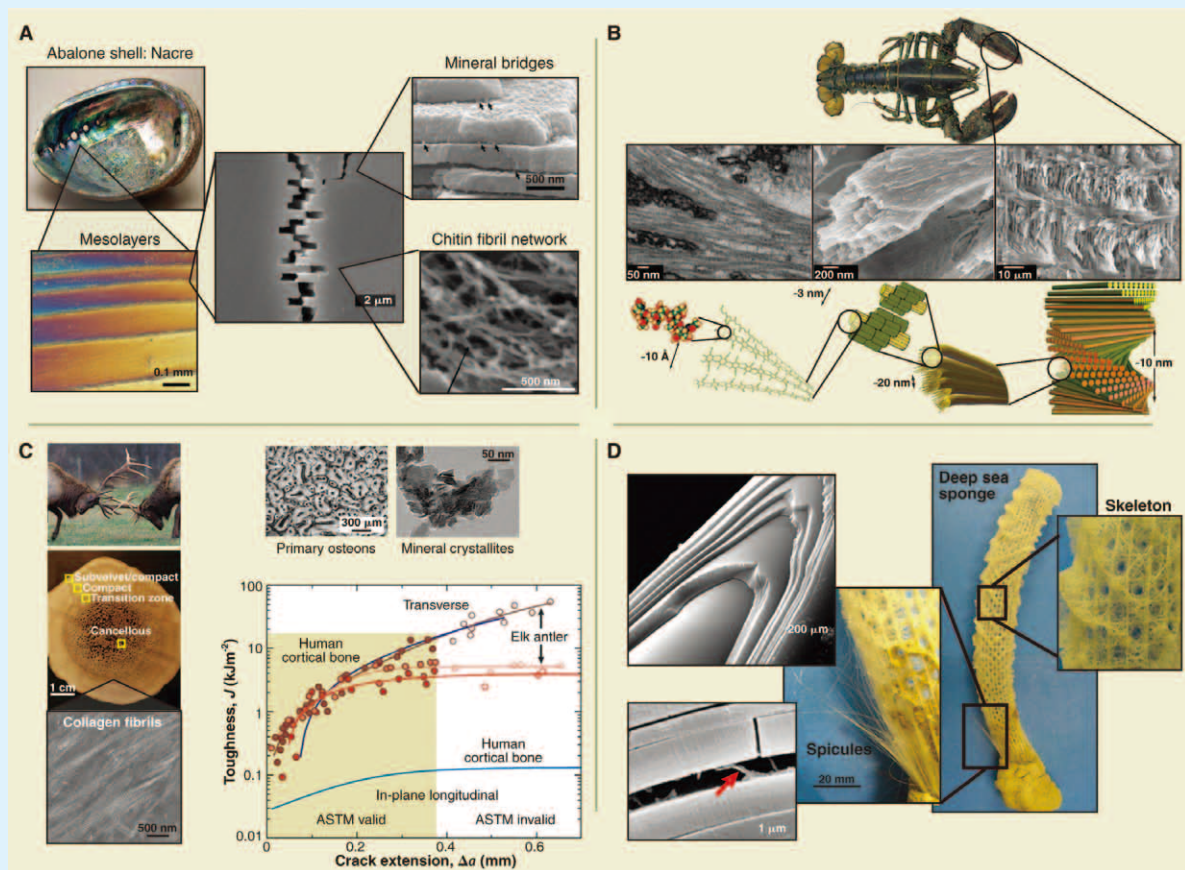


Fig 1.

Hierarchical structures of tough biological materials demonstrating the heterogeneous interfaces that provide crack deflection: (A) Abalone shell; (B) Deer antler; (C) Lobster exoskeleton; (D) Sea sponge spicule.

Authors

Marc André Meyers*, Joanna McKittrick, Po-Yu Chen (陳柏宇)

<http://www.sciencemag.org/content/339/6121/773.full>

Parallel Neural Pathways Mediate CO₂ Avoidance Responses in *Drosophila*

Prof. Ann-Shyn Chiang

Science, vol. 340, pp. 1338–1341 (2013)

Different stimulus intensities elicit distinct perceptions, implying that input signals are either conveyed through an overlapping but unique sub-population of sensory neurons or channeled into divergent brain circuits according to intensity. In *Drosophila*, CO₂ is detected by a single type of olfactory sensory neuron but information is conveyed to higher brain centers through second-order projection neurons (PNs). Two distinct pathways, PNv-1 and PNv-2, are necessary and sufficient for avoidance responses to low and high CO₂ concentrations, respectively. While low concentrations activate PNv-1, high concentrations activate both PNvs and GABAergic PNv-3, which may inhibit PNv-1 pathway-mediated avoidance behavior. Channeling a sensory input into distinct neural pathways allows the perception of an odor to be further modulated by both stimulus intensity and context.

Taiwanese scientists discover shunting mechanism to direct information flow in the complex brain networks

A research group led by Professor Ann-Shyn Chiang of National Tsing Hua University in Taiwan has discovered a shunting mechanism for gating information flow in parallel neural circuits. Using FlyCircuit, a virtual fly brain database containing thousands of single neurons, Chiang's team predicted and validated neural circuits relaying olfactory information to higher brain centers in the *Drosophila* brain. They found that odor information takes specific pathways in the brain, depending on concentration context in order to orchestrate locomotion behavior.

“A grand challenge in neuroscience is to understand how the internal brain circuits represent external world and eventually result in memory underlying learning and behaviors. To this end, understanding how the information flows and turns in the complex brain networks has great and fundamental implication in

not only biomedicine but also neuro-inspired engineering,” exclaimed by Chiang.

The finding was reported in the 2013/6/14 issue of Science.

Neuroscientists have long realized the value of using animals to model and understand how the billions of neurons in the human brain function. The brain of the adult *Drosophila*, commonly known as fruit fly, contains only approximately 100,000 neurons and uses the same set of neurotransmitters such as acetylcholine, GABA, glutamate, dopamine, serotonin, histamine, octopamine, and tyramine. While significantly different in gross anatomy, both insect and mammalian brains are composed of neural circuits with a cohort of shared gene products governing normal function of sensory modalities and complex behavior. A sophisticated genetic

tool box, simple brain circuits for intricate behaviors, and complete genomics and proteomics information make *Drosophila* an ideal model system for studying basic mechanisms underlying brain operation.

Humans are often attracted to certain smells at low concentrations but repelled by the same scents if they become too strong. Each odorant is detected by specific receptor neurons that relay information to particular brain regions. How the brain interprets the same sense in differing context remains unclear; however, research carried out by Chiang's team on the *Drosophila* brain sheds light on this question.

Carbon dioxide generated by stressed flies alerts surrounding flies, causing them to move away. On the other hand, flies in flight are attracted to the CO₂ released by yeast in fermented fruits. How does the same odor produce two opposite behaviors?

Hui-Hao Lin, a graduate student in Chiang's lab, demonstrated that the CO₂ signal detected by specific olfactory sensory neurons is sent to a small spherical region underneath the antennal lobe and then relayed to higher brain centers through multiple parallel pathways. Lin first traced all projection neurons linking between antennal lobe and the brain with a mutated protein that turns into a regular green fluorescent protein after UV irradiation, developed by Tsai-Fung Fu at the National Chi Nan University. Following FlyCircuit analysis, the team predicted that perception of the CO₂ signal involves six brain regions and utilizes three different pathways. Next, in collaboration with Barry Dickson at the Institute of Molecular Pathology in Vienna, they developed a set of specific genetic drivers to manipulate these putative CO₂ pathways. Calcium imaging with GCaMP fluorescent probes showed that all projection neurons connected structurally are functionally responsive to CO₂. Blocking neurotransmission with a temperature sensitive dynamin, a mutant protein stops neurotransmitter retrieval at high temperature, showed that two independent neural pathways are required for avoidance behavior under low or high concentrations of CO₂, respectively. Interestingly, the third inhibitory GABA-

transmitting pathway blocks the low CO₂ pathway when flies are exposed to high levels of CO₂.

To verify this information shunting model, a graduate student Li-An Chu of Chiang's lab developed an optogenetic device that uses an intense blue light to trigger channelrhodopsin induced activation of specific neural pathways. Optogenetic activation of the first and second pathways triggered avoidance behavior, which mimics the stimulation of low and high CO₂ concentrations, respectively. In contrast, these flies did not respond to the activation of the third pathway alone. What is particularly surprising was the discovery that blocking both the second and third pathways under high CO₂ stimulation triggered avoidance behavior via the first pathway.

According to Chiang, "our finding is the first time to show that there are parallel neuronal pathways for signal processing and mechanisms that allow information shunting in the brain. What remains unknown is whether such a shunting phenomenon occurs in other sensory modalities and how often it is executed as an intermediary step between sensory stimulus and behavioral output in the complex brain networks. It would be truly exciting if such a shunting mechanism, which greatly increases the flexibility of behavioral responses, also occur in the human brain."

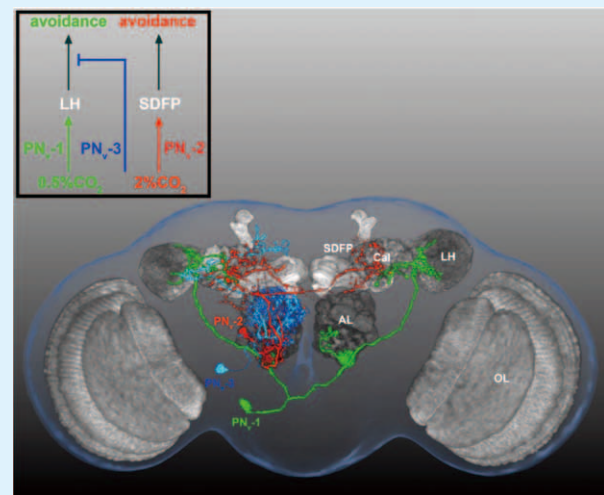


Fig 1. Information routing for fruitfly avoidance behavior. Two distinct neural pathways, PNv-1 (green) and PNv-2 (red), are integral for avoidance behavior in response to low (0.5%) and high (2%) concentrations of carbon dioxide, respectively. While 0.5% activates only PNv-1, 2% triggers PNv-1, PNv-2, and a third class of inhibitory PNv-3 neurons (blue) that blocks the PNv-1 downstream pathway, leaving PNv-2 as the final output. AL, antennal lobe; Cal, calyx; LH, lateral horn; OL, optic lobe; SDFP, superior dorsofrontal protocerebrum.

Authors

Hui-Hao Lin (林暉皓), Li-An Chu (朱麗安), Tsai-Feng Fu (傅在峰), Barry J. Dickson, Ann-Shyn Chiang (江安世)*

<http://www.sciencemag.org/content/340/6138/1338.full>

Direct observation of the transition from indirect to direct band gap in atomically thin epitaxial MoSe₂

Prof. Horng-Tay Jeng

Nature Nanotechnology 9, 111-115 (2014)

Two-dimensional (2D) materials have attracted attention because their potential applications in valley/spintronics. Graphene is a most widely studied material, which possess highly mobility and displays rich physics, driven by two Dirac cone band dispersions near the Fermi level (E_F) at K and K' points. However, graphene is a gapless system and the spin on the Dirac cone is a pseudospin, which limited its applications in semiconductor industry or spintronics device technologies. For these reasons, it is important to find new 2D materials, which contain a large band gap and support spin-polarized states.

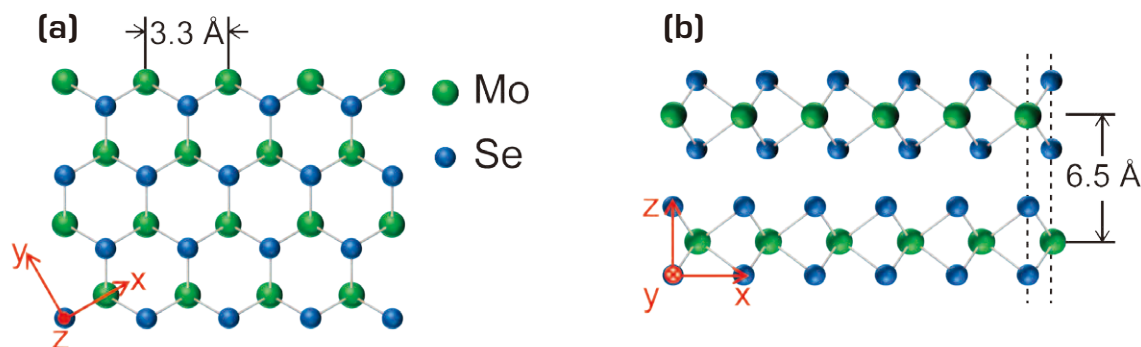


Fig 1. Crystal structure of MoSe₂. Green and blue balls indicate Mo and Se atoms, respectively. (a) Top view. (b) Side view.

Transition metal dichalcogenides (TMDs) MX₂ (M = Mo, W; X = S, Se, Te) is a new class of 2D materials, which attracted significant interest because these layered materials can easily exfoliated mechanically to provide monolayers (Fig. 1). Unlike graphene, MX₂ family, has been demonstrated with large band gap, are candidates for new generation devices. In this work, we report layer-by-layer growth of high-quality single-crystal MoSe₂ thin films (~5mm×2mm) by molecular beam epitaxy (MBE) on an epitaxial graphene terminated 6H-SiC(0001) substrate and investigated its electronic structures by using angle-resolved photoemission spectroscopy (ARPES) and first-principles calculations (Fig. 2). We provide first experimental evidence that direct observation of the transition from indirect to direct band gap in monolayer samples. Meanwhile, we find a large spin-splitting (~ 180 meV) at the top of valence band of monolayer MoSe₂ film. Most importantly, the spin polarization of each splitting state reaches nearly 100%. Large band gap and high spin polarization allow MX₂ family has great potential for spin/valley electronic applications.

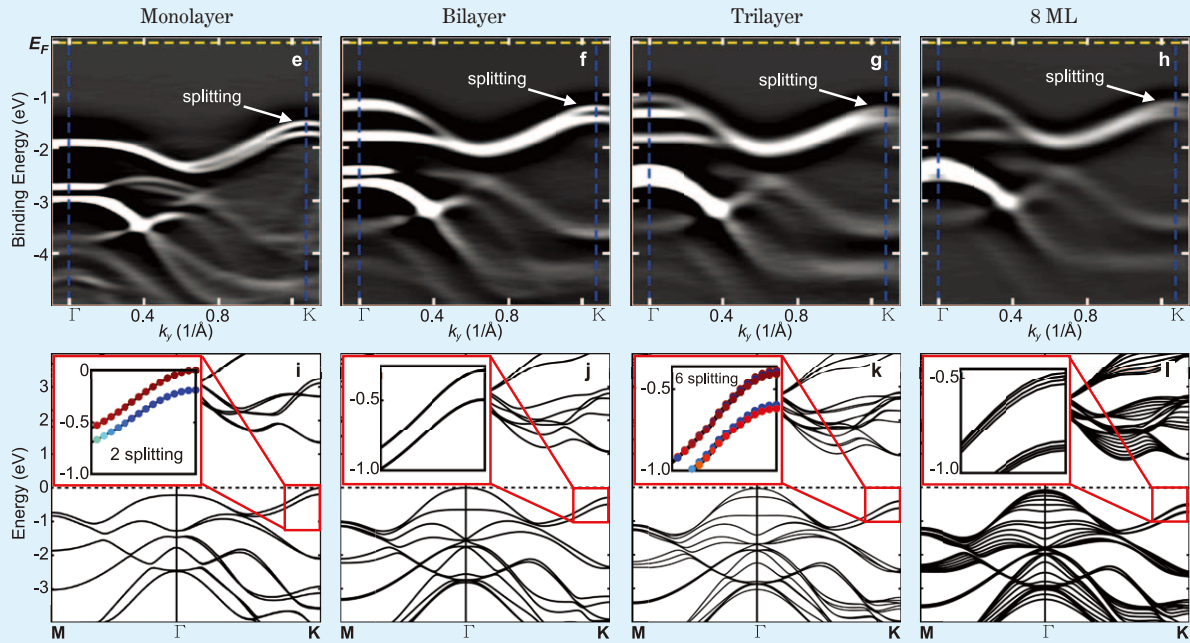


Fig 2. Electronic structure of MoSe₂. Top and bottom panel is ARPES second-derivative spectra and first-principles calculated band structure. Red and blue circles indicate opposite spin directions.

Horng-Tay Jeng group:

Our research interests involve study fundamental physics in complex materials, such as interacting electron and topological systems. Using first-principles calculations, we investigated the electronic structures and ferroelectric polarization in magnetite, multiferroic and iridate compounds. Recently, we focus on study the electronic structures and spin (orbital) texture of many kind of topological systems, including topological insulator, magnetic topological insulator, topological Kondo insulator, and topological Dirac semimetal. Our research also involves spin/valley electronic applications, such as propose designs silicene and transition metal dichalcogenides devices.

Authors

Yi Zhang^{1,2}, Tay-Rong Chang³(張泰榕), Bo Zhou^{1,4,5}, Yong-Tao Cui^{2,4}, Hao Yan^{2,4}, Zhongkai Liu^{2,4}, Felix Schmitt^{2,4}, James Lee^{2,4}, Rob Moore^{2,4}, Yulin Chen^{1,4,5}, Hsin Lin⁶, Horng-Tay Jeng^{3,7}(鄭弘泰), Sung-Kwan Mo^{1*}, Zahid Hussain¹, Arun Bansil⁶ and Zhi-Xun Shen^{2,4*}

¹Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA,

²Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA, ³Department of Physics, National Tsing Hua University, Hsinchu 30013,

Taiwan, ⁴Geballe Laboratory for Advanced Materials, Departments of Physics and Applied Physics,

Stanford University, Stanford, California 94305, USA, ⁵Department of Physics and Clarendon Laboratory,

University of Oxford, Parks Road, Oxford OX1 3PU, UK, ⁶Department of Physics, Northeastern University,

Boston, Massachusetts 02115, USA, ⁷Institute of Physics, Academia Sinica, Taipei 11529, Taiwan.

In situ observation of step-edge in-plane growth of graphene in a STEM

Prof. Po-Wen Chiu

Nature Communications, doi:10.1038/ncomms5055 , 2014

It is extremely difficult to control the growth orientation of the graphene layer in comparison to Si or III-V semiconductors. A direct observation of graphene growth and domain boundary formation in a scanning transmission electron microscope, with residual hydrocarbon in the microscope chamber being used as the carbon source for in-plane graphene growth at the step-edge of bilayer graphene substrate provides an important insight into growth orientation of graphene. We show that the orientation of the growth is strongly influenced by the step-edge structure and areas grown from a reconstructed 5–7 edge are rotated by 30° with respect to the mother layer. Furthermore, single heteroatoms like Si may act as catalytic active sites for the step-edge growth. The findings provide an insight into the mechanism of graphene growth and defect reconstruction that can be used to tailor carbon nanostructures with desired properties.

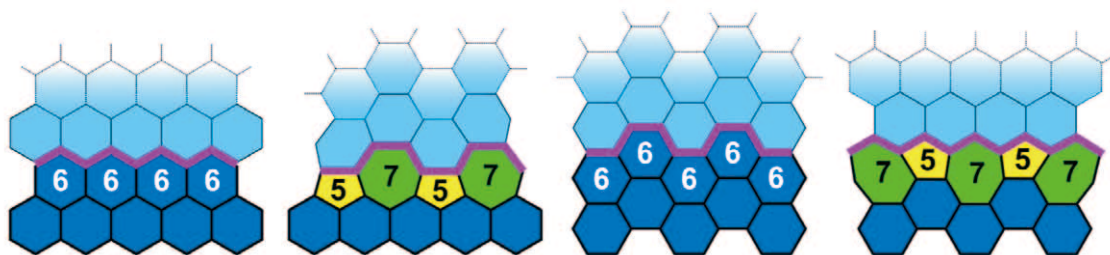


Fig 1. Four categories of the growth model. From the left to the right panels are: from ZZ to ZZ; from reconstructed ZZ (57) to AC; from AC to AC, and from reconstructed AC (57) to ZZ.

Direct visualization of how the graphene network evolves during growth is highly desired in an effort to precisely understand the atomic processes of the growth mechanism. To realize well-controlled graphene nanodevices, identifying the orientation relationship between the seed crystal and the growing layer or detecting the influence of the catalytic atoms during growth would be of immense benefit. However, the extremely high CVD growth rate (on the order of micrometres per minute) makes atomic resolution analysis during CVD unfeasible.

As the vacuum system in an electron microscope is not perfect, the residual hydrocarbon gas in the sample chamber can be used to grow graphene at high temperatures, although the properties of the hydrocarbon gases cannot be characterized. Here we show that graphene grows extremely slowly (several angstroms per minute) in a transmission electron microscope, allowing simultaneous growth and atomic resolution imaging. We visualize the *in situ* in-plane growth of graphene on the terrace of the first layer using aberration-corrected scanning TEM (STEM), and observe the activity of a single Si atom catalyst during graphene growth on an atomic scale. STEM has the added advantage in that the focused high-density electron beam is able to modify the structure of the sample, and thus, this method can be used to manipulate the graphene growth. Although previous reports have shown reknitting holes in monolayer graphene with the reknitted areas that are composed of many 5–7 defects showing an ‘amorphous’ characteristic, the mechanism of in-plane growth from a step-edge in this study is different from that of reknitting holes. Holes have a limited circumference without substrate, however, edges have a half opened space to grow graphene. More importantly, the newly grown graphene is not amorphous but crystalline in the current study. The relationship between the growth speed of graphene and the residual hydrocarbon gas pressure is also investigated.

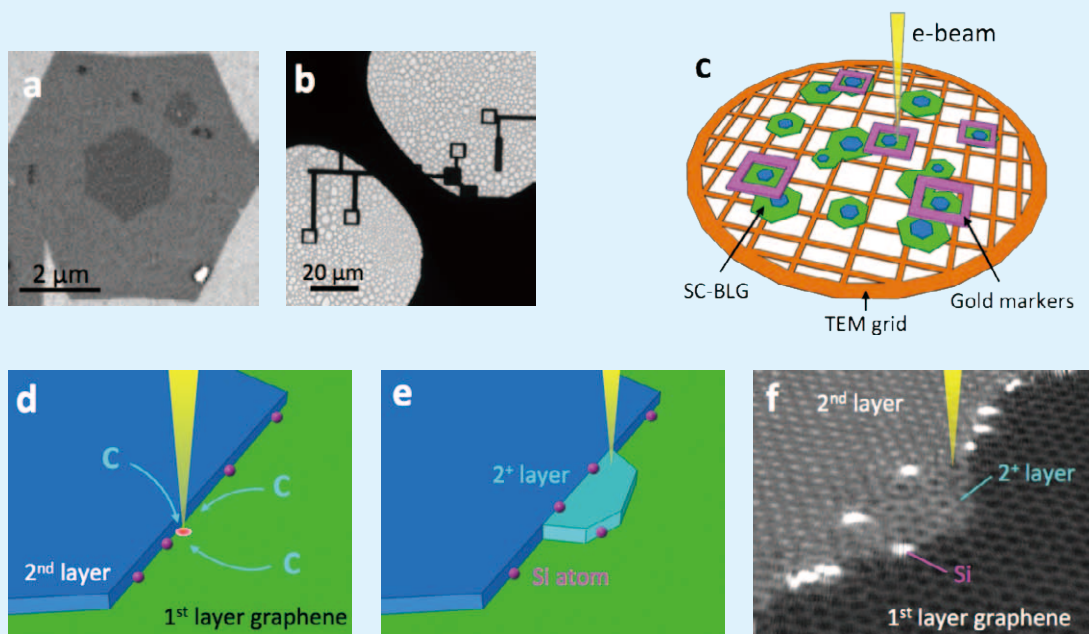


Fig 2. (a) Scanning electron microscopy image of a single-crystal bilayer graphene, (b) marked by e-beam lithography, (c) transferred to a Mo TEM grid and (d) schematic drawing of the 2nd-layer graphene step-edge. Hydrocarbon accumulates to the e-beam scanning area. (e) The new growth graphene layer (2^+ layer, light blue) at the BLG step-edge. Single Si atoms (pink) located at the step-edge. (f) ADF image in a perspective view showing the e-beam-induced growth from the step-edge of the bilayer graphene where the single Si atoms (brighter contrast) existed.

Authors

Zheng Liu (劉錚), Yung-Chang Lin (林永昌), Chun-Chieh Lu (呂俊韻), Chao-Hui Yeh (葉昭輝), Po-Wen Chiu (邱博文), Sumio Iijima, Kazu Suenaga

Prof. Po-Wen Chiu (Department of Electrical Engineering)

<http://www.nature.com/ncomms/2014/140602/ncomms5055/full/ncomms5055.html>

Optogenetic control of selective neural activity in multiple freely moving *Drosophila* adults

Prof. Ann-Shyn Chiang

Prof. Chien-Chung Fu

PNAS, vol. 111, no. 14, 5367-5372. (2014)

Authors present an automated laser tracking and optogenetic manipulation system (ALTOMS) for studying social memory in fruit flies (*Drosophila melanogaster*). ALTOMS comprises an intelligent central control module for high-speed fly behavior analysis and laser scanning (~40 frames per second) for targeting two lasers (a 473-nm blue laser and a 593.5-nm yellow laser) on any specific body parts of two freely moving *Drosophila* adults. By using ALTOMS to monitor and compute the locations, orientations, wing postures, and relative distance between two flies in real time and using high-intensity laser irradiation as an aversive stimulus, this laser tracking system can be used for an operant conditioning assay in which a courting male quickly learns and forms a long-lasting memory to stay away from a freely moving virgin female. With the equipped lasers, *channelrhodopsin-2* and/or *halorhodopsin* expressed in selected neurons can be triggered on the basis of interactive behaviors between two flies. Given its capacity for optogenetic manipulation to transiently and independently activate/inactivate selective neurons, ALTOMS offers opportunities to systematically map brain circuits that orchestrate specific *Drosophila* behaviors.

To study social memory in fruit flies (*Drosophila melanogaster*), an automated laser tracking system for manipulating brain circuits (ALTOMS) has been developed by an interdisciplinary research team in the Brain Research Center at National Tsing Hua University. This work appears on the 2014/4/8 issue of Proceedings of the National Academy of Science of the United States of America (PNAS).

Scientists who conducted this work include 5 students, Ming-Chin Wu, Chen-Chieh Chi and Tsung-Ho Liu from Dr. Chien-Chung Fu's lab in Power Mechanical Engineering Department and Institute of NanoEngineering and Microsystems, Li-An Chu and Po-Yen Hsiao from Dr. Ann-Shyn Chiang's lab in Department of Life Science and Institute of Biotechnology, and a research fellow Yen-Yin Lin from Department of Electrical Engineering and Institute of Photonics Technologies

and, This system, which co-designed and developed by students from both Engineering and Biology departments, is composed of an automated high-intensity laser-tracking module as an aversive stimulus for flies and an online data analyze system, which reports flies' activities in real-time. Such laser tracking system can be utilized for an operant conditioning assay in which a courting male rapidly learns and forms a long-lasting memory to stay away from a freely moving virgin female.

It is remarkable while fruit flies may be "primitive" as compare to human beings physiologically, their interactions between male and female species bear great resemblance to human male-female interactions. For instance, two lovers present gifts to each other on Valentine's Day, keep away from each other when they disputes arise, and place wedding rings on each other when married. Even

tiny creatures like fruit flies know how to flirt with one another. Male flies would sing love songs, dance and chase virgin female flies to “win her heart.” After mating, female flies would reject other males’ courtship. Interestingly, rejected male flies are more likely to become alcoholic than naive male flies. Scientists believe that studying these sophisticated interactions in flies could pave way to understanding how humans would shape behaviors according to the past experiences to fit into the society.

Thus far, fly social behaviors are studied through analysis of pre-recorded video. New tools are needed if scientists want to interfere flies’ behavior during their fast interactions. To understand how neurons process signals during social interactions, flies’ behaviors need to be analyzed in real-time and their neuronal activities need to be controlled acutely during interaction. By using ALTOMS, authors found that activating the pain neurons in a male fly whenever it courts near a female, the male will

quickly learns and forms long-lasting memory to avoid the female. This is the first demonstration of operant learning in flies since the male decreases the frequency of courting during training. In another word, the male flies effectively learn to control the initiation of laser irradiation. By using ALTOMS, the puzzle of how genes and neurons control social behavior will be lit up in the foreseeable future. Therefore, PNAS editorial office promoted this work in the list of Highlight and New & Newsworthy. They also eagerly invited us to provide a short video of our work to the public.

The success in building ALTOMS to manipulate neural circuit in two freely moving flies for the first time in the world is a mile stone of interdisciplinary research in Taiwan. Committed to cultivate next-generation top scientists, the Brain Research Center at National Tsing Hua University will continue to emphasize interdisciplinary collaborations to uncover mysteries of life.

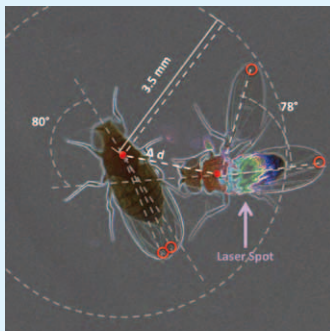


Fig 1.

Restraining order in fruit flies: Pictured are two freely moving fruit flies, a courting male irradiated simultaneously by a blue laser and a yellow laser when encountering a virgin female. Wu et al. developed an automated laser tracking and optogenetic manipulation system for studying social memory in fruit flies. They designed an operant learning paradigm in which a male fly was trained to follow an invisible “restraining order” by being punished upon violating the order. The trained male quickly learns and forms a long-lasting memory to stay away from the virgin female. Given its capacity for online analysis of flies’ movement and optogenetic manipulation of target neurons, this new laser tracking system offers opportunities to systematically map brain circuits orchestrating specific fruit fly behavior.

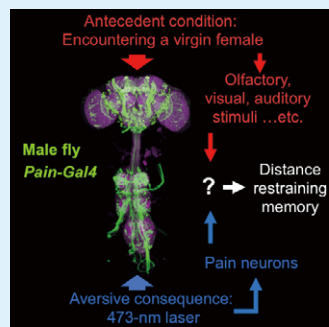
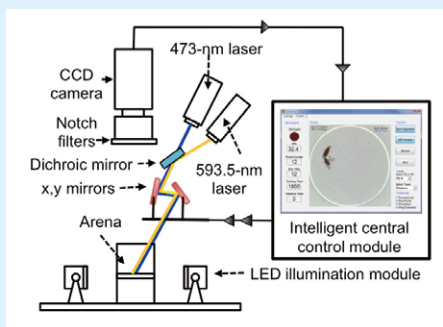


Fig 2.

ALTOMS is an automated laser tracking system that comprises four parts: an image capture module (ICM), an intelligent central control module (ICCM), a laser scanning module (LSM), and a fly arena. This allows the development of an operant learning paradigm in which a male fly was trained to follow an invisible “restraining order” by being punished upon violating the order. By optogenetic activation of specific neural circuits

during social interactions, authors found that pain neurons in the male fly signal aversive consequence to the brain where it associates with the antecedent condition of encountering a virgin female. ALTOMS offers opportunities to systematically map brain circuits that orchestrate specific behaviors in fruit flies.

Authors

Ming-Chin Wu[#] (吳明親), Li-An Chu[#] (朱麗安), Po-Yen Hsiao[#] (蕭伯彥), Yen-Yin Lin (林彥穎), Chen-Chieh Chi (齊振傑), Tsung-Ho Liu (劉宗和), Chien-Chung Fu* (傅建中), and Ann-Shyn Chiang* (江安世)

<http://www.pnas.org/content/111/14/5367>

<http://www.pnas.org/site/misc/14-00997.mp4>

Modern Recipe for Preserving Ancient Chinese Scrolls

Prof. Tzay-Ming Hong

Physical Review Letters 112, 034302 (2014)

Qi-Wa refers to the up curl on the lengths (see Fig.1) of hand scrolls and hanging scrolls, which has troubled Chinese artisans and emperors for as long as the art of painting and calligraphy has existed. This warp is unwelcomed not only for aesthetic reasons, but its potential damage to the fiber and ink. Although it is generally treated as a part of the cockling and curling due to moisture, consistency of paste, and defects from the mounting procedures, we demonstrate the spontaneous extrinsic curvature incurred from storage is in fact more essential to understanding and curling Qi-Wa. In contrast to the former factors whose effects are less predictable, the plastic deformation and strain distribution on a membrane are a well-defined mechanical problem. We study this phenomenon by experiments, theoretical models, and molecular dynamics simulations, and obtain consistent scaling relations for the Qi-Wa height. This knowledge enables us to propose modifications on traditional mounting techniques that are tested on real mounted paper to be effective at mitigating Qi-Wa. By experimenting on polymer-based films, we demonstrate possible relevance of our study to modern development of flexible electronic paper.



Fig 1. Qi-Wa or the curling edges are most pronounced in the hanging scroll on the right.

As art conservators know, long-term storage of rolled up scrolls—such as ancient Chinese paintings and calligraphy (see Fig.2)—can cause the long edges of the paper to curl outwards, with potentially damaging effects. In collaboration with the National Palace Museum in Taipei, researchers led by Prof. Tzay-Ming Hong in the Center for Fundamental Science Research(基礎科學研究中心)

at National Tsing Hua University now have a theory for what causes this curling, known in Chinese as Qi Wa (起瓦). Their model, presented in *Physical Review Letters*, could help conservators find better ways to prepare and store the artworks, and it may be applicable to biological membranes or other flexible materials. This work has garnered multiple accolades including being selected as the Editor's Suggestion and a Synapse in the Physics website in conjunction with the PRL paper. It was also featured in international magazines like *Science*¹, *Physics Today*², and *New Scientist*³. Due to its possible relevance to modern development of flexible electronic paper, this work was also reported by many engineering websites⁴.

Hong *et al.* boil down the edge-curling problem to what is called the Poisson effect—the tendency of an elastic material compressed in one direction to expand in the perpendicular direction. In a rolled-up scroll, the scroll backing forms the outer layer and, to accommodate the bending, has to stretch—often irreversibly. To lay the scroll flat again, the outer (back) layer's length must contract, causing the backside to expand along the width of the scroll and the long edges to curl up.

The researchers derived simple power-law equations that relate the height of the curled edges to the scroll's bulk moduli along its length and width, its dimensions, and the radius of the scroll when it was rolled for storage. Hong *et al.* confirmed their model by rolling up differently sized sheets of copy paper and polyethylene terephthalate—the polymer found in plastic bottles and polyester—and measuring the resulting curling. To prevent curling, Hong *et al.* advise lining up the least elastic direction of the paper (the direction of the paper fibers) with the length of the scroll, and adopting the Japanese practice of using a stiff brush to perforate the scroll backing, which—like a meat tenderizer on steak—loosens the fibers.

Authors

Ming-Han Chou (周明翰), Wei-Chao Shen (沈維昭), Yi-Ping Wang (汪依平), Sun-Hsin Hung (洪順興), and Tzay-Ming Hong (洪在明)

1. <http://news.sciencemag.org/math/2014/01/scienceshot-how-save-your-scroll>
2. <http://scitation.aip.org/content/aip/magazine/physicstoday/article/67/3/10.1063/PT.3.2300>
3. <http://www.newscientist.com/article/dn24959-save-ancient-chinese-scrolls-with#.VBe51PmwJrU>
4. <https://advanceseng.com/applied-physics/curling-edges-problem-plagued-scrolls-millennia/> and <http://www.smartplanet.com/blog/bulletin/what-flexible-electronics-can-learn-from-ancient-chinese-scrolls/>

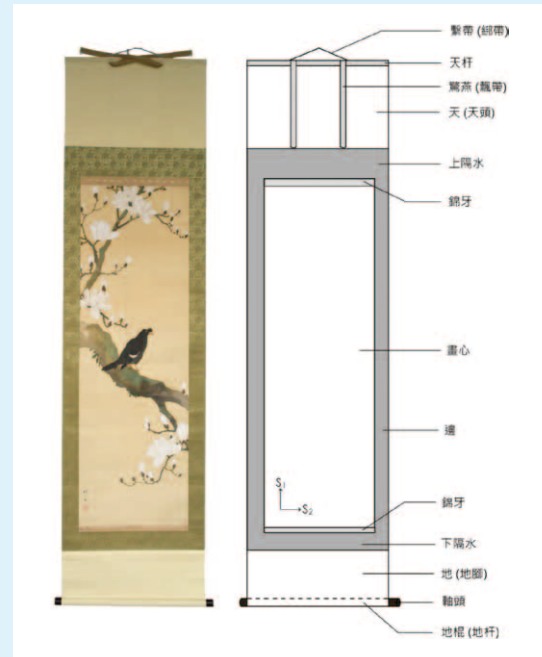
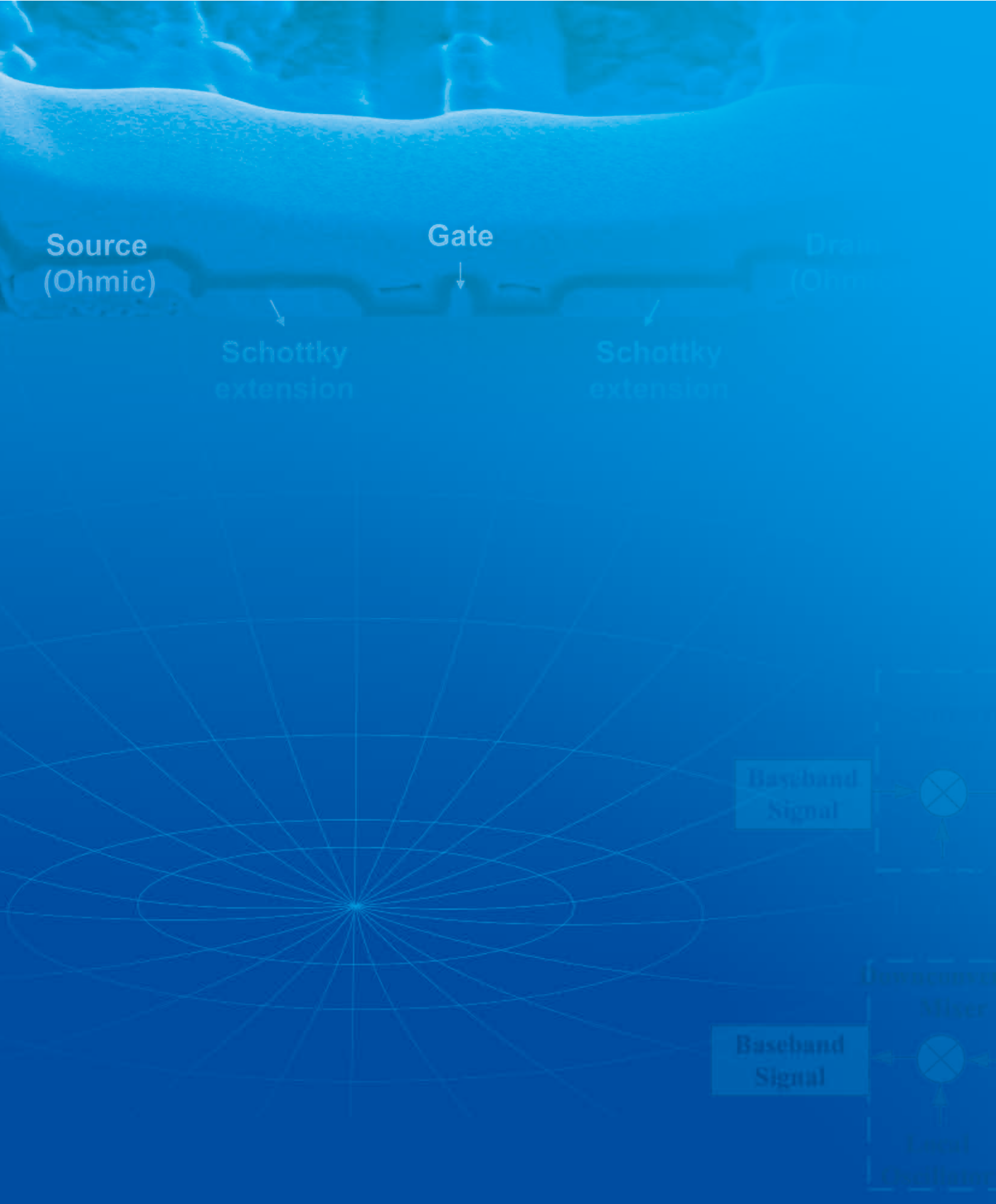


Fig 2. Being part of a long tradition, many jargons exist in the trade of mounting.



Making an impact on technology

Design and Implementation of Hydrostatic Bearings - An Academia-Industry Collaborative Program

Prof. Cheng-Kuo Sung

GaN-on-Si: An Enabling Technology for High Efficiency, Low Cost Power and RF Electronics

Prof. Shawn S. H. Hsu

Cancer Companion Diagnostics & Therapeutics: The Next Generation for Comprehensive Cancer Control

Prof. Shiaw-Der Yang

Millimeter-Wave Ultra High Speed Circuits

Prof. Jenny Yi-Chun Liu



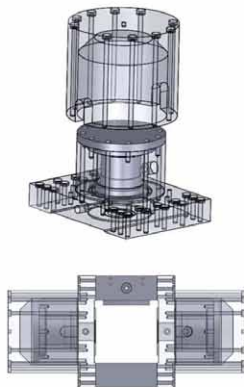
Design and Implementation of Hydrostatic Bearings - An Academia-Industry Collaborative Program

Prof. Cheng-Kuo Sung



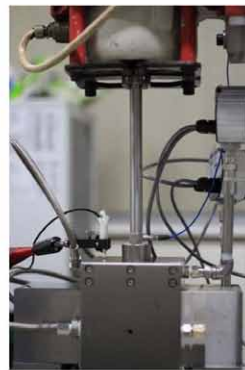
2011

Design of a new type of pressure sensing restrictor for hydrostatic bearings



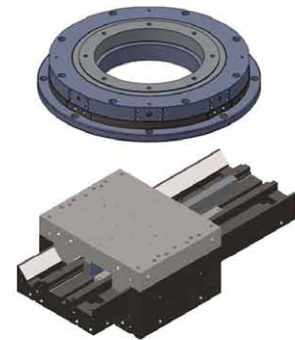
2012

Design of a self-sensing compensating restrictor/pad module for hydrostatic bearings



2013

Design of the dynamic stiffness and damping characteristic of hydrostatic bearings



2014

Design of a hydrostatic rotary bearing stage and a hydrostatic linear bearing stage

Research on demand is the key factor for a successful academia-university collaborative program. Having worked together with HIWIN Company on a number of projects for years, we decided to establish “HIWIN-NTHU R&D Center” to expand the collaboration by incorporating Tsing Hua faculty’s research strength and versatility with HIWIN’s capacity on technology and product development. This center aims to research fundamental and advanced industrial technologies and to develop innovative and reliable products, so as to promote HIWIN to be a world leading company in Precision Transmission Technology. Most importantly, via this collaborative program, we can cultivate high level precision mechatronics talents with sound theoretical knowledge and practical experiences.

Hydrostatic bearings feature high stiffness and large load-carrying capacity, but experiences only a little friction force because of the high pressure oil film between the journal and bearing. These advantages results in the bearings being widely employed in various precision machinery. Nevertheless, the hydrostatic bearing was invented by Girard, a French scientist, in 1862. American engineers took the advantages of the hydrostatic bearing to drive a large telescope weighing 500 tons with only 0.5 horsepower in 1938. Subsequent applications of these bearings have been implemented in machine tools to achieve ultraprecision.

Under the demands of domestic machine tools manufacturers, we designed and fabricated a rotary hydrostatic bearing stage being mounted to a high-precision gear grinding machine. In addition, a linear hydrostatic bearing stage and a patented self-sensing compensating fluid restrictor will also be delivered to companies to develop ultraprecision machine tools. The outcomes of the related researches are described as follows:

1. Design of a self-sensing compensating restrictor/pad module for hydrostatic bearings

The module consists of a bearing pad and a self-sensing compensating restrictor. The lumped parameter model was used to derive the equations governing the stiffness and load-carrying capacity of the bearing. Influences of the design parameters on bearing performance were explored both analytically and experimentally. Superior performances on stiffness and load-carrying capacity as well as minimum time delay due to the distance between restrictor and bearing pad were achieved.

2. Design of a hydrostatic rotary bearing stage

We designed and fabricated a hydrostatic rotary bearing with self-made capillary restrictors. The design process commenced with the analysis of the flow resistance between the journal and bearing to delve into the pressure ratio of the oil chamber and supply. Then, we carried out the load capacity analysis of the single pad and the opposed pad hydrostatic bearings, as well as the stiffness under the usage of capillary restrictors. Finally, this work optimized the performances with the estimation and the redesign of the bearing's total flow rate, the oil film thickness, the temperature variation and the pocket pressure distribution.

3. Design of a hydrostatic linear bearing stage

We designed, fabricated, and tested a hydrostatic linear stage equipped with either the capillary restrictor or the patented pressure self-sensing compensating restrictor. Except the designed stiffness and load capacity of the hydrostatic linear stage were confirmed with experiments, we analyzed the error-averaging effect of the oil film on the vertical straightness of hydrostatic slideway. The error motion of the hydrostatic slideway was greatly improved with deliberate design.

Authors

Prof. Cheng-Kuo Sung (宋震國)

Precision Transmission Laboratory, Department of Power Mechanical Engineering

GaN-on-Si: An Enabling Technology for High Efficiency, Low Cost Power and RF Electronics

Prof. Shawn S. H. Hsu

The rapidly increased global energy consumption has put our environment in danger. This urges the researches to look for new technologies with high energy efficiency and low economic barrier for achieving environmental sustainability. Owing to the superior material properties of Gallium Nitride (GaN), and the cost-effective large-scale silicon substrate, the GaN-on-Si technology for advanced devices is promising for the emerging applications of power and RF electronics. We focus on the innovation and development of GaN-on-Si Schottky barrier diodes (SBDs) and High Electron Mobility Transistors (HEMTs). The proposed device structures such as the P-buried layer, hybrid contact structure, and selective silicon diffusion have demonstrated improved breakdown voltage, lowered leakage current, and increased operating speed. With the great efforts of our research team, these ideas are turning into real products by collaborating with world class industry. The research results have also led to several patents and prestigious journal publications. The highly efficient power and RF devices realized by the low cost GaN-on-Si technology are expected to minimize the energy consumption in various systems, which have a significant impact on establishing a sustainable environment in the coming decades.

The boom in the information technology (IT) creates a new era of human civilization. However, the energy use becomes a critical issue for the facilities and devices such as data centers in telecommunications and cloud computing, and base stations and smartphones in wireless communications. This urges the need to develop new technologies for high efficiency, low cost power and RF electronics. Gallium Nitride (GaN), as a wide bandgap semiconductor material ($E_g = 3.4$ eV), has attracted significant attentions from both academia and industry recently. GaN offers advantages over other semiconductor materials including a much higher saturation velocity under a high electric field, a high breakdown voltage, a large carrier density, and superior thermal stability, making it an excellent candidate for power and RF applications with high efficiency. In addition, the growth of the high quality GaN epitaxial layer on a large-scale silicon substrate (12-inch wafer demonstrated) has shown substantial progress in recent years, which allows the production of GaN-on-Si devices taking advantage of modern silicon technology with low cost.

Professor Hsu's research group, *High Speed Devices and Integrated Circuits Group*, has focused on the research and development of GaN-on-Si technology for Schottky Barrier Diodes (SBDs) and High Electron Mobility Transistors (HEMTs), which are essential components in power conversion and RF communication systems. He collaborates with world class companies such as Vishay Semiconductors (one of the world's largest manufacturers of discrete semiconductors) and Taiwan Semiconductor Manufacturing Company (world's largest semiconductor foundry), aiming for high efficiency and low cost GaN-on-Si devices for power and RF applications. His research results have also led to several patents and publications in prestigious journals.

One major issue of GaN-on-Si technology is the much smaller breakdown voltage of silicon compared with GaN. Professor Hsu proposed adding a P-buried layer in the conventional N-type GaN buffer in the device structure (*US patent granted, May 2013*). Based on the principle of charge compensation, this invention can reduce the non-

uniformity of electric-field distribution in the SBDs. Fig. 1 compares the E-field in the buffer layer for the SBDs with/without the P-buried layer. The charges between the P-type and N-type GaN layers are in equilibrium, and the peak of the electric field is significantly lowered, resulting in a much improved breakdown voltage.

In the target of power electronics applications, buffer leakage causes significant power loss, leading to degradation of efficiency and breakdown voltage of devices. A hybrid ohmic-Schottky drain structure was proposed to reduce buffer leakage in GaN-on-Si HEMTs. Without extra process steps, the hybrid drain design forms a Γ -shaped electrode to smooth the electric field distribution at the drain side, which improves the breakdown voltage and lowers the leakage current. As reported in the front page news in *Semiconductor Today*, “By combining ohmic and Schottky drain regions, the Tsing Hua researchers increased breakdown voltage by up to 65% with almost no degradation of on-resistance.” This idea has led to another new idea for improving the operating frequency of transistors in RF applications. Using the self-aligned technology for both the hybrid source and drain contacts, as shown in Fig. 2 of the device cross section, the gate-source and gate-drain distances can be effectively reduced, resulting in improved frequency response (*Patent pending*).

The electrode contact is also of extreme importance to determine the performance of the GaN-on-Si devices. Professor Hsu proposed a selective silicon diffusion approach for contact engineering in the GaN SBDs. Fig. 3(a) shows the cross section of the diode, where silicon is doped underneath both the anode and cathode. The Si diffusion layer forms a dual Schottky barrier anode structure, which results in a low Schottky barrier portion to reduce the onset voltage. With the Si diffusion layer that is also applied to the cathode, the electric-field distribution is reshaped to suppress the alloy spike induced premature breakdown. An improved breakdown voltage can be clearly observed, as shown in Fig. 3(b). The proposed GaN-on-Si SBDs are capable of high speed and low loss operation, which enables highly efficient power conversion systems for megahertz operation and beyond. (*Published in IEEE Electron Device Letters, Aug. 2013; Invited article in Semiconductor Science and Technology, July 2013; Patent pending*).

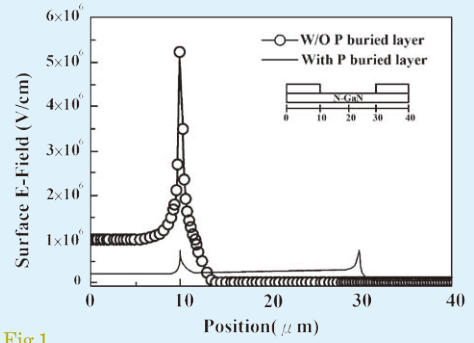


Fig 1. Comparison of the electric field distribution with and without the proposed P-buried layer in the buffer of a GaN-on-Si Schottky barrier diode (SBD). The peak E-field is reduced significantly to improve the device breakdown voltage.

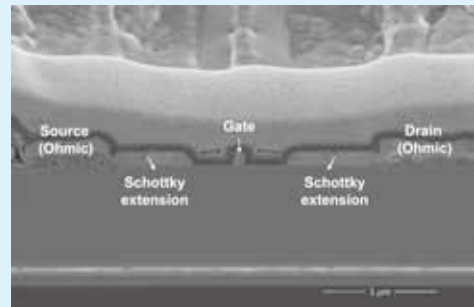


Fig 2. Focused Ion Beam (FIB) image of a GaN-on-Si High Electron Mobility Transistor (HEMT) with the proposed hybrid Schottky-ohmic contact electrodes. The gate-source and gate-drain distances are effectively reduced to enhance the device frequency response.

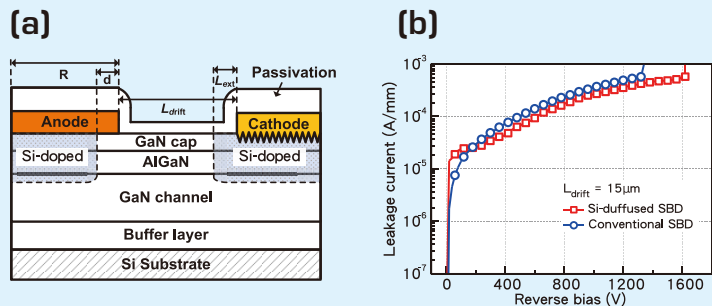


Fig 3. (a) Cross section view of the proposed Si-diffused SBD. The dual Schottky barrier anode is realized to reduce the onset voltage by a Si diffusion layer under the Schottky contact with an indented length d . The Si doped region underneath the Ohmic contact with an extended length L_{ext} can improve the breakdown voltage and minimize the contact resistance. (b) Comparison of the Reverse I - V characteristics of the Si-diffused and conventional SBDs. The breakdown voltage shows a clear improvement by the Si diffusion design.

Authors

Yi-Wei Lian (連羿韋), Yu-Syuan Lin (林于軒), Chuan-Wei Tsou (鄒權煒), Hou-Cheng Lu (呂厚錚), Yen-Chieh Huang (黃彥傑), Jui-Ming Yang (楊瑞銘), Chih-Hsuan Cheng (鄭智軒), Shawn S. H. Hsu (徐碩鴻)

<http://www.ee.nthu.edu.tw/shhsu/>

Cancer Companion Diagnostics & Therapeutics: The Next Generation for Comprehensive Cancer Control

Prof. Shiaw-Der Yang

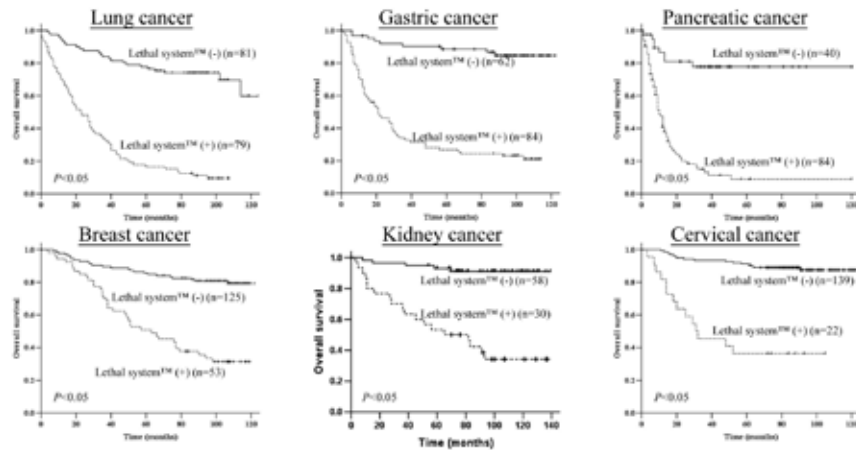
Rather than a single cell disease, cancer has been recognized as a systemic disease and systemic spread may represent an early event. Precise diagnosis is the key to successful personalized treatment on cancer patients (Roche, 2014). On the basis of molecular, cellular, animal, clinicopathological, epidemiological, psychosocial, and human studies combined and interplayed together, we have discovered common molecular, cellular and systemic origins collectively termed the lethal system of various types of cancers including cancer of bladder, breast, brain, bile duct, cervix, colorectum, endometrium, esophagus, stomach, liver, lung, nasopharyngus, oral cavity, ovary, pancreas, prostate and kidney, leukemia and lymphoma for comprehensive cancer control. The lethal system comprises vicious cycles of chronic stress, inflammation and aging-related molecular biomarker signaling network deregulation in bone marrow stem/progenitor cells, immune and stromal cells involved in aberrant wounding, chronic inflammation, systemic immune disorder, tissue fibrosis and related chronic systemic diseases such as generation and maintenance of cancer stem cells responsible for poor outcome cancers even after potentially curative treatment. The lethal system represents the molecular, cellular and systemic action mechanism governing simultaneous progression of primary tumor and micrometastasis and the following metastatic dormancy reactivation in very early stage I cancer patients with poor outcome tumors even after curative surgery. The core technology (Fig. 1) has been patented and issued in USA, Taiwan, Japan, Australia and mainland China and allowable in European Union (Yang, 2012, 2013, 2014).

While the global trend is shifting from cancer treatment medicine toward personalized preventive medicine due to incurable disease development, the multifunctional/multifaceted biomarkers signaling networks-based precise diagnosis is now recognized as the key to successful personalized prevention and early intervention on cancer patients and family members and normal human subjects for early health before symptom appears. Thus, the NTHU patented core technology can be applied to very early detection and preventive treatment of various types of cancer patients, cancer family and ostensibly healthy people to tip the delicate balance among a repertoire of recruited ostensibly normal cells for cancer outcome prediction, prevention, health promotion, patient participation and personalized healthcare for the best quality of life. Simultaneously, the NTHU patented core technology can be applied to pharmaceutical and insurance companies and government to reduce clinical trial cost and healthcare cost dramatically (Figs. 2).

Fig 1.

Unique Core Technology in NTHU

Three-dimensional (Tumor-Microenvironment-Host) Study on Molecular, Cell and Systemic Targeted Comprehensive Cancer Tissue/Blood Based Diagnostics Development



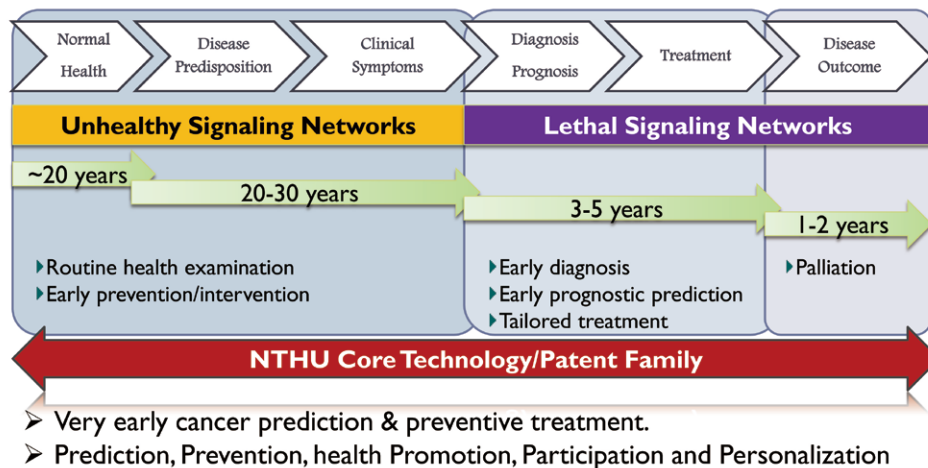
Common risk factors:

Vicious cycles of multifunctional/multifaceted biomarkers signaling networks in simultaneous progression of primary tumor and micrometastasis followed by metastatic dormancy reactivation.

Fig 2.

Personalized healthcare

Lifespan of poor outcome cancer patients or cancer family members who tend to develop poor outcome tumors



Authors

Shiaw-Der Yang (楊孝德), Tsing Hua Chair Professor

Institute of Molecular and Cellular Biology & Department of Medical Science

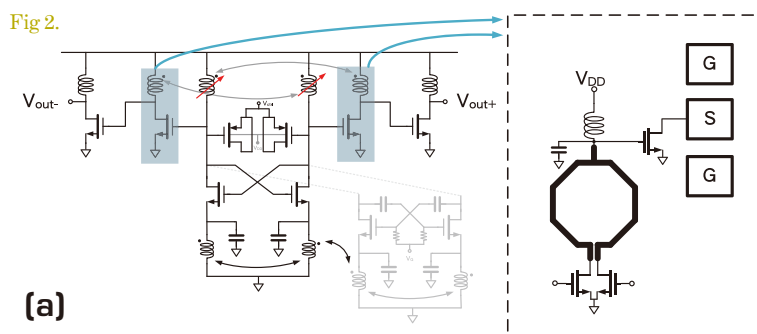
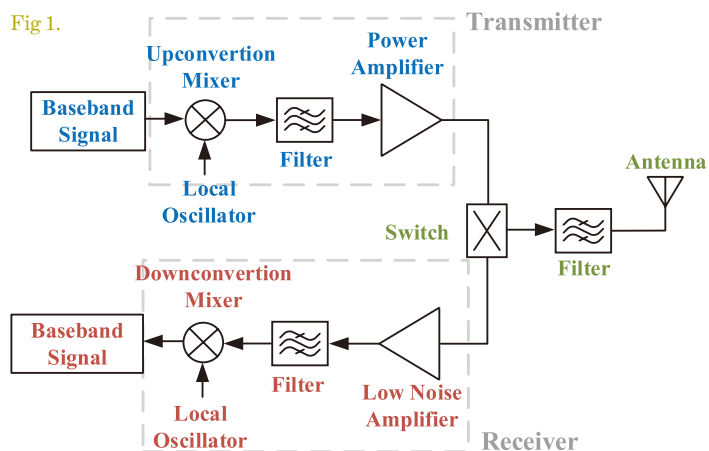
Millimeter-Wave Ultra High Speed Circuits

Prof. Jenny Yi-Chun Liu

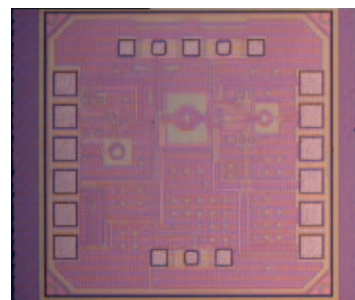
The rapid increase of mobile data and the ubiquitous use of the mobile devices such as the tablets and the smartphones are creating unprecedented demands and challenges for the wireless system and circuit designers to overcome the global bandwidth shortage. This phenomenon motivates the exploration of the millimeter-wave frequency spectrum for future ultra high speed communication networks. Millimeter-wave applications

are mainly located on the spectrum from around 30 GHz to 300 GHz, which corresponds to the wavelength of 1 mm to 10 mm. In the recent years, many research focuses on the 24 GHz and 79 GHz band for the short-range radar, the 60 GHz band for IEEE 802.11ad WPANs, the 94 GHz band for imaging systems, and the 155 GHz for 20-Gb/s wireless communication link.

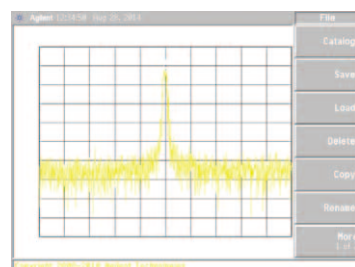
For the mentioned applications, front-end transceivers are crucial in the systems. Fig 1. shows the fundamental architecture of a transceiver and we work on the high performance local oscillator, mixer, power amplifier, low noise amplifier, and antenna based on this architecture, or some advanced transceiver architectures. Novel ultra high frequency device design and modeling are as well part of our research. Some recently proposed circuits would be presented in the following paragraphs.



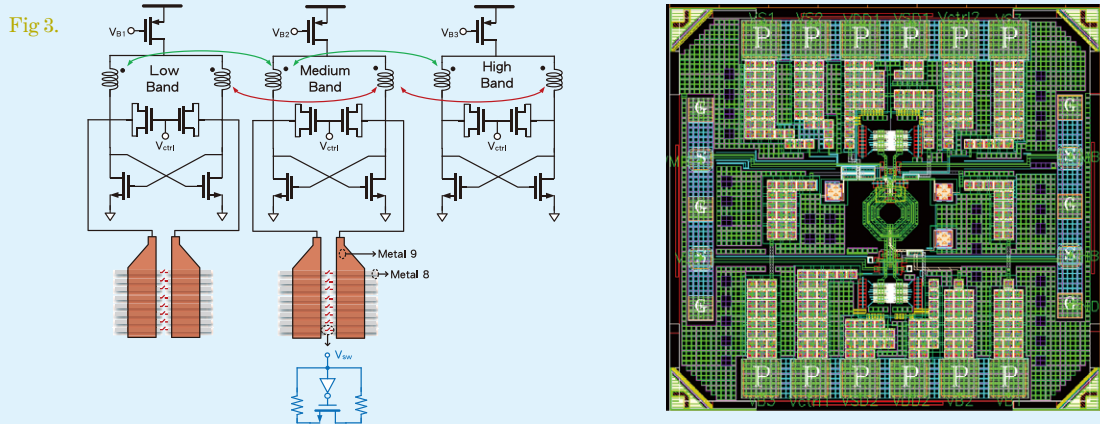
(b)



(c)

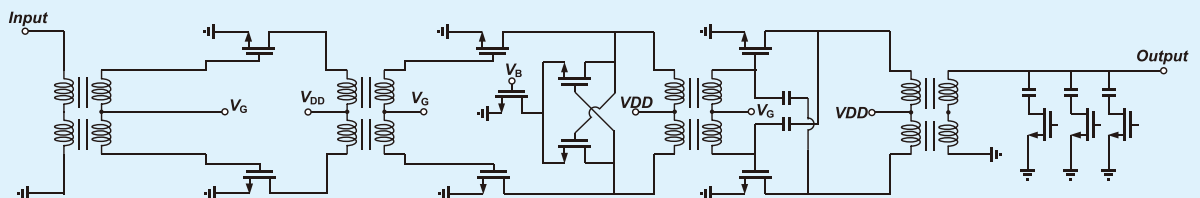


The first design is an ultra-low power/supply voltage voltage-controlled oscillator with push-push technique as shown in Fig. 2. With the process scaling, the supply voltage scales simultaneously and it poses difficulties on the millimeter-wave circuit design. In this work, a high performance voltage-controlled oscillator under a supply voltage of 0.7 V is proposed to accommodate the voltage scaling. Class-B and class-C types are in shunt to lower the phase noise and maintain the fast settling time at the same time. In addition, by designing with a Colpitts-like structure and alternating the tail current to the inductor, the oscillation frequency is achieved in the following ranges: 38.4 GHz – 40.3 GHz, 42.83 GHz – 46.53 GHz, 76.7 GHz – 80.68 GHz, and 85.46 GHz – 93.23 GHz. The lowest measured phase noise is -123.27 dBc/Hz at 10-MHz offset frequency.

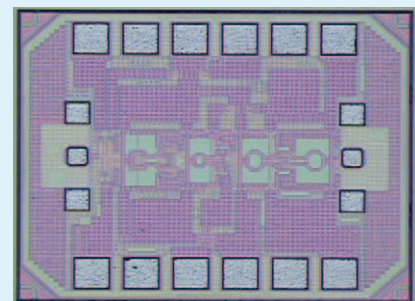


The second design is a tri-band resonance voltage-controlled oscillator with switched transformer and DiCAD tuning as shown in Fig. 3. To improve the tuning range of the voltage-controlled oscillator in the software-defined radio, switched transformer and DiCAD techniques are proposed. In this work, 51.43% of tuning range is achieved, which is the largest tuning range at millimeter-wave to the authors' knowledge.

Fig 4. (a)



The third design is a three-stage reconfigurable power amplifier with switched capacitors, power combiner, cross-coupled capacitors as shown in Fig. 4. Design methodologies of the active and passive devices are proposed to optimize the power, gain and efficiency. Cross-coupled capacitors are designed to improve the available gain by more than 3 dB at millimeter-wave and simplify the matching condition. Low-loss combiner is designed to improve the power performance. Switched capacitors at the output stage provide an alternate to change the output impedance, therefore, the performance can be reconfigurable to various frequencies and power levels.



(b)

Authors

Jenny Yi-Chun Liu 劉怡君

Institute of Electronics Engineering/ Department of Electrical Engineering



DNA-CTMA:NP
composite

Exemplary Achievements

Photo-sensitization of singlet oxygen and Photodynamic Therapeutic Effects Mediated by PEGylated $W_{18}O_{49}$ Nanowires on Destruction of Tumors

Prof. Kuo Chu Hwang

Hyperthermia-Mediated Local Drug Delivery by a Bubble-Generating Liposomal System for Tumor Specific Chemotherapy

Prof. Hsing-Wen Sung

Shifting Networks to Achieve Subgroup Symmetry Properties - A Story about Biomimicking Butterfly Wing Structure

Prof. Rong-Ming Ho

JMJD5 regulates PKM2 nuclear translocation and reprograms HIF-1 α -mediated glucose metabolism

Prof. Wen-Ching Wang

A High Efficient Micro-Proton Exchange Membrane Fuel Cell by Integrating Micro-Nano Synergical Structures

Prof. Fan-Gang Tseng

The Central Role of Engagement in Online Communities

Prof. Soumya Ray

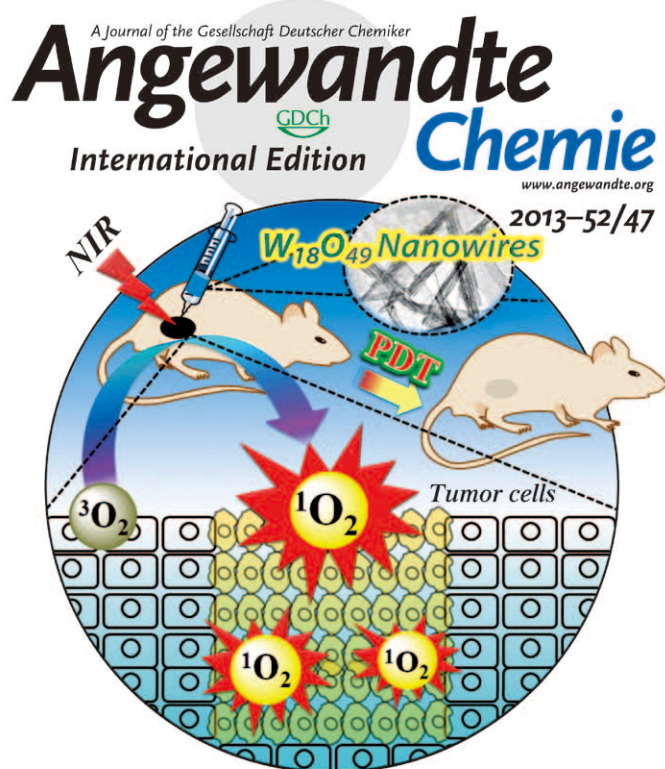
Invisible Agency: A Theory of Displacement for Subaltern

Prof. Wen-yuan Lin

Photo-sensitization of singlet oxygen and Photodynamic Therapeutic Effects Mediated by PEGylated $W_{18}O_{49}$ Nanowires on Destruction of Tumors

Prof. Kuo Chu Hwang

Angew. Chem. Int. Ed. 2013, 52(47), 12332-12336.



$W_{18}O_{49}$ nanowires ...

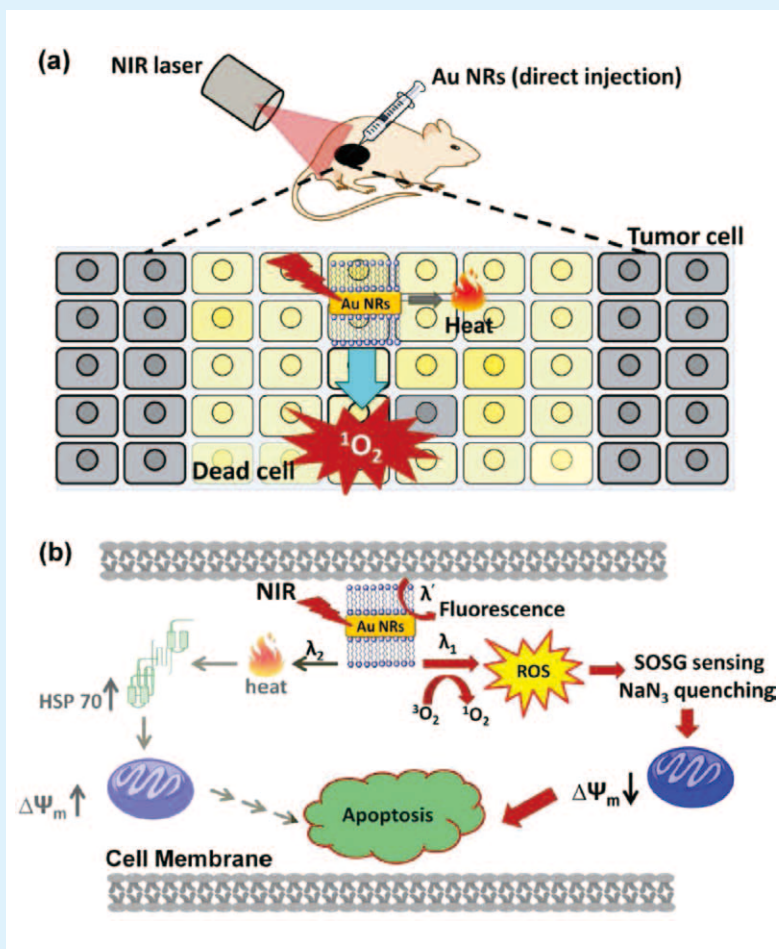
... can sensitize the formation of singlet oxygen upon irradiation with near-infrared (NIR) light. In their Communication on page 12332 ff., K. C. Hwang and co-workers describe the complete destruction of solid tumors in mice by $W_{18}O_{49}$ -nanowire-mediated photodynamic therapy (PDT). This effect was not achieved when employing photothermal therapy or the anticancer drug doxorubicin.

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In 2011, professor Kuo Chu Hwang and coworkers reported the first discovery that metal nanoparticles, including Pt, Au and Ag NPs, are able to sensitize formation of singlet O_2 , a key ROS leading to photodynamic therapy effects, upon visible light and near-IR light photo irradiation (*Angew. Chem. Int. Ed.* 2011, 50, 10640-10644). In the paper, they predicted that these metal nanoparticles will be excellent inorganic photosensitizers for generation of singlet oxygen to be used in photodynamic therapy (PDT) treatments of cancers. To treat deep tissue-buried tumors by PDT, the NIR excitation light is required to be used as the excitation light since only NIR light with wavelengths within the first biological window of 650~900 nm is able to penetrate deep tissues and excite the photo-sensitizers. NIR light activatable organic

photosensitizers are very rare. Since metal nanoparticles have 4~6 orders higher extinction coefficients than organic photo-sensitizers and are resistant to photo-/enzymatic degradation, we predict that metal nanostructures will be excellent and very important NIR activatable PDT



reagents for clinic treatments of cancers and solid tumors. They further demonstrated the use of Au and Ag NPs to kill *in vitro* cancer cells upon NIR light irradiation (*J. Mater. Chem. B.* **2013**, 1, 4379-4387; selected as HOT article by editor for 2013). Very recently, they also demonstrated the first literature example of “nanomaterials-mediated photodynamic therapy” (NmPDT) effects on complete destruction of tumors in mice upon 980 nm NIR light activation (*Angew. Chem. Int. Ed.* **2013**, 52(47), 12332-12336. Cover page article; and *Small* **2014**, 10(8), 1612–1622). They also demonstrated that Au NRs, Au NRs-in shell, WOx NW, and Au nanoechinus all can mediate photodynamic

therapy (NmPDT) effects and their effects are far more effective in destruction of solid tumors in mice than their corresponding photothermal therapy (PTT) effects as well as the well-known anticancer drug, doxorubicin (*Biomaterials* **2014**, 35(21), 5527-5538; SCI IF = 8.3).

References

1. Kuo Chu Hwang et al, *Angew. Chem. Int. Ed.* **2013**, 52(47), 12332-12336. Cover page article.
2. Kuo Chu Hwang, et al, *J. Mater. Chem. B.* **2013**, 1, 4379-4387, selected as HOT article.
3. Kuo Chu Hwang et al, *Small* **2014**, 10(8), 1612–1622. , highlighted by Nanowerk, *Future Med Chem.* (2014) 6(4), 370, and the #1 Antibody Resource website.
4. Kuo Chu Hwang et al, *Biomaterials* **2014**, 35(21), 5527-5538.
5. Kuo Chu Hwang et al, *Adv. Mater.* **2014**, DOI: 10.1002/adma.201400703, Frontispiece in Advanced Materials, published onweb on 2014-07-14.

Authors

Poliraju Kalluru, Raviraj Vankayala, Chi-Shiun Chiang (江啓勳), Kuo Chu Hwang*(黃國柱)

<http://onlinelibrary.wiley.com/doi/10.1002/anie.201307358/abstract>

Hyperthermia-Mediated Local Drug Delivery by a Bubble-Generating Liposomal System for Tumor Specific Chemotherapy

Prof. Hsing-Wen Sung

ACS Nano, vol. 8, issue 5, pp.5105-5115, 2014.

As is widely suspected, lysolipid dissociation from liposomes contributes to the intravenous instability of ThermoDox[®] (Lysolipid liposomes), thereby impeding its antitumor efficacy. This work evaluates the feasibility of a thermoresponsive bubble-generating liposomal system without lysolipids for tumor-specific chemotherapy. The key component in this liposomal formulation is its encapsulated ammonium bicarbonate

(ABC), which is used to actively load doxorubicin (DOX) into liposomes and trigger a drug release when heated locally. Incubating ABC liposomes with whole blood results in a significantly smaller decrease in the retention of encapsulated DOX than that by Lysolipid liposomes, indicating superior plasma stability. Biodistribution analysis results indicate that the ABC formulation circulates longer than its Lysolipid counterpart. Following the injection of ABC liposome suspension into mice with tumors heated locally, decomposition of the ABC encapsulated in liposomes facilitates the immediate thermal activation of CO₂ bubble generation, subsequently increasing the intratumoral DOX accumulation. Consequently, the antitumor efficacy of the ABC liposomes is superior to that of their Lysolipid counterparts. Results of this study demonstrate that this thermoresponsive bubble-generating liposomal system is a highly promising carrier for tumor-specific chemotherapy, especially for local drug delivery mediated at hyperthermic temperatures.

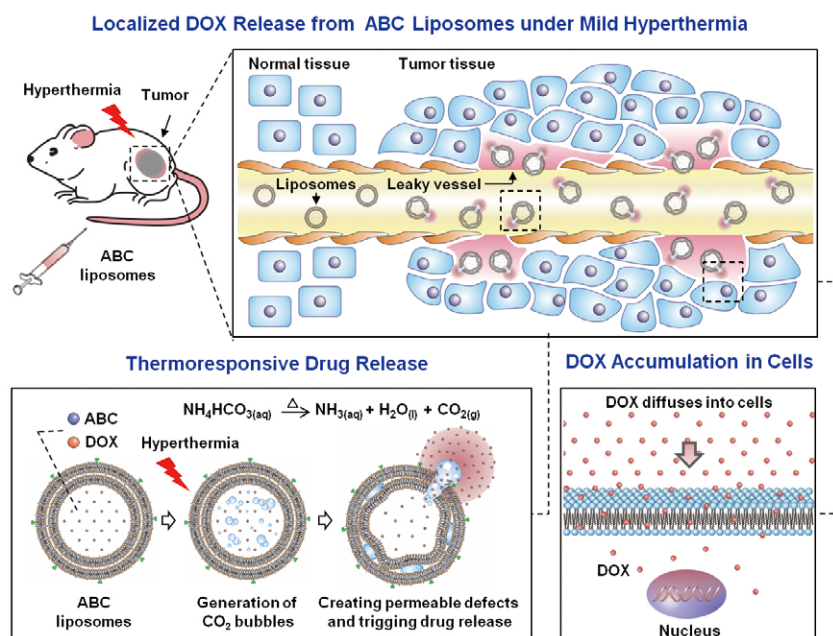


Fig 1. Schematic diagrams showing the composition of the thermoresponsive bubble-generating ABC liposomes with their working mechanism of the action that delivers high concentrations of drug in a tumor region targeted with the application of localized hyperthermia.

Widely recognized for their ability to increase intratumoral accumulation, PEGylated liposomes are employed as stable vehicles for carrying doxorubicin (DOX; Doxil[®]). However, the slow and passive drug release from the Doxil[®] formulation (<10% in 24 h) significantly inhibits its antitumor efficacy. Therefore, an approach must be developed to actively trigger a drug release from PEGylated liposomes and enhance their therapeutic outcome. A thermoresponsive liposomal formulation (ThermoDox[®]) has been developed that rapidly releases DOX in regions where local tissue temperatures are elevated. ThermoDox[®] contains three lipid components in a 90:10:4 molar ratio: dipalmitoylphosphatidylcholine (DPPC); monostearoylphosphatidylcholine (MSPC), which is a lysolipid; and polyethylene glycol 2000-distearoylphosphatidylethanolamine (PEG 2000-DSPE).

The underlying mechanism of the rapid drug release from the ThermoDox[®] formulation is that the lipids (DPPC and MSPC) undergo a gel-to-liquid phase transition in the region of their phase transition temperature (T_m ; approximately 41°C). When heated to 40–42°C, temperature-induced membrane instability increases the permeability of liposomes, subsequently releasing their encapsulated drugs. Related studies have demonstrated that the ThermoDox[®] formulation performs superior to the Doxil[®] formulation in releasing encapsulated DOX.

While proven effective in reducing tumor volume in animal models, ThermoDox[®] has recently begun Phase III clinical trials for hepatocellular carcinoma treatment. Despite the significant therapeutic potential of ThermoDox[®], approximately 50% of its encapsulated DOX is released within 1h in physiological environments. As is widely suspected, lysolipid dissociation from the liposomes mediated by plasma proteins contributes to their intravenous instability.

To resolve the above problem, our group recently developed a thermoresponsive liposomal formulation without lysolipids. This thermoresponsive liposomal formulation consists DPPC, cholesterol, and PEG 2000-DSPE in a molar ratio of 60:40:5. As the key component of this liposomal formulation, its encapsulated ammonium bicarbonate (ABC; NH_4HCO_3) creates the transmembrane gradient needed for a highly efficient DOX encapsulation. Moreover, at a high temperature of roughly 42°C, ABC decomposition generates CO_2 bubbles, subsequently creating permeable defects in the lipid bilayer and ultimately inducing a rapid DOX release to instantly increase the drug concentration locally. Notably, ABC is a raising agent commonly found in the food industry to generate gas bubbles in baked goods. Physiologically, bicarbonate ions are generated in red blood cells and used to maintain a balanced pH; once completing their task, these ions are released by the lungs as CO_2 .

This work evaluates the feasibility of using this thermoresponsive bubble-generating liposomal system (ABC liposomes) for tumor-specific chemotherapy under mild hyperthermia. Clinically, local hyperthermia may be produced by ultrasound energy, microwave, radiofrequency, or using magnetic hyperthermia. The thermosensitive ABC formulation is administered intravenously *via* the tail vein in mice during hyperthermia treatment at roughly 42°C, thereby triggering the immediate release of the encapsulated drug within the heated tumor. The released drug diffuses into the tumor along a high drug concentration gradient, specifically attacking tumor cells (Figure 1). The control groups consist of liposomes formulated in aqueous ammonium sulfate (AS liposomes), a preparation that resembles the Doxil[®] formulation, together with a formulation that resembles that of ThermoDox[®] (DPPC:MSPC:PEG 2000-DSPE = 90:10:4 containing AS; Lysolipid liposomes). Moreover, the *in vitro* drug-release profiles are quantified from test liposomes under mild hyperthermia conditions. Their *in vivo* biodistribution, pharmacokinetics, drug accumulation, and antitumor activity against locally heated tumors are examined as well.

Authors

Ko-Jie Chen (陳可潔), Er-Yuan Chaung (莊爾元), Shiaw-Pyng Wey (魏孝萍), Kun-Ju Lin (林昆儒), Felice Cheng (鄭淑珍), Chia-Chen Lin (林佳瑱), Hao-Li Liu (劉浩禮), Hsiang-Wen Tseng(曾湘文), Chih-Peng Liu (劉志鵬), Ming-Cheng Wei (魏明正), Chun-Min Liu (劉俊旻), and Hsing-Wen Sung (宋信文)

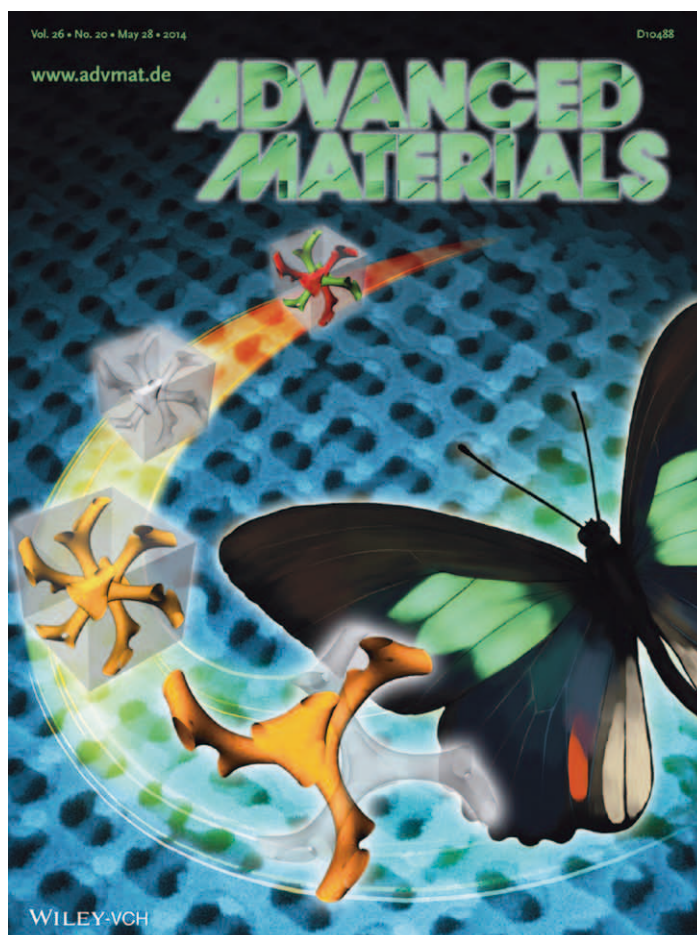
Shifting Networks to Achieve Subgroup Symmetry Properties - A Story about Biomimicking Butterfly Wing Structure

Prof. Rong-Ming Ho

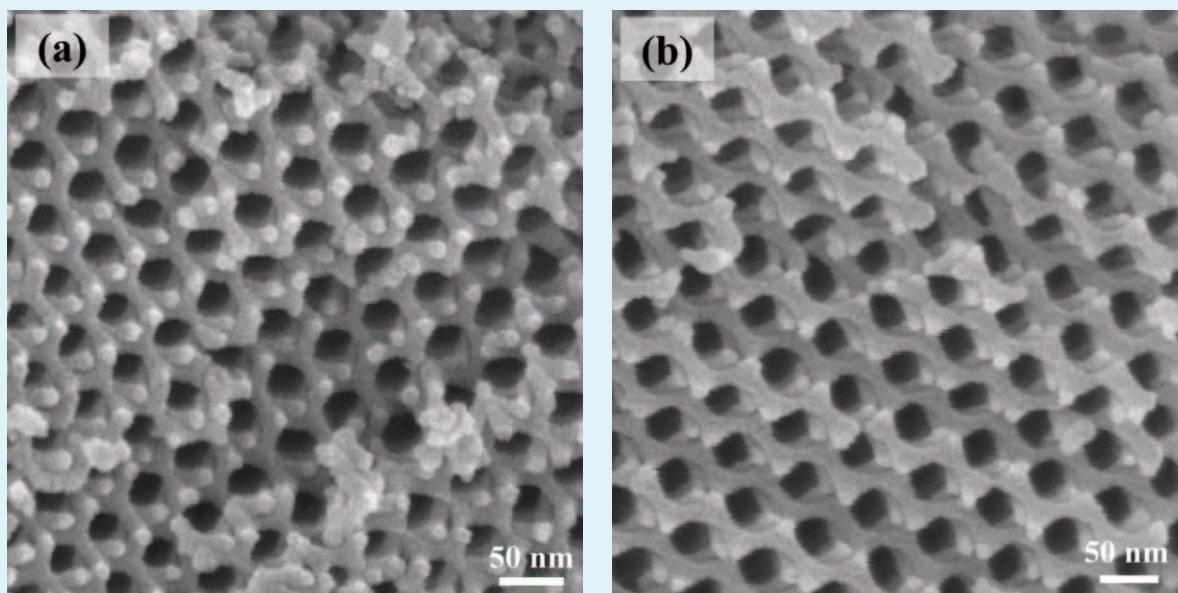
Adv. Mater. 2014, 26, 3165.

A double gyroid structure is used as a model system for the demonstration of shifting networks to achieve single gyroid-like scattering properties, similar to the photonic properties of butterfly wing structure.

In this article, Professor Rong-Ming Ho and co-workers suggest a simple method for the preparation of new material systems by network shifting from high symmetry to low symmetry. A double gyroid (DG) structure from the self-assembly of polystyrene-*b*-poly(L-lactide) (PS-PLLA) is used as a model system for the demonstration of shifting networks to achieve subgroup symmetry properties from the materials with supergroup symmetry. Inorganic networks in a PS matrix are fabricated by using hydrolyzed PS-PLLA as a template for sol-gel reaction.



Owing to the soft polymer matrix, two registered bicontinuous (DG) inorganic networks can be dismissed by thermal annealing to give single gyroid-like (*pseudo*-single gyroid, *p-SG*) nanohybrids. After removal of the PS matrix, free-standing *p-SG* network materials as shown below can be fabricated to give nanophotonic properties. This approach develops a platform technology to fabricate novel network from bicontinuous cubic phases through supergroup/subgroup transformation.



References

1. Han-Yu Hsueh, Yi-Chun Ling, Hsiao-Fang Wang, Lung-Yu Chang Chien, Yu-Chueh Hung, Edwin L. Thomas and Rong-Ming Ho* *Adv. Mater.* **2014**, *26*, 3225. **Front Cover Story**
2. Hsiao-Fang Wang, Lv-Hong Yu, Xin-Bo Wang*, Rong-Ming Ho* *Macromolecules* **2014**, *47*, 7993. **Front Cover Story**
3. Han-Yu Hsueh, Hung-Ying Chen, Chun-Ku Chen, Rong-Ming Ho*. Shangjr Gwo, Satoshi Akasaka, Hirokazu Hasegawa, *Nano Lett.*, **2010**, *10*, 4994.

Authors

Han-Yu Hsueh (薛涵宇), Yi-Chun Ling (凌顛鈞), Hsiao-Fang Wang (王孝方), Lung-Yu Chang Chien (張簡隆宇), Yu-Chueh Hung (洪毓珣), Edwin L. Thomas and Rong-Ming Ho (何榮銘)*

<http://onlinelibrary.wiley.com/doi/10.1002/adma.201470130/abstract>

JMJD5 regulates PKM2 nuclear translocation and reprograms HIF-1 α -mediated glucose metabolism

Prof. Wen-Ching Wang

PNAS, vol. 111, pp. 279-284 (2014)

Significance:

Revealing mechanisms for altered metabolic metabolism in cancer cells and highlighting a new direction of breast cancer interventions.

One of the hallmarks of cancer cells is their altered metabolism, referred to aerobic glycolysis, or the Warburg effect. This generally involves an increased uptake of glucose, use of intracellular glucose to pyruvate via glycolysis, and the conversion into lactate even in the presence of sufficient oxygen. However, the detailed mechanisms about this altered metabolism are mostly unknown. A collaborative research between Professors Wen-Ching Wang (NTHU) and Hsing-Jien Kung (National Health Research Institutes, Taiwan) and revealed the long-lasting mystery. They showed that Jumonji C domain-containing dioxygenase (JMJD5) modulates a key gate-player enzyme pyruvate kinase muscle isozyme (PKM2) in the glycolytic flux in two ways. JMJD5 regulates PKM2's tetramer-dimer equilibrium to lower pyruvate kinase activity and, at the same time, facilitates PKM2's nuclear translocation, via direct physical binding. Together, they modulate hypoxia-inducible factor 1 α -mediated transcriptional reprogramming of metabolic genes in cancer cells. The results of this work are published in Proc. Natl. Acad. Sci. USA. Importantly, this study provides important evidence for "cancer as a metabolic disease" and points out a new direction for breast cancer interventions.

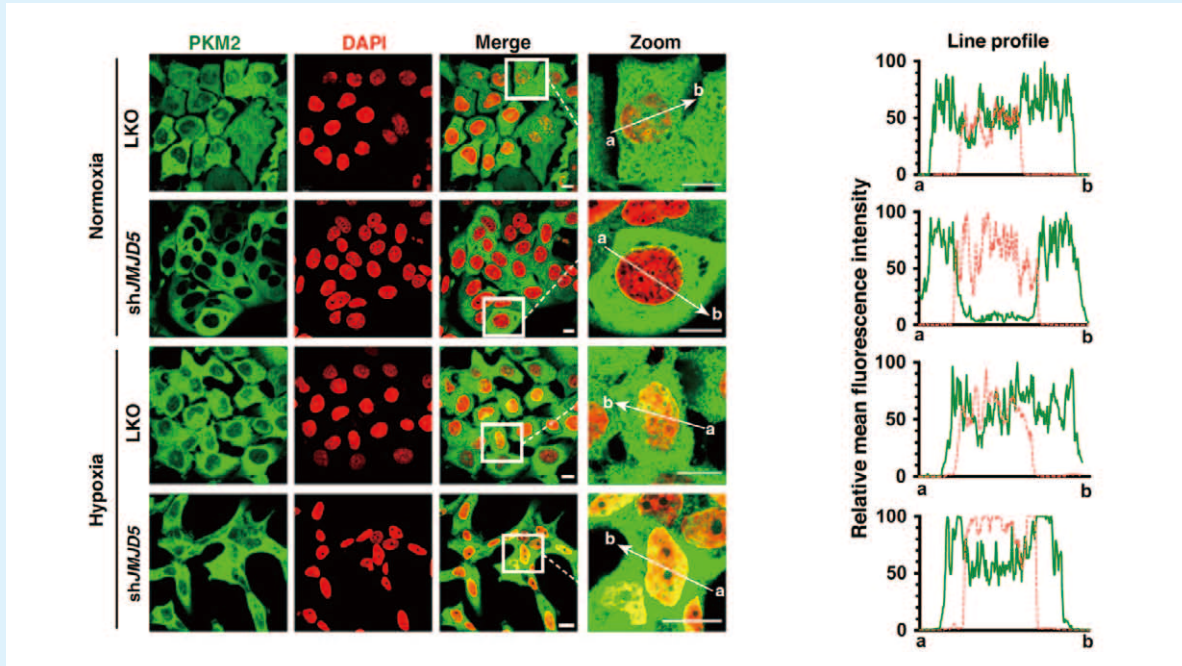


Fig 1.

JMJD5 regulates the nuclear translocation of PKM2. Subcellular localization of PKM2 in MCF-7 cells. Cells were immunostained with anti-PKM2 (PKM2, green). The nucleus is marked with DAPI (red). Merged images (Merge) are shown. The framed regions are zoomed in the fourth row (Zoom). The line profiles of PKM2 and DAPI signals were measured by ZEN2011 (Carl Zeiss) software. (Scale bars, 10 μ m.)

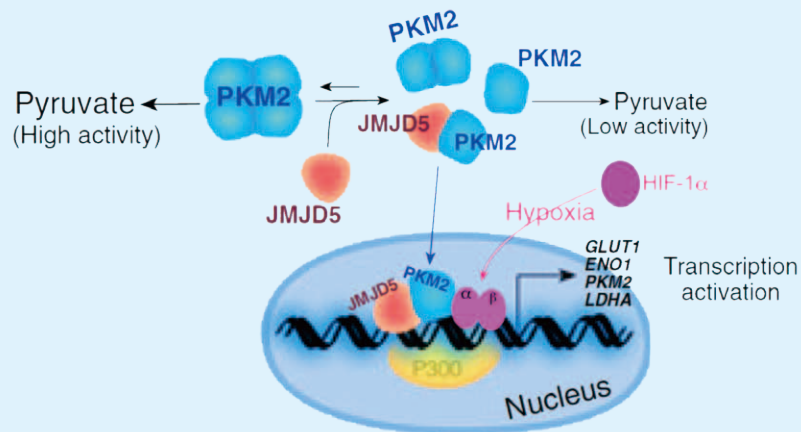


Fig 2.

The proposed model that depicts JMJD5 as a major regulator in PKM2-stimulated HIF-1 α metabolic reprogramming.

Authors

Hung-Jung Wang (王鴻俊), Ya-Ju Hsieh (謝雅如), Wen-Chi Cheng (鄭文琦), Chun-Pu Lin (林均璞), Yu-Shan Lin (林瑜珊), So-Fang Yang (楊所芳), Chung-Ching Chen (陳仲勤), Yoshihiro Izumiya, Jau-Song Yu (余兆松), Hsing-Jien Kung (龔行健), Wen-Ching Wang (王雯靜)

Institute of Molecular and Cellular Biology / Department of Life Science

<http://www.pnas.org/content/111/1/279.long>

A High Efficient Micro-Proton Exchange Membrane Fuel Cell by Integrating Micro-Nano Synergical Structures

Prof. Fan-Gang Tseng

Journal of Power Sources, vol 225, pp. 277-285(2013)

A silicon-based micro-proton exchange membrane fuel cell (μ -PEMFC) which carries out an outstanding cell performance and high efficient catalyst utilization ratio is proposed in this paper by the employment of three micro-nano synergical techniques. Firstly, a novel design incorporating multi-walled carbon nano-tubes (MWCNTs) on radial shaped micro-channel walls to form micro/nano reaction chambers which significantly enhance the reaction surface areas for the performance improvement. In the second, the dispensing of ionomer onto the three-phase zones in the reaction chambers is controlled by different rotation speed and the optimized distribution can therefore be achieved for the improvement of catalyst utilization. In the third, the cell interfacial strength is greatly enhanced by the employment of microinterlocks for maintaining excellent interface between Nafion membrane and reaction chambers while minimizing the system size. A μ -PEMFC is successfully fabricated by integrating aforementioned synergical micro/nano structures altogether. The best cell efficiency is 26 mW cm^{-2} which corresponds to a catalyst utilization ratio of 38.2 Wg^{-1} , and can be considered among the best performed micro-fuel cells.

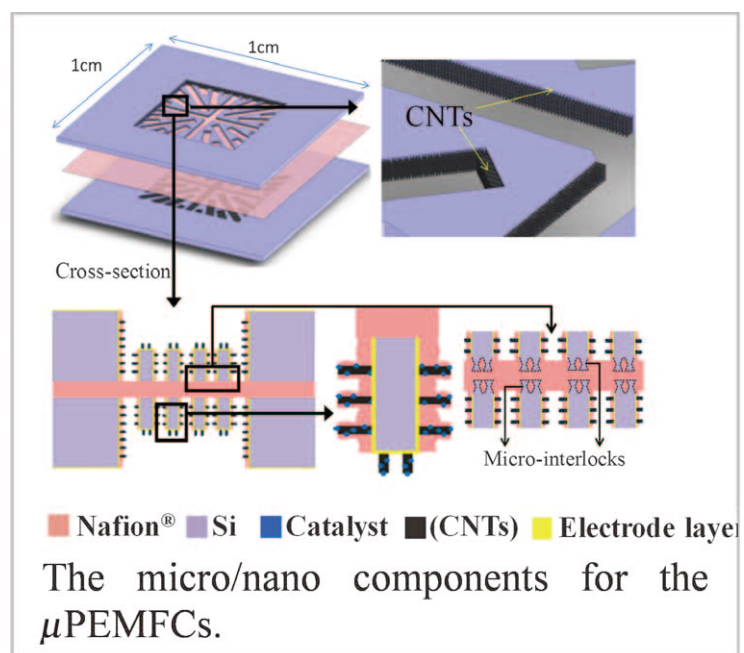


Fig 1.

The schematic diagram of the m-PEMFC, which consists of radial type micro- and nano-structured electrodes and micro-interlocks.

We present water droplets that undergo spontaneous self-directed motion upon contact with a chemically patterned nanotextured surface with wedge-shape gradient. The surface exhibits two distinct wetting properties and low hysteresis. The droplet velocity depends on the droplet position and gradient angle. A wide range of droplet volume can be transported and a droplet velocity as high as 0.5 m/s has been achieved herein. Ascension of water droplets with all-round acclivity and a subnanoliter droplet movement were also demonstrated. A μ -PEMFC is successfully fabricated by integrating aforementioned synergical micro/nano structures altogether. The best cell efficiency is 26 mW cm^{-2} which corresponds to a catalyst utilization ratio of 38.2 W g-pt-1 , and can be considered among the best performed micro-fuel cells. We conclude that it is the combination of surface tension gradient and nano-wetting actuation that governs the droplet motion.

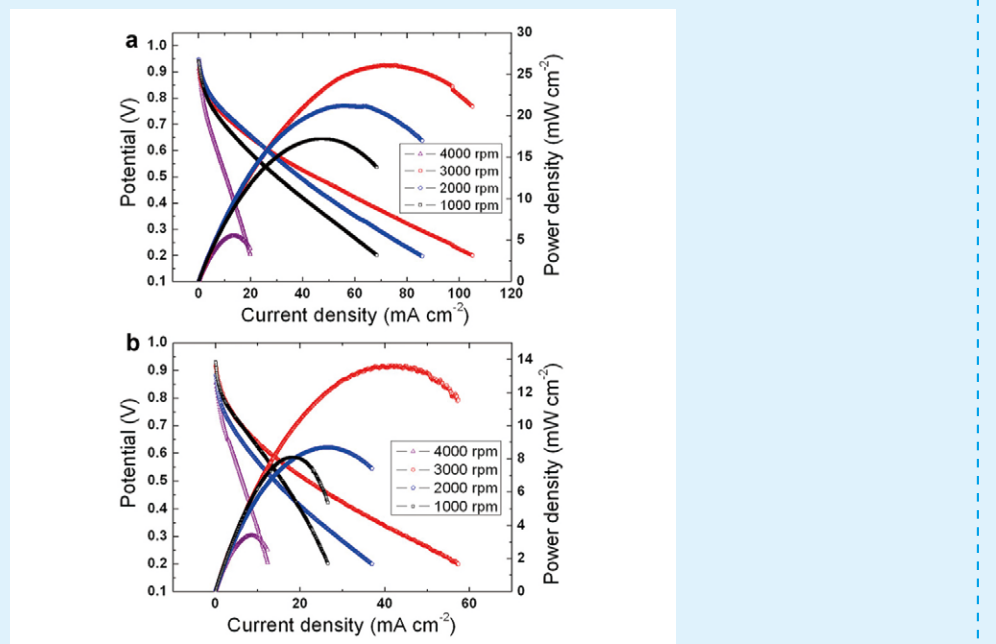


Fig 2.

The polarization curves of the m-PEMFCs with different ionomer spinning-in conditions at the cathodes; (a) active testing condition, and (b) passive testing condition. The black square, blue pentagon, red hexagon and purple triangle represent the spinning-in conditions of 1000, 2000, 3000, and 4000 rpm, respectively.

Authors

Hsien-Chih Peng(彭顯智), Chung-Nan Wang(王中南), Tsung-Kuang Yeh(葉宗洸),
Yu-Chuan Su(蘇育全), Chin Pan(潘欽), Fan-Gang Tseng(曾繁根)*

<http://www.sciencedirect.com/science/article/pii/S0378775312014930#>

<http://yzhsu.feg.com.tw/tw/awards/winner.aspx?cid=1&id=4&n=49>

The Central Role of Engagement in Online Communities

Prof. Soumya Ray

Ray, S., Kim, S. S., & Morris, J. G. (2014). *Information Systems Research*, forthcoming

An international research team led by Prof. Soumya Ray of National Tsing Hua University undertook a study to ascertain what it takes to create a positive sense of engagement in online communities. Online communities are new social structures that allow disparate members from around the world to virtually gather, organize, and exchange knowledge in web-based discussion forums. These new forms of social interaction allow people to engage with others who share similar interests or viewpoints, or offer a space for general discussion. Like members of nations, clans, and tribes, members of online communities quickly form a collective sense belonging and mutual responsibility. With time, they realize their own rituals and traditions, and begin to form norms of obligation toward each other and the community as a whole.

But online communities are entirely dependent on modern information technology as the medium of operation, and they face equally modern challenges that come from it. Although satisfied members regularly consume content, it is considerably harder to coax them to contribute new content and help recruit others because they face unprecedented social comparison and criticism. The anonymous nature of online communities creates an atmosphere of unregulated social comparison that inhibits thoughtful participation and deters newcomers. As a result, even though the number of online communities continues to mushroom, they quickly lose participants and most lie dormant before too long.

The researchers conducted an empirical study of members of numerous online communities, and constructed a framework to demonstrate what engagement is, where it comes from, and how it powerfully explains both knowledge contribution and word of mouth.

The study gathered data from 301 subjects across numerous online communities. The table below shows a small subset of the kinds of communities that research subjects regularly visited.

Table 1

Online Community Website	Description
www.talkbass.com	Bass guitar, bass guitarists, instruction, news, etc.
www.600rr.net	Honda Motorcycles
cruisecritics.com	cruiselines and cruising in general
brightideas.com	To exchange household ideas
fountainpennetwork.com	It's about fountain pen use, collecting, repair, reviews, ink reviews, and lots and lots of sales.
forums.joerogan.net	the discussion is about EVERYTHING! people visit it because it's an awesome place to talk and get info.
www.healthcentral.com	depression- it helps to talk with people with my illness
threadbanger.com	arts and crafts, ideas and helpful info for sewing projects and such
exascape.proboards.com	about any and all topics of interest to adults, with a particular concentration in matters relating to environmentalism, social causes, human and animal rights and welfare and the like
whattoexpect.com	It's a website/discussion board for mothers to be and new moms. People visit it to discuss what's going on with their pregnancies and talk to other moms due around a similar time.
deadspin.com	It's a fun way to discuss the latest events in sports

Notes: These are a subset of the reported online communities for which respondents provided a Web address; Online community website addresses have been formatted for consistency; Descriptions of the online communities are the unedited, original descriptions by subjects.

The data gathered included survey items around many key constructs. The key concept measured was that of *community engagement*, which refers the psychological state in which members are cognitively and emotionally energized to exemplify the positive ways in which they prefer to think of themselves. Engaged people are exceedingly heedful of the need to produce value for others. Engaged people go are dutiful in pursuing good citizen behaviors that are informal, emergent, helpful, and conscientious of the fellow members of their group. Moreover, they strive to harness their full energies in helpful ways and accomplish tasks that are innovative and collaborative. This is in contrast to traditionally studied concepts in management such as *satisfaction*, which refers to the overall assessment of how well prior expectations of community membership were fulfilled. Satisfaction is a common focus of management studies because it influences intentions by acting as an indicator of potential future value.

The authors sought to demonstrate that engagement and satisfaction arise from a few common sources. Chief among them is *community identification*, which refers to the extent to which the personal identity of members overlaps with the perceived traits of their chosen community. This overlap leads members to conflate their own identity with a larger social identity, which makes them treat other members as they would like to be treated themselves. While community identification is a common force in even traditional communities, members of online communities require something further. They need *self-identity verification*, which refers to the cognitive processes of analyzing one’s interactions with others to determine if our view of ourselves matches how others see us. Receiving self-identity verification helps confirms that we are playing the role that our community expects of us. This signals to people that future interactions, even with strangers, may proceed safely and keep us free from attack or ridicule. Finally, individual members of online communities differ in their *knowledge self-efficacy*, or their belief that they have the ability and expertise to contribute to discussions, solve problems, or to otherwise make a difference by participating. This belief of self-efficacy enables us to overcome fear and difficulties, and predictably achieve desired outcomes.

The researchers of this study showed that long-term members primarily contribute to and revisit an online community from a sense of engagement. Nonetheless, word of mouth is partly influenced by prior satisfaction. Therefore, engagement and satisfaction appear to be parallel mediating forces at work in online communities. Both mediators arise from a sense of communal identity and knowledge self-efficacy, but engagement also emerges from validation of self-identity. Nevertheless, there are signs that the contributions of the most knowledgeable users are not purely from engagement, but also from a competing sense of knowledge self-efficacy.

Fig 1.

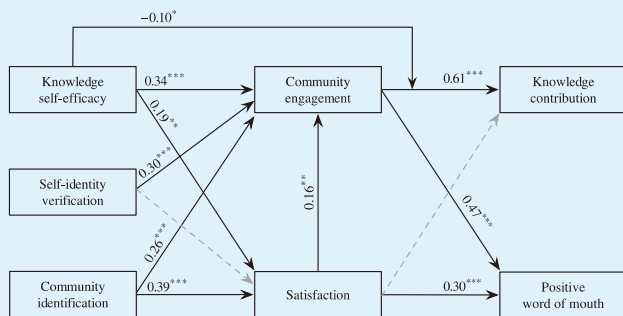
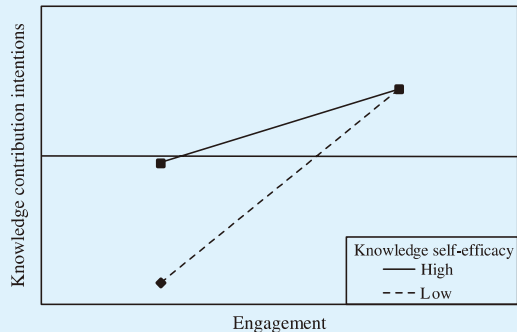


Fig 2.



Online communities are the modern equivalents of nations and tribes. But they are traversing an unknown path in the technological evolution of social discourse. Heeding the emerging dynamics at these communities will allow researchers and managers to steer these new social structures of the Internet age in positive directions for business and society at large.

Invisible Agency: A Theory of Displacement for Subaltern

Prof. Wen-yuan Lin

2014 466 Pages, Institute of Sociology, Academia Sinica.

This book explores the elusive character of subaltern agency. Many theoretical and empirical perspectives assume that agency is primarily about autonomy and the capacity to act in different ways, and even the capacity to transform social structures. At the same time, these perspectives assume that this autonomy is configured in ways that reflect social structures. Theories differ, but they locate agency in actors' intentions, dispositions, structural positions, or the circulations among them. Such inconsistent prefigurations lead to the longstanding dualist dilemma of the division between "structure and agency," prioritizing partial constitutions of agency that fit theoretical preferences, rather than understanding how it actually unfolds in practice. This then makes the notion of subaltern agency self-contradictory. Such a combination of inconsistency, dualism, partiality, and contradictory suggests that the standard approach to agency is a poor match if we want to understand subalterns and their agency.

This book draws from and interrogates social theory, medical sociology, and science and technology studies (STS) to propose an alternative by examining the experiences of a specific form of subaltern, that of dialysis patients in Taiwan. Following the empirical ontology and material-semiotics developed in STS, instead of asking "what is agency?" and locating prefigured agency as a universal disposition or as something that is partially constituted, this book asks "where is agency?" It traces the transformation of patients' agency by drawing on fifteen years of multi-layered and multi-sited ethnography, thirty year's history of dialysis medicine, and the author's long-term experiences of being on dialysis, advising patients' organizations, and serving on committees on medical policy in Taiwan.

Exploring how agency unfolds in situated enactments of clinical dialysis, daily lives, organizational practices, and policy contests, this book proposes a Synopsis 465 new framework for understanding subaltern agency. This framework includes the notions of driftworks ontology, methods of regime analysis, and displacement theory, which this book addresses by making four symmetrical moves that examine alternative cases, types, patterns, and phrases. This book starts by interrogating the prevalent theorization of heroic agency for entrepreneurs. Then, and in contrast to this version of agency, it elaborates an alternative perspective for situating subaltern experiences. Instead of being autonomous or heroic, patients are seen to be drifting along with multiple influences while working on them to make their own ways at the same time. The notion of "driftworks," which prioritizes process over essence, is proposed to portray the making of subaltern existence in such drifting but nevertheless active enactments. This "driftworks ontology" more realistically describes the mundane daily lives of patients, and its processual framework transcends the inconsistent dualistic prefiguration of standard models of agency.

This book next examines the politics of perspective and representation in the making and unmaking of subaltern agency in driftworks. Subaltern agency is not so much paradoxical as invisible; patients are not passive, but their practices are usually rendered unnoticeable and unaccountable. This suggests that the presence of an unrecognized subaltern type of agency is unlike the standard antagonistic prefiguration of actors, which casts them as being either passive or heroic. In this examination, this book probes into situations where patients work hard to use both biomedical and alternative therapies at the same time in clinical dialysis whilst concealing this from biomedical personnel most of the time. Rather than conveying antagonism, patients enact tacit displacements in order to sustain co-existence with – and within – biomedical hegemony. Such a displacement model of agency is neither about attaining universal autonomy nor achieving hegemony; it has different dynamics in its constitution and must be examined in the contingent ways in which it manifests in practice.

Accordingly, in this displacement perspective agency is made and deployed with situated textures. Most theories assume a particular model of agency but fail to recognize how agency could be made differently across a variety of situations. Drawing from and interrogating the insights of theories that emphasize differentiation of action, this book examines the practices of individual and collective patients and proposes that agency is made of textures with specific interrelated situations, material-spatial practices, and subjectivities. Amongst these, particular tactical displacements can be stabilized and turned into obdurate deployments. Patients' organizations develop strategies that contest the deployments of sociomedical regimes, and the patterns of these engagements reveal the various textures of their agency. In this sense, agency is not universal but located in the situated ways that it is constituted, and different patterns of agency therefore have their own specific textures.

Finally, this displacement-deployment-texture framework is used to treat the constitution of patients' agency and sociomedical regimes in the same terms and traces their continual transformation through the textures of deployment. Given that agency is constituted in ways that are situated, the regime of practice where it is deployed no longer has a specific structure of its own, but is understood to be co-constituted. In this sense, the regime and agency have isomorphic textures and co-constituted genealogies. Thus, instead of partially theorizing agency at the point of its manifestation, this book develops a method of regime analysis in order to portray the continual transformation of patients' agency, including both how patients have contributed to the making of the Taiwanese dialysis regime and how the "structuralization" of the regime has rendered them subaltern over the past three decades.

This thought-provoking study of subaltern agency provides a multidimensional historical and situated account of dialysis medicine in Taiwan, engages with critical issues of patients' practices, and challenges the theoretical alternatives by offering insights into how to improve health care and related policies, empower patients, and extend the theoretical landscape of agency by envisioning the invisible.

Authors

Wen-yuan Lin (林文源)

Center for General Education, Commission of General Education

<http://www.ios.sinica.edu.tw/ios/publish/bk10/synopsis.pdf>



Notable Publications



▼ Multiple Zeta Values in Positive Characteristic

Prof. Chieh-Yu Chang

Department of Mathematics

We study multiple zeta values in positive characteristic and show that they form a graded algebra that is defined over the base rational function field. This shows completely the analogue of Goncharov's conjecture for classical multiple zeta values.

The main results are published in *Compositio Mathematica* 150 (2014) p. 1789-1808.

▼ Competition of phytoplankton species for light with photo-inhibition in a well-mixed water column

Prof. Sze-Bi Hsu

Department of Mathematics

Light is an essential resource for photosynthesis and the major source of energy for both terrestrial and aquatic ecosystems. Excess light, however, causes damage to the photosynthetic machinery, and thereby lessens photosynthetic production. This phenomenon, known as photoinhibition, is prevalent to all photosynthetic organisms from cyanobacteria to higher plants. However, influences of photoinhibition on ecological community structure are rarely investigated both empirically and theoretically. One exception is Gerla et al. (2011), where they extended the classical light competition model of phytoplankton (Huisman and Weissing 1994; Weissing and Huisman 1994) by including the effect of photoinhibition (see also Huisman 1997). Their results suggested that phytoplankton population may exhibit a strong Allee effect and competitive facilitation. A strong Allee effect is a phenomenon that population goes extinct when the density is below a threshold, while it persists when the density is above the threshold. Competitive facilitation is a phenomenon that a species that cannot grow in monoculture can grow and take over the community under the presence of another species. Their theory and predictions, based on previous results of Huisman and Weissing (1994), Weissing and Huisman (1994) and graphical approach, indicated significance of photoinhibition in shaping phytoplankton community structure. In this work we analyzed a model of phytoplankton competition for light in a well-mixed water column. The model, proposed by Gerla et al. (*Oikos* 120:519–527, 2011),

assumed inhibition of photosynthesis at high irradiance (photoinhibition). We prove and classify the global behavior through mathematical analyses, providing a general solution to the multi-species competition for light with photoinhibition. Numerical simulations with published p - I curves indicate that photoinhibition may often lead to strong Allee effects and competitive facilitation among species. Hence, our results suggest that photoinhibition may play a major role in organizing phytoplankton communities.

<http://www.math.nthu.edu.tw/~sbhsu>

▼ Symplectic geometry, representation theory and algebraic combinatorics

Prof. Meng-Kiat Chuah

Department of Mathematics

My research interests include geometric quantization and diagrammatic presentation of structures of Lie algebras. In geometric quantization, we use Hamiltonian actions on symplectic manifolds to construct unitary representations of Lie groups. I earlier have used this method to obtain multiplicity free unitary representations of semisimple Lie groups with compact and split Cartan subgroups, and in [4], I combine these methods to deal with Lie groups with arbitrary Cartan subgroups. In [5], I also show that Dirac cohomology incorporates nicely with geometric quantization. Another aspect of my research is the diagrammatic presentation of Lie algebras. Certain algebraic structures are difficult to be described by mathematical symbols, and I discover some diagrams which capture their algebraic properties. Consequently I work out certain automorphisms, real forms and symmetric pairs of Lie algebras and Lie superalgebras in [1][2][3].

- [1] Cartan automorphisms and Vogan superdiagrams, *Math. Zeitschrift* 273 (2013), 793-800.
- [2] Contragredient supersymmetric pairs, *J. Mathematical Physics* 54 (2013), 091702.
- [3] Double Vogan diagrams and irreducible pseudo-Hermitian symmetric spaces, *Math. Research Letters* 20 (2013), 477-487.
- [4] Partially harmonic forms and models of H-series, *J. Functional Analysis* 266 (2014), 2740-2764.
- [5] Dirac cohomology and geometric quantization (with J. S. Huang), *J. Reine Angewandte Mathematik*, to appear.

▼ Advanced research of 3-D topological insulator thin films: materials and physical properties

Prof. J. Raynien Kwo

Department of Physics

A new research direction in current era of “*post Si CMOS*” is the pursuit of emergent quantum matters in realization of exotic quantum phenomena in pushing computer speed and power consumption beyond current limitations. The new states of 2-D quantum matters such as topological insulators (TI) have received unparalleled attentions worldwide due to their extraordinary physical properties and potential applications in dissipationless spintronics and quantum computing.

3-D topological insulator thin film epitaxy and properties: In our work high quality 3-D TI Bi_2Se_3 , Bi_2Te_3 films by van der Waals epitaxy showed the surface states with distinct Dirac cone features detected by both ARPES and STS. The search for Majorana fermions by tunneling experiments is in progress via STM/STS on junctions made of TIs with s-wave *SC*.

Spin pumping study of ferromagnetic metal/III-V semiconductor heterostructure: Spin pumping experiment on high quality, epitaxial $\text{Fe}_3\text{Si}/\text{GaAs}$ structures by molecular beam epitaxy detected clear inverse spin Hall Effect voltage up to $50\mu\text{V}$ under an input microwave power of 100 mW. The results demonstrate the close relationship of spin current injection with excellent crystallinity and interface, as well as the potential of next generation spin devices based on semiconductors.

Spin pumping of topological insulator/ferromagnetic metal heterostructure: Spin-momentum locking of surface states in topological insulators leads to much higher conversion efficiency in pure spin current devices. “Spin battery” may be fabricated with TI/FM heterostructures, producing giant spin current outputs under small microwave input. Epitaxial Bi_2Se_3 (001) and Bi_2Te_3 (001) films on ferromagnetic Fe_3Si (111) and Fe (111) surfaces showed very large voltages of Inverse Spin Hall Effect at room temperature up to $60\mu\text{V}$ at 100 mW microwave power. The J_c of both FM/TI and TI/FM structures are significant enhanced over conventional devices by 3-5 times, and demonstrate the exciting potential of exploiting TI-based structures for spintronics.

<http://scitation.aip.org/content/aip/journal/apl/105/15/10.1063/1.4898781>

▼ Precision spectroscopic measurements of atomic helium

Prof. Li-Bang Wang

Prof. Jow-Tsong Shy

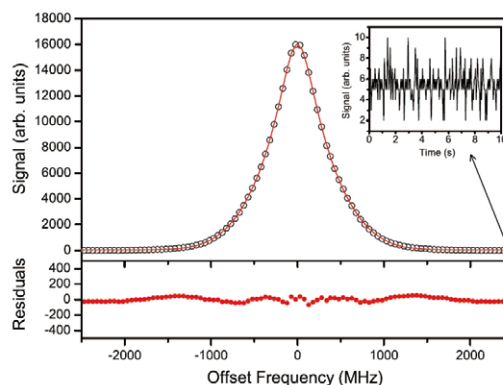
Department of Physics

In a collaboration led by professor Li-Bang Wang and professor Jow-Tsong Shy in the physics department, researches have precisely measured important transition lines of atomic helium. The result revealed some problems in many-body QED (quantum electrodynamics) calculations and was published in the important physics journal, Physical Review Letters.

The electronic structure of helium is relatively simple and can be calculated to a very high precision. By comparison between theories and experimental results, physicists can examine QED effects and probe nuclear size and moments. In this experiment, an infrared laser system was constructed to perform precision spectroscopy on the singlet states of helium. PhD student, Pei-Ling Lou has carefully investigated many systematic effects. The frequency measuring system is developed by Dr. Jin-Long Peng from Center for Measurement Standards in Industrial Technology Research Institute (ITRI). The final result was obtained after three years of experimental efforts.

- [1] P.-L. Luo, J.-L. Peng, J.-T. Shy, and L.-B. Wang, Precision frequency metrology of helium $21S_0 \rightarrow 21P_1$ transition, Phys. Rev. Lett. 111, 013002 (2013)
- [2] P.-L. Luo, Y.-C. Guan, J.-L. Peng, J.-T. Shy, and L.-B. Wang, Measurement of the $21P_1 \rightarrow 31D_2$ transition frequency in 4He , Phys. Rev. A 88, 054501 (2013)

<http://www.phys.nthu.edu.tw/newresearch/2014/libwang/libwang.htm>



▼ High Storage Efficiency Makes Better Quantum Memory for Photons

Prof. Ite A. Yu

Department of Physics

Photons are ideal information carriers. We can foresee that photons will be employed to carry quantum information among devices in quantum communication due to the excellent fidelity for the carried information. Storing light using the effect of electromagnetically induced transparency (EIT) is compatible with quantum state operations. Theory has predicted that the storage efficiency (SE) of the EIT-based quantum memory for photons could approach unity. However, previous experiments revealed that a maximum SE is disappointingly about 50% and seemingly excluded the EIT medium as an efficient quantum memory. In a work led by Prof. Ite Yu, a high-performance EIT-based memory with an SE of 78% has been produced. Such a high SE, reported in *Physical Review Letters* 110, 083601 (2013), was achieved with a cold atomic medium of a very large optical density plus an ultralow decoherence rate. A long decay time constant of about 100 μs was observed in this EIT memory. This time constant gives the delay-bandwidth product (DBP) of 74 at 50% SE. The work also demonstrated that the fidelity of the recall pulse is better than 90% and nearly independent of the storage time. The result of the best up-to-date SE, large DBP, as well as excellent fidelity has suggested that the EIT-based quantum memory is a great candidate for practical quantum information applications with photons.

<http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.110.083601>

▼ Complex quantum Hamilton-Jacobi equation with Bohmian trajectories for wave packet dynamics

Prof. Chia-Chun Chou

Department of Chemistry

The wave function is expressed in an exponential form in terms of the complex action. Substituting this expression into the time-dependent Schrödinger equation yields the complex quantum Hamilton-Jacobi equation. We then transform the complex quantum Hamilton-Jacobi equation to the arbitrary Lagrangian-Eulerian version by choosing the grid

velocity equal to the Lagrangian flow velocity of the probability fluid. The resulting equation describes the rate of change in the complex action transported along Bohmian trajectories. Then, we solve the arbitrary Lagrangian-Eulerian version of the complex quantum Hamilton-Jacobi equation by propagating an ensemble of Bohmian trajectories in real space. This novel trajectory approach has been applied to quantum dynamical problems such as chemical reactive scattering and photodissociation. This method can combine considerable advantages of both real and complex quantum trajectory methods previously developed for wave packet dynamics. These studies have been published in *Chem. Phys. Lett.* 591, 203 (2014) and *J. Chem. Phys.* 140, 104307 (2014).

<http://cechou.yolasite.com/>

▼ Complementary Helicity Interchange of Optically Switchable Supramolecular- Enantiomeric Helicenes with (-)-Gel-Sol-(+)-Gel Transition Ternary Logic

Prof. Chien-Tien Chen

Department of Chemistry

We have developed a specific optically switchable helicene pair that can self assemble into optically switchable, complementary helical fibers, respectively, by well-defined intermolecular N-H bonding, π - π and paired van der Waals interactions. To our knowledge, this constitutes the first successful example of optically switchable fibers of complimentary helicity based on pseudo-enantiomeric helicenes with high switching selectivities (from 90/10 to $<1/>99$). The helical superstructure can be reversibly tuned by light. Therefore, *the helical organic superstructure with a helical tunnel*, for the first time, that can be reversibly tuned by light through the (-)-gel-sol-(+)-gel interconversion augurs well for its potential nano device application as optically switchable helical fibers of ternary logics. Besides, the internal helical channel may allow for chiral recognition applications.

J. Am. Chem. Soc. 2013, 135, 5294-5297.

▼ Plasmonic Nanostructures for Controlling Nanoscale Light-matter Interaction: Plasmon-enhanced solar cells, Near-field Optical Trapping, Optical Nanocircuits, Chiral Plasmonics

Prof. Jer-Shing Huang

Department of Chemistry

Interaction between light and matter strongly depends on the properties of the optical field, including the frequency, intensity, phase, polarization and the spatial distribution. The ability to control these properties at nanometer scale promises future sub-wavelength deterministic manipulation of light-matter interaction. To this goal, our research focuses on the design, fabrication, and characterization of plasmonic nanostructures that can sculpt the electromagnetic field for enhancing specific nanoscale light-matter interaction. We perform numerical simulations and develop various spectroscopic and microscopic methods to characterize the linear and non-linear optical response of the nanostructures. Recently, we have successfully demonstrated plasmon-enhanced dye-sensitized solar cells using self-assembled Au@TiO₂ core-shell nanoparticles (Fig. 1, [1]). We have also developed plasmonic optical lattice and bi-functional traps for sub-wavelength optical manipulation (Fig. 2, [2-3]). For the first time, we have successfully demonstrated mode conversion in an ultrahigh-frequency plasmonic nanocircuit. Such nanocircuit offers a platform for controlling nanoscale light-matter interaction (Fig. 3, [4]). Finally, we have proposed a slant-gap nanoantenna to enhance optical chirality, which is useful for ultra-sensitive circular dichroism analysis on metal surface with linearly polarized excitation (Fig. 4, [5]).

[1] *Nanoscale* **2013**, *5*, 7953-7962.

[2] *Nano Letters* **2013**, *13*, 4118-4122.

[3] *Nano Letters* **2014**, *14*, 547-552.

[4] *Nano Letters* **2014**, *14*, 3881-3886.

[5] *Optics Express* **2014**, *22*, 7434-7445.

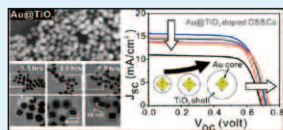


Fig.1 Plasmon-enhanced Solar Cells

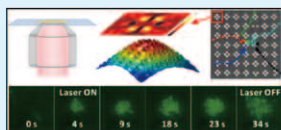


Fig.2 Sub-wavelength Optical Lattice

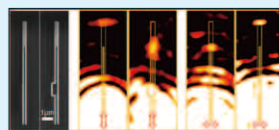


Fig.3 Optical Nanocircuit

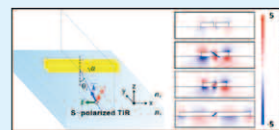


Fig.3 Plasmon-enhanced Chiroptical Response

▼ Facet-Dependent Optical Properties of Polyhedral Au-Cu₂O Core-Shell Nanocrystals

Prof. Michael H. Huang

Department of Chemistry

We fabricated Au-Cu₂O core-shell octahedra, cuboctahedra, and nanocubes having sizes of 90-220 nm using 50-nm octahedral cores. The smaller particle sizes enable the surface plasmon resonance absorption band of the gold cores to be clearly identified. Beyond a lower shell thickness limit, the SPR band positions of the gold cores are independent of the shell thickness, but are strongly dependent on the exposed particle surfaces. The plasmonic band red-shifts differ by as much as 26 nm between the octahedra and the nanocubes. The Cu₂O shells are also found to exhibit facet-dependent optical behavior. These nanocrystals can respond to changes in the solvent environment such as solvents with different refractive indices, indicating the plasmonic field of the gold cores can extend beyond the particle surfaces despite the presence of thick shells. The observation of facet-dependent optical properties should be related to the different degrees of band bending for the different surfaces of Cu₂O, as evidenced by their dramatically different electrical conductivity behaviors.

Nanoscale **2014**, *6*, 4316-4324.

Link1: <http://pubs.rsc.org/en/content/articlelanding/2013/nr/c3nr02800c>

Link2: <http://pubs.acs.org/doi/abs/10.1021/nl4016254>

Link3: <http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-22-7-7434>

Link4: <http://pubs.acs.org/doi/abs/10.1021/nl501102n>

Jer-Shing Huang Research: <http://chem.web.nthu.edu.tw/files/13-1078-32038.php?Lang=zh-tw>

▼ Parallels Between Inorganic and Organic Chemistry

Prof. Yi-Chou Tsai

Department of Chemistry

The metal-metal quintuple bonding is in its infancy, compared to the mature quadruple bonding. There are less than 20 quintuple bonded group VI dinuclear complexes up to date, and we contributed 8 of them. We aim to discover parallels between inorganic and organic chemistry by examining reactivity of the quintuple bonded dinuclear amidinato complexes. Although chromium predominates in the field of quintuple bonding and there are only three quintuple bonded dimolybdenum complexes reported by my group, the quintuple bonded dimolybdenum amidinate, however, displays reactivity similar to alkynes. For example, two typical reactions of alkynes are transition metal-catalyzed [2+2+2] cyclootrimerization to give benzene and derivatives, and Lewis acid-mediated Friedel-Crafts reaction, where the C-Cl bonds of acyl chlorides are added to C-C triple bond to produce β -chloro α, β -vinyl ketones, from which many pharmaceutical heterocycles can be prepared. Similarly and interestingly, the quintuple bonded molybdenum amidinate auto-catalyzes its reactions with terminal alkynes to give new type of aromatic dimetalacyclic compounds via the [2+2+2] cycloannulation reaction. The quintuple bonded molybdenum amidinate undergoes Friedel-Crafts type of 1,2-addition reactions with various acyl halides to give β -halo α, β -quadruple bonded dimolybdenum acyls, from which dimolybdenum containing heterocycles can be prepared. These reactions are catalyst-free, which is in marked contrast with organic reactions.

<http://onlinelibrary.wiley.com/doi/10.1002/anie.201304750/pdf>

<http://onlinelibrary.wiley.com/doi/10.1002/anie.201205027/pdf>

▼ Progenitor Star of a Stellar Explosion Found

Prof. Albert Kong

Institute of Astronomy

From a series of old images by the Hubble Space telescope (HST) taken in 2005, astronomers from National Tsing Hua University in Taiwan, as well as the international project intermediate Palomar Transient Factory (iPTF), find the progenitor star of a newly discovered stellar explosion, known as Type Ib supernova, for the first time in the history of astronomy. The unprecedented discovery has been published in *The Astrophysical Journal Letters*.

Based on observations obtained with iPTF on 16 June 2013, the scientific collaboration discovered a supernova, called iPTF13bvn, in the nearby galaxy NGC 5806, located in the constellation Virgo about 80 million light years away from us. Based on a series of follow-up spectroscopic observations, the supernova is classified as Type Ib because there is no hydrogen feature in the optical spectrum.

Shortly after the supernova explosion, the team including Professor Albert Kong, from National Tsing Hua University, announced that a possible progenitor star was found in the pre-explosion high-resolution HST archival images. Following the initial alert, high-resolution optical images of the supernova were obtained with the 10m Keck I telescope together with an adaptive optics system (a special technique to improve the spatial resolution by counteracting for the distortions caused by the atmosphere). The team successfully refined the explosion position and confirmed the progenitor candidate identified in the HST images.

The team members from Taiwan also discovered the X-ray emission from the supernova by using NASA's Swift X-ray Telescope. X-rays from supernova explosion are difficult to be detected because they are usually faint. By accumulating the X-ray data for nearly a month, the Taiwanese team finally found the trace of the X-rays. The results will provide important information how the shock wave of the explosion interacts with the interstellar medium.

<http://iopscience.iop.org/2041-8205/775/1/L7/>

▼ Preparation of Water-Soluble Negative Photoresist and Graphene Nanocomposites for Photopatternable Microsensor via UV-Radiation Curing

Prof. Yu-Der Lee

Department of Chemical Engineering

Minimize size of biosensor is a major topic for sensor development in the future. The small size biosensor can be easy to carry and photolithography technique can prepare a multifunction microsensor in a small region. In this research, our purpose is prepared a portable and mult-target detectable microsensor.

Here, we blended graphene and water-soluble environment friendly photoresist to produce an electrically conductive and photo-curable ink. Then, it was conducted photolithography process to prepared microcircuit and used as microsensor. The electrical conductivity is promoted about 10 order to 28.9 S/m from 1.9×10^{-9} S/m by added 4wt% graphene. This microsensor could detect the glucose and lead in water solution and it might be used as a multifunction biosensor.

Photolithography: <http://en.wikipedia.org/wiki/Photolithography>

Graphene: <http://en.wikipedia.org/wiki/Graphene>

Biosensor: <http://en.wikipedia.org/wiki/Biosensor>

▼ Self-assembly of Chiral Block Copolymer and Corresponding Applications

Prof. Rong-Ming Ho

Department of Chemical Engineering

1. Long-Range Ordering of Block Copolymer Cylinders Driven by Combining Thermal Annealing and Substrate Functionalization.

The neutral substrate can be used with the SiO₂ surface, which is functionalized with PS-OH followed by PLLA-OH, to enable truly film-spanning perpendicular cylinders in films to be fabricated using the high-temperature thermal treatment. The ability to create these film-spanning perpendicular cylinders in films with a well-ordered texture and submicrometer thickness opens up possible applications in nanotechnology.

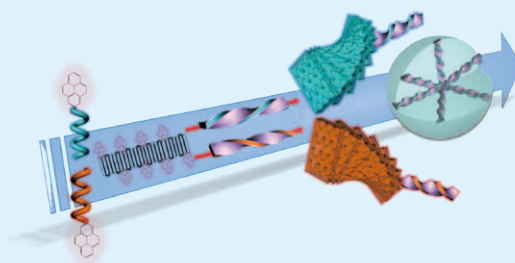
2. Lamellar Twisting Induced Circular Dichroism of Achiral Chromophore Moiety in Banded Spherulites with Homochiral Evolution

A homochiral evolution from the helical polymer chain (conformation chirality) to the twisting lamellae (hierarchical chirality), banded spherulites with

preferential handedness are formed by crystallization of helical polymers endcapped with an achiral chromophore through cooperative intramolecular and intermolecular interactions (i.e., surface imbalanced stress and chiral steric hinderance), giving the chromophore moiety from “achiral” to “chiral” through the crystalline lamellar twisting as evidenced by induced circular dichroism of the achiral chromophore.

<http://pubs.acs.org/doi/abs/10.1021/nn305725q>

<http://onlinelibrary.wiley.com/doi/10.1002/anie.201310078/abstract>



▼ (Ni-Co-Cu)(OH)₂-CuO//activated carbon asymmetric supercapacitors

Prof. Chi-Chang Hu

Department of Chemical Engineering

Ternary Ni-Co-Cu oxy-hydroxide nanosheets with excellent pseudo-capacitive characteristics are prepared by cathodic deposition. From the x-ray photoelectron spectroscopic and Fourier transform-infrared spectroscopic analyses, the as-deposited material consists of ternary hydroxides and some copper oxide (denoted as (Ni-Co-Cu)(OH)₂-CuO). The charge capacity and capacitance retention of (Ni-Co)(OH)₂ are significantly improved by introducing Cu(OH)₂/CuO. An asymmetric supercapacitor consisting of a positive (Ni-Co-Cu)(OH)₂-CuO electrode and a negative activated carbon (AC) electrode shows ideal capacitive performances with a cell voltage of 1.8 V. This asymmetric supercapacitor exhibits 94.5% cell-capacitance retention and 99.4% coulombic efficiency at 5 A g⁻¹ in a 4000-cycle test, meanwhile about 86% cell-capacitance retention is obtained in another 47000-cycle test at 25 A g⁻¹, revealing its excellent stability.

▼ The preparation, property and application of graphene nanocomposites

Prof. Chen-Chi M. Ma

Department of Chemical Engineering

Our laboratory focuses on CNT and Graphene Hybrid materials, including basic research, such as intramolecular interaction between the molecules and conductivity, thermal conductivity, mechanical properties, material and surface properties of carbon materials. The applications of the relevant research are shown in the following:

- (1) In-situ polymerization graphene oxide (Graphene oxide, GO) / polyimide (Polyimide, PI) film composite was prepared, the composite material has excellent mechanical properties (Figure 1)
- (2) Graphene sheet (graphene Nanosheet, GNS) was used as a filler for polymer, which is introduced into the polymer matrix for preparing a conductive polymer composite, with higher surface area and the excellent electrical properties. This composite possesses light weight, flexible, high conductivity and excellent electromagnetic interference shielding properties (Figure 2).
- (3) Carbon nanotubes - graphene (= 10wt%: 90wt%) blend materials was used as the supporter for 40wt% platinum catalyst and platinum-ruthenium alloy catalyst. Carbon nanotubes can suppress the restacking of graphene, effectively increasing the total surface area, reducing the platinum particle size and increase its activity (Figure 3).
- (4) Graphene drug carriers with triple curing types (target / hyperthermia / chemotherapy) was prepared (PEG-NGO-C225/EPI, as shown in Figure fourteen), successfully applied glial treated mice tumor xenograft model. This drug not only cured cancer completely but also avoided the problem of multi-drug resistant.

▼ Practical applicability of promoted decomposition of NO_x and SO₂ by electro-catalytic converters

Prof. Ta-Jen Huang

Department of Chemical Engineering

The basic design of the electro-catalytic converters utilizes the principle of electrochemical cell. A novel design at the micro level is done on current honeycomb structure for automotive catalytic

converters, with one invention named electro-catalytic honeycomb (ECH, as shown on next page), so that an electromotive force (EMF) can be generated, as in the fuel cells, to highly promote the decomposition of nitrogen oxides (NO_x) to O₂ and N₂. Decomposition of very high NO_x concentration is highly effective and thus the fuel efficiency of the engines can be highly increased to become much higher than any other currently-proposed method.

The electro-catalytic honeycomb is mainly for effective treatment of NO_x in the diesel exhaust. It can be utilized to completely not affect the design of current automobile's structure. For immediate application, the reactor's honeycomb for selective catalytic reduction (SCR) can be simply replaced by a same-sized electro-catalytic honeycomb. However, no urea solution or other reducing agent is needed any longer; thus, one can simply close (not use) the injecting and controlling devices of urea solution. In later applications, the exhaust treatment system can be simplified by having only this electro-catalytic honeycomb; the engine system can be simplified by removing the exhaust gas recirculation (EGR) device; then, one can design a new engine, such as the Gasoline Direct-injection Compression Ignition (GDCI) engine, so that the engine efficiency can be highly increased and zero pollution can be done.

The practical applicability of NO_x removal by the electro-catalytic honeycomb has been verified by the tests utilizing real automotive engine's exhausts as well as the boiler's flue gases of a petrochemical plant. The electro-catalytic converters can also have promoted decomposition of sulfur dioxide by the self-generated EMF to oxygen and sulfur vapor, which is condensed to sulfur solid after leaving the converter and is recovered. The decomposition efficiency has been tested to show being able to be the same as that of NO_x; thus, the electro-catalytic converters can be practical for removing SO₂ from boilers' flue gases.

http://www2.che.nthu.edu.tw/Ta_Jen/A%20ceramic%20monolith%20for%20promoted%20decomposition%20of%20NOx%20in%20diesel-like%20exhausts.pdf

▼ Process analysis and quality prediction of chemical batch processes based on regularization methods

Prof. Yuan Yao

Department of Chemical Engineering

Prediction accuracy and model interpretation are two important aspects with regard to regression models. In the field of statistical modeling of chemical batch processes, most research focuses on prediction accuracy, while the importance of the latter aspect is often overlooked. In multiphase batch processes, it is possible that only a few phases are relevant to certain quality indices, while different time points belonging to the same relevant phase usually have similar contribution to the quality. The regression coefficients of batch process model should reflect such process characteristics, that is, the coefficients corresponding to the irrelevant phases should be close to zero, while the coefficients of each variable within the same phase should vary smoothly. In this study, regularization techniques are introduced to statistical modeling of chemical batch processes to achieve both accurate prediction and good interpretation. The application to an injection molding process shows the feasibility of the proposed methods.

<http://www.sciencedirect.com/science/article/pii/S0169743913000634>

▼ Microcavity-embedded, Colour-tuneable Transparent Organic Solar Cells

Prof. Hao-Wu Lin

Department of Materials Science and Engineering

Transparent solar cells are particularly interesting due to their aesthetics and their combined functions of light harvesting, lighting, and indoor temperature control. H.-W. Lin and co-workers demonstrate a novel approach for developing transparent, universally applicable, and continuously color-tunable solar cells by embedding a metal/organic/metal microcavity structure as the device electrode. The devices show monochromatic colors across the whole visible-light range with power conversion efficiencies up to approximately 5%.

<http://onlinelibrary.wiley.com/doi/10.1002/adma.201470046/abstract>

▼ Novel Functionalized Smart Biomaterials: Development and Applications in Tissue Engineering and Drug Delivery System

Prof. Tzu-Wei Wang

Department of Materials Science and Engineering, and Institute of Biomedical Engineering

The Wang's Lab has developed a series of novel functionalized smart biomaterials for the applications in tissue engineering and drug delivery system. These biopolymers not only possess satisfactory biocompatibility but also can be tailed into different forms, types and multiple scales as needed by the clinics. Some examples of these products are: 1) Injectable and thermoresponsive self-assembled nanocomposite hydrogel for anticancer drug delivery, 2) Functionalized self-assembling nanopeptides for immediate hemostasis and accelerative neural tissue regeneration, 3) Thermo-induced shape memory copolymer as dual drug-eluting biodegradable stent, 4) Redox and pH-sensitive nanoparticles for stem cells gene therapy, 5) Electrospun composite nanofibers with staged release of multiple growth factors for chronic wound healing.

<http://www.ncbi.nlm.nih.gov/pubmed/?term=tzu-wei+wang>

▼ (A) Patent informatics and intellectual property analysis ▼ (B) Green manufacturing and renewable energy decision supports

Prof. Amy J.C. Trappey

Department of Industrial Engineering and Engineering Management

Develop advanced engineering informatics, knowledge engineering, and decision support algorithms. The main focuses of research are in two areas, i.e., (A) novel methodologies for intelligent patent and IP analysis and (B) decision support analysis and modeling for green manufacturing and renewable and sustainable energy development.

<http://www.sciencedirect.com/science/journal/14740346/27/3>

▼ Big Data Analytics and Decision Support System in High-tech Manufacturing Industry

Prof. Prof. Chen-Fu Chien

Department of Industrial Engineering and Engineering Management

Semiconductor manufacturing includes a lot of recursive, sub-batch and compensative process. Conventional statistical methods and information technologies cannot efficiently handle these so called "Big data" which is named for its volume, velocity, variety and veracity. The NSC STEP (Semiconductor Technologies Empowerment Partners) consortium has developed several big data analytics methods, such as real-time total monitoring the equipment condition, vertical integration on semiconductor process data, event pattern recognition. Numerical experiments have shown practical viability of this approach by real data. After on-line validations, these methods efficiently detect events and empower the intelligent manufacturing.

For the enterprise resource, the research team also developed decision support systems to integrate and arrange the resources. We clarified the relationship between the decision elements by PDCCR framework and we build optimization model and solving algorithms in the system. Furthermore, several real cases have shown practical viability of this approach, including LED and solar cell industry.

<http://step.unicon.org.tw>

▼ A paper-based immunoaffinity platform for separating subsets of extracellular vesicles

Prof. Chihchen Chen

Institute of NanoEngineering and MicroSystems

Background: Extracellular vesicles (EVs) are small membranous vesicles shed from both healthy and diseased cells and contain nucleic acid and protein cargo. EVs have been increasingly recognized as a means of cell-cell communication and hold a great potential for clinical applications. However, current protocols for isolation of EVs are often lengthy, cumbersome and require expensive equipment.

Methods: We present a paper-based immunoaffinity platform for separating subsets of EVs. This method is inexpensive, robust, easy-to-use (easy-to-prepare), and compatible with downstream analyses, such as

scanning electron microscopy (SEM), enzyme-link immunosorbent assays (ELISA), and transcriptome analysis.

Results: Here, we have isolated EVs from small volumes of both human serum and aqueous humor samples using paper-based immunoaffinity devices. Captured EVs were analyzed morphologically using scanning electron microscopy (SEM) and appeared statistically different in size (p -value $< 2.4 \times 10^{-22}$) and circularity (p -value $< 3.6 \times 10^{-9}$) between subsets of EVs bearing different surface markers. Assessing the amount of EVs captured using paper-based ELISA using antibodies conjugated to horseradish peroxidase (HRP) to produce a colorimetric readout was accomplished within 10 minutes.

RNAs contained in EVs can be extracted to provide information for disease management.

Conclusions: These paper-based immunoaffinity devices, we believe, open opportunities for a wide range of applications in both basic biology and clinical medicine.

<http://link.springer.com/article/10.1007%2Fs10404-014-1359-1>

▼ 3D rolled-up magnetic biosensor for single cell detection

Prof. Mei-Feng Lai

Institute of NanoEngineering and MicroSystems

The designed 3D biosensor made of SiO₂ layer and fishbone-like magnetic thin film is a very sensitive biosensor that can detect the presence of a single cell through measuring the variation of the magnetoresistance. Our proposed 3D magnetic biosensor possesses some major advantages over traditional 2D magnetic biosensors such as much higher sensitivity, and helping attract and trap a single magnetic cell to be detected due to the stronger stray field of the 3D structures compared with 2D structures. The 3D magnetic biosensor designed here can provide very important information for future biochip research and applications. Our research results have been published on Lab on a Chip 13, 4225 (2013).

<http://140.114.56.183/mflai>

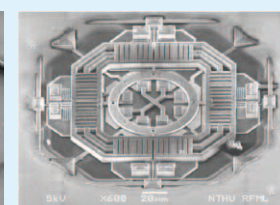
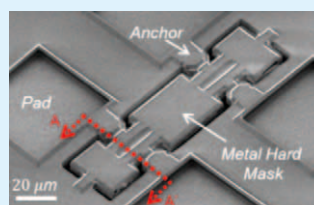
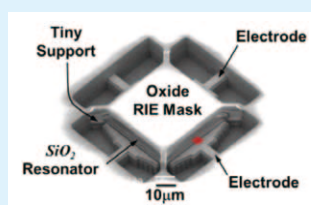
▼ Intelligent Electronic Nose (E-Nose) System

Prof. Da-Jeng Yao

Institute of NanoEngineering and MicroSystems

Olfaction is one of the main human senses. The olfactory neural pathway is very close to the part of emotion in the cerebrum. Thus it is known long that odors can strongly affect one's emotion. In nowadays, olfaction is not only important to individual but also to the industry. Applications of artificial olfaction (e.g. electronic nose) have drawn more and more attentions, including indoor/outdoor air quality control, factory safety, food quality control, environmental quality control, medical diagnosis, military application, and hazardous gas detection, etc. Recent technological advances allow gases to be detected in various ways; because of its low-cost and room-temperature operation, the polymer type of chemical sensors, both resistant and surface acoustic wave (SAW), is a feasible option in handheld devices. In contrast to metal oxide sensors, the polymer type of chemical sensors can be operated at room temperature and efficiently conserves power; the sensitivity, linearity, rapid response time, and ease of production of this technology facilitates its application in handheld devices. The sensor interface circuit could be simple and small, although sensitivity to humidity is a drawback of the conductive polymer chemical sensor, this can be overcome by the circuit design. In addition to sensing chip and circuit design, the algorithms used to recognize and categorize the gas type and concentration would be very important for the developed detection system.

This research now has been focused on wireless signal transmission based on the developed detection e-nose system. A plug-in handheld smart gas sensing device; Indoor or outdoor environmental gas sensing system with wireless network; Medical applications; and Wearable type of gas sensing applications.



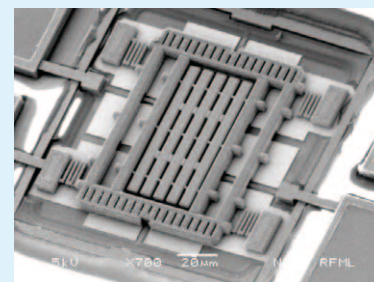
▼ Temperature Compensated Low-Power Single-Chip CMOS-MEMS Oscillators

Prof. Sheng-Shian Li

Institute of NanoEngineering and MicroSystems

A fully monolithic CMOS-MEMS oscillator comprised of an ovenized resonator to enable ultra-low heater power operation of only 0.47 mW over entire temperature span (-40 °C to 85 °C) and a low noise sustaining circuit to achieve low phase noise has been demonstrated in a TSMC 0.35µm CMOS process. The combination of low thermal conductivity material and high thermal isolation design is the key to attaining ultra-low-power heater operation in a sub-mW level. Passive temperature compensation scheme is also conducted in the CMOS-MEMS resonator by an oxide-metal composite structure, showing a low temperature coefficient of frequency (TC_f) of only +5.1 ppm/°C which is suited for the use in ovenized oscillator systems. By implementing a constant-resistance temperature control scheme, the frequency drift of the resonator smaller than 120 ppm from -40°C to 85°C is demonstrated in this work, indicating an equivalent TC_f smaller than 1 ppm/°C, a record-low value against its CMOS-MEMS counterparts. The CMOS-MEMS oscillator operating at 1.2 MHz demonstrates a phase noise of -112 dBc/Hz at 1-kHz offset and -120 dBc/Hz at 1-MHz offset while drawing less than 1.3 mW. The entire power consumption of the ovenized oscillator system is confirmed to be less than 1.8 mW (oscillator + micro-oven), verifying the great potential of low power oven-controlled MEMS oscillators realized in CMOS-MEMS technology.

<http://mx.nthu.edu.tw/~ssli/>



▼ High-Resolution, Contact-Lens-Shaped Flexible Retinal Prosthesis Image-Sensing Chip Technology

Prof. Long-Sheng Fan

Institute of NanoEngineering and MicroSystems

We have implemented a flexible 16,328-element retina chip 30 μm thick using a flexible 180 nm mixed-signal CMOS Image Sensor technology. The electrodes capable of inducing RGC spiking *in vitro* are 10 μm in size, and photo sensors 30 μm in pitch. The retina chip with a large FOV is 6 mm in size including multiplexing electronics for pixel characterizations and perfusion openings, and it is formed into a spherical-shaped patch during the packaging process to have good conformation to the surface of an eyeball. This device enables a visual acuity of 20/168 or the resolution to read big print books in 14pt font size.

Toward a high visual-acuity retinal prosthesis

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6626872&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6626872

A contact-lens-shaped IC chip technology

<http://iopscience.iop.org/0960-1317/24/4/045025>

In vivo thermal evaluation of a subretinal prosthesis using an integrated resistance temperature detector
<http://nanolithography.spiedigitallibrary.org/article.aspx?articleid=1828623>

▼ 1. AlGa_N/Ga_N High electron mobility transistor (HEMT)-based biosensors

▼ 2. Conducting polymer-based biosensors

Prof. Yu-Lin, Wang

Institute of NanoEngineering and MicroSystems

AlGa_N/Ga_N High electron mobility transistor (HEMT)-based biosensors

We have been developing AlGa_N/Ga_N High electron mobility transistor (HEMT)-based sensors and the sensor models for studying ligand-receptor binding affinity and demonstrating various novel applications. The sensors can work as a good platform to explore scientifically fundamental knowledge, leading to our research with high impact.

We have also demonstrated that the method we develop can be used for HIV drug development. The FDA approved HIV drug, efavirenz, was shown to bind only one binding-site on the HIV RT enzyme, and the dissociation constant was also resolved. This work successfully shows that the conventionally time-consuming and costly drug development can become quick, efficient, and cheap process, by using our devices and developed methods.

Conducting polymer-based biosensors

The conducting polymer is allowed to have charge transfer with the biomolecules. This feature is quite useful because many biochemical reactions are under going oxidation or reduction. For example, many enzyme reactions are oxidative or reductive reactions. For these reactions, conducting polymer becomes a good candidate. Horseredish peroxidase-immobilized conducting polymer sensor was fabricated to detect hydrogen peroxide. Hydrogen peroxide is an important signaling molecule for many biological reactions and one of the reactive oxidative species, which is often measured for oxidative stress studies. Oxidative stress is currently an important research topic and is believed to be relevant to tumors, cancers, parkinsus disease, and aging.

We fabricated an ultra-sensitive hydrogen peroxide sensor by using horseradish peroxidase (HRP)-immobilized conducting polymer, polyaniline (PANI). With the proposed detection mechanism, hydrogen peroxide first oxidizes HRP, which then oxidizes polyaniline, thus resulting in decreased conductivity of the polyaniline thin film. The reduced HRP can be further oxidized by hydrogen peroxide and the cycle of the oxidation/reduction would continue until all hydrogen peroxide are reacted, leading to the high sensitivity of the sensor due to the signal contributed from all hydrogen peroxide molecule. The detection limit of this sensor is only 0.7 nM. The detectable concentration of H₂O₂ is from 0.7 nM to 1 μM . This electronic hydrogen peroxide sensor is promising in applications for low concentration hydrogen peroxide detections, such as the reactive oxygen species (ROS) in oxidative stress studies.

<http://dx.doi.org/10.1063/1.4803916>

▼ Differential effects of sorafenib on liver versus tumor fibrosis mediated by SDF1 α /CXCR4 axis and Gr-1+ myeloid cell infiltration in mice

Prof. Yunching Chen

Institute of Biomedical Engineering

Sorafenib—a broad kinase inhibitor—is a standard therapy for advanced hepatocellular carcinoma (HCC), and has been shown to exert anti-fibrotic effects in liver cirrhosis, a precursor of HCC. However, the effects of sorafenib on tumor desmoplasia—and its consequences on treatment resistance—remain unknown. We demonstrate that sorafenib has differential effects on tumor fibrosis versus liver fibrosis in orthotopic models of HCC in mice. Sorafenib intensifies tumor hypoxia, which increases stromal-derived factor 1 α (SDF1 α) expression in cancer and stromal cells, and subsequently Gr-1+ myeloid cell infiltration. The SDF1 α /CXCR4 pathway directly promotes hepatic stellate cell (HSC) differentiation and activation via MAP kinase pathway. This is consistent with the association between SDF1 α expression next to fibrotic septa in cirrhotic liver tissues and in desmoplastic regions of human HCC samples. We demonstrate that after treatment with sorafenib, SDF1 α increased the survival of HSCs and their α -SMA and Collagen I expression, thus increasing tumor fibrosis. Finally, we show that Gr-1+ myeloid cells mediate HSC differentiation/activation in a paracrine manner. CXCR4 inhibition by AMD3100 in combination with sorafenib treatment prevents the increase in tumor fibrosis—despite persistently elevated hypoxia—in part by reducing Gr-1+ myeloid cell infiltration, and inhibits HCC growth. Similarly, antibody blockade of Gr-1 reduces tumor fibrosis and inhibited HCC growth when combined with sorafenib treatment.

▼ Harvesting Water Energy by a Sequential Contact-Electrification and Electrostatic-Induction Process

Prof. Zong-Hong Lin

Institute of Biomedical Engineering

The water-related energy sources including ocean wave, waterfall, and raindrop in the environment have abundant amounts of energy, which are inexhaustible and can be good alternatives to solar energy. In this

research, we design a new prototype triboelectric nanogenerator (TENG) that can convert the energy into electricity. The structure of the TENG can be simplified to an insulating superhydrophobic polymer film and a metal electrode. The working mechanism can be explained as a result of contact electrification and electrostatic induction. For example, when a water drop falls down and contacts with the polymer film surface, ionization of surface groups on the polymer film will cause the polymer film to be negatively charged. Therefore, a positively charged electrical double layer (EDL) on the contact surface of the water drop will be formed to maintain electrical neutrality. Once the charged water drop is leaving the polymer film, a negative electric potential difference will be established between the metal electrode and ground. In the short-circuit condition, electrons are transferred from the metal electrode to ground and reach equilibrium. This process produces an instantaneous negative current. Because the triboelectric charges on the polymer film can be retained for a long time, as another water drop is falling to contact with the polymer film, the negative charges on the polymer film will attract counter ions from the water drop to form another positively charged EDL and establishes a positive electric potential difference. Therefore, electrons will flow from ground to the metal electrode until achieving a new equilibrium. This process produces an instantaneous positive current. If the following water drops are contacting with the polymer periodically, a continuous output from the TENG will be obtained. The generated output from a 30- μ L water drop can reach a peak voltage of 9.3 V and a peak current of 17 μ A. The TENG is also utilized to collect the energy of flowing water from a household faucet, and the output current and instantaneous power densities of 1.5 μ A cm^{-2} and 20 mW cm^{-2} , respectively, have been achieved, which can directly drive 20 LEDs. The rectified output has also been demonstrated to charge a commercial capacitor. All these results clearly show that the novel concept and design of the TENG will serve as the stepping stone for future related TENG studies and inspire the development of TENG toward discovering and facilitating new renewable energy sources from the environment in daily life.

▼ Self-Powered Nanosensors for Light, Mercury Ion, and Catechin Molecule Detection

Prof. Zong-Hong Lin

Institute of Biomedical Engineering

Self-powered nanosensors that can function without external power sources have recently been demonstrated as new approaches for pH, humidity, and temperature sensing. By harvesting energy directly from the environment, these self-powered devices are advantageous in minimizing the size and avoiding the use of environmentally unfriendly materials in battery. Since the first invention of triboelectric nanogenerator (TENG) in 2012, it has been developed into a new energy technology. TENG has been applied to efficiently convert the mechanical vibration into electricity. The fundamental mechanism of the TENG is based on surface charge transfer, which is through the contact between two materials with different triboelectric polarity. The serial contact and separation of the material surfaces with opposite charges establishes a potential difference, which will drive the electrons flow through the external load. Since the capability of surface charge transfer depends on the physical and chemical properties of the surfaces, in this research we further functionalize the material surface for selective detection of light, mercury ion, and catechin molecule. The self-powered nanosensors developed here are future sensing system for unreachable and access-denied extreme environments.

▼ Robust Synthesis of Gold Cubic Nanoframes through a Combination of Galvanic Replacement, Gold Deposition, and Silver Dealloying

Prof. Dehui Wan

Institute of Biomedical Engineering

Au-Ag nanocages are attractive because of their unique structural and optical properties, including high specific surface areas, high porosities, low densities, and tunable LSPR features. However, the remaining Ag in the Au-Ag nanocages represents a major drawback that could eventually limit their use in living systems. Herein, we present a facile and robust approach to the synthesis of Au nanoframes with low Ag contents by introducing thin layers of pure Au onto the surfaces of Au-Ag alloyed nanocages before the dealloying step. The synthesis involved three major steps: 1) preparation of Au-Ag alloyed

nanocages using a galvanic replacement reaction between Ag nanocubes and HAuCl_4 ; 2) deposition of thin layers of pure Au onto the surfaces of the nanocages by reducing HAuCl_4 with ascorbic acid; and 3) formation of Au cubic nanoframes through a dealloying process with HAuCl_4 . The key to the formation of Au cubic nanoframes is to coat the surfaces of Au-Ag nanocages with sufficiently thick layers of Au before they are dealloyed. The Au layer could prevent the skeleton of a nanocage from being fragmented during the dealloying step. The as-prepared Au cubic nanoframes exhibited tunable LSPR peaks in the near-infrared region, but with much lower Ag contents as compared with the initial Au-Ag nanocages.

▼ 1. Microturbine Power Generation Testing and Analysis

▼ 2. System analysis and parameter optimization of Solar ORC system: cases study in local areas in Taiwan.

▼ 3. Performance analysis and optimization of a transcritical ORC system.

Prof. Hsiao-Wei D. Chiang

Department of Power Mechanical Engineering

1. Microturbine rotor blade design using CFD analysis including hollow blade design, inner shaft turbine blade design, and rotor dynamics analysis. Very good agreements between test data and computational analysis were demonstrated.
2. A system analysis model combined solar collection system and ORC system was developed. A parameter optimization of solar ORC system was done according to the local climate characteristics around Taiwan. This work has established a systematic method to assess the feasibility of solar ORC in different area.
3. Transcritical ORC system is a feasible way to improve the efficiency of ORC system. A series of system analysis were performed with a wide heat source range (125~225° C) and 10 organic working fluids. The result shows that a R134a TRC system can produce more electricity compared to a R245fa ORC system. 15~20% increase in electricity is expected. Moreover, a sensitivity study shows that TRC system is more sensitive to the isentropic efficiency of pump and expander than subcritical ORC system.

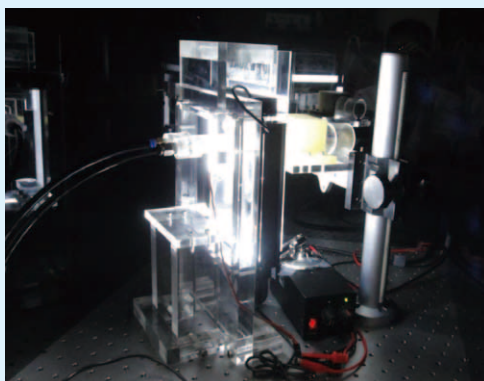
<http://oz.nthu.edu.tw/~g9733516/index.htm>

▼ Collector for Moving Virgin Drosophila with Time-varying Features

Prof. Hung-Yin Tsai and Rong-Shun Chen
Department of Power Mechanical Engineering

A drosophila has a complete analysis of nucleic acid sequence, a common model organism used by brain neural research. The genes of drosophila and human genes have about 60% similarity, because of this, drosophilas are commonly used to study human genes. A drosophila research would need a lot of data which means it needs a lot of drosophila to be studied and it also needs to be counted and separated during classification. But the traditional way of classifying drosophilas are done manually, it not only wastes man power and time, it can also be the cause of human error. For this purpose, the research invented a "Collector for Moving Virgin Drosophila with Time-varying Features." We expect this machine can count and classify the different types of drosophilas automatically, especially to be able to still classify a drosophila going through the stages of growing from a larva to adulthood. This machine has these following functions: (1) Rolling drive system: using a rolling tube to guide the drosophila out on a certain direction. (2) Multiple tube revolver system: using multiple tubes to collect multiple numbers of automated classifications of drosophila. (3) Image processing system: using CCD and image processing method to classify female drosophila. (4) Counting and collecting system: using light sensor to count the number of drosophila and using a pump to collect the drosophila. Using these following systems, this machine can classify female drosophilae with a recognition rate of 100% and can automatically count and classify the drosophila.

http://mag.udn.com/mag/edu/storypage.jsp?f_ART_ID=484700

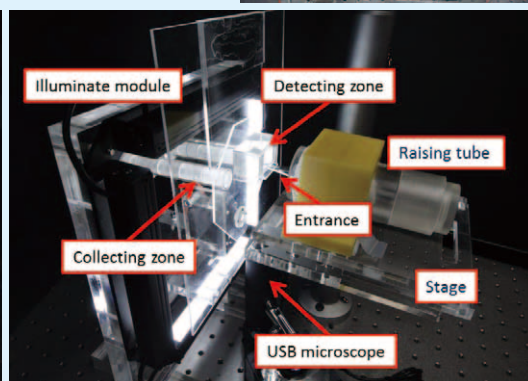
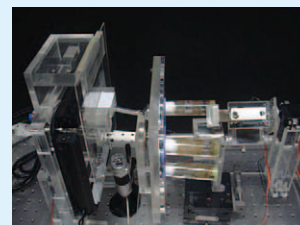


▼ Intercultural theatre, postdramatic theatre, Shakespearian studies, Deleuze studies

Prof. Lia Wen-Ching Liang
Department of Foreign Languages and Literature

Dr Lia Wen-Ching Liang (Ph.D, Royal Holloway, University of London) teaches Contemporary British Theatre, Shakespeare, and Deleuze and Literature. Taking points of departure from Deleuze's concepts, she has published articles on Shakespearean productions, intercultural theatre, postdramatic theatre, and popular entertainment. She is currently a board member of Taiwan Shakespeare Association. Her latest research project is about the post-911 landscapes in Martin Crimp's plays

http://muse.jhu.edu/login?auth=0&type=summary&url=/journals/asian_theatre_journal/v031/31.1.liang.html



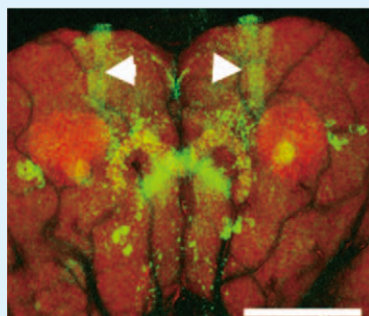
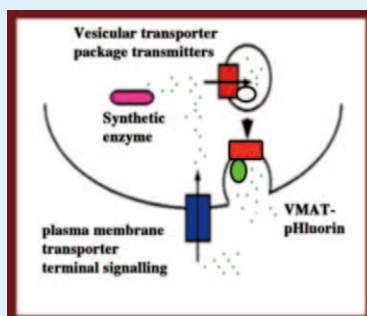
▼ Investigation on proton translocating H⁺-pyrophosphatase by single molecule fluorescence resonance energy transfer (*smFRET*)

Prof. Rong-Long Pan

Department of Life Science, and Institute of Bioinformatics and Structural Biology

H⁺-translocating pyrophosphatase (H⁺-PPase, EC 3.6.1.1) plays an important role in acidifying lumens by transporting protons across membranes at the expense of pyrophosphate (PP_i) hydrolysis. The electrochemical gradient built up is used for transporting substances, such as ions, metabolites and even toxicants, into lumens. The three-dimensional structure of H⁺-PPase have been published in 2012 in *Nature*; however, the proton transport channel is yet to be validated. In this study, *smFRET* technique was employed to investigate the residues surrounding the entrance of the transport pathway in H⁺-PPase, where the initial event of proton translocation was proposed to occur. Accordingly, a working model is proposed delineating substrate mediating squeeze at the entrance of the proton transport pathway in H⁺-PPase. This research firstly displays that substrate mediates movement at the pathway entrance of H⁺-PPase.

<http://www.ncbi.nlm.nih.gov/pubmed/23720778>



▼ Develop a novel *in vivo* molecular probe to detect vesicular dopamine release for Parkinson's disease

Prof. Hui-Yun Chang

Institute of Systems Neuroscience,
Department of Medical Science

Our lab is currently engaged in the study of *Drosophila* dopaminergic system in which manipulation of this system has dramatic behavioral consequences, underscoring its central role in modulating neuronal circuits that control animal motivation, motor and learning and memory. In human, dysfunction of dopaminergic system has been implicated potentially relevant to several neuropsychiatric disorders including schizophrenia, bipolar disease and depression; and neurological diseases including the most common movement disorder, Parkinson's disease (PD). Many groups including ours have using *Drosophila melanogaster* as an excellent genetic model organism to investigate the underlying pathological mechanisms of neurodegenerative and other diseases due to, surprisingly, nearly 70% of human disease-causing genes have conserved orthologues in the fruit flies. In this study, we established a novel convertible molecular probe, VMAT-pHluorin, to monitor synaptic vesicular release of dopamine *in vivo*. Expression this probe in fly brain visualizes the synaptic vesicular releases to many brain regions that include the mushroom bodies and central complex whose functions have been shown to regulate motor behaviors, and learning and memory. As an initial endeavor to apply this molecular probe, we started with the study of the association of dopamine neurotransmission and animal motor behaviors, and learning and memory that are relevant to PD. Flies expressing PD associated tau protein exhibited progressive impairments of both motor and learning behaviors. To our surprise, longitudinal systematic characterizations of the pathogenesis of tau at different ages demonstrate an early molecular impairment of synaptic vesicular release to nerve terminals that preceded both the age-dependent formation of tau tangle and the progressive loss of DA neurons. This study suggests that correction or prevention of this deficit may be appropriate targets for early therapeutic intervention. Our finding of this novel molecular probe and its utilization in probe of pathogenesis in PD associated human tau has been published in a prestigious journal of *acta neuropathologica*.

<http://life.nthu.edu.tw/~labhuiyun/wbepage/Leader.html>

▼ Microtubule depolymerization activates Epstein-Barr virus lytic cycle

Prof. Lily Hui-Ching Wang

Institute of Molecular and Cellular Biology

Elevated levels of antibodies against Epstein-Barr virus (EBV) and the presence of viral DNA in plasma are reliable biomarkers for the diagnosis of nasopharyngeal carcinoma (NPC) in high-prevalence areas, such as South-East Asia. The presence of these viral markers in the circulation suggests that a minimal level of virus reactivation may have occurred in an infected individual, although the underlying mechanism of reactivation remains to be elucidated. Here, we showed that treatment with nocodazole, which provokes the depolymerization of microtubules, induces the expression of two EBV lytic cycle proteins, Zta and EA-D, in EBV-positive NPC cells. This effect was independent of mitotic arrest, as viral reactivation was not abolished in cells synchronized at interphase. Notably, the induction of Zta by nocodazole was mediated by transcriptional upregulation via protein kinase C (PKC). Interestingly, the effect of nocodazole, as well as colchicine and vinblastine, on lytic gene expression occurred only in NPC epithelial cells but not in cells derived from lymphocytes. These results establish a novel role of microtubule integrity in controlling the EBV life cycle through PKC and its downstream pathways, which represents a tissue-specific mechanism for controlling the life-cycle switch of EBV.

<http://www.ncbi.nlm.nih.gov/pubmed/24062531>

▼ Method for one step purification of recombinant *Helicobacter pylori* neutrophil activating protein (HP-NAP)

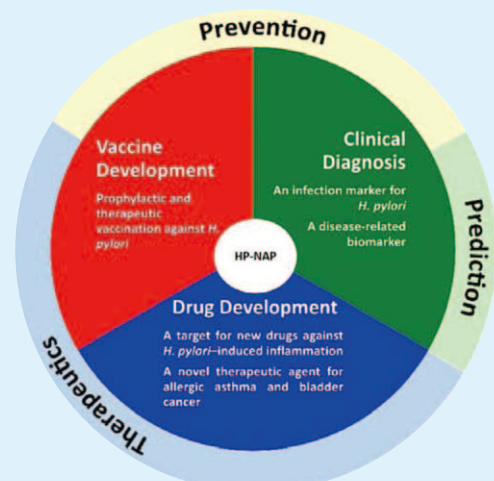
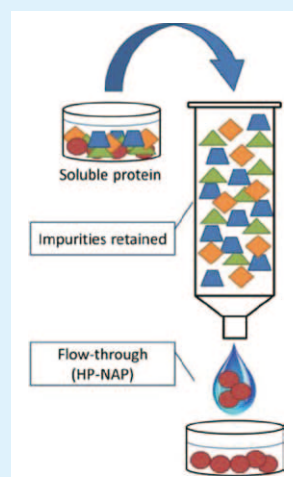
Prof. Hua Wen Ruth Fu

Institute of Molecular and Cellular Biology

Helicobacter pylori neutrophil-activating protein (HP-NAP) was first identified from the water extract of *H. pylori* for its ability to promote neutrophil adhesion to endothelial cells. This protein is thought to play a crucial role in *H. pylori*-induced gastric inflammation via activation of ROS production from human neutrophils. HP-NAP is a vaccine candidate possessing both prophylactic and therapeutic effects against *H. pylori* infection. In addition, HP-NAP may act as a potential therapeutic agent in allergic asthma and bladder cancer due to its immunomodulatory property. Hence, an efficient way to obtain pure HP-NAP needs to be developed. In this study, onestep anion-exchange chromatography in negative mode was applied to purify the recombinant HP-NAP expressed in *E. coli* and *B. subtilis*. This purification technique was based on the binding of host cell proteins and/or impurities other than HPNAP to DEAE Sephadex or Sepharose resins. At pH 8.0 to pH 9.0, almost no other proteins except HP-NAP passed through the DEAE Sephadex or Sepharose columns. The recombinant HP-NAP purified by this one-step chromatographic method could be further utilized for the development of new drugs, vaccines, and diagnostics for *H. pylori* infection or for other new therapeutic applications. The US and ROC patents have been issued for this invention in 2014.

<http://www.plosone.org/article/>

[info%3Adoi%2F10.1371%2Fjournal.pone.0060786](http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0060786)



▼ Mechanisms that enhance neurite outgrowth

Prof. Linyi Chen

Institute of Molecular Medicine

Neurite outgrowth is an essential process during the development and regeneration of the nervous system. Thus, understanding the molecular control of neurite outgrowth is one of strategies to help us to develop appropriately therapeutic targets for neuroregeneration. SH2B1 is a signaling adaptor protein that regulates cellular signaling in various physiological processes. We find that knocking down SH2B1 reduces neurite formation of cortical neurons whereas overexpression of SH2B1 β promotes the development of hippocampal neurons. We further demonstrate that SH2B1 β promotes BDNF-induced neurite outgrowth of PC12 cells stably expressing TrkB, SH2B1 β through enhancing BDNF-induced MEK-ERK1/2, and PI3K-AKT signaling pathways. SH2B1 β also undergoes nucleocytoplasmic shuttling and regulates a subset of neurotrophin-induced genes. We also show that SH2B1 β interacts with the transcription factor, signal transducer, and activator of transcription 3 (STAT3). SH2B1 β affected the transcriptional activity and subcellular distribution of STAT3 as well as enhanced FGF1-induced expression of STAT3 target genes Egr1 and Cdh2. We provided evidence showing that overexpression of SH2B1 β promotes the in vivo occupancy of STAT3-Sp1 heterodimers at the promoter of Egr1 and Cdh2 during neuronal differentiation. Electrical stimulation (ES) has been shown to enhance both neurite outgrowth and nerve regeneration. In collaboration with Dr. Michael Shiang-Cheng Lu at the Department of Electrical Engineering, National Tsing Hua University, we design the transparent indium tin oxide (ITO) conductive chip dishes to investigate whether ES promotes Nerve growth factor (NGF)-induced neurite outgrowth and signaling in PC12 cells. Our findings suggest that ES of 100 mV/mm together with NGF provides optimal effect on neurite outgrowth of PC12 cells. One mechanism that ES enhances neurite outgrowth is through increasing NGF-induced phosphorylation of ERK1/2 (pERK1/2) and expression of Egr1 gene. ES has previously been demonstrated to increase the activity of protein kinase C (PKC). Our result indicates that activating PKC further increases NGF-induced pERK1/2 and thus neurite outgrowth.

<http://life.nthu.edu.tw/~labcli/>

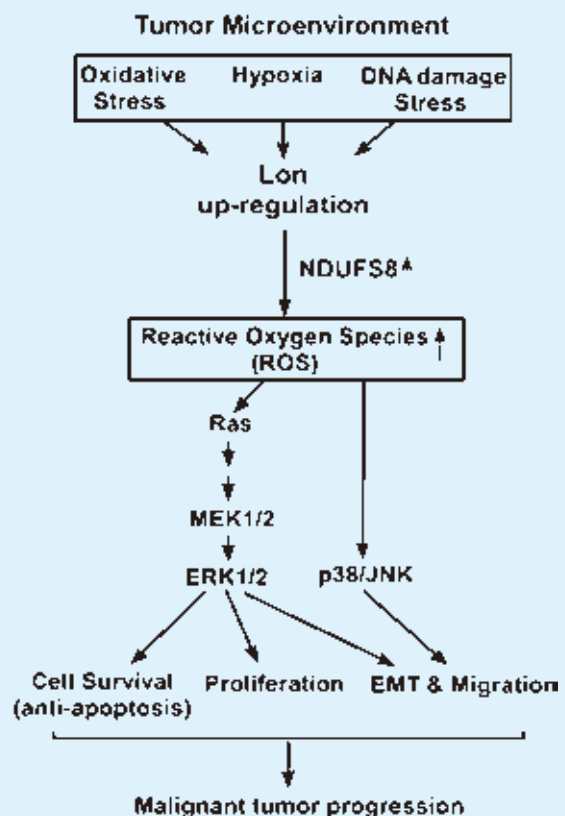
▼ Assessing the contribution of Lon to survival and aggressive phenotype of cancer cells through mitochondrial complex I-mediated generation of reactive oxygen species

Prof. Mou-Chieh Kao

Institute of Molecular Medicine

Lon protease is a multifunction protein and operates in protein quality control and stress response pathways in mitochondria. By teaming up with Dr. AY-L Lee from National Health Research Institutes (NHRI), we demonstrated the role of Lon overexpression in tumorigenesis. Lon overexpression gives an apoptotic resistance to stresses and induces mitochondrial ROS production through up-regulation of NDUFS8 (a mitochondrial Fe-S protein in complex I of electron transport chain) as signaling molecules to activate Ras and MAPK signaling, giving the survival advantages and adaptation to cancer cells. In addition, we also found Lon is overexpressed specifically in various types of cancer tissue including oral cancer.

<http://www.nature.com/cddis/journal/v4/n6/full/cddis2013204a.html>



▼ Protein allostery described by time-dependent linear response theories

Prof. Lee-Wei Yang

Institute of Bioinformatics and Structural Biology

Protein allostery is a phenomenon that happenings on one site of the protein can influence the biological activities of other remote sites in the protein. Researches suggest almost all the proteins bear certain degree of allostery. One example that substantially matters our lives is hemoglobin on which oxygen binding on one subunit promotes the binding of oxygen in other subunits. Without such binding cooperativity, our blood would not release (in exercising muscle) and absorb (in the lungs) oxygen timely and efficiently. The inter- and intra-molecular controls are determined by the connectivity of amino acids comprising a protein and usually facilitated by observable conformational changes. Recently we formulated linear response theories to take account ligand-(or other perturbations) induced protein conformational changes. CO binding triggers mechanical signals that propagate from heme throughout the physiochemically connected myoglobin network. The relaxation time we predicted from the theory well agrees with site-specific UVRR data and time-resolved X-ray crystallography evidence. According to our theory, those residues that disseminate the signal the fastest throughout the molecule are found to impact the CO/O₂ rebinding kinetics the most upon their mutation. Further more, we identify signal communication centers that are shown to most frequently communicating the signals when considering perturbations that occur at all residues along all possible directions in a protein. In the study of dihydrofolate reductase, we found strong communicators are those that, upon mutation, severely impair hydride transfer activity. Those least communicating ones, upon mutation, are found to barely impact the hydride transfer rates. We hope the theory revealing the coupling between mechanical physics and chemical modification of side-chains can bring new insights on the nature of allostery.

<http://dyn.life.nthu.edu.tw/LRT/myoglobin.html>

▼ Diacylglycerol lipase regulates lifespan and oxidative stress response by inversely modulating TOR signaling in *Drosophila* and *C. elegans*

Prof. Horng-Dar Wang

Institute of Biotechnology

Target of rapamycin (TOR) signaling is a nutrient-sensing pathway controlling metabolism and lifespan. Although TOR signaling can be activated by a metabolite of diacylglycerol (DAG), phosphatidic acid (PA), how the genetic regulation of DAG metabolism influences lifespan remains unknown. DAG is metabolized to either PA via the action of DAG kinase or 2-arachidonoyl-*sn*-glycerol (2-AG) by diacylglycerol lipase (DAGL). Here, we report that in both *Drosophila* and *C. elegans*, overexpression of *diacylglycerol lipase (DAGL/inaE/dagl-1)* or knockdown of *diacylglycerol kinase (DGK/rdgA/dgk-5)* extends lifespan and enhances oxidative stress resistance. Phosphorylated S6 kinase (p-S6K) levels are reduced following these manipulations, implying the involvement of TOR signaling. In addition *DAGL/inaE/dagl-1* mutants have reduced lifespan, lower tolerance to oxidative stress and elevated levels of p-S6K. Genetic interaction studies support the hypothesis that DAG metabolism interacts with TOR and S6K signaling to affect lifespan and oxidative stress resistance. These findings add insights on how the genetic regulation of DAG metabolism modulates lifespan and oxidative stress response. This research article has recently been published in *Aging Cell*, a high impact journal in aging research field. As our study proved this pathway could be evolutionarily conserved. Therefore, in the future it would be very intriguing to study whether similar manipulation of this pathway also produce similar phenomena in mammals, and to find a means to pharmacologically or dietarily modulate this pathway for extended longevity and stress resistance in mankind, and to prevent aging-related diseases and achieve healthy aging.

<http://www.ncbi.nlm.nih.gov/pubmed/24889782>

▼ Low voltage low power CMOS image sensor & ADC

Prof. Chih-Cheng Hsieh

Department of Electrical Engineering

A 0.5V operational CMOS imager is proposed with threshold-variation cancelling (TVC) and programmable current controlled threshold (PCCT) schemes to achieve a 0.055% fixed-pattern noise (FPN) and 56.5dB boost of dynamic range, respectively. A 0.4V operated 10b SAR ADC with proposed charge average switching (CAS) DAC is developed to achieve the best FoM of 2.4fJ/conv-step in 2013.

<http://www.ee.nthu.edu.tw/cchsieh/>

▼ A 0.5V 1.27mW Nose-on-a-Chip for Rapid Diagnosis of Ventilator-associated Pneumonia

Prof. Kea-Tiong Tang

Department of Electrical Engineering

Ventilator-associated pneumonia (VAP) is the most frequently acquired infection among patients that receive mechanical ventilation in the intensive care unit (ICU). The mortality rate for VAP lies in 20-50% and could be even higher in some ICUs. A standard operation procedure to VAP treatment includes a sequence of chest radiography, sputum gram stain, sputum culture, and empiric therapy, initially with antibiotics covering broad pathogens. However, collection of the gram stain and culture of lower respiratory tract specimen is usually not time-efficient (up to 5 days), delaying the initiation of therapy and unacceptable for critically ill patients. A rapid and accurate diagnosis for VAP is therefore crucial, but still unavailable. It is known that microorganisms generate complex metabolites during infection. Fast detection is feasible by examining metabolic wastes in proximal end of the expiratory device, demanding a miniaturized, battery-powered, gas-sensing device. In this work, a fully-integrated low-power nose-on-a-chip with a robust learning kernel is developed for such a vital clinical need.

http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6757496&tag=1

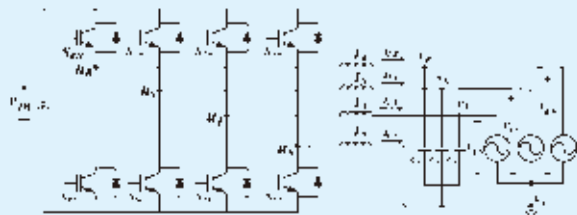
▼ D- Σ (Division-Summation) Digital Control

Prof. Tsai-Fu Wu

Department of Electrical Engineering

High-power components of converters usually play an important role in power-electronic applications. Due to their non-linear characteristics and grid-voltage distortion, the Park transformation, abc to dq frame transformation, having been adopted for near 30 years, cannot be used for deriving valid duty-ratio control laws, which results in current fluctuation and increases core size to limit filter-inductance variation. Based on the considerations of the wide inductance variation and the grid-voltage distortion, our team develops a D- Σ digital control including the advantages of deadbeat control and current feed-forward control to increase dynamic response. The proposed D- Σ digital control can cover wide inductance variation and reduce core size significantly. For example, if filter inductance has nine-time variation, it can reduce core size about five times. With the proposed D- Σ digital control, the inverter can be operated in current-control modes, such as grid connection, rectification with power factor correction (PFC), active power filter (APF) and static synchronous compensator (STATCOM). Moreover, with our proposed impedance estimation approach, the D- Σ digital control can also cover voltage-control inverter applications, *i.e.* UPS. The proposed D- Σ digital control has breakthrough innovation and can be applied to many converter applications, which can cover wide inductance variation and grid-voltage distortion, reducing the cost of power converters about 15%. Thus, the proposed D- Σ digital control is a very important key-technique innovation.

<http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=6579076>



▼ Wide-Area Measurement-Based Voltage Stability Indicators by Modified Coupled Single-Port Models

Prof. Chia-Chi Chu

Department of Electrical Engineering

As the power system becomes more stressed and the penetration of renewable energies increases, voltage stability assessment (VSA) becomes a key issue for monitoring and controlling the security of modern bulk power grids. In recent years, real-time voltage stability monitoring systems have become a trend for wide-area VSA. The coupled single-port model has been proposed for representing equivalent Thevenin parameters from wide-area measurements. This concept consists in decoupling a mesh power grid into an individual equivalent single-port circuit to predict VSA. Under a proportional-increase load scenario, the current coupled single-port model poses its accuracy in VSA. However, the current coupled single-port model may yield underestimations if loads are not proportionally increasing. In our work, based on real-time PMU measurements of individual load bus, a modified coupled single-port model will be proposed for measurement-based VSA. This model will improve under-estimations of existing coupled single-port models since the reactive power response extracted from the extended Ward-type equivalent is explored to compensate the reactive power mismatch in the existing coupled single-port model. Then, a mitigation factor based on this reactive power response will be defined to provide a direction for adjusting circuit parameters of the current model, and modified models can be constructed accordingly. The simulation in an IEEE 14-bus test system will be used to illustrate our contributions.

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6632943>

▼ A Fully Integrated Direct-Sampling Impulse Radar System in 65nm CMOS

Prof. Yuan-Hao Huang, Prof. Shi-Yu Huang, and Prof. Ta-Shun Chu

Department of Electrical Engineering

This work presents a wireless sensor system for monitoring human cardiopulmonary activities. The sensor is composed of a fully-integrated CMOS impulse radar chip and a DSP platform that is

used for human respiratory feature extraction. The proposed and implemented radar chip was fabricated using in the TSMC 65nm CMOS technology. Impulse radar detects object by short-duration impulses which occupies wide bandwidth with low spectral power density. Short-duration signals provide high resolution in time domain which is beneficial in detection resolution. Besides, short duration is more resistant to multipath issue inherently. Low spectral power density does not interfere adjacent narrow band wireless communication systems. In a crowded spectrum environment, the impulse radar is still possible to operate normally and less aggressive to nearby wireless communications. These features make impulse radar suitable for indoor localization, ranging, monitoring and sensing applications. It can achieve the 1.5mm scanning resolution over the 15 meters scanning range with total 21mW power consumption. Moreover, the timing circuitry supporting range gated sensing and the pulse generator in the transmitter are all digital standard cell-based design which is very favorable to the technology scaling. The realtime DSP platform captures the wireless data via the CMOS radar chip and processes that data through a human feature extraction algorithm. The entire system can fully operate in a simple outdoor environment to validate the performance of the wireless sensor system.

▼ Optical Trapping in Nanoscale Plasmonic Lattice

Prof. Ya-Tang Yang (Electrical Engineering)

Prof. Jer-Shing Huang (Chemistry)

Department of Electrical Engineering

Department of Chemistry

Optical trapping is invented by A. Askin in 1970s and is based on the principle that the focused light exerts forces on microscopic object. Multiple optical trap can form periodic optical lattice that can perform high efficiency optical sorting in or provide a platform to study statistical transport in microfluidic environments. Plasmonic resonance of metallic nanostructure can overcome the diffraction limit and confine the light field well below the wavelength of light. We have created two dimensional optical lattice based on plasmonics and for the first time observe the transport and trapping of nanoparticles over such optical potential. We also observe the particle of 500 nm forms hexagonal closed pack structure.

<http://pubs.acs.org/doi/abs/10.1021/nl4016254>

▼ 1. Circuit Designs for Resistive Memory (ReRAM)

▼ 2. Circuit Designs for Low-Voltage SRAM

Prof. Meng-Fan Chang

Department of Electrical Engineering

1. This study proposes a swing-sample-and-couple (SSC) voltage-mode sense amplifier (VSA) to enabling $1.8\times$ greater sensing margin for lower read-VDDmin and $1.7\times$ faster read time across various VDD, compared to conventional sense amplifiers. To reduce 99+% SET energy, we use a 4T self-boost-write-termination (SBWT) scheme, with an area penalty below 0.5%. This work was published in 2014 ISSCC.

2. This work proposes an L-shaped 7T cell (L7T) and read-bitline (RBL) swing expansion scheme (RBL-EXPD) to minimize $A\times VDDmin$ for low-voltage applications. This L7T features an area-efficient cell layout and a read-disturb free decoupled 1T read port (RP) capable of providing a wide space for write margin improvement. This work was published in 2013 Symp. VLSI Circuits.

▼ High-speed Si modulator with high modulation efficiency and low free carrier absorption through fringe-field carrier-depletion

Prof. Ming-Chang Lee

Institute of Electronics Engineering and
Institute of Photonics Technologies

A new Si modulator implemented by fringe-field carrier depletion is demonstrated. Through the strong fringe field, the depletion regions of two parallel pn junctions near the waveguide corners are efficiently modulated across the waveguide center without introducing too much free carrier absorption. The pn junctions are precisely defined through a self-aligned ion implantation and a subsequent thermal drive-in process. The measured $V_{\pi}L$ and attenuation coefficient are 1.8 V-cm and 1.3 dB/mm, respectively. The figure-of-merit (FOM) is 23.4 V-dB, which is superior to contemporary depletion type modulators. The operation speed can be potentially beyond 30 GHz by replacing poly-Si with c-Si.

<http://mx.nthu.edu.tw/~leemc/>

▼ Halftone QR Codes

Prof. Hung-Kuo Chu

Department of Computer science

QR code is a popular form of barcode pattern that is ubiquitously used to tag information to products or for linking advertisements. While, on one hand, it is essential to keep the patterns machine-readable; on the other hand, even small changes to the patterns can easily render them unreadable. Hence, in absence of any computational support, such QR codes appear as random collections of black/white modules, and are often visually unpleasant. We propose an approach to produce high quality visual QR codes, which we call halftone QR codes, that are still machine-readable. First, we build a pattern readability function wherein we learn a probability distribution of what modules can be replaced by which other modules. Then, given a text tag, we express the input image in terms of the learned dictionary to encode the source text. We demonstrate that our approach produces high quality results on a range of inputs and under different distortion effects. This work is accepted by SIGGRAPH ASIA 2013 and published in ACM Transaction on Graphics.

http://cgv.cs.nthu.edu.tw/Projects/Recreational_Graphics/Halftone_QRCodes/

▼ High-Speed Light-Emitting Diodes Emitting at 500 nm With 463-MHz Modulation Bandwidth

Prof. Meng-Chyi Wu

Institute of Electronics Engineering

Light-emitting diode (LED) is one of the most important light sources due to its low power consumption and long lifetime. In this letter, we present the high-frequency characteristics of GaN-based green LEDs with different aperture diameters. In order to get higher current density, we use ring-shaped electrode to confine the current injection. Unlike conventional LEDs, we only use its natural feature to get a high modulation bandwidth. The LEDs investigated have a peak emission wavelength of 500 nm. The highest optical 3-dB modulation bandwidth is ~ 463 MHz at 50 mA for the 500-nm green GaN-based LED with an aperture diameter of 75 μm . It is the highest bandwidth yet reported for the green GaN-based LEDs. The LED also exhibits a relatively high output power of ~ 1.6 mW at 50 mA as compared with other high-speed LEDs. Such the LEDs can be applied to plastic optical fiber and visible light communication in the future.

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6786982>

▼ Simultaneous Multiple Carrier Frequency Offsets and Channels Estimation for Coordinated Multi-point Transmission in OFDM Systems

Prof. Tsai, Yuh-Ren

Institute of Communications Engineering

Orthogonal frequency division multiplexing (OFDM) combined with the coordinated multi-point (CoMP) transmission technique has been proposed to improve performance of the receivers located at the cell border. However, the inevitable carrier frequency offset (CFO) will destroy the orthogonality between subcarriers and induce strong inter-carrier interference (ICI) in OFDM systems. In a CoMP-OFDM system, the impact of CFO is more severe because of the mismatch in carrier frequencies among multiple transmitters. To reduce performance degradation, CFO estimation and compensation is essential. For simultaneous estimation of multiple CFOs, the performance of conventional CFO estimation schemes is significantly degraded by the mutual interference among the signals from different transmitters. In this work, our goal is to propose an effective approach that can simultaneously estimate multiple CFOs in the downlink by using the composite signal coming from multiple base stations corresponding to CoMP transmission. Based on the Zadoff-Chu sequences, we design an optimal set of training sequences, which minimizes the mutual interference and is robust to the variations in multiple CFOs. Then, we propose a maximum likelihood (ML)-based estimator, the robust multi-CFO estimation (RMCE) scheme, for simultaneous estimation of multiple CFOs. In addition, by incorporating iterative interference cancellation into the RMCE scheme, we propose an iterative scheme to further improve the estimation performance. According to the simulations, our scheme can eliminate the mutual interference effectively, approaching the Cramer-Rao bound performance.

<http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=06571314>

▼ New Statistical Studies on OFDM-QAM Peak-to-Mean-Envelope-Power Ratio

Prof. Scott CH Huang

Institute of Communications Engineering

Orthogonal frequency-division multiplexing (OFDM) is a popular modulation scheme for wireless applications especially due to its capability of coping with severe channel conditions such as multipath propagation. Nevertheless, a significant disadvantage of the OFDM system is its high peak-to-mean-envelope-power ratio (PMEPR). High PMEPRs cause transmitter amplifiers to operate at very low power efficiencies in order to avoid signal clipping. High PMEPRs also increase the complexity of the transmitter amplifier hardware design. A number of techniques, namely distortion-based and redundancy-based techniques, have been proposed to reduce the PMEPRs in OFDM systems. The distortion-based techniques such as clipping and peak truncation directly cut off high signal amplitudes if they exceed a certain threshold. Usually, these distortion-based techniques result in poor error performance and significant out-of-band power. The redundancy-based techniques include coding, selected mapping, tone reservation, and tone injection. Selected mapping (SLM) and partial transmitting sequences (PTS) are used to facilitate promising PMEPR reduction approaches. In an SLM system, an OFDM symbol is mapped to a set of independent candidate sequences and the one with the lowest PMEPR will be selected for actual transmission. The tradeoff for PMEPR reduction in the SLM scheme is its redundancy. The more candidate sequences we generate, the less efficiency we achieve. Therefore, two crucial questions arise. How many candidate sequences do we need to code an OFDM symbol? If an OFDM symbol consists of n information symbols, how likely the transmitted OFDM symbol will be clipped? In the existing literature, only asymptotic analysis has been presented to address these problems. However, this analysis is applicable only when n is very large and it is not useful for small or moderate n in practice. To countermeasure these problems, we study the two aforementioned questions both theoretically and empirically. Through mathematical maneuver, we theoretically derive the relationship between the PMEPR upper-bound and the clipping probability for moderate n (i.e. $n \leq 100$) for OFDM-QPSK sequences. In addition, the PMEPR distributions are also empirically investigated and they are used to rectify our theoretical results. Our PMEPR analysis is extended to OFDM-QAM sequences as well.

▼ Discriminatory Channel Estimation – A Signal Processing Approach to Enhance Physical Layer Secrecy

Prof. Y.-W. Peter Hong

Institute of Communications Engineering

Due to the broadcast nature of wireless transmissions, communication over the wireless medium is often susceptible to eavesdropping, which makes securing transmissions over these channels important and challenging. Physical layer secrecy refers signal processing and information-theoretic approaches used to achieve secrecy in the physical layer of a communication system. These approaches differ from conventional cryptographic approaches in the sense that no secret key is required to secure the messages. In recent years, Dr. Hong examined in depth the impact of imperfect channel knowledge on the achievable secrecy performance. In particular, his group developed novel designs of training sequences and channel estimation procedures, referred to as discriminatory channel estimation (DCE) schemes, for the purpose of constructing favorable secrecy channels in the channel estimation phase (even before the data is transmitted). A key feature of DCE designs is the insertion of artificial noise (AN) in the training signal to degrade the channel estimation performance at the eavesdropper. Two DCE schemes were proposed, namely, the feedback-and-retraining DCE scheme and the two-way training DCE scheme. These works lead to new research directions in the field of physical layer secrecy and lay a strong foundation for follow-up work in this area. Related publications have appeared in 2013 in leading signal processing journals, such as IEEE Transactions on Signal Processing and IEEE Signal Processing Magazine. In 2013, Dr. Hong also served as the leading coauthor of the book entitled “*Signal Processing Approaches to Secure Physical Layer Communications in Multi-Antenna Wireless Systems*”, which was published in the Springer Briefs series.

<http://www.ee.nthu.edu.tw/~ywhong/>

▼ Silicon Intellectual Property of 8x8 Lattice Reduction Aided MIMO Detector

Prof. Yuan-Hao Huang

Institute of Communications Engineering

This silicon IP is a multiple-input-multiple-output (MIMO) detector with lattice reduction

and QR decomposition preprocessing for MIMO communication systems. This IP was designed, fabricated, and verified by using TSMC 90nm 1P9M CMOS Technology. This chip consumes 37mW power at 65MHz which achieving 3Gbps without preprocessing and 585Mbps with preprocessing. The chip performance satisfies the requirements of 3GPP-LTE-Advanced and WiFi 802.11ac systems.

<http://www.ee.nthu.edu.tw/~yhuang>

▼ NTHU coherent, attosecond EUV Lab

Prof. Ming-Chang Chen

Institute of Photonics Technologies

Multi-cycle femtosecond driving lasers can produce attosecond pulse trains through high order harmonic up-conversion processes, e.g. one cycle of driving laser field produces two attosecond bursts. The train structure of such attosecond pulses limits the experimental resolution to the order of femtoseconds rather than attoseconds due to undistinguishable attosecond events in the pulse trains. In order to achieve attosecond resolution, an intense motivation for the ultrafast community for a decade has a clear goal of a single isolated attosecond generation. Recently our IPT NTHU research team, collaborating with KMgroup in JILA, University of Colorado at Boulder, University of Delaware, and Universidad de Salamanca in Spain has achieved a breakthrough of finding a simple and very straightforward way for isolated single attosecond pulse generation, called phase-matching gating Chen et al. PNAS 111 (23) , E2361(2014). The physical principle behind this process is that high harmonic generation always comes with an ionization process, a transition from neutral to plasma, which naturally creates a temporal refractive index ramp. Since a bright phase-matched attosecond pulse just happens at one specific refractive index, the generation process itself creates one very narrow phase-matching window, leading to single isolated attosecond pulse generation simultaneously. This mechanism works especially for a longer wavelength-driving laser. This new technique presents an accessible and reliable route to generate stable, isolated attosecond and makes it possible to capture the attosecond motion of electrons in a broader range of atoms, molecules, liquids, and materials.

<http://mx.nthu.edu.tw/~mingchang/>

Chen et al. PNAS 111 (23) , E2361(2014)

▼ Reflecting on an Alternative Quantum Theory

Prof. Ray-Kuang Lee

Institute of Photonics Technologies

Since 1998, physicists have explored a modified quantum theory based on spacetime reflections. This so-called *PT* symmetric theory makes certain predictions—such as time shortcuts in the evolution between two states—that conflict with conventional quantum mechanics, while still being compatible with observations. However, a new assessment of this alternative model suggests that it is fundamentally flawed. In *Physical Review Letters*, the authors show the *PT* symmetric theory violates the proscription against faster-than-light communication.

A basic tenet of quantum mechanics is that the Hamiltonian equation describing the energy in a quantum system should have a mathematical property, called Hermiticity, so as to guarantee that the predicted energy values are all real. But one can ensure real energy values another way, by insisting that the Hamiltonian is symmetric to a combination of reflections in space (*P*) and time (*T*). In the past, researchers have used the *PT* symmetric model to describe certain optical systems.

If *PT* symmetry were actually fundamental—replacing the Hermiticity constraint—then radical consequences would arise, such as quantum systems evolving faster than normally predicted. But a challenge to this notion comes from Yi-Chan Lee of National Tsing-Hua University in Hsinchu City, Taiwan, and colleagues. They consider two implicit assumptions in the *PT* symmetric theory, involving how it is locally defined and how its predictions are computed. They put these assumptions to the test with a classic thought experiment, in which Alice and Bob share two entangled states. By choosing how she measures her state, the team found that Alice could send information to Bob faster than the speed of light. The authors believe this result rules out *PT* symmetry as a fundamental theory, but it still could be useful as an effective theory and an interesting model for open systems in classical optics.

– Michael Schirber

<http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.112.130404>

▼ Using Tangible Companions for Enhancing Learning English Conversation

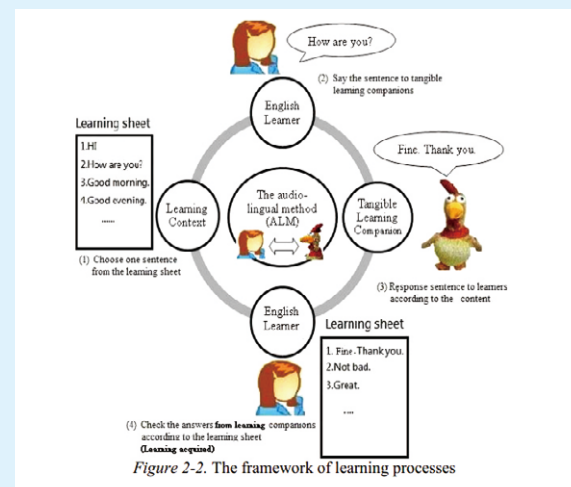
Prof. Shelley Shwu-ching Young

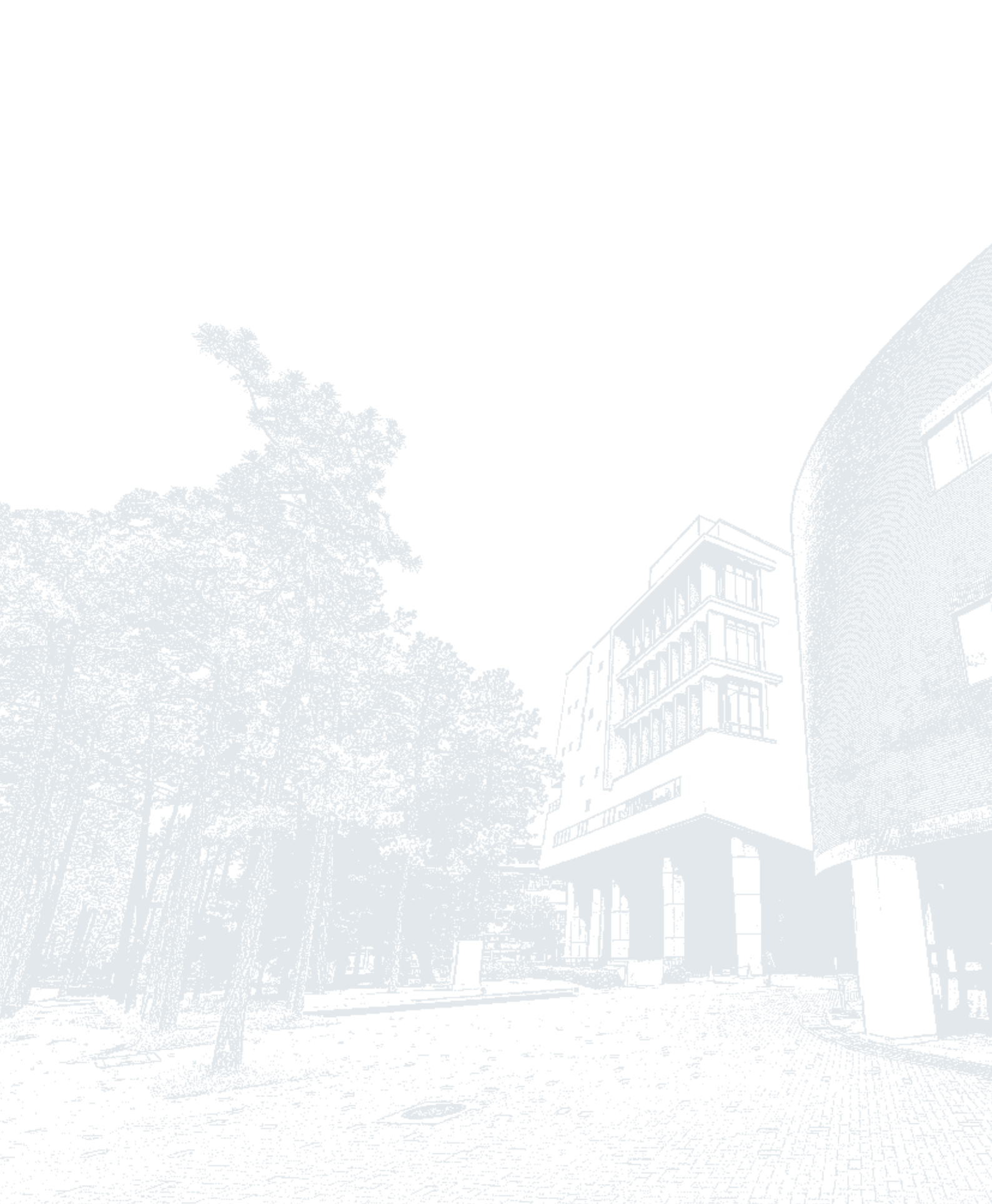
Institute of Learning Sciences

In this study, the researchers attempted to extend the concept of learning companions from the virtual world to the real physical environment and made a breakthrough in technique development of tangible learning robots. The aim of this study was to explore an innovative way by combining the speech recognition technology with educational robots in the hope that the state-of-the-art technology could provide learners with more opportunities of bi-directional language learning in the English class settings. The quasi-experimental design was adopted in this study and a total of 63 Taiwanese students in the fifth grade participated in the experiment.

The results reveal that using the tangible learning companions in learning had positive effects on learners' learning motivation, confidence and engagement especially for the lower-achievement learners. Two learning methods were identified in the study, co-discovery and peer tutoring method. The co-discovery method enhanced the lower-achievement learners' learning involvement and their English speaking ability. Both English instructor and students agreed that uses of the tangible learning companions effectively improved the class atmosphere, and raised their and positive attitude toward learning English.

http://www.ifets.info/journals/16_2/24.pdf





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Office of Research and Development
National Tsing Hua University

No. 101, Section 2, Kuang-Fu Road,
Hsinchu, Taiwan 30013, R.O.C.

Tel : +886-3-571-7470

<http://rdweb.nthu.edu.tw/Default.aspx>

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National Tsing Hua University

No. 101, Section 2, Kuang-Fu Road, Hsinchu,
Taiwan 30013, R.O.C.

Tel : +886-3-571-5131

<http://www.nthu.edu.tw>