2014-2015
R&D REPORT

National Tsing Hua University

A Brief History of NTHU

National Tsing Hua University (NTHU) was established in Beijing in 1911 as "Tsing Hua Academy." The Academy was renamed as "National Tsing Hua University" in 1928. In 1956, NTHU was re-established at its present location in Hsinchu, Taiwan.

Since its relocation, NTHU has developed into a comprehensive research university offering a full range of degree programs in science, technology, engineering, humanities, social sciences, and management. NTHU has been consistently ranked as one of the premier universities in East Asia, and is widely recognized as a leading incubator for future leaders. Our outstanding alumni highlight the success of NTHU students, including Nobel Physics laureates Dr. Cheng-Ning Yang and Dr. Tsung-Dao Lee, Nobel Chemistry laureate Dr. Yuan-Tseh Lee, and Wolf Prize winner in mathematics Dr.Shiing-Shen Chern.

Contents

Message from the President

National Tsing Hua University (NTHU) is a 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-nine years, NTHU has transformed herself into a comprehensive university and is recognized in all disciplines.

NTHU provides a stimulating and nurturing environment within which our faculty can offer quality teaching and conduct innovative research. We have been regarded as one of the top-tier research universities. Our research and development activities across the University emphasize fundamental discoveries at the forefronts of basic sciences and exploration of breakthrough technologies with a high potential for real applications. These can be reflected from our publications in the world's preeminent journals, awarded international patents, and technology transfer cases. In the 2014-2015 R&D annual report, we highlight several key papers published in Scientific Breakthrough. We also provide the facts and figures related to other important R&D activities, including a coverage of three NTHU-industry cooperative R&D centers. This volume is undoubtedly too limited to give the full scope of R&D at NTHU, but a glimpse into our recent achievements. Hopefully, this can serve as a catalyst for further interactions, exchange of ideas, and establishment of collaborations.

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

President
Dr. Hong Hocheng

National Tsing Hua University
Hsinchu, Taiwan
November 2015

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 acres) scenic land with lakes and trees. The campus has a convenient access to neighboring industrial sectors, 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 Tsing Hua College , 17 Departments and 24 Institutes

- **College of Science**
- **College of Engineering**
- **College of Nuclear Science**
- **College of Life Science**
- **College of Electrical Engineering and Computer Science**
- **College of Humanities and Social Sciences**
- **College of Technology Management**
- **Commission of General Education (Tsing Hua College)**

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 Astronomy	M / D
Institute of Statistics	M / D
Interdisciplinary Program of Science	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 Power Mechanical Engineering	B / M / D
Department of Materials Science and Engineering	B / M / D
Department of Industrial Engineering and Engineering Management	B / M / D
Industrial Engineering and Engineering Management Professional Master's Program	M
Institute of NanoEngineering and MicroSystems	M / D
Institute of Biomedical Engineering	M
Interdisciplinary Program of Engineering	B
Molecular Engineering Program	M
Graduate 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
Institute of Nuclear Engineering and Science	M / D
Interdisciplinary Program of Nuclear Science	B
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
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
Interdisciplinary Program of Humanities and Social Sciences	B
College of Life Science	**Degree Program Offer**
Department of Life Science	B
Department of Medical 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
Interdisciplinary Program of Life Science	B
Graduate Program of Biotechnology in Medicine	M / D
Structral Biology Program	D
College of Electrical Engineering and Computer Science	**Degree Program Offer**
Department of Computer Science	B / M / D
Department of Electrical Engineering	B / M / D
Institute of Communications Engineering	M / D
Institute of Electronics Engineering	M / D
Institute of Information Systems and Applications	M / D
Institute of Photonics Technologies	M / D
Interdisciplinary Program of Electrical Engineering and Computer Science	B
College of Technology Management	**Degree Program Offer**
Department of Quantitative Finance	B / M
Department of Economics	B / M / D
Institute of Technology Management	M / D
Institute of Law for Science and Technology	M / D
Institute of Service Science	M / D
MBA	M
EMBA	M
IMBA	M
Double Specialty Program of Management and Technology	B
Commission of General Education (Tsing Hua College)	**Degree Program Offer**
Institute of Learning Sciences	M

Personnel

Faculty	Title	Total
Full-Time(644)	Professor	362
	Associate Professor	170
	Assistant Professor	100
	Instructor	4
	Military Instructor	8
Research Fellow		232
Faculty Term Appointment		23
Adjunct Professor		290

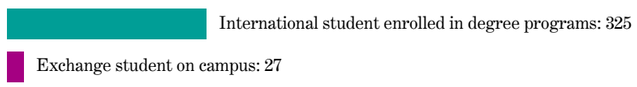
Staff	Total
Regular	212
Campus Police	26
Term Appointment	453
Research Staff (Funded by projects)	455

Number of domestic students, as of 2015

Total: 12,335

Number of international students, as of 2014

Total: 352



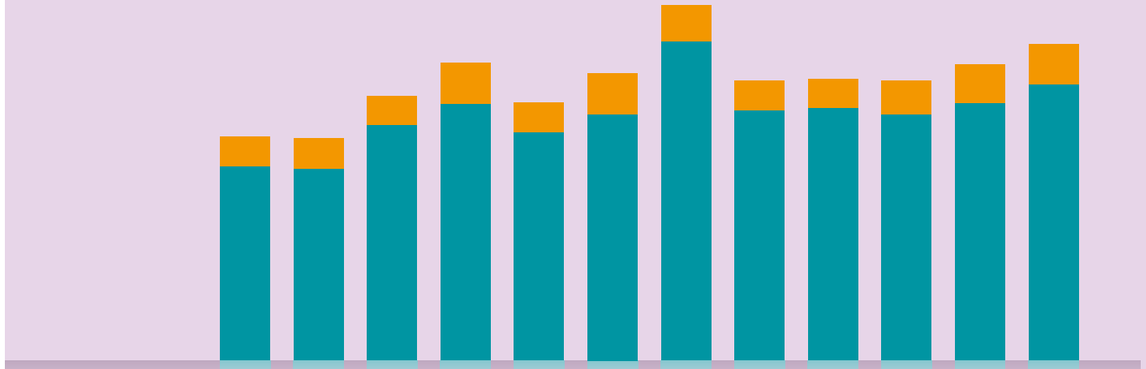
Number of graduates, as of 2014

Total: 2,744

R&D Facts and Figures

Research Funding (2003-2014)

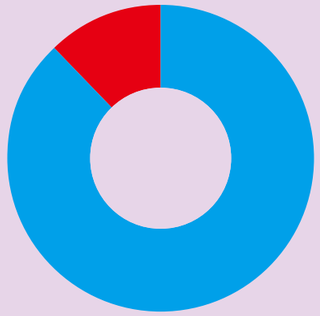
Unit：Million NTD (30 NTD ≈ 1 USD)



Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Government	1,265	1,251	1,535	1,673	1,490	1,603	2,082	1,628	1,647	1,608	1,680	1,800
Industry & Others	191	196	190	265	193	268	234	194	190	221	250	260
Total	1,456	1,447	1,725	1,939	1,682	1,871	2,317	1,822	1,837	1,827	1,930	2,060

Sponsored Research Funding (2014)

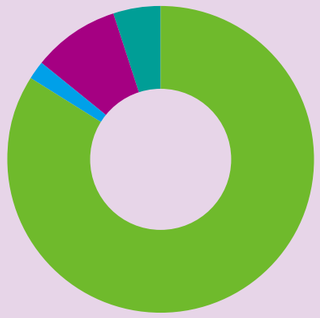
Unit：Million NTD (30 NTD ≈ 1 USD)



- Research grant income from public sources and charities 1,936 88%
- Research contract income from industry and commerce 260 12%

Government-Sponsored Research Funding (2014)

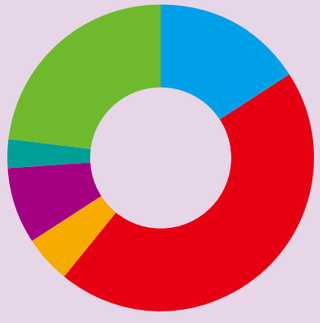
Unit：Million NTD (30 NTD ≈ 1 USD)



National Science Council	1,625	84%
Ministry of Economy	44	2%
Ministry of Education	169	9%
Others	98	5%

Funding by Discipline (2014)

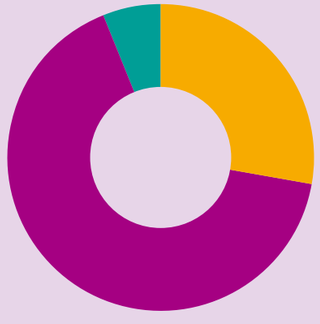
Unit：Million NTD (30 NTD ≈ 1 USD)



Physical Sciences	447	16%
Engineering	1,294	45%
Social Sciences	138	5%
Life Sciences	240	8%
Arts & Humanities	72	3%
Clinical, Pre-Clinical & Health	664	23%

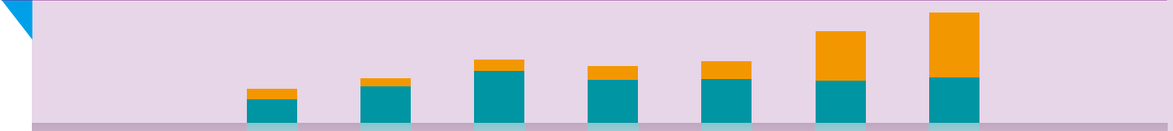
Non-Government Sponsored Research Funding (2014)

Unit：Million NTD (30 NTD ≈ 1 USD)



Non-Profit Organization	73	28%
Industry	171	66%
Overseas	16	6%

Taiwan Patent Application and Registration(2008-2014)



Year	2008	2009	2010	2011	2012	2013	2014
Applications	72	111	157	130	133	128	139
Registrations	31	24	33	39	53	148	193
Total	103	135	190	169	186	276	332

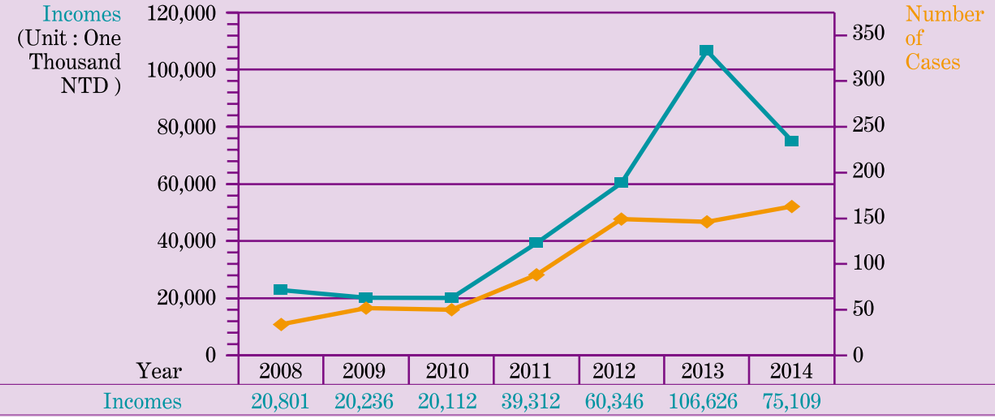
International Patent Application and Registration (2008-2014)

Year	2008	2009	2010	2011	2012	2013	2014
Applications	78	127	224	176	209	146	175
Registrations	23	25	39	75	111	125	136
Total	101	152	263	251	320	271	311

US Patent Application and Registration (2008-2014)

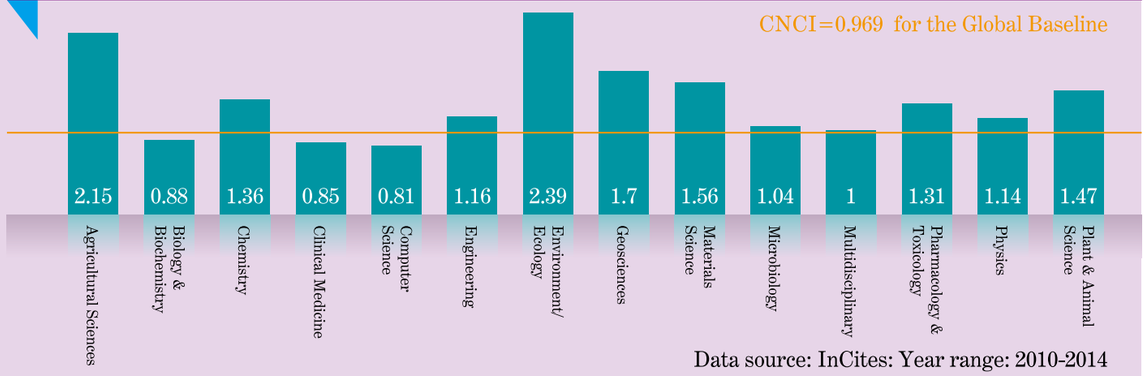
Year	2008	2009	2010	2011	2012	2013	2014
Applications	76	117	157	126	178	146	143
Registrations	20	21	38	70	104	125	112
Total	96	138	195	196	282	271	255

Technology Transfer Incomes (2008-2014)



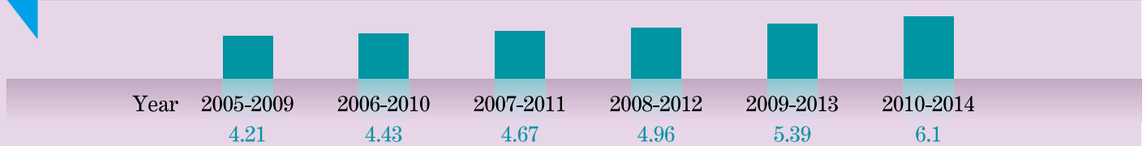
	2008	2009	2010	2011	2012	2013	2014
Incomes	20,801	20,236	20,112	39,312	60,346	106,626	75,109
Number of Cases	34	52	50	88	149	146	163

Category Normalized Citation Impact



Data source: InCites: Year range: 2010-2014

Citations per Paper (2005-2014)



Year	2005-2009	2006-2010	2007-2011	2008-2012	2009-2013	2010-2014
	4.21	4.43	4.67	4.96	5.39	6.1

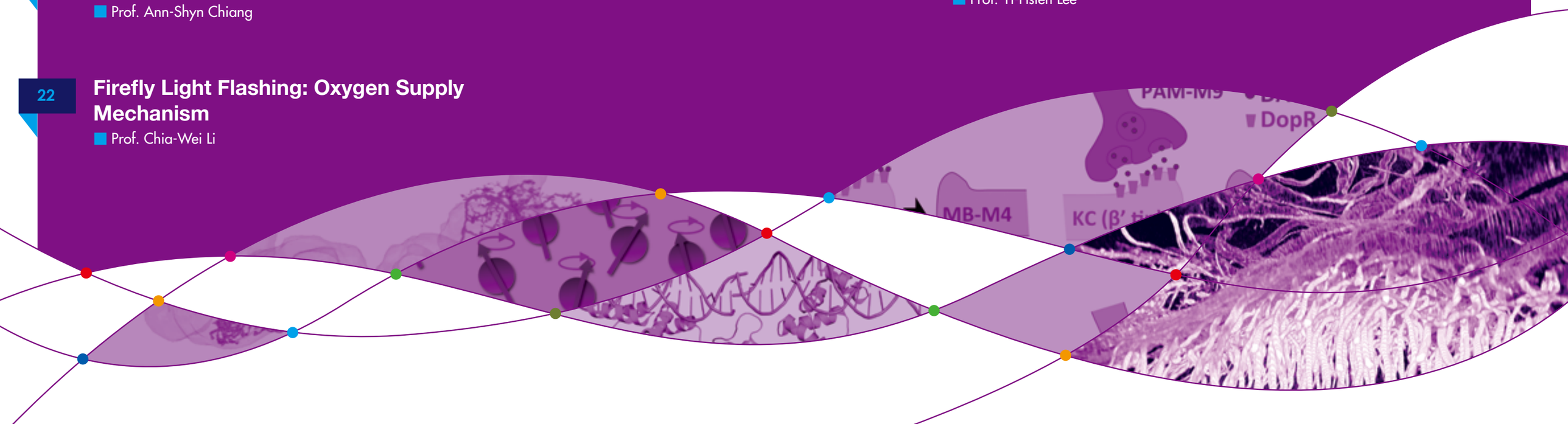
Data source: InCites ESI 2015/9

International Research Collaboration

(69 Countries / 1,006 Institutions / 10,793 Articles)

Data source: InCites: Year range: 2010-2015/9

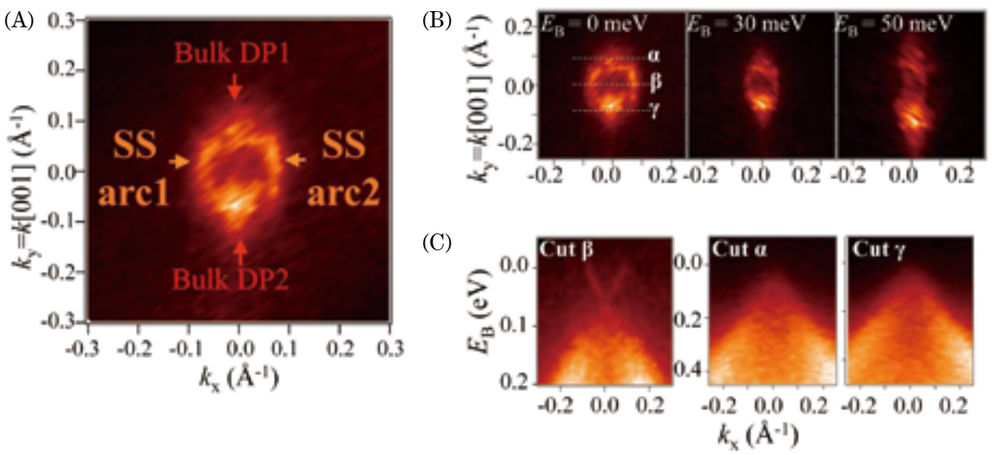
Scientific Breakthroughs



Science 347, 294 (2015)

Observation of Fermi arc surface states in a topological metal

Prof. Horng-Tay Jeng
Department of Physics



The topology of the electronic structure of a crystal is manifested in its surface states. Recently, a distinct topological state has been proposed in metals or semimetals whose spin-orbit band structure features three-dimensional Dirac quasiparticles. We used angle-resolved photoemission spectroscopy and first-principles calculations to observe a pair of spin-polarized Fermi arc surface states on the surface of the Dirac semimetal Na_3Bi at its native chemical potential. Our systematic results collectively identify a topological phase in a gapless material. The observed Fermi arc surface states open research frontiers in fundamental physics and possibly in spintronics.

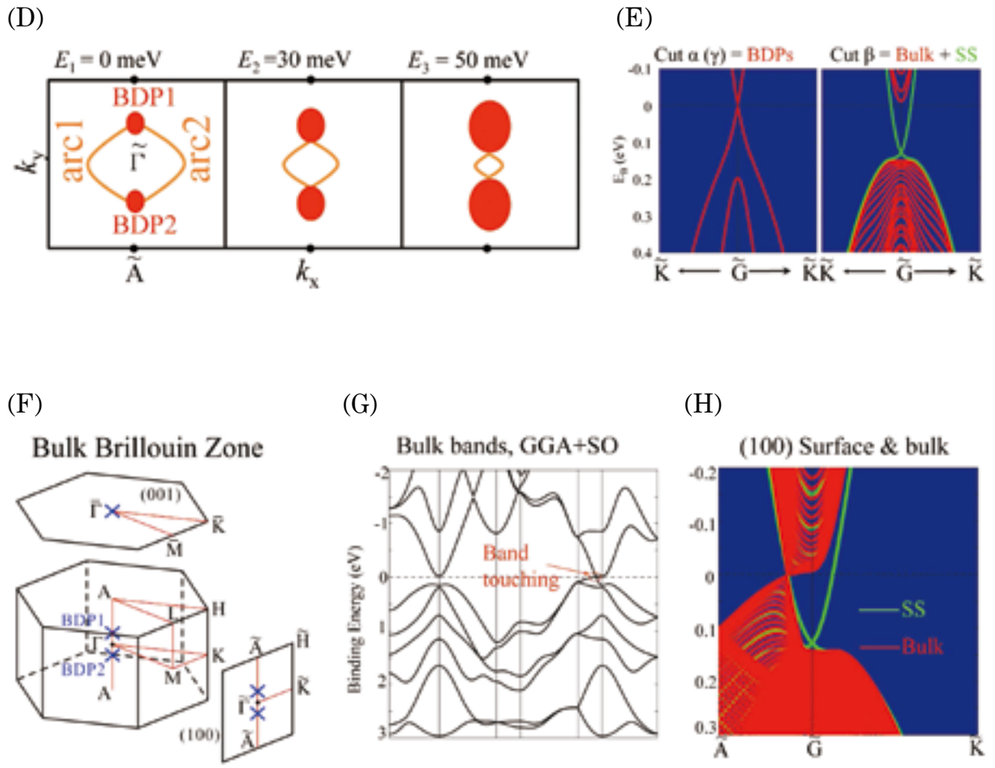


FIG. 1: Observation of Fermi arc surface states.
(A) Fermi surface map of the Na_3Bi sample at photon energy 55 eV. BDP1 and BDP2 denote the two bulk Dirac points. (B) ARPES constant energy contours as a function of binding energy at photon energy 55 eV. The dotted lines indicate the momentum space cuts shown in (C). (C) ARPES dispersion cuts α, β, and γ as defined in (B) at photon energy 55 eV. (D) Schematic Fermi surface of Na_3Bi. The red shaded areas and the orange lines represent the bulk and surface states, respectively. (E) Calculated band structure along cut β and cut α(γ). (F) The bulk BZ and surface BZs of the (001) and (100) surfaces. Bulk Dirac nodes are marked by blue crosses. (G) First-principles bulk band calculation for Na_3Bi. GGA+SO means that the calculations are based on the generalized gradient approximation (GGA) method in the presence of spin-orbit (SO) coupling. (H) First-principles calculation of the (100) surface electronic structure.

Authors
Su-Yang Xu, Chang Liu, Satya K. Kushwaha, Raman Sankar, Jason W. Krizan, Ilya Belopolski, Madhab Neupane, Guang Bian, Nasser Alidoust, Tay-Rong Chang, Horng-Tay Jeng (鄭弘泰), Cheng-Yi Huang, Wei-Feng Tsai, Hsin Lin, Pavel P. Shibayev, Fang-Cheng Chou, Robert J. Cava, M. Zahid Hasan
http://www.sciencemag.org/content/347/6219/294.short

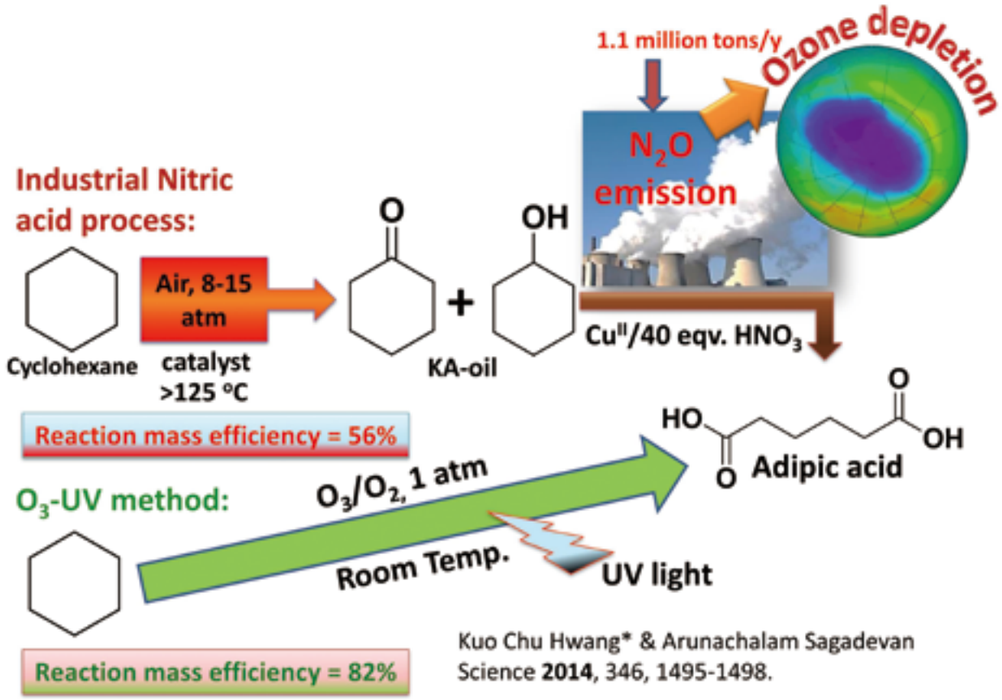
Science 346, 1495 (2014)

One-pot room-temperature conversion of cyclohexane to adipic acid by ozone and UV light

Prof. Kuo-Chu Hwang
Department of Chemistry

Nitric acid oxidation of cyclohexane accounts for ~95% of the worldwide adipic acid production and is also responsible for ~5 to 8% of the annual worldwide anthropogenic emission of the ozone-depleting greenhouse gas nitrous oxide (N_2O). Here we report a N_2O-free process for adipic acid synthesis.Treatment of neat cyclohexane, cyclohexanol, or cyclohexanone with ozone at room temperature and 1 atmosphere of pressure affords adipic acid as a solid precipitate. Addition of acidic water or exposure to ultraviolet (UV) light irradiation (or a combination of both) dramatically enhances the oxidative conversionof cyclohexane to adipic acid.

Green synthesis of adipic acid without production of global warming, ozone depleting N_2O gas.



Authors
Kuo-Chu Hwang (黃國柱) and Arunachalam Sagadevan
http://www.sciencemag.org/content/346/6216/1495.full

Physical Review Letters 113, 210402 (2014)

Quantum Quench and Prethermalization Dynamics in a Two-Dimensional Fermi Gas with Long-Range Interactions

Prof. Miguel A. Cazalilla
Department of Physics

We study the effect of suddenly turning on a long-range interaction in a spinless Fermi gas in two dimensions. The short- to intermediate-time dynamics is described using the method of bosonization of the Fermi surface. The space-time dependence of the nonequilibrium fermion density matrix as well as the evolution after the quench of the discontinuity at the Fermi momentum of the momentum distribution are computed. We find that the asymptotic state predicted by bosonization is consistent with the existence of a prethermalization plateau, which is also predicted by a perturbative approach in terms of the fermionic degrees of freedom. The bosonized representation, however, explicitly allows for the construction of the generalized Gibbs ensemble describing the prethermalized state.

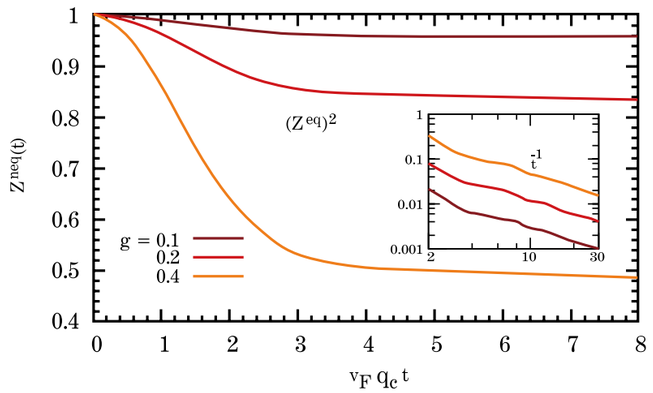


FIG. 2. (Color Online) The discontinuity in the zero-temperature momentum distribution at the Fermi momen- tum, Z^{neq} (t), exhibits a Gaussian decay at short times. Asymptotically, it saturates to a finite value $Z^{st} \simeq (Z^{eq})2$ (horizontal lines) in the stationary (prethermalized) state. The effective interaction strength is $g^2 = \frac{4f02qcN(0)}{In\text{-}(2\pi)3}$. In-set: $\ln(Z^{neq}(t)/Z^{st})$ showing the asymptotic behavior $\sim \exp[-t^{-1}]$.

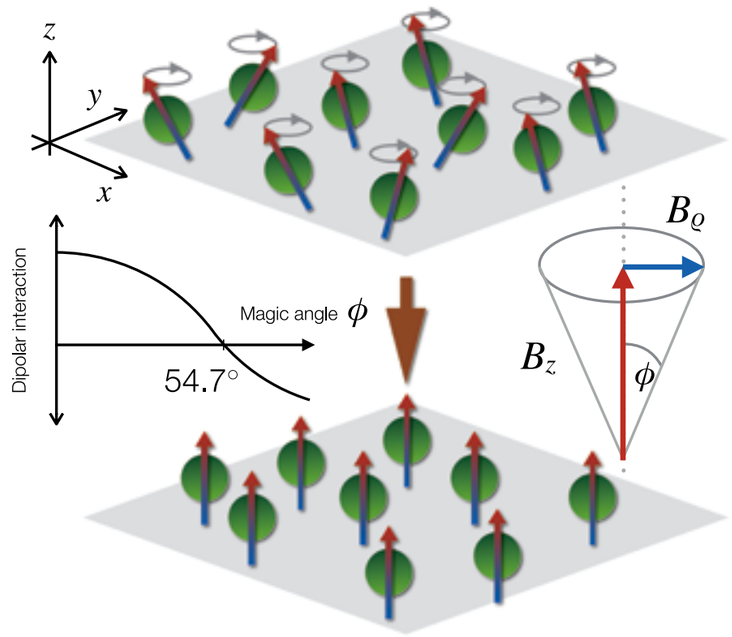


FIG. 1. (Color Online) Interaction Quench Protocol: Initially a two dimensional dipolar Fermi gas of, e.g., ^{167}Er atoms is subject to a DC magnetic field, perpendicular to the plane of atomic motion (Bz) and an in plane AC field (Bp). The relative magnitude of the two is fixed so that the atomic dipole moments precess around the z axis with a precession angle equal to the magic angle for which the long range dipolar interaction between the atoms averages to zero and the non- interacting initial state is realized (upper panel). At t = 0 the DC field is turned off (lower panel).

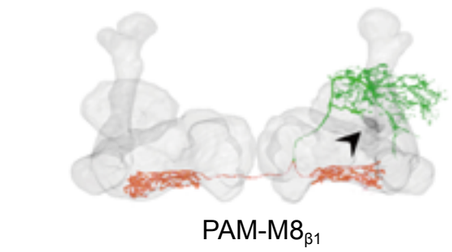
Authors
N. Nessi, A. Iucci, and Miguel A. Cazalilla (米格爾)
http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.113.210402

Nature Communications 10, 8775 (2015)

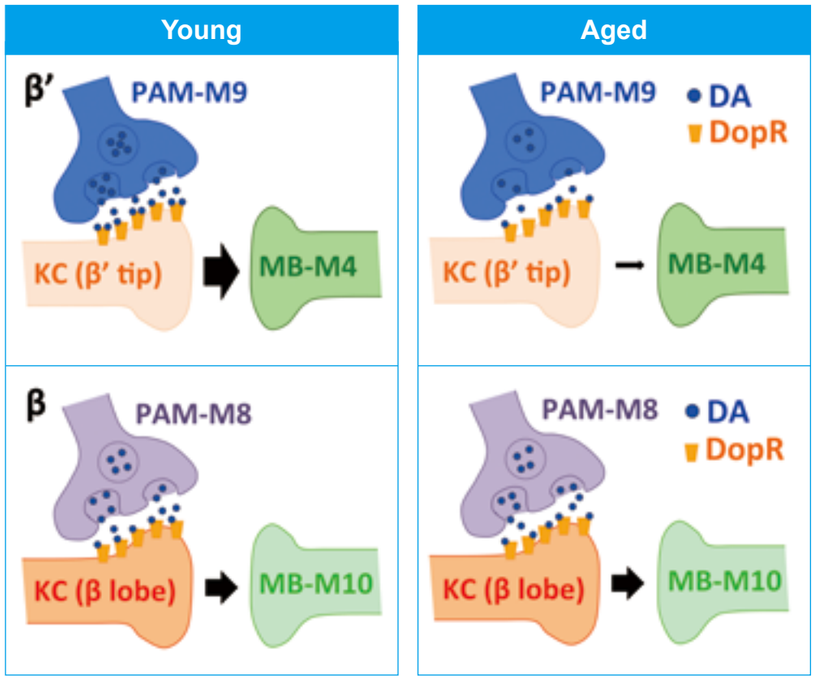
Parallel circuits control temperature preference in *Drosophila* during aging

Prof. Ann-Shyn Chiang
Brain Research Center
Elected to Academia Sinica 2014

A research team led by Prof. Ann-Shyn Chiang in Brain Research Center, has successfully identified the key brain circuits modifying temperature preference, through manipulating the release of dopamine, during the course of aging. Prior studies observed lifespan extension in many organisms including fish, mice, and monkeys if their body temperature were kept low, resulted from a reduction of free radical-mediated damage, which believed to be a major contributor to neurodegenerative disease. They discovered that wild type fruit flies become less avoiding to cold in aged individuals, which is controlled by a brain structure called Mushroom Body (MB). The age-related temperature preference alterations resulted from a shift in the relative contribution of two parallel mushroom body circuits β' and β that are modulated by dopamine. The β' circuit controls cold avoidance in young flies with releasing dopamine. However, the amount of dopamine declines to half as fly ages, resulted in a significant decline of cold avoidance in aged flies. On the other hand, another parallel brain circuit, MB β, take over the cold avoidance control with its relatively modest but sustained dopamine as flies aging. MB β circuit maintains flies' ability to avoid extreme cold environment that may be fatal. The two parallel brain circuits co-regulate flies' cold avoidance during the process of aging, allowing flies to tolerate a modest cold environment without sacrificing their ability to avoid environment with extreme temperatures. The study is published in 2015 *Nature Communications* (6, doi: 10.1038/ncomms8775 (2015).).



Morphology and innervation patterns of individual PAM-M8 (composed of PAM-M8$_{\beta 1}$ and PAM-M8$_{\beta 2}$) and PAM-M9 neurons in the context of the MB volume model. Individual PAM- M8 and PAM-M9 neurons were derived from flip-out labeling of *0279-GAL4* and *Ddc-GAL4*, respectively. Dendrites (green) and axons (red) were manually assigned. Arrowheads indicate cell bodies.



Age- dependent changes in the contribution of the β' and β circuits. In young flies, the β' circuit plays a more important role than the β circuit in maintaining temperature preference through dopamine signaling. However, as flies age, the dopamine level in PAM-M9 neurons

Authors
Hsiang-Wen Shih, Chia-Lin Wu, Sue-Wei Chang, Tsung-Ho Liu, Jason Sih-Yu Lai1, Tsai-Feng Fu, Chien-Chung Fu & Ann-Shyn Chiang (江安世)
http://www.nature.com/ncomms/2015/150716/ncomms8775/abs/ncomms8775.html

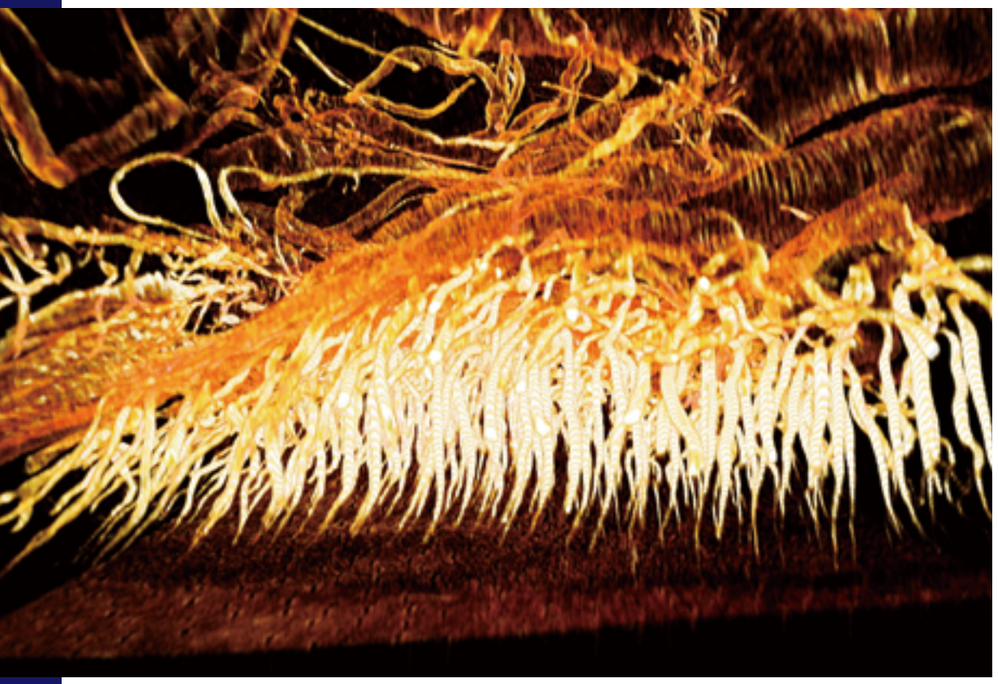
Physical Review Letters 113, 258103 (2014)

Firefly Light Flashing: Oxygen Supply Mechanism

Prof. Chia-Wei Li
Institute of Molecular and Cellular Biology

The mechanism by which fireflies emit light has long been an unsolved mystery in the biological sciences. However, in a recent study, researchers at NTHU's Institute of Molecular and Cellular Biology working in conjunction with researchers at Academia Sinica's Institute of Physics used synchrotron phase contrast micro tomography and transmission x-ray microscopy to observe the biological mechanism by which these fascinating insects produce light.

Some time ago scientists succeeded in identifying the enzyme by which various insects produce light, and then went on to extract and synthesize it for use in a wide variety of applications. However, fireflies are unique in their ability to control their glow and use it for mating and communicating with one another.



The tracheal system of a firefly as seen through synchrotron phase contrast micro tomography and transmission X-ray microscopy.

According to Tsai Yueh-Lin, the lead author and a 2012 graduate of NTHU's Master Program in molecular and cellular biology, until recently there were two main theories for explaining the mechanism by which fireflies control the rate at which they flash: 1) Fireflies use their highly efficient tracheal system to simultaneously supply a sufficient amount of oxygen to their light-producing cells as well as the mitochondrion and the fluorescence mechanism; and 2) Prior to flashing, the amount of oxygen consumed by the mitochondrion is reduced in order to have enough oxygen for the fluorescence mechanism. In order to test these two theories it was necessary to first gain a sufficient understanding of the efficiency with which the firefly's tracheal system supplies oxygen. According to the former theory, since the oxygen supply is more than sufficient, there is no need to consider the possibility of the mitochondrion and the fluorescence mechanism competing for oxygen. According to the latter theory, the firefly's tracheal system is unable to simultaneously supply enough oxygen to both the mitochondrion and the fluorescence mechanism.

Using the traditional methods of biological research to study a live insect, it wasn't possible to carry out a real-time imaging analysis with a sufficiently precise dot per inch (DPI) level, making it impossible to test these two theories. To solve this problem, the research team used synchrotron phase contrast micro tomography and transmission X-ray microscopy to obtain a three-dimensional image of the firefly's flash mechanism, including the highly complex structure of its tracheal system and its bronchial tubes, which are less than 200 nanometers in diameter. After quantifying the results, it was possible to precisely calculate the rate at which oxygen flows to the light-producing cells and the amount of energy they consume. Based on this data they then estimated the overall efficiency of the mechanism by which the oxygen is supplied and consumed.

Having already confirmed the relationship between the mitochondrion and the duration of the luminescence, it was possible to infer that under normal metabolic conditions, when all the oxygen supplied by the tracheal system is consumed by the mitochondrion, then no oxygen would be available to enter into the illumination system. They found that the flash rate depends on the deactivation of the mitochondrion, as demonstrated by using nobelium to suppress the action of the mitochondrion, which resulted in a flash due to oxygen being made available to the illumination system.

In addition to Tsai, the research team included Professor Li Chia-Wei (Tsai's academic advisor), Hong Tzay-ming of NTHU's Department of Physics, Hwu Yeu-Kuang of Academia Sinica's Institute of Physics, and several researches from the Endemic Species Research Institute in Nantou County and the Faculté des Sciences de Base, Ecole Polytechnique Fédérale de Lausanne in Switzerland. The research took over one year to complete, and the results have been published in the prestigious journal Physical Review Letters (DOI: 10.1103/physrevlett.113.258103).

Describing the research carried out while he was still completing his Master degree, Tsai states, "We had to try out a wide variety of possible solutions. We also had to continually overcome our own limitations." Corresponding author Li Chia-Wei commented that he is proud that one of his students has successfully conducted such painstaking and fruitful research, and that such an interdisciplinary approach is the best way to solve difficult problems.

Authors
Yueh-Lin Tsai, Chia-Wei Li (李家維), Tzay-Ming Hong, Jen-Zon Ho, En-Cheng Yang, Wen-Yen Wu, G. Margaritondo, Su-Ting Hsu, Edwin B. L. Ong, and Y. Hwu
http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.113.258103

PNAS 112, 6613 (2015)

Insight into ParB spreading from the complex structure of Spo0J and *parS*

Prof. Yuh-Ju Sun
Institute of Bioinformatics and Structural Biology

In ParABS, the bacterial chromosome partitioning system, ParB/Spo0J and its regulatory protein, ParA, act cooperatively through *parS* DNA to facilitate chromosome segregation. Various ParB molecules can associate together and spread along the chromosomal DNA. ParB oligomer and *parS* DNA interact together to form a high order nucleoprotein that is required for the loading of the SMC (structural maintenance of chromosomes) proteins onto the chromosome for chromosomal DNA condensation.

In this report, we characterized the binding of *parS* and Spo0J from *Helicobacter pylori* (*Hp*Spo0J) and determined the crystal structure of the Ct-*Hp*Spo0J and *parS* complex. Ct-*Hp*Spo0J folds into an elongated structure that includes a flexible N-terminal domain for protein-protein interaction and a conserved DNA-binding domain for *parS* binding. Ct-*Hp*Spo0J carries out multiple protein-protein interactions with neighboring molecules through the N-terminal domain and forms an oligomer. These significant interactions might be used for molecular assembly and spreading to form a high order nucleoprotein complex. A structural model for ParB spreading and chromosomal DNA condensation that lead to chromosome segregation is established.

From these results, we propose how ParB possibly associates with other proteins through its protruded N-terminal domains, how ParB spreads along the chromosomal DNA by *parS* binding, and how ParB bridges DNA to compact and condense the chromosome during chromosome partitioning.

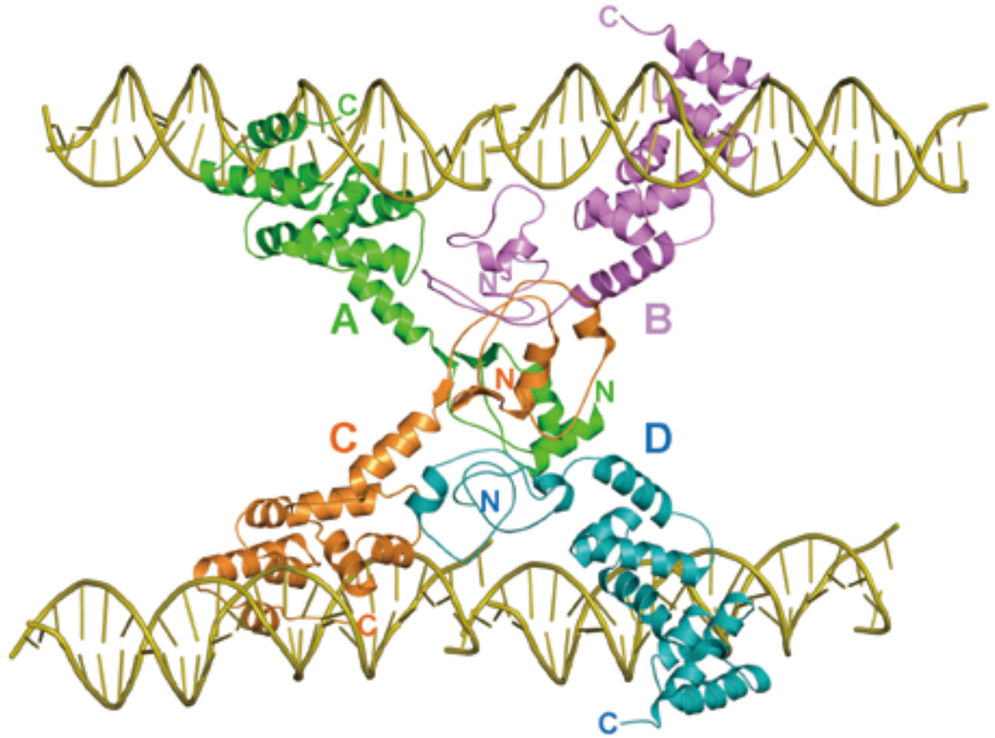


Figure 1 The *Hp*Spo0J-*par*S complex

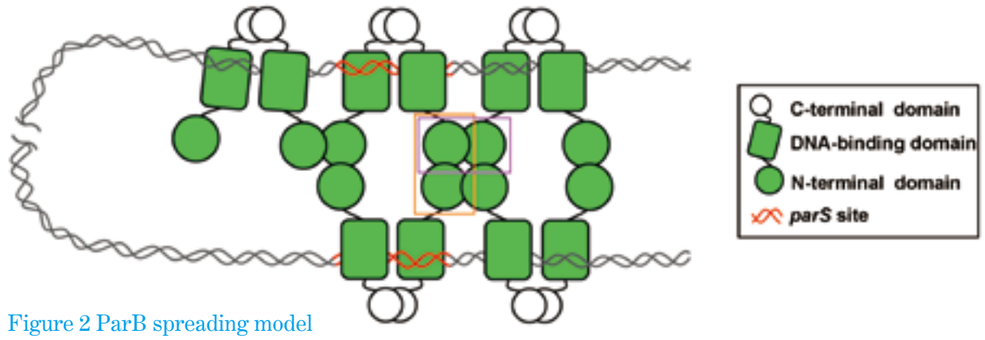


Figure 2 ParB spreading model

Authors
Bo-Wei Chen, Ming-Hsing Lin, Chen-Hsi Chu, Chia-En Hsu, and Yuh-Ju Sun (孫玉珠)
http://www.pnas.org/content/112/21/6613.abstract

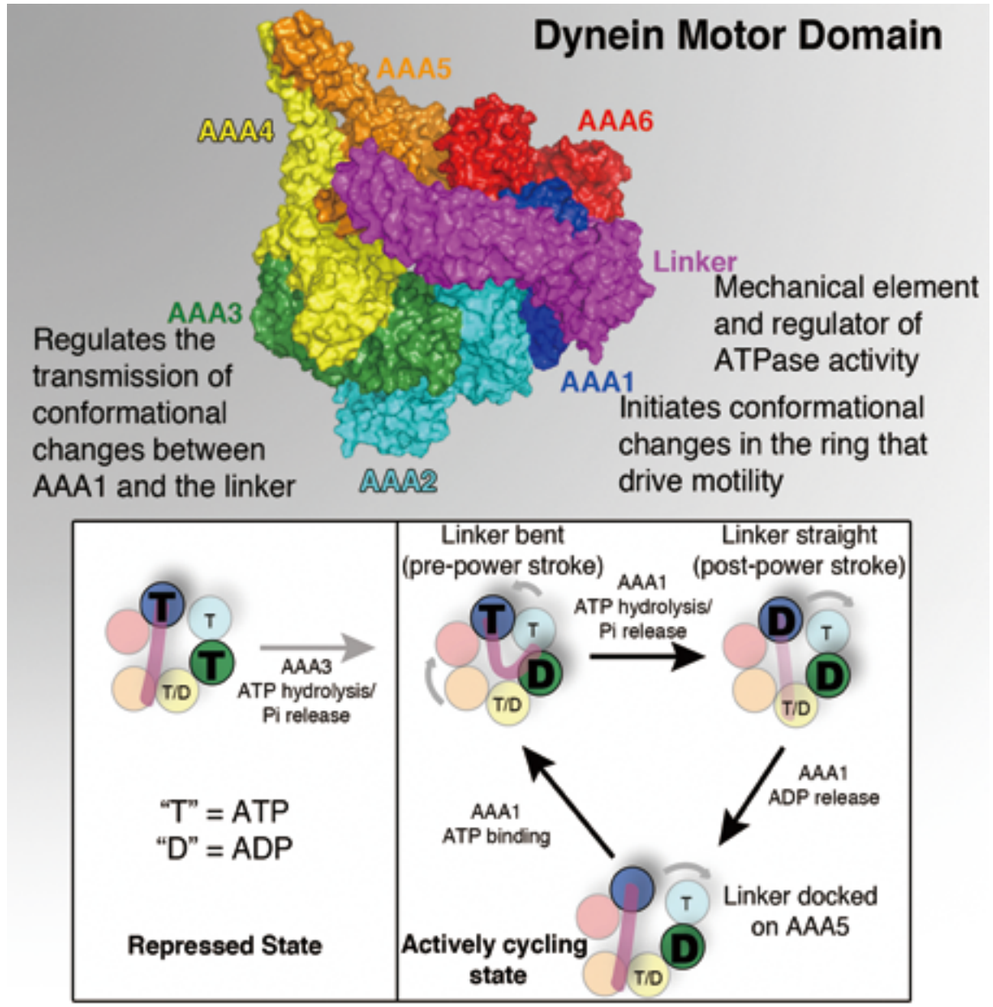
Cell 159, 857 (2014)

Allosteric Communication in the Dynein Motor Domain

Prof. Hui-Chun Cheng
Institute of Bioinformatics and Structural Biology

- **X-ray and EM data provide a model for dynein's structural changes during motility**
- **ATP binding at domain AAA1 triggers domain rearrangements throughout the ring and linker**
- **The linker, in addition to being a mechanical element, regulates the ATPase cycle at AAA1**
- **AAA3 acts as a "gate" that can block AAA1 from communicating with the linker**

Dyneins power microtubule motility using ring-shaped, AAA-containing motor domains. Here, we report X-ray and electron microscopy (EM) structures of yeast dynein bound to different ATP analogs, which collectively provide insight into the roles of dynein's two major ATPase sites, AAA1 and AAA3, in the conformational change mechanism. ATP binding to AAA1 triggers a cascade of conformational changes that propagate to all six AAA domains and cause a large movement of the "linker," dynein's mechanical element. In contrast to the role of AAA1 in driving motility, nucleotide transitions in AAA3 gate the transmission of conformational changes between AAA1 and the linker, suggesting that AAA3 acts as a regulatory switch. Further structural and mutational studies also uncover a role for the linker in regulating the catalytic cycle of AAA1. Together, these results reveal how dynein's two major ATP-binding sites initiate and modulate conformational changes in the motor domain during motility.



Authors
Gira Bhabha, Hui-Chun Cheng (鄭惠春), Nan Zhang, Arne Moeller, Maofu Liao, Jeffrey A. Speir, Yifan Cheng, Ronald D. Vale
http://www.sciencedirect.com/science/article/pii/S0092867414013063

IEEE Transactions on Fuzzy Systems 23, 387 (2015)

Pareto Optimal Filter Design for Nonlinear Stochastic Fuzzy Systems via Multiobjective H_2 / H_∞ Optimization

Prof. Bor-Sen Chen

Lab of Control and System Biology, Department of Electrical Engineering

This paper is concerned with the multiobjective H_2 / H_∞ filtering design problem in nonlinear stochastic signal processing which can be approximated by a Takagi-Sugerno (T-S) fuzzy signal system. The multiobjective filter design is to estimate state variables from noisy measurements for nonlinear signal systems, and to achieve optimal concurrent performance for H_2 and H_∞ filtering. In general, it is difficult to solve the multiobjective (MO) H_2 / H_∞ fuzzy filter problem directly. Thus, an indirect method is proposed by minimizing the upper bounds of H_2 and H_∞ performance indices. The proposed indirect method can be widely employed to practically address the MO filter design problem in nonlinear stochastic signal processing. By applying the indirect method, the MO H_2 / H_∞ filtering problem can be transformed to a linear matrix inequality (LMI)-constrained multiobjective problem (MOP). Moreover, an LMI-based multiobjective evolution algorithm (MOEA) is also proposed to efficiently find Pareto optimal solutions for the MOP of multiobjective fuzzy filter design for nonlinear stochastic signal processing. Finally, a trajectory estimation of the six degree-of-freedom reentry vehicle by radar is provided to illustrate the design procedure and to validate the performance of the Pareto MO optimal filter.

The estimation of a reentry vehicle trajectory plays an important role in target tracking systems. The geometry of six degree-of-freedom reentry vehicle is shown in Fig. 1. Based on the proposed design procedure, we use a population size of 50 and run the LMI-based MOEA for 50 generations. 50 Pareto optimal solutions belonging to the final population are shown as the Pareto front in Fig. 2, of which three are selected for comparison in Table I. We can see that Pareto solution 1 sacrifices more H_2 filtering performance than H_∞ filtering performance; Pareto solution 2 makes a compromise between the optimal H_2 solution and the optimal H_∞, and Pareto solution 3 sacrifices more H_∞ filtering performance than H_2 filtering performance. According to Monte Carlo simulation results of 100 runs for trajectory estimation of reentry vehicles by radar, presented in Table II, the MO filtering performance of three Pareto optimal solutions are not much different with respect to the squared estimation error in the example, they all also show good performance when compared with the extended Kalman filter and the mixed H_2 / H_∞ filter with a given H_∞ performance $\alpha = 0.31$. The computation time to solve MO H_2 / H_∞ filter for the trajectory estimation of reentry vehicle with 100 runs of Monte Carlo simulation is about 215 minutes. The method we have proposed will help application of trajectory estimation to reentry vehicles. In the example, the operator or designer is therefore able to select any Pareto optimal solution for MO fuzzy filter design according to their own preference.

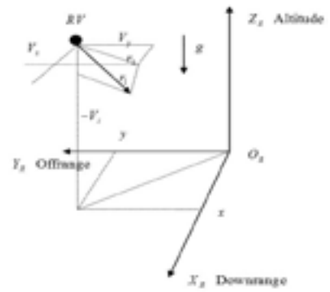


Fig.1. The six degree-of-freedom reentry vehicle geometry.

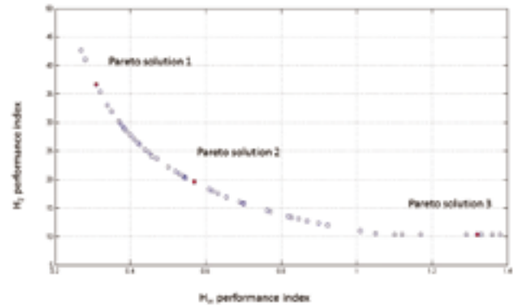


Fig.2. Pareto front for 50 Pareto optimal solutions by the proposed method in example 2, in which three Pareto optimal solutions are chosen for comparison in Table II.

Table I Three Pareto optimal solutions of example for comparison

	Pareto solution 1	Pareto solution 2	Pareto solution3
(α*, β*)	(0.31, 36.63)	(0.57 ,19.58)	(1.32 , 10.35)

Table II Ratios of the estimation errors to state variables in example

$\frac{\|X_i - \hat{X}_i\|_2}{\|X_i\|_2}$	Pareto solution1	Pareto solution2	Pareto solution3	Extend Kalman Filter	Mixed H_2/H_∞ Filter
i=1	2.57×10^{-6}	2.57×10^{-6}	2.57×10^{-6}	7.92×10^{-5}	7.71×10^{-4}
i=2	5.43×10^{-5}	5.43×10^{-5}	5.43×10^{-5}	8.66×10^{-5}	1.3×10^{-3}
i=3	4.23×10^{-3}	4.23×10^{-3}	4.23×10^{-3}	0.03	1.38×10^{-4}
i=4	0.04	0.04	0.03	0.07	0.31
i=5	0.02	0.02	0.02	0.02	0.40
i=6	0.04	0.04	0.03	0.10	0.06

Authors

Bor-Sen Chen,(陳博現) Fellow, IEEE, Hsin-Chun Lee, Chien-Feng Wu

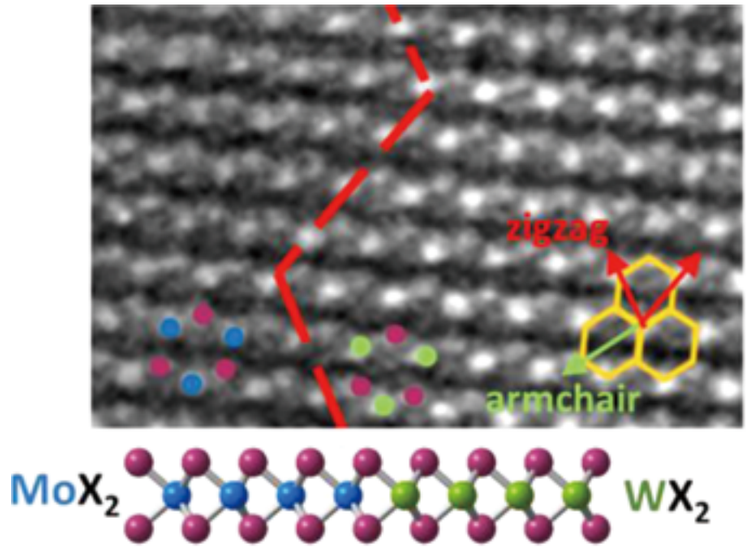
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6776415&queryText=Chien+Feng+Wu&newsearch=true&searchField=Search_All

Nano Letters 15, 410 (2015)

Synthesis of Lateral Heterostructures of Semiconducting Atomic Layers

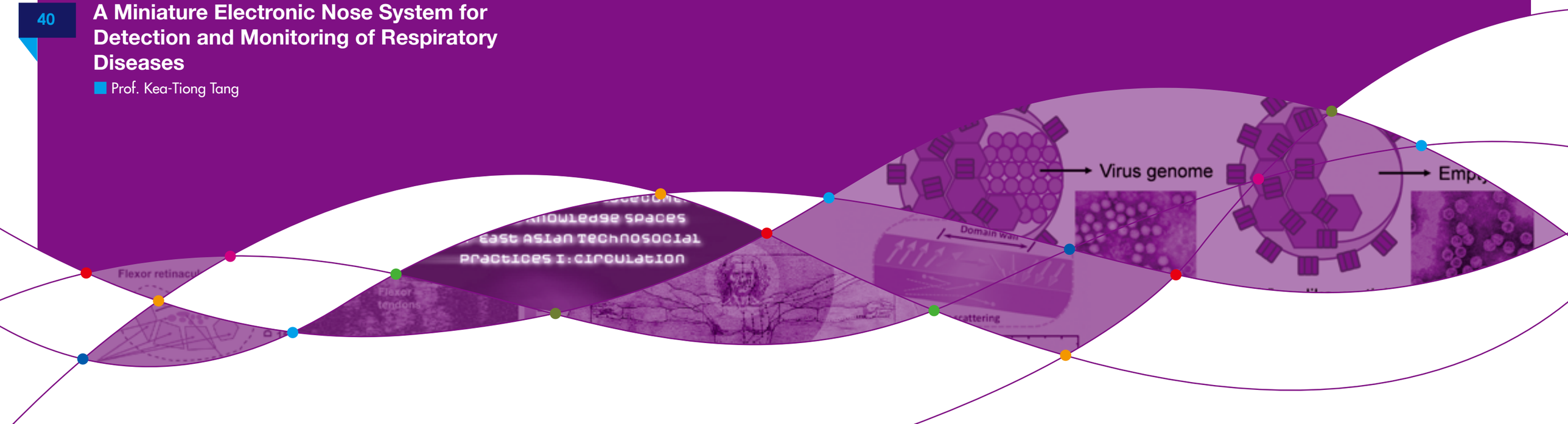
Prof. Yi-Hsien Lee
Department of Materials Science and Engineering

Atomically thin heterostructures of transition-metal dichalcogenides (TMDs) with various geometrical and energy band alignments are the key materials for next generation flexible nanoelectronics. The individual TMD monolayers can be adjoined laterally to construct in-plane heterostructures, which are difficult to reach with the laborious pick-up-and-transfer method of the exfoliated flakes. The ability to produce copious amounts of high quality layered heterostructures on diverse surfaces is highly desirable but it has remained a challenging issue. Here, we have achieved a direct synthesis of lateral heterostructures of monolayer TMDs: MoS_2–WS_2 and $MoSe_2$–WSe_2. The synthesis was performed using ambient-pressure chemical vapor deposition (CVD) with aromatic molecules as seeding promoters. We discuss possible growth behaviors, and we examine the symmetry and the interface of these heterostructures using second-harmonic generation and atomic-resolution scanning TEM. We found that the one-dimensinal (1D) interface of the lateral heterostructures picks the zigzag direction of the lattice instead of the armchair direction. Our method offers a controllable synthesis to obtain high-quality in-plane heterostructures of TMD atomic layers with 1D interface geometry.



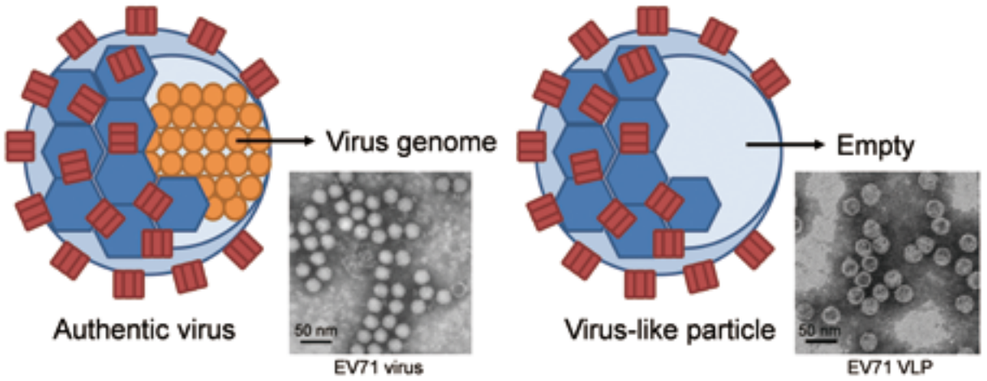
Authors
Xin-Quan Zhang, Chin-Hao Lin, Yu-Wen Tseng, Kuan-Hua Huang, Yi-Hsien Lee (李奕賢)
http://pubs.acs.org/doi/abs/10.1021/nl503744f

Making an Impact on Technology



Development of Enterovirus 71 Virus-Like Particle Vaccine

Prof. Yu-Chen Hu
Department of Chemical Engineering



☐ **Safety**

No virus genome inside, noo-infectious

☐ **Similar virion structure**

Induce broad and strong immune responses

☐ **High productivity**

Produced by high-level expression sysytem

Fig. 1. Virus-like particles (VLPs) are empty particles consisting of viral structural proteins but lack of virus genome, making VLPs possess the pros of safety, immunogenicity and high productivity.

Enterovirus 71 (EV71) is a major etiological agent responsible for the outbreaks of hand-foot-and-mouth disease (HFMD) in Taiwan and such Asian countries as China, Singapore, Malaysia and Vietnam. Severe EV71 infection of children may lead to death cases, especially those under 5 years of age. Without effective therapeutic drugs, the increasing frequency of EV71 epidemics and fatality rates underscore the urgent need to develop vaccines against EV71.

Virus-like particles (VLPs) are empty nanoparticles consisting of viral structural proteins but devoid of viral nucleic acids. Thanks to the similarity of VLPs with authentic viruses in structure, VLPs can generally induce broad and strong immune responses. Therefore, using non-infectious VLPs as a vaccine is promising and also safer than using whole viruses (Fig. 1).

We have developed EV71 VLP vaccine by using baculovirus/insect cell expression system for years. Baculovirus is an insect virus, non-infectious to mammals, and has been used as a recombinant vector carrying genes of interest to express in insect cells. The recombinant baculovirus that expresses EV71 structure protein and processing protease after infecting insect cells produced EV71 VLPs which resemble the authentic EV71. Injection of EV71 VLPs in mice and monkeys induced effective immune responses, and conferred protection to neonatal mice against EV71 lethal infection, thus EV71 VLP is a promising vaccine candidate (Fig. 2). We have also developed a new baculovirus which further promotes the VLP yield by≈10 folds, reaching 170 mg/L, thus rendering EV71 VLP vaccine economically viable. Our works move the EV71 VLP one step further to the clinical application and commercialization.

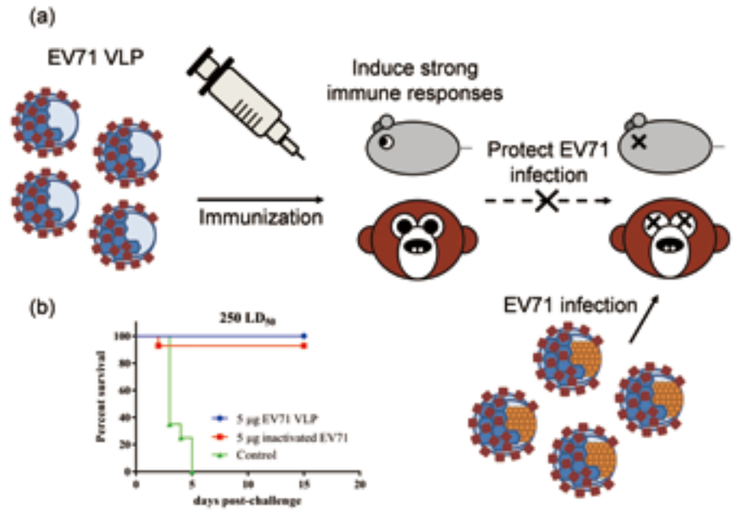


Fig. 2. Immunization of EV71 VLPs in mice and monkeys induced effective immune responses to protect EV71 infection (a). The neonatal mice (1-3 day age) born to the EV71 VLP-immunized dams are able to survive under EV71 lethal challenge as well as those born to the inactivated EV71-immunized dams (positives), while no mice of control groups survive more than 5 days (b).

Authors
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http://dx.doi.org/10.1002/bit.25625

Carpal Tunnel Syndrome: US Strain Imaging for Diagnosis

Prof. Chih-Kuang Yeh
Department of Biomedical Engineering and Environmental Sciences

Dr. Yeh research group developed a new 2D ultrasound strain imaging technique demonstrated its effectiveness in diagnosing carpal tunnel syndrome (CTS), and at an earlier stage than other imaging techniques. The study found that ultrasound strain imaging can quantify and map tissue kinematics effectively enough to detect CTS. The study was published in the April 2015 issue of *Radiology* and also highlighted on the August 2015 special issue of *Radiological Society of North America (RSNA) News*.


FEATURE

Ultrasound Aids Carpal Tunnel, Plantar Fasciitis

BY ED BANNON

Applications for ultrasound continue to grow with one recent study demonstrating the modality's effectiveness in diagnosing carpal tunnel syndrome (CTS) and another showing its potential in treating chronic plantar fasciitis.

Ultrasound Aids Chronic Plantar Fasciitis

"We have treated well over 100 patients with chronic plantar fasciitis and we are seeing greater than 90 percent improvement."
RAHUL S. RAZDAN, M.D.

Figure 1: August 2015 special issue of *RSNA News*.

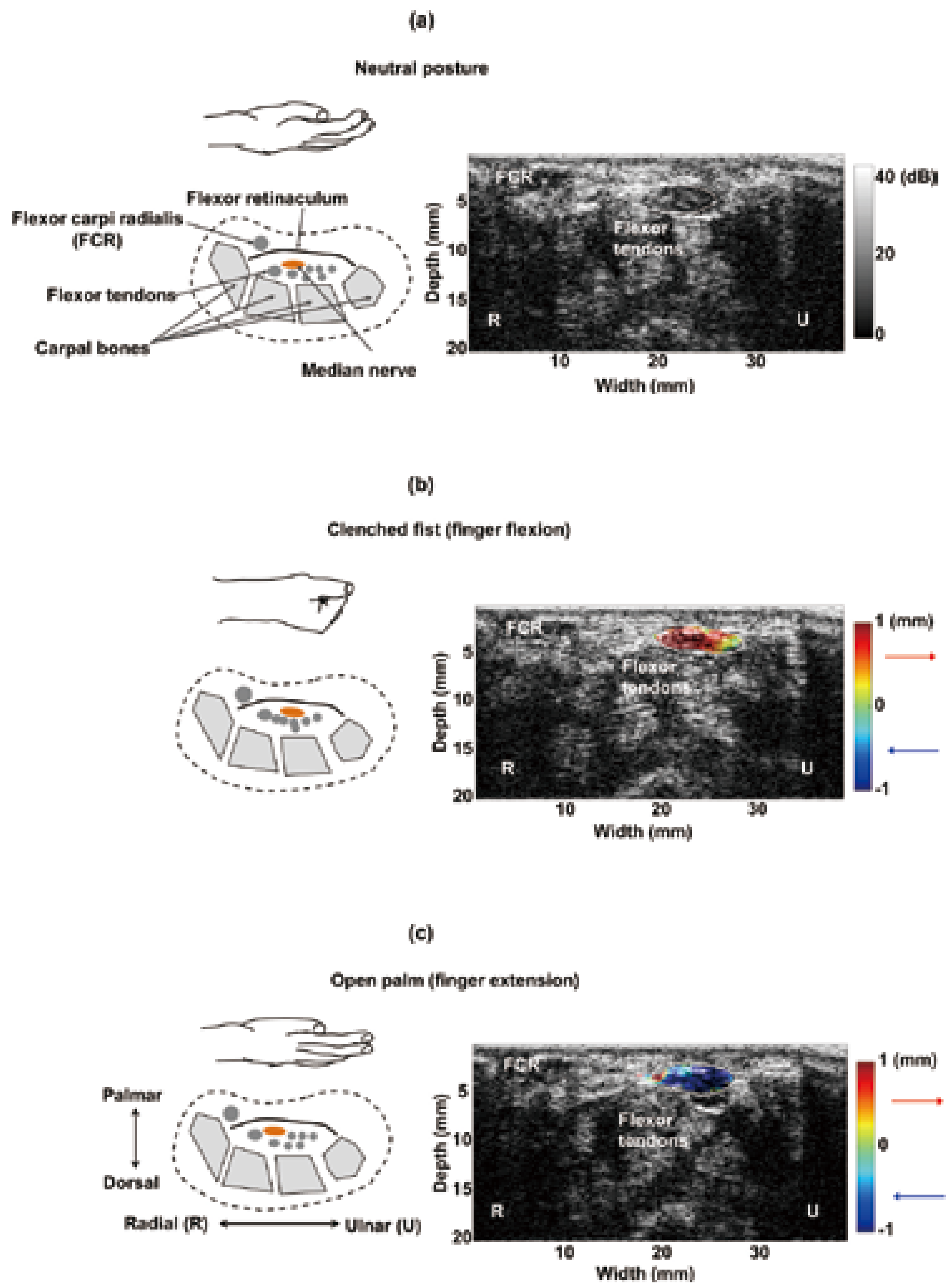


Figure 2: Median nerve motion during one cycle of the finger motion from (a) the neutral posture to (b) a clenched fist (i.e., finger flexion at acquisition time of 1s) and then to (c) an open palm (i.e., finger extension at acquisition time of 2s). In panels b and c, positive and negative lateral displacement values refer to rightward motion of the median nerve to an ulnar side and motion toward the radius side, respectively.

Authors

Chih-Kuang Yeh (葉秩光)

Radiology: http://pubs.rsna.org/doi/abs/10.1148/radiol.14140017
RSNA News: http://rsna.org/News.aspx?id=17023

Realtime Container Cloud for Software Radio Access Networks

Prof. Yeh-Ching Chung, Prof. Cheng-Hsin Hsu
Department of Computer Science

The global mobile traffic amount is expected to increase from 52 million terabytes in 2015 to 173 million terabytes in 2018. As the huge growth of mobile traffics, conventional Radio Access Networks (RANs) suffer from high capital and operating expenditures, especially when new cellular standards are deployed. Software and cloud RANs have been proposed to overcome the limitations of traditional hardware for next generation RANs. However, the stringent latency requirements, e.g., 1 ms transmission time interval, dictated by cellular networks is difficult to satisfy. That is because running software RANs in cloud leads to high latency, which may violate the latency requirements.
To fulfill such a latency requirement, quality assurance provided by cloud is crucial to the success of cloud RANs. In particular, both computational and networking latencies need to be guaranteed before the cloud RANs become a reality. Our main goal is to study the problem of minimizing latencies in lightweight container cloud, so as to provide quality assurance in latency. Our contributions are twofold: (i) present a real testbed for software RAN using an open-source LTE implementation, and (ii) investigate the issue of quality assurance when running such a realtime application in cloud.

Real Testbed for Software RANs

Our testbed adopts the OpenAirInterface (OAI) to deploy an open-source LTE implementation running on Intel Linux. Fig. 1 illustrates the architecture of our testbed. A laptop computer equipped with an LTE dongle acts as the User Equipment (UE). We separate the OAI into three components: Evolved Node B (ENB), Evolved Packet Core (EPC), and Home Subscriber Server (HSS). These components are deployed on different physical machines and connected via Ethernet. The RF front end is equipped with a USRP B210 card and the UE is equipped with a Hauwei E3372 LTE dongle for connecting to the LTE software modem.
Once UE sets up a radio resource control connection with ENB, the authentication procedure is handled by MME and HSS. If the information of UE is well configured in the HSS, UE can attach to MME via the ENB unit. Then, the evolved packet system barrier for the UE and the data flow are established. In this setup, we have verified the connection of OAI and the authentication procedure on MME. After the success of authentication, the data transmission is established and the UE has access to the Internet via our testbed. Preliminary test shows that the ping latency is 32 ms on average which is higher than the requirement of next generation RANs.

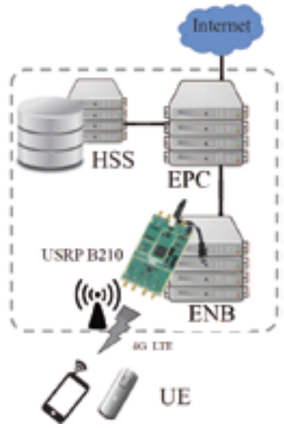
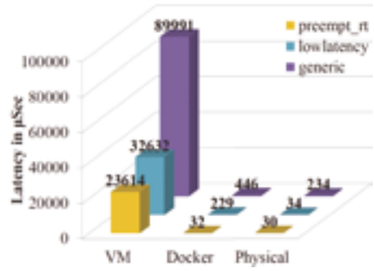
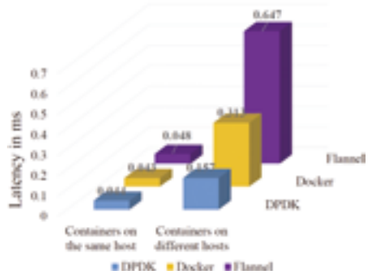


Fig. 1. Architecture of a real testbed for software RANs.



(a) Computing latency



(b) Networking latency

Fig. 2. Performance results. (a) Cyclictest benchmark in 500,000 cycles with system load; (b) Containerized environments over different network architectures.

Minimizing Latency of Realtime Container Cloud

Our cloud adopts containers and strive to minimize the latency by leveraging: (i) realtime Linux kernel, which is key for fine-grained switching among realtime applications, and (ii) Intel Data Plane Development Kit (DPDK), which is a framework for fast packet processing in data plane applications. More precisely, we build a real platform to quantify the performance of several realtime Linux kernels and DPDK networking.
Two kinds of kernels are considered for our realtime OS: one is the preempt_rt kernel as hard realtime and the other is the low-latency kernel as soft realtime. Docker and Google Kubernetes are adopted to provision computing resources for containerized applications. The DPDK-enabled OpenVSwitch networking is further applied to gain the better performance. Preliminary results illustrate that preempt_rt kernel outperforms the computing latency when compared to generic and low-latency kernels running the realtime Cyclictest benchmark. Fig. 2-(a) shows that the Docker container achieves near-native computing latency of less than 35 μs with system loads. Fig. 2-(b) further shows that Docker containers with DPDK networking gains the lowest networking latency of less than 45 μs and 160 μs when containers are deployed on the same host and different hosts, respectively.

Summary

To satisfy the strict latency requirement for running software RANs in cloud, we proposed two approaches to reduce latencies: (i) fine-tuned realtime kernel for computing latency, and (ii) Docker with DPDK for networking latency. Experimental results show the feasibility of running software RANs in realtime container cloud. More specifically, a feasible solution to host software RANs in cloud is to adopt lightweight containers with a hard realtime kernel and fast packet processing networking. Based on current experiences, more variety of realtime Network Function Virtualization (NFV) services will come true based on our platform.

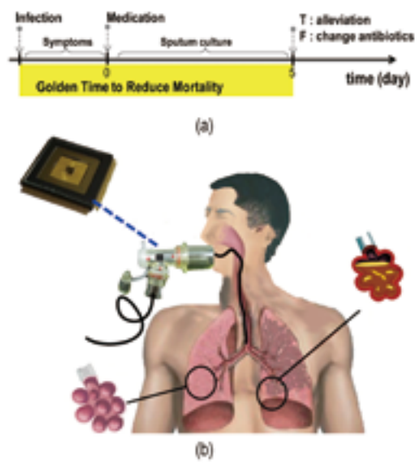
Authors
Yeh-Ching Chung (鍾葉青), Cheng-Hsin Hsu(徐正炘)

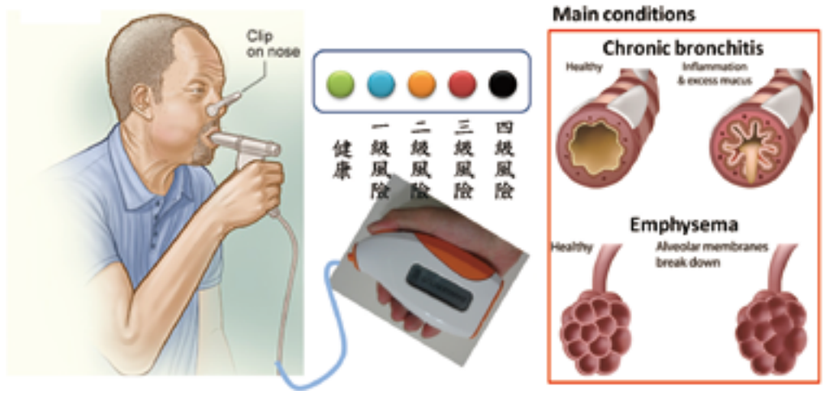
A Miniature Electronic Nose System for Detection and Monitoring of Respiratory Diseases

Prof. Kea-Tiong Tang
Department of Electrical Engineering
Ta-You Wu Memorial Award, MOST, 2014

Electronic noses can potentially be used in daily life, but their application is restricted by their bulky size and high price. We have developed a miniature electronic nose (E-nose) system based on Integrated Circuit (IC) technology. The E-nose system has been applied for respiratory disease detection and monitoring, such as ventilator associated pneumonia (VAP) and Chronic obstructive pulmonary disease (COPD).

In Taiwan, thousands of people need to stay in intensive care unit (ICU) for all kinds of reason every day. Because there are many kinds of bacteria, a ventilated patient is easily infected, causing pneumonia, septicaemia shock, cardiopulmonary failure, and even death. The standard operating procedure (SOP) is to take chest X-ray, draw blood, and perform sputum culture, and then treat the patient with antibiotics of the speculated microorganisms, according to the doctor's experience. No one knows if the given antibiotics are suitable, because specimen culture needs five days, which may be the most crucial time for the patient to survive.





Since the microorganisms generate gases during metabolism, these gases could be very good candidates for early prediction and real-time detection of the microorganisms of pneumonia. If we can install a chip that can smell to the respirator, there is a very big chance to achieve real-time detection for every ventilated patient in the ICU and reduce the death rate due to this problem.

This research proceeded in both clinical inspection and engineering ways, and integrate these two ways together to test the proposed system in clinical trials. In clinical inspection, the exhaled gases of patients were collected and analyzed, at the same time sputum culture was performed to assure the microorganisms. This established a database of the relationship between the exhaled gases and the microorganisms. In engineering, we proceeded with researches on sensor, signal processing, algorithm, and system integration, to design, develop, and integrate a low-power, low-voltage electronic nose system-on-chip (SoC). The electronic nose SoC was integrated to the expired circuit of the respirator for clinical trials to verify the feasibility of early prediction and real-time detection of the microorganisms of pneumonia. Four bacteria were successfully classified with 96% and higher accuracy.

We established a miniature E-nose system based on the VAP research results. This E-nose system was applied to fast screening and long-term monitoring of COPD. The detection rate of COPD and its severity based on our system is over 85%.

Authors
Kea-Tiong Tang (鄭桂忠)
http://innoaward.ibmi.org.tw/AwardDetail.php?REFDOCTYPID=0mgfrxjbg4db3qwm&NumID=0nhqcz7l0hba10dv&REFDOCID=0nhquk0da6t4s6d8
http://140.114.14.182/drupal7_qs/about

Nano Letters 15, 2773 (2015)

Influence of Magnetic Domain Walls and Magnetic Field on the Thermal Conductivity of Magnetic Nanowires

Prof. Zung-Hang Wei
Institute of NanoEngineering and MicroSystems, Department of Power Mechanical Engineering
Ta-You Wu Memorial Award, MOST, 2014

We investigated the influence of magnetic domain walls and magnetic fields on the thermal conductivity of suspended magnetic nanowires. The thermal conductivity of the nanowires was obtained using steady-state Joule heating to measure the change in resistance caused by spontaneous heating. The results showed that the thermal conductivity coefficients of straight and wavy magnetic nanowires decreased with an increase in the magnetic domain wall number, implying that the scattering between magnons and domain walls hindered the heat transport process. In addition, we proved that the magnetic field considerably reduced the thermal conductivity of a magnetic nanowire. The influence of magnetic domain walls and magnetic fields on the thermal conductivity of polycrystalline magnetic nanowires can be attributed to the scattering of long-wavelength spin waves mediated by intergrain exchange coupling.

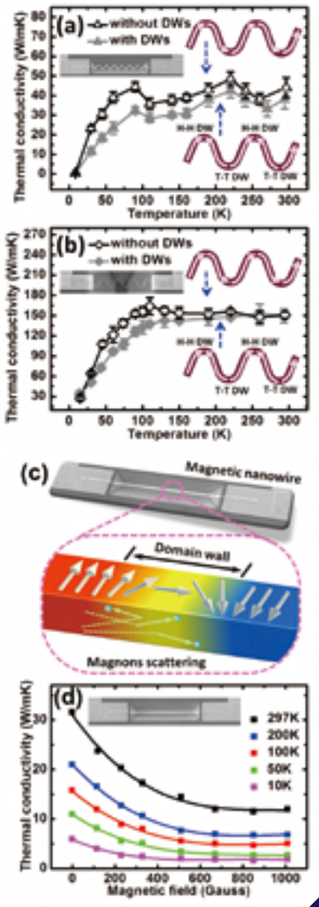


Figure 1 (a,b) Thermal conductivity versus temperature curves of the wavy permalloy nanowire without and with magnetic DWs. (c) Magnon transport in a magnetic nanowire is influenced by the scattering of domain walls. (d) Thermal conductivity versus magnetic field curves of the straight Ni nanowire at various ambient temperatures.

Authors

Hao-Ting Huang, Mei-Feng Lai, Yun-Fang Hou and Zung-Hang Wei
http://pubs.acs.org/doi/abs/10.1021/nl502577y

Adv. Funct. Mater. 25 2670 (2015)

Anisotropic Wettability of Biomimetic Micro/Nano Dual-Scale Inclined Cones Fabricated by Ferrofluid-Molding Method

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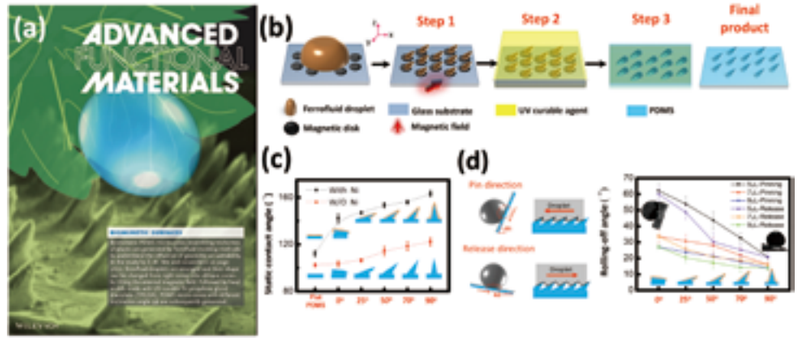

Leaf surface contains various trichomes that for some incline at an acute angle to guide water while others retain water on leaves to improved photosynthetic environment. Inspired by the peculiar trichome structures, this study attempted to adopt cone-shaped structures to systematically understand how the inclination of the trichome influences the wettability of leaves (Fig. 1 a).
Ferrofluid microdroplets are generated under an external magnetic field, and their shape can be changed from right cones into oblique cones by tilting the external magnetic field. Followed by hard molds made with UV-curable TPGDA, PDMS microcones with different inclination angle (θ) are subsequently generated (Fig. 1 b). Nickel thin film is deposited onto the microcones to form micro/nano dual-scale structures. The largest contact angle (CA) is obtained in nickel-deposited right cones (CA =163.1° ± 2.5°) (Fig. 1 c).
Anisotropic wettability is exhibited in oblique cones (Fig. 1 d) and the retention forces in the pin and release directions differ up to 12 μN (cones θ = 50 °). As explained by a model as a function of the inclination angle of the cone structures, the contact and retention forces of droplet move along or against the orientation of the nickel-deposited cone-shaped structures exhibit considerable differences. Results can be used to explain that the inclination of leaf trichomes is optimized through natural selection.

Authors

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http://onlinelibrary.wiley.com/enhanced/doi/10.1002/adfm.201500359/

Social Studies of Science 44, 801 (2014)

A Correlative STS: Lessons from a Chinese Medical Practice

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Ta-You Wu Memorial Award, MOST, 2014

This paper works for a re-theorization from and for local knowledge spaces, and related series of works, includes two special issues on East Asian Science, Technology and Society Studies. Cover Image of 9.2: Technoscience circulates around the globe and creates versions of knowledge spaces through which we know the world and where we are. Cover Image of 9.4: The knowledge spaces of East Asia are heterogeneous and multiple, partly 'Eastern' and partly 'Western'. Perhaps the entanglement of knowledge institutions, representations and possible realities is like the mixture in the body between biomedical anatomy on the one hand and meridians with their context of yin-yang cosmology on the other.

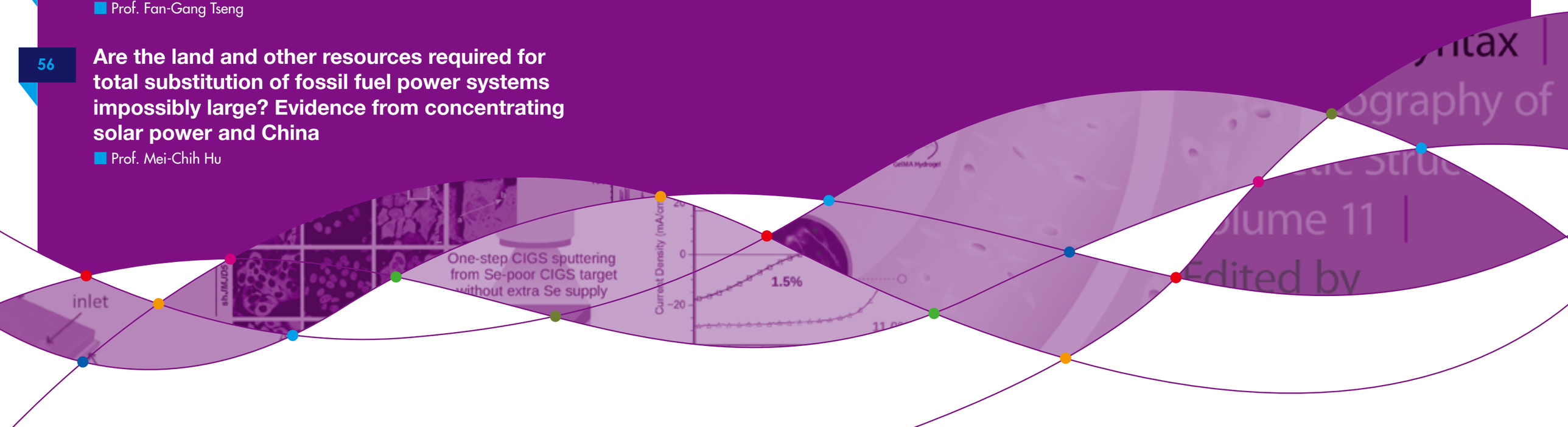
How might Science and Technology Studies learn more from the intersection between 'Western' and 'other' forms of knowledge? STS treats knowledges as expressions of practice. But what does this mean in a post-colonial context? How might one think about the overlaps and intersections between 'Western' and 'other' ways of knowing and intervening in the world? To pose the question in this way is already to risk being tugged from the specificities of practice. The so-called post-colonial is multiple and diverse. So too is the 'West'. And the locations of overlap are indefinitely complex. The quick lesson and the starting point is that while large categories may catch something important, they also have to be treated with extreme caution. So how to think about difference without reifying it or washing it away into a confusion of complexity?

In this article, Lin and Law use Eduardo Viveiros de Castro's writing on equivocal translation to explore a moment of encounter in a Chinese Medical consultation in Taiwan in which a practitioner hybridizes Chinese Medicine and biomedicine. Our description is symmetrical, but creates a descriptive equivocation in which 'Western' analytical terms are used to describe a 'Chinese' medical reality. Drawing on the history of Chinese Medicine, we argue that the latter is not analytical, but 'correlative' in a specifically 'Chinese' manner that explores patternings, flows, and propensities in local collections of things and symptoms. In particular, it both handles difference without seeking to unearth stable causal mechanisms and absorbs new elements including relevant features of biomedicine.

We conclude by briefly considering the scope of a 'correlative' description of the same Chinese Medical consultation would differ markedly from one making use of 'Western' analytical assumptions. If we were to bring this home then STS – in this possible correlative version – would begin to change socially, administratively, epistemically and educationally. What counted as an 'explanation' would be different. 'Western' STS or post-colonial STS is not a monolith and has to be re-situated as well. But the implications of this novel multiplicity of correlative STS would themselves be multiple.

Authors
Lin, Wen-yuan (林文源 corresponding author), John Law
http://sss.sagepub.com/content/44/6/801.abstract

Exemplary Research Achievements



Angewandte Chemie International Edition 53, 14216 (2014)

Nanocomposites of Tantalum-Based Pyrochlore and Indium Hydroxide Showing High and Stable Photocatalytic Activities for Overall Water Splitting and Carbon Dioxide Reduction

Prof. Chia-Min Yang
Department of Chemistry

Direct photocatalytic conversion of water and CO_2 into solar fuels is an attractive prospect, serving to provide an alternative energy source on a renewable basis. To date, very few catalysts are capable of catalyzing both water splitting and CO_2 reduction. As compared to water splitting, photocatalytic CO_2 reduction with water as a reductant is even more challenging. Several photocatalytic systems have also been reported for CO_2 reduction, but conversion remains low and the stability is often poor. Moreover, the loading processes of effective cocatalysts are often complicated with problems of reproducibility. Recently, Professor Chia-Min Yang and co-workers discovered a hydrothermal process at 170-220°C to prepare nanocomposites of tantalum-based pyrochlore (TP) nanoparticles and indium hydroxide ($In(OH)_3$). For UV-driven photoreforming of methanol, all the synthesized nanocomposites outperformed benchmark photocatalyst sodium tantalate $NaTaO_3$, while the acid-washed $In(OH)_3$-free samples (denoted as TIM-x-A containing only TP nanoparticles) were more active than TIM-x. TIM-190-A was the best photocatalyst exhibiting the very high H_2 evolution rate of 5.82 mmol $g^{-1}h^{-1}$. Obviously, the TP nanoparticles must be the major active component for H2 production. Moreover, for the reaction of overall water splitting, all the nanocomposites were more active than the benchmark catalyst, while TIM-190 and TIM-190-A was the most active among the same type of samples (Figure 1a). Remarkably, the H_2 evolution rate (357.7 μmol $g^{-1}h^{-1}$) of TIM-190-A is more than twenty times higher than that (17.0 μmol $g^{-1}h^{-1}$) of $NaTaO_3$. With these encouraging results for water splitting, Professor Yang and co-workers further investigated the photocatalytic performance in gas-phase CO_2 reduction with saturated water vapor at 25°C with $NaTaO_3$ and Degussa P25 TiO_2 as benchmark photocatalysts. They found that TIM-190 again exhibited the highest CO evolution rate of 14.2 μmol $g^{-1}h^{-1}$ (Figure 1b), while most TIM-x and TIM-x-A samples showed very low activities. More importantly, the TIM-190 nanocomposite produced stoichiometric amounts of CO and O_2 with 2:1 ratio from the start of UV irradiation. In order to clarify the experimental observations, density functional theory (DFT) calculations were performed to understand the band alignment between these two materials. Figure 2 shows the DFT results of the heterojunction between $In(OH)_3$ and TP. The electrons generated upon UV irradiation in the conduction band of TP nanoparticles reduce water or CO_2 to produce H_2 or CO, whereas the holes are transferred to the valance band of $In(OH)_3$ for water oxidation to produce O_2.

In summary, Professor Yang and co-workers have successfully developed a method to prepare nanocomposites of tantalum-based pyrochlore nanoparticles and $In(OH)_3$. They have also found that the pyrochlore nanoparticles catalyze the water reduction to produce hydrogen, whereas $In(OH)_3$ is the major active component for water oxidation. With optimum hydrothermal synthesis conditions, the nanocomposite shows superior and stable catalytic performance and generates stoichiometric products. These results show immense promise for a new type of photocatalysts for energy and environmental-related reactions.

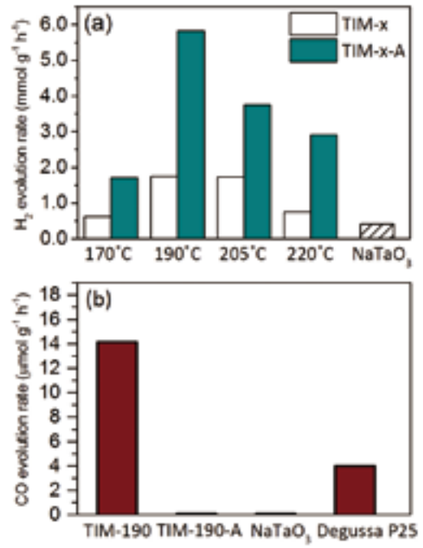


Figure 1: Comparison of photocatalytic activity of selected samples for (a) H_2 evolution rates from pure water and (b) CO_2 reduction with water vapor as reductant.

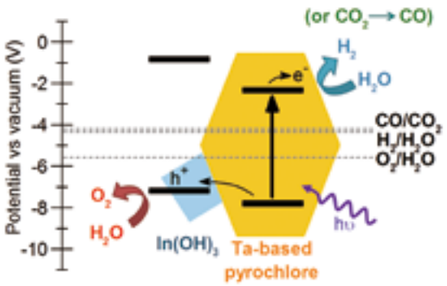


Figure 2: Schematic diagram of photo-catalytic overall water splitting and CO_2 reduction with water on TIM-190 containing nanocomposites of $In(OH)_3$ and defect TP nanoparticles.

Authors
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http://onlinelibrary.wiley.com/enhanced/doi/10.1002/anie.201408868/

Progress in Photovoltaics: Research and Applications 23, 1621 (2015)

Na-induced efficiency boost for Se-deficient Cu(In,Ga)Se_2 solar cells

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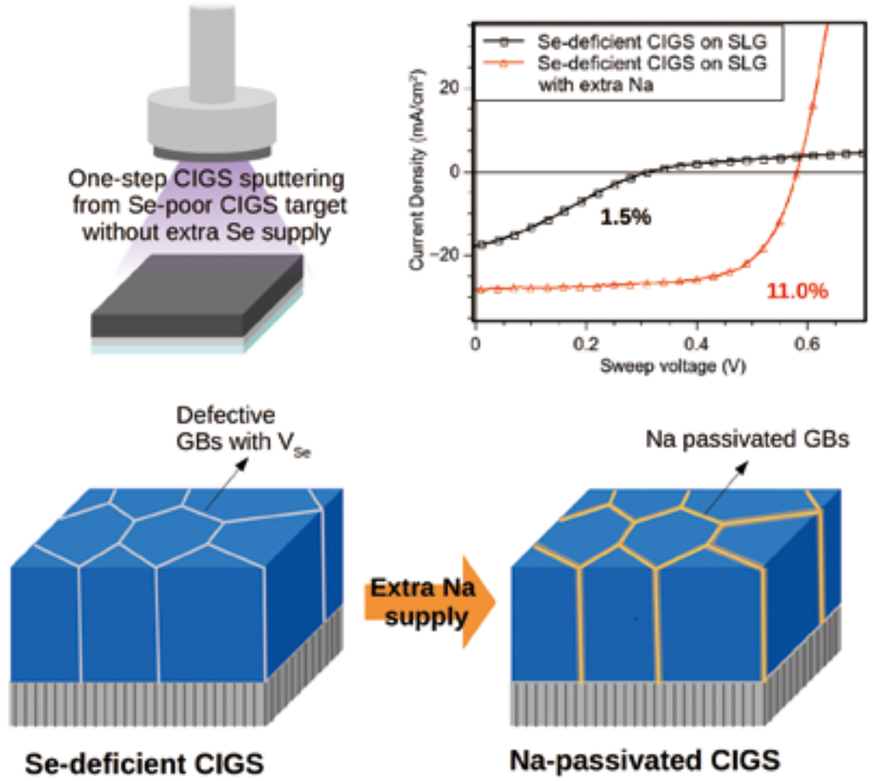
Among different process routes for Cu(In,Ga)Se_2 (CIGS) solar cells, sufficient Se supply is commonly required to obtain high-quality CIGS films. However, supplying extra Se increases the cost and the complexity. In this work, we demonstrate that extra Na incorporation can substantially increase efficiency of Se-deficient CIGS solar cells, fabricated by sputtering from a quaternary CIGS target *without extra Se supply*, from 1.5% to 11.0%. The Se-deficient CIGS device without extra NaF reveals a roll-over *I–V* curve at room temperature as well as significantly reduced J_{sc} and fill factor at low temperatures. The electrical characteristics of Se-deficient CIGS films are well explained and modeled by the low p-type doping due to high density of compensating donors and the presence of deep defects possibly originating from the anti-bonding levels of Se vacancies. The significant improvement after extra Na incorporation is attributable to the Na-induced passivation of Se vacancies and the increased p-type doping. Our result suggests that extra Na addition can effectively compensate the Se deficiency in CIGS films, which provides a valuable tuning knob for compositional tolerance of absorbers, especially for the Se-deficient CIGS films. We believe that our findings can shine light on the development of novel CIGS processes, distinct from previous ones fabricated in Se-rich atmosphere.

Adding extra Na to Se-deficient CIGS films, fabricated by one-stage sputtering from a CIGS target without extra Se supply, significantly improves the device performance, from 1.5% to 11.0%. The detrimental defects induced by Se-deficiency could be removed not only by supplying extra Se during CIGS formation but by increasing Na content in the film. This approach shines light on the development of novel low-cost CIGS processes without extra Se supply.



Authors
Chia-Hao Hsu, Yue-Shun Su, Shih-Yuan Wei, Chia-Hsiang Chen, Wei-Hao Ho, Chuan Chang, Yan-Huie Wu, Chun-Jun Lin, Chih-Huang Lai (賴志煌)
http://onlinelibrary.wiley.com/doi/10.1002/pip.2600/abstract

IEEE Transactions on Cloud Computing 3, 42 (2015)

Placing Virtual Machines to Optimize Cloud Gaming Experience

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Department of Computer Science

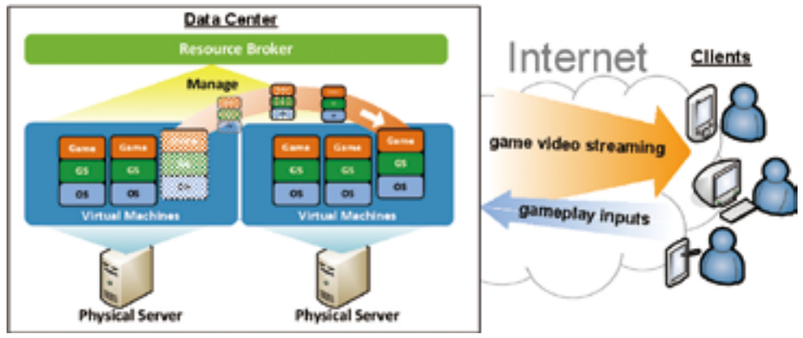


Fig. 1. The architecture of cloud gaming services, where GS denotes cloud gaming server.

Cloud gaming providers, such as Gaikai, Ubitus, and OnLive, offer on-demand gaming services to many gamers using heterogeneous client computers, such as desktops, laptops, and smartphones. The providers push computer games to powerful cloud servers and stream the game scenes to a simple application running on client computers. As illustrated in Fig.1, in this project, we study the Virtual Machine (VM) placement problem and propose two algorithms to: (i) maximize the provider's total profit while providing the just-good enough QoE to gamers (called QDH_L), and (ii) maximize total quality of experience (called QDH'_L), respectively.

We have implemented a complete cloud gaming system consisting of a broker, physical servers, and GA servers/clients, as illustrated in Fig. 2. We adopt VMWare ESXi 5.1 as the virtualization software on physical servers. ESXi allows us to create VMs on physical servers, and each VM hosts a GA server and a game chosen by the corresponding gamer. We employ VMware vCenter 5.1 as the platform for our broker, which is comprised of Single-Sign-On for user authentication and Inventory Service for managing/monitoring the VMs on ESXi servers. The Inventory Service comes with different APIs, and we use its Java API to interface with the vCenter on the broker so as to control ESXi servers on all physical servers.

We set up a testbed using the prototype system in our lab shown in Fig. 2. The testbed contains an i7 3.2 GHz broker with the management web page, several i5 3.5 GHz physical servers with NVidia Quadro 6000 cards, and several i5 client computers. The broker, physical servers and client computers are connected via Gigabit Ethernet.

To quantify the QDH_L and QDH'_L algorithms, we employ a testbed with 9 physical servers, 15 gamers, and 3 games–Limbo, PSR, and Normandy. In every minute, each gamer joins (leaves) a game session with a probability of $D\%$ $(1\text{-}D\%)$, where D is a system parameter. Each simulation lasts for T minutes. We assume that each physical server can serve up to two VMs and each VM launches a randomly selected game. In each simulation, we measure the fps (frame-per-second) and processing delay, and use them in the quality model. Also, we measure the CPU and GPU utilizations, and use them in the profit model. We inject realistic network latency using Dummynet. Last, we set $D = 90\%$, $T = 15$ minutes and consider the two performance metrics: profit and quality of experience.

Fig. 2. The cloud gaming testbed in our lab.

We compare the QDH_L and QDH'_L algorithms against the optimal solution that exhaustively checks all servers for each new gamer. We refer to the optimal solutions as OPT_L/OPT'_L. Fig. 3(a) shows that QDH_L and OPT_L result in similar profit. More specifically, the OPT_L algorithm outperforms the QDH_L algorithm in the first half of the experiment, but the QDH_L occasionally performs better in the second half. A closer look indicates that since once game sessions start, they will be executed until the gamers leave, therefore, even though OPT_L selects the best VM placements for the incoming gamers, it cannot foresee the future (e.g., when will the gamers leave), and thus its profit may be lower than that of the QDH_L algorithm. Fig. 3(b) reveals that QDH'_L leads to exactly the same (optimal) performance in QoE, compared to OPT'_L.

Sample results in Fig. 3 and more results in our paper show the merits of QDH_L and QDH'_L, and demonstrate the advantages of adopting our algorithms for intelligent VM placement.

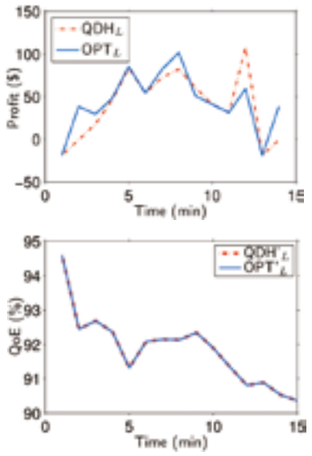


Fig. 3. Comparisons between QDH_L/QDH'_L and OPT_L/OPT'_L: (a) profit and (b) quality.

Authors

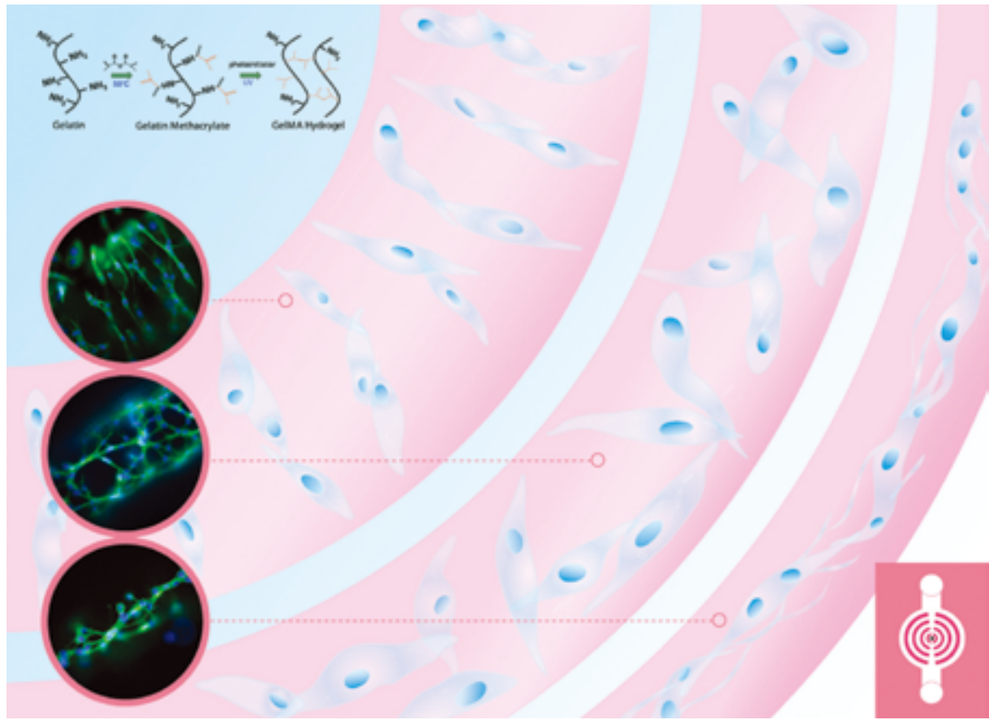
Hua-Jun Hong, De-Yu Chen, Chun-Ying Huang, Kuan-Ta Chen, and Cheng-Hsin Hsu (徐正炘)

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6853364&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6853364

Lab on a Chip 14, 482 (2014)

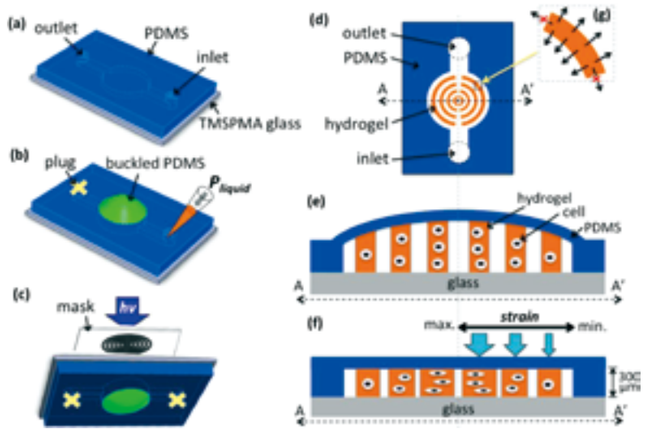
Gradient static-strain stimulation in a microfluidic chip for 3D cellular alignment

Prof. Fan-Gang Tseng
Department of Engineering and System Science



A simple and low-cost approach was developed using photopatternable concentric circular gelatin methacrylate (GelMA) hydrogel under the convex PDMS membrane in the microfluidic chip to simultaneously apply gradient static-strain on three- dimensional cell-laden hydrogels for the investigation of cellular behaviors.

Cell alignment is a critical factor to govern cellular behavior and function for various tissue engineering applications ranging from cardiac to neural regeneration. In addition to physical geometry, strain is a crucial parameter to manipulate cellular alignment for functional tissue formation. In this paper, we introduce a simple approach to generate a range of gradient static strains without external mechanical control for the stimulation of cellular behavior within 3D biomimetic hydrogel microenvironments. A glass-supported microfluidic chip with a convex flexible polydimethylsiloxane (PDMS) membrane on the top was employed for loading the cells suspended in a prepolymer solution. Following UV crosslinking through a photomask with a concentric circular pattern, the cell-laden hydrogels were formed in a height gradient from the center (maximum) to the boundary (minimum). When the convex PDMS membrane retracted back to a flat surface, it applied compressive gradient forces on the cell-laden hydrogels. The concentric circular hydrogel patterns confined the direction of hydrogel elongation, and the compressive strain on the hydrogel therefore resulted in elongation stretch in the radial direction to guide cell alignment. NIH3T3 cells were cultured in the chip for 3 days with compressive strains that varied from ~65% (center) to ~15% (boundary) on hydrogels. We found that the hydrogel geometry dominated the cell alignment near the outside boundary, where cells aligned along the circular direction, and the compressive strain dominated the cell alignment near the center, where cells aligned radially. This study developed a new and simple approach to facilitate cellular alignment based on hydrogel geometry and strain stimulation for tissue engineering applications. This platform offers unique advantages and is significantly different from the existing approaches owing to the fact that gradient generation was accomplished in a miniature device without using an external mechanical source.



(a)-(c) Schematic of the fabrication processes for gradient strain hydrogels in a microfluidic chip.

(d) Concentric circles were formed in the chip.

(e) A height gradient along the radius.

(f) Gradient force applied onto the cell-encapsulated hydrogels.

(g) The stretch direction of the circular hydrogel.

Authors
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https://www.researchgate.net/profile/Fan-Gang_Tseng

Renewable & Sustainable Energy Reviews 46, 257 (2015)

Are the land and other resources required for total substitution of fossil fuel power systems impossibly large? Evidence from concentrating solar power and China

Prof. Mei-Chih Hu
Institute of Technology Management

The task of substituting the entire global fossil-fuelled energy system by renewables is increasingly discussed in the energy literature, but in the social sciences academy it is widely viewed as impossibly large within any meaningful timeframe. In this article, we argue that such pessimism is ill-founded. CSP (concentrating solar power) is based on the earth's solar energy input, which is almost never exhausted. It has great potential to produce dispatchable power 24/7 and work as a base load of electricity source while molten salt technology is utilized for energy storage. In addition, the CSP does not call for any major technological breakthroughs to achieve this. More to the point, it can be scaled; it is a manufactured system where economies of scale can be expected to kick in, thus driving down costs through the experience curve. This is a source of advantage of manufactured renewable energy systems that is not available to nuclear power (where plants are built one by one, without economies of scale or increasing returns) nor to "new" fossil fuels like coal seam gas and shale oil (which are subject to diminishing returns). Taking as our starting point the material and energy requirements of existing operating systems such as the Shams1 Concentrating Solar Power plant, we scale these up to generate the real resource demands of a renewable electrical energy system to supply the entire planet -- and find these to be technically, financially and economically feasible, particularly if it is China that takes on the manufacturing challenge. We offer this article as a corrective to the profound pessimism that engulfs serious thinkers about the world's future, when they contemplate the scale of the industrial transformation required to clean the world's energy system. Our conclusion is that the tasks are large – indeed there have never been larger tasks – but they are technically, financially and economically feasible. It is the task of energy policy theorists and practitioners to present these challenges as feasible – and on the scale required to make a difference. Whether they will prove to be politically feasible is another matter entirely.

Project Developer	Materials	Components	EPC* and Operation	Distribution
• China Huaneng • China Datang • China Huadian • China Guodian • China Power Investment • China Guangdong Nuclear Solar Energy • Lenon New Energy • Hanas New Energy • Shanghai Gongdian (GD) Energy • Tianwei (Chengdu) Solar Thermal Power Development • Tianjin Solar & Environmental • Beijing Control (Beijing Kangtuo) • China Three Gorge Corporation • Guangdong Yudean Group • CAMDA • Avic Xi'an Aero Engine Group • Guangdong Kangda • SETC Tianjin • Shandong Penglai Dianli	• **Steel:** Hebei steel; Bao steel; Wuhan steel; Jiangsu Shagang; Shougang; Anshan iron and steel; Xinxing Cathay International; Taiyuan steel; Shandong steel; Tianjin Pipe • **Glass/Mirror**: Shandong Jinjing Technology; Lanzhou Blue Sky Float; Zhejiang Daming Glass; Rayspower New Energy; Taiwan Glass; Beijing TeraSolar Photothermal Technologies; Dalian Great Ocean New Energy • **Concrete:** China Resources Cement; Shanghai Jiangong Construction; Jidong Concrete; China Construction; Jinyu; Shanghai Jiangong; Western Construction; Jiangsu Weiye; Shanghai City Construction; Jiangsu Minghe • **Molten Salt**: Tianjin Yuanlong Chemical; Wentong Group Tianjin Xinyuan Global; Xiaxian Yunli Chemicals; Tianjin Xinyuan Global; Shenyang Xin Guang Chemical; Zouping Changshan Zefeng Fertilizer; Su Jia Trading	• **Mirrors:**Zhejiang Daming Glass; Rayspower; Lanzhou Blue Sky Float Glass; Beijing TeraSolar Photothermal Technologies • **Receiver:** IEECAS; Himin Solar Energy; Beijing Sunda Solar Energy Technology; BSERI; Huayuan New Energy; Linuo Solar Thermal Group; Sunrain New Energy; Huiyin Group; Lanzhou Dacheng Technology; Beijing Tianruixing Solar Thermal Technology; Shenzhen Weizhen Solar Energy Products; Royal Tech. Solar • **Support Structure:** Beijing Jingcheng Cailong Steel Structure; Jiangsu Henglida Machine; Baotou Hydraulic Mechanical • **Control System:** Beijing Tianyi Energy Technology; Zhejiang Supcon Solar Energy; Beijing Guodian Zhishen Control Technology; Nanjing Sciyon Automation Group • **Heat Storage:** Changzhou Pressure Container Testing; Jiangsu Sunhome New Energy; Huiyin Group • **Steam Generator:** Jiangsu Taihu Boiler; Changsha Boiler; Livo equipment; Dongfang Boiler; Xinde Tangshan Boiler; Shanghai Boiler • **Power Block and Pumps:** Dongfang Electric Group; Shanghai Electric Group; Harbin Turbine; Hangzhou Steam Turbine; Nanjing Steam Turbine; Xi'an Aero-Engine; CAMDA New Energy; • **System Integration:** Beijing Zhonghang Airport General Equipment; Penglai Electric Power Equipment Manufacturing; Shanghai Gongdian Energy	• China Datang • China Guodian • CGN Solar Energy • China Huaneng: Huaneng Tibet Power Generation; Huaneng Gansu Energy Development; Huaneng Xinjiang Energy Development; Huaneng Hainan Power Generation • China Huadian Engineering • North China Power Engineering • Northwest Electric Power Design Institute (NWEPDI)	• State Grid Company of China (SGCC): Northeast China Grid; Northwest China Grid; North China Grid; East China Grid; Central China Grid; • China South Grid Company

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http://www.sciencedirect.com/science/article/pii/S1364032115001331
http://mx.nthu.edu.tw/~mchu/Mei-Chih_Hu_CV.html

PNAS 111, 279 (2014)

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

Prof. Wen-Ching Wang
Institute of Molecular and Cellular Biology, Department of Life Science

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.

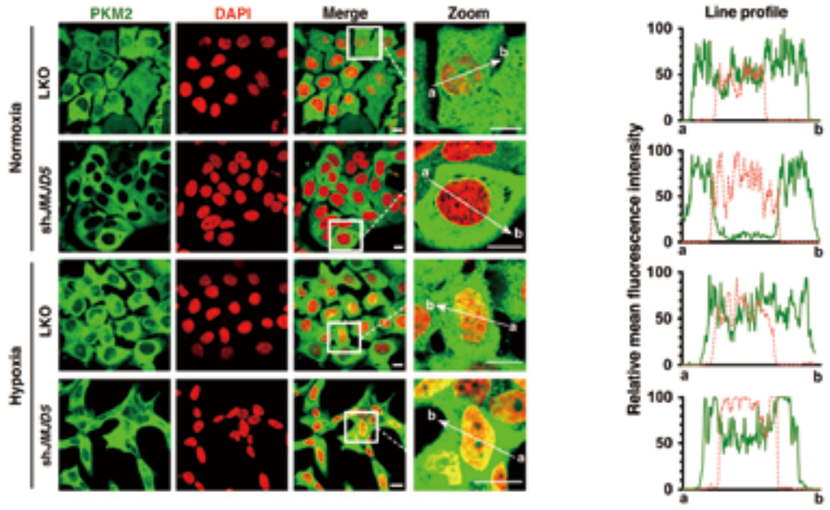


Fig 1.
JMJD5 regulates the nuclear translocation of PKM2. Subcellular localization of PKM2 in MCF-7 cells. Cells were immunostained with anti-PKM2 (PKM2, green). The nucleus is marked with DAPI (red). Merged images (Merge) are shown. The framed regions are zoomed in the fourth row (Zoom). The line profiles of PKM2 and DAPI signals were measured by ZEN2011 (Carl Zeiss) software. (Scale bars, 10 μm.)

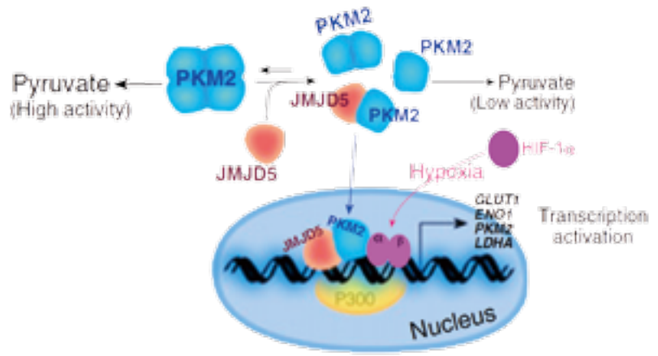


Fig 2.
The proposed model that depicts JMJD5 as a major regulator in PKM2-stimulated HIF-1 α metabolic reprogramming.

Authors
Hung-Jung Wang, Ya-Ju Hsieh, Wen-Chi Cheng, Chun-Pu Lin, Yu-Shan Lin, So-Fang Yang, Chung-Ching Chen, Yoshihiro Izumiya, Jau-Song Yu, Hsing-Jien Kung, Wen-Ching Wang (王雯靜)
http://www.pnas.org/content/111/1/279.long

The Commercial Press (2015)

From Microscopic View to Cosmic Perspective: Generative Landscape of Chinese Syntax

Prof. Wei-Tien Dylan Tsai
Institute of Linguistics

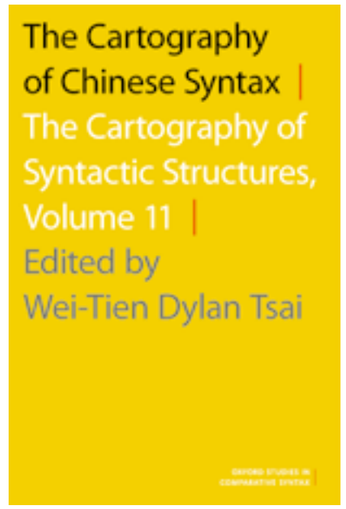
This book is a collection of 16 articles that investigate the syntax and semantics of modals, *wh*-adverbials, reflexive adverbials, and affected arguments in Chinese from a comparative point of view. It presents a comprehensive picture of how modification, predication and quantification work together to form the backbone of Chinese grammar, while singling out its analyticity as the dominating factor that shapes the "topography" of a variety of syntactic constructions under the so-called cartographic approach. Firstly, it is pointed out that there is an inner-outer dichotomy of adverbials and applicatives in correspondence to the semantic division between comitativity and causality. Secondly, relevant issues are tackled from the vantage point of the syntax-semantics interface, which in turn leads to an explicit account of how elements of different heights systematically map to distinct types of interpretation. Finally, armed with the knowledge obtained from field studies of Formosan languages and Chinese dialects, it becomes possible to explore those issues further on the historical and typological fronts. In particular, the notion of "conjunctive reduction" is introduced to explain numerous instances of linker grammaticalization across languages. All in all, this book offers insights into the inner workings of language faculty, and lends further support to the postulation of Universal Grammar as one of the defining features of human evolution.

Oxford University Press (2015)

The Cartography of Chinese Syntax

Prof. Wei-Tien Dylan Tsai
Institute of Linguistics

This edited volume provides new insights into the architecture of Chinese grammar from a comparative perspective, using principles of cartography. Cartography is a research program within syntactic theory that is guided by the view that syntactic structures contain grammatical and functional information that is ideal for semantic interpretation - by studying the syntactic structures of a particular language, syntacticians can better understand the semantic issues at play in that language. The chapters in this book map out the "topography" of a variety of constructions in Chinese, specifically information structure, *wh*-question formation, and peripheral functional elements. The syntactic structure of Chinese makes it an ideal language for this line of research, because functional elements are often spread throughout sentences rather than clumped together as is usually dictated by language-specific morphology. Mapping Chinese syntactic structures therefore offers a window into the origin of heavily "scrambled" constructions often observed in other languages. The seven original articles included in this volume contain invaluable data and observations that contribute greatly to future research in cartography, and the collection as a whole paints a broader picture of how the alignment between syntax and semantics works in a principled way.



Authors

Wei-Tien Dylan Tsai (蔡維天)

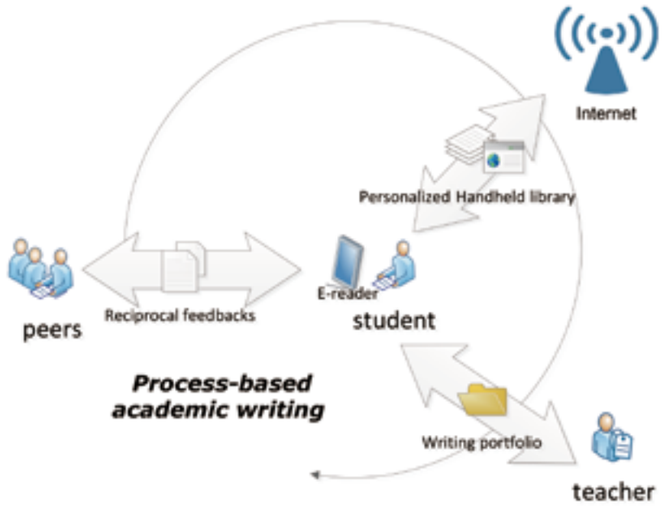
http://www.cp.com.cn/book/9cfbbfb2-4.html

https://global.oup.com/academic/product/the-cartography-of-chinese-syntax-9780190210694?cc=tw&lang=en&

Educational Technology & Society 18, 250 (2015)

The Effectiveness of Adopting E-Readers to Facilitate EFL Students' Process-Based Academic Writing

Prof. Shelley Shwu-Ching Young
Institute of Learning Sciences



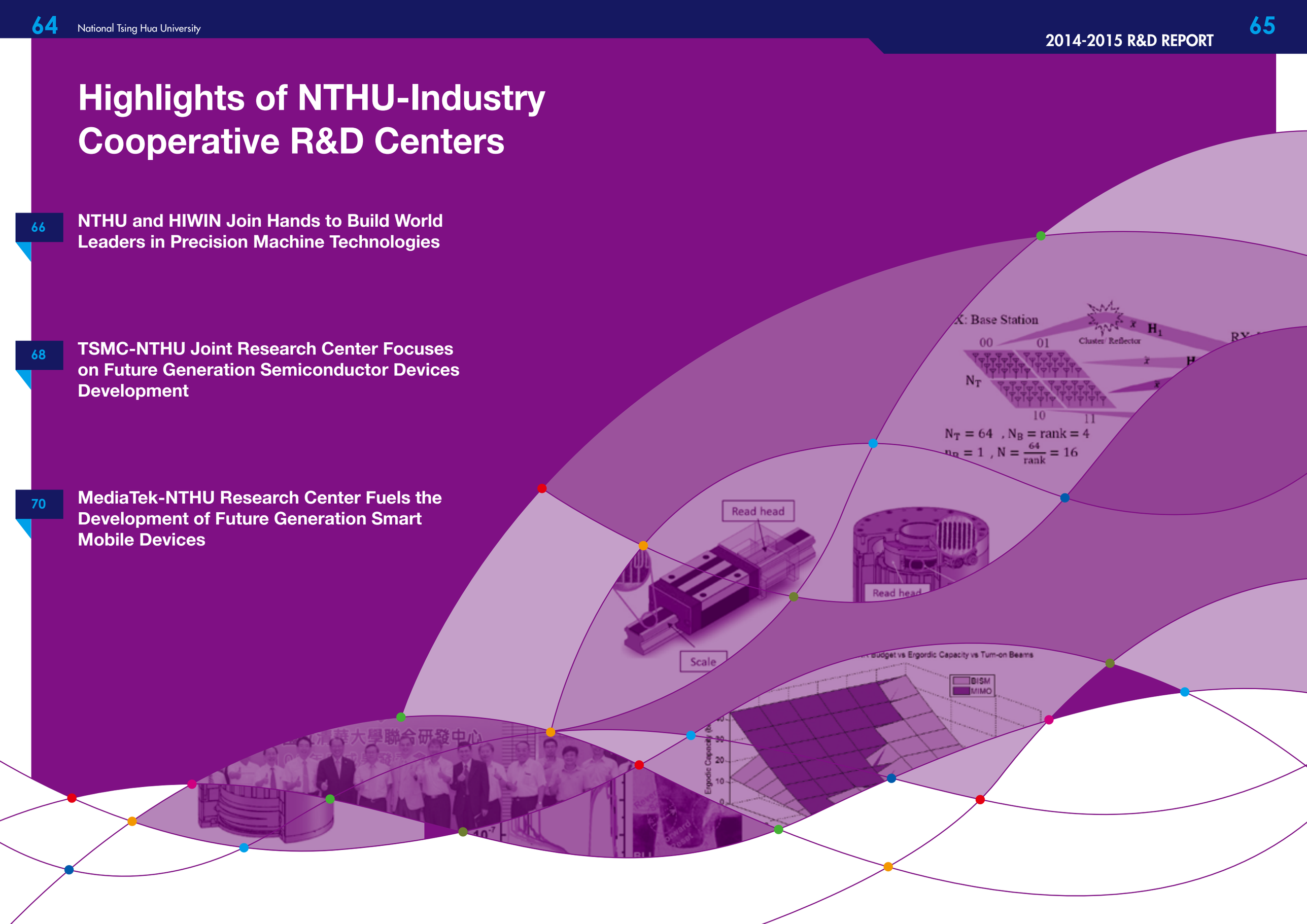
E-readers affording a better academic writing environment

English as Foreign Language (EFL) students face additional difficulties for academic writing largely due to their level of language competency. An appropriate structural process of writing can help students develop their academic writing skills. This study explored the use of the e-readers to facilitate EFL students' process-based academic writing. The experiment was conducted in the graduate level class entitled "Technical and Scientific English Writing" in a northern Taiwan university for the entire semester, about 5 months. Students' perceptions, writing outcome and portfolio were collected and were later evaluated. Both qualitative and quantitative approaches were adopted in this study. Empirical data were collected and analyzed to report on the performance of EFL students' academic writing with and without the e-readers. Findings indicate that e-readers affected the process of reading, annotation, and information retrieval with the unique functions. For EFL students' academic writing, e-reader can be a tool for reciprocal peer review that aided academic writing. Moreover, e-readers are significantly beneficial for students' academic writing progress compared to the conventional paper-based materials. The functions of e-readers can assist students' writing process and make the recursive circle of steps more efficiently. E-readers could afford creating a better writing environment in the process-based writing approach. This study further discussed the role of e-readers in the academic writing classroom and further discusses how to use e-readers to facilitate academic writing in the classroom.

The English language has been increasingly highlighted as an important medium of communication in academia between English native speakers and non-native speakers (Leki, 2001; Zhu, 2004). However, academic writing is different for these two populations (Silva, 1993). English as Foreign Language (EFL) students face additional difficulties and stress for academic writing largely due to their level of language competency (Al Fadda, 2012; Bacha, 2002; Olivas & Li, 2006). To deal with the extra cognitive burden that EFL students are likely to experience for academic writing, an appropriate structural process of writing can help students develop their academic writing skills (Bacha, 2002). The writing process approach is a non-linear activity in which students need to go recursively through steps of planning, drafting, revising, editing, and publishing. It emphases on the continual interactions with the instructor and peers during the writing process (Greene, 2000; Tribble, 2002). Several studies have proposed a process-based writing instruction and the need for a supplementary tool for EFL students has been justified (Arslan & ahin-Kızıl, 2010; Shang, 2007; Wang, Shang, & Briody, 2013). Meanwhile, the advancements of technology have led to the use of electronic reading systems for digital contents (Wright, Fugett, & Caputa, 2013). An electronic device such as the e-reader has the potential for aiding students in the process of writing. E-readers are generally portable and contain a built-in dictionary, and also tools for annotation and information browsing. However, few studies have examined the effect of adopting e-readers as an aiding device in academic writing for EFL students.

Authors
Hui-Chun Hung and Shelley Shwu-Ching Young (楊叔卿)
http://www.ifets.info/issues.php?id=66
http://www.ifets.info/journals/18_1/21.pdf

Highlights of NTHU-Industry Cooperative R&D Centers



NTHU and HIWIN Join Hands to Build World Leaders in Precision Machine Technologies

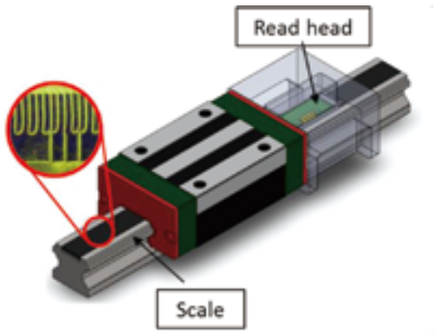


Figure 1.
Linear type of magnetic encoder assembled on linear guideway

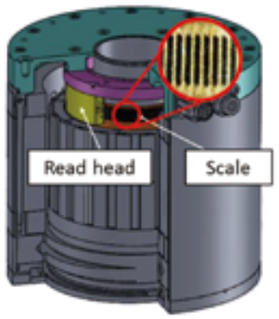


Figure 2.
Rotary type of magnetic encoder assembled on motor

This joint research and development center is the largest and longest-invested efforts by industry in university in Taiwan. It is not an exaggeration to call it the "Apollo moon landing program" among industry-university collaborative programs in Taiwan, indicated by Professor Hong Hocheng, the President of NTHU. The center will play a unique role in developing and adapting basic science and engineering to creative state-of-the-art engineering pathways for value-added precision components and systems that position Taiwan and HIWIN Company as world leaders in precision intelligent machine industry. Currently, a few joint research programs are undertaking, all of which involve in-depth cross-disciplinary knowledge contents on top of solid practical experiences. As an example, the R&D on precision magnetic encoders is briefly introduced herein.

Magnetic encoders are mainly used in machines to detect the position of a motion stage to which they are installed. Motivated by the drawbacks of optical encoders such as high cost, unable being applied in harsh environment, etc., this research dedicates in developing magnetic encoders to compete with optical encoders in the future marketplace. The scope ranges from magnetic material design for realizing high-density recording, precision magnetization for either incremental or absolute coding, design, characterization of self-made magneto-resistance sensors and Hall sensors as signal detection devices, signal processing IC design, to mechanical assembly calibration and system verification. Under the demands of machine tools manufacturers, we have designed and fabricated a linear- and a rotary-type magnetic scales, which will be mounted to linear guideways and servomotors, respectively.

Figure 3. Open Ceremony of The HIWIN-National Tsing Hua University Joint Research and Development Center on May 19, 2014

Figure 4. Annual program review meeting on June 10, 2015

TSMC-NTHU Joint Research Center Focuses on Future Generation Semiconductor Devices Development

2015 TSMC Elite Camp

Collaborative research between TSMC and NTHU has been in the form of individual research projects (JDPs) between interested faculty members and business units of TSMC for many years. In order to integrate all JDPs with focuses on front-end integrated circuits technology development as well as attracting young talents into the semiconductor field, the Center was established in January, 2014 with a pledged annual financial support of at least NTD 15 Million from TSMC. A unique design is that 30% of the total Center budget is allocated to educate talented students in semiconductor field in the form of scholarships.

Since then, at least 30 Professors and more than 200 students from different departments have participated in the TSMC-NTHU Joint Research Center with the annual budget exceeding NTD 27.5 Million in 2015. The current major research focuses of the Center include advanced memory (flash, ReRAM, MRAM, etc) development, investigation of FINFET beyond 16 nm, process reliability improvement, 2D material exploration, as well as CMOS/MEMS sensors development for IoT applications. For example, the project led by Prof. Ya-Chin King on 'Self-Rectifying Twin-bit RRAM IN 28nm CMOS Process' has successfully demonstrated a new self-rectifying twin-bit RRAM using TSMC 28nm CMOS process. The structure of the RRAM, which consists of Cu/TaN/TaO_xN/Cu, is well defined between M1 (metal layer 1) and via without any additional mask or process. The project 'Topological Insulator Thin Film Advanced Research for Spintronics' led by Prof. Ray-Nien Kuo studies the high-k back-gate dependent 2D carrier concentration for 10QL Bi_2Se_3/Al_2O_3 and Y_2O_3/Al_2O_3 structures. They also studied the large current generation via spin pumping in topological insulator/ferromagnetic bilayers including Bi_2Se_3/Fe_3Si/GaAs and Fe/Bi_2Te_3/Al_2O_3.

Besides research activities, the TSMC-NTHU Joint Research Center offers many scholastic activities to attract students of all grades into semiconductor related fields for advanced studies. For example, a number of sophomore and junior students are invited to join the summer Elite Camp with the opportunity to interact directly with center professors so as to inspire their interests in semiconductor research. The Center Research Project Competition offers an opportunity for students to learn semiconductors through competition among NTHU students as well as their peers at NTU, NCTU and NCKU. Above all, a sizable portion of the Center budget, over NTD 3 Million, is allocated for center students in the form of scholarships to retain excellent students to study semiconductors.

Topological insulator thin film advanced research for spintronics
Prof. J. Raynien Kwo

Utilization of high k back gate field effect devices

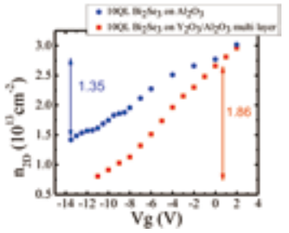


Fig. 1 Gate dependent, 2D carrier concentration for 10QL Bi_2Se_3 grown on Al_2O_3 (blue circles); and Y_2O_3/Al_2O_3 multilayer (red cubes).

Large electrical current generation via spin pumping in TI/FM bilayers

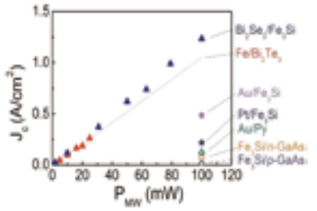


Fig. 2 Microwave power dependence (PMW) of J_c for Bi_2Se_3/Fe_3Si/GaAs(111)A and Fe/Bi_2Te_3/Al_2O_3(0001). J_c at P_{MW} of 100 mW of other conventional FM/NM and FM/semiconductor films were plotted for comparison.

Spin pumping in TI/YIG

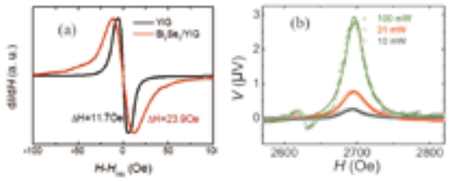
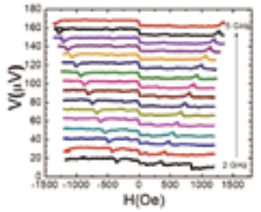


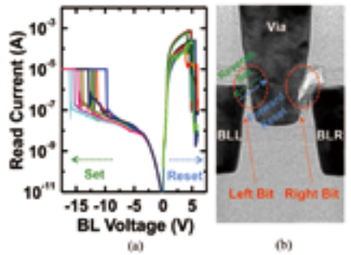
Fig. 3 (a) FMR spectra and the peak-to-peak widths for bare YIG and Bi_2Se_3/YIG; (b) The voltage signals of Bi_2Se_3/YIG measured simultaneously with FMR spectra.

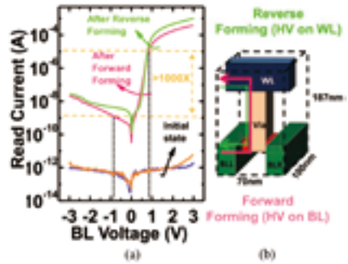


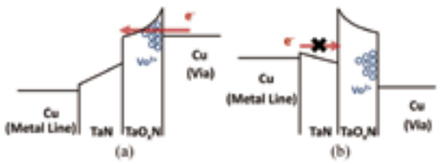
Spin pumping in TI/YIG

Fig. 4 ST-FMR voltage signal versus external field obtained at several frequencies for YIG(25 nm) /Pt(10nm) bilayer.

Self-Rectifying Twin-bit RRAM in 28nm CMOS Process
Prof. J. Raynien Kwo







A new self-rectifying twin-bit RRAM has been successfully demonstrated in TSMC 28nm HKMG CMOS BEOL process. Fig. 1 shows the TEM of twin-bit RRAM cell with selected right bit. The MIM structure of RRAM, which consists of Cu/TaN/TaO_xN/Cu, is well-defined between M1 and via. Without any additional mask or process, this twin-bit RRAM cell can be easily fabricated and shows large read window between states. The transfer functions of bipolar RRAM switching are demonstrated in Fig. 2 with over 1000 times of read current ratio.

The twin-bit RRAM also have its own self-rectifying characteristics. The initially symmetric device can be transformed into a self-rectifying RRAM indifference to its forming directions. And the self-rectifying characteristic only occurs at low resistive state causing different current level in different directions, as shown in Fig. 3. With proper forming/set operations, oxygen vacancies (Vo^{2+}) would generate at the surface junction of Cu and TaO_xN. The energy diagram of different read directions are demonstrated in Fig. 4 and 5. The excellent selectivity by its asymmetric IV characteristic enables this twin-bit RRAM cells to be efficiently stacked in 3D cross-point arrays.

MediaTek-NTHU Research Center Fuels the Development of Future Generation Smart Mobile Devices

MediaTek Inc. and National Tsing Hua University have joined hands to establish the MediaTek-NTHU Research Center in March 4, 2014. By combining the world's leading IC design technologies of MediaTek and the top-rate faculty and research capabilities of National Tsing Hua University, the center is tasked with the mission of developing the most advanced technologies for future generation smart mobile devices. The tight cooperation between MediaTek and NTHU through the center is expected to foster innovative, forward-looking technologies that ensure Taiwan's industry a competitive edge in the future global market and a continual supply of top quality researchers and engineers.

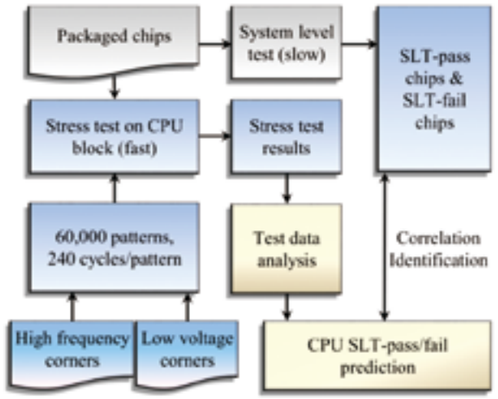


Figure 1.
The correlation mining flow for stress test and SLT.

The center is currently undertaking a number of advanced joint research projects. The project, "System-Level Test Coverage Prediction by Structural Stress Test Data Mining" led by Prof. Cheng-Wen Wu, studies ways in which the high cost *system-level test* (SLT) can be replaced by the lower cost structural stress tests, while at the same time maintaining the test quality. The project applies structural stress tests to the CPU block of a real SOC product and tries to identify the correlation between the stress test data and SLT-pass/fail results of the CPU block (see the correlation mining flow below). By comparing with previous works, 91% of the total CPU-fail suspects matched. This research shows more evidences that test data mining can be further explored for test time reduction and/or quality improvement.

In the project, "Enable OpenCL Runtime on HSA Platform", Prof. Jenq-Kuen Lee and his students are working hard to enable the OpenCL, a programming framework for parallel computing on heterogeneous architecture, on the industry open standard HSA (Heterogeneous System Architecture) platform. The project builds the OpenCL runtime by extending PoCL (Portable Computing Language) framework, a portable OpenCL implementation for different parallel hardware. The developed runtime can pass most benchmarks from AMD APP SDK 2.8, and it has been posted on the official HSA Foundation GitHub for downloading by researchers worldwide.

The project, "Spatial Modulation with Massive MIMO over mmWave Channel" led by Prof. Jen-Ming Wu, considers using the "millimeter wave (mmWave) channel" in the next generation (5G) wireless systems to provide 10 times better data rate than current 4G-LTE systems. The challenge is to overcome the high pass loss. This project exploits the massive MIMO approach to combat the large path loss. The idea is to combine massive MIMO (64 antennas), hybrid-beamforming and spatial modulation to enable efficient allocation of different MIMO gains to achieve either higher spectral efficiency or energy efficiency. The Beam-Indexed Spatial Modulation (BISM) method is proposed, which generalizes spatial modulation from antenna level to beam level and use multiple RF chains to support spatial multiplexing and different MIMO modes.

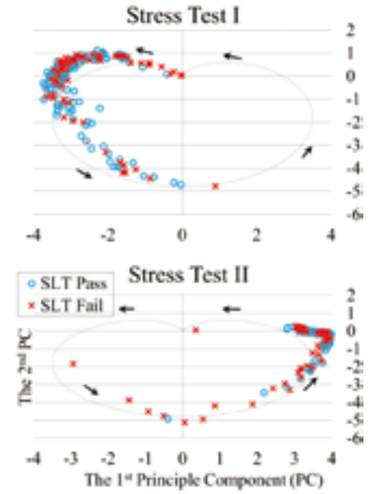


Figure 2. The transformed test data distribution in different stress corners.

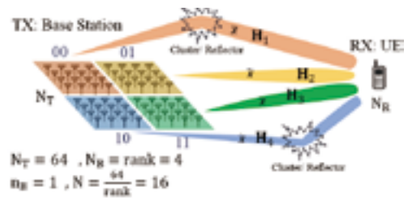


Figure 3. The BISM architecture based on antenna grouping for rank = 4.

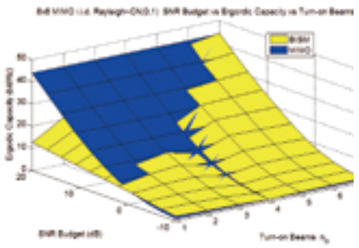


Figure 4. Ergodic capacity simulation over 8x8 Rayleigh channel for different turn-on beam and energy budget. BISM (Yellow surface) is better than MIMO-BF (Blue surface) when yellow surface is over blue one.

Research Highlights

Research Highlights

Natural Sciences

▼ Microfluid Chemostat for the growth of bacteria

Prof. Sze-Bi Hsu
Department of Mathematics

Bacteria culture is a fundamental technique in microbiology. Traditionaly bacteria culture method uses chemostat which was invented in 1950 by Novick and Szilard ,to maintain a nearly steady population for microbiology study, such as carbon metabolism, antibiotic resistance, population dynamics and survival of population. Recent technological advances in microfluidics has enable researchers to develop microfluidic bioreactor from micro to nano liter scale for various applications such as enzyme yield optimization, system biology etc. The researchers are able to design microfluidic chip with almost arbitrary complexity. In this collaborated research with Prof. Ya-Tang Yang (EE,NTHU) we develop a mathematical theory of models for the growth of planktonic and biofilm bacteria in microfluid chemostat. By mathematical analysis we establish the criteria for the extinction and persistence of both population. We expect the theory will be useful for the design of microfluidic devices for microbial competition and microbial biofilm growth which is crucial to understand the effect of drug resistance.

http://www.math.nthu.edu.tw/~sbhsu
http://kishony.med.harvard.edu

▼ Patterns and waves in activator-inhibitor systems

Prof. Chao-Nien Chen
Department of Mathematics

Reaction-diffusion systems serve as models for studying pattern formation in science. For an activator-inhibitor system, an important subject is to understand the mechanism based on the interaction between activators and inhibitors. Although many interesting phenomena have been observed in experiment and numerical simulation, we need new ideas for the mathematical analysis to find out the fundamental and intrinsic properties in such a chemical process. Particle-like structures are commonly observed in various fields of science; for instance, the nerve pulses in biological systems, concentration drops in chemical systems and current filaments in physical systems. In recent years, we developed new techniques in calculus of variations to establish the existence of localized patterns and waves. In order to capture the generation of self-organized patterns and waves, we utilized index theory to derive several criteria to distinguish stable and unstable solutions. In addition, our results give very precise and detailed information on the profiles of localized waves. It can enlighten new links and potential applications to some areas of mathematical biology or physiology.

http://www.math.nthu.edu.tw/people/bio.php?PID=745

▼ Representation theory of Lie groups

Prof. Meng-Kiat Chuah
Department of Mathematics

I study the representation theory of noncompact Lie groups, and extend Gelfand's notion of model to a more general sense. This leads to a model of certain representation series, where every irreducible representation of that series occurs once in the given unitary representation. This includes the model of discrete series, principal series, as well as the H-series which combines them. The results are published in:

M. K. Chuah, Partially harmonic forms and models of H-series, *Journal of Functional Analysis* **266** (2014), 2740-2764.

I have academic interaction with Prof. R. Fioresi of University of Bologna, Italy. Her interest lies in the representation theory of Lie supergroups, and she finds that my technique of Dynkin diagram efficiently handles the root system. We obtain results in root systems of contragredient Lie superalgebras, published in: M. K. Chuah and R. Fioresi, Hermitian real forms of contragredient Lie superalgebras, *Journal of Algebra* **437** (2015), 161-176.

I collaborate with Prof. J. S. Huang of the Hong Kong University of Science and Technology. We successfully incorporate Dirac cohomology into geometric quantization, and hence use Dirac cohomology to construct a model of discrete
series. This important result is published in:

M. K. Chuah and J. S. Huang, Dirac cohomology and geometric quantization, *Journal für die Reine und Angewandte Mathematik*, to appear.

http://www.math.nthu.edu.tw/people/bio.php?PID=47

▼ Linear Independence of Multiple Zeta Values in Characteristic p

Prof. Chieh-Yu Chang
Department of Mathematics

In this project, we study transcendence theory of the multiple zeta values in characteristic p. We show that they form a graded algebra. This result is the analogue of Goncharov's conjecture for classical multiple zeta values.

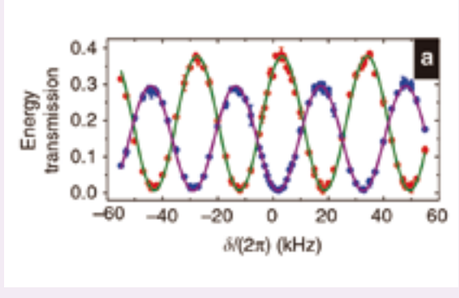
http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=9427627&fulltextType=RA&fileId=S0010437X1400743X

▼ Spinor Slow Light

Prof. Ite A. Yu
Department of Physics

In the collaboration with a Lithuanian theory group, we report the first experimental observation of two-component or spinor slow light (SSL) using the double-tripod (DT) atom-light coupling scheme. Based on the storage of light, our data showed the DT scheme behaves like the two outcomes of an interferometer enabling precision measurements of frequency detuning. As for the nonlinear frequency conversion, our study suggests that the SSL is a better method than a widely used double-Λ scheme. Single-photon SSL can be considered as the qubit with the superposition state of two frequency modes or, simply, as the two-color qubit. We also demonstrated a possible application of the DT scheme as quantum memory (and quantum rotator) for the two-color qubit with high fidelity after a storage time of 30μs. This work opens up a new direction in the slow light research, which may result in novel applications in quantum information manipulation, precision measurement and nonlinear optics.

http://www.nature.com/ncomms/2014/141124/ncomms6542/abs/ncomms6542.html



▼ Electrical Field Effect and Spin Pumping of Topological Insulator Thin Films

Prof. J. Raynien Kwo
Department of Physics

The efficient manipulation of magnetization via pure spin current is of upmost importance for spintronic research. To achieving even lower critical switching current viable for magnetic memory, topological insulators (TIs) are promising materials due to their dissipationless spin transport from the helical Dirac fermions, and spin-momentum locked surface states. We have recently incorporated TIs into ferromagnetic heterostructures, and effectively modulated the Fermi level in gate biased devices by employing high-κ dielectrics. High quality 3-D TI thin films of Bi_2Se_3 and Bi_2Te_2Se have been obtained by van der Waals epitaxy on atomic-layer-deposited high-κ dielectrics such as Al_2O_3, and Y_2O_3/Al_2O_3 multilayers using molecular beam epitaxy. Large electrical gating effect has been demonstrated: the modulation of resistance can reach 1200%, and the E_F is tuned into the band gap with the applied bias an order smaller relative to conventional SiO_2 back gate.

Moreover, spin pumping and ST-FMR measurements were also conducted to quantify pure spin current phenomena and to investigate the spin transfer mechanism between TIs and magnetic nanostructures. The charge current densities generated for ferromagnetic metals (FMs) deposited on TIs are about 2-5 times higher than typical FMs on normal metal results, and were attributed to strong SOC inherent of TIs.[1] Furthermore, the well-defined interfaces of *YIG*/Bi_2Se_3 bi-layers enabled the observation of uncommon ferromagnetic resonance characteristics, and was attributed to be the signature of topological interface states. The manifestation of room temperature topological surface states via spin pumping suggests high feasibility of Bi_2Se_3 for spintronic applications in future.

1. http://scitation.aip.org/content/aip/journal/jap/117/17/10.1063/1.4918631

▼ Functional helical silica nanofibers with coaxial mixed mesostructures for the fabrication of PtCo nanowires that display unique geometry-dependent magnetism

Prof. Chia-Min Yang
Department of Chemistry

We have discovered a confinement-free synthesis of chloropropyl-functionalized mesoporous silica nanofibers with coaxial helical/columnar mesostructures. With the organic groups mainly localized at the center, the nanofibers have been applied for the selective inclusion of Pt and/or Fe_2O_3. We have also fabricated 3-nm-wide ferromagnetic PtCo helical nanowires and exhibited distinct ferromagnetic properties as compared with their straight counterpart. The results show the uniqueness of the functional nanofibers and the tremendous opportunities for use in innovative applications.

NPG Asia Materials (2015) 7, e181; doi:10.1038/am.2015.39
http://www.nature.com/am/journal/v7/n5/full/am201539a.html

▼ Synthesis of naphthyridine and indolo[3,2-*a*]carbazole and their applications in organic light-emitting diodes (OLEDs)

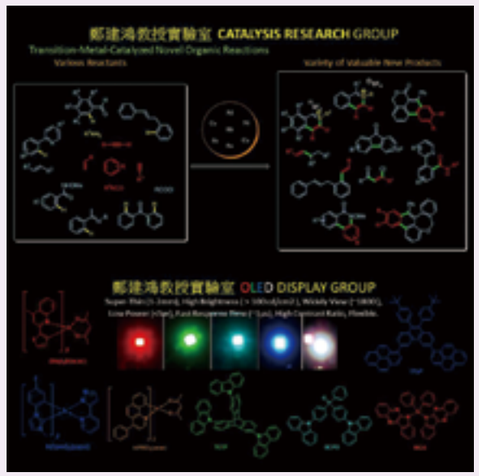
Prof. Chien-Hong Cheng
Department of Chemistry

Prof. Chien-Hong Cheng is interested in transition-metal catalyzed novel organic reaction and the development of materials for organic light-emitting diode.

Our group designed new metal complexes as catalysts to synthesize natural product or bioactive molecules efficiently. Selective carbon-carbon bond formation through reductive coupling reaction or C-H bond activation by transition-metal catalyst provided a new concept and method in organic synthesis. In 2014, we have successfully developed a simple and effective method for the synthesis of highly substituted naphthyridine-based polyheteroaromatic compounds in high yields proceeds through rhodium(III)-catalyzed multiple C-H bond cleavage and C-C and C-N bond formation in a one-pot process. Furthermore, a possible mechanism, which involves multiple chelation-assisted *ortho* C-H activation, alkyne insertion, and reductive elimination, is proposed for this transformation. Because of their unique π-conjugation, which make them suitable materials for organic semiconductors and luminescent materials.

Our group also developed the novel host materials to apply in RGB and white phosphorescence OLEDs. In 2015, we present for the first time three new indolocarbazole-based materials (ICDP, 4ICPPy, and 4ICDPy) composed of 6,7-dimethylindolo[3,2-*a*] carbazole and phenyl or 4-pyridyl group for hosting blue, green, and red phosphors. The twisted conformations of the indolocarbazole and phenyl or 4-pyridyl group in these materials greatly reduce the π–conjugation and thus retain the high triplet energy for energy transfer to the phosphors. Compared with ICDP, 4ICPPy and 4ICDPy give higher thermal stability, homogeneous morphology, and balanced carrier transporting ability because of the incorporation of 4-pyridyl moiety. Among this three host materials, 4ICDPy-based devices reveal the best electroluminescent performance with maximum EQEs of 22.1%, 27.0%, and 25.3% for blue (FIrpic), green (*fac*-$Ir(ppy)_3$), and red ($(piq)_2Ir(acac)$) PhOLEDs. A two-color and single-emitting-layer WOLED hosted by 4ICDPy with FIrpic and $Ir(pq)_3$ as dopants achieves high external quantum efficiency (EQE) of 20.3% and power efficiency (PE) of 50.9 lm/W with good color stability; this performance is among the best for a single-emitting-layer white PhOLEDs. All 4ICDPy-based devices show low efficiency roll-off probably due to the excellent balanced carrier transport arisen from the bipolar character of 4ICDPy.

http://mx.nthu.edu.tw/~chcheng/
http://onlinelibrary.wiley.com/doi/10.1002/anie.201405183/abstract



▼ A study of a millisecond pulsar binary system at different evolutionary states by using the NuSTAR high-energy X-ray telescope

Prof. Albert Kong
Institute of Astronomy

In this study, we used the world's first hard X-ray imaging telescope to study a millisecond pulsar (MSP) binary system in different evolutional states. This system has been shown transiting between a low-mass X-ray binary (LMXB) state and a rotation-powered MSP state. The NuSTAR observations were taken in both LMXB state and rotation-powered state. The source is clearly seen in both states up to ~79 keV. During the LMXB state, the 3-79 keV flux is about a factor of 10 higher than in the rotation-powered state. The hard X-rays show clear orbital modulation during the X-ray faint rotation-powered state but the X-ray orbital period is not detected in the X-ray bright LMXB state. We suggest that the hard X-rays are due to the intrabinary shock from the interaction between the pulsar wind and the injected material from the low-mass companion star. During the rotation-powered MSP state, the X-ray orbital modulation is due to Doppler boosting of the shocked pulsar wind. At the LMXB state, the evaporating matter of the accretion disk due to the gamma-ray irradiation from the pulsar stops almost all the pulsar wind, resulting in the disappearance of the X-ray orbital modulation.

http://iopscience.iop.org/0004-637X/797/2/111/

▼ Proposing a new distance measure to *z*>6 using sub-millimeter galaxies

Prof. Tomo Goto
Institute of Astronomy

A key question in understanding Dark Energy is whether it varies over time. Type Ia supernovae have been used to map the accelerating expansion of the universe to z~1.7 (Riess et al. 1998; Perlmutter et al. 1999, ApJ,517, 565), receiving a Nobel prize in 2011. However, type Ia Supernovae cannot be used to measure distances much further. The rate of events declines at higher redshift due to the time delay of supernova explosion (Rodney et al. 2014, AJ, 148,13). They are too faint to be observed in the more distant Universe even with the largest telescopes to date. To constrain the time dependence of dark-energy equation of the state parameter, w, it is necessary to observe the Universe at higher redshift in order to break degeneracies between cosmological models (Linder & Huterer 2003, Phys. Rev. D, 67, 081303; King et al. 2014, MNRAS, 441, 3454). In this regard, a new, more luminous standard candle that can be observed in the more distant Universe is needed.

In Goto & Toft (2015, A&A accepted, arXiv:1505.00013), we proposed a new distance measure to z~6 using *L'CO*-FWHM correlation of sub-millimeter galaxies (Fig.1). **Our new method can measure distances to z~6, and potentially can bring a breakthrough to the field** (c.f. Type Ia supernovae are at z<1.7). To exploit this method, I plan to carry out a large survey with ALMA, to measure accurate distances to z~6, and thereby **to constrain the time variability of Dark Energy in the early, previously unexplored Universe.**

http://dx.doi.org/10.1051/0004-6361/201526062

▼ Discovery of occultation events caused by Trans-neptunian Objects of sub-kilometer size

Prof. Hsiang-Kuang Chang
Institute of Astronomy

A team led by Prof. Hsiang-Kuang Chang of the Institute of Astronomy, in collaboration with researchers at Paris Observatory, discovered 13 Trans-Neptunian Objects (TNOs) of sub-kilometer size with the method of occultation. This result was published in Monthly Notices of the Royal Astronomical Society (MNRAS). MNRAS is a major international journal in astronomy and astrophysics, published by Oxford University Press.

The formation of the sun and its planetary system is an important issue in astronomy. It is generally believed that beyond the orbit of Neptune there is a resevoir of small celestial bodies, which not only account for the origin of comets but also encrypt the early history of the solar system formation. Those small ones, of kilometer size or even smaller, are too dim to oberve. Their population properties, such as total amount and size distribution, record the physical condition of the early solar system.

This NTHU-Paris Observatory collaboration team analyzed a huge amount of asteroseismology data taken with CoRoT(COnvection ROtation and planetary Transits) satellite, a mission led by CNES and ESA, and found 13 sub-kilometer TNOs. The TNO size distribution at sub-kilometer size range inferred from this discovery implies a wavy shape for that distribution across different size ranges. This result obviously poses clear constraints, if not challenges, to all the existing theoretical models of the solar system formation.

http://mnras.oxfordjournals.org/content/446/1/932

Research Highlights

Engineering and Applied Sciences

▼ Dismantling Planetary Systems: Revealing the Imprint of Extra-solar Planet-Planet Interactions

Prof. Ing-Guey Jiang
Institute of Astronomy

The discoveries of extra-solar planets have opened up humans' view towards other parts of the Universe as there could be something similar with our Solar system, our Earth, or even ourselves. Most extra-solar planetary systems are known to have one planet only but there are getting more multiple planetary systems now.

In order to study the possible planet-planet interactions within multiple planetary systems, we took the latest data and calculated the period-ratio and mass-ratio of adjacent planet pairs. A positively correlated distribution is found and confirmed. This indicates that some kind of relations in terms of periods and masses were set up between adjacent planet pairs through planet-planet interactions during their formation and evolutionary stages. Thus, we found the imprint of extra-solar planet-planet interactions.

Our results are published in one of the top journals as a letter, i.e. MNRAS Letters, on May 1, 2015.

http://mnrasl.oxfordjournals.org/content/449/1/L65
http://arxiv.org/abs/1501.03562

▼ Magnetic Field Structure in the Flattened Envelope and Jet in the Young Protostellar System HH 211

Prof. Shih-Ping Lai
Institute of Astronomy

HH 211 is a young Class 0 protostellar system with a flattened envelope, a possible rotating disk, and a collimated jet. We have mapped it with the Submillimeter Array in the 341.6 GHz continuum and SiO J = 8-7 at ~0."6 resolution. The continuum traces the thermal dust emission in the flattened envelope and the possible disk. Linear polarization is detected in the continuum in the flattened envelope. The field lines implied from the polarization have different orientations, but they are not incompatible with current gravitational collapse models, which predict a different orientation depending on the region/distance. Also, we might have detected for the first time polarized SiO line emission in the jet due to the Goldreich-Kylafis effect. Observations at higher sensitivity are needed to determine the field morphology in the jet.

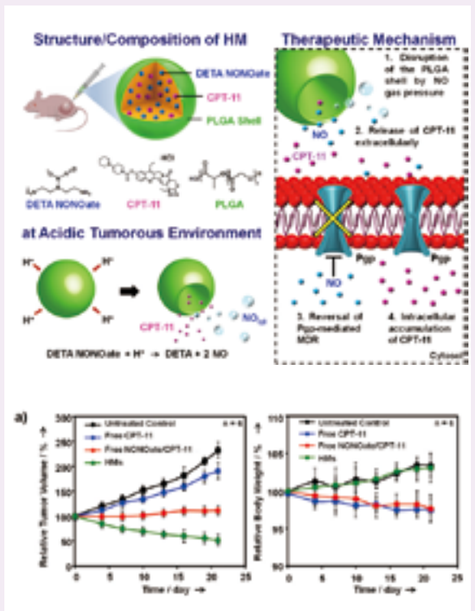
http://iopscience.iop.org/2041-8205/797/1/L9/

▼ A pH-Responsive Carrier System that Generates NO Bubbles to Trigger Drug Release and Reverse P-Glycoprotein-Mediated Multidrug Resistance

Prof. Hsing-Wen Sung
Department of Chemical Engineering

Multidrug resistance (MDR) resulting from the overexpression of drug transporters such as P-glycoprotein (Pgp) increases the efflux of drugs and thereby limits the effectiveness of chemotherapy. To address this issue, this work develops an injectable hollow microsphere (HM) system that carries the anticancer agent irinotecan (CPT-11) and a NO-releasing donor (NONOate). Upon injection of this system into acidic tumor tissue, environmental protons infiltrate the shell of the HMs and react with their encapsulated NONOate to form NO bubbles that trigger localized drug release and serve as a Pgp-mediated MDR reversal agent. The site-specific drug release and the NO-reduced Pgp-mediated transport can cause the intracellular accumulation of the drug at a concentration that exceeds the cell-killing threshold, eventually inducing its antitumor activity. These results reveal that this pH-responsive HM carrier system provides a potentially effective method for treating cancers that develop MDR.

http://onlinelibrary.wiley.com/doi/10.1002/anie.201504444/abstract



▼ Online estimation and monitoring of local permeability in resin transfer molding
▼ Steady state identification and multivariate statistical process monitoring of batch-to-batch startups
▼ Multivariate control performance assessment and control system monitoring via hypothesis test
▼ Improved non-destructive testing of carbon fiber reinforced polymer (CFRP) composites using pulsed thermograph

Prof. Yuan Yao
Department of Chemical Engineering

▼ Resin transfer molding (RTM) is a popular manufacturing method of composite materials. In RTM, permeability of fiber reinforcement varies with its geometric formation and affects the property of resin flow, which influences the final product quality. Therefore, effective estimation of permeability is crucial to achieving good process control and satisfactory quality product. In this research, a method of online estimating and monitoring local permeability is proposed based on flow visualization. It can deal with variation in local permeability within preform caused by irregular arrangement of fibers among different regions.

▼ Usually, batch processing can be divided into two stages: batch-to-batch start-up and steady-state operation. During the runs in start-up, incoming materials usually have not been mixed well, while material properties and machine conditions have not been stabilized. Consequently, the batch operations in start-up are unsteady. Reliable products are only manufactured in steady-state batch operations. Therefore, an efficient method for batch process steady-state identification (SSID) is desired. Variable trajectories in batch processes are often composed of three levels of signals: high-frequency noise, within-batch variations and disturbances, and long-term trend from batch to batch. The SSID information is only contained in the long-term trend. Moreover, because of the existence of long-term trend, the batch process data in the start-up stage do not obey multivariate normal distribution. As a result, statistical process monitoring cannot be applied to the start-up process data directly. To solve both problems, ensemble empirical mode decomposition (EEMD) is adopted in this research to analyze batch process data. Based on the long-term trend signal, SSID can be performed by using statistical hypothesis testing. In addition, after removing the long-term trend, the batch process data during start-up obey the normal distribution assumption and can be monitored using the coventional statistical methods.

▼ Control loops widely exist in industrial processes, whose performance directly influences the efficiency, safety, and product quality of production plants. Therefore, control performance assessment (CPA) and control system monitoring (CSM) are critically important for industrial processing. In consideration of multivariate control systems, the covariance matrix of closed-loop outputs plays an important role in both CPA and CSM. In this research, a multi-objective scheme is proposed for both CPA and CSM of multivariate control systems, which takes the entire covariance matrices into account by conducting a hypothesis test on the equality of the matrices.

▼ Pulsed thermography (PT) is a widely used non-destructive testing (NDT) method for detecting defective regions in carbon fiber reinforced polymers (CFRP) structures. The conventional PT data processing methods only perform data filtering along the time direction, while the spatial information is not exploited for noise reduction. In addition, the non-uniform backgrounds commonly existing in thermal images cannot be handled. To get around these problems, this research extends the utilization of the penalized least squares methods to defect detection in CFRP structures. The experiment results show that, with the aid of penalized least squares, the defective regions in thermal images are characterized more clearly, while the signal-to-noise ratio (SNR) values are increased significantly.

http://onlinelibrary.wiley.com/doi/10.1002/pc.23290/abstract

http://www.4spepro.org/view.php?article=005728-2015-01-19

http://www.sciencedirect.com/science/article/pii/S0169743914001634

http://onlinelibrary.wiley.com/doi/10.1002/aic.14939/abstract

http://pubs.acs.org/doi/abs/10.1021/ie502743f
http://www.sciencedirect.com/science/article/pii/S1359836815002875

http://www.sciencedirect.com/science/article/pii/S0142941815001488

▼ Enhancement of energy usage efficiency – Development of thermoelectric materials

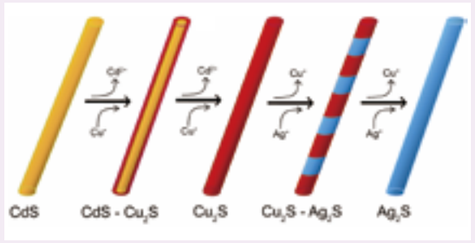
Prof. Sinn-wen Chen
Department of Chemical Engineering

Energy consumption increases, while supply is limited. Enhancement of energy usage efficiency and more sources of renewable energies are critical for sustainability. Thermoelectric devices have attracted great interests due to their abilities to convert waste heat directly into electricity and thus enhance the energy usage efficiency. Materials with higher figure of merits and devices of better efficiencies are the top issues of thermoelectric studies. Research teams of Caltech and National Tsing Hua University work together on thermoelectric materials with financial support from Ministry of Science and Technology. Professor G. Jeffrey Snyder from Caltech is the leading expert in thermoelectric materials design and property measurements. Professor Sinn-wen Chen from NTHU is specialized in phase diagram determinations and reaction mechanism analysis. They found doping of Ce into $CoSb_3$ can significantly enhance the figure of merit of $CoSb_3$ to 1.3. The results are published in the 7/20/2015 issue of Nature Communication. They also found the figure of merit of $CoSb_3$ can be as high as 1.2 with doping of In, and the results are published in the Journal of Energy and Environmental Science.
http://www.nature.com/ncomms/2015/150720/ncomms8584/full/ncomms8584.html

▼ Sequential cation exchange generated superlattice nanowires forming multiple p-n heterojunctions

Prof. Lih Juann Chen
Department of Materials Science and Engineering

Fabrication of superlattice nanowires (NWs) with precisely controlled segments normally requires a sequential introduction of reagents to the growing wires at elevated temperatures and low pressure. Here we demonstrate a new approach to fabricating superlattice NWs possessing multiple p-n heterojunctions by converting the initially-formed CdS to Cu_2S NWs first and then to segmented Cu_2S–Ag_2S NWs through the sequential cation exchange at low temperatures. In the formation of Cu_2S NWs, twin boundaries generated along the NWs act as the preferred sites to initiate the nucleation and growth of Ag_2S segments. Varying the immersion time of Cu_2S NWs in a $AgNO_3$ solution controls the Ag_2S segment length. Adjacent Cu_2S and Ag_2S segments in a NW were found to display the typical electrical behavior of a p-n junction.
ACS Nano 8, 9422-9426 (2014)



▼ Large-Scale Micro- and Nanopatterns of Cu(In,Ga)Se2 Thin Film Solar Cells by Mold-Assisted Chemical-Etching Process

Prof. Yu-Lun Chueh
Department of Materials Science and Engineering

A reactive mold-assisted chemical etching (MACE) process through an easy-to-make agarose stamp soaked in bromine methanol etchant to rapidly imprint larger area micro- and nanoarrays on CIGS substrates was demonstrated. Interestingly, by using the agarose stamp during the MACE process with and without additive containing oil and triton, CIGS microdome and microhole arrays can be formed on the CIGS substrate. Detailed formation mechanisms of microstructures and the chemical composition variation after the etching process were investigated. In addition, various microand nanostructures were also demonstrated by this universal approach. The microstructure arrays integrated into standard CIGS solar cells with thinner thickness can still achieve an efficiency of 11.22%, yielding an enhanced efficiency of ~ 18% compared with that of their planar counterpart due to an excellent absorption behavior confirmed by the simulation results, which opens up a promising way for the realization of high-efficiency micro- or nanostructured thin-film solar cells. Finally, the complete dissolution of agarose stamp into hot water demonstrates an environmentally friendly method by the mold-assisted chemical etching process through an easy-to-make agarose stamp.
http://pubs.acs.org/doi/abs/10.1021/acsnano.5b00701

▼ Nano-to-Microdesign of Marimo-Like Carbon Nanotubes Supported Frameworks via In-spaced Polymerization for High Performance Silicon Lithium Ion Battery Anodes

Prof. Jenq-Gong Duh
Department of Materials Science and Engineering

Silicon (Si) has been perceived as a promising anode material for lithium-ion batteries for decades due to its superior theoretical capacity, environmental benignity, and earth abundance. To accommodate the drastic volume expansion during lithiation, which is the primary drawback leading to poor cycling life, a novel structural design via fabricating the Marimo-like carbon nanotubes frameworks with silicon nanoparticle (SiNP) filling in internal space has been developed. This facile fabrication procedure involves an in-spaced polymerization process through ex situ polymerization, using pyrrole monomers with a soft organic template in which well-dispersed SiNPs are present. Carbonization post-treatment is then performed to construct rigid conductive networks. The thus-fabricated 3D Marimo-like hybrid structure exhibits a remarkably improved electrochemical performance compared with that of the simple ball-milling method, which mainly originates from their structural advantages, including the built-in buffer spaces and the robust line-to-line contact mode between the components. The state-of-the-art structure exhibits an optimal high-rate capability (422 mAh g-1 at a current rate of 2 A g-1) and long cycling stability (916 mAh g-1 for 200th cycles at a current rate of 0.2 A g-1) and achieves the requirements for industrial production with the facile and cost-effective synthetic approach.
http://onlinelibrary.wiley.com/resolve/doi?DOI=10.1002/smll.201402952

▼ Non-stoichiometric $W_{18}O_{49-x}S_x$ nanowires for wide spectrum photosensors with high internal gain

Prof. Tri-Rung Yew
Department of Materials Science and Engineering

This study reports successful synthesis of non-stoichiometric single-crystal $W_{18}O_{49-x}S_x$ nanowires for photosensors with a high absorption rate (>83%) across a wide spectrum (300-2000 nm), a high internal gain ($G = 10^6$-10^7) and a relatively fast response time (approximately 1-3 s). In addition, the correlation between the photoconductivity gain (G) and the surface-to-volume ratio of non-stoichiometric single-crystal $W_{18}O_{49-x}S_x$ nanowires was studied. The surface-to-volume ratio and non-stoichiometric material of $W_{18}O_{49-x}S_x$ contributed to the photoconductivity gain; hence, the nanowires are favorable for photosensor devices. The wide spectrum obtained also suggests their extensive applications in numerous fields.
http://nanoscale18.rssing.com/browser.php?indx=5372174&item=8428

▼ New light-quality index

Prof. Jwo-Huei Jou
Department of Materials Science and Engineering

Natural light provides joyful and comfortable sensations. The light to which human beings are most accustomed is none other than the natural light. Taking natural light as the basis for light-quality quantification is hence justified. Meanwhile, artificial lights should be designed, developed, and characterized in light of this. Besides, macular degeneration or other eye damages would be resulted if one 'unnaturally' uses all day long "light bulbs" with a fixed color temperature, especially those with a blue-enriched and blue-hazard causing white light. Moreover, DOE of the United States announced in 2013 in the SSL Research and Development Multi-Year Program Plan that new light quality index be developed before 2020 to correctly describe light chromaticity. We had, on the other hand, published a paper entitled 'A universal, easy-to-apply light-quality index based on natural light spectrum resemblance' in 2014 APL, volume 104, 203304, a new light-quality index, namely SRI (natural light spectrum resemblance index, or spectrum resemblance index in short), to replace the current CRI (color rendering index), which will, for example, incorrectly give low pressure sodium lamps a negative index value, to timely echo the call from DOE. Hopefully, truly better pseudo-natural light can hence be designed and fabricated accordingly.
http://onlinelibrary.wiley.com/doi/10.1002/adom.201400366/abstract

▼ Investigation of Novel Photomechanics Methods for Inspecting Stress and Thickness of Materials

Prof. Wei-Chung Wang
Department of Power Mechanical Engineering

In Taiwan, flat panel display (FPD) is one of the most important industries. The residual stresses and thickness non-uniformities of the glass substrates used in the FPD may cause the defect on the display to affect the product yield rate. However, how to measure the stress and thickness distributions of the glass substrate has been a thorny problem in industrial and academic fields. Therefore, Professor Wei-Chung Wang leads his research team to develop the novel optical measurement methods - Transmissivity Extremities Theory of Photoelasticity (TEToP) and Angular Incidence Interferometry (AII) to non-destructively measure the stress and thickness distributions of the glass substrate. Further, they integrate the optical paths and setups of TEToP and AII into one system to construct a prototype of the automatic optical inspection equipment able to perform the stress and thickness measurement simultaneously to response the request of the on-line rapid inspection.

TEToP is a novel low-level stress measurement method developed by integrating the white light photoelasticity and spectrometer. So far, in total 5 invention patents of ROC, US, and CHN with respect to the apparatus and method of TEToP have been issued. TEToP can directly calculate the stress value by the transmissivity spectrum of the specimen. Moreover, with the use of the hyperspectrometer, TEToP can determine the values of the stresses in a line or an area at the same time. Therefore, TEToP can accurately and fast obtain the full-field low-level stress values.

AII is a novel full-field thickness measurement method developed upon the thin film interferometry. Recently, the ROC invention patent with respect to the apparatus and method of AII has been issued. AII can analyze the thickness distribution by using only one interference fringe pattern. Moreover, no special optical component is used in the AII setup. Therefore, fast large-area full-field thickness measurement can be achieved by employing AII. In addition, the cost of equipment is relatively low.

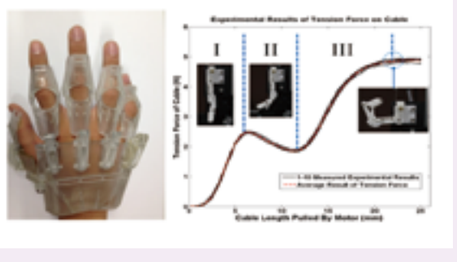
The developed measurement method and inspection system can also be used in other materials which the light ray can penetrate through such as the silicon wafer, light guide plate, optically clear adhesive, substrate of the flexible display, etc. Therefore, it is expected that the developed measurement method and inspection system can be beneficial to Taiwan technology industries.

http://sdj.sagepub.com/content/50/4/252.abstract
http://www.sciencedirect.com/science/article/pii/S0030401814007123

▼ Development of Customized Robotic-Assistive Exoskeleton System for Palm-Finger Physical Rehabilitation

Prof. Jen-Yuan (James) Chang
Department of Power Mechanical Engineering

This research project combines synergies from experienced attending physician and experts in ergonomics and mechatronic research for precision machines to conduct an applied research to develop a physiologically compatible wearable and customized robotic-assistive exoskeleton system for palm-finger dysfunction persons. Approved human trials have been conducted through which calibrated quantitative data on finger force will be collected to help understand degree of damage as well as degree of recovery of the dysfunction persons. The proposed device will also assist the attending physician in studying bio-medical responses from the persons in performing clinically proved palm-finger motions. The design and development of the exoskeleton mechatronic system have taken into account biomedical requirements and physician's needs in medical practice. In addition to pending US and Taiwan patents that will be published alongside with TFDA and US TFDA approvals, a spin-off company based on the technology developed in this research project will be established in December 2015 through NTHU's Center of Innovation Incubation. It is anticipated that the technology developed in this project will not only lead to societal impact of offering precise digital medical treatment for palm/finger impaired persons but also will enable advancement of medical knowledge in palm/finger rehabilitations.



▼ Supercritical CO_2 Brayton Cycle Turbine Blade Analysis

Prof. Hsiao-Wei Chiang
Department of Power Mechanical Engineering

The thermal efficiency of SCO_2 Brayton Cycle has been of importance from the recent literature. However, challenges remain in integration of the overall system including the development of the various components. The purpose of this study is focused on research of the Turbine-Alternator-Compressor (TAC) system. Working with the Metal Industries Research & Development Centre (MIRDC), 8Mpa, 400K, 50kg/s are our design point. With this design point, we have established a supercritical fluid rotor simulation and design system (BladeGen-TurboGrid-CFX-Model). By using data from our previously developed micro-turbine (P-15), our results can be summed up as:

1. High pressure fluid accelerated by guided blade, and converse energy between static pressure and kinetic energy. The kinetic energy of the fluid and the rotor will have higher energy conversion efficiency.
2. The low rotating speed of design point can increase the radius of the rotor and enhance the efficiency, and the low mass flow rate can reduce the radius of the rotor in order to improve efficiency.
3. The greater tangential velocity will cause greater tip clearance, and total pressure difference between the pressure surface and the suction surface. This can be improved by IFG blade shape.
4. The system net power generation is of square to the mass flow rate. Therefore, we expect that the net power generation will be 500W at 0.5kg / s due to such a low mass flow rate.

http://www.swri.org/4org/d18/sCO2/default.htm

▼ User Experience Data-Driven Product Design and Innovation for Consumer Electronics

Prof. Chen-Fu Chien
Department of Industrial Engineering and Engineering Management

Due to increasing global competition, consumer electronics are facing shortening product life cycles and severe time-to-market pressure. NTHU Decision Analysis Lab has developed a framework with systematic methodologies for user experience (UX) data-driven product design and innovation. To effectively extract user preferences over product and the related factors, the proposed framework consists of six stages: (1) understand and define the problem, (2) identify the niche for decision quality improvement, (3) structure the objective hierarchy to generate the alternatives, and clarify the influence relationships among uncertain events, (4) sense and describe expected outcomes, (5) overall judgments and value assessments, (6) tradeoff among the attributes and reach the decision. Sponsored by a world leading EMS firm since 2012 with total funding over NT$10millions, we have conducted a number of empirical studies for notebook computers, tablet PCs, wearable devices, internet of things and smart home products. The derived results and managerial implications have been adopted in this company for supporting related decisions. The results have shown practical viability to assist the designers and decision makers to develop product strategies based on characteristics of consumers and product concepts on the basis of user experience. We have published a number of journal papers and applying invention patents.

http://dalab.ie.nthu.edu.tw/

▼ Energy Planning and Management

Prof. Hsiao-Fan Wang
Department of Industrial Engineering and Engineering Management

After several years' study on green supply chain management, energy planning and management becomes the theme of my research. In particular, this year we have cooperated with Green Energy Department of ITRI to develop a decision support system for the energy forecasting, optimal energy combination and energy pricing of Taiwan.

The results not only supported the government to plan the energy supply, but also inspired the participated students for which they have shown their devotion on both international and domestic academia with CIIE best paper award.

http://softlab.ie.nthu.edu.tw

▼ Digital microfluidic system, In vitro fertilization on chip, Cancer cell and microalgae separation and detection, Intelligent gas sensing system

Prof. Da-Jeng Yao
Institute of NanoEngineering and MicroSystems

Da-Jeng Yao is professor and director at Institute of NanoEngineering and MicroSystems (NEMS), National Tsing Hua University, Taiwan. He received his Ph.D. from Department of Mechanical and Aerospace Engineering, University of California at Los Angeles (UCLA) in 2001. Dr. Yao's current research is to be divided into four categories: Bio-sensing system, including proteins and amino acids detection, DNA sequencing recognition, and electronic nose for odd vapor detection; Neuron Engineering, including multi-electrode arrays for brain research; Bio-sample preparation system, including EWOD (Electrowetting on Dielectrics) on micro fluidic system and surface modification of magnetic nanoparticles for drug delivery development; and Microfluidic Reproductive Medicine on a chip, including motile sperm separation and embryo formation on a digital microfluidic chip. Dr. Yao has published more than 70 Journal papers 250 international conference papers, and 40 patents. He got the best patent and best paper award from Industrial Technology Research Institute (ITRI) in 2010, Wu-Da-Yu Memorial Award (Young Investigator) from National Science Council in 2009, Shen-Yin award in 2010. Young Investigator award from Society of Theoretical and Applied Mechanics of the Republic of China (STAM) in 2013, National Innovation Award in 2012 and in 2014. Nanoscience Award by Publishing Division of Cognizure in 2015.
Dr. Yao is an ASME fellow since 2013.
http://mx.nthu.edu.tw/~djyao

▼ Resonant Transducers using CMOS-MEMS Technology

Prof. Sheng-Shian Li
Institute of NanoEngineering and MicroSystems

My research work conducted at the NTHU mainly focuses on high-*Q* integrated micromechanical circuits using foundry-based "CMOS-MEMS technology" and "encapsulated SOI-MEMS technology" for monolithic MEMS/IC integration. The technology developed here offers small form factor, easy prototyping, fast turnaround time, mass production, low cost, low power, co-optimization and co-fabrication of MEMS/IC. Specifically, my research group leverages IC and semiconductor strength in Taiwan to develop several unique CMOS-MEMS and SOI-MEMS resonator fabrication platforms targeted for inherent integration of MEMS and circuitry, as a result towards single-chip implementation for timing reference, oscillator, filter, switch, and sensor applications. We believe our technology will certainly answer urgent demands of the upcoming Internet of Things (IoT) applications.
http://mx.nthu.edu.tw/~ssli/

▼ A multi-layered interdigitative-electrodes-based triboelectric nanogenerator for harvesting hydropower

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 current. If the following water drops are contacting with the polymer periodically, a continuous output from the TENG will be obtained. The TENG is also utilized to collect the energy of flowing water from a household faucet, which can directly drive commercial 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.
http://linzhatnthu.wix.com/suerte

▼ Food Quality Monitors: Rapid Detection of Biogenic Amine Odorants with Inkjet-Paper-Based Sensors Prepared by Reversal Nanoimprint Technique

Prof. Dehui Wan
Institute of Biomedical Engineering

In this study, we successfully fabricated low-cost, eco-friendly and highly sensitive paper-based plasmonic sensor for the detection of food safety and heavy metal ions. We first prepared molds with monolayer of metal nanoparticles (NPs) via self-assembly. Then, we transferred the metal NPs from the mold onto the paper by nanoimprinting process. 11 types of daily-used papers were examined according to their optical, mechanical and thermal properties, then we found the inkjet paper is an excellent substrate with highly-reflective surface and great stability under the imprinting process. To optimize the imprinting process and the sensibility, we used photos, SEM and AFM images to evaluate the best imprinting parameters. Then, we utilized the optimized paper-based sensor to detect gaseous putrescine for monitoring the freshness of salmon. We found a linear relationship between putrescine concentration and the wavelength redshift of the SPR dip. Finally, real samples spiked with putrescine were used to inspect the sensibility of the paper sensor.
http://www.cna.com.tw/news/ahel/201503275018-1.aspx

▼ Multifunctional nanoparticles for oral delivery of protein drugs

Prof. Hsing-Wen Sung
Institute of Biomedical Engineering

Chemotherapy-induced neutropenia often increases the likelihood of life-threatening infections. In this study, a nanoparticle (NP) system composed of chitosan and poly(γ-glutamic acid) conjugated with diethylene triamine pentaacetic acid (γPGA-DTPA) was prepared for oral delivery of granulocyte colony-stimulating factor (G-CSF), a hematopoietic growth factor. The therapeutic potential of this NP system for daily administration of G-CSF to treat neutropenia associated with chemotherapy was evaluated in a rat model. In vitro results indicated that the procedures of NP loading and release preserved the structural integrity and bioactivity of the G-CSF molecules adequately. Those results further demonstrated the enzymatic inhibition activity of γPGA-DTPA towards G-CSF against intestinal proteases. Additionally, the in vivo biodistribution study clearly identified accumulations of G-CSF in the heart, liver, bone marrow, and urinary bladder, an indication of systemic absorption of G-CSF; its relative bioavailability was approximately 13.6%. Moreover, significant glucose uptake was observed in bone marrow during G-CSF treatment, suggesting increased bone marrow metabolism and neutrophil production. Consequently, neutrophil count in the blood increased in a sustained manner; this fact may help a patient's immune system recover from the side effects of chemotherapy.

▼ *In Vivo* Delivery of miRNAs For Cancer Therapy: Challenges and Strategies

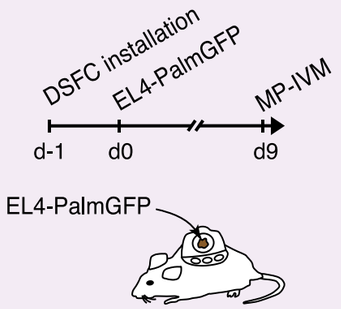
Prof. Yunching Chen
Institute of Biomedical Engineering

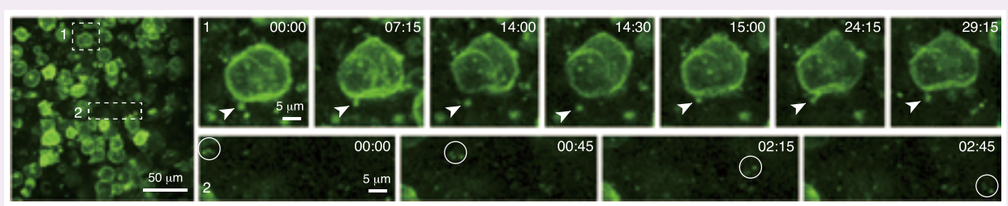
MicroRNAs (miRNAs), small non-coding RNAs, can regulate post-transcriptional gene expressions and silence a broad set of target genes. miRNAs, aberrantly expressed in cancer cells, play an important role in modulating gene expressions, thereby regulating downstream signaling pathways and affecting cancer formation and progression. Oncogenes or tumor suppressor genes regulated by miRNAs mediate cell cycle progression, metabolism, cell death, angiogenesis, metastasis and immunosuppression in cancer. Recently, miRNAs have emerged as therapeutic targets or tools and biomarkers for diagnosis and therapy monitoring in cancer. Since miRNAs can regulate multiple cancer-related genes simultaneously, using miRNAs as a therapeutic approach plays an important role in cancer therapy. However, one of the major challenges of miRNA-based cancer therapy is to achieve specific, efficient and safe systemic delivery of therapeutic miRNAs *in vivo*. This review discusses the key challenges to the development of the carriers for miRNA-based therapy and explores current strategies to systemically deliver miRNAs to cancer without induction of toxicity.
http://www.sciencedirect.com/science/article/pii/S0169409X14001033

▼ Visualization and tracking of tumour extracellular vesicle delivery using multiplexed reporters

Prof. Charles Pin-Kuang Lai
Institute of Biomedical Engineering

Normal and diseased cells release nanometer sized extracellular vesicles (EVs; 100 – 1,000 nm in diameter) which carry DNA, RNA and protein to deliver their cargo, thereby mediating cell-to-cell communications without direct physical contacts between cells. Recent studies have investigated the use of EVs to carry drug compounds as an endogenous therapeutic vehicle. We have previously elucidated important *in vivo* properties of EVs including biodistribution, blood level and renal clearance. Here we further develop multiplexed reporters to visualize spatiotemporal properties of EVs at subcellular levels by a combination of fluorescent (i.e. palmitoylated GFP/tdTomato, bacteriophage MS2 coat protein and its RNA tag) and bioluminescence (*i.e. Gaussia* luciferase) reporters. Using this system, we demonstrate that EVs are dynamically exchanged between multiple cell populations, and witness endogenously transcribed EV-RNA cargo. Translation of EV-delivered mRNA was further shown to occur quickly and within 1-hour post-horizontal transfer between cells. This study shows EV-mediated intercellular communication is dynamic with delivery of functional mRNA cargos, thereby revealing its implication in diseases as well as under therapeutic applications.



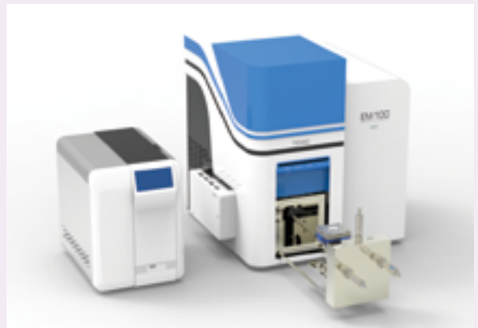


▼ Desktop Electron Microscope

Prof. Fu-Rong Chen
Department of Engineering and System Science

The development of Desktop Electron Microscope (DEM) is now the trend of the EM to use in the bio-technology, to offer the users a more comfortable environment to operate. And we are now successfully develop the first homemade DEM in Taiwan (fig. 1a) and try to enhance the resolution and expand the additional function of the EM system. The CFEM in fig. 1b is the combine of the fluorescence microscope (FM) and EM. This can mark bio-sample on the EM gray level image. By using the permanent magnet lens as a part of aberration corrector, we can enhance the image resolution, while maintain the physical size of the DEM system. Finally, we cooperate with the ITRI to promote a WETSEM to observe the liquid sample It will be the first DEM system which include the FM and WETSEM in the world.

https://www.itri.org.tw/chi/Content/Publications/contents.aspx?SiteID=1&MmmID=2000&MSid=621024041110117540



▼ 1. Bayesian Inference for Neighborhood Filters with Application in Denoising
▼ 2. Five-View Depth-Estimation Processor for Light-field Applications

Prof. Chao-Tsung Huang
Department of Electrical Engineering

1. This work proposes the first statistical model for the powerful image processing tools: bilateral filters and non-local means filter (or neighborhood filters). It can explain their excellent properties and also estimate the parameters empirically from a single image. The neighborhood filters are originally proposed as intuitional tools, and therefore they are used mostly in a heuristic way. This work can fundamentally change this workflow and use them in an empirical Bayesian way. (This work was reported at the top computer vision conference, IEEE CVPR, on Jun 2015.)

2. Light-field cameras will revolutionize how people capture and view pictures. Among different kinds of settings, the sparse light fields can use much less storage space, and therefore are more likely to be massively commercialized in the near future. This work developed the first digital chip design which is capable of estimating depth maps for sparse light fields (five views) of Full HD resolution. While the state-of-the-art designs still focus on two- or three-view systems of standard-definition quality, this work pushes the performance to a new level and also accelerates the commercializing progress of light-field cameras. (This work was reported at the top solid-state circuits conference, IEEE ISSCC, on Feb 2015. This is also a joint work with Prof. Liang-Gee Chen at NTU.)

http://www.ee.nthu.edu.tw/chaotsung/nnm/index.html
http://www.cv-foundation.org/openaccess/content_cvpr_2015/papers/Huang_Bayesian_Inference_for_2015_CVPR_paper.pdf
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7063106

▼ Applications of Nonlinear Control for Fault Ride-Through Enhancement of Doubly Fed Induction Generators

Prof. Chia-Chi Chu
Department of Electrical Engineering

Applications of several nonlinear control laws, including differential geometric approach and the robust variable structure system (VSS) approach, will be investigated for the fault ride-through (FRT) enhancement of the doubly fed induction generator wind power system. In differential geometric approach, both input–output feedback linearization and state feedback linearization will be studied for rotor-side converter and stator-side converter control. In robust VSS approach, supplementary control generated by the complete models is achieved for FRT enhancement. Two objectives, maximizing the active power output as well as regulating the terminal voltage, will be utilized for designing the sliding manifold. Since the proposed methods are based on the general nonlinear system theory, the FRT capability can be indeed improved even under severe fault conditions. Simulations on a one-machine infinite bus system and a two-area four-machine system are presented to validate this result. Performance comparisons among several existing FRT enhanced control will also be examined to show the effectiveness of these nonlinear control schemes.

http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6837475

▼ Millimeter-Wave Transceiver Front-End Circuit Design and Integration

Prof. Jenny Yi-Chun Liu
Department of Electrical Engineering

The research interests are the CMOS millimeter-wave (30 GHz – 300 GHz) receiver and transmitter front-end circuits. With its wide bandwidth, this spectrum can be used for the wireless high-speed communications, real time high quality video streaming, home multimedia entertainment systems, etc. The implemented circuits including the low noise amplifiers, multi-mode wideband oscillators, multi-mode power combined power amplifiers. The research focuses on the novel active and passive component modeling and design, and the innovative circuit architectures to improve their high frequency performance and chip area. Systematic design approaches are proposed. In the past year, we demonstrated 60-GHz and 100-GHz oscillators, power amplifier, and low noise amplifier. Among them, the W-band oscillator achieves a tuning range of 13%, and a -115 dBc/Hz phase noise at 10-MHz at its fundamental. The W-band power amplifier provides more than 15 dBm of output power with proposed power combining and mode control circuits. With transformers as its matching networks, the W-band low noise amplifier has more than 15 dB gain and 7 dB noise figure in a small chip area. The results are published in some international journals and conferences such as International Microwave Symposium, European Integrated Circuits Conference, and Asia Pacific Microwave Conference.

http://www.ee.nthu.edu.tw/jennyliu

▼ Viralets: Learning from Viral Videos to Identify Semantic Highlight in Personal Videos

Prof. Min Sun
Department of Electrical Engineering

We present a novel approach to identify ”semantic“ highlights in personal videos by learning from viral videos. We collected one of the biggest viral video dataset (about 1.5 times the size of [10]) including highlights, original videos, and a large number of comments. The highlights and comments enable us to learn “viralets”, a novel mid-level representation consisting of an overcomplete set of se- mantic and appearance-wise compact concepts. For each viralet, we train a classifier to differentiate relevant high-lights from others (relevance measured from user comments), and treat the classifiers' confidences as our representation. The learned viralets along with pairs of high-lights and non-highlights in viral videos are used to discover domains for training a highlight ranker which outperforms the state-of-the-art ranker [28] with a single do-main. Moreover, viralets are utilized to infer semantics of a highlight by predicting relevant terms. On the challenging task of predicting top 10 terms out of a vocabulary with erms, our proposed method outperforms the state-of-the-art method (adapted from [11]) relying on raw video features by ∼ 4% accuracy (a significant 23% relative improvement). Most importantly, we show that highlight detection is an essential step for inferring important semantics in a video. Without identifying highlights, top 10 terms pre-diction accuracy of our method (i.e., applied on the whole video) is significantly decreased by 8.1%.

http://languageandvision.com/

▼ Energy harvesting systems for wireless sensor networks and machine-to-machine applications

Prof. Ping-Hsuan Hsieh
Department of Electrical Engineering

Remotely powered devices, also known as passively powered devices, have attracted increasing attention in recent years. These devices do not require any internal power source while extracting energy from ambient environment, such as sunlight, thermal energy, electromagnetic waves, and mechanical vibrations. This eliminates the need for batteries and therefore makes the devices especially useful for application scenarios in which battery replacement is impractical or the cost is prohibitively high, including biomedical implants, radio-frequency identification (RFID), environmental monitoring in inaccessible locations, or disaster recovery.

Our research focuses on the interface circuit designs for radio-frequency and vibrational energy harvesting. With efficient power path structure and adaptive control, the RF energy harvesting system demonstrates excellent power conversion efficiency with input power as low as –20 dBm. We have also proposed interface designs that improve the piezoelectric energy harvesting performance at off-resonance. Complex impedance matching at different frequencies is achieved by introducing delay into the conventional switching methods. Analytical results show that, with the electromechanical coupling coefficient k_e^2 of 0.076, the mechanical damping ratio ζ_m of 0.02, and a flipping quality factor of 10, the proposed techniques can improve the 3-dB bandwidth by 76%.

▼ 2D Materials

Prof. Po-Wen Chiu
Department of Electrical Engineering

2D layered materials possess only 1-3 atoms in thickness, with exotic electronic and optoelectronic properties, and have aroused considerable excitement in fundamental and applied research. Its unique properties in devices include the ultra-low power consumption in a field-effect transistors, an important factor for wearable electronic devices, negligible short-channel effect in comparison with the Si-based FETs, and ultrasensitive photoresponsivity that may be used to create novel electronic and optoelectronic devices.

Due to the low dimensionality, any sorts of structural imperfections will be directly reflected in the bandstructure of the 2D materials, changing the charge transport and optical properties. Therefore, looking into the lattice defects of the 2D materials is the first step to understand its physical properties. We report a new class of point defects in single-layer WSe2, which can be created through 60 ° rotations of metal-chalcogen bonds in WSe2 trigonal prismatic lattice, with the simplest among them being a three-fold symmetric trefoil-like defect. The defects, which are inherently related to the crystal symmetry of TMDs, can expand through sequential bond rotations, as evident from in situ scanning transmission electron microscopy (STEM) experiments, and eventually form larger linear defects consisting of aligned 8-5-5-8 membered rings.

http://www.nature.com/ncomms/2015/150402/ncomms7736/full/ncomms7736.html

▼ 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
http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=6803618
http://www.ipec2014.org/pdf/20140514_IPEC2014.pdf
http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=6644277

▼ SMARTANNOTATOR: An Interactive Tool for Annotating Indoor RGBD Images

Prof. Hung-Kuo Chu
Department of Computer Science

RGBD images with high quality annotations, both in the form of geometric (i.e., segmentation) and structural (i.e., how do the segments mutually relate in 3D) information, provide valuable priors for a diverse range of applications in scene understanding and image manipulation. While it is now simple to acquire RGBD images, annotating them, automatically or manually, remains challenging. We present SMARTANNOTATOR, an interactive system to facilitate annotating raw RGBD images. The system performs the tedious tasks of grouping pixels, creating potential abstracted cuboids, inferring object interactions in 3D, and generates an ordered list of hypotheses. The user simply has to flip through the suggestions for segment labels, finalize a selection, and the system updates the remaining hypotheses. As annotations are finalized, the process becomes simpler with fewer ambiguities to resolve. Moreover, as more scenes are annotated, the system makes better suggestions based on the structural and geometric priors learned from previous annotation sessions. See video demo for more details:

https://www.youtube.com/watch?v=TbdsUGWrfpo
http://cgv.cs.nthu.edu.tw/Projects/Smart_Geometry/SmartAnnotator/

▼ Environment-aware wearable applications for assisted living

Prof. Jerry Chou
Department of Computer Science

Global personal mobile device products have gradually moving from smart handhold devices to smart wearable devices. This project aims to develop environment-aware wearable applications for assisted living. In particular, our research is based on a wearable ECG device. The ECG signal can be applied to several healthcare applications. For example, by observing the Heart Rate Variability, we can detect the antagonism of parasympathetic and sympathicus nervous system, and analyze human emotion and brain activity.

The signal collected from sensors can contain lots of noise. So, it must be pre-processed and analyzed before meaningful health information can be extracted or discovered. However, due to the constraints of computation power and battery lifetime, the capability of wearable devices is limited.

In order to store, process and analyze sensor data in real-time fashion, we build a health service platform on cloud. On one hand, it can utilize the unlimited resources in cloud to achieve reliable data store and real-time data process. On the other hand, it allows us to combine the online health signal from sensor with the offline history record from database to conduct more thorough and accurate health data examination. Therefore, our healthcare cloud system is a step to achieve better medicare services.

▼ Pseudo-Multiple-Exposure based Tone Fusion with Local Region Adjustment

Prof. Ching-Te Chiu
Department of Computer Science

New generations of display technologies provide significantly improved dynamic range over conventional display devices. Inverse tone mapping are proposed to convert low dynamic range (LDR) images to HDR ones but they generally require multiple exposure LDR images of the same scene as inputs. However, the vast majority of LDR images and videos available have only one single exposure.

We propose an exposure dependent S curve to convert one normal exposure LDR image to multiple images with different brightness. The S curve enhances the mid-tone regions, avoids saturation in bright regions and boosts intensity in dark regions of an image. In addition, we propose the exposure and region dependent Gaussian weighting functions to fuse multiple images with different brightness. The fused image has enhanced detail in the bright region of the dark image and dark region of the bright image.

According to our implementation results, the dynamic range can reach from 0.0001~100. Compared with other inverse tone mapped images, our results have lower visual difference and higher contrast measure. The emulated multiple exposure tone fusion method can be applied to LDR images to preserve and enhance details of the image.

IEEE Transactions on Multimedia 17(4): 470-484(2015)

▼ Binary & ternary boride-carbide super-Kalvin fused composites

Prof. Swe-Kai Chen
Center for Nanotechnology, Materials Science, and Microsystems

The new fused bulk binary and ternary boride and carbide 3000°C super-Kalvin composites, having solidus temperature of higher than 3000°C, are a better substitute for super alloys as well as refractory high-entropy alloys in the turbine engine applications of aero aviation and nuclear power stations. By rapid high-temperature arc melting, a product of 100% relative density can be achieved. There is also cost effective in raw materials. The compositions can be extended to numerous arrangements. Pilot production is available at present. The composites have values of hardness between 1400 and 2000 HV, and of toughness higher than 11 MPa m $^{1/2}$ at 300 K, while they have values of hardness from 800 to 1450 HV at 1273 K. Abrasion resistance of fused composite against $A_{l2}O_3$ grinding belt is high. Corrosion resistance in 3.5 wt% NaCl solution is good. Hence, the composites are suitable for uses in the manufacturing of tools in oil exploration and tool machining, in the hard-facing of grinding tools and rolls in cement and metal working industries, and in the refractory parts in nuclear power stations, rockets, and aero aviation turbine engines.

▼ Characterization and synthesis of vectorial optical field in the femtosecond time scale, realizing the limit of optical field manipulation

Prof. Shang-Da Yang
Institute of Photonics Technologies

Vectorial Optical Arbitrary Waveform (V-OAW) with ultrafast evolution of amplitude, phase, state of polarization (SOP) that can span up to the entire repetition period (100% duty cycle) is supposed the electromagnetic wave of ultimate complexity in the time/frequency domain. Characterization and synthesis of V-OAW is expected to have unique applications to ultrafast plasmonics.

Unfortunately, the coupling between the vectorial nature and 100% duty cycle of V-OAW prohibits the employment of most of the established ultrafast pulse measurement techniques in characterizing V-OAW. The only demonstrated technique is far from practical because of the requirements of sequentially measuring four pieces of information (the x- and y-polarized pulse shapes, the delay and absolute phase shift between x- and y-polarizations) and a setup of interferometric stability. We proposed and experimentally demonstrated the VECTOR method that can simultaneously measure and synthesize V-OAW by simply measuring two pieces of information (the x-polarized pulse shape and SOP spectrum). The new method is free of any external reference, restriction on the repetition rate (can be more than 100 GHz), and the nearly-common-path configuration is inherently stable.

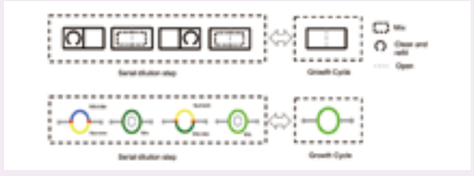
https://www.osapublishing.org/oe/abstract.cfm?uri=oe-22-23-28838

▼ Theory of a microfluidic serial dilution bioreactor for growth of planktonic and biofilm populations

Prof. Yang Ya Tang
Institute of Electronics Engineering

Bacterial cultivation is a fundamental technique in microbiology. Traditional milliliter- to liter-scale bioreactors consume excessive growth medium and are very laborious to maintain and operate. with recent technological advances in microfluidics, nano- to micro-scale microfluidic bioreactors have become available for enzyme yield optimization, systems biology, bioenergy generation and similar investigations. Motivated by our experimental work, we present the theory of a microfluidic bioreactor with a two-compartment growth chamber and periodic serial dilution. In the model, coexisting planktonic and biofilm populations exchange by adsorption and detachment. The criteria for coexistence and global extinction are determined by stability analysis of the global extinction state. Also, the special case of equal uptake function and logistic growth is analytically solved and explicit growth curves are plotted, which can be readily compared with experimental results. The presented theory is applicable to generic microfluidic bioreactors with discrete growth chambers and periodic dilution at discrete time points. Our theory can be used to optimize the design of microfluidic devices for investigating microbial biofilm growth under serial dilution conditions.

Reference: S. B. Hsu and Y. T. Yang, *Theory of a microfluidic se bioreactor for growth of pla biofilm populations*, Journal of Math Biology, DOI 10.1007/s00285-015-0913-0.

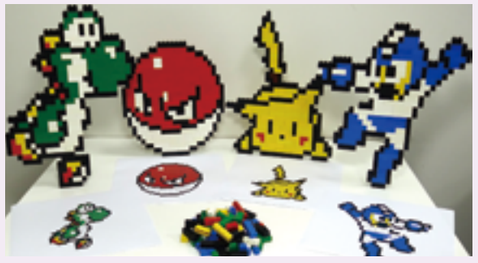


▼ 1.Pixel2Brick: Constructing Brick Sculptures from Pixel Art
▼ 2.Tone- and Feature-Aware Circular Scribble Art

Prof. Hung-Kuo Chu, Prof. Ruen-Rone Lee
Department of Computer Science

1. LEGO, a popular brick-based toy construction system, provides an affordable and convenient way of fabricating geometric shapes. However, building arbitrary shapes using LEGO bricks with restrictive colors and sizes is not trivial. It requires careful design process to produce appealing, stable and constructable brick sculptures. In this work, we investigate the novel problem of constructing brick sculptures from pixel art images. In contrast to previous efforts that focus on 3D models, pixel art contains rich visual contents for generating engaging LEGO designs. On the other hand, the characteristics of pixel art and corresponding brick sculpture pose new challenges to the design process. We propose a novel computational framework to automatically construct brick sculptures from pixel arts. This is based on implementing a set of design guidelines concerning the visual quality as well as the structural stability of built sculptures. We demonstrate the effectiveness of our framework with various bricks sculptures (both real and virtual) generated from a variety of pixel art images. Experimental results show that our system is efficient and gains significant improvements over state-of-the-arts.

2. Circular scribble art is a kind of line drawing where the seemingly random, noisy and shapeless circular scribbles at microscopic scale constitute astonishing grayscale images at macroscopic scale. Such a delicate skill has rendered the creation of circular scribble art a tedious and time-consuming task even for gifted artists. In this work, we present a novel method for automatic synthesis of circular scribble art. The synthesis problem is modeled as tracing along a virtual path using a parametric circular curve. To reproduce the tone and important edge structure of input grayscale images, the system adaptively adjusts the density and structure of virtual path, and dynamically controls the size, drawing speed and orientation of parametric circular curve during the synthesis. We demonstrate the potential of our system using several circular scribble images synthesized from a wide variety of grayscale images. A preliminary experimental studying is conducted to qualitatively and quantitatively evaluate our method. Results report that our method is efficient and generates convincing results comparable to artistic artworks.



▼ Futuristic Interactive Writing Environment

Prof. Jason S. Chang
Department of Computer Science

We have developed a new writing assistance system, WriteAhead, which makes it easy to obtain writing, editing, and translation tips as you type away. For learner-writers, WriteAhead does two things really well. First, it examines the unfinished sentence you just typed in and then automatically gives you tips in the form of grammar patterns (Hunston and Francis 2000), (accompanied with examples similar to those found in a good dictionary. The prompt definitely help users finish their sentences more quickly and correctly. Second, WriteAhead automatically ranks suggestions relevant to your writing, so you spend less time looking at tips, and focus more on writing your piece.

You might type in "*This paper presents a method*" and are not sure about how to continue. You will instantly receive tips on grammar as well as content. At a quick glance, you might find a relevant pattern, **method for doing something** with examples such as *This paper presents/describes a method for generating solutions*. That could tip you off as to change the sentence into *This paper presents a method*, thus getting rid of tense and article errors, and help you continue to write something like *method for extracting information*.

Using *WriteAhead* this way, you could at once speed up writing and avoid making common writing errors. Most autocompletion systems such as *Google Suggest* and *TransType* offer word-level suggestions, while WriteAhead organizes, summarizes, and ranks suggestions, so you can, at a glance, grasp complex linguistic information and make quick decision. Our philosophy is that it is important to show information from general to specific to reduce the cognitive load, so while minding the form, you can still focus on the content.

For editing, WriteAhead provides grammar-based correction rules, based on Pattern Grammar to highlight potential grammatical errors and corrections. For translation, WriteAhead provides bi-directional lexical grammar, called Synchronous Pattern Grammar (Chang et al. 2015, to appear) to provide tips not just how to translate word for word, but a specific word and its lexical grammatical context.

http://writeahead.nlpweb.org
http://teenswrite.nlpweb.org

▼ Research and Development of Wide Bandgap Power Devices

Prof. Chih-Fang Huang
Institute of Electronics Engineering

In the WBG lab in NTHU, we focus on the development of wide bandgap power devices, including the novel devices in vertical and lateral types and the critical issues of fabrication process. The main two topics are 4H-SiC diodes and AlGaN/GaN HEMTs.

For the 4H-SiC PiN diodes, counter-doped junction termination extension (CD-JTE) structure was experimentally implemented and studied in the device structure. Two groups of 4H–SiC PiN diodes were fabricated with two n-type drift layer thicknesses of 11 and 30 μm, respectively, and with different termination structures, in order to demonstrate the wide JTE dose tolerance of CD-JTE. Three different doses, 1.7×10^{13}, 2.2×10^{13}, and 2.8×10^{13} cm^{-2}, were used for the critical JTE implantation. The measured breakdown voltages (BVs) of the diodes with all termination structures and JTE doses were compared with simulation predictions. Electroluminescence at the BV was recorded and used to locate the peak electrical field. The test results matched well with the simulation results. As a result of the effectiveness and robustness of the CD-JTE, the best achieved BVs from the diodes on the 11-μm and 30-μm epi layers were 1850 and 4800 V, respectively.

For analysis of the stability of AlGaN/GaN HEMTs, we use the pulse measurement to replace the traditional DC measurement to investigate repeatable device characteristics and to avoid the self-heating effect. In this study, we analyzed the threshold voltage instability of the Schottky gate HEMT, the p-GaN gate HEMT, and the recessed MIS gate HEMT. The negative shift in Vth when Vg is large enough indicates the trapping of positive charges in the gate region. Because of the non ohmic contact to the p-GaN gate, the isolated p-GaN layer acts as a floating gate. This new finding identifies the importance of suitable ohmic contact to the p-GaN gate for stable device operation. The threshold voltage shift of the recessed MIS gate HEMT, which is attributed to the trapping of electrons in the gate dielectric, can be as large as 2.5 V depending on the stress conditions. The result show that the annealed p-GaN gate HEMT and Schottky gate HEMT are relatively stable.

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7098328&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7098328

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6907990&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6907990

http://ecst.ecsdl.org/content/66/7/127.short

▼ Energy-efficient precoding matrix design for relay-aided multiuser downlink networks

Prof. Chong-Yung Chi
Institute of Communications Engineering

We have investigated several central challenging problems on 1) multiuser transmit beamforming, 2) multi-cell interference channels, and 3) cooperative communication. Specifically, for multiuser downlink channels, we have developed two robust transmit beamforming designs, namely the worst-case robust design and the chance-constrained robust design. Both approaches can provide guaranteed receiver performance in the presence of channel state information errors. For multi-cell interference channels, we have developed one robust multi-cell coordinated beamforming design and one outage-constrained system rate maximization beamforming design. For both designs, efficient convex optimization methods are proposed to achieve near-optimal performance. We further propose distributed implementation for the two beamforming designs which are more suitable for large-scale or ad-hoc networks. These research results partly have been published in IEEE Trans. Signal Processing and partly have been presented in major flagship international conferences (e.g., IEEE ICASSP).

http://www.ee.nthu.edu.tw/cychi/publications/Conference_papers/Energy-efficient%20precoding%20matrix%20design%20for%20relay-aided%20multiuser%20downlink%20networks.pdf
http://www.ee.nthu.edu.tw/cychi/publications/Conference_papers/A%20fast%20hyperplane-based%20MVES%20algorithm%20for%20hyperspectral %20unmixing.pdf

▼ Robustness analysis on interspecies interaction network for iron and glucose competition between Candida albicans and zebrafish during infection

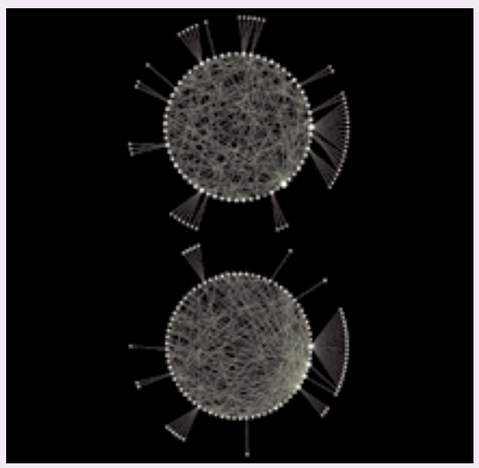
Prof. Che Lin
Institute of Communications Engineering

Candida albicans has emerged as an important model organism for the study of infectious disease. Using high-throughput simultaneously quantified time-course transcriptomics, this study constructed host-pathogen interspecies interaction networks between C. albicans and zebrafish during the adhesion, invasion, and damage stages. Given that iron and glucose have been identified as crucial resources required during the infection process between C. albicans and zebrafish, we focused on the construction of the interspecies networks associated with them. Furthermore, a randomization technique was proposed to identify differentially regulated proteins that are statistically eminent for the three infection stages. The behaviors of the highly connected or differentially regulated proteins identified from the resulting networks were further investigated.

"Robustness" is an important system property that measures the ability of the system tolerating the intrinsic perturbations in a dynamic network. This characteristic provides a systematic and quantitative view to elucidate the dynamics of iron and glucose competition in terms of the interspecies interaction networks. Here, we further estimated the robustness of our constructed interspecies interaction networks for the three infection stages. The constructed networks and robustness analysis provided significant insight into dynamic interactions related to iron and glucose competition during infection and enabled us to quantify the system's intrinsic perturbation tolerance ability during iron and glucose competition throughout the three infection stages. Moreover, the networks also assist in elucidating the offensive and defensive mechanisms of C. albicans and zebrafish during their competition for iron and glucose. Our proposed method can be easily extended to identify other such networks involved in the competition for essential resources during infection.

This research work won the Best Paper Award for 2014 GIW-ISCB-ASIA conference.

http://www.biomedcentral.com/1752-0509/8/S5/S6



Research Highlights

Renewable Energy

▼ Photoelectron spectroscopy controlled by two-color counter- and co- fields

Prof. Ming-Chang Chen
Institute of Photonics Technologies

Strong-field ionization provides fundamental insight into light-matter interactions, encoding the structure of atoms and molecules on the subångström and subfemtosecond scales. In this Rapid Communication, we explore an important regime: strong-field ionization by two-color circularly polarized laser fields. In contrast to past work using linearly polarized drivers, we probe electron trajectories that are driven in a two-dimensional plane, thus separating the tunneling angle from the rescattering angle. This allows us to make several findings. First, we observe a single-lobed electron distribution for co-rotating fields, and a three-lobed distribution for counter-rotating fields, providing experimental validation of the theoretical model explaining the generation of circularly polarized high harmonic light. Second, we discover that there is significant electron-ion rescattering using counter-rotating fields, but not with co-rotating fields. Finally, we show that the rescattered electrons are well separated from the directly ionized electrons, in striking contrast to similar low-energy structures seen with linearly polarized fields. These findings help overcome the long-standing problem of how to decouple the tunneling and rescattering steps in strong-field ionization, which will enable new dynamic probes of atomic and molecular structure.
https://journals.aps.org/pra/abstract/10.1103/PhysRevA.91.031402

▼ A low-temperature partial-oxidation-methanol micro reformer with high fuel conversion rate and hydrogen production yield

Prof. Yu-Chuan Su
Prof. Yuh-Jeen Huang
Prof. Fan-Gang Tseng
Low Carbon Energy Research Center

A partial oxidation methanol micro reformer (POM-μReformer) with finger-shaped channels for low operating temperature and high conversing efficiency is proposed in this study. The micro reformer employs POM reaction for low temperature operation (less than 200° C), exothermic reaction, and quick start-up, as well as air feeding capability; and the finger type reaction chambers for increasing catalyst loading as well as reaction area for performance enhancement. In this study, centrifugal technique was introduced to assist on the catalyst loading with high amount and uniform distribution. The solid content (S), binder's ratio (B), and channel design (the ratio between channel's length and width, R) were investigated in detail to optimize the design parameters. Scanning electron microscopy (SEM), gas chromatography (GC), and inductively coupled plasma-mass spectrometer (ICP-MS) were employed to analyze the performance of the POM-μReformer. The result depicted that the catalyst content and reactive area could be much improved at the optimized condition, and the conversion rate and hydrogen selectivity approached 97.9% and 97.4%, respectively, at a very low operating temperature of 180° C with scarce or no binder in catalyst. The POM-μReformer can supply hydrogen to fuel cells by generating 2.23 J/min for 80% H2 utilization and 60% fuel cell efficiency at 2 ml/min of supplied reactant gas, including methanol, oxygen and argon at a mixing ratio of 12.2%, 6.1% and 81.7%, respectively.
http://www.sciencedirect.com/science/article/pii/S0306261914010745

▼ Automatically Constructing Semantic relationships

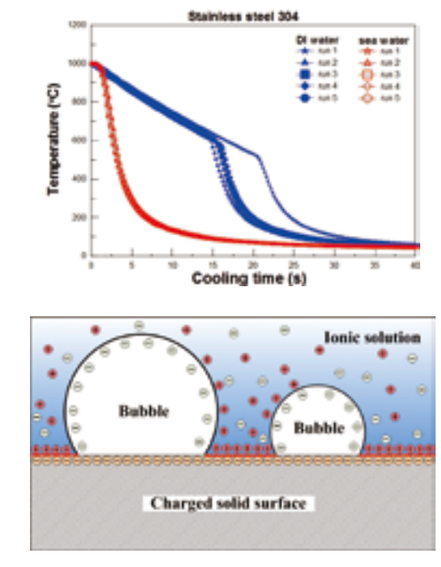
Prof. Yi-Shin Chen
Department of Computer Science, Institute of Information Systems and Applications

The common critical barrier of the information integration techniques is the quality of the relationship sets that indicates the correlation among different concepts (or vocabularies) and their hierarchical relationships. Such data sets are needed and achieved by manual designs (via Entity-Relationship Model or UML model) in the traditional databases or data warehouses. Thus, the automatic construction of the relationship data for all web pages is demanded for web information integration. The objective of this project is to automatically construct the relationship data (using the Ontology model). Prof. Chen and her team propose a framework for automatically extracting various semantic relationships from heterogeneous unstructured Web data, such as query logs and Twitter. Based on the most common characteristics of these data, the embedded concepts are detected and associated based on semantic meanings. The experimental results demonstrate that our framework is able to extract satisfactory semantic relationships. This work is published at Journal of Web Semantics.
http://www.websemanticsjournal.org/index.php/ps/article/view/389

▼ Enhancement of nuclear safety using natural sea water as a backup emergency coolant

Prof. Chin Pan
Institute of Nuclear Engineering and Science

The Ultimate Response Guideline (URG) is proposed to cope with compound disasters and enhance the safety of nuclear power plant. Ultimately, sea water may be used to cool down the high temperature fuel rods. This study investigated experimentally the quenching of stainless steel and zircaloy spheres with very high temperature (~1000°C) in deionized water and sea water. By visualization using a high speed video camera, this is the first time in literature revealing that the formation of a stable vapor film around the metallic quenching test spheres occur through the coalescence of bubbles nucleated at ultra-high temperatures. Conversely, sea water was observed to enable much rapid quenching through the prevention of stable film boiling due to a zeta-potential effect and quenching starting with transition boiling characterized with moderate bubble nucleation sites and possible burst out of bubble clusters. The much more rapid quenching in sea water may enhance nuclear safety, although the potential rapid corrosion of the metals, especially stainless steel, is also of significant concern. The paper was published in International Journal of Heat and Mass Transfer, 86 (2015) 65-71
http://www.sciencedirect.com/science/article/pii/S0017931015002124



▼ 1. Development of CO_2 Capture Technologies for Post-Combustion
▼ 2. Traditional Industrial Energy Saving and Development of Key Chemical Processing Technologies of Green Energy Industry

Prof. Shi-Shang Jiang
Low Carbon Energy Research Center

1. We assisted the Formosa Plastic Petroleum Chemical Company to build a pilot with 1 ton carbon dioxide per day capture rate at Mai-liao 6th Naphtha Cracking Plant Area. The developed CO_2 captured technology by rotating bed chemical absorption method will be tested in this plant. The achievements in research and development on CO_2 reduction technique by cooperation with industry and exhibiting the intention of Taiwan to reduce CO_2 emission.
2. We developed the high-valued chemical technologies to attain optimum operation strategy of energy saving. The technologies were implemented in China Still Company for the flue gas treatment system with freeze ammonia water. During this semester, 7 SCI refereed papers and 3 international conference papers has been published. The research projects are 7 and total research funding is 64.3 million NT$.
http://www2.che.nthu.edu.tw/~pie/index.htm

▼ Thiolation method for modifying carbon nanotubes

Prof. Ming-Hua Hsu
Nuclear Science & Technology Development Center

We established a highly efficient and simple method to directly functionalize the surface of carbon nanotubes (CNTs) with thiol groups (-SH). The -SH groups on the surface of the CNTs were characterized using Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), elemental analysis (EA), and transmission electron microscopy (TEM). The TEM indicated that gold nanoparticles (AuNPs) or other metals can be attached to thiolated CNTs (CNT-SHs) through thiol-metal bonding. Hence, the proposed approach can be used for developing selfassembled materials, sensors, catalysts, and CNT nanodevices.
http://pubs.rsc.org/en/Content/ArticleLanding/2014/RA/c4ra00051j#!divAbstract
http://pubs.rsc.org/en/content/articlepdf/2014/ra/c4ra00051j

Research Highlights

Life Sciences

▼ A Study of Downward-Facing Heat Transfer and Critical Heat Flux Mechanisms with External Vessel Bottom for the Severe Accident of Advanced Nuclear Reactors

Prof. Bau-Shei Pei
Low Carbon Energy Research Center

The impacts of water degassing and water inlet distance adjustment to the critical heat flux of downward-facing heating surface, which are investigated and discussed in the study. The experimental results can be organized as the following 3 conclusions.

1) Water degassing can extend the critical heat flux limit efficiently to the downward-facing heating surface. Additionally, comparing with the best degassing condition and the non-degassing case, the increasing of critical heat flux limit can be up to 2.63 times.
2) The shorter distance between cooling water inlet and the downward-facing heating surface has performed the better heat removal capability. Comparing the shortest 0.08 m condition and pool boiling condition, the surface critical heat flux limit is increased about 2 times.
3) The higher degassing temperature and shorter water injection distance conditions have larger CHF occurring surface temperatures then lower degassing temperature and longer water injection distance cases. The study results can be taken as reference for industrial related applications.

▼ Sustainable photovoltaic technology development: step-by-step guidance for countries facing PV proliferation turmoil under the feed-in tariff scheme, Renewable and Sustainable Energy Reviews 43 (2015) 156–163.

Prof. Anton Ming-Zhi Gao
Prof. Chien-Te Fan
Prof. Ji-JungKai
Prof. Chao-Ning Liao
Low Carbon Energy Research Center

The project is entitled “A study on the Strategy to Promote low-carbon energy industry and technology: Focus on law, economics and finance tool”. Under this project, PI, two co-PI, and former director of Environmental and Energy Research Centre of NTHU, try to collaborate with each other and complete the tough work of publishing in this high-impact-factor journal. (Impact Factor: 5.901; 5-Year Impact Factor: 7.445)

In this article, we try to summarize the development of Feed in tariff scheme in the past few decades. Also this article focuses on the dynamic development of FIT after the PV proliferation.

This article is not only of academic value *per se*. It would also benefit Taiwan’s PV industry as well, since how to assist the sustainable PV development in other countries would be very helpful for Taiwan’s export PV.

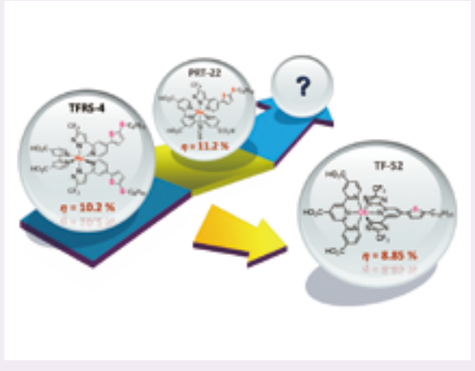
http://www.sciencedirect.com/science/article/pii/S1364032114009472

▼ Dye sensitized solar cells

Prof. Yun Chi
Low Carbon Energy Research Center

Ru(II) and Os(II) metal sensitizers offer unique photophysical and electrochemical properties arising from the intrinsic electronic properties, i.e. the higher propensity in forming the lower-energy ligand-to-metal charge transfer (MLCT) transition, and their capability to support chelate with multiple carboxy groups, which served as the bridge to the metal oxide and efficient injection of photoelectron. Basic principles on the molecular designs, structural relationship versus photophysical and electrochemical properties, and performances for the as-fabricated DSCs are highlighted. The success in the breakthrough of the synthetic protocols and potential applications may provide strong stimulus to future development of technologies such as DSCs, organic light emitting diodes, solar water splitting, etc.

http://www.ncbi.nlm.nih.gov/pubmed/25630960

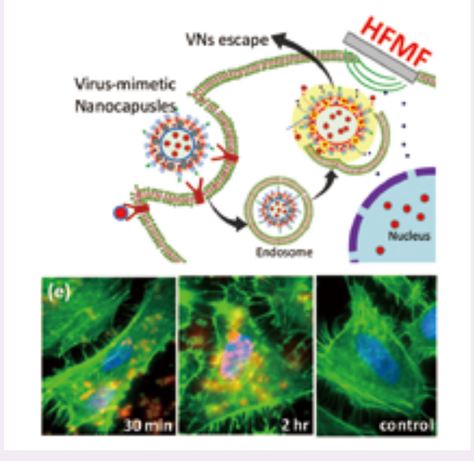


▼ The Targeted Delivery of Multiple component Cargos to Cancer Cells by Core/shell Nanocapsules

Prof. Shang-Hsiu Hu
Department of Biomedical Engineering and Environmental Sciences

Stimuli-responsive drug delivery systems constitute an appealing approach to direct and restrict drug release spatiotemporally at the specific site of interest. However, it is difficult for most systems to affect every cancer cell in a tumor tissue due to the presence of the natural tumor barrier, leading to potential tumor recurrence. Here, we report core/shell magneto-responsive virus mimetic nanocapsules (VNs) which can infect cancer cells sequentiallyand double as a magnetothermal agent fabricated through anchoring iron oxide nanoparticles in a single-component protein (lactoferrin) shell. With large payload of hydrophilic/hydrophobic anticancer cargos, doxorubincin (Doxo) and palictaxel (PTX), VNs can simultaneously give a rapid drug release and intense heat while applying an external high-frequency magnetic field (HFMF). Furthermore, after being liberated from dead cells by HFMF manipulation, the constructive VNs can sequential infect neighboring cancer cells and deliver sufficient therapeutic agents to next targeted sites. With high efficiency for sequential cell infections, VNs have successfully eliminated subcutaneous tumor after a combinatorial treatment. These results demonstrate that the VNs could be used for locally targeted, on-demand, magnetoresponsive chemotherapy/hyperthermia, combined with repeatedly cell infections for tumor therapy and other therapeutic applications.

https://sites.google.com/site/sshow210/home

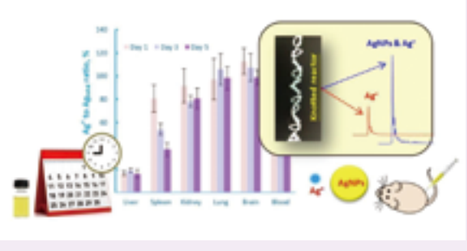


▼ Quantitatively Profiling the Dissolution and Redistribution of Silver Nanoparticles in Living Rats Using a Knotted Reactor-Based Differentiation Scheme

Prof. Yuh-Chang Sun
Department of Biomedical Engineering and Environmental Sciences

Whether silver nanoparticles (AgNPs) degrade and release silver ions (Ag^+) *in vivo* has remained an unresolved issue. To evaluate the biodistribution and dissolution behavior of intravenously administered AgNPs in living rats, we employed a knotted reactor (KR) device to construct a differentiation scheme for quantitative assessment of residual AgNPs and their released Ag^+ ions in complicated animal tissues. After method’s optimization, our proposed differentiation system was confirmed to be tolerant to rat tissue and organ matrix and provide superior reliability of differentiating AgNPs/Ag^+ than the conventional centrifugal filtration method. We then applied this differentiation strategy to investigate the biodistribution and dissolution of AgNPs in living rats, andit was found that the administered AgNPs accumulated predominantly in the liver and spleen, then dissolved and released Ag^+ ions that were gradually excreted, resulting in almost all of the Ag^+ ions becoming deposited in the kidney, lung, and brain. Histopathological data also indicated that toxic responses were specifically located in the AgNP-rich liver, not in the Ag^+-dominated tissues and organs. Because our developed KR-based differentiation scheme can be used to identify residual AgNPs and released Ag^+ ions from intact animal tissues, it could open an avenue for methodical exploration of the more general dissolution behavior of AgNPs. In addition, our quantitative assessments of AgNP dissolution and Ag^+ redistribution in living rats emphasize the need to pursue the chemical fate of administered AgNPs when performing future nanotoxicological studies *in vivo*.

http://pubs.acs.org/doi/abs/10.1021/ac501691z



▼ Ribose-5-phosphate isomerase A regulates hepatocarcinogenesis via PP2A and ERK signaling

Prof. Horng-Dar Wang
Department of Life Science

Cancer occurrence rate is positively correlated with aging progression. Thus, uncovering gene effect to extend longevity may be able to help in the understanding the formation of cancer and even the development of cancer therapy. The deregulated nonoxidative pentose phosphate pathway (PPP) is known to promote oncogenesis, but the molecular mechanism remains unknown. Our recent study identified that the reduced neuronal expression of ribose-5-phosphate isomerase (rpi) extends lifespan and ameliorates polyglutamine toxicity in Drosophila. Therefore, we examined the role of ribose-5-phosphate isomerase (rpi) gene expression in cancer formation. Here, we report that human ribose-5-phosphate isomerase A (RPIA) plays a role in human hepatocellular carcinoma (HCC). A significant increase in RPIA expression was detected in both tumor biopsies of HCC patients and in liver cancer tissue arrays. In addition, we demonstrated that the ability of RPIA to regulate cell proliferation and colony formation in different liver cancer cell lines required ERK signaling as well as the negative modulation of PP2A activity and that the effects of RPIA could be modulated by the addition of either a PP2A inhibitor or activator. Furthermore, the xenograft studies in nude mice revealed that the modulation of RPIA in liver cancer cells regulated tumor growth and that NIH3T3 cells overexpressing RPIA exhibited increased proliferation, enhanced colony formation, elevated levels of p-ERK1/2, and accelerated tumor growth. This study provides new insight into the molecular mechanisms by which RPIA overexpression can induce oncogenesis in HCC. It suggests that RPIA can be a good prognosis biomarker and a potential target for HCC therapy. Furthermore, the information may be useful for the development of RPIA inhibitor drugs for HCC therapy and promoting healthy longevity.

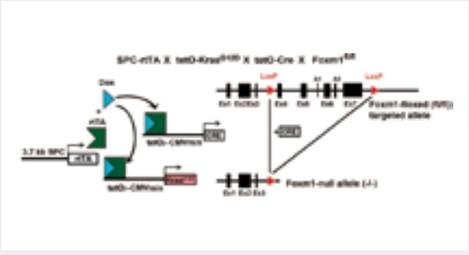
http://www.ncbi.nlm.nih.gov/pubmed/22040003
http://www.ncbi.nlm.nih.gov/pubmed/25429733

▼ Foxm1 transcription factor is required for the initiation of lung tumorigenesis by oncogenic $Kras^{G12D}$

Prof. I-Ching Wang
Department of Life Science

Lung cancer is the leading cause of deaths in cancer patients in the United States. Identification of new molecular targets is clearly needed to improve therapeutic outcomes of this devastating human disease. Activating mutations in K-Ras oncogene and increased expression of FOXM1 protein are associated with poor prognosis in patients with non-small-cell lung cancer. Transgenic expression of activated $Kras^{G12D}$ in mouse respiratory epithelium is sufficient to induce lung adenocarcinomas; however, transcriptional mechanisms regulated by K-Ras during the initiation of lung cancer remain poorly understood. Foxm1 transcription factor, a downstream target of K-Ras, stimulates cellular proliferation during embryogenesis, organ repair and tumor growth, but its role in tumor initiation is unknown. In the present study, we used transgenic mice expressing $Kras^{G12D}$ under control of *Sftpc* promoter to demonstrate that Foxm1 was induced in type II epithelial cells before the formation of lung tumors. Conditional deletion of *Foxm1* from $Kras^{G12D}$-expressing respiratory epithelium prevented the initiation of lung tumors *in vivo*. The loss of *Foxm1* inhibited expression of K-Ras target genes critical for the nuclear factor-κB (NF-κB) and c-Jun N-terminal kinase (JNK) pathways, including *Ikbkb, Nfkb1, Nfkb2, Rela, Jnk1, N-Myc, Pttg1* and *Cdkn2a*. Transgenic overexpression of activated FOXM1 mutant was sufficient to induce expression of these genes in alveolar type II cells. FOXM1 directly bound to promoter regions of *Ikbkb, Nfkb2, N-Myc, Pttg1* and *Cdkn2a*, indicating that these genes are direct FOXM1 targets. FOXM1 is required for K-Ras-mediated lung tumorigenesis by activating genes critical for the NF-κB and JNK pathways.

http://www.nature.com/onc/journal/v33/n46/full/onc2013475a.html



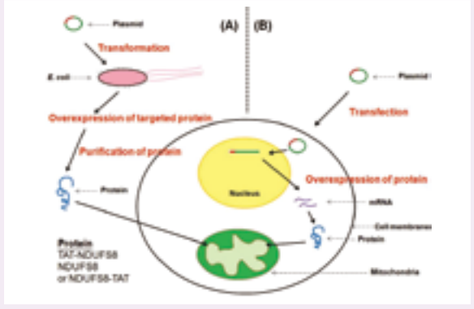
▼ Studies on targeting NADH dehydrogenase (ubiquinone) Fe-S protein 8 to mitochondria by HIV-transactivator of transcription and rescuing mitochondrial complex I deficiency

Prof. Mou-Chieh Kao
Institute of Molecular Medicine

In this study, we tried to apply the protein transduction concept of HIV-1 transactivator of transcription (TAT) with the mitochondrial-targeting capability of the specific leader sequence to generate a therapeutic protein delivery system which can specifically carry target proteins into mitochondria. Here, NADH dehydrogenase (ubiquinone) Fe-S protein 8 (NDUFS8), the first complex I subunit linked to Leigh syndrome, was used as the model subunit to test our specific aims, with a hope that this newly developed method could become a novel treatment for complex I deficiency.

Currently, our findings showed that both exogenously produced TAT-NDUFS8 and NDUFS8-TAT could be delivered into mitochondria and processed into the mature forms of NDUFS8. We also showed that the mechanism of TAT-NDUFS8 and NDUFS8-TAT entering mitochondria is not through the well-recognized translocase of the outer membrane (Tom) / translocase of the inner membrane (Tim) mitochondrial import pathway. Furthermore, in order to mimic the rescue of complex I deficiency, a NDUFS8 expression knockdown cell line (shRNA-C3) was used in functional analyses as the therapeutic model. Treating with TAT-NDUFS8 could completely restore the assembly and functionality of complex I in shRNA-C3 cells. Moreover, we demonstrated that when cells were cultured with TAT-NDUFS8, endosomes were found to be retrieved in close proximity to mitochondria, indicating that TAT-NDUFS8 may enter mitochondria via the endosomes-mitochondria juxtaposition.

http://www.nyas.org/Publications/Annals/Default.aspx



▼ Intrinsic Dynamics & Perturbed Dynamics

Prof. Lee-Wei Yang
Institute of Bioinformatics and Structural Biology

Computational predictions of protein-protein docking (PPD) and protein-ligand docking sites are of great scientific and medicinal interest. The entropic changes together with enthalpic changes, the difference in Gibbs free energy (ΔG), would determine the interaction strength between two proteins that dock with various poses. It is computationally expensive and difficult to correctly calculate the entropic contributions in the free energy in order to find the (near-) native docking pose using molecular dynamics (MD) simulations and other dynamics analyses. Here, instead of examining energetics of two proteins before and after binding, we proposed a new criterium based on intrinsic dynamics domains (IDDs) of isolated proteins to discern near-native PPD poses. Furthermore, with the novel approach to partition a protein into "domains" of robust but disparate intrinsic dynamics, 90% of catalytic residues in enzymes can be found within the first 50% of the residues closest to the interface of these dynamics domains. A more efficient scoring function could be developed by considering the favored docking orientations/positions suggested in this study to improve the PPD algorithm.

In addition, there has been renewed interest in using linear response theory (LRT) to describe such ligand-triggered motions. In the framework of LRT, observed conformational changes result from a delicate interplay between protein intrinsic dynamics and the external perturbations that excite the most relevant global modes. Here we formulate two time-dependent LRTs that use constant and impulse forces to address the physical nature of two-stage time responses in myoglobin as shown by ultraviolet resonance Raman (UVRR) data. With the new formula, in which impulse forces are used, mechanical signal propagation upon ligand binding can be tracked in terms of both time and space. The formula also explains at the theoretical level why certain modes are excited during ligand binding. We further examine how fast perturbations on a specific residue can propagate throughout the molecule. The residues that most rapidly disseminate signals are found to be evolutionarily conserved. Overall, the general theories we provided serve as a simple scaffold for enzymologists, medicinal chemists, and protein scientists to understand protein-protein/ligand binding by reconciling the paradigms of preexisting equilibrium and induced fit.

http://compbiol.life.nthu.edu.tw/?page_id=76

Research Highlights

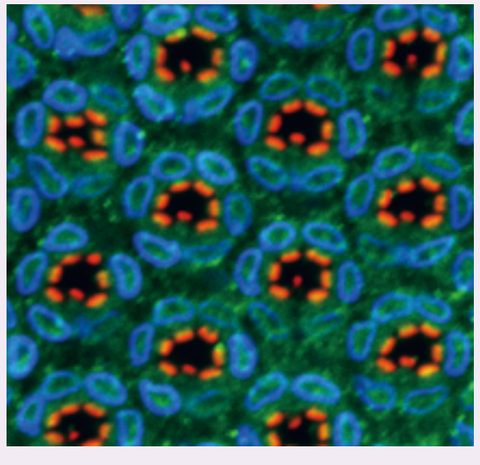
Humanities and Social Sciences

▼ Derlin-1 Regulates Mutant VCP-Linked Pathogenesis and Endoplasmic Reticulum Stress-Induced Apoptosis

Prof. Tzu-Kang Sang
Institute of Biotechnology

Mutations in VCP (Valosin-containing protein), an AAA ATPase critical for ER-associated degradation, are linked to IBMPFD (Inclusion body myopathy with Paget disease and frontotemporal dementia). Using a Drosophila IBMPFD model, we have dentified the ER protein Derlin-1 as a modifier of pathogenic TER94 (the fly VCP homolog) mutants. Derlin-1 binds to TER94 directly, and this interaction is essential for Derlin-1 overexpression to suppress the pathogenic TER94- induced neurodegeneration. Derlin-1 overexpression reduces the elevated ATPase activity of pathogenic TER94, implying that IBMPFD is caused by ATPase hyper-activation. Under physiological condition, Derlin-1 expression is increased upon ER stress to recruit TER94 to the ER. However, in response to severe ER stress, Derlin-1 is required for activating apoptosis to eliminate damaged cells. This pro-apoptotic response is mimicked by Derlin-1 overexpression, which elicits acute ER stress and triggers apoptosis via a novel C-terminal motif (α). As this Derlin-1-dependent cell death is negated by TER94 overexpression, we propose that while Derlin-1 and VCP work cooperatively in ER stress response, their imbalance has a role in removing cells suffering prolonged ER stress.

http://journals.plos.org/plosgenetics/article?id=10.1371/journal.pgen.1004675
http://journals.plos.org/plosgenetics/article?id=10.1371/journal.pgen.1001288



▼ International Muslim Science Students in Taiwan, The Vocational Development of Asian Americans

Prof. Yung-Lung Chen
Center for General Education

In contemporary psychology, multicultural and ethnic minority research have been one of the most important research areas that challenges the assumptions and theories of psychology based on Euro-American individualistic and middle-class cultures. Following this trend, I have recently published two empirical studies.

In the first study, important research findings about the religious practices of international Muslim science students in Taiwan were identified and published in the *Journal of Counseling Psychology*. Fourteen male Muslim graduate students from Indonesia, who studied in Taiwan, were recruited in this study to participate in a qualitative interview. In terms of conventional content analysis, two types of major adaptation strategies were identified for dealing with adjustment problems, including religious coping through their Islamic beliefs and bicultural connections. Their major concerns about religious practices (e.g., praying 5 times per day) were resolved by communicating their needs directly with their laboratory classmates and advisors; however, they navigated the gender boundaries in the laboratory both subtly and inwardly through their Islamic beliefs. The practical implications regarding counseling and education (e.g. cross-cultural advising) are discussed both in a local and a global context.

In the second study, an important psychological scale for the work motivation of Asian Americans was developed and published by the *International Journal of Educational and Vocational Guidance*. For this study, we conducted two studies on the initial reliability and validity of the Bicultural Work Motivation Scale (BWMS) by combining qualitative and quantitative methods. Results from the exploratory and confirmatory factor analyses supported a stable four-factor structure of the BWMS: Honoring Parents, Family Financial Obligation, Fulfilling Personal Interest, and Being Independent. Adequate reliability and evidence for concurrent and discriminant validity are presented. Implications of the scale for further vocational assessment and research (e.g. its use at the university counseling center in the US) are discussed in the research paper.

http://psycnet.apa.org/psycinfo/2015-23481-001/
http://link.springer.com/article/10.1007%2Fs10775-015-9305-7

▼ 1. The New Pictorial Canon of Imperial Gardens: The Production and Meaning of Kangxi Yuzhi Bishu shanzhuang shi (Imperial Poems on Mountain Estate for Escaping the Summer Heat)
2. Jin (Shanxi) Merchants of Yangzhou: Thoughts on Paintings by Yuan Yao

Prof. Ya-Chen Ma
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1. The reconstruction of Chinese imperial palaces and gardens usually relies on historical texts and archaeological findings as most of the architecture does not survive. Qing (1644-1911) palaces and gardens, however, are less problematic due to well-preserved sites and contemporaneous images made by the court. Although most Chinese images of contemporary imperial gardens do not describe them in detail, Qing representations of imperial gardens often contain dozens of comprehensive views printed both as independent volumes and as part of gazetteers. Such a deviation from the tradition of Chinese court art should be understood as a deliberate invention. Why do Qing images of imperial gardens have no parallel in Chinese art? As the first production of the Qing series, Kangxi *Yuzhi Bishu shanzhuang shi (Imperial Poems on Mountain Estate for Escaping the Summer Heat)* must be the starting point of any investigation. This paper examines the creation of Kangxi *Yuzhi Bishu shanzhuang shi*: after an overview of the cultural meanings of garden imagery in late imperial China, this paper will discuss how the Kangxi scenes appropriated and transformed the pictorial tradition of gardens to construct the ideal imperial garden and to reflect the emperor's sage rule.

2. Huizhou merchants played a significant role in the Qing-period production of local culture in Yangzhou. Nonetheless, while Hui merchants clearly dominated local society, were there other social groups who could, or at least, have tried to make their mark on the cultural map of Yangzhou? Jin (Shanxi) merchants might have been one of the few groups who could somehow compete with Hui merchants. Yuan Yao, who was closely associated with Shanxi merchants, and his 1747 painting *Grand Views of Hanjiang*—one of the few huge topographical paintings of Yangzhou in the eighteenth century—might be crucial to answering this question. This article first identifies the topographical sites depicted in this painting, its potential patrons, as well as its distinctive features that emphasize the sties' parallel relationship with Pingshan Hall, the famous sight of Yangzhou, and their openness to the public. All these have to do with Shanxi merchants who tried to cultivate their influence in Yangzhou's cultural realm so dominated by Hui merchants. This article further argues that Shanxi merchants, supported by their fellow northerners, on the one hand imitated and competed with Hui merchants and on the other distinguished themselves by reviving ruins built by their predecessors to increase their visibility on the cultural map of Yangzhou.

▼ Hou Hsiao-hsien Studies

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Many film critics have noted Hou Hsiao-hsien's distinguished film style and associated it with traditional Chinese aesthetics, but few scholars have succeeded in articulating Hou's translation of traditional Chinese aesthetics into his cinematic work. This paper intends to fill this gap by proposing that the static tragedy is the form that Hou consciously or unconsciously appropriates in his films. According to sinologist Chen Shixiang, the static tragedy of traditional Chinese poetry lacks antagonism and dynamic conflict typical of Greek tragedy, but it embodies a kind of cosmic sorrow that insignificant human beings feel while facing nature's grand scale and noticing the unstoppable passage of time. While looking or gazing at nature, the poet occupies a bystander position; he keeps a sympathetic eye without intervention, detaching himself from the observed world while avoiding being completely indifferent. This bystander position has been duplicated in Hou's films through the use of static camera, long takes, and medium/long shots. Through this distinctive style of film language, two of Hou's films in particular, *A Time to Live, A Time to Die* (1985) and *The Puppetmaster* (1993), inquire into the universal life circle of birth, growth, illness, and death as well as meditate on the impermanence of life against the background of eternal nature, and thereby serve as examples that illustrate the characteristics of static tragedy.

http://www.tl.nthu.edu.tw/people/bio.php?PID=160

▼ Child language acquisition

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In the past few years, my research has been focused on examining how Mandarin-acquiring children interpret sentences with pronouns and reflexives, how syntactic structure constraints and pragmatic/discourse constraints influence their interpretations, and whether children's interpretations differ from adults'.

http://www.ling.nthu.edu.tw/faculty/ycsu/index.html

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2014-2015 R&D REPORT

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