NanoTechnology and Green Energy Research Activities in ESS NTHU

Keh-Chyang (KC) Leou, Professor

Engineering and System Science Dept.

National Tsing-Hua University, Hsinchu, Taiwan

Where are we?

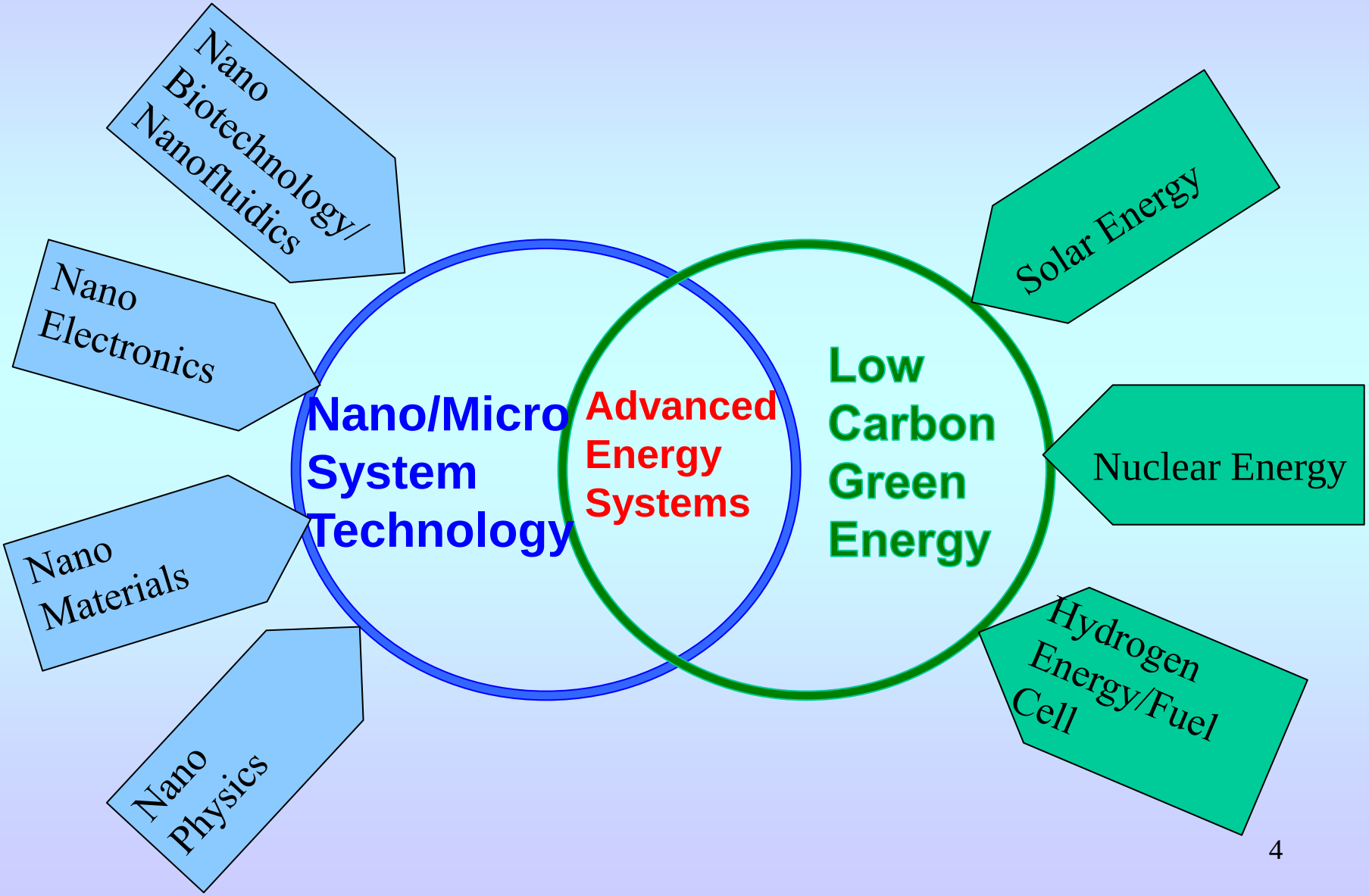
From Google Map

Hsinchu Science and In

National Synchrotron Radiation Research Center

國立清華大學
National Tsing Hua University

The Research Focuses of NTHU ESS



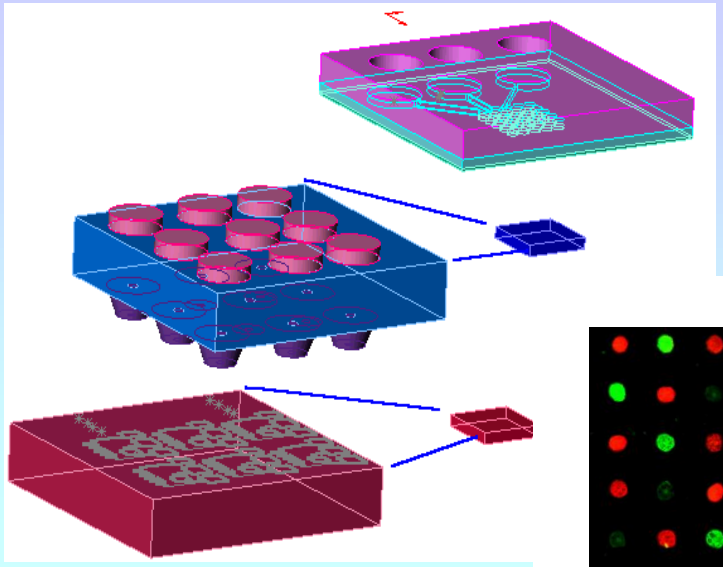
Nano/Micro Systems Technology

BioNEMS & Nano/Micro Fluidics

Prof. Fan-Gang Tseng
Yu-Chuan Su
Ben-Cheng Wang
Chin Pan
Da-Jen Yao

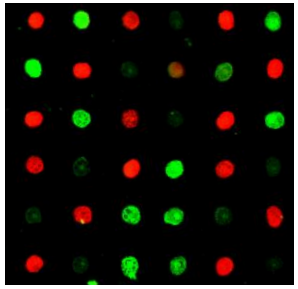
BioNEMS and Nanofluidics Lab

Prof. Fan-Gang Tseng



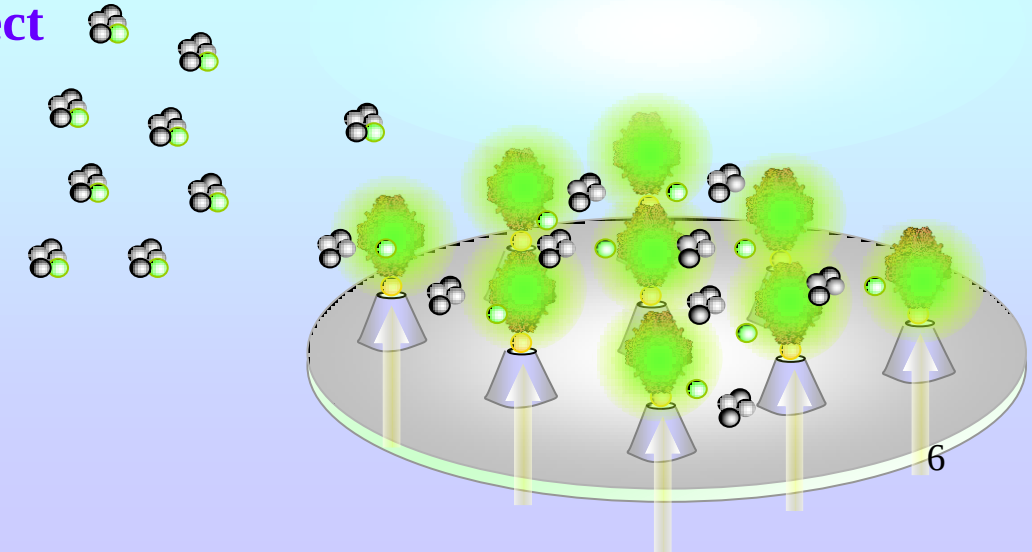
- **3-in-1 Protein Chip**

Pharmaceutical and Biotechnology National Project 2000-2007



- **Single Enzyme Molecule Array**

Nanotechnology National Project 2007-2013

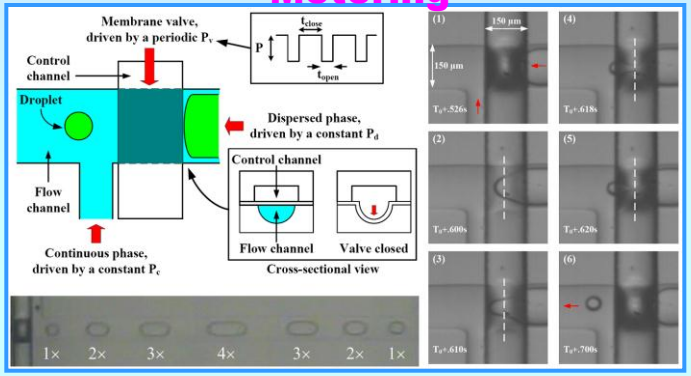


Microfluidic System Integration – Su's Group

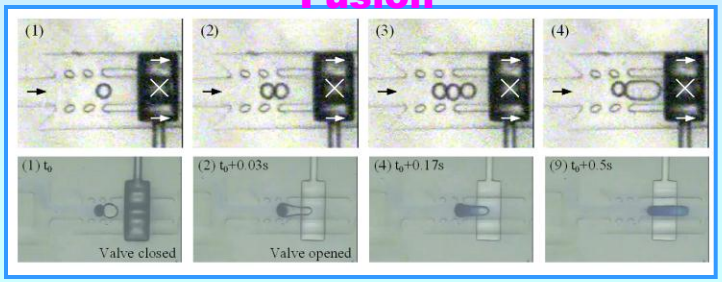
Composed of members with specialty covering a variety of engineering disciplines, our research group studies the fundamentals of multiphase systems and develops microfluidic components and integrated systems based on the findings.

Droplet-Based Microfluidic Platforms

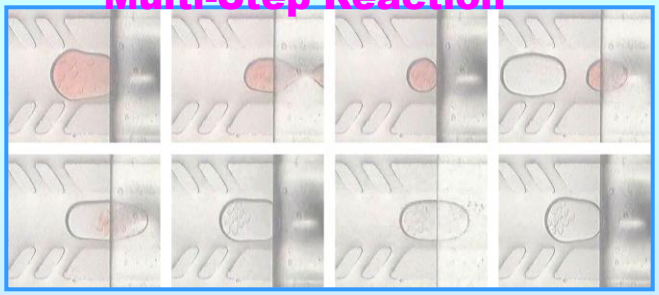
Metering



Fusion



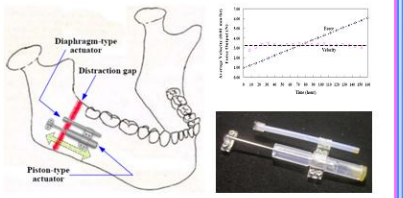
Multi-Step Reaction



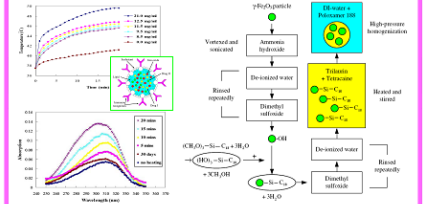
Double Emulsification

Drug Delivery Systems

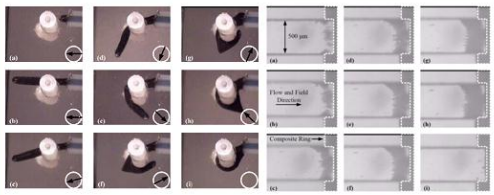
Distraction Osteogenesis



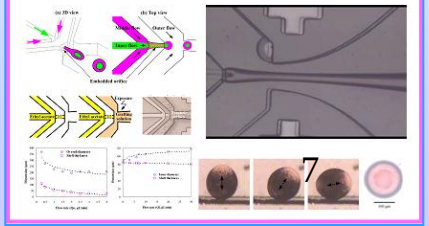
Magnetic Heating and Drug Delivery



Magnetic Shaping and Targeting



Biodegradable Microcapsules

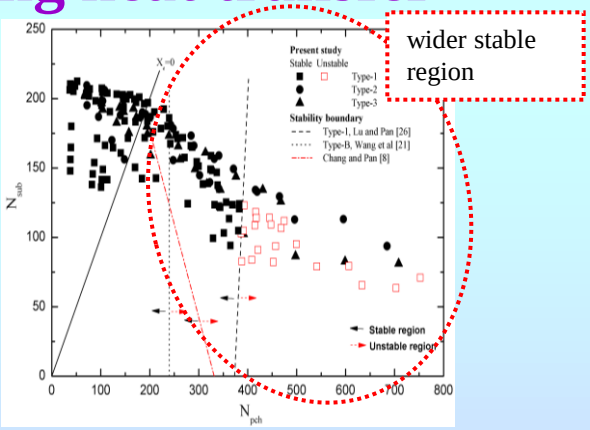


Boiling Heat Transfer & Multiphase Flow Lab

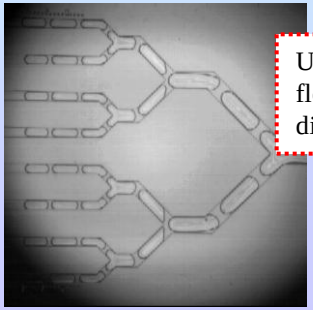
- **Supervisor**: Prof. Chin Pan (ESS Building, R507)
- **Current research interest**

  Two-phase flow in microchannels, such as boiling heat transfer for electronic cooling, micro fuel cell (two-phase flow phenomena of steam condensation and bubble generated from chemical reactions), and thermal-fluid systems of high temperature molten salt.
- **Results of the present studies**

- Boiling heat transfer



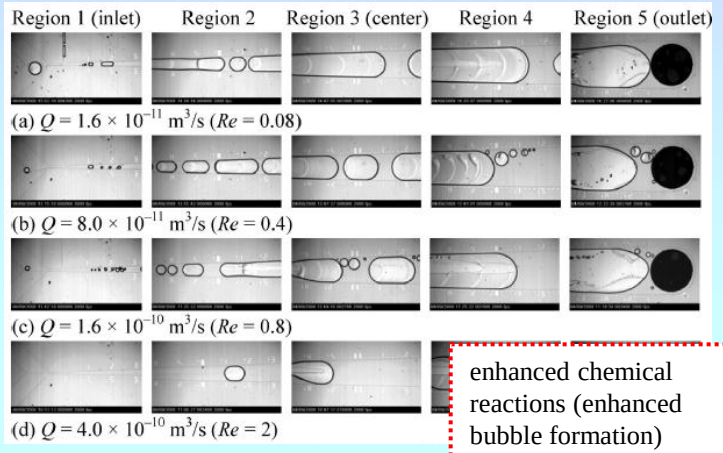
The microchannel with the **diverging cross-section design** and **artificial nucleation sites** distributed uniformly along the downstream half of the channel presents the best stability performance. This system can be regarded as **a highly stable microchannel heat sink for convective boiling**.



Using the **branching inlet design** to obtain the **more uniform flow distribution** and has a significant **enhancement on critical heat flux** (CHF).

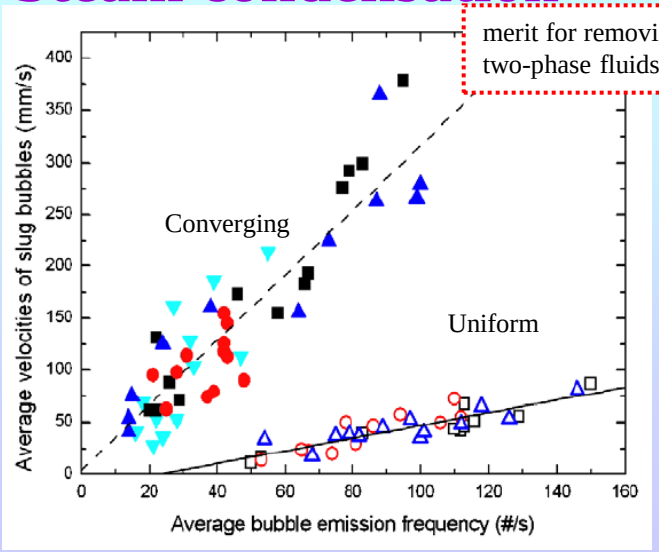
Two-phase flow application of the micro fuel cell

- Bubble generated from chemical reactions



enhanced chemical reactions (enhanced bubble formation)

- Steam condensation



merit for removing the two-phase fluids

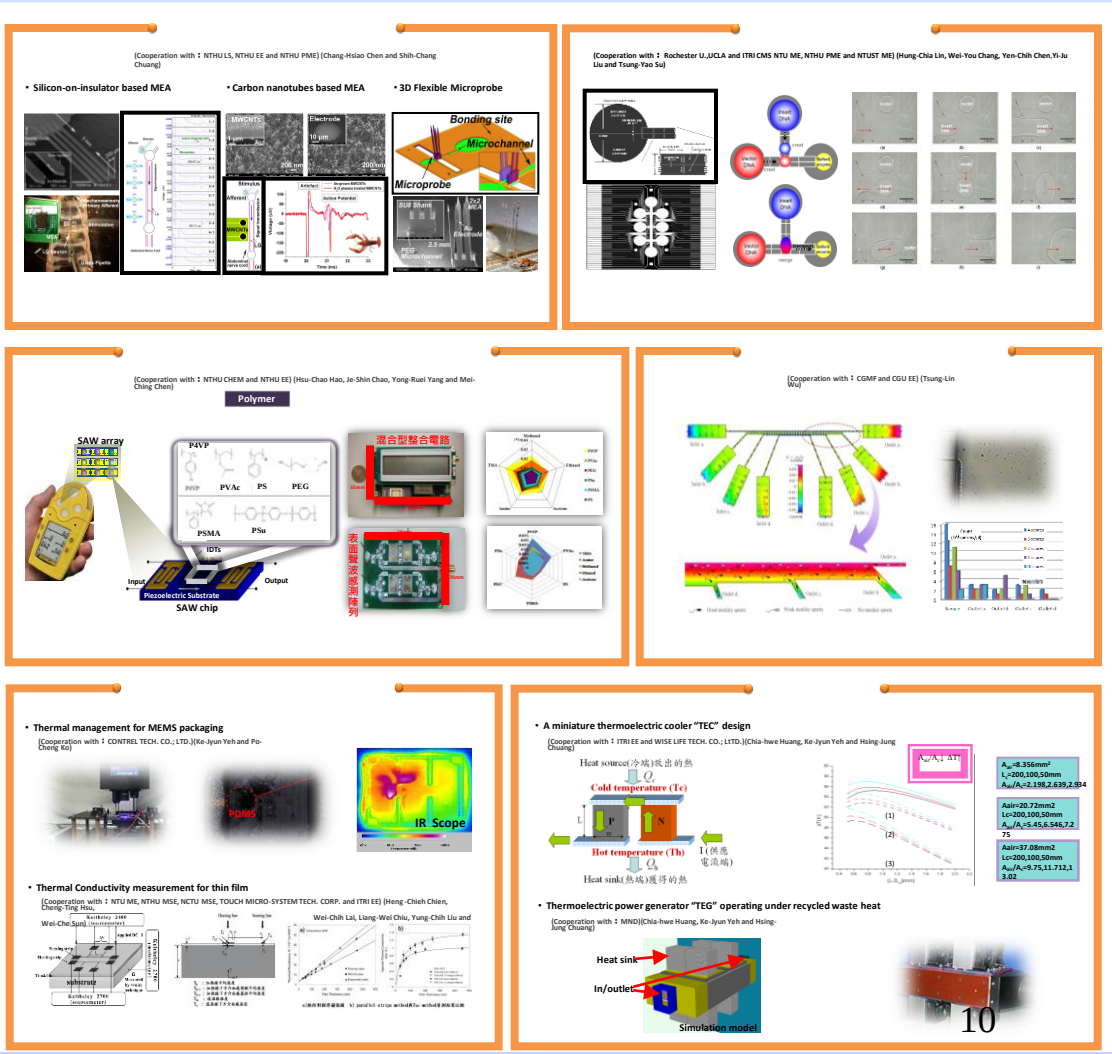
The simple **diverging cross-section design** of a microchannel can be recommended to develop microfluidic systems in which **enhanced chemical reactions** (enhanced bubble formation) occur as a result of **better diffusive mixing** therein, which was further confirmed by both qualitative mixing experiments as well as a theoretical analysis.

The microchannels with a **converging cross-section design** are **better for draining the two-phase fluids** composed of condensed liquid water and uncondensed bubbles. The converging microchannel presents the **lowest two-phase flow pressure drop and higher velocity of slug bubbles**, suggesting its merit for removing the two-phase fluids during **steam condensation in microchannels**.

Micro Fabrication Lab

Prof. Da-Jen Yao

- **Digital (EWOD) microfluidic systems**
- **MEMS packaging and reliability**
- **Electronic Nose**
- **Thermoelectric applications**



Nano/Micro Systems Technology

NANOELECTRONICS

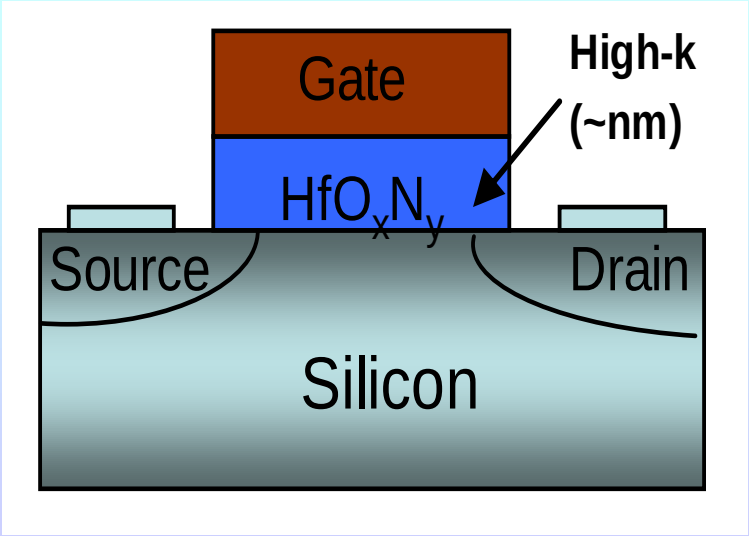
Prof. K.S. Chang-Liao
Yung-Hsien Wu

Nano-Electronics Devices
Prof. K.S. Chang-Liao, lkschang@ess.nthu.edu.tw

High-k MOSFET Device	Main stream Integrated Circuit devices
Flash Cell Device	Most crucial semiconductor memory
Carbon Nanotube - FET	Emerging nano-electronic devices

MOSFET/ Flash devices

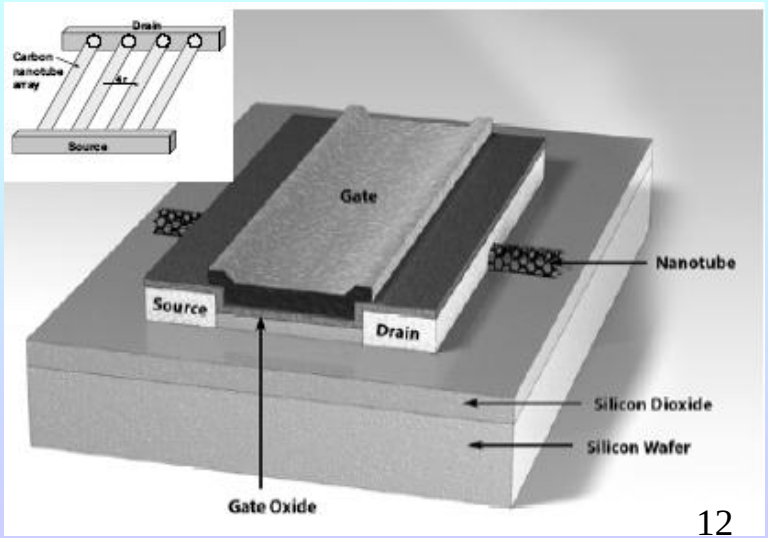
High-k dielectric, metal gate, Process/measurement/simulation



CNTFET

Very low current/high freq operation

Metal/CNT contact, Process/measurement



Research Field of Yung-Hsien Wu

For the microelectronic industry, the euphoric days of the era of “happy scaling” are over and we are confronted with the difficulties to achieve performance improvement as MOS devices approach scaling limits. Gordon Moore, co-founder of Intel, remarked ***”No exponential forever. But you can delay forever.”*** We are now at the critical juncture in silicon technology innovation. What can we do to delay forever? The following are my research interests:

Process development for DRAM including high-k material for storage dielectric and metal electrode for storage capacitor

Nonvolatile memory innovation based on crystalline high-k dielectrics

Development of high performance Ge MOSFET formed on Si substrate

Nano/Micro Systems Technology

NANOPHYSICS

Prof. Pai-Yi Hsiao
Chih-Hao Lee
K.C. Leou
T.L. Lin

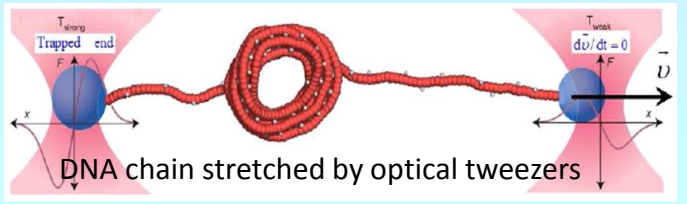
Prof. Pai-Yi Hsiao

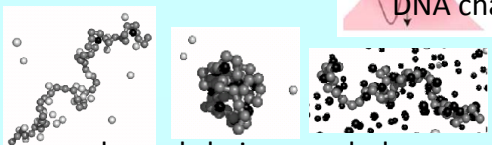
http://mx.nthu.edu.tw/~pyhsiao/

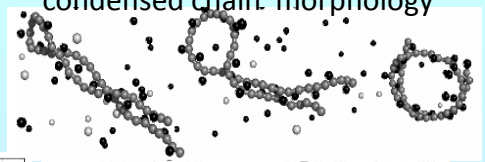
To study soft / hard condensed matter physics
using molecular dynamics simulations

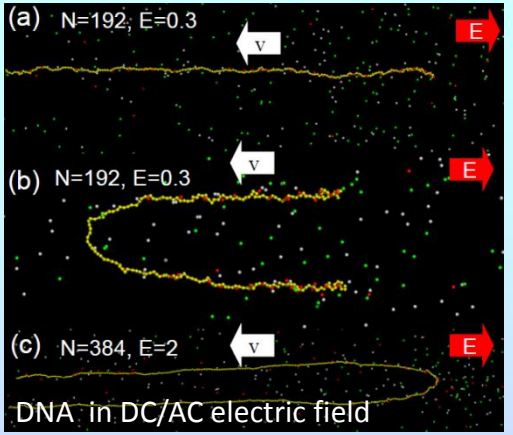
Research topics include:

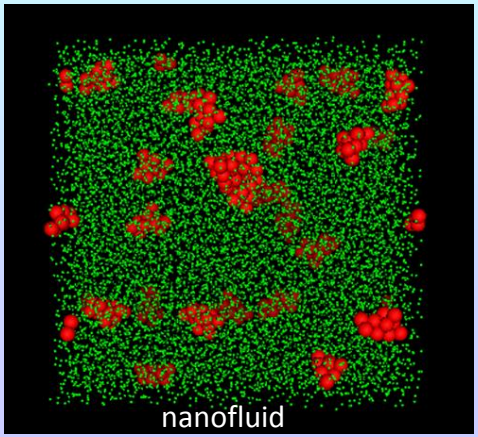
1. DNA condensation
2. Electrokinetics of macromolecules
3. Stability of lipid bilayer systems
4. Membrane crumpling
5. Thin film deposition
6. Magnetic anisotropy materials
7. Nanofluids

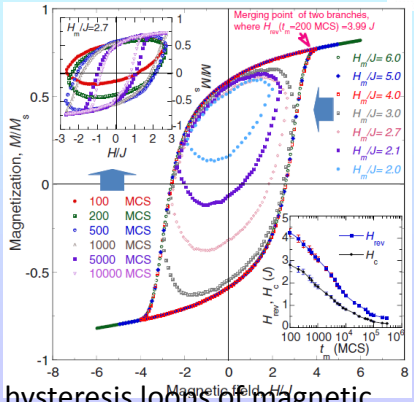



condensed chain morphology

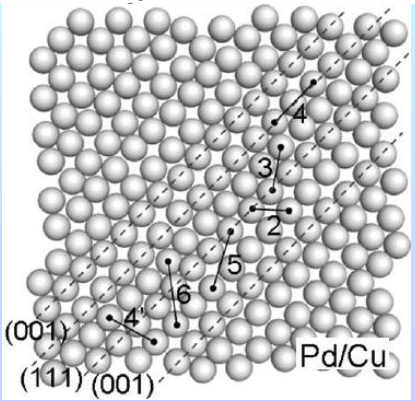




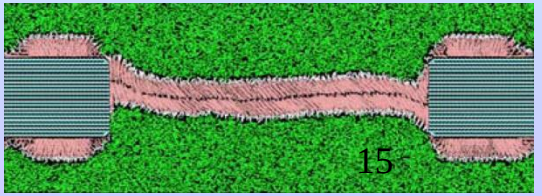

nanofluid



hysteresis loops of magnetic anisotropy materials



thin film deposition


lipid bilayer hanged on a nano-hole

The Thin Film and Nano-scattering Laboratory

Project leader: Professor Chih-Hao Lee (1977BS, 1979MS, 1987PhD)

Interesting area:

Thin film material fabrication and characterizations:

1. Organic light emitting diode thin films
2. Magnetic multilayers
3. Transparent conducting oxidation thin film
4. MRAM, ReRAM, organic transistors thin film
5. Solar cell material: CuInSe2, DSSC, Organic solar cells
6. Thin film Li-battery
7. In-situ thin film growth and characterization

Applications of synchrotron radiation techniques:

Nanoprobe beamline, coherent X-ray beamline construction; In power diffraction, thin film scattering, Small angle scattering, X-ray absorption spectroscopy, XMCD, X-ray microscopy imaging

Applications of neutron beams:

In power diffraction, reflectometer, small angle neutron scattering,

Inelastic neutron scattering, neutron radiography.

The Thin Film and Nano-scattering Laboratory

Professor Chih-Hao Lee

Basic Facilities in the laboratory:

1. X-ray machine for XRD, reflectometer, X-ray fluorescence; NIM detector systems for measuring X-ray, gamma-ray and alpha particles.
2. Neutron de-polarized beamline and neutron diffraction beamline at THOR.
3. Simple photo-luminescence spectrometer, MOKE, I-V measurement;
4. Ultra-high vacuum system with e-gun evaporator, ion sputtering and LEED/retarded field Auger; thermal evaporator, two-gun sputtering system;
5. Basic sample preparation tools: Tube oven(1000 C), box oven (1700C), polishing machine, spin coating machine, chemical hood, milling machine and wheel cutting machine.

Recent published papers:

89. T.W.Huang, et al., "Anomalous grazing incidence small angle X-ray scattering investigating the surface morphology of FePt magnetic nanoparticle monolayer on functional modulated substrates", *J. Appl. Cryst.*, 40, s480-484(2007)

94. M.Z.Lin, et al., "Synchrotron Radiation and Polarized Neutron Study of the Enhancement of Orbital Magnetic Moment of Fe in the Epitaxial NiFe/Ru Multilayer", *Surf. Sci.*, **601**, 5707-5711 (2007).

95 H.Y.Lee, et al., " Surface morphology of sputtered Ta2O5 thin film on Si substrates from X-ray reflectivity at a fixed angle.", *J. Appl. Cryst.*, **41**, 356-362 (2008).

98. C.H.Lee and Y.D.Tzeng, "Study of the morphology of ultra-thin Pt films as the anode of an organic light emitting display", *Thin Solid Film,* **517**, 5116-5119 (2009).

99. Y.F.Liao, et al., "X-ray absorption spectroscopy study of the Co implanted ZnO eptiaxial films", *IEEE Trans. Magn.*, **45**, 2431-2433 (2009).

101. C.H.Lee, et al., "The the polyol process of preparing the Ru doped FePt nanoparticles", *Intern. J. Modern Physics B,* **23**, 3561-3566(2009).

102. C.H.Lee, et al.," Neutron Depolarization Study on the Magnetic Correlation Lengths of Nickel Ferrite with Different Packing Densities", *Physica B* **404**, 2565-2567 (2009).

103. Yuet-Loy Chan, et al."Magnetic Response of an Ultrathin Cobalt Film in Contact with Organic Pentacene Layer", *Phys. Rev. Lett.*, **104**, 177204 (2010).

104. H. S. Hsu et al., "Observation of bias-dependent low field positive magneto-resistance in Co-doped amorphous carbon films", *Appl. Phys. Lett.*, **97**, 032503(2010).

Nano/Micro Systems Technology

NANOMATERIALS

Prof. P.C. Wang
T.K. Yeh
Fu-Rong Chen
J.J. Kai
C.H. Huang
F.Y. OYang

Nanomaterials Chemistry Lab

(P.I.: Pen-Cheng Wang)

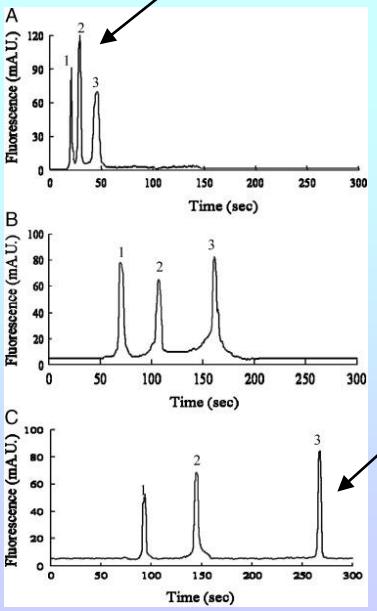
Research Subjects:

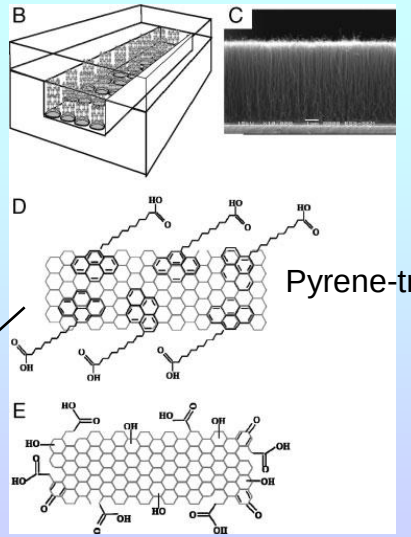
- **Synthesis and characterization of advanced nanomaterials**
- **Integration of advanced nanomaterials for use in organic electronics, miniaturized biomedical devices and renewable energy**

1. CNT-based stationary phase for rapid high-resolution DNA separation

(PC Wang and FG Tseng, Electrophoresis, 2009)

Poor DNA Separation Result





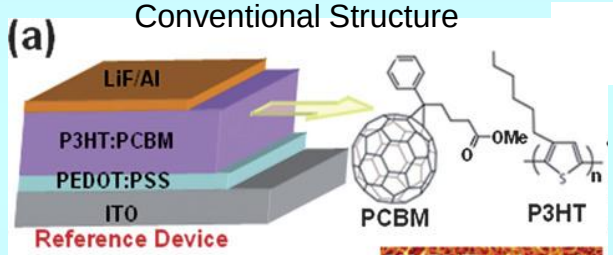
Pyrene-treated CNT

High resolution DNA Separation

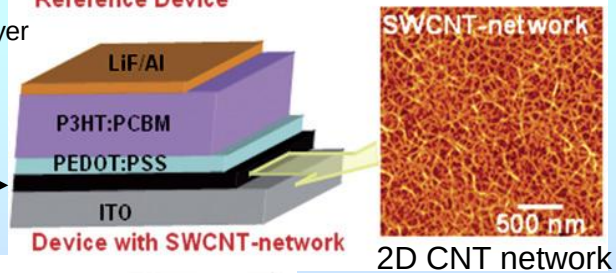
2. CNT-based penetrating electrodes for ballistic hole transport in organic solar cells

(PC Wang and CH Tsai, J. Mater. Chem., 2010)

Conventional Structure

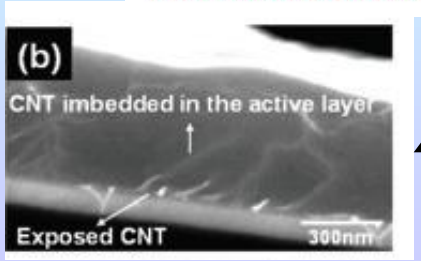


Extra CNT Layer



2D CNT network
(Top View)

Hydrazine treatment

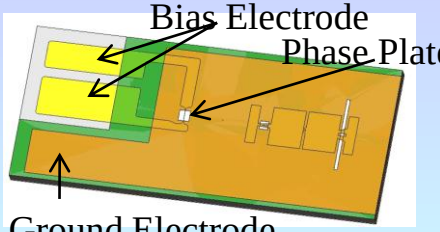


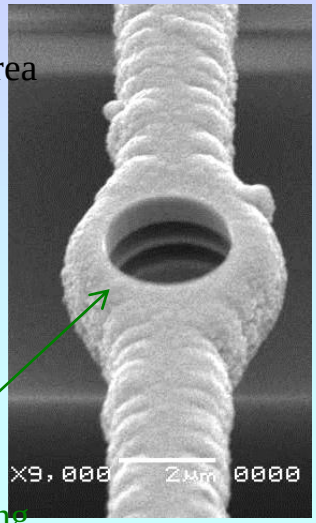
3D CNT Penetrating electrodes
(Cross Section View)

Phase plate Design

Prof. FG Tseng

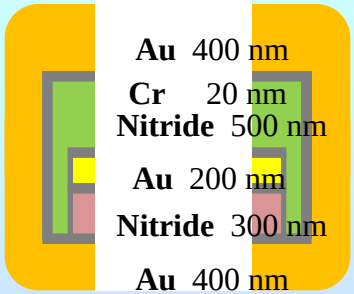
Top View

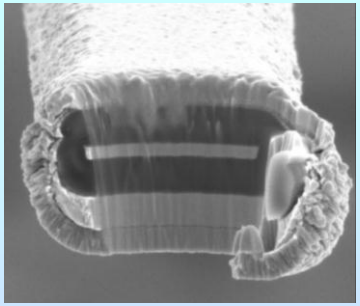




Phase Shift Ring

Cross-section View

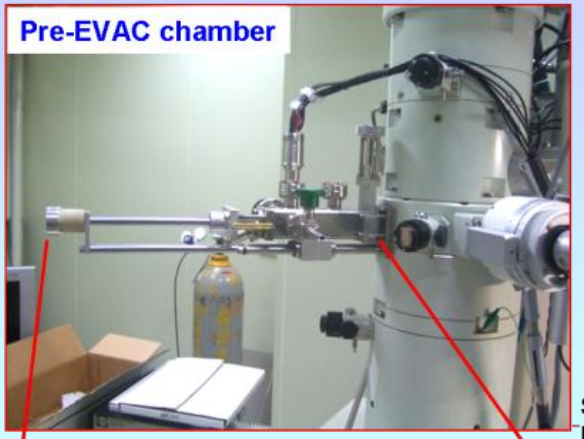


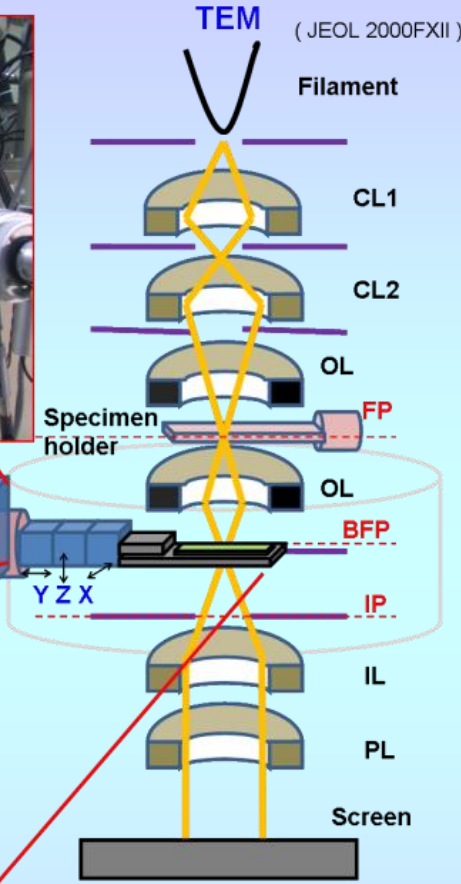


- 單懸臂支撐五層相位環結構
- 穿透光通過相位環內，被靜電場改變相位
- 高角度繞射光由光圈穿透區通過，不受電場影響

Phase Contrast TEM

Prof. FR Chen





Translation Stage

- 相位板需插入電子顯微鏡之物鏡後聚焦面
- 預抽腔體可於不破整體真空下快速抽換相位板
- 壓電三軸移動平台提供電子束與相位環孔洞的精密對準

Low Carbon Green Energy

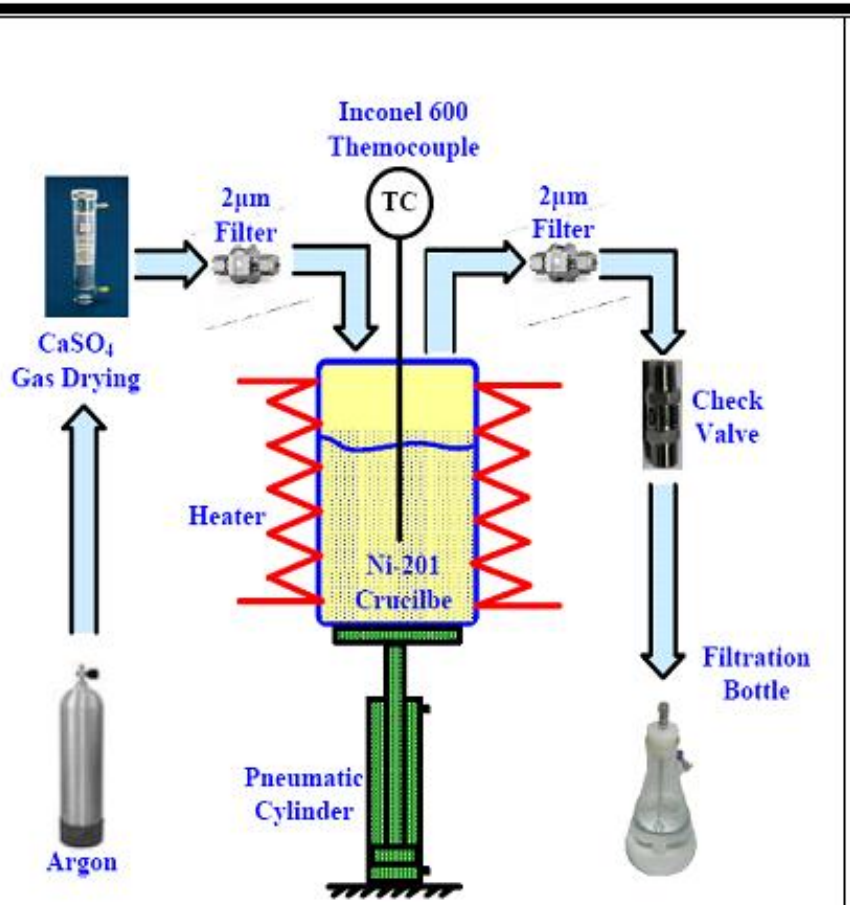
NUCLEAR ENERGY

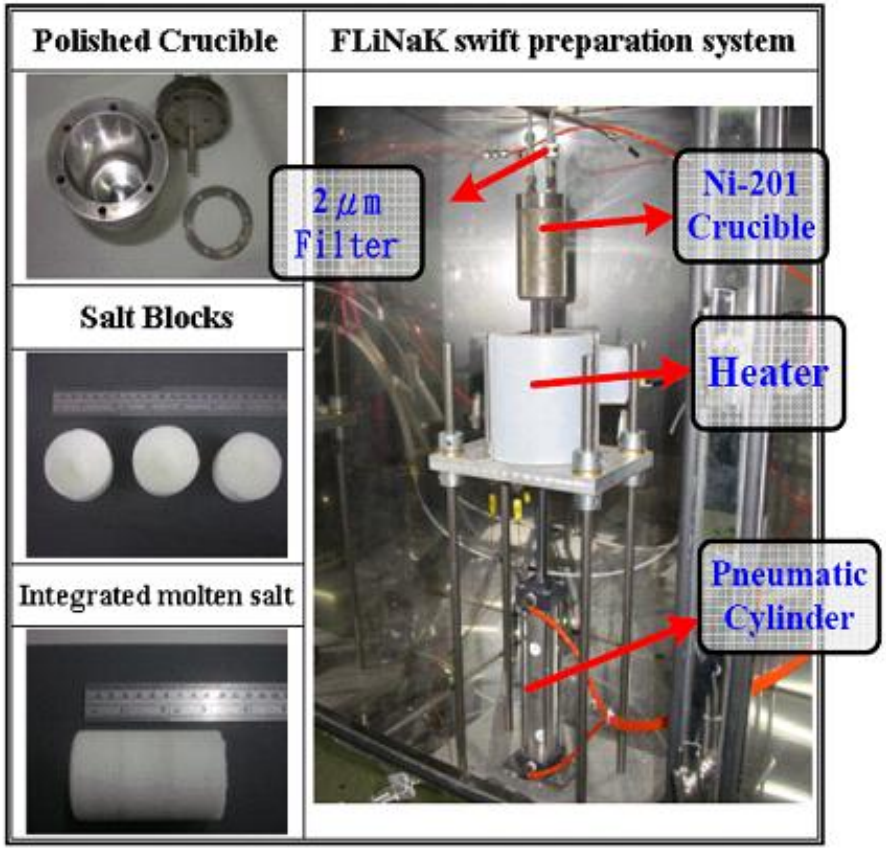
Prof. Y.M. Fun

Nanofluids
Prof. Y. M. Fun

- Nanofluids are engineered colloids made of a base fluid and nanoparticles (1–100 nm)
- Nanofluids have higher thermal conductivity and single-phase heat transfer coefficients than their base fluids
- We are constructing the test loop of heat transfer in molten salt reactor (MSR).Because the Flinak has high corrosive on metal, and graphite is one of the few that will not be eroded,we use graphite nano powder.

Preparation of FLiNaK





Adding Graphite Powder

- Fig.1 shows the theoretical prediction of thermal conductivity coefficient,Φ is the volume percent of nano-particle ,the thermal conductivity increases with Φ .
- Fig.2 shows addition of graphite powder in the Flinak .

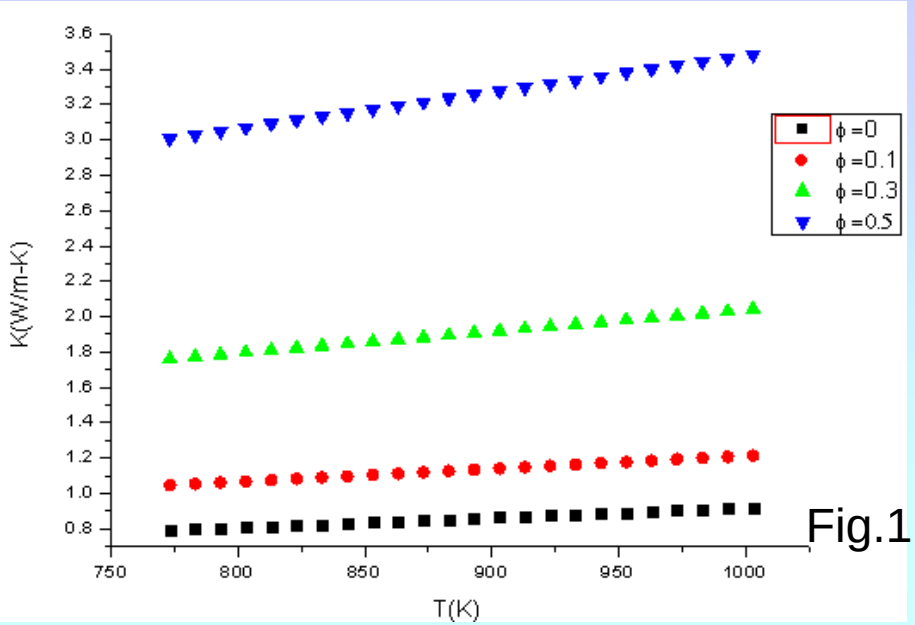


Fig.1

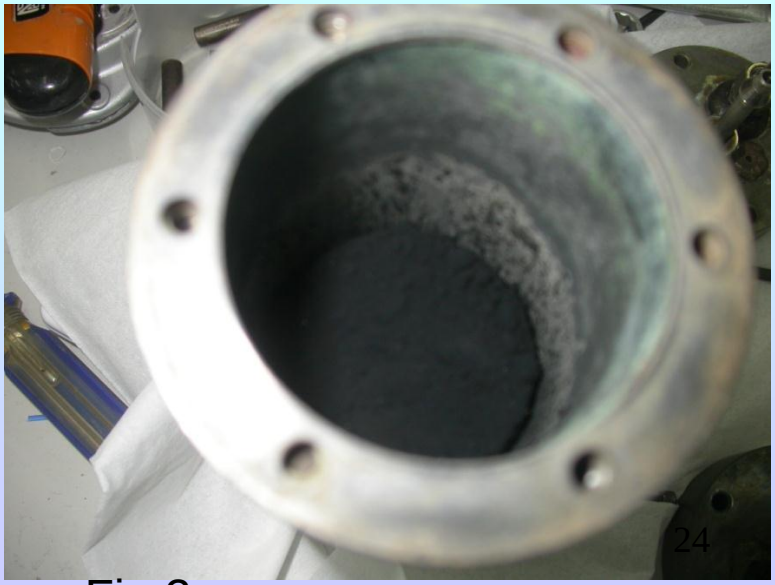


Fig.2

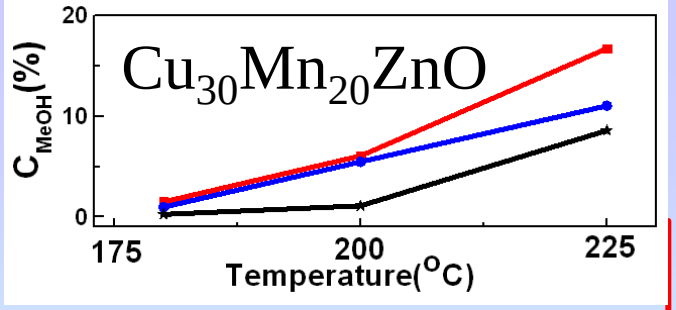
Low Carbon Green Energy

HYDROGEN ENERGY/ FUEL CELL

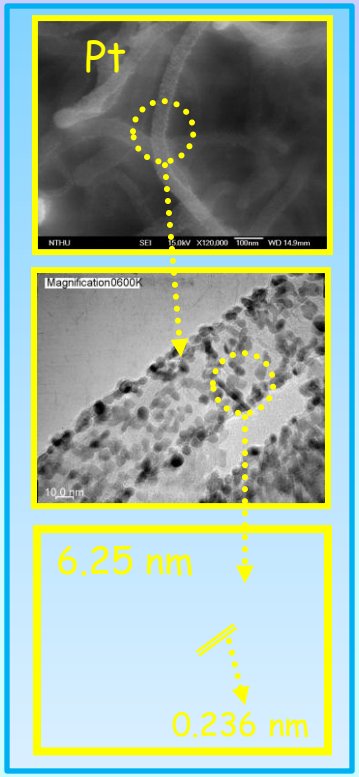
Prof. F.-G. Tseng
T. K. Yeh
B.C. Wang
Y.C. Su
Chin Pan

Energy National Project
Reforming Type-Micro PEMFC

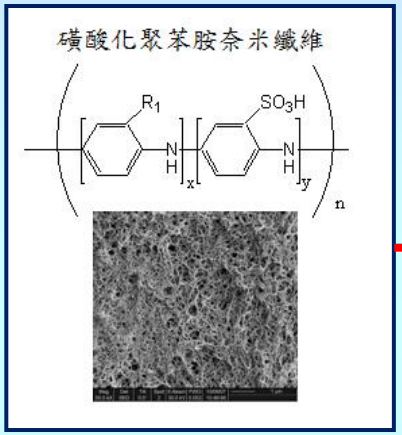
Prof. Y. C. Su, F.G. Tseng, T.K. Yeh, B.C. Wang, C. Pan, and Y. C. Huang



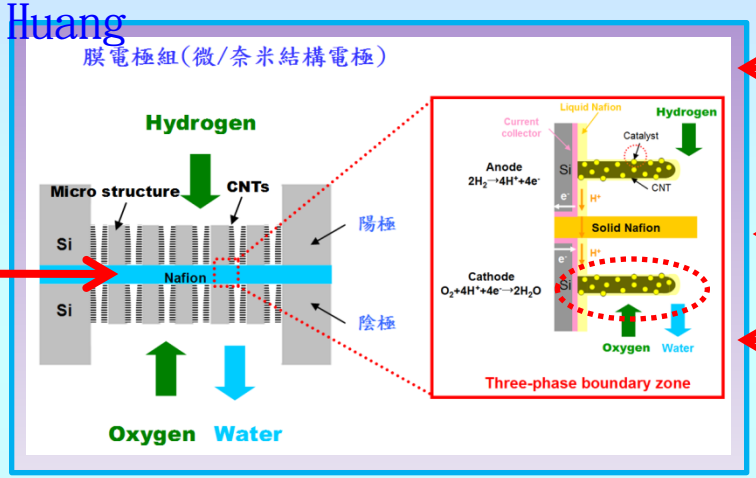
Low T High E Nano CuZn catalyst, Huang



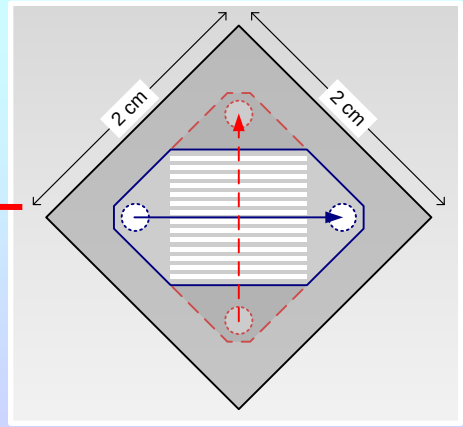
High E Pt/Ru Catalyst, Yeh



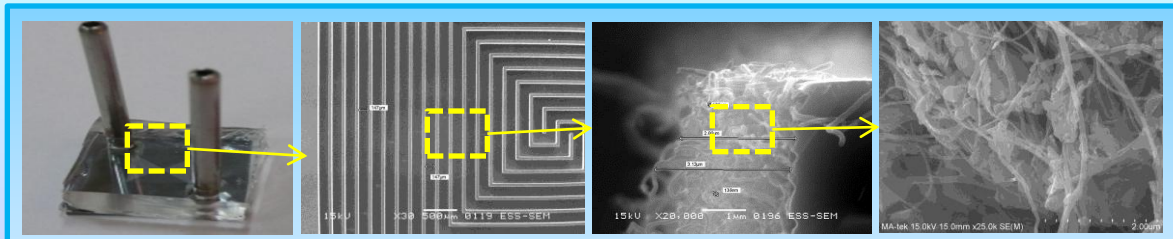
High T PE Membrane, Wang



Micro PEMFC, Su



Water/Thermal Management, Pan

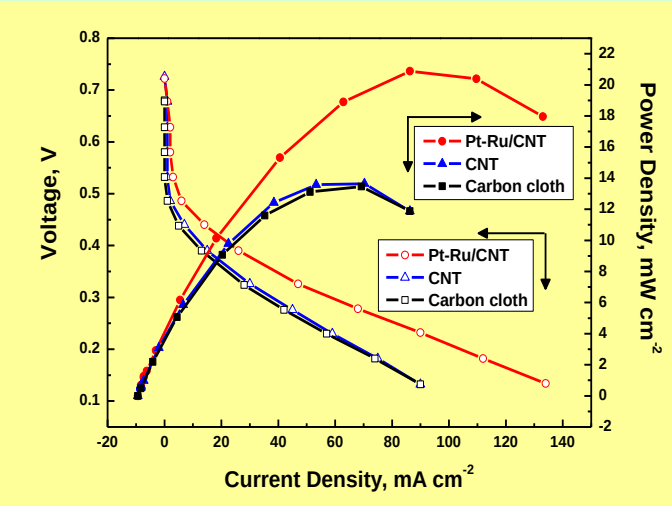


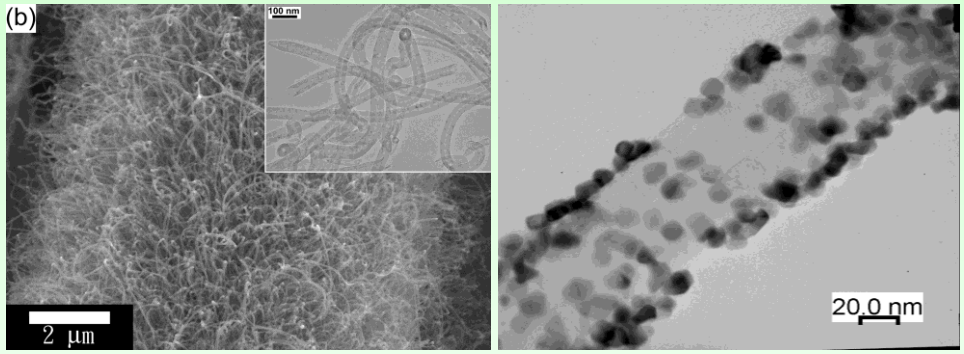
微型甲醇重組器　微流道形貌　微流道側壁成長CNT　於CNT上還原觸媒

Micro Reformer, Tseng

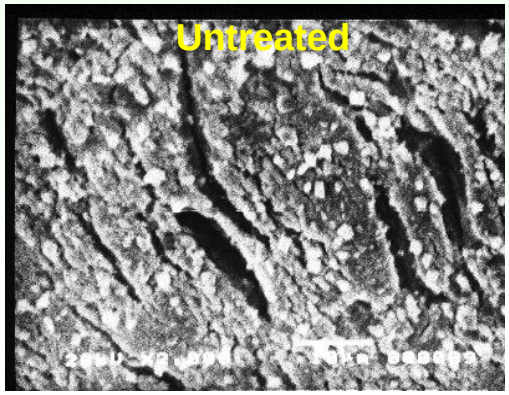
The Electrochemistry Laboratory (Prof. Tsung-Kuang Yeh)

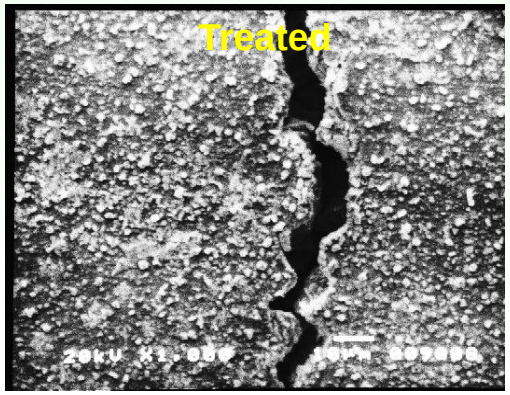
The lab is devoted to research on fuel cells and nuclear materials. We improved the efficiency of direct methanol fuel cells by a better dispersion of nano-size catalyst particles. We also developed novel techniques (nano-size ZrO_2 and TiO_2 coatings) for corrosion mitigation in structural materials of light water reactors.





Nano-size catalyst particles deposited on CNTs directly grown carbon cloth at the anode helped improve the efficiency of a DMFC.





The 304 stainless steel sample treated with nano-size ZrO_2 particles showed significantly less cracks in simulated BWR environments. This technique may be applied on line at an in-service nuclear power plant.

Low Carbon Green Energy

SOLAR ENERGY

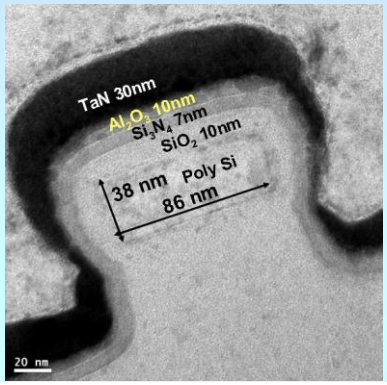
Prof. Y. C. Wu
F. R. Chen
B.C. Wang
J. J. Kai
C. H. Lee

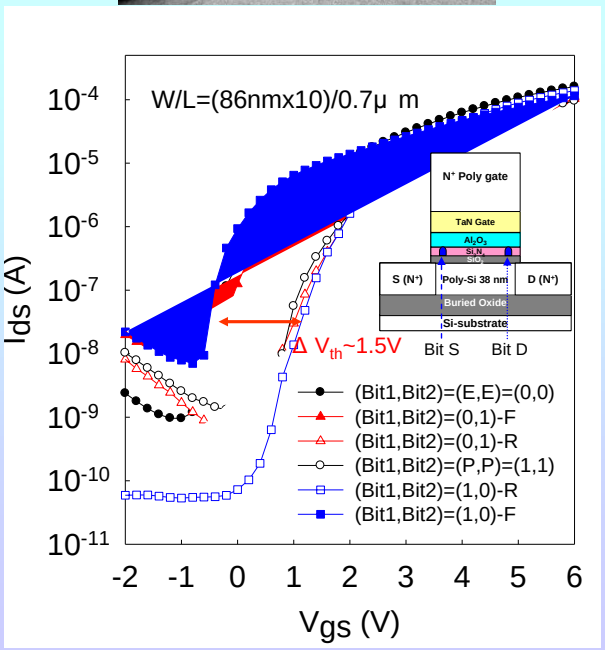
Ess Novel Nano & Green Energy Device Lab

Yung-Chun Wu 吳永俊

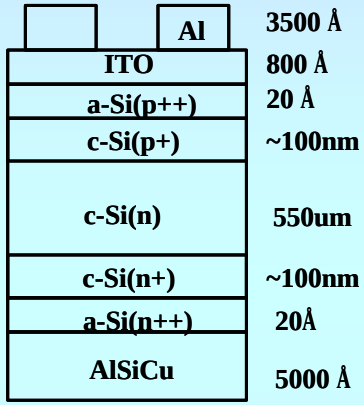
1. Semiconductor memory

TANOS Flash memory

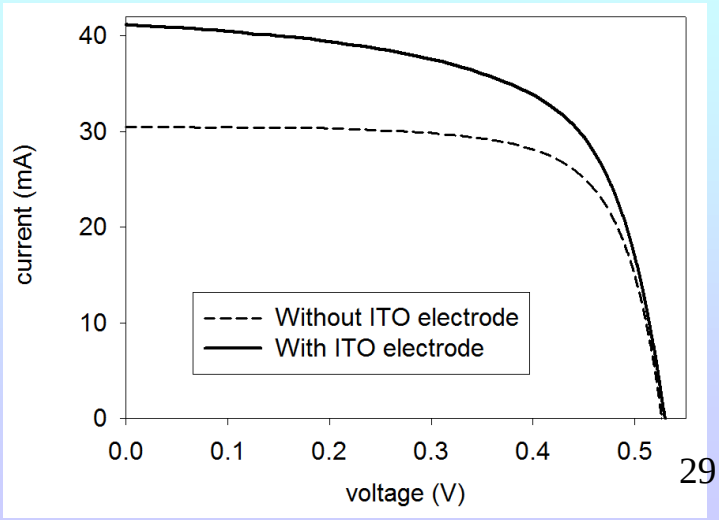




2. Hetreojuction Si solar cells



HJ SC	
Jsc (mA/cm²)	**41.17**
Voc(V)	**0.53**
FF (-)	**0.63**
η(%)	**13.64**



NTHU ESS

The leader for Low Carbon Green Energy!

Thank You for Your Attention