From Kyushu University to the world.
Introducing research activities that will bring us to the realization of a carbon-neutral society.

Hello! I²CNER

MAY 2014

vol.10

International Institute for Carbon-Neutral Energy Research

Science Cafe

Thin, Light, and Bendable! The Potential of Cutting-Edge Organic EL Technology

Chihaya Adachi

International Institute for Carbon-Neutral Energy Research, Kyushu University
Principal Investigator/Professor,
Hydrogen Production Research Division
Director of the Center for Organic Photonics and Electronics Research

Omuta High School students

Impacting Society By Solving Problems

wpi World Premier International Research Center Initiative

I²CNER

KYUSHU UNIVERSITY

ILLINOIS

Introduction of New Researchers

Welcome to I²CNER!

Roman Selyanchyn

Post-doctoral
Research Associate:
CO_2 Capture and Utilization
Research Division

I am from Ukraine. I conduct research related to gas separation by thin free-standing membranes. In the past, I have tried various interdisciplinary research topics primarily related to gas-sensors, analytical description of odors, and material science. I am thrilled to be a member of I²CNER and hope to contribute effectively to the accomplishment of the Institute's mission, leading society towards more efficient and green energy technologies. I spend my free time with my family, investigating the interesting and beautiful places throughout mysterious Japan.

Shuai Wang

Post-doctoral
Research Associate:
Hydrogen Materials
Compatibility Research Division

I am originally from China. Before joining I²CNER in February, I earned my Ph.D. in engineering at Hokkaido University. My research area is hydrogen embrittlement in metals with a focus on the interactions of dislocations, grain boundary, and fracture with hydrogen atoms. In I²CNER, I will dedicate my efforts to linking the experimental data with simulation work toward the goal of identifying a microscopic and atomic mechanism for prediction of hydrogen embrittlement. I was happy to join I²CNER, as it has a very professional and international environment for research, and the people are kind and helpful. In my free time, I enjoy playing basketball and hiking.

Biao Shen

Post-doctoral
Research Associate:
Thermal Science and
Engineering Research Division

After finishing my Ph.D. at Shanghai Jiao Tong University in China, I worked for a CREST (Core Research for Evolutionary Science and Technology)-funded program at Kyushu University as a postdoctoral researcher and joined I²CNER starting this February. My research focuses on enhanced boiling heat transfer based on a novel design of micro textured surface topography and wettability manipulation, with an aim to improve the system efficiency of energy utilization. Hopefully, this work will lead to more efficient use of heat and bring us one step closer to sustainable energy in the future. I very much enjoy living in Fukuoka. In my leisure time, I enjoy reading Manga and playing video games.

Taking the First Step

As a Ph.D. student at Kyushu University, Thomas Bayer has taken the first step in the journey towards becoming a world-renowned researcher. Having taken an opportunity to join I²CNER as Super Research Assistant (SRA), Thomas experiences each day what it will be like to be a researcher in full-time.

Thomas Bayer

Faculty of Engineering
Graduate School of Engineering
Kyushu University

Fuel Cells Research Division, I²CNER

Nationality: Germany
Hobbies: Rugby, Athletics, Traveling by bicycle

Career Path

2010 March
Graduated from Stuttgart University (Diploma in Engineering)

2010 April
Joined the Fuel Cell Division of the German Aerospace Center (Germany)

2011 September
Came to Japan for Japanese study

2012 June
Joined BMW Japan (Tokyo, Japan)

2013 April
Joined Kyushu University / I²CNER as Ph.D. student and SRA

Research Experience

My research topic is based on graphene, a monolayer of carbon atoms, which is the strongest material in the world. I try to incorporate graphene into a fuel cell to improve its performance to aid the development of a Carbon-Neutral society. Working at I²CNER is amazing! The laboratories are well equipped and provide ample space for experiments. The people working at I²CNER are very friendly and helpful. From time to time, we have some nice after work events like going to see fireworks or having a barbecue, which are, in my opinion really important for forming a good team.

Experience in Japan

Japan is an amazing country. The people are very friendly, the food is delicious, that I love them very much! I like participating in traditional Japanese festivals such as the Hakata Dontaku Festival. It's a wonderful way to learn about Japanese culture and habits, while having a lot of fun and making new friends.

A day in the Lab

8:00 Prepare experimental set-up(start oven, prepare the fuel cell assembly, check set-up for gas leakage)

9:00 Check emails and compose necessary correspondence

9:30 Start fuel cell performance measurement

10:00 Preparation of new membranes (dispersion preparation, filtering)

12:30 Lunch (Usually a good ramen in the Cafeteria)

13:00 Read scientific papers and write my own publication

16:00 Discussion with colleagues about last results

17:00 Finish fuel cell measurements, clean up

18:00 Join Kyushu University Rugby Club or Athletics Team for practice

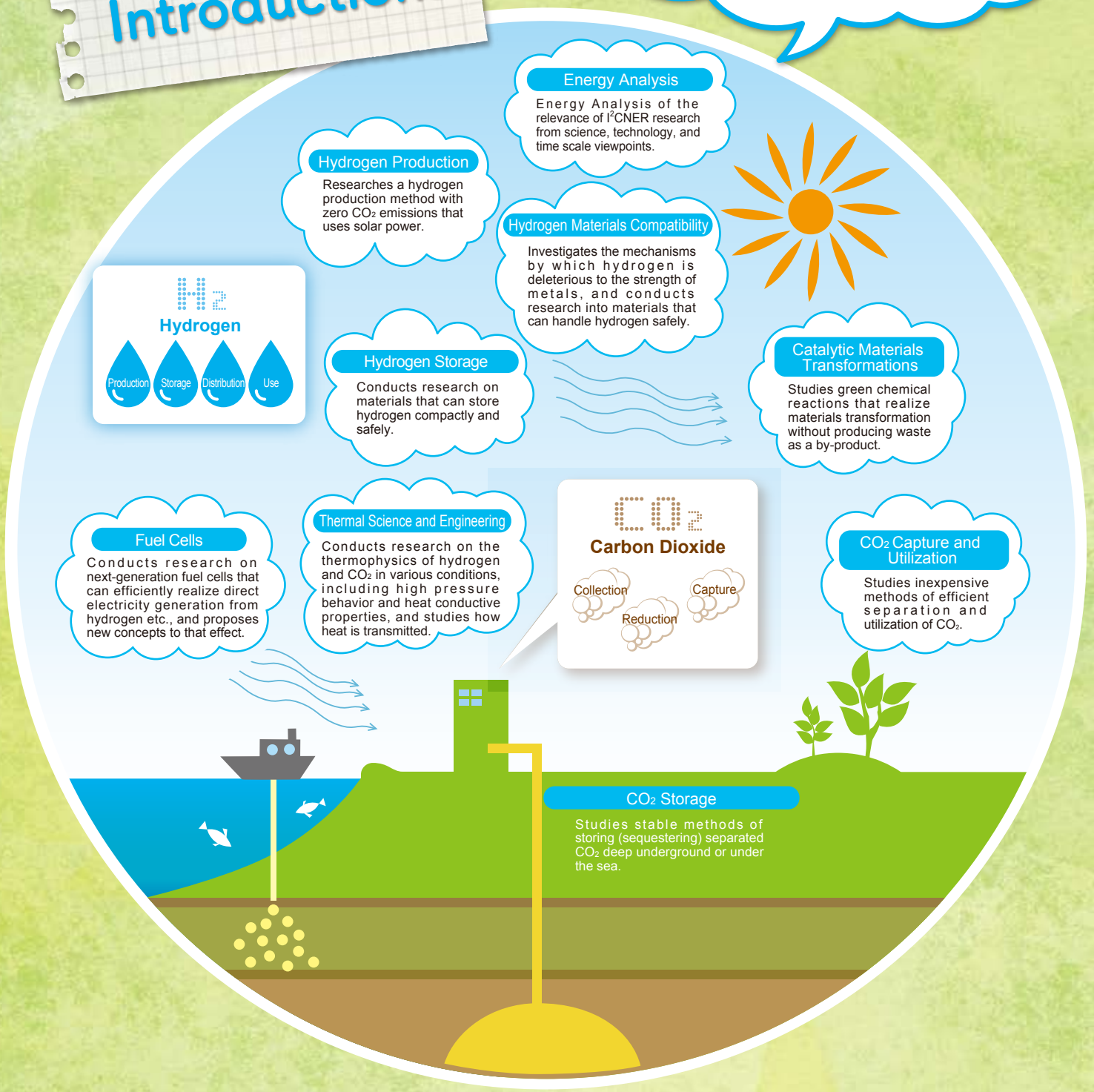
20:00 Data evaluation and summarize experiment results

21:30 Finish work

Research Division Introductions

What is a carbon-neutral society?

This is a society where CO_2 emissions generated by energy use are reduced to a minimum, and where a balance is achieved between emissions and the amount absorbed and stored in the nature world.



Introducing the nine research divisions of I²CNER, who are engaged in cutting edge research to create a green and clean carbon-neutral society free of CO_2 emissions.

Discussion Members
Chihaya Adachi
International Institute for Carbon-Neutral Energy Research(I²CNER), Kyushu University
Principal Investigator/Professor,
Hydrogen Production Research Division
Director of the Center for Organic Photonics and Electronics Research(OPERA)
&
Omuta High School
second-year students
Yukio Shiomitsu
Takumi Nakagawara
Masako Hiromatsu
Madoka Miyazaki

Thin, Light, and Bendable!
The Potential of Cutting-Edge Organic EL Technology

The development of the electronics technology used to control the electrical currents in devices around us, such as mobile phones and flat-screen TVs, has until now been based on "inorganic electronics," such as silicon semiconductors and light-emitting diodes (LEDs). However, in recent years, "organic electronics," specifically, semiconductors manufactured using organic materials, has come to the fore as a next-generation technology capable of achieving new and unprecedented "thin, light, and bendable" functionality. Among these "organic electronic" technologies, there are advances being made in the practical development of organic electroluminescence ("organic EL") technology used in next-generation displays and next-generation illumination, as well as in research into the application of organic semiconductors to organic solar cells, which will be a key to building a clean energy society. In light of these issues, a leading expert on organic EL technology development, Professor Adachi, and a group of Omuta High School students had a discussion about the potential of organic EL technology.

What is Organic EL?

Adachi The research institute I have invited you all to today is known as the

Center for **O**rganic **P**hotonics and **E**lectronics **R**esearch, or OPERA. Does anyone know what we research here?

Hiromatsu Organic means "organic chemistry" and Photonics means "light," right?

Adachi That's right. How much does everyone know about organic EL, which is our main research focus?

Nakagawara It has to do with light-emitting diodes made from organic compounds, doesn't it?

Adachi You certainly know a lot about the subject! The EL in organic EL is an abbreviation of "electroluminescence," which refers to a phenomenon whereby an organic substance emits light when voltage is applied.

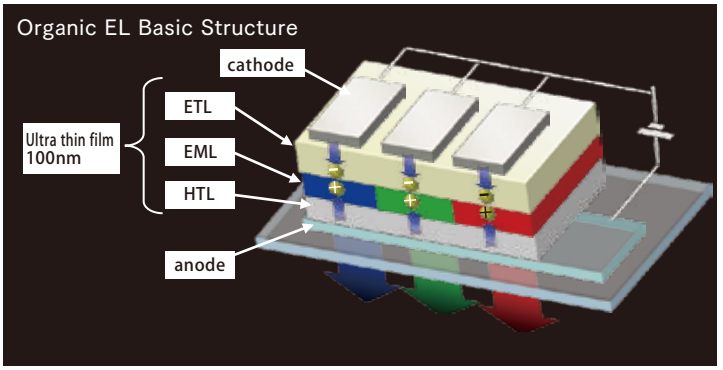
Miyazaki But aren't organic compounds primarily insulators? Why would they conduct electricity?

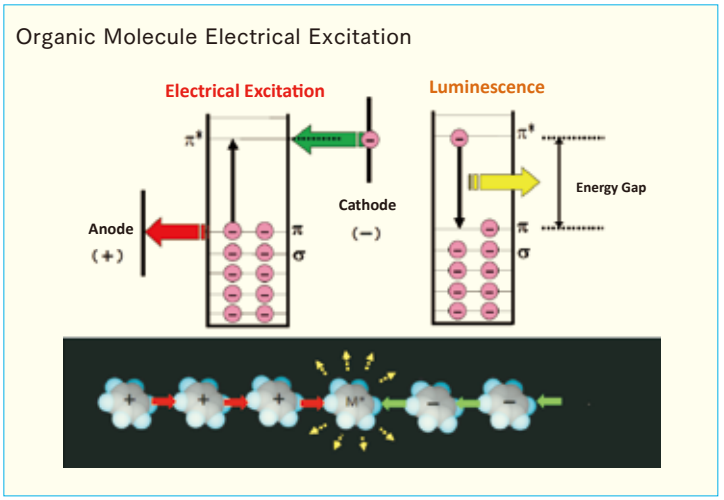
Adachi That's a good question. Organic compounds such as plastic films are primarily considered insulators, but by reducing them to a thin film about one two-hundredths the thickness of a strand of hair (100 nm), they will conduct electricity.

Shiomitsu A thin film—in other words, it's in an extreme state. Is the principle

that a substance's special characteristics will change when it enters an extreme state, similar to the logic of Newton's equation of motion not applying when an object moves at the speed of light?

Adachi Exactly. If, for example, you applied 10 volts of electricity to a 100 nm thin film, you would have the same result as if you had applied 1,000,000 volts to a 1 cm thick film. By creating an extreme state like this, organic compounds can be made to conduct electricity and emit light. This technology makes possible the development of extremely thin displays and lighting equipment.





Organic EL Structure and the Light Emission Principle

Hiromatsu Please tell us about the basic structure of organic EL and its light emission principle.

Adachi The basic structure is a thin film made of organic materials sandwiched between a positive electrode, also acting as substrate, and a negative electrode. If voltage is applied to the thin film, electrons and electron holes will be injected from the positive and negative electrodes, and the electric charges recombine to give rise to high energy state (excited state) in the organic material. After this, in a process where the substance reverts to its previous low energy state (ground state), energy will radiate and light will be emitted. This is the basic light emission principle. Additionally, an LED is a point light source with a narrow range of light, but a special characteristic of organic EL is that it is a surface light source with a wide angle of emission.

Organic EL Super Luminescent Materials

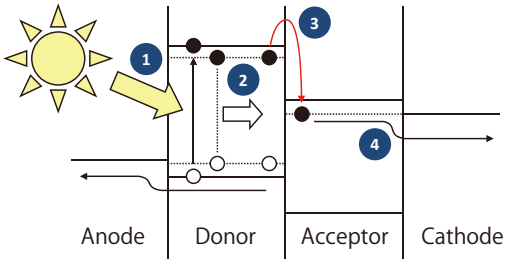
Adachi Organic EL research started with organic light-emitting diode (OLED) development using fluorescent materials as luminescent materials, then shifted to using phosphorescent materials, which made high-efficiency EL light emission possible. However, those materials have some issues such as the use of rare metals like iridium and platinum.

Miyazaki Rare metals are costly because they are limited global resources with high prices, isn't that right?

Adachi Yes, so we tackled the development of a new organic EL light-emitting material, and in 2012, we

Laboratory Visit

William Potscavage
Post-Doctoral Research Associate
Center for Organic Photonics and Electronics Research (OPERA)
Kyushu University



Basic Operation of Organic Solar Cell
①Absorption of light to create an exciton
②Diffusion of exciton to donor/acceptor interface
③Separation of exciton into charge carriers
④Collection of holes at the anode and electrons at the cathode

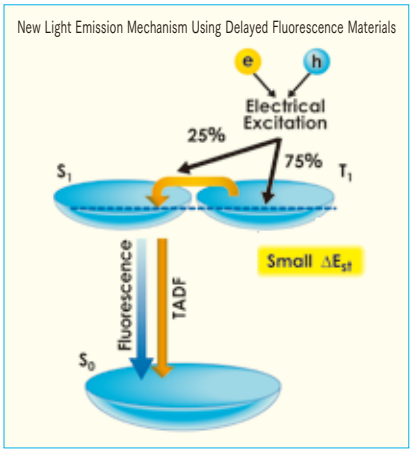
If the mechanism of applying voltage to the organic EL, which causes light emission, is reversed, electric energy can be generated by taking in light energy.
Using this principle, we are advancing the development of organic thin-film solar cells.

succeeded in developing thermally activated delayed fluorescence that does not use any rare elements and can convert electrons to light with almost 100% efficiency. Thermally activated delayed fluorescence is drawing attention as a third-generation organic EL luminescent material that simultaneously achieves both cost reduction in materials and highly efficient EL light emission.

Shiomitsu By about how much were you able to cut costs?

Adachi They dropped to about one tenth of what they had been.

Nakagawara Having high luminous efficiency and low cost really makes it the ideal material, then, doesn't it?

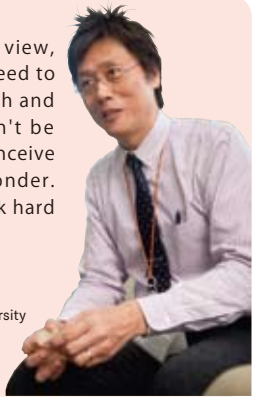


A Future Society Built with Organic EL

Adachi Organic EL is expected to be used in such applications as next-generation illumination and displays. Additionally, we are working on the development of organic thin-film solar cells that use organic semiconductors. Organic thin-film solar cells are different from the conventional brittle and heavy silicon solar cells, and can be manufactured at low temperatures, meaning we have been able to reduce costs and save energy in their production. Also, because they are thin, light and bendable, they can be developed for use in locations not possible with conventional solar cells (windows, walls, etc.). So by expanding the scope of their application, we expect them to contribute greatly to building a clean energy society. Likewise, organic EL technology, with its great potential, is expected to lead to the development of new materials, further evolve, and give rise to device innovations. But for this kind of innovative technological development to happen, we really need young people like you who are thinking freely and overflowing with ideas. I look forward to the day when you too can harness your creative power to help drive the next leap forward in the technological development of organic EL!

Message to Students

If you look at things from your own unfettered point of view, unconstrained by conventional wisdom, you are guaranteed to make new discoveries. A great deal of innovative research and development is brought about by young people. Don't be satisfied simply learning existing knowledge, but try to conceive of an even better future, never losing your sense of wonder. Don't ever make do with the way things are now, but work hard to realize your dreams in the spirit of rising to a challenge!



Chihaya Adachi
International Institute for Carbon-Neutral Energy Research(I²CNER), Kyushu University
Principal Investigator/Professor, Hydrogen Production Research Division
Director of the Center for Organic Photonics and Electronics Research(OPERA)

Post-discussion

Omuta High School

This discussion was made possible by the cooperation of students from Omuta High School. Omuta High School is a private institution which was established in Omuta City, Fukuoka Prefecture, Japan over 90 years ago. Many of the school's club activities, including Brass Band Club and Ekiden Club (long-distance relay road race), are active throughout the nation. In fact, the Ekiden Club has participated in the All Japan Inter-High School Ekiden for 28 successive years, winning 5 championships overall. International exchange is one of the top priorities of Omuta High School, which has led to their joint study-abroad program with a school in France. In addition to general courses, they offer a wide variety of elective courses, including integrated courses, culinary courses, etc. This wide selection of courses is one of the main attractions of the school.

Yukio Shiomitsu

Being able to visit a place where cutting-edge technological development is being carried out, I could feel the underlying strength of Japan's technological development. The research institute has really left an impression on me in that it wasn't stiff and starchy, but was an environment where people could freely come up with ideas.

Takumi Nakagawara

It was really exciting being able to observe the most advanced experimental equipment in the world. I thought someday I'd also like to contribute to building a better future by drawing on my own creativity and developing a wealth of ideas.

Masako Hiromatsu

I'll always remember Professor Adachi's saying "Question what is currently considered obvious." I was able to see things today that I hadn't ever imagined before, and I'm looking forward to future research.

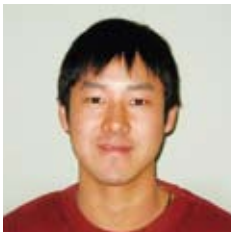
Madoka Miyazaki

I was happy to learn about "the unlimited potential of materials" during this visit. And Professor Adachi's advice regarding approaches to research was very useful.

Report

Exchange Program Report from University of Illinois at Urbana-Champaign

The Kyushu University Faculty of Engineering and the International Institute for Carbon-Neutral Energy Research (WPI-I²CNER) Satellite at the University of Illinois at Urbana-Champaign (UIUC) jointly launched the pilot "I²CNER Undergraduate Exchange program" from February 25th to March 25th, 2014. One of the primary aims of this program is to fulfill objectives of the World Premier International Research Center Initiative (WPI) by exposing young engineering students to US culture, including the university research culture. This pilot program provided 5 Kyushu University undergraduate engineering students with the opportunity to travel to UIUC to observe and assist with research in UIUC laboratories under the supervision of 5 Illinois Satellite faculty. The students also gained valuable hands-on laboratory experience through their daily work in the labs and participation in group meetings. As you will see below, these students gained an appreciation of a very different way of life during their month-long stay at UIUC.



Ryota Sakemi

Department of Mechanical Engineering
Faculty of Engineering
(3rd Year)

Affiliation at UIUC Department of Mechanical Science & Engineering
Host Professor Placid Ferreira, Department Head

Can you describe the research project(s) you were working on during your time at UIUC?

Using the "transfer printing" method, I worked to develop a 4-armed swimming robot whose single arm works independently.

What was your favorite piece of equipment that you worked with during your stay?

My favorite equipment was the computer controlled machine that works with a precision of 1nm in 3 axial directions. The machine was equipped with a camera so it could record the state of the movement onto a computer.

Were there any unforgettable experiences during your stay?

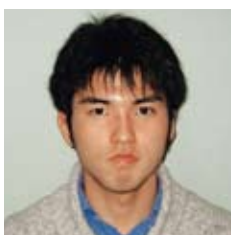
I participated in a lab meeting once where students shared their research progress with their professor. I found the meeting to be very impressive because the students carried out their discussions with the professor very actively and exchanged ideas without hesitation in order to confirm their next steps.

What was your favorite activity on campus, outside of your lab?

My favorite activity was playing basketball with the UIUC students who gathered in the ARC (Activities and Recreation Center) gym during break time and after school. I joined a few games each week where we formed free teams and enjoyed our play! It was good opportunity for me to mingle with UIUC students outside of the lab and get to know them!

What advice would you give to students who are considering a visit to Illinois in the future?

Although this program was just one month in length, there was so much to learn! As for English communication, it won't be much trouble if you prepare for it well in advance. The program provides you with new perspectives and fruitful experiences, so just apply!



Yoshihiro Nishimura

Department of Mechanical Engineering
Faculty of Engineering
(3rd Year)

Affiliation at UIUC Department of Materials Science & Engineering
Host Professor Angus Rockett

Can you describe the research project(s) you were working on during your time at UIUC?

I studied the material structure of a thin film for photovoltaics.

What was your favorite piece of equipment that you worked with during your stay?

My favorite equipment was the Differential Scanning Calorimeter (DSC), which is used to measure the melting point of materials, glass transition, crystallization temperature, and the heat of fusion.

What was your favorite activity on campus, outside of your lab?

There are many recreation facilities on campus, including squash courts and an ice skating rink. I really enjoyed them. During a free weekend, I went to Chicago to watch an NBA game, visit museums, and tour Shedd Aquarium. Also, I went to Springfield, Illinois, the state capital, for sightseeing. At my guesthouse, I joined an English workshop to talk and play games with guests from all over the world. It was a great way to learn about their culture and practice my English.

What was the most difficult challenge you faced during your stay?

I suffered from the transition to daylight savings time, which was a new experience for me. When I got up in the morning, I noticed that all of my clocks were different (1 hour behind the actual time). It took time before I got used to it.

What advice would you give to students who are considering a visit to Illinois in the future?

My group was very well taken care of through this program. I could contact the staff about my concerns anytime, which allowed me to concentrate on my studies. Even if you worry about studying in English, you should try. Your experiences in this program will stay with you for the rest of your life.

AWARDS

The Society of Polymer Science, Japan / Hitachi Chemical Award

Assoc. Prof. Takuma Yasuda

(Hydrogen Production Research Division)

Assoc. Prof. Takuma Yasuda received the "Hitachi Chemical Award" from the Society of Polymer Science for his outstanding research achievement on the "Development of Self-Organizing Organic Semiconductor Materials and Their Application to Organic Electronics." (Nov. 28, 2013)

THERMEC' 2013 / Distinguished Award

Prof. Setsuo Takaki

(Principal Investigator, Hydrogen Materials Compatibility Research Division)

At the International Conference on Processing & Manufacturing of Advanced Materials, Prof. Setsuo Takaki received the "THERMEC' 2013 Distinguished Award" for his outstanding contribution to the fundamental understanding of microstructure control by the deformation of steels and other ferrous alloys, and for his distinguished leadership in materials science and engineering in Japan. (Dec. 4, 2013)

The Japan Institute of Metals and Materials / Tanikawa-Harris Award

Prof. Zenji Horita

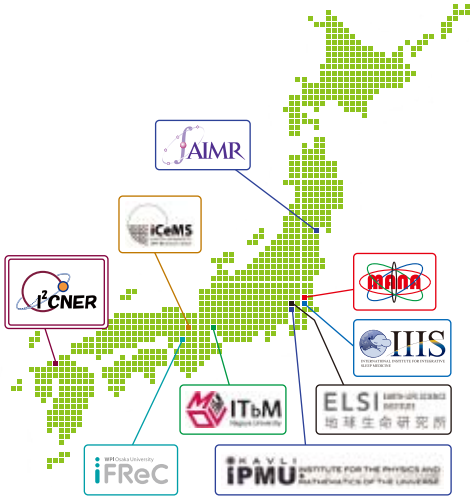
(Principal Investigator, Hydrogen Storage Research Division)

Prof. Zenji Horita received "The Japan Institute of Metals and Materials Tanikawa-Harris Award" from the Japan Institute of Metals and Materials for his work on "Microstructure Control using Giant Straining Process." (Mar. 21, 2014)

What is WPI?

wpi World Premier International Research Center Initiative

The World Premier International Research Center Initiative (WPI) is a project that was launched by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2007. The WPI seeks to form an ideal research environment within visible research centers that maintain high research standards, where leading researchers will be attracted from all over the world.



Refer to:
MEXT Website http://www.mext.go.jp/english/research_promotion/1303822.htm
JSPS Website http://www.jsps.go.jp/english/e-toplevel/index.html

I²CNER Kyushu University International Institute for Carbon-Neutral Energy Research (I²CNER)

Toward the realization of a low-carbon society, I²CNER aims to resolve the challenges of the use of hydrogen energy and CO_2 capture and sequestration by fusing together sciences from atomic level to global scale.

AIMR Tohoku University Advanced Institute for Materials Research (AIMR)

Integrating physics, chemistry, materials science, bioengineering, electronics and mechanical engineering, AIMR is striving to create innovative functional materials. A mathematical unit joined the team in 2011 to help establish a unified theory of materials science, aiming at the realization of a global materials research hub.

iFReC Osaka University Immunology Frontier Research Center (IFReC)

An innovative research center, which pursues the goal of comprehensive understanding of immune reactions through the fusion of immunology, various imaging technologies, and Bioinformatics.

MANA National Institute for Materials Science International Center for Materials Nanoarchitectonics (MANA)

A major focus of our activities is the development of innovative materials on the basis of a new paradigm "nanoarchitectonics," ground-breaking innovation in nanotechnology.

iCeMS Kyoto University Institute for Integrated Cell-Material Sciences (iCeMS)

Established to integrate the cell and material sciences, the iCeMS combines the potential power of stem cells (e.g., ES/iPS cells) and of mesoscopic sciences to benefit medicine, pharmaceutical studies, the environment, and industry.

IPMU Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), Todai Institutes for Advanced Study, The University of Tokyo

With accumulated research on mathematics, physics and astronomy, this research core works to bring light to the mysteries of the universe, such as its origin, and to provide an analysis of evolution.

ELSI Tokyo Institute of Technology EARTH-LIFE SCIENCE INSTITUTE(ELSI)

ELSI focuses the origins of Earth and life. Both studies are inseparable because life should have originated in unique environment on the early Earth. To accomplish our challenge, we establish a world-leading interdisciplinary research hub by gathering excellent researchers in Earth and planetary sciences, life science, and related fields.

IIIS University of Tsukuba International Institute for Integrative Sleep Medicine(IIIS)

IIIS seeks to elucidate the fundamental mechanism of sleep/wakefulness, to develop strategies to regulate sleep, and to contribute to the enhancement of world health by combatting sleep disorders and associated diseases.

ITbM Nagoya University Institute of Transformative Bio-Molecules (ITbM)

The goal of ITbM is to develop innovative functional molecules that make a marked change in the form and nature of biological science and technology (transformative bio-molecules). ITbM will connect molecules, create value, and change the world, one molecule at a time.

Editor's note: "Hello I²CNER" "Energy Outlook"

- I²CNER holds a variety of events.
  For details, please see: ➡ http://i2cner.kyushu-u.ac.jp/ja/results/seminar.php
  (I²CNER Event Information)
  Search by I2CNER
- Mountains, trees, and bushes are all covered in a fresh layer of green leaves. Not only does the bright green color make us feel refreshed, but it is also very "easy on the eyes." The construction of the second I²CNER research building has started and the entire campus is increasingly decorated with spring blooms. In this spring issue, we're presenting a few "fresh" features, including a report on the "UIUC Exchange Program" and a new section called "Taking the First Step." As always, if you have any feedback, please feel free to write to us.

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