

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

Hello!

I²CNER

January
2015

vol.12

International Institute for Carbon-Neutral Energy Research



Science Café
Producing Eco-Friendly Fuel Cell Vehicles at Lower Cost and in Larger Quantities
Masaaki Sadakiyo
Assistant Professor, Catalytic Materials Transformations Research Division International Institute for Carbon-Neutral Energy Research (I²CNER), Kyushu University
Fukuoka Chuo High School



Impacting Society By Solving Problems

Welcome to I²CNER!



Takahiro Kikunaga
Post-doctoral Research Associate
Catalytic Materials
Transformations
Research Division

After finishing my Ph.D. at Kyushu University, I joined I²CNER in October 2014. My research focuses on small molecules activation by metal complexes. In particular, I study H₂ and O₂ activation chemistry, which are both necessary for improving fuel cells. I work on developing efficient electrode catalysts in fuel cells in order to help establish a non-fossil based energy carrier system. I am delighted to work with the wide array of top tier researchers who are involved in I²CNER. I enjoy spending my free time playing sports and listening to music.



Shinichi Hata
Post-Doctoral Research Associate
Catalytic Materials
Transformations
Research Division

I am from Fukuoka. I am very pleased to be able to conduct research with the fantastic researchers and lab members who are involved in I²CNER. My previous research focused on the synthesis and properties of surfactants, molecular aggregates. In I²CNER, I am working on the development of high-efficiency catalysts suitable for a carbon-neutral energy cycle. Though these studies seem to be very disparate, they are closely related because the interface/surface governs the properties of materials. By tailoring interface/surface properties, I would like to work on the development of an ingenious particulate catalyst, which would enable technologies for the realization of a sustainable energy society.



Hiroki Fukagawa
Post-Doctoral
Research Associate
CO₂ Storage
Research Division

After finishing my Ph.D. in Fluid Dynamics at Keio University, I worked for an engineering software company and spent time at Penn State University as a visiting researcher. I joined the CO₂ storage research division of I²CNER in August 2014. The division's research focuses on efficient storage of the CO₂ emitted from plants deep underground, under high temperature and pressure conditions. My research focuses on the dynamics of the CO₂ in the environment in terms of theoretical physics. In my leisure time, I enjoy playing Shogi on the internet and taking walks with my wife.



Yukio Fujiki
Administrative Director

I am Yukio Fujiki. Following my tenure as a Distinguished Professor of the Faculty of Sciences, and my terms as Senior Vice President and Executive Vice President for Kyushu University, I have assumed the post of Administrative Director in the International Institute for Carbon-Neutral Energy Research (I²CNER) Administrative Office as of November 1, 2014. I²CNER was inaugurated as the sixth institute of the World Premier International Research Center Initiative (WPI) by the Ministry of Education, Culture, Sports, Science and Technology in 2010. Achieving and even exceeding CO₂ emission reduction targets and developing innovative, safe, and reliable energy systems are serious challenges. They require a paradigm shift in our approach to research that bridges not only multiple spatial, molecular to miles, and temporal scales, nanoseconds to decades, but it also necessitates bringing together scientists and engineers from disparate disciplines. To meet these challenges, I²CNER has established the international environment and framework necessary to stimulate novel research endeavors amongst some of the world's leading experts in disciplines such as chemistry, physics, materials science, mechanics, geoscience, oceanic science, and biomimetics. In addition, through such an international research environment, I²CNER educates students, and provides the US, Japan, and the international community with the next generation of scientists needed to address the critical, complex technological and societal challenges in energy. We, the Administrative Office, not only support the research within the Institute, but we also try to gain more recognition for I²CNER through our outreach activities, collaborations at home and abroad, and events, such as symposia.

Event Information

I²CNER Annual Symposium ~Fuel Generation and Use for the 21st Century~

Date: February 2, 2015

Time: 9:30 a.m. – 6:30 p.m. *Reception starts at 6:30 p.m.

Fee: Free (JPY 1,000 per person for the Reception)

Venue: I²CNER Hall, International Institute for Carbon-Neutral Energy Research (I²CNER) Building

Language: English

I²CNER ANNUAL 2015 

Plenary Speakers

Prof. Kazuhito Hashimoto, The University of Tokyo
"Towards Novel Energy Acquisition Systems
~Multiple-electron transfer catalysts for energy conversion~"

Mr. Taiyo Kawai, TOYOTA MOTOR CORPORATION
"Fuel Cell Vehicle (FCV) Development and Initial Market Creation"

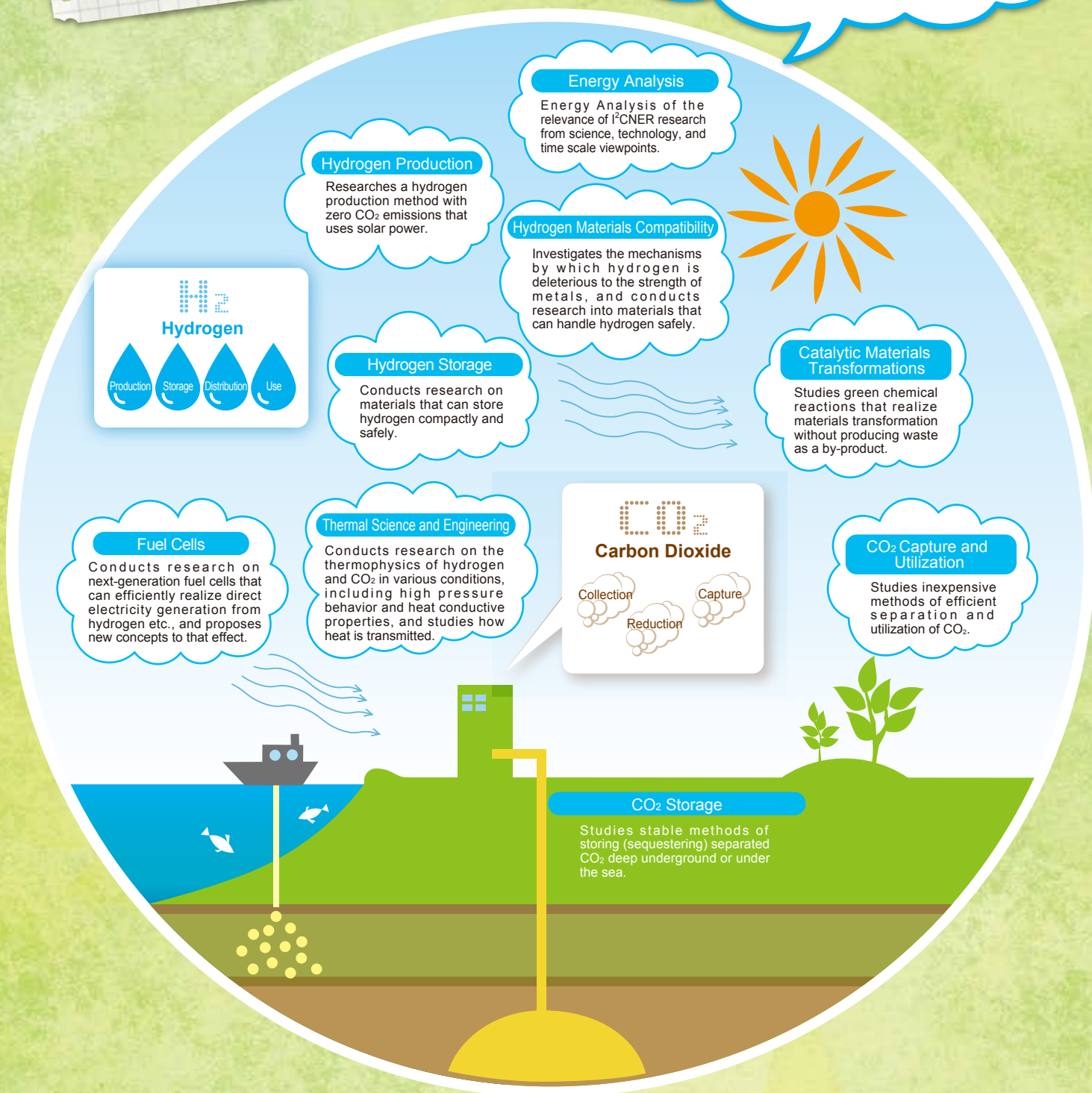
Special Lecture

Prof. Toyoki Kunitake, Kitakyushu Foundation for the Advancement of Industry Science and Technology
"Bilayer Membranes and Nano-Membranes"

Research Division Introductions

What is a carbon-neutral society?

This is a society where CO₂ 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 CO₂ emissions.



Producing Eco-Friendly Fuel Cell Vehicles at Lower Cost and in Larger Quantities

On December 15, 2014, fuel cell vehicles (FCVs) went on sale in Japan. FCVs discharge only water when they are running; they do not emit CO₂ like gasoline-powered automobiles. FCVs are ideal vehicles because they are “green” and energy-efficient. However, the one disadvantage of a FCV is the high price. Assistant Professor Masaaki Sadakiyo is engaged in research on hydroxide ion conductors with the aim of developing new fuel cells that will lower the price of FCVs. He had a discussion on FCVs with students from Fukuoka Chuo High School.

Eco-Friendly Fuel Cell Vehicles (FCVs)

Sadakiyo FCVs have finally hit the market. Now I have a question for you. What is a fuel cell? Do you know how one works?

Yamagata I think it uses a system where electrical energy is generated by burning hydrogen.



Sonokawa To put it more precisely, it generates electrical energy “by reacting hydrogen and oxygen”, right?

Sadakiyo That’s right. Speaking of hydrogen, oxygen, and electricity, is there anything you notice in particular about these?

Ayukawa I know that impressing water to extract oxygen and hydrogen is called electrolysis.

Nakagawa Does that mean fuel cells use the opposite reaction of electrolysis?

Sadakiyo Exactly. The only waste product of cars powered by fuel cells is water, which makes them very environmentally-friendly. In addition, whereas gasoline engines reach only 10-odd percent efficiency when



extracting kinetic energy from chemical energy, the efficiency of a fuel cell in creating electrical energy from chemical energy approaches 50%.

Ayukawa That means an FCV is the perfect automobile.

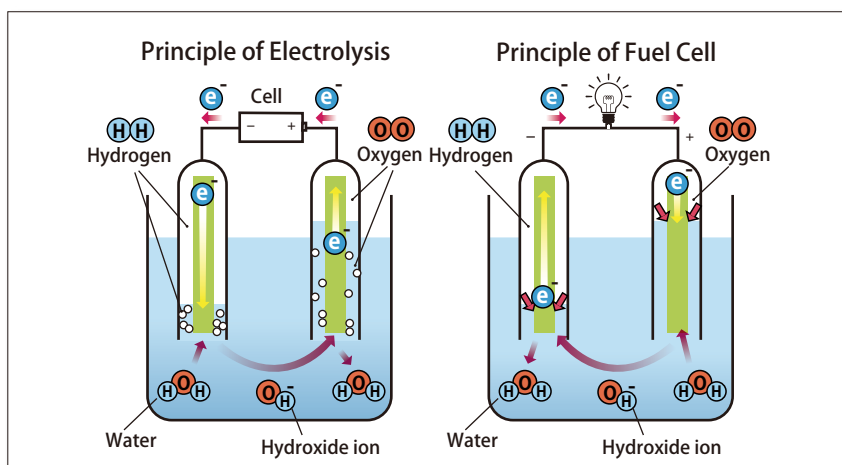
Expensive Platinum Needed for Fuel Cells

Yamagata But I heard they are too expensive for most people to buy.

Sadakiyo That leads to another question. Why are FCVs so expensive?

Sonokawa Because the materials used in fuel cells are very expensive. Particularly platinum.

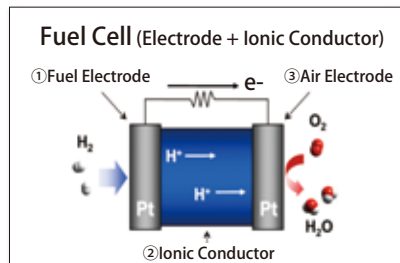
Sadakiyo Why is it so expensive?



Nakagawa As a precious metal, I think it has special value.

Yamagata I heard it rarely rusts—it's like a diamond.

Sadakiyo It seems everyone has a lot of knowledge on this subject. In addition to the points you mentioned, platinum cannot be obtained in large quantities. The annual amount of platinum produced all over the world is only 180 tons. So one gram of platinum costs almost 5,000 yen (as of December 2014).



Ayukawa It is expensive. How much platinum is in a car's fuel cell?

Sadakiyo Approximately 50 to 100 grams of platinum per vehicle.

Nakagawa When each car requires 100 grams of platinum, which costs

5,000 yen, that alone amounts to as much as 500,000 yen.

Sadakiyo And the platinum requires processing, so the unit price per gram is actually more than 5,000 yen. That makes FCVs very expensive. Furthermore, as the annual output of platinum is only 180 tons, even if all the platinum produced in the world were available just for vehicles, we could only produce 1.8 million units annually.

Sonokawa How many cars are sold all over the world per year?

Yamagata I remember it being around 87 million.

Sadakiyo That means replacing all those automobiles with FCVs is totally impossible in the present circumstances.

Electrode (Catalyst) and Ion Conductor

Ayukawa Why do fuel cells need platinum?

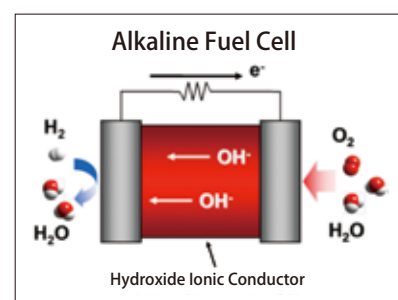
Sadakiyo A fuel cell is composed of two electrodes and an ion conductor. Platinum is used as a catalyst for the electrode. By the way, do you know what a catalyst is?

Yamagata I learned that it is a

substance used to increase the speed of a chemical reaction. Also, the catalyst itself does not change before or after the chemical reaction.

Sonokawa For example, when we put manganese dioxide into a hydrogen peroxide solution as a catalyst, it decomposes into water and oxygen, generating bubbles.

Sadakiyo You've learned a lot. In the case of fuel cells, there are several kinds of electrodes and ion conductors, depending on the fuels used and the operating temperatures. Ion conductors are substances that conduct ions, as the name indicates. When hydrogen is used as the fuel for a fuel cell and it is operated at a normal temperature, the ion conductor is generally a protonic (H^+) conductor.



Nakagawa You mean if we change the ion conductor, electrodes will change, too? Does that mean there may be an alternative to using expensive platinum?

Sadakiyo Exactly. Since the proton (H^+) conductor is highly acidic, we have to use platinum, which resists acids, as an electrode catalyst. For another type of ion conductor, specifically for an alkaline ion conductor, we could use a less expensive material as the electrode catalyst.



Laboratory Visit



Let's Make a Metal-organic Framework

In the laboratory, we conducted an experiment aimed at creating a coordination polymer. We put zinc nitrate and 2-Methylimidazole into methanol (the solvent). According to Assistant Professor Sadakiyo, "Most parts of chemical experiments are composed of mixing and heating." For this experiment, we simply mixed and

waited. After about five minutes, we noticed that something cloudy was appearing at the bottom of the flask. As time went by, it turned into clear sediment. The materials started to self-accumulate and a kind of coordination polymer called ZIF-8: $\{Zn(C_4N_2H_3)_2\}_\infty$ was created.

Research on Hydroxide Ion Conductor

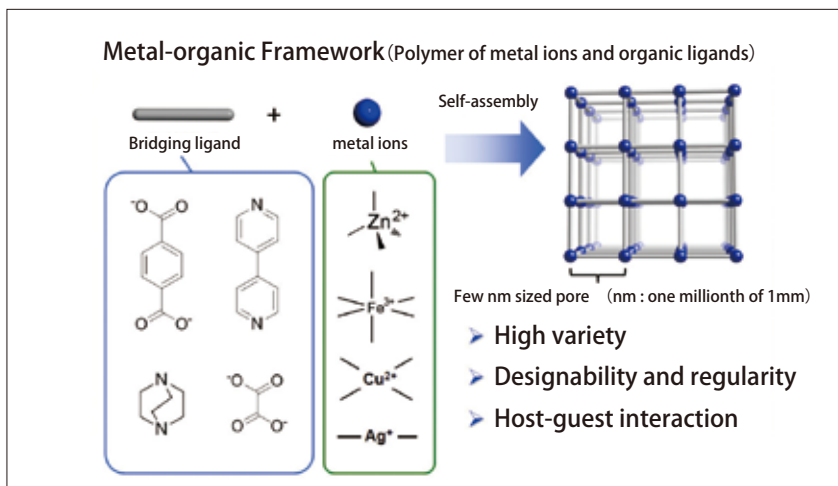
Yamagata What kind of ion conductor are you studying?

Sadakiyo I am studying an alkaline ion conductor known as a hydroxide ion conductor. It is one of the coordination polymers. We make polymer molecules using metal ions and organic molecules. Do you know what the metal ion is?



Sonokawa I learned that vanadium is one metal ion.

Sadakiyo You are well informed. A coordination polymer is made up of metal ions and organic molecules, which act just like building blocks. It offers excellent material variability, and the solid structure can be manipulated artificially with very little



effort. This is a hydroxide ion conductor that conducts a hydroxide ion (OH⁻).

Ayukawa That would open the door to producing fuel cells at a much lower cost, wouldn't it?

Nakagawa By the time I start working, I expect that everyone will be able to buy an FCV.

Sadakiyo Actually, solid hydroxide ion conductors have not attracted a lot of attention yet. That means there is a lot left to study, and we have the chance to create a

world-changing ion conductor. However, this research project will take some time. I would definitely like to see you enter Kyushu University and join I²CNER so we could advance this research together.



Message to Students from Assistant Professor Sadakiyo



Masaaki Sadakiyo

Assistant Professor,
 Catalytic Materials Transformations Research Division
 International Institute for
 Carbon-Neutral Energy Research (I²CNER),
 Kyushu University

Research can be defined as taking on a new subject. Copying what other people have already done is not research. So, when starting research, we need to confirm whether other people have already conducted research on what we are trying to do. Next, once we start research and get ahead of other people, we need to proceed with it as quickly as possible. For this, chemistry is ideal. Using only our own hands, we can advance our research as far as we desire. Also, in chemistry, we take on a different subject each day. If you are interested in this kind of chemical research, you should consider joining I²CNER to pursue research to enable the dream fuel cell.

Post-discussion

Fukuoka Chuo High School

This discussion was made possible through the cooperation of students from Fukuoka Chuo High School. This 116-year-old school is the only public high school in Chuo Ward of Fukuoka City. Under the educational philosophy of "fostering dreams and aspirations," it offers careful academic advice and extensive career guidance, with recognition given to each student's unique character. The school actively pursues educational programs to respond to a diverse international society. For example, lectures are delivered by foreign professors to promote international understanding, and students participate in a lodging workshop to improve problem-solving skills under the instruction of Kyushu University professors. The school puts a great deal of effort into nurturing creative talent, which is demonstrated by its initiative to have a round-table discussion with researchers from Kyushu University this academic year.



Makoto Ayukawa



I was impressed by the gas cylinder in the laboratory. Conducting an actual experiment had a big impact on me. In the future, I would like to bring about a revolution in agriculture. I hope to develop cooking ingredients that can solve food problems.

Yuto Nakagawa



After listening to Assistant Professor Sadakiyo's talk, I realized that researchers are engaged in more difficult themes than I had imagined. I want to be a researcher on environmental issues in the future, and work on solving problems.

Miruhō Sonokawa



As I want to be a radiological technologist in the future, I was interested in the X-ray equipment in the laboratory. Technology that allows us to see things that are otherwise invisible is amazing.

Makoto Yamagata



I belong to a science club at my high school, and I was excited to work with so many devices I had never seen before. After directly experiencing the excitement and pleasure of research, I decided that I would definitely join I²CNER in the future.

AWARDS

IUMRS-ICA 2014 Encouragement of Research Award

Dr. Helena Tellez-Lozano (JSPS Postdoctoral Fellowship for Foreign Researchers, Hydrogen Production Research Division)

At IUMRS-ICA 2014 held in Fukuoka, Dr. Helena Tellez-Lozano received the "Encouragement of Research Award" for her presentation entitled "Blocking of electro-active surfaces in mixed ionic-electronic conductors studied by Low-Energy Ion Scattering (LEIS)" for encouragement of future progress. (Aug. 24, 2014)

Outstanding Contribution and Innovation in Fluoropolymer Science

Prof. Atsushi Takahara (Principal Investigator, Hydrogen Production Research Division)

At FLUOROPOLYMER 2014 held in San Diego, Prof. Atsushi Takahara was presented the award for "Outstanding Contribution and Innovation in Fluoropolymer Science" for his work in the area of fluoropolymer science. (Oct. 15, 2014)

The Order of Culture

Prof. Toyoki Kunitake (WPI Visiting Professor, Fuel Cells Research Division)

Prof. Toyoki Kunitake, President of the Kitakyushu Foundation for the Advancement of Industry Science and Technology, was awarded the Order of Culture 2014 for his considerable contribution to the development and advancement of molecular organization chemistry, which is recognized as an important area of modern chemistry and an advancement of science and technology in general. (Nov. 3, 2014)

KUDOS

Fellowship in the American Physical Society

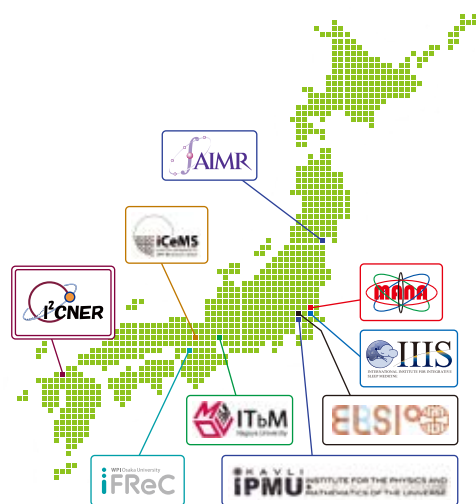
Prof. Atsushi Takahara (Principal Investigator, Hydrogen Production Research Division)

Prof. Atsushi Takahara was elected as a Fellow of the American Physical Society for his new insights into the surface dynamics and glassy behavior of polymer thin films, and his development of charged side-chains polyelectrolyte brushes, and polymer nano hybrids from aluminosilicate nanotubes. (Dec. 4, 2014)



What is WPI?

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.



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 CO₂ capture and sequestration by fusing together sciences from atomic level to global scale.

Refer to:

MEXT Website http://www.mext.go.jp/english/research_promotion/1303822.htm
JSPS Website <http://www.jspis.go.jp/english/e-toplevel/index.html>



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.



WPI Osaka University
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.



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.



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.



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.



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.



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

IIS 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.



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)

i2CNER

Search

One of the main objectives i2CNER's basic research aims to enable is the drastic reduction of CO₂ emissions in the next 20-40 years. Since CO₂ reduction is such an important issue for society as a whole, the purpose of this magazine is to describe our research in simple terms so that anyone who is interested in the low-carbon society can learn about what we are doing. We would like to wish you a happy and healthy 2015. We look forward to receiving your comments or questions regarding this magazine via email or phone.

Hello! i2CNER vol.12 January 2015

[Published by] International Institute for Carbon-Neutral Energy Research (i2CNER)
i2CNER Administrative Office, 744, Motooka, Nishi-ku, Fukuoka City
Fukuoka Prefecture, 819-0395 (Kyushu University Ito Campus)
Tel. +81-(0)92-802-6935 Fax. +81-(0)92-802-6939
Email : wpinewsletter@i2cner.kyushu-u.ac.jp
URL : <http://i2cner.kyushu-u.ac.jp>
Facebook: <https://www.facebook.com/i2CNER.news>
Twitter: <https://twitter.com/i2CNER>

[Edit & Design] Ishida Taisheisha Inc.

[Writer] Atsumi Takebayashi [Photography] Osamu Irie

[Edit & Planning] i2CNER Administrative Office, Public Relations
(Yumiko Masumoto, Ruri Hirashima, Aya Mako)



I²CNER Event Reports

2014.
8.6▶7
(WED.) (THU.)

Super Science High Schools (SSH) student workshop



(Assoc. Prof. Tsuji at "Researchers Mini Live")



(At the WPI booths)

The World Premier International Research Center Initiative (WPI) Institutes, including I²CNER, ran booths at the "Super Science High Schools (SSH) student workshop," which was held at the Pacifico Yokohama on August 6th and 7th. This event is intended to foster students' interest in science and technology as well as to promote the SSH project. I²CNER, along with the

Tohoku University Advanced Institute for Materials Research (AIMR) and the International Center for Materials Nanoarchitectonics (MANA), ran a booth to introduce our research. 5 WPI researchers, including Assoc. Prof. Takeshi Tsuji (Lead Principal Investigator, CO₂ Storage Research Division), gave lectures at "Researchers Mini Live" to showcase their latest

research. More than 50 high school students and teachers participated in the Assoc. Prof. Tsuji's lecture. The event ended with a question and answer session. Students and teachers of the Super Science High Schools, invited international schools, and the general public all participated in the event.

2014.
8.21
(THU.)

Jonan High School, Super Science High Schools (SSH) "International Science Program"



(Asst. Prof. Nishihara with a hydrogen car kit)



(In Asst. Prof. Kitamura's lab)



(Q&A session)



(Questions and Answers)

On August 21st, students from Jonan High School, Busan High School, and Busan Jangan High School visited I²CNER as part of the "International Science Program." First, Assoc. Prof. Shigenori Fujikawa (Lead Principal Investigator, CO₂ Capture and Utilization Research Division) explained the outline of I²CNER and his research, then, Asst. Prof. Masamichi Nishihara (Fuel Cell

Research Division) introduced his research and explained how fuel cells work using a hydrogen car kit. After the lectures, the students visited 2 laboratories. In Asst. Prof. Huaiyu Shao's lab, the students learned about a hydrogen storage system which uses renewable energy. In Asst. Prof. Keigo Kitamura's lab, the students observed the difference in the apparent degree of

penetration of drops of water between two different rocks. At the end of the visit, the students and researchers engaged in a lively question and answer session. In order to highlight the international spirit of the "International Science Program," all lectures and discussion between the researchers and students were conducted in English.



I²CNER Event Reports

2014.
9.12
(FRI.)

23rd Science Café @ Fukuoka



(Assoc. Prof. Fujikawa giving his lecture)



(Discussion with the participants)

Assoc. Prof. Shigenori Fujikawa (Lead Principal Investigator, CO₂ Capture and Utilization Research Division) gave a lecture at the "23rd Science Café @ Fukuoka" held at the BIZCOLI, "Business Communication Library" on September 12th, 2014. Approximately

30 people participated in the event. Following his lecture, Assoc. Prof. Fujikawa engaged the participants in a casual discussion about CO₂ related topics. The event ended with a question and answer session.

What is a Science Café?

A Science Café is an event that takes place in a casual setting such as a coffee shop, which is open to everyone and features an engaging conversation with a scientist about a particular topic.

2014.
10.31
(FRI.)

A special Science and Mathematics Course lecture, Shingu High School



(Discussion with the students)



(Prof. Matsumoto giving his lecture)

On October 31st, a special "Science and Mathematics Course lecture" was held at Shingu High School. Prof. Matsumoto (Hydrogen Production Research Division) gave a talk with the theme of "Science and Technology for Supporting

Environment and Energy." Among the topics he addressed were his life at the university, including his research experience, what got him interested in hydrogen research, and the process of becoming a researcher. About 80

students attended Prof. Matsumoto's inspiring talk and participated in the discussion about the society that will be created by the development of science and technology which can solve the world's looming energy problems.