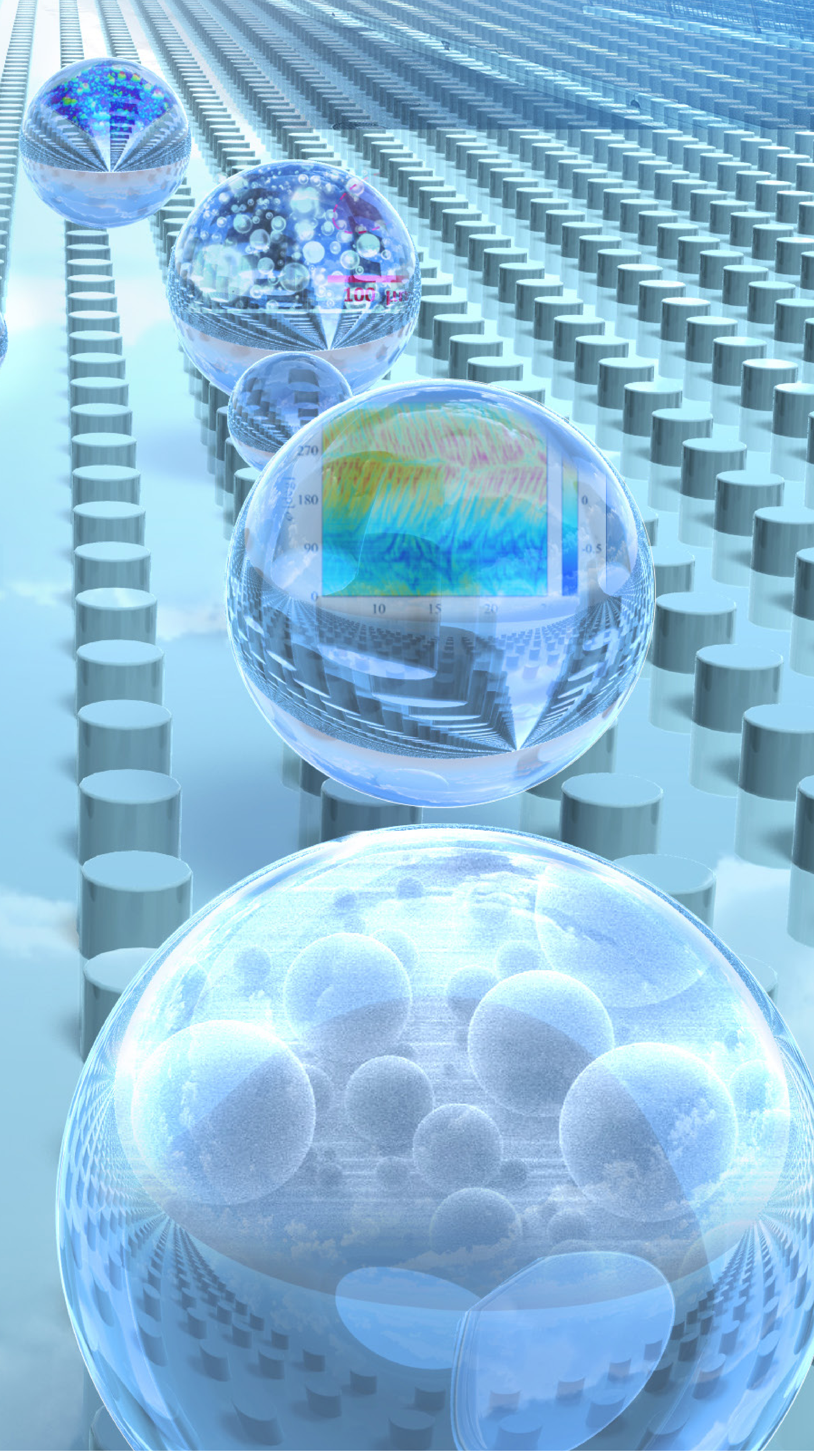
International Institute for Carbon-Neutral Energy Research

2018 I^{2}CNER Annual Symposium

Challenges in Thermal Science and Engineering towards a Sustainable Society

January 31, 2018

I^{2}CNER Hall, Ito Campus, Kyushu University



Vision

To provide a platform for discussion and debate on the science and engineering for efficiency increase in power generation, smart utilization of waste heat, nanomaterials and metal-organic frameworks for efficient heat pump cycles, next generation working fluids, and nanoscale transport and heat transfer mechanisms

Keynote Lectures

Thermal Waste Heat Utilization for Achieving Super Smart Community
Prof. Takao Kashiwagi
International Research Center of Advanced Energy Systems for Sustainability, Tokyo Institute of Technology

Different Regimes of Pool Boiling
Prof. Gautam Biswas
Director
Indian Institute of Technology Guwahati

Registration:
http://i2cner.kyushu-u.ac.jp/en/

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MESSAGE FROM THE DIRECTOR

This year's Annual Symposium is organized by our Thermal Science and Engineering Division. Our focus is to address efficiency in power generation, energy production and storage, and energy utilization. It is well known that one of the objectives of our Institute is that, through our scenarios, we develop energy solutions that aim to reduce CO_2 emissions by 70% from the 1990 levels by the year 2050. A key technology strategy toward achieving our goal is to increase efficiency in both energy generation and utilization, and it is precisely the target that this year's symposium will aim to review. From this discussion, we hope to establish a more concerted pathway for our research efforts.

In particular, this year we wish to: assess our efforts toward improved and smart conversion of waste heat, consider the use of nanomaterials and metal-organic frameworks for efficient heat pump cycles, explore next generation working fluids and their thermophysical properties, and discuss the subject of nanoscale transport and heat transfer mechanisms.

Lastly, through discussion and debate we aim to review the efficacy of I^2CNER's research portfolio regarding the energy technologies we are aiming to enable as well as the associated CO_2 emission reductions.

I would like to take this opportunity to express, on behalf of all faculty, researchers, and administrative staff of I^2CNER, our sincere appreciation to all who have supported the Institute and contributed to its progress. It is my great hope that we engage each other in active discourse, find and establish new research connections, and leave with a renewed excitement and appreciation for scientific discovery.

Petros Sofronis
Director, I^2CNER

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

2018 I^{2}CNER ANNUAL SYMPOSIUM: CHALLENGES IN THERMAL SCIENCE AND ENGINEERING TOWARDS A SUSTAINABLE SOCIETY

I^{2}CNER Hall
Ito Campus
Kyushu University

WEDNESDAY, JANUARY 31, 2018

9:30 AM	Opening Remarks **Prof. Masato Wakayama,** *Executive Vice President, Kyushu University* (5 min) **Dr. Akira Ukawa,** *WPI Program Director, Japan Society for the Promotion of Science* (5 min) **Mr. Ross Matzkin-Bridger,** *Energy Attaché, U.S. Embassy Tokyo, and Director, U.S. Department of Energy's Japan Office* (5 min) **Prof. Petros Sofronis,** *Director, International Institute for Carbon-Neutral Energy Research (I^{2}CNER)* (5 min) **Prof. Bidyut Baran Saha,** *I^{2}CNER, Kyushu University* (10 min)
10:00 AM	**Keynote Lecture** Thermal Waste Heat Utilization for Achieving Super Smart Community Prof. Takao Kashiwagi *International Research Center of Advanced Energy Systems for Sustainability, Tokyo Institute of Technology*
10:50 AM	***COFFEE BREAK***
11:10 AM	*Invited Lecture* Water Adsorption on Various MOFs for Next Generation Cooling Applications Prof. Anutosh Chakraborty *School of Mechanical and Aerospace Engineering, Nanyang Technological University*

11:40 AM *Invited Lecture*
Using Carbon Dioxide in Efficient Energy Conversion Systems as the Way to Carbon-Neutral Society
Prof. Pega Hrnjak
Air Conditioning and Refrigeration Center/Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign

12:10 PM ***GROUP PHOTO SESSION***

12:20 PM ***LUNCH & POSTER SESSION***

1:10 PM **Keynote Lecture**
Different Regimes of Pool Boiling
Prof. Gautam Biswas
Indian Institute of Technology Guwahati

2:00 PM Renewable Energy and the Minerals Industry: Focus on Thermal Energy Applications
Benjamin McLellan
Graduate School of Energy Science, Kyoto University

2:30 PM Thermophysical Measurement Methods for Individual Nanomaterials and Control of Nanoscale Thermal Transport
Prof. Koji Takahashi
I^2CNER, Kyushu University

3:00 PM Potential of an Ambient Air for Energy Saving Technologies through the Maisotsenko Cycle
Prof. Takahiko Miyazaki
I^2CNER, Kyushu University

3:30 PM *Invited Lecture*
Efficient Electricity Generation Cycles Driven by Low Grade Heat
Prof. Liwei Wang
Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University

4:00 PM ***COFFEE BREAK***

4:20 PM *Invited Lecture*
Low Global Warming Potential Working Fluids
Prof. J. Steven Brown
School of Engineering, The Catholic University of America

4:50 PM Thermodynamic Property Measurements of Low-GWP Refrigerant Mixtures
Prof. Yukihiro Higashi

I^2CNER, Kyushu University

5:20 PM	Thermophysical Property Measurements of High-Pressure Hydrogen up to 100 MPa and Applications of the Database to Design for Hydrogen Infrastructure Prof. Naoya Sakoda *I^2CNER, Kyushu University*
5:50 PM	Effects of Condensate Flow and Thickness on Heat Transfer of Film-wise Condensation Prof. Akio Miyara *Department of Mechanical Engineering, Saga University/ I^2CNER, Kyushu University*
6:20 PM	Closing Remarks ***Prof. Yasuyuki Takata,*** *Associate Director, I^2CNER, Kyushu University*
6:30 PM	**RECEPTION** *Venue: I^2CNER Lounge*

2018 I^{2}CNER Annual Symposium

Abstracts

Thermal Waste Heat Utilization for Achieving Super Smart Community

Takao Kashiwagi

Distinguished Professor/Emeritus Professor
Director, International Research Center of Advanced Energy Systems for Sustainability,
Tokyo Institute of Technology

Paris agreement has made a great impact on the existing energy and environment systems. In the year 2050, oil will be restricted to transportation sector and chemical usages whilst fuel cells and renewable energy technologies start realizing their full commercialization potential. On the other hand, residential sector can be synergistically synchronized with the transport sector, thus, zero-energy and low-carbon emission housing will be realized in major parts of the world. Still in Japan, the Great East Japan Earthquake followed by the nuclear plant accidents in March, 2011, has huge impact on the Japan's energy systems. Therefore, it is imperative to develop and demonstrate new energy technologies including waste heat utilization as well as system applications, and propose a grand design and energy policy plan.

Taking full consideration of these matters and forward guidance, Japanese government undertakes the creation of advanced energy systems for sustainability. In order to contribute to environmental protection and energy security, future energy systems should introduce not only a large amount of renewable but also the development of innovative technologies such as higher utilization of waste thermal energy in smart energy network systems based on existing base load power stations. This presentation examines the recent advances of Japanese thermal energy policy focusing on the integrated thermal infrastructure. Smart society will be built around three key features: integrated mega-structure, renewable power production, and mobile energy storage with rapid charging. Figure 1 shows such smart society where the residential buildings are interconnected with micro-grid features. Power generation fully employs renewable energy potential whilst electric and plug-in hybrid vehicles will be employed for transportation as well as mobile energy storage and carriers by exploiting rapid charging facilities.

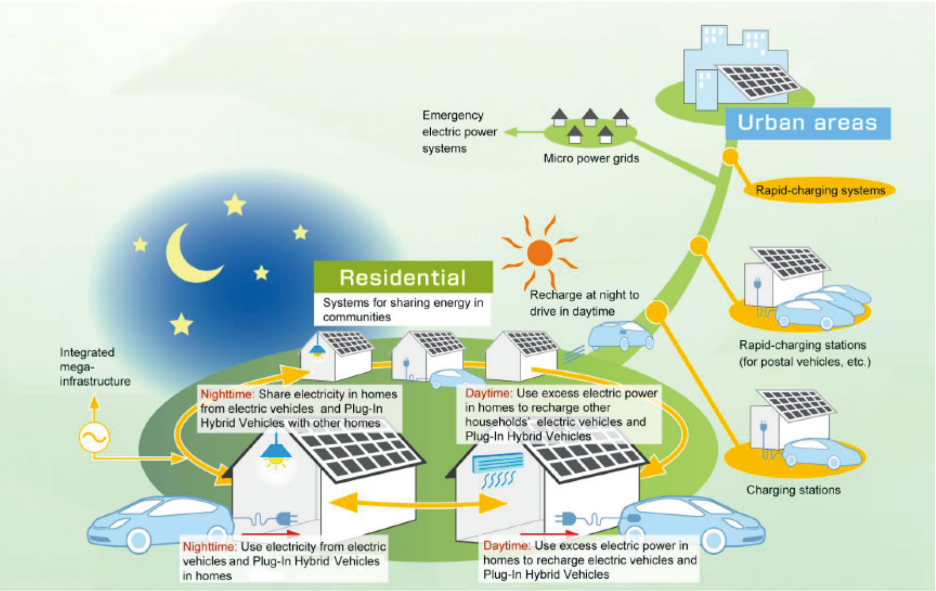


Figure 1: Renewable energies, electric vehicles, and plug-in hybrid vehicles in residential communities.

Water Adsorption on Various MOFs for Next Generation Cooling Applications

Anutosh Chakraborty, How Wei Benjamin Teo, and Sibnath Kayal

School of Mechanical and Aerospace Engineering, Nanyang Technological University

The knowledge of water uptakes on metal organic frameworks (MOFs) under static and dynamic conditions are necessary for understanding adsorption isotherms and kinetics, which enables us to design thermal compressor for adsorption assisted heat transmission applications such as adsorption cooling and desalination. In this article, we report an experimental study to calculate the amount of water uptakes on MOFs for the temperatures ranging from 25°C to 65°C and pressures up to the saturated conditions. We use gravimetric method to calculate water uptakes. Hence various types of MOFs (types MIL-101(cr), alkali doped MIL-101 (Cr), CAU-10, Al-Fum with various formic acid and zeolite doped Al-Fum) are investigated using a surface characteristic analyzer, which employs the static volumetric method with liquid Nitrogen at 77.4 K as the filing fluid. The surface area of each adsorbent is studied using Brunauer–Emmett–Teller (BET) method whilst the pore size distribution (PSD) analysis is conducted with the Non-Local Density Functional Theory (NLDFT). The experimentally measured isotherms and kinetics data are fitted with various models. The synthesis procedures of MOFs are also presented here.

Figure 1 shows the SEM (Scanning Electro-Microscopy) diagram for the Al-Fum samples. The original synthesis has shown a strong agglomeration between the particles of the samples. By adding formic acid, the particles of Al-Fum has shown less agglomeration with more individual, quadarhedral shaped, nano-sized particles. The effect is stronger with higher dosage of formic acid added. This effect is known as the modulation of MOF structure due to the addition of formic acid. Based on the modulated Al-Fum, the particle is approximately 1 nm.

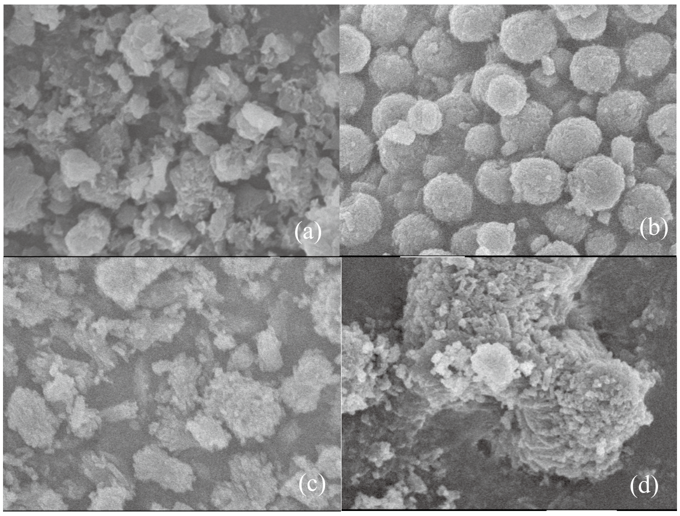


Figure 1: SEM of Al-Fum (a) and modulated Al-Fum samples with formic acid of (b) 5ml, (c) 10ml and (d) 15ml added. Modulated samples show less agglomeration of particles due to the addition of formic acid.

Using Carbon Dioxide in Efficient Energy Conversion Systems as the Way to Carbon-Neutral Society

Pega Hrnjak

ACRC, Department of Mechanical Science and Engineering,
the University of Illinois at Urbana-Champaign

One of the ways to reduce quantity of carbon dioxide in the atmosphere is to use it in the energy conversion systems instead of high GWP fluids used in vapor compression cycles. Even being relatively small in mass, combined with high GWP value of currently used refrigerants and excellent system efficiency overall effects is significant.

The paper will present major differences between cycles and systems using two types of working fluids, with examples of options to increase the efficiency of transcritical carbon dioxide systems. The presentation will also show the level of efficiencies reached and trends in current applications.

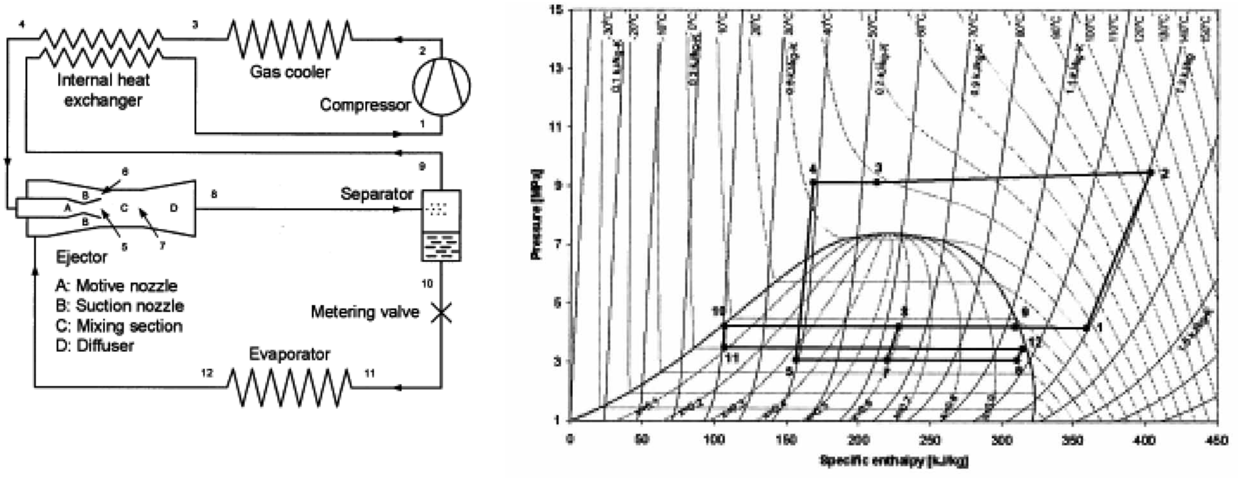


Figure 1: Trans critical CO_2 system with ejector and internal heat exchanger.
(Elbel, S.W., Hrnjak, P.S., 2004. Int. Refrigeration A/C Conf., no.708.)

Different Regimes of Pool Boiling

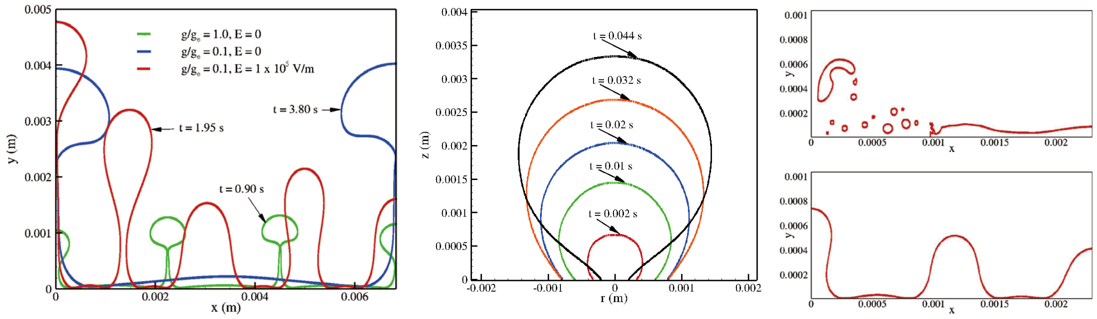
Gautam Biswas, Vinod Pandey, and Amaresh Dalal

Indian Institute of Technology

Boiling is an intricate phenomenon exhibiting various regimes from bubble generation over the surface during nucleate boiling to bubble generation through a vapor film during film boiling. In the present study, we incorporated a numerical technique (CLSVOF) to simulate the bubble generation, growth and its departure during pool boiling. In the film boiling regime, the bubble growth is governed by the instabilities at the liquid-vapor interface. The instability mode transforms from Rayleigh-Taylor at the low wall-superheat temperature to Taylor-Helmholtz at the higher superheat values, governing the bubble-separation distance. The bubble morphology varies from discrete bubbles at low superheat to vapor columns at the higher superheat values. The heat transfer rate during film boiling therefore depends on the degree of superheat. The application of electric field across the interface intensifies the bubble growth rate, reducing the critical wavelength and enhancing the heat transfer rate. A threshold intensity of applied electric field is required to achieve a significant effect in bubble morphology and heat transfer rate. In the reduced gravity condition, the electrohydrodynamic forces are the dominant reason for the instability at the interface. Hence, the electric field can be utilized to acquire the same heat transfer rate during boiling as in the earth's condition. The vapor generation rate can also be controlled.

When the wettability of the solid surface is considered during film boiling, the vapor film ruptures for the high wettability surfaces leading to the transition from the film boiling to nucleate boiling regime. For the low wettability surface where the liquid-solid contact does not occur, the application of electric field is found to result in increased vapor generation rate and eventually the transition to nucleate boiling.

Unlike to the bubble growth in film boiling where the heat transfer occurs solely from the heated surface to the vapor film, in nucleate boiling the growth of bubble is due to the combined effect of heat transfer from superheated liquid and microlayer evaporation. Through the numerical simulations, the effect of surface superheat on the growth rate and heat transfer is analyzed. The effect of liquid subcooling on the bubble growth and after its departure is also studied.



(a) (b) (c)

Figure 1: (a) Effect of EHD and buoyancy during film boiling (b) Growth of a single bubble during nucleate boiling and (c) transition due to surface wettability (top = ψ = 30° ,bottom= ψ = 120°) .

Renewable Energy and the Minerals Industry: Focus on Thermal Energy Applications

Benjamin C. McLellan

Graduate School of Energy Science, Kyoto University

The minerals industry is a vital sector globally, underpinning much of the technology that is both fundamental for modern society’s operations and also for the clean energy technologies that are key for future decarbonisation. While the industry contributes significantly to the energy sector, it also requires a significant proportion of the world’s energy to produce minerals, and subsequently produces a significant amount of greenhouse gas emissions from the current carbon-based energy system. One of the limiting elements of lowering emissions in this sector, is the requirement for high quantity and high quality electricity, fuel and heat. Most renewable energy technologies are focused on the provision of electricity as a key to decarbonisation of the energy system. However, the provision of thermal energy is also possible from technologies such as geothermal, concentrating solar power and biomass, or from the transformation of electricity into hydrogen or synfuels. Figure 1 shows that the amount of renewable energy utilised in the minerals subsectors is significantly lower than the average of all economic sectors, globally. At the same time, the amount of electricity used is differentiated across the sectors. This study explores the potential and limitations of renewable energy in the minerals sector, specifically thermal applications across the supply chain of minerals.

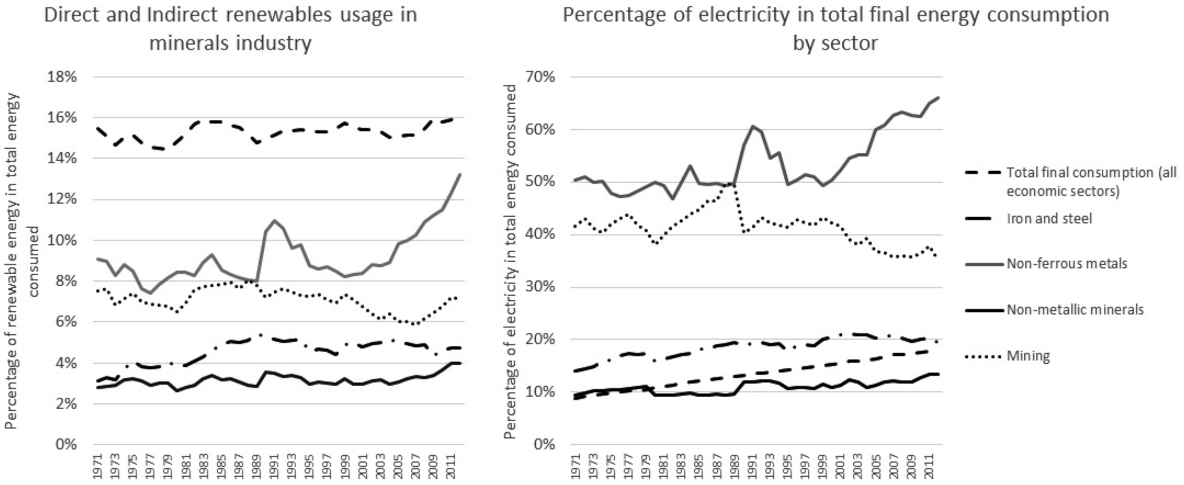


Figure 1: Renewable energy usage (left); and Electricity usage as a percentage of total final energy consumption in the minerals industry subsectors compared to all economic sectors

Thermophysical Measurement Methods for Individual Nanomaterials and Control of Nanoscale Thermal Transport

Koji Takahashi[1,2], Qin-Yi Li[1,2], and Xing Zhang[1,3]

[1]International Institute for Carbon-Neutral Energy Research (WPI-I²CNER), Kyushu University
[2]Faculty of Engineering, Kyushu University
[3]Department of Engineering Mechanics, Tsinghua University

Low-dimensional nanomaterials have attracted worldwide attention due to their promising applications in next-generation electronics and energy harvesting devices. Accurate measurement and precise control of nanoscale thermal transport are of crucial importance for both device development and fundamental research. In this talk, I will introduce our recent progress on the development of thermal measurement methods for individual nanomaterials and control of nanoscale thermal transport. Above all, I will present both contact and non-contact nanoscale thermal measurement methods, including a T-type method for comprehensively measuring the thermal and thermoelectric properties of individual nanomaterials and a dual-mode Raman optothermal method for *in-situ* measuring the thermal properties of suspended and device-geometry nanomaterials. In the second part of my talk, I will present how to experimentally tune the thermal as well as thermoelectric properties of carbon nanomaterials through shape control, defect engineering and chemical modification. For example, we realized length control on the thermal transport in individual single-walled carbon nanotubes, indicating ballistic-to-diffusive crossover in one-dimensional thermal transport. Significant width dependence of thermal transport have been observed in suspended graphene ribbons over a width range between ~40nm to ~2μm, indicating 2D nature of phonon transport in this ultrathin carbon sheet. Through unsymmetrical shape control, we have realized remarkable 2D thermal rectification in suspended graphene sheets. Through defect engineering via focused ion beams, thermal conductivity of suspended graphene has been effectively reduced by ~40%. Through fluorination in graphene, thermal conductivity in this chemically modified 2D sheet was reduced by 95%. Furthermore, through bromine doping in graphene fibers, we have obtained record high thermoelectric performance in carbon nanomaterials.

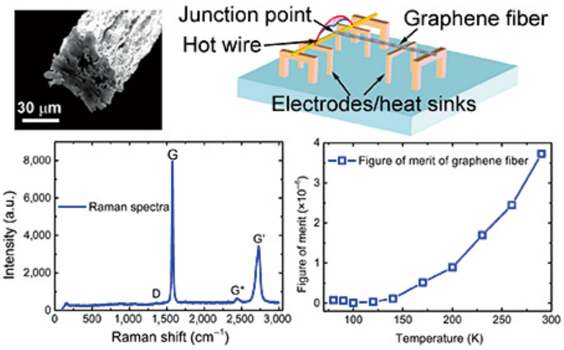


Figure 1: T-type method and its application in measuring thermal and thermoelectric properties of an individual graphene fiber

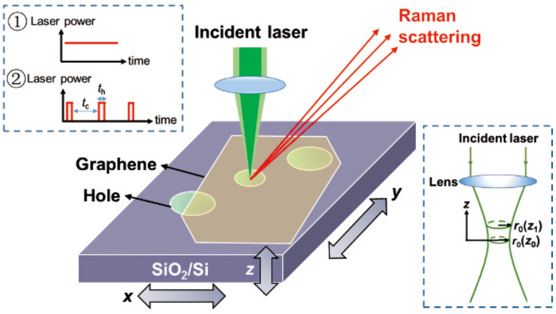


Figure 2: Dual-mode Raman optothermal method and its application in measuring thermophysical properties of suspended and supported graphene

Potential of an Ambient Air for Energy Saving Technologies through the Maisotsenko Cycle

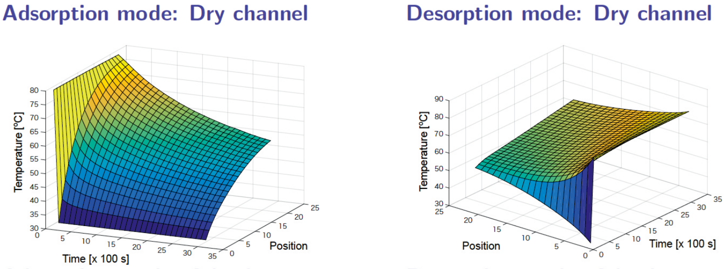
Takahiko Miyazaki[1,2] and Valeriy S. Maisotsenko[3]

[1]Faculty of Engineering Sciences, Kyushu University
[2]International Institute for Carbon-Neutral Energy Research (WPI-I²CNER), Kyushu University
[3]Seeley International Americas, Coolerado

The air has a large capacity to hold water in the vapor phase and the air holding water vapor is called the wet air. In general atmosphere contains 1 to 3 % of water vapor, which means that 1 kg of dry air can hold up to 20 g of water vapor at ambient temperature of 25 degree Celsius, for instance. This amount of water is equivalent to 50 kJ of thermal energy. Therefore, 1 kg of dry air has a capacity of holding 50 kJ as a latent heat. Moreover, the capacity is boosted with temperature rise; for example, at 40 degree Celsius, 1 kg of dry air can hold 50 g of water, which is equivalent to 125 kJ of thermal energy.

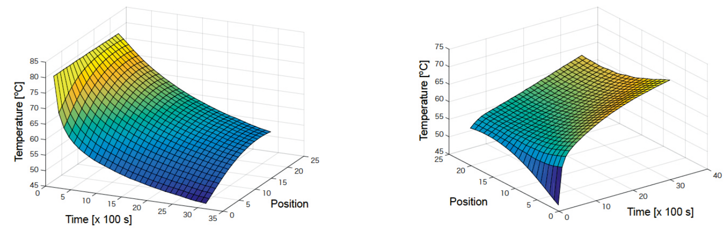
The Maisotsenko Cycle (M-Cycle) is a thermodynamic concept to fully utilize the potential of wet air for heat and mass transfer processes. The M-Cycle is a proven technology and it is used for efficient evaporative coolers. One of the most major advantages of the M-Cycle is the enhancement of the cooling capacity by lowering the minimum temperature from the wet-bulb, which is the case of conventional evaporative cooling processes, to the dew point. It is a significant improvement from the viewpoint of energy savings because thermodynamic cycles, for both heat engines and heat pumps, improve the thermal efficiency and coefficient of performance with lower heat sink temperature, even if it is a few degrees of difference.

Possibility of the M-Cycle application to a various kinds of energy related technologies, such as heat engine, heat pump, and air conditioning will be given in the presentation. The integration of the M-Cycle concept with adsorption technology will be also discussed and a predicted result of heat and mass transfer in a M-Cycle process with adsorbent will be shown.



Adsorption mode: Dry channel

Desorption mode: Dry channel



Adsorption mode: Adsorbent channel

Desorption mode: Adsorbent channel

Figure 1: The temperature profiles of air passing through a dry channel and a wet cannel (adsorbent channel) of the M-Cycle with adsorbent.

Efficient Electricity Generation Cycles Driven by Low Grade Heat

Liwei Wang

Institute of Refrigeration and Cryogenics, Key Laboratory for Power Machinery and Engineering of
M.O.E, Shanghai Jiao Tong University

The electricity generation cycle driven by low grade thermal energy form industries waste heat or solar energy is an efficient way for energy utilization. But the efficiency for small-scale electricity generation systems, which is commonly for the dispersed waste heat or solar energy recovery, is always very small. In order to improve the efficiency of such systems, three types of energy conversion cycles adapting different temperature ranges are studied and analyzed. Results show that cycles using ammonia-water and resorption working pairs are the best choices for the temperature range between 150°C and 250°C. Ammonia-water power cycles using a distillation stage and thermal tank for driving the fluid are proposed. The study showed the cycle can produce 6%-10% more power than the reference Kalina cycles. The heat exchanger with small diameter pipes is also proposed, which decreases the volume of system by 40%. The study of the resorption cogeneration cycle showed that the power generation of the cycle is slightly lower than the Goswami cycle, but the refrigeration performance of the cycle improves greatly. For the low grade heat of 80~150°C the Organic Rankine Cycle (ORC) is more efficient than ammonia-water and resorption cycle. The pumpless ORC is developed for small-scale electricity generating systems. Compared with the conventional ORC, whose efficiency is generally zero or negative when the electricity output is less than 500 W, the net electricity generation efficiency of pumpless ORC is can reach up to 3% when electricity output is around 300 W. The cascading cycle of ammonia-water and pumpless ORC is analyzed, and the energy utilization efficiency could be improved over 15% compared with the single stage cycles.

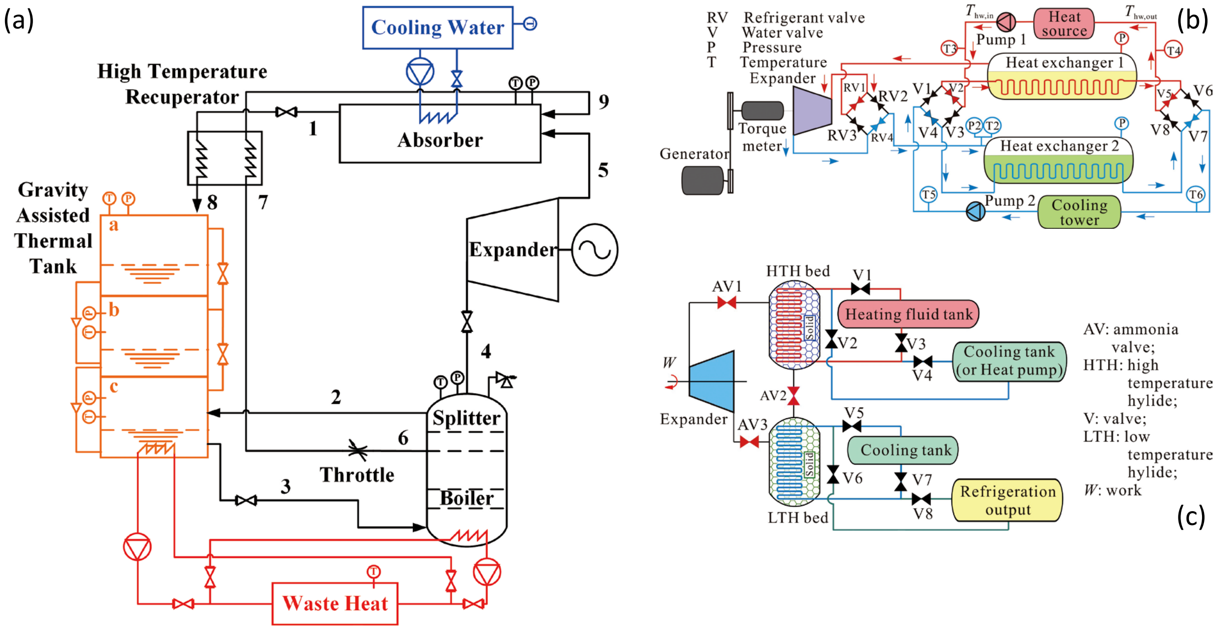


Figure 1: Electricity generation cycles. (a) ammonia-water cycle without electricity driven pump; (b) pumpless ORC; (c) resorption cogeneration cycle

Low Global Warming Potential Working Fluids

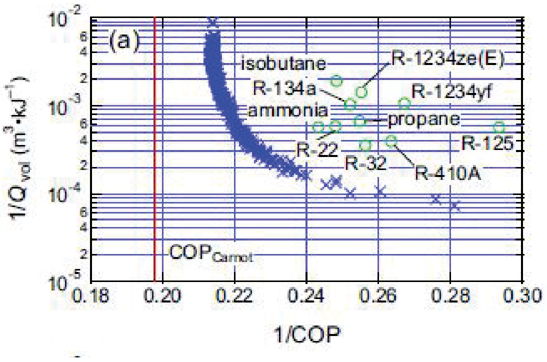
J. Steven Brown

Department of Mechanical Engineering
The Catholic University of America

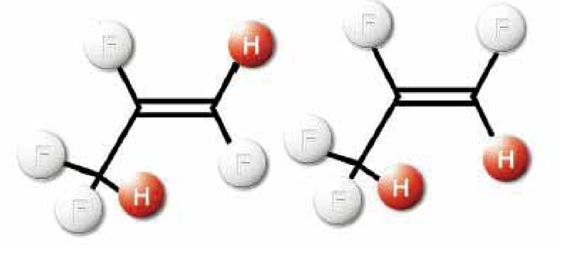
From the 1930s into the 1970s, halocarbon refrigerants were increasingly used in large quantities in a large number of applications (from air conditioning and refrigeration applications to solvents, propellants, foam blowing agents, fire suppressants, inter alia) because by selectively substituting the hydrogens of simple unsaturated hydrocarbons primarily with chlorine, fluorine, and bromine one could “design” the “optimal” refrigerant to satisfy the previously mentioned criteria. However, this continual, unchecked march forward with halocarbon refrigerants faltered in the 1980s following the identification in the early 1970s that the chlorine and bromine contained in many of these halocarbon working fluids acted as catalysts to continuously breakdown stratospheric ozone. This recognition led to a number of these refrigerants being regulated by the Montreal Protocol (1987) beginning as early as 1989 in some cases, with chlorine and bromine containing ones being replaced primarily with saturated hydrofluorocarbons (HFCs). Soon after the widespread ramp up in the use of HFCs, the international community began to move toward the regulation of HFCs since many of them possess large global warming potentials (GWP).

The first agreement aiming to regulate HFCs was the Kyoto Protocol (1997) with the most recent one being the Kigali Amendments (2016) to the Montreal Protocol, which dictates a phase-down in the production and use of HFCs. In addition to regulatory actions, society at large is increasingly recognizing that many of these saturated halocarbon working fluids are potent greenhouse gases possessing unacceptably large GWP values. Therefore, more alternative “environmentally-friendly” working fluids must be identified and commercialized to adhere to regulations, serve society, and to slow the process of global climate change. This goal is the aim of my current research, which is directed toward the identification of and characterization of alternative, low-GWP working fluids for a wide-range of heating, ventilating, air conditioning, and refrigeration (HVAC&R) and organic Rankine cycle (ORC) applications.

This presentation summarizes some of our recent work and unfolds in two parts. (1) A brief review of some thermodynamic property measurements for several unsaturated halocarbon refrigerants. (2) A brief summary of a large screening and simulation study undertaken to identify potential alternative refrigerants for several HVAC&R applications.



International Journal of Refrigeration, 38: 71-79.



ASHRAE Journal, 51(8): 22-29.

Thermodynamic Property Measurements of Low-GWP Refrigerant Mixtures

Yukihiro Higashi

Research Center for Next Generation Refrigerant Properties (NEXT-RP)
International Institute for Carbon-Neutral Energy Research (WPI-I^{2}CNER), Kyushu University

The depletion of ozone layer has been recognized as a serious challenging issue since the 1970s, and the production of CFCs (chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons) has been regulated by the Montreal Protocol since 1987. Moreover the global warming effect on the earth becomes more serious. Recently not only CFCs and HCFCs but also HFCs (hydrofluorocarbons), which was the alternatives of CFCs and HCFCs, have been added as the target of the refrigerant regulation by the Paris Agreement of a review of the Kyoto Protocol. Specific targets for a phase down of the HFCs were agreed at the 28th Meeting of the Parties (MOP28) to the Montreal Protocol (known as the Kigali Amendments). As a candidate for next generation refrigerants instead of HFCs, HFO (hydrofluoroorefin) refrigerants with a carbon-carbon double bond in the chemical formula are expected as the refrigerants with the low ozone depletion potential (ODP) and the low global warming potential (GWP).

Many HFOs and their mixtures have been proposed over the last decade. There is a strong expectation for refrigerant mixtures because they have a huge possibility to be able to produce many kinds of combination. Especially, our NEXT-RP (Research Center for Next Generation Refrigerant Properties) is paying attention to the refrigerant mixtures to be the four kinds of HFO component materials, HFO-1234yf, HFO-1234ze(E), HFO-1123, and HFC-32, summarized in Figure 1(a). In order to develop and design new air-conditioners and heat pumps, basic thermodynamic-properties of new refrigerant mixtures as shown in Figure 1(b) is indispensable. In this talk, the trend of the next generation refrigerant mixtures and the research of accurate thermodynamic property measurements at the present stage will be introduced. Moreover, I would like to talk about the relationship between the research of new refrigerants and global environmental issues including the CO_2 reduction and energy problem.

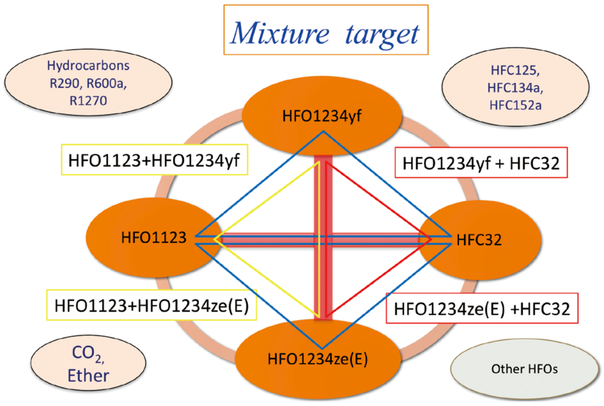


Figure 1(a): Possible combination for low-GWP refrigerants mixtures.

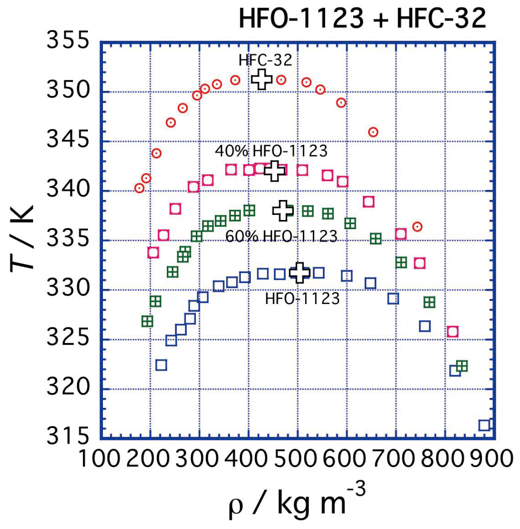


Figure 1(b): Experimental saturated density for binary HFO1123 + HFC32 mixture

Thermophysical Property Measurements of High-Pressure Hydrogen up to 100 MPa and Applications of the Database to Design for Hydrogen Infrastructure

Naoya Sakoda[1, 2, 3], Taichi Kuroki[3], Kan'ei Shinzato[3], and Yasuyuki Takata[1, 2, 3]

[1]Faculty of Engineering, Kyushu University
[2]International Institute for Carbon-Neutral Energy Research (WPI-I^{2}CNER), Kyushu University
[3]Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS), Kyushu University

Hydrogen is expected to be a next-generation clean energy carrier, and fuel cell vehicles (FCVs) and hydrogen refueling stations (HRSs) are promising technologies in the hydrogen society. Accurate thermophysical properties of hydrogen are essential for efficient design of the FCVs and HRSs, but few reliable experimental data of hydrogen were available at a high-temperature and high-pressure region. In this study, thermophysical properties of hydrogen; PVT property, viscosity, and thermal conductivity were measured at temperatures and pressures up to 773 K and 100 MPa, respectively. An equation of state and correlations for hydrogen were formulated based on the experimental data, and a thermophysical properties database compiling them was developed. For the demand of precooling hydrogen at the HRSs, thermal conductivity and viscosity have been measured at low temperatures down to 233 K. Figure 1 shows the experimental apparatus of the thermal conductivity measurement with a transient short-hot-wire method and a measured temperature rise of a sample of hydrogen by heating the platinum wire of the probe in the pressure vessel. The present database easily calculates the thermophysical properties of hydrogen at arbitrary conditions, and it is applied to a HRS dynamic simulation, which enables to estimate the change in the temperatures and pressures of hydrogen flowing the devices such as accumulators, valves, tubes, and a pre-cooler consist of the HRS and a FCV container.

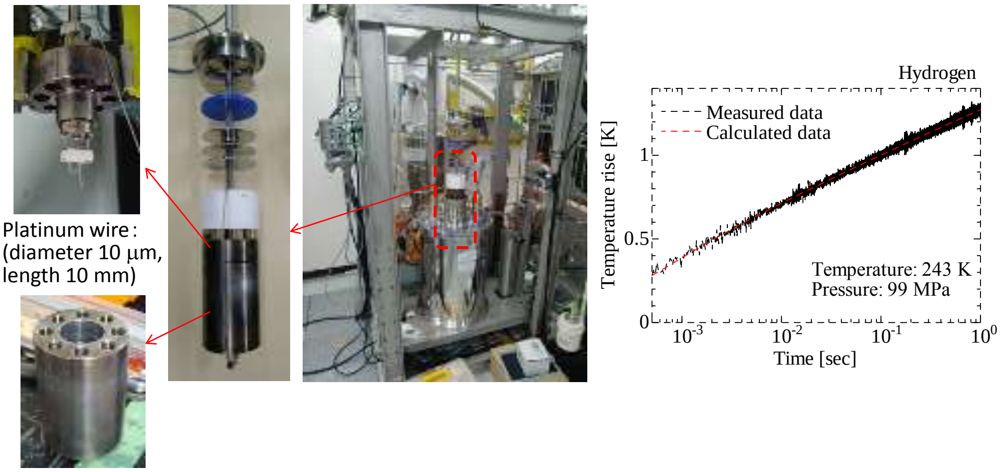


Figure 1: Thermal conductivity measurement apparatus and a measured temperature rise of a sample of hydrogen at 243 K and 99 MPa by heating the platinum wire.

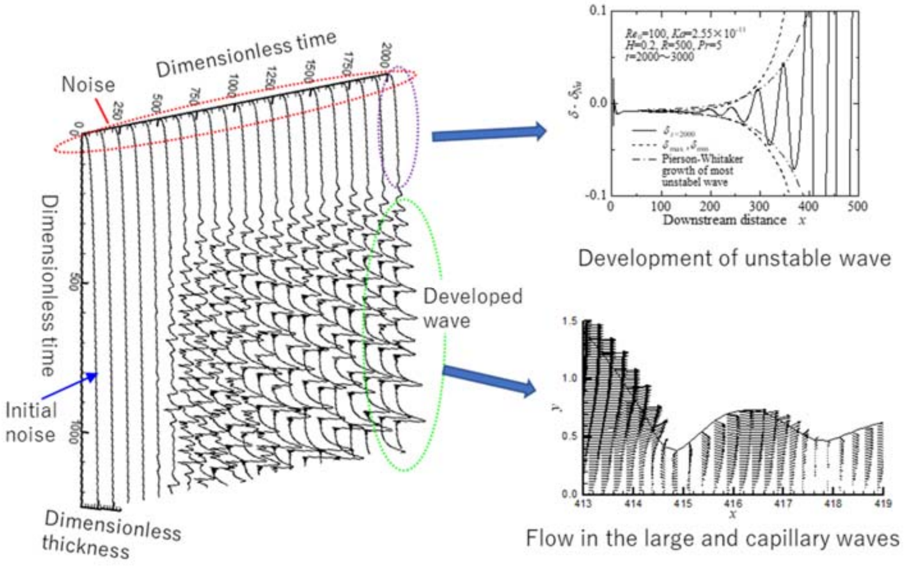
Effects of Condensate Flow and Thickness on Heat Transfer of Film-wise Condensation

Akio Miyara

Department of Mechanical Engineering, Saga University
Research Center for Next Generation Refrigerant Properties (NEXT-RP),
International Institute for Carbon-Neutral Energy Research (WPI-I^{2}CNER), Kyushu University

Condensation heat transfer seems to be well known because Nusselt theory and other theories developed decades ago can be explained its mechanism in many cases of film-wise condensation analytically. However, some unknowns are remained in wavy and turbulent film regions. As shown in figure 1, small noise in the laminar smooth condensate film develops according to the instability of the phenomena. Amplitude of the most unstable waves is developed to large waves and enhances the heat transfer by means of thinning and convecting the film. The circulation flow appears in the large wave and capillary waves are generated in front of the large wave. In the downstream, the waves collapse and the wavy film change to the turbulent film.

Additionally, there are variety of application fields of film-wise condensation and heat transfer enhancement technology should be developed. In case of condensation in a horizontal tube, heat transfer is dominated by thinner arear of condensate film flow. The thin film is formed on upper part for smooth tube, very thin film is formed on fin edge for spiral microfin tube, and the very thin film becomes thinner by drainage effect of herringbone microfin tube. Condensation in plate heat exchanger is very complex. Two phase flow observation and local heat transfer measurement are explained. The heat transfer coefficient is vary along flow direction and cross direction to the flow. Condensation of vapor mixture is explained by using experimental data and physical model. Heat transfer enhancement for condensation of vapor mixture has not been developed yet.



Development of unstable wave

Flow in the large and capillary waves

Figure 1: Wave development and flow in the wavy film

I^{2}CNER International Workshops
February 2, 2018

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

-HIGHLY EFFICIENT ENERGY CONVERSION MATERIALS-

I^{2}CNER INTERNATIONAL WORKSHOP

MOLECULAR PHOTOCONVERSION DEVICES DIVISION
& ELECTROCHEMICAL ENERGY CONVERSION DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 8:50 AM- 5:30 PM
VENUE: I^{2}CNER HALL B

Time	Speaker	Affiliation	Title
8:50-9:00	Prof. John A. Kilner	Imperial College London	Opening remarks
9:00-10:00	Prof. Ugur Pasaogullari	Center for Clean Energy Engineering (C2E2), University of Connecticut	Introduction of C2E2 activity and advanced analysis of PEFC
10:00-10:30	Prof. Kondo-Francois Aguey-Zinsou	University of New South Wales (UNSW)	Hydride materials for hydrogen storage and CO_2 catalysis
10:30-11:00	Dr. Mariya Ivanova	Forschungszentrum Jülich	Hydrogen separation Membranes
11:00-11:30	Dr. Wilhelm A. Meulenberg	Forschungszentrum Jülich	Ceramic Gas Separation Membranes – From Microstructural Aspects to Application
11:30-11:50	Prof. Thomas Lippert	Paul Scherrer Institut (PSI)	Thin films by Pulsed Laser Deposition
11:50-1:00	Lunch		
1:00-1:20	Prof. Colin Atkinson	Imperial College London	Mathematical Methods for Solving Tracer Diffusion Equations
1:20-1:40	Prof. Taner Akbay	ACE2, Kyushu University	Back-exchange Tracer Diffusion Problem
1:40-2:00	Dr. Vincent Thoréton	I^{2}CNER, Kyushu University	How steam and CO_2 influence the oxygen transport kinetics of IT-SOFC cathodes
2:00-2:20	Dr. Kwati Leonard	I^{2}CNER, Kyushu University	Application of Proton conductor for steam electrolysis

2:20-2:40	Dr. Nuttavut Kosem	I^2CNER, Kyushu University	Hydrogen evolution from water using GaN:ZnO coupled to hydrogenase-producing Escherichia coli
2:40-3:00	Prof. Songmei Sun	I^2CNER, Kyushu University	Inorganic Photocatalyst for CO_2 conversion
3:00-3:20	Dr. Gabseok Seo	I^2CNER, Kyushu University	Understanding the performance limitation factors; Deep level trapped defect in perovskite solar cells
3:20-3:40	Coffee break		
3:40-4:00	Prof. Toshinori Matsushima	I^2CNER, Kyushu University	High performance from extraordinarily thick organic light-emitting diodes
4:00-4:20	Dr. Wei Ma	I^2CNER, Kyushu University	Halloysite nanotubes based hybrid coating with both superhydrophobic and superoleophobic properties
4:20-4:40	Prof. Hironobu Ozawa	Faculty of Science, Kyushu University	Molecular-Based Photoelectrochemical Cells for Visible-Light-Driven Hydrogen Production from Water
4:40-5:00	Prof. Motonori Watanabe	I^2CNER, Kyushu University	Anchor effect of dye in dye-sensitized photocatalytic water splitting for effective hydrogen production reaction
5:00-5:20	Prof. Aleksandar Staykov	I^2CNER, Kyushu University	Oxygen Reduction Reaction on Carbon-coated Iron Nanoparticles
5:20-5:30	Prof. Tatsumi Ishihara	I^2CNER, Kyushu University	Closing remarks

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

- HYDROGEN-MATERIALS INTERACTIONS -

HYDROGENIUS, I^{2}CNER & HYDROMATE JOINT RESEARCH SYMPOSIUM

I^{2}CNER HYDROGEN MATERIALS COMPATIBILITY DIVISION,
HYDROGENIUS FATIGUE AND FRACTURE DIVISION,
& HYDROMATE

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 9:20 AM-5:20 PM
VENUE: LECTURE ROOM, 3F, SHIIKI HALL

Time	Speaker	Affiliation	Title
9:20-9:30	Prof. Hisao Matsunaga	Kyushu University	Opening Remarks
	Dr. Brian Somerday	Southwest Research Institute	*Chair*
9:30-10:00	Prof. Eiji Akiyama	Tohoku University	*Invited Talk* Electrochemical hydrogen permeation tests to study hydrogen embrittlement
10:00-10:30	Prof. Abdelali Oudriss	University of La Rochelle	*Invited Talk* Some advances on the implication of crystalline defects on hydrogen diffusion and trapping mechanisms in fcc materials : Experimental and modelling approaches
10:30-11:00	Prof. Ryusuke Matsumoto	Kyoto University	*Invited Talk* Atomistic Study of Hydrogen Effects on Stability and Mobility of Vacancy and Vacancy-Clusters
11:00-11:20	Break		
	Prof. Junichiro Yamabe	HYDROGENIUS, Kyushu University & HydroMate, AIST	*Chair*

11:20-11:50	Prof. Shuai Wang	University of Wisconsin	*Invited Talk* Collective dislocation behavior in the presence of hydrogen
11:50-12:20	Prof. Bai An	AIST	*Invited Talk* Application of SPM-related nanotechnology in hydrogen embrittlement studies
12:20-1:20	Lunch		
1:20-2:20	Poster Session		
	Prof. Arnaud Macadre	I^2CNER, Kyushu University	*Chair*
2:20-2:50	Prof. Michal Lewandowski	TWI	*Invited Talk* Influence of high-pressure hydrogen atmospheres on mechanical performance of austenitic stainless steels at low temperatures
2:50-3:20	Prof. Masanobu Kubota	I^2CNER, Kyushu University	*Invited Talk* Effect of impurities added to hydrogen environment on fracture toughness of Cr-Mo steels with different strength levels
3:20-3:50	Prof. James Burns	University of Virginia	*Invited Talk* The effect of microstructure on the hydrogen environment assisted cracking susceptibility of a precipitation hardened Ni-Cu alloy
3:50-4:10	Break		
	Dr. Akihide Nagao	JFE Steel	*Chair*
4:10-4:40	Mr. Yuhei Ogawa	Kyushu University	*Invited Talk* Interpretation of hydrogen-assisted fatigue crack propagation in a pure BCC iron based on crack tip plasticity evolution
4:40-5:10	Prof. Osamu Takakuwa	HYDROGENIUS, Kyushu University	*Invited Talk* Compatibility of Type 304 stainless steel to high-pressure hydrogen gas
5:10-5:20	Dr. Brian Somerday	Southwest Research Institute	Closing Remarks

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

-VARIOUS ASPECTS OF HYDROGEN-RELATED PROCESSES AT TRIBO-INTERFACES-

2018 HYDROGENIUS and I²CNER Tribology Symposium

I²CNER HYDROGEN MATERIALS COMPATIBILITY DIVISION
& HYDROGENIUS TRIBOLOGY DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 10:00 AM-6:00 PM
VENUE: LECTURE ROOM, 3F, SHIIKI HALL

Time	Speaker	Affiliation	Title
10:00-10:05	Joichi Sugimura	Kyushu University	Opening Remarks
10:05-11:55 Session 1 Chairperson: Yoshinori Sawae, Kyushu University			
10:05-10:45	Géraldine Theiler	BAM, Germany	*Keynote Lecture* Tribology of Polymers Materials in Cryogenic Hydrogen and Methane
10:45-11:10	Naofumi Kanei	Kobe Steel, Ltd.	*Invited Talk* Technological trends of high pressure hydrogen compressor - Approach of KOBELCO Group -
11:10-11:35	Go Tatsumi[1], Yuji Shitara[1], Peng Yao[2], Toshiaki Wakabayashi[2]	[1] JXTG Nippon Oil & Energy Corporation, [2] Kagawa University	*Invited Talk* Influences of sulfur-containing additives on grease decomposition and hydrogen generation by nascent metal surface
11:35-11:55	Vlad B. Niste, Hiroyoshi Tanaka, Joichi Sugimura	Kyushu University	*Invited Talk* Inhibiting hydrogen permeation in bearing steel by controlling tribofilm growth in the contact

11:55-12:50 Lunch			
12:50-2:45 Session 2 Chairperson: Kanao Fukuda, Universiti Teknologi Malaysia			
12:50-1:30	Ali Erdemir	Argonne National Laboratory, USA	*Keynote Lecture* The role of hydrogen in carbon tribology: A mechanistic overview
1:30-1:55	Shinya Sasaki, Hiharu Okubo	Tokyo University of Science, Japan	*Invited Talk* Super-low friction mechanism of diamond-like carbon lubricated with an environmentally friendly ester based oil
1:55-2:20	Yusuke Ootani	Tohoku University, Japan	*Invited Talk* Tribochemical wear of silicon-based materials mediated by proton transfer: Molecular dynamics sliding simulation analysis
2:20-2:45	Satoru Maegawa	Tottori University, Japan	*Invited Talk* Visualization of real contact area of rubber materials sliding on hard substrates
2:45-3:00	Break		
3:00-4:25 **Joint Symposium of Hydrogen Tribology Team and Hydrogen Polymers Team** Chairperson: Dr. Neha RUSTAGI, Fuel Cell Technologies Office, DOE, USA			
3:00-3:40	Dr. Kevin Simmons	Pacific Northwest National Laboratory, USA	*Invited Talk* Hydrogen Compatible Polymeric Materials
3:40-4:20	Joichi Sugimura	Kyushu University	Tribology of rubbers in hydrogen
4:20-4:25	Prof. Shin Nishimura		Closing Remarks of Oral Session Prof. Shin Nishimura, Kyushu University
4:25-4:30	Break		

4:30-6:00 **Poster Session**				
	PT 01	Hikaru Okubo, Shinya Sasaki	Tokyo University of Science, Japan	Frequency modulation atomic force microscopy (FM-AFM) observation of adsorbed films on diamond-like carbon (DLC) surfaces
	PT 02	Prabakaran Saravanan, Roman Selyanchyn, Hiroyoshi Tanaka, Joichi Sugimura	Kyushu University	Tribology of polyethylenimine / molybdenum disulphide (PEI/MoS$_2$)$_{15}$ films in dry atmospheres
	PT 03	Kohei Shirahama[1], Hiroyoshi Tanaka[1], Takeshi Maeda[2], Joichi Sugimura[1]	[1] Kyushu University, [2] Kyocera Corporation, Japan	Effect of environmental gas on friction and wear of various ceramics
	PT 04	Keisuke Manabe, Hiroyoshi Tanaka, Joichi Sugimura	Kyushu University	Effects of oxygen and water on friction and wear of DLC slid against pure metals
	PT 05	Naotoshi Shimizu[1], Yoshinori Sawae[2], Takehiro Morita[2], Shugo Onitsuka[2], Joichi Sugimura[2]	[1] IHI Corporation , [2] Kyushu University	Friction and wear of polymer composites in hydrogen environment at low temperature
	PT 06	Reona Umei, Keiji Sakaki, Takehiro Morita, Yoshinori Sawae, Joichi Sugimura	Kyushu University	Effect of trace moisture content on low friction mechanism of carbon fiber filled PTFE in high purity hydrogen
	PT 07	Yoshinori Sawae, Eiichi Miyakoshi, Shunichiro Doi, Takehiro Morita, Joichi Sugimura	Kyushu University	Friction and wear of polymer composites in high pressure hydrogen
	PT 08	Shotaro Koizumi[1], Hiroyoshi Tanaka[1], Yuuya Hayashi[2], Naruhiko Inayoshi[2], Joichi Sugimura[1]	[1] Kyushu University, [2] DENSO Corporation, Japan	Effects of environmental gases on friction and wear of stainless steels
	PT 09	Daisuke Takekawa[1], Yoji Sunagawa[1], Hiroyoshi Tanaka[2]	[1] Idemitsu Kosan Co., Ltd., [2] Kyushu University	Hydrogen generation from cyclic compounds in rolling contact of steel, Joichi Sugimura[2] Japan
	PT 10	Hiromitsu Kakudo, Satoshi Takada, Makoto Yoshida	Japan Aerospace Exploration Agency, Japan	Evaluation of new type bearing retainer for liquid rocket engine turbopump

- THERMAL ISSUES FOR HYDROGEN AND NEW REFRIGERANTS FOR ENERGY SYSTEMS –

HYDROGENIUS AND I^{2}CNER JOINT RESEARCH SYMPOSIUM

(I^{2}CNER THERMAL SCIENCE AND ENGINEERING DIVISION
& HYDROGENIUS THERMOPHYSICAL PROPERTIES DIVISION)

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 9:50 AM – 4:55 PM
VENUE: CONFERENCE ROOM, 2F, I^{2}CNER BLDG. 1

Time	Speaker	Affiliation	Title
9:50-10:00	Yasuyuki Takata	Kyushu University	Opening remarks
10:00-10:40	Shalabh C. Maroo	Syracuse University	Experimental and Molecular Study of Microlayer in Pool Boiling and Thin-Film Evaporation
10:40-11:20	Prashant Valluri	University of Edinburgh	Watching Sessile Droplets Evaporate: Beautiful (and Never Boring) Phenomena
11:20-11:40	Askounis Alexandros	Kyushu University	Can Ultrathin Water Films Remain Stable in Nanoconfinement?
11:40-12:00	Daniel Orejon	Kyushu University	Coalescence-induced Droplet-jumping Suppression by Microstructures on Superhydrophobic Surfaces
12:00-1:20	Lunch		
1:20-2:00	Emadabathuni Anil Kumar	Indian Institute of Technology Tirupati	Effective Thermal Conductivity of Metal Hydride Beds: Measurement, Simulation and Augmentation
2:00-2:40	Khairul Habib	Universiti Teknologi Petronas (UTP)	Photo Thermoelectric Air Duct Systems for Self-Sustainable Buildings
2:40-3:00	Biao Shen	Kyushu University	Boiling on Surfaces with Heterogenous Wettability
3:00-3:10	Break		

3:10-3:40	Kenji Takizawa	National Institute of Advanced Industrial Science and Technology (AIST)	Evaluation of Low Flammability for Next Generation Refrigerants
3:40-4:10	Ryo Akasaka	Kyushu Sangyo University	Current Status and Future Development of a New Fundamental Equation of State for cis-1,1,1,4,4,4-Hexafluoro-2-butene (R-1336mzz(Z))
4:10-4:30	Yutaku Kita	Kyushu University	Drop mobility on Microtextured Surfaces with Wettability Contrasts
4:30-4:50	Taichi Kuroki	Kyushu University	Temperature Rise of Hydrogen Storage Cylinders by Thermal Radiation from Fire at Hydrogen-Gasoline Hybrid Refueling Stations
4:50-4:55	Naoya Sakoda	Kyushu University	Closing Remarks

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

-HYDROGEN ACTIVATION FOR EFFICIENT MATERIALS TRANSFORMATION-

I^2CNER INTERNATIONAL WORKSHOP

CATALYTIC MATERIALS TRANSFORMATIONS DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 12:55 PM-5:15 PM
VENUE: I^2CNER HALL A
CO-SPONSOR: CENTER FOR SMALL MOLECULE ENERGY, KYUSHU UNIVERSITY

Time	Speaker	Affiliation	Title
12:55-1:00	Prof. Miho Yamauchi	I^2CNER, Kyushu University	Opening remarks
1:00-1:35	Prof. Chang Ho Chol	Chuo University	Photo-induced Hydrogen Transfer *via* Redox-active Ligand
1:35-1:50	Prof. Tatsuya Uchida	I^2CNER, Kyushu University	Catalytic Dehydrogenation using Oxygen as a Hydrogen Accepter
1:50-2:25	Prof. Kyungsu Na	Chonnam National University	Catalytic Conversion of C1 Feedstocks to Value-Added Chemicals using Nanostructured Catalysts
2:25-2:40	Coffee break		
2:40-3:15	Prof. Hideaki Ogata	Hokkaido University	Hydrogen activation by hydrogenases
3:15-3:30	Dr. Miho Isegawa	I^2CNER, Kyushu University	DFT Study on Fe(IV)-Peroxo Formation and H-Atom Transfer Triggered O2 Activation in a Bio-Inspired Model of [NiFe]-Hydrogenase
3:30-4:05	Dr. Takanori Shima	Riken	Molecular Multimetallic Polyhydrides: Activation and Functionalization of Dinitrogen and Aromatics
4:05-4:20	Coffee break		
4:20-4:35	Prof. Yukina Takahashi	I^2CNER, Kyushu University	Site-selective Nanoscale-photopolymerization on Gold Nanoparticles via Plasmon Induced Charge Separation
4:35-5:10	Dr. Yong Nam Choi	KAERI	Hydrogen Storage by Catalytic Ionic Hydrogenation
5:10-5:15	Prof. Ki-Seok Yoon	I^2CNER, Kyushu University	Closing remarks

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

- CHALLENGES IN MEMBRANE SCIENCE -

I^2CNER INTERNATIONAL WORKSHOP

CO_2 CAPTURE AND UTILIZATION DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 1:00 PM-5:25 PM
VENUE: SEMINAR ROOM 3105-6, CENTER ZONE BLDG. 3

Time	Speaker	Affiliation	Title
1:00-1:10	Prof. Shigenori Fujikawa	I^2CNER, Kyushu University	<Opening Remarks>
1:10-2:00	Prof. Jong Hak Kim	Yonsei University	POEM-based graft copolymers: Synthesis, Nanostructure and Applications
2:00-2:35	Prof. Masakoto Kanezashi	Hiroshima University	Pore size controllability and gas permeation properties of sol-gel derived amorphous silica membranes
2:35-3:10	Prof. Masamichi Nishihara	Kyushu University	Charge-transfer complex hybrid films as a ionic conductive membrane for fuel cell application
3:10-3:30	Coffee break		
3:30-4:00	Prof. Satoshi Kodama	Tokyo Institute of Technology	Process analysis for CO_2 capture technology
4:00-4:30	Dr. Masahiro Seshimo	Research Institute for Innovative Technology for the Earth	Inorganic membranes and its applications
4:30-4:55	Dr. Roman Selyanchyn	I^2CNER, Kyushu University	Creation of size sieving domains in polydimethylsiloxane for higher selectivity and permeability gas separation membranes
4:55-5:20	Prof. Ikuo Taniguchi	I^2CNER, Kyushu University	Polymeric membranes for negative carbon emission
5:20-5:25	Prof. Shigenori Fujikawa	I^2CNER, Kyushu University	<Closing Remarks>

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

-CO_2 BEHAVIOR FROM MOLECULAR TO FIELD SCALE TO ACHIEVE BETTER CO_2 STORAGE-

I^2CNER INTERNATIONAL WORKSHOP

CO_2 STORAGE DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018
TIME: 1:00 PM-5:12 PM
VENUE: I^2CNER HALL C

Time	Speaker	Affiliation	Title
1:00-1:15	Takeshi Tsuji	Kyushu Univ.	Activity in CO_2 storage division
1:15-1:35	Kazuya Ishitsuka	Hokkaido Univ.	Field-scale temperature estimation based on resistivity using neural network: Application to the Kakkonda geothermal field
1:35-1:50	Tatsunori Ikeda	Kyushu Univ.	Monitoring of CO_2 storage sites using a controlled and continuous seismic source system
1:50-2:20	Osamu Takano	JAPEX	Tectonic and depositional system transition of the Cretaceous to Neogene Sanriku-Shimokita-Hidaka-oki forearc to foreland basin: transformation scenario from coal-bearing fluvio-deltaic forearc to deeper-marine foreland
2:20-2:32	Chandoeun Eng	Kyushu Univ.	Hydrocarbon characterization using seismic attributes for Sanriku-Oki Forearc basin, northeast Japan
2:32-2:44	Chanmaly Chhun	Kyushu Univ.	Characterization of hydrate and gas reservoirs using automatic seismic velocity analysis and rock physics: Example from Kumano forearc basin of the Nankai Trough, Japan
2:44-3:00	Coffee break		
3:00-3:30	Diogo Bolster	Univ. of Notre Dame	Comparison of micromodel experiments and numerical simulations of multiphase displacement flows under CO_2 sequestration relevant conditions

3:30-3:50	Fei Jiang	Yamaguchi Univ. & I^{2}CNER	Effect of wettability alternation on multiphase flow behavior in porous media
3:50-4:10	Kazuki Sawayama	Kyushu Univ.	Numerical investigation about the effect of aperture closure on fluid behavior in digitalized fracture
4:10-4:40	Yunfeng Liang	Univ. of Tokyo	Recent Progresses in Molecular Scale Investigation of CO_2-Brine-Clay Interactions for CO_2 Geo-Sequestration
4:40-5:00	Jihui Jia	China Univ. of Petroleum	Ab Initio Molecular Dynamics Study of Carbonation and Hydrolysis of Quartz and Basalt Andesine Reactive Surface
5:00-5:12	Hiroki Matsui	Kyushu Univ.	Influence of the addition of H_2S on replacement reaction of CH_4 and CO_2

IN THE MORNING (10:00-12:00), WE HAVE 4 GROUP DISCUSSION.

1. MONITORING: IKEDA, ISHITSUKA, NIMIYA, FERNANDO, NAGTA,
2. GEOLOGIC MODEL CONSTRUCTION: TAKANO, ENG, MALY, KAKDA
3. FLUID FLOW: BOLSTER, JIANG, IKUO, SAWAYAMA, KITAMURA
4. NANO-SACALE: LIANG, JIA, MATSUI

INTERNATIONAL INSTITUTE FOR CARBON-NEUTRAL ENERGY RESEARCH

-ENERGY TRANSITION PATHWAYS FOR JAPAN-

I^{2}CNER INTERNATIONAL WORKSHOP

ENERGY ANALYSIS DIVISION

DATE: FRIDAY, FEBRUARY 2, 2018

TIME: 9:30 AM–4:00 PM

VENUE: SEMINAR ROOM 203, CENTER FOR CO-EVOLUTIONAL SOCIAL SYSTEMS

Time	Speaker	Affiliation	Title
9:30 – 9:40	Prof. Kenshi Itaoka	I^{2}CNER, Kyushu University	Opening remark: Low-Carbon and Sustainable pathway considerations and modelling approaches
9:40 – 10:00	Prof. Andrew Chapman	I^{2}CNER, Kyushu University	A brief review of transition theory and the Japanese energy policy approach and targets
10:00 – 11:00	Prof. Benjamin McLellan Dr. Atsushi Kurosawa TBD	Kyoto University Institute of Applied Energy TBD	DOMESTIC landscape: Factors, problems, barriers, policies and analytical approaches on energy transition pathways
11:00 – 11:10	Coffee break		
11:10 – 11:50	Prof. Andrew Chapman	I^{2}CNER, Kyushu University	Exercise 1: DOMESTIC landscape: Open discussion on the pathway and modelling inputs and approach. Notes taken to guide Exercise 2
11:50 – 1:00	Lunch		
1:00 – 1:40	Prof. Kenshi Itaoka	I^{2}CNER, Kyushu University	Exercise 2: DOMESTIC landscape: Gathering input from members on a timeline for “potential transition pathways” including policy, technology and exogenous impact inputs
1:40 – 2:10	Dr. Monterey Gardiner Prof. James Stubbins	BMW Group University of Illinois Urbana-Champaign	INTERNATIONAL landscape: Factors, problems, barriers, policies and analytical approaches on energy transition pathways:

2:10 – 2:20	Coffee break		
2:20 – 3:00	Prof. Andrew Chapman	I^2CNER, Kyushu University	Exercise 3: INTERNATIONAL landscape: Open discussion on the pathway and modelling inputs and approach. Notes taken to guide Exercise 4
3:00 – 3:40	Prof. Kenshi Itaoka	I^2CNER, Kyushu University	Exercise 4: INTERNATIONAL landscape: Gathering input from members on a timeline for “potential transition pathways” including policy, technology and exogenous impact inputs
3:40 – 4:00	Prof. Andrew Chapman	I^2CNER, Kyushu University	Closing and future steps, collaboration opportunities

International Institute for Carbon-Neutral Energy Research

-Scenery of Applied Mathematics in Energy Problem-

I^2CNER International Workshop

Initiative on Applied Math for Energy

Date: Friday, February 2, 2018
Time: 9:30 am- 5:30 pm
Venue: Seminar room 3213, Center zone Bldg. 3

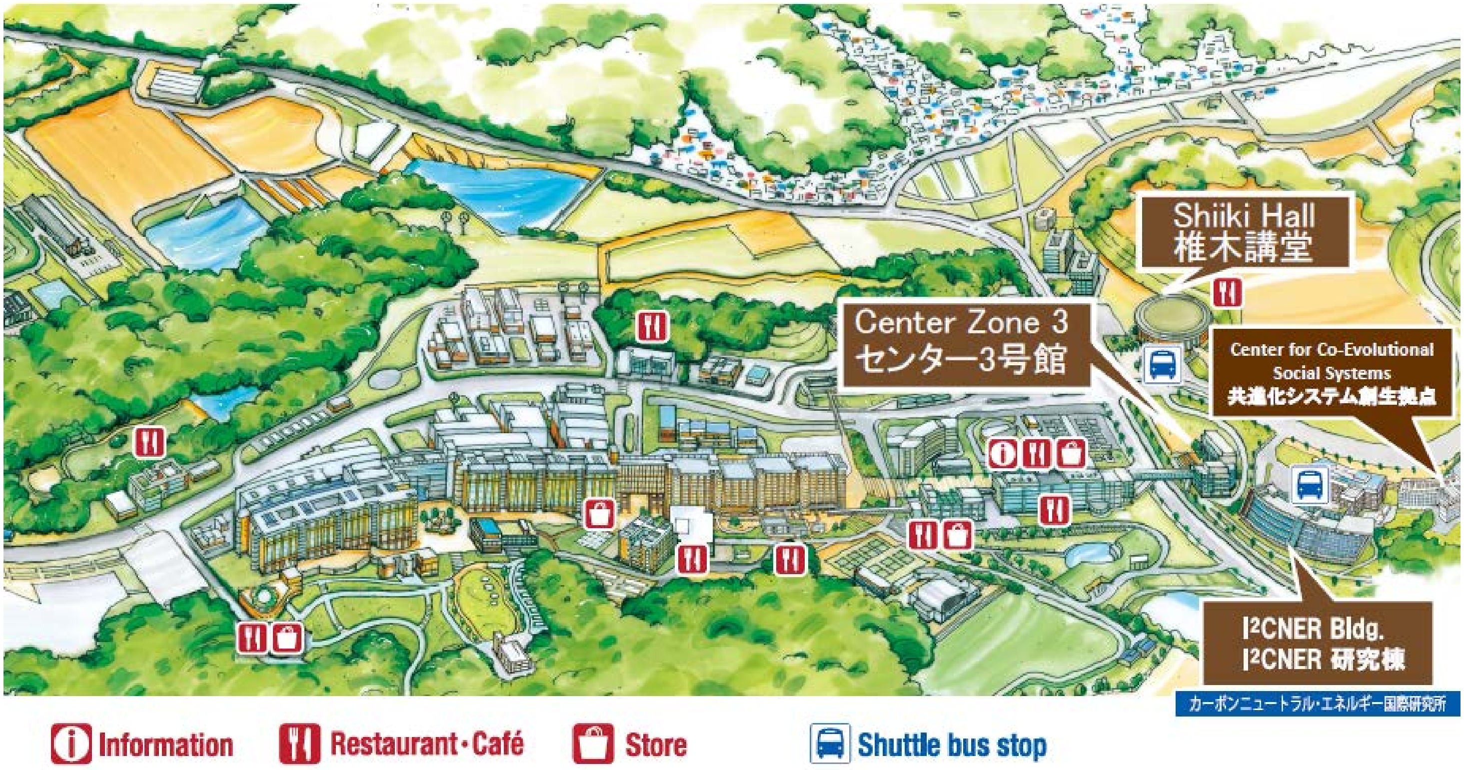
Time	Speaker	Affiliation	Title
9:30 - 9:35	Kaname Matsue	IMI / I^2CNER, Kyushu University	Opening Address
9:35 - 10:15	Kong Joo Shin	Dept. of Urban and Environmental Engineering, Kyushu University	Liberalisation of retail electricity market: Household switching behaviour and consumer satisfaction in Japan
10:25 - 11:10	Atsushi Kawamoto	Toyota Central R&D Labs., Inc.	Topology Optimization in Multiphysics Problems
11:20 - 12:00	Hiroaki Watanabe	Dept. of Mechanical Engineering, Kyushu University	Recent R&D on Combustion Simulation for Energy Industry
12:00-1:00	Lunch		
1:00 - 1:45	TBA	TBA	TBA
1:55 - 2:40	Ippei Obayashi	AIMR, Tohoku University	Theory and Application of persistent homology
3:05 - 3:45	Jun'ichi Murata	Dept. of Electrical Engineering, Kyushu University	Maths-ish techniques in electrical power management
3:55 - 4:40	Daniel Packwood	iCeMS, Kyoto University	Mathematical modeling and dissimilarity analysis for nanomaterial assembly
4:50 - 5:30	Kei Hirose	IMI, Kyushu University	Statistical analysis of energy consumption data
TBA	Dinner		

*Please confirm your attendance at https://secure.congress.ne.jp/q_pit2018/regist_e_q_pit2018.html if you would like to join the workshop and/or dinner.

Programs

Date	Jan. 31	Feb. 1	Feb. 2										
Event	I^{2}CNER Annual Symposium	International Hydrogen Energy Development Forum 2018	I^{2}CNER International Workshops						HYDROGENIUS and I^{2}CNER Joint Research Symposium				HYDROGENIUS Research Symposium
Venue	I^{2}CNER Hall	ACROS Fukuoka (Tenjin)	I^{2}CNER Hall A	I^{2}CNER Hall B	I^{2}CNER Hall C	Seminar Room 203 COI	Seminar Room 1F, Center Zone 3	Seminar Room 2F, Center Zone 3	Conference Room 2F, I^{2}CNER Bldg.1	Lecture Room 3F, Shiiki Hall	Lecture Room 3F, Shiiki Hall	Lecture Room 3F, Shiiki Hall
9:00 30 10:00 30 11:00 30 12:00 30 13:00 30 14:00 30 15:00 30 16:00 30 17:00 30 18:00 30 19:00 30 20:00 30	I^{2}CNER Annual Symposium (9:30-18:30) & Reception (18:30-20:00)	International Hydrogen Energy Development Forum 2018 (13:30-16:50) & Reception (17:00-18:30)	Catalytic Materials Transformations (12:55-17:15)	Molecular Photoconversion Devices & Electrochemical Energy Conversion (8:50-17:30)	CO$_2$ Storage (13:00-17:12)	Energy Analysis (9:30-16:00)	CO$_2$ Capture and Utilization (13:00-17:25)	Initiative on Applied Math for Energy (9:30-17:30)	Thermal Science and Engineering (Thermophysical Properties Division) (9:50-16:55)	Hydrogen Materials Compatibility (Fatigue and Fracture Division) (9:20-17:20)	Hydrogen Materials Compatibility (Tribology Division) (10:00-18:00)	Polymers Division (11:00-18:00)

Campus Map



Shuttle Bus Schedule

Wednesday, January 31

AM

Grand Hyatt	7:50		
Nishitetsu Grand Hotel	↓	8:20	
Hilton Sea Hawk	8:20	↓	
The Residential Suite	8:30	↓	
I²CNER	9:00	9:00	

PM

I²CNER	19:00	20:10	20:10
The Residential Suite	19:35	↓	20:50
Hilton Sea Hawk	19:45	↓	20:55
Nishitetsu Grand Hotel	20:10	21:00	21:05
Grand Hyatt			21:30

Friday, February 2

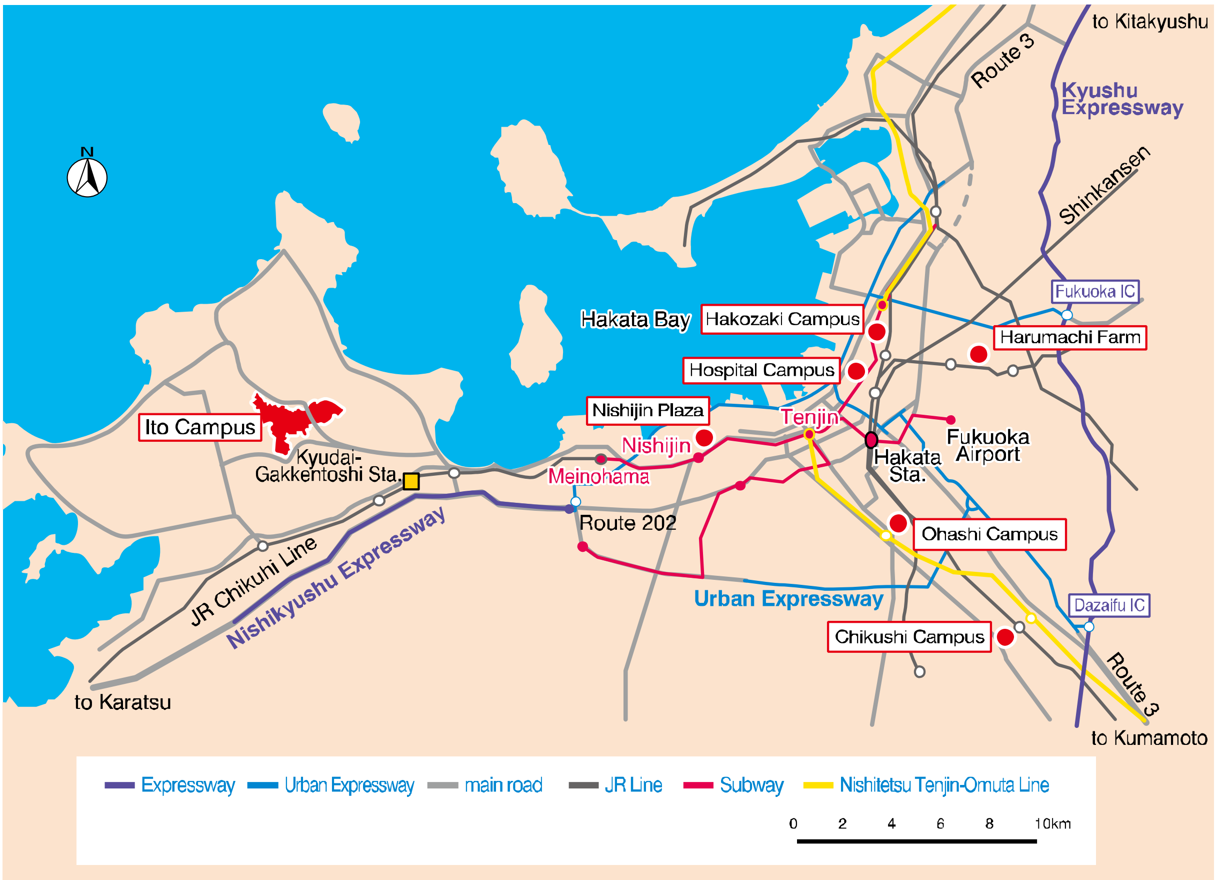
AM

Grand Hyatt	7:25		8:05	10:50
Nishitetsu Grand Hotel	↓	7:55	8:35	11:20
Hilton Sea Hawk	7:55	↓	↓	11:50
The Residential Suite	8:05	↓	↓	12:00
I²CNER	8:35	8:35	9:15	12:30

PM

I²CNER	16:15	17:40	17:45		
Shiiki Hall	↓	↓	17:55	18:20	20:15
Meinohama	↓	18:10	↓	18:50	↓
Nishijin	↓	18:30	↓		↓
The Residential Suite	↓		↓		20:55
Hilton Sea Hawk	↓		↓		21:05
Nishitetsu Grand H	↓		↓		21:35
Tenjin	17:00		18:50		
Nakasu			19:05		

Travel Information



Directions to Ito Campus

(It takes approx. 90 min. by train and bus from Fukuoka Airport to Ito Campus, Kyushu University.)

From Fukuoka Airport to Kyudaigakkentoshi Station (35 min.)

Take a train on the Fukuoka City Subway Line bound for "Meinohama" or "Karatsu/Nishi-Karatsu" at Fukuoka Airport Station.
For Meinohama: Change trains to the JR Chikuhi Line bound for "Karatsu/Nishi-Karatsu " at Meinohama Station. Get off at Kyudaigakkentoshi Station.
For Karatsu/Nishi-Karatsu: Get off at Kyudaigakkentoshi Station.

From Hakata Station to Kyudaigakkentoshi Station (30 min.)

Take a train on the Fukuoka City Subway Line bound for "Meinohama" or "Karatsu/Nishi-Karatsu at Hakata Station.
For Meinohama: Change trains to the JR Chikuhi Line bound for "Karatsu/Nishi-Karatsu" at Meinohama Station. Get off at Kyudaigakkentoshi Station.
For Karatsu/Nishi-Karatsu: Get off at Kyudaigakkentoshi Station.

From Tenjin Station to Kyudaigakkentoshi Station (25 min.)

Take a train on the Fukuoka City Subway Line bound for "Meinohama" or "Karatsu" at Tenjin Station.
For Meinohama: Change trains to the JR Chikuhi Line bound for "Karatsu/Nishi-Karatsu" at Meinohama Station. Get off at Kyudaigakkentoshi Station.
For Karatsu/Nishi-Karatsu: Get off at Kyudaigakkentoshi Station.

From Kyudaigakkentoshi Station to Ito Campus (15 min.)

Take a Showa Bus going to Kyushu University's Ito Campus and get off at "Kyudai Big Orange-mae."

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Contact

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