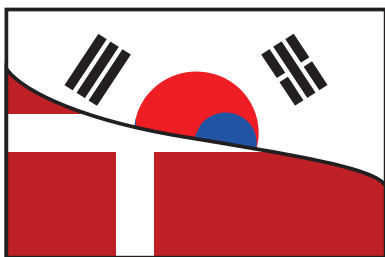


Danish Korean PEM Fuel Cell Workshop

Seoul
November 18-19, 2013



Danish Korean
PEM Fuel Cell Network

Introduction of participants



Danish Korean
PEM Fuel Cell Network

The workshop was financed by a grant from International Network Programme of Danish Agency for Science Technology and Innovation.

It was held 18-19 November 2013
at Korea Institute of Science and Technology in Seoul.

The organizing Committee was:

Jens Oluf Jensen, *DTU Energy Conversion* (DK)

Dirk Henkensmeier, *KIST* (KR)

Hans Aage Hjuler, *Danish Power Systems* (DK)

Jin Soo Park, *Sangmyung University* (KR)

Lars N. Cleemann, *DTU Energy Conversion* (DK)

With kind support and endorsement from the
Embassy of Denmark in Seoul.

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Printet in Korea

In both Korea and Denmark there are strong communities for research, development and early commercialization of PEM fuel cells. Both countries are recognized for their pronounced efforts to promote new energy technologies of which fuel cells constitute an important field with high expectations. The climate challenge has made the need for accelerated development of improved energy technologies even stronger. Besides, niche applications for which PEM fuel cells show a competing edge also from a commercial perspective are already emerging.

Some initial contacts between members of the Korean and the Danish fuel cell communities are seen in line with the overall interest for collaboration between the two countries in the fields of green technology, exemplified by the Green Growth Alliance and last spring by the Danish business delegation headed by the Danish Crown Prince Couple.

The scope of this bilateral PEM fuel cell workshop is to bring together scientists and business developers from the two countries in a two day event in Seoul - to get updated, to make new contacts or to strengthen and widen the networks already established. Common challenges are best met in common and the markets of today are global.

**Welcome,
the organizers**



DTU Energy Conversion



Danish Power Systems®



INSPIRING DENMARK

Embassy of Denmark, Seoul



The workshop is financed by a grant from International Network Programme of Danish Agency for Science Technology and Innovation



**Danish Agency for Science
Technology and Innovation**
Ministry of Science, Innovation
and Higher Education

Programme for Monday 18th of November 2013

09:30	Registration	
10:00	Welcome	Dirk Henkensmeier, KIST (KR)
		Jens Oluf Jensen, DTU Energy Conversion (DK)
10:05		Opening talk Dr. Kil-Choo Moon, President, KIST
10:15		Opening talk Peter Lysholt Hansen, Ambassador, Embassy of Denmark
10:25	Session 1, University/research	Chairs: Jens Oluf Jensen (DK), Dirk Henkensmeier (KR)
10:30		Polymer Morphology for Efficient Ion Transport in Fuel Cell Application Young Moo Lee, Hanyang University (KR)
10:50		New Pt Alloy Catalyst for The Oxygen Reduction Reaction Ib Chorkendorff, DTU Physics (DK)
11:10		Development of nano-composite polymer electrolyte membrane (PLM) for HII PLM fuel cell Hak Soo Han, Yonsei University (KR)
11:30		An approach to improve durability of sulfonated poly ether electrolytes Young Woo Choi, KIER (KR)
11:50	LUNCH	
12:55	Session 2, Industry	Chairs: (KR), Ib Chorkendorff (DK)
12:55		Progress in high temperature PFM fuel cells Hans Aage Hjuler, Danish Power Systems (DK)
13:15		Design of Durable MLAs for High Temperature PLMI C Jung-Ock Park, Samsung Electronics (KR)
13:35		Hyundai's Fuel Cell Electric Vehicle Development and Deployment Soonil Jeon, Hyundai Motors (KR)
13:55		High temperature PFM; part of the solution Mads Friis Jensen, Serenergy (DK)
14:15	COFFEE	
14:50	Session 3, Public Institutions	Chairs: Hans Aage Hjuler (DK), Jin-Soo Park (KR)
14:50		The Danish Energy Technology Development and Demonstration Programme (EUDP) Lennart Andersen, Danish Energy Agency (DK)
15:10		Innovation Centre Denmark in Seoul Maria Skou, Counsellor (Innovation), Embassy of Denmark
15:30		Introduction to NIAS Geir Helgesen, NIAS (DK)
15:50	COFFEE	
16:20	Session 4, University/research	Chairs: Jung-Ock Park (KR), Qingfeng Li (DK)
16:20		PFM fuel cell activities at DTU Energy Conversion Jens Oluf Jensen, DTU Energy Conversion (DK)
16:40		Carbon composite bipolar plates and light weight PLMI C stacks Jun Woo Lim, KAIST (KR)
17:00		Characterization and design of HII PLM fuel cells - from single cells to complete systems Søren K. Kær, Aalborg University (DK)
17:20		Durability issues of the cathode electrocatalysis in polymer electrolyte fuel cells Gu-Gon Park, KIER (KR)
17:40		Fuel Cell activities at University of Southern Denmark Eivind Skou, University of Southern Denmark (DK)
18:00	Dinner in KIST (Buffet style)	

Programme for Tuesday 19th of November 2013

08:30	Registration, Coffee	
09:00	Announcements	
09:10	Session 5,	Chairs: Mads Friis Jensen (DK), S. I. Woo (KR)
09:10	University/research	Development of electrocatalysts for PEM fuel cells and related electrochemical devices Jong Hyun Jang, KIST (KR)
09:30		Super critical synthesis of catalyst materials with a nano scale precision Leif Højslet Christensen, Danish Technological Institute (DK)
09:50		PLM fuel cell modeling for water management in cathode catalyst layer Young-Jun Sohn, KIER (KR)
10:10		Theoretical study of key phenomena in high temperature PLM fuel cells (HT-PLM Cs) Hyunchul Ju, Inha University (KR)
10:30	COFFEE	
10:55	Session 6,	Chairs: Jong Hyun Jang (KR), Eivind Skou (DK)
10:55	Industry	Development of High Temperature PLM C stack Tae-Won Song, Samsung Electronics (KR)
11:15		IRD Fuel Cell A/S - Providing Sustainable Power and Heat in Denmark and beyond Mikkel Juul Larsen, IRD Fuel Cells (DK)
11:35		An introduction to the commercialization of Hugreen Power's portable fuel cell systems Shinuang Kang, Hugreen Power (KR)
11:55	LUNCH	
12:55	Session 7,	Chairs: Leif Højslet Christensen (DK), (KR)
12:55	University/research	Modelling and Controlling Fuel Cell Systems using an Adaptive Neuro-Fuzzy Inference System Strategy Søren Juhl Andreassen, Aalborg University (DK)
13:15		Design of Carbon-based Oxygen Reduction Reaction Electrode for Fuel Cell S. I. Woo, KAIST (KR)
13:35		Better understanding HT-PLM durability Lars N. Cleemann, DTU Energy Conversion (DK)
13:55		Nafion membranes with a porous surface Dirk Henkensmeier, KIST (KR)
14:15	COFFEE	
14:40	Session 8,	Chairs: Hyunchul Ju (KR), Lars N. Cleemann (DK)
14:40	University/research	Nanocomposite membranes for auto applications Hee Woo Rhee, Sogang University (KR)
15:00		Crosslinked water soluble polymer based anionic ionomer binders for solid alkaline fuel cells Jin-Soo Park, Sangmyung University (KR)
15:20	Closing	
15:40	End	
15:40	Bustrip to 63 building	
17:00	Observation platform 63 building	
18:00	Dinner in 63 building	



Danish Participants:

<i>Embassy of Denmark, Seoul</i>	<i>page 8 - 9</i>
<i>Aalborg University, Department of Energy Technology</i>	<i>page 10-11</i>
<i>Danish Power Systems</i>	<i>page 12-13</i>
<i>Center for Individual nanoparticle Functionality (CINF) Department of Physics, DTU</i>	<i>page 14-15</i>
<i>Technical University of Denmark, Department of Energy Conversion and Storage (DTU Energy Conversion)</i>	<i>page 16-17</i>
<i>DTU - Thermal Energy section</i>	<i>page 18-19</i>
<i>Energy Technology Development and Demonstration Programe (EUPD)</i>	<i>page 20-21</i>
<i>IRD Fuel Cells A/S</i>	<i>page 22-23</i>
<i>NIAS, Nordic Institute of Asian Studies</i>	<i>page 24-25</i>
<i>University of Southern Denmark</i>	<i>page 26-27</i>
<i>SerEnergy A/S</i>	<i>page 28-29</i>
<i>Danish Technological Institute</i>	<i>page 30-31</i>



Korean Participants:

<i>Chung-Ang University</i>	<i>page 32-33</i>
<i>Eco-Smart Power Lab</i>	<i>page 34-35</i>
<i>Green Technology Center</i>	<i>page 36-37</i>
<i>Hanyang University, Membrane Laboratory</i>	<i>page 38-39</i>
<i>Hugreen Power Inc.</i>	<i>page 40-41</i>
<i>Hyundai Motor Company</i>	<i>page 42-43</i>
<i>KIST, Korea Institute of Science and Technology</i>	<i>page 44-45</i>
<i>KOLON Industries, Inc.</i>	<i>page 46-47</i>
<i>Korea Institute of Energy Research</i>	<i>page 48-49</i>
<i>LG Chem Research Park</i>	<i>page 50-51</i>
<i>NCML, Nano Catalysis & Materials Laboratory</i>	<i>page 52-53</i>
<i>OMS Lab, Incheon National University</i>	<i>page 54-55</i>
<i>Samsung Advanced Institute of Technology</i>	<i>page 56-57</i>
<i>Sangmyung University</i>	<i>page 58-59</i>
<i>Electronic Material Laboratory in Yonsei University</i>	<i>page 60-61</i>



Embassy of Denmark. Seoul

The Embassy of Denmark works towards building trade and cooperation between companies, organizations, authorities and research institutions in Denmark and Korea.

Our services include assisting companies that either wish to develop new business or expand current activities. This is typically done by providing market information/research, by partnering up Danish and Korean companies, by arranging seminars and exhibitions as well as a number of other activities based on specific client requests.

The newly opened Innovation Centre (ICDK), work towards securing knowledge exchange between institutions of higher education and innovative and R&D intensive companies. Examples of specific activities include innovation camps, seminars, planning and implementing fact finding missions and tech scouting.

Finally, the Embassy is working to attract more Korean investments to Denmark. This is done by providing detailed information about framework conditions in Denmark, by highlighting Danish core competencies both in business and academia, but also by providing specific help in relation to company establishment.



The Ambassador giving a speech at the residence



Our staff are all experienced and equipped with a significant network of contacts combined with an in-depth knowledge about the various sectors they cover. Please feel free to contact us if you want to learn more about how we can assist you.



Signing of contracts with high level Government participation



Minister visits



Promotional activities

Embassy of Denmark, Korea

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Aalborg University, Department of Energy Technology

Aalborg University, Department of Energy Technology has an inter-disciplinary fuel cell system research program with about 15 researchers.

The program is centered on fundamental and applied research in fuel cell components, subsystems and complete systems and involves experimental as well as modeling activities.

The technologies cover low temperature as well as high temperature PEM fuel cells and associated fuel processing technologies. Recently low temperature PEM water electrolysis activities were also initiated. During the past 10 years the group has gradually intensified the high temperature PEM research that today represent about half of the activities. In particular the areas of MEA characterization and modeling and various aspects of system design, modeling and control are major focus areas.



The group operates a state-of-the-art laboratory with commercial as well as in-house test stations covering the entire range from single cells to complete stacks.

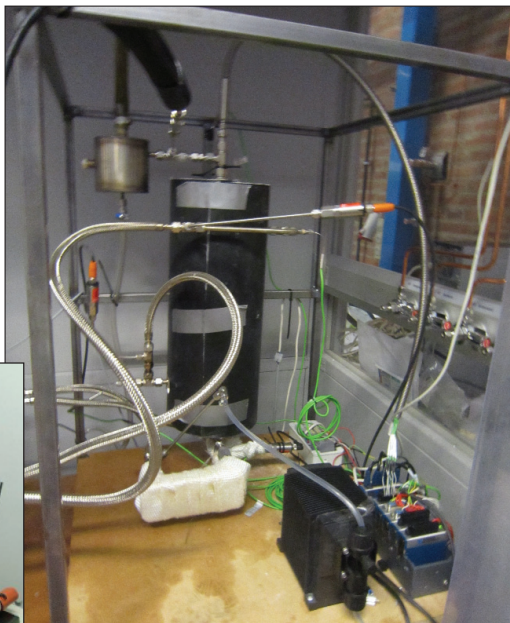
HTPEM stack testing using a Greenlight test station in the fuel cell laboratory at Aalborg University, Denmark



AALBORG UNIVERSITY
DENMARK



*Porosimeter for detailed characterization
of porous transport media*



*Methanol reforming test facility
at Aalborg University*

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Danish Power Systems

Danish Power Systems is developing and manufacturing Membrane Electrode Assemblies (MEAs) for high temperature PEM fuel cells. The MEAs are available in a number of standard sizes.

Danish Power Systems is actively engaging in several partnerships with leading universities and companies worldwide.

This is an important factor for our leading innovation capacity, which is enabling us to deliver continuous improvement of the Dapozol MEAs.

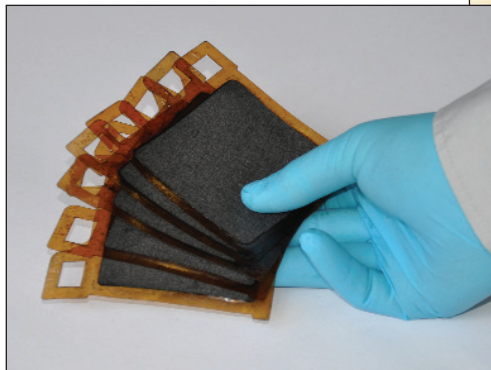
Danish Power Systems has established a production facility and has a number of strategic partnerships in order to bring us closer to the market and therefore understand the individual needs, demands, specifications and requirements of our customers. This facilitates our effort and belief in delivering state of the art and customized technology to the benefit of our customers.

Danish Power Systems has the company IoneerCell as sales agent in Korea.



Part of Danish Power Systems' production facility in Kvistgaard, Denmark

Samples of 50 cm² MEAs



Part of the production facility



Part of the production facility

Danish Power Systems

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Center for Individual nanoparticle Functionality (CINF), Department of Physics, DTU

CINF has a solid basis in experimental surface science and catalysis, focusing on the fundamental interactions taking place at the surface-gas or surface-liquid interface. The ultimate goal is to capitalize on the derived fundamental understanding to design, synthesize, and test new functional materials. These materials can be used in catalysis related to energy production, energy conversion, and environmental protection. Thus the common denominator in our research is the basic surface and reactivity properties of nanoparticles which, allows for a deep insight, whether they are used for heterogeneous catalysis, electrocatalysis and photocatalysis. The center has access to world leading experimental setups see Figure 1.

Our main objective is to educate and create knowledge and develop new materials. One example is to find the optimal size of Pt nanoparticles for ORR see figure 2 or to find entire new alloys that are better than those we know today see figure 3.



Figure 1.
Picture of the experimental hall in building 312. Here most of the UHV and surface science tools are located, while catalyst testing is taking place in Building 307.

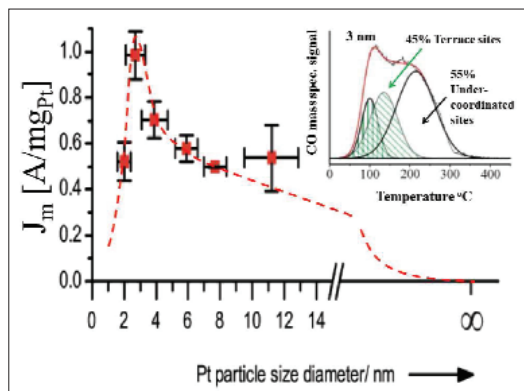


Figure 2 displays the effect of particle size on the mass activity of Platinum nanoparticles in the ORR reaction. The maximum activity occurs at approximately 3 nm, where the fraction of surface sites is dominated by under-coordinated sites. As particle size increases, the fraction of terrace sites increases, leading to a decrease in mass activity. The inset shows the temperature programmed desorption of CO used to distinguish between under-coordinated sites and those on the terraces.

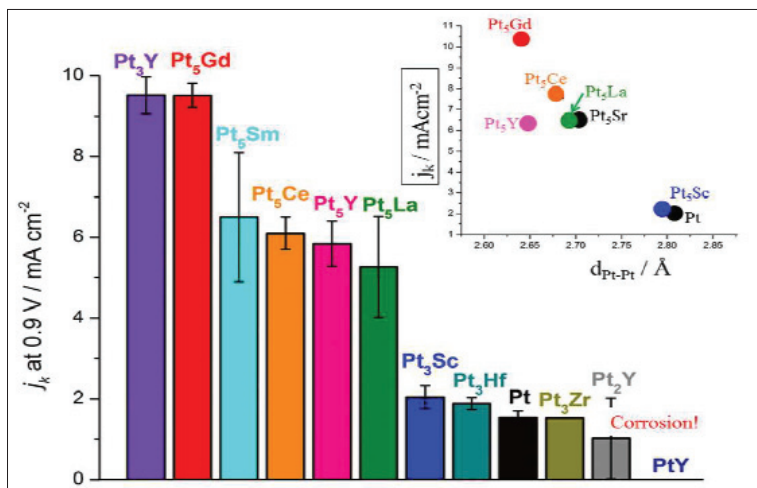


Figure 3. The ORR activity for the alloys tested so far. The Insert shows how it for similar structures depends on the lattice parameter for the alloys

Danish National Research Foundation's Center for Individual Nanoparticle Functionality (CINF)
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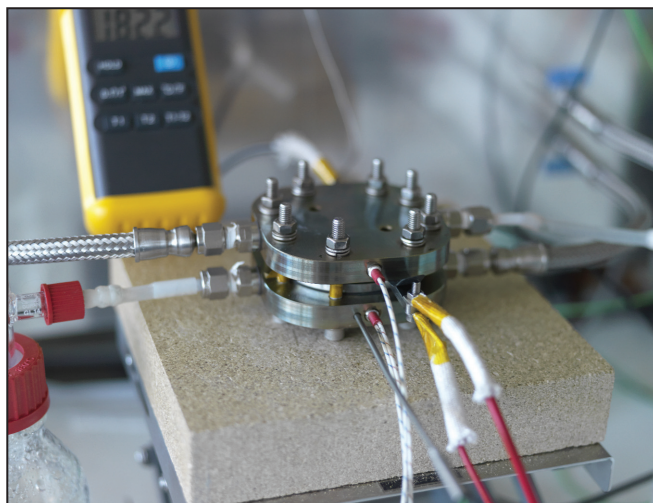
Technical University of Denmark, Department of Energy Conversion and Storage (DTU Energy Conversion)

Research

The research at DTU Energy Conversion focuses on energy technologies for conversion and storage of energy. It spans from fundamental materials investigations at the nanoscale to manufacture and test of components produced by industrially relevant processes. The research builds on strong competences within materials science, synthesis and electrochemistry. Selected technologies are fuel cells (SOFC, PEMFC), electrolyzers (SOEC, PEMFC, AEC), batteries and polymer solar cells,

Section for Proton Conductors

The PEMFC research is carried out at Section for Proton Conductors. The main activity is high temperature PEMFC (HT-PEMFC), i.e. cells operating at temperatures above 140°C. The high temperature provides several advantages including easy integration with a fuel processor. All components including polymer membranes, catalysts and whole cells are being developed in house. The work on HT-PEMFC has led to the development of equivalent PEM steam electrolyzers for operation at elevated temperature. A significant effort is also devoted to alkaline electrolyzers with the aim of reducing cost.

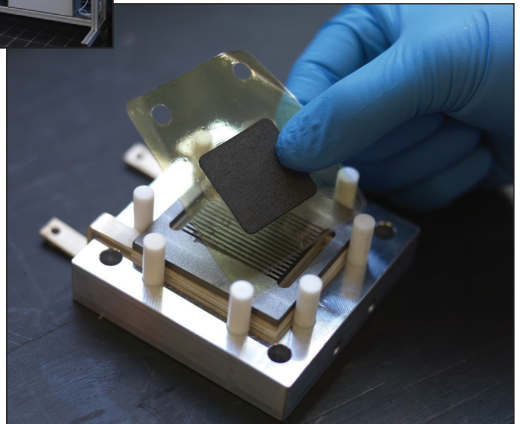


Finally, on a more fundamental level novel inorganic proton conducting materials for temperatures above 200°C and non-noble metal based catalysts are studied.

A test cell with novel proton conducting electrolyte.



*The 2x12 channel
fuel cells durability rig*



*An open test cell with a
HT-PEM fuel cell.*

DTU Energy Conversion

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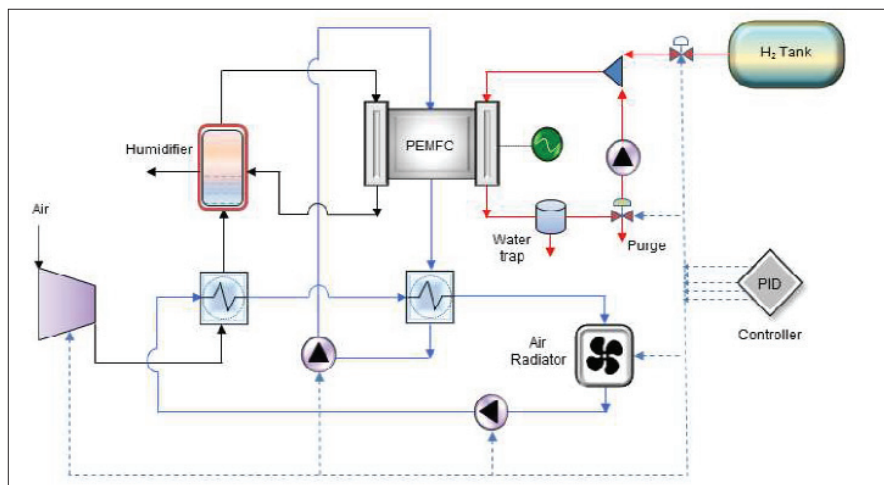
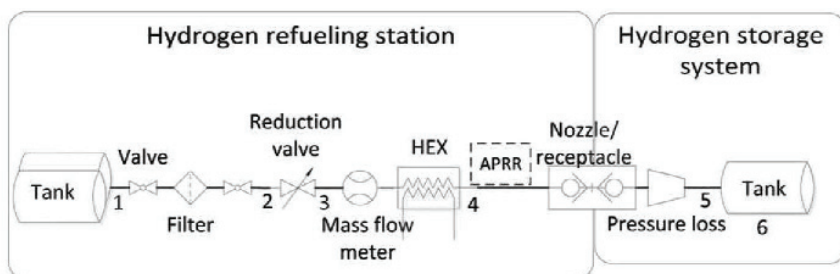
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Jens Oluf Jensen)

Web: www.pro.ecs.dtu.dk

Thermal Energy section at Department of Mechanical Engineering of Technical University of Denmark is working on fuel cell system and hydrogen technology. Different PEM fuel cell system for transport sector has been designed and their dynamic response has been investigated in detail. SOFC based power plants are widely explored fuelled by different fuels such as natural gas, methanol, ethanol, DME, ammonia and syngas from biomass gasification as well as municipal solid waste gasification. Different hydrogen refuelling stations have been suggested and studied in details.

Thermal Energy sections is actively engaging in several partnerships with leading universities and companies. The section has published more than 20 articles in international journals and conferences since 2007.





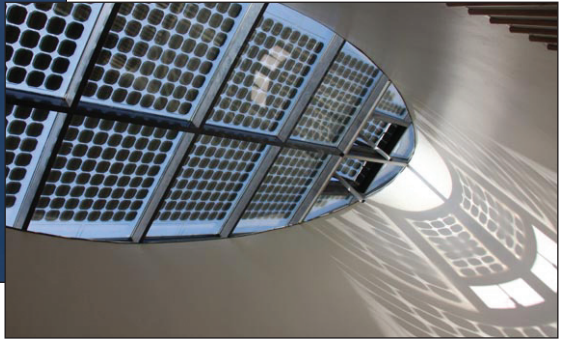
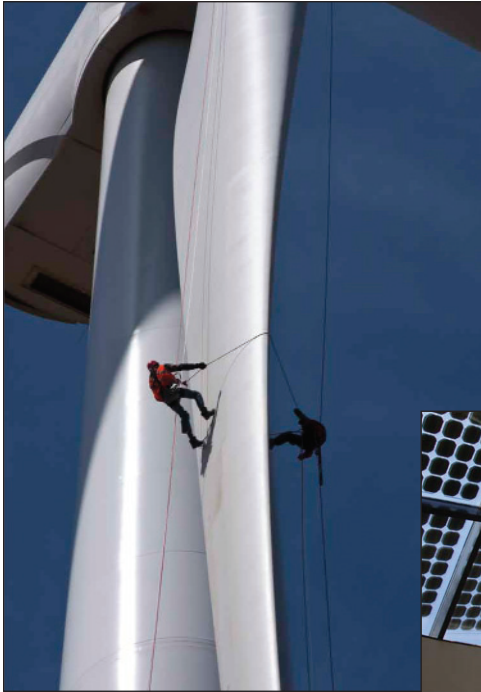
Energy Technology Development and Demonstration Programme (EUDP)

The Energy Technology Development and Demonstration Programme (EUDP) funds development and demonstration of new energy technologies which can contribute to meeting energy political objectives. At the same time, the projects should develop Danish business potential for growth and employment. The program supports in particular the demonstration of new technologies when basic research is completed. All types of new energy technologies can be supported.

EUDP initiated 71 new projects in 2012. The 71 new projects were funded with a total grant of DKK 371.2 million. Of this, 44 are new energy technological development and demonstration projects, while 27 are new collaboration projects under International Energy Agency (IEA). In 2012, the largest funding amount was in 2012 given to hydrogen and fuel cells. The areas receiving the second-largest funding amount are Smart Grid systems and wind power.



A large proportion of the projects focus on developing new technologies which can become central in a future non-fossil energy system supplied with electricity from for example wind turbines and biomass. Technologies concerning 'intelligent electricity consumption' and technologies for storage and conversion of energy are in focus. It is very likely that these projects will be able to provide a valuable contribution to a future without fossil energy and at the same time create economic growth and workplaces.



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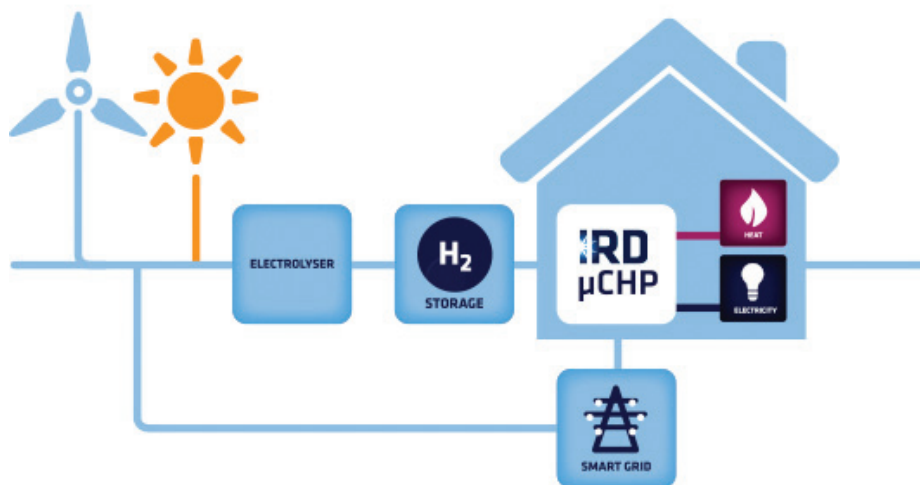


IRD Fuel Cells A/S

IRD Fuel Cells A/S is a high technology company devoted to research, development and production of fuel-cell technology, components and systems.

Through strong competences within electrochemistry and materials science along with electronic and mechanical engineering, IRD has transformed ideas and patents – developed during more than 15 years – into commercial products.

Efforts made in cooperation with international research groups, strategic partners and customers have led to leading technology and products within Polymer Electrolyte Membrane Fuel Cells (PEMFC) for micro-scale combined heat & power (μ CHP) generation, Direct Methanol Fuel Cells (DMFC) for power backup (UPS) and auxiliary power unit (APU) applications, and Flow Plates and Membrane Electrode Assemblies (MEA) for a wide range of fuel-cell types.



Excess renewable energy is converted to hydrogen through electrolysis. The hydrogen is stored in tanks and lead to households through pipes, where IRD's 1.5-kWAC and 1.5-kWth μ CHP unit converts it to 100 % green and renewable energy. Some of the electricity may be distributed through the power grid.



*Hydrogen-fuelled μ CHP unit from IRD.
Nominal power output: 1.5 kWAC.
Nominal heat output: 1.5 kWth.
Combined efficiency: 94 % (of LHV).*



IRD's satellite MEA production facility in Albuquerque, New Mexico.



One of IRD's hydrogen-fuelled 1.5-kWAC and 1.5-kWth μ CHP units installed in a Danish household.

IRD Fuel Cells A/S

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Nordic Institute of Asian Studies

NIAS: Global Outreach, Nordic Value

What is NIAS?

NIAS - the Nordic Institute of Asian Studies - is an academically independent Nordic research and resource center, focusing on modern Asia from a predominantly social sciences perspective. NIAS is an integrated part of the University of Copenhagen with the status of a centre under the Department of Political Science.

Nordic Focus

The study of Asia in the Nordic region is fragmented across many, relatively small, research environments. Therefore collaboration at a regional level is needed to ensure that support, networks and opportunities exist for scholars and students active in Asian studies in the Nordic region. Through the Nordic NIAS Council (NNC), in which leading Nordic universities and research institutions participate, NIAS organizes a well-functioning institutionalized cooperation that strengthens collaboration in the Nordic countries.

More than research

NIAS is more than a research institute. We are also a resource centre containing a wide array of knowledge and skills, and with a broad network of contacts connecting people and institutions with expertise on Asia. Through conferences and workshops, accessible information resources, commentary on current affairs, and contact with media, government and businesses, we constantly seek to broaden knowledge of modern Asia in the Nordic region.

NIAS Press

The institute's autonomous publishing arm, NIAS Press, is a scholarly press specialized in publishing innovative research on modern Asia. The Press focuses mainly on the social sciences and history - particularly research dealing with contemporary Southeast Asia and East Asia - but is open to relevant and focused, quality publications in any field of Asian studies.

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Department of Chemical Engineering, Biotechnology and Environmental Technology, University of Southern Denmark

Fuel cell activities

The energy materials group works on materials and processes associated with electrochemical energy conversion and storage.

In addition to the groups own equipment and expertise a close collaboration is taking place with other groups at the university working with Solid State Nuclear Magnetic Resonance Spectroscopy, surface physics methods like XPS and AES and Raman spectroscopy.

Present fuel cell related research activities:

- Synthesis and characterization of electro-catalysts, catalyst supports and electrolyte materials.
- Synthesis of platinum nanoparticles with a well defined, narrow size distribution.
- Synthesis of catalyst materials via nano templates.
- Electrochemical characterization using rotating ring-disc electrodes as well as coupled electrochemistry and mass spectrometry (EMS).
- Characterization of interactions between electro-catalyst, catalyst support and ionomer binder in electrode-materials for PEM.
- Synthesis and characterization of solid acid electrolytes for fuel cells and electrolyzers working at elevated temperatures.
- Studies of degradation mechanisms and durability of electrode and electrolyte materials for PEM.
- Recovery and reuse of materials from PEM.
- Development of hollow fiber (CMS) modules for separation of hydrogen from other gases.



*University of Southern Denmark.
Main entrance.*

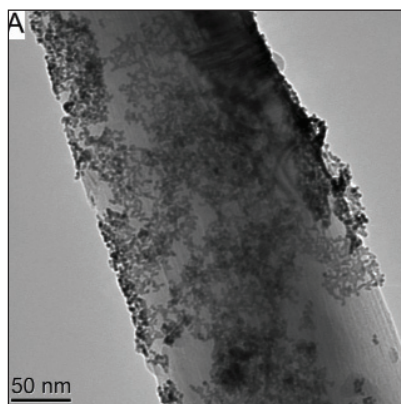


SYDDANSK UNIVERSITET
UNIVERSITY OF SOUTHERN DENMARK

*Loading in glove box
of transfer cell to XPS
or Auger spectroscopy*



*Pt catalyst of narrow
size distribution
on carbon nanofibers*



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SerEnergy A/S

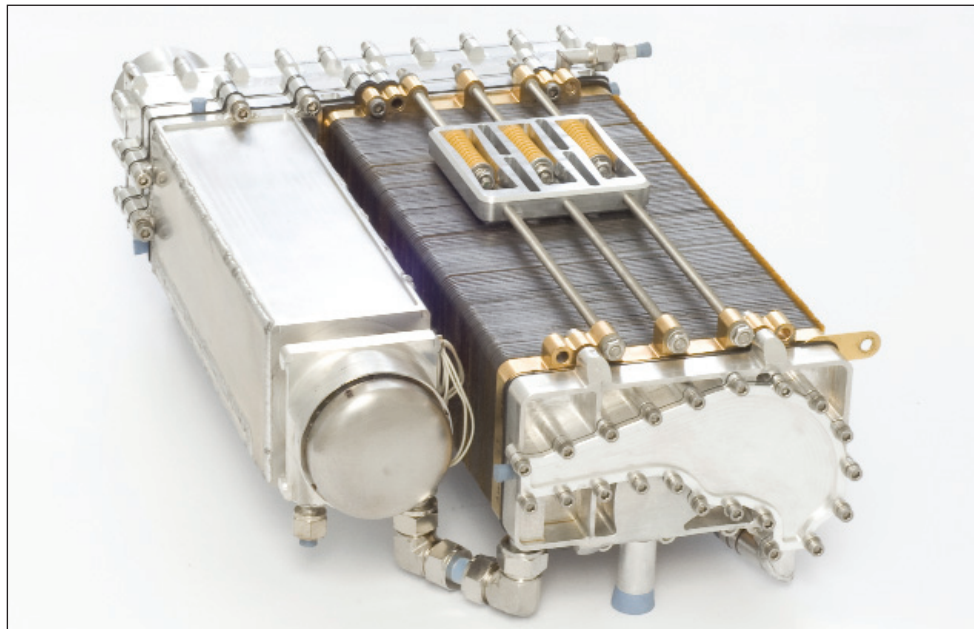
The Company

Serenergy was founded in 2006 by leading researchers at the Institute of Energy Technology at the University of Aalborg in Denmark. Our state-of-the-art Serenus product line is based on newly patented technology developments resulting in highly competitive performance. Our products are used in a broad range of markets and applications.

Our Focus

We design, manufacture and sell fuel cell stacks and fuel cell power modules for system integrators. Serenergy is a leading manufacturer of fuel cell stack modules featuring the HTPEM (High Temperature Polymer Electrolyte Membrane) technology. Our fuel cell modules transform methanol and hydrogen rich gas into electricity.

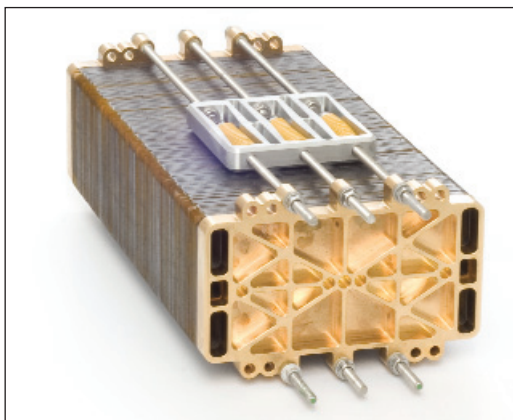
H & Power represent SerEnergy in Korea.



5 kW reformed methanol Fuel cell system



*350 W Reformed
Methanol fuel cell*



*HT PEM liquid cooled
stack – S165L*

SerEnergy A/S

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Danish Technological Institute

The Danish Technological Institute is a non-for-profit organisation approved by the Danish Ministry of Science, Innovation, and Higher Education.

The Institute has served primarily the Danish industry since 1906.

The Institute employ around 1.000 persons of whom 70% are scientists/ engineers many with a Ph.D. curriculum.

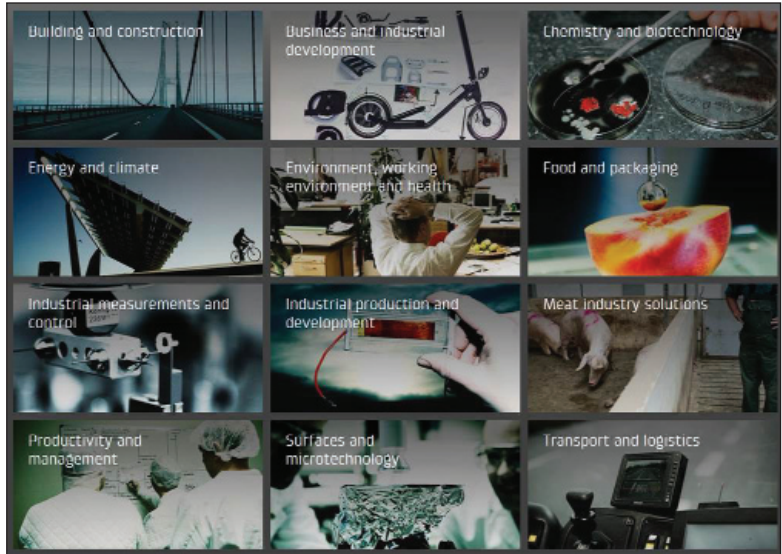
The Institute manage more than 15.000 commercial assignments every year and more than 200 national and international projects carried out in close collaboration with industry and universities.

The Centre for Nano- and Microtechnology is a high tech unit within the Institute employing 30 scientist and technical specialists. The centre is engaged in a great number of projects carried out in an industry/ university partnership collaboration. The centre is managing an outstanding laboratory infrastructure for materials characterisation. The focus of our R&D is the development of nanotechnology based energy systems, e.g. micro fuel cells using our proprietary catalyst.





DANISH TECHNOLOGICAL INSTITUTE



The DTI portfolio of industry/ technology sectors

Danish Technological Institute

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Chung-Ang University

Chung-Ang University is a private institution with 30,000 students and 982 faculty members. It consists of 10 undergraduate colleges and 16 graduate schools. It operates two campuses, in Seoul and Anseong, Korea.

Established in 1918, CAU has endured through the painful course of Korea's modern history, upholding its ideal of "Truth and Justice". Since then, CAU has taken a leading role in nurturing intellectuals of the nation. Respected as leading institution providing quality education, CAU has sped up the pace of innovation in local education.

Fully accredited by the Ministry of Education and Science Technology of Korea, CAU offers a wide range of bachelor's, master's and doctoral programs including a law school, global MBA programs and a medical school. Thanks to these schools' vibrant activities, CAU gained top recognition in the nation from the MEST for the last eight years.

Furthermore, CAU is recognized as the nation's best in the fields of pharmacy, culture and art education. With the help of its schools of art and culture, the university stands at the center of the Korean culture wave, currently sweeping Asia and beyond.

As a major private institution, Chung-Ang University is fully committed to guiding its Korean and international students to envision their life goals and achieve their maximum potential in the increasingly competitive global society (from CAU website: <http://www.cau.ac.kr>).



CAU Seoul
Campus



CAU Campus Facility

Chung-Ang University

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Eco-Smart Power Lab (ESPL)

The ESPL's general research interest is to investigate and develop a new type of energy conversion/storage technology that can conserve our natural resources, have a high-energy efficiency and be environmentally friendly. Presently, the primary research of the ESPL is focused on fuel cells and advanced batteries for vehicle propulsion, stationary power generation, portable electronics, etc.

The ESPL pursues fundamental-oriented and multidisciplinary research, collaborating with many faculty and researchers from academia, national labs, and worldwide companies. The ESPL's broad range of expertise includes thermal-fluid transport, electrochemistry, nano and micro fabrication, chemical kinetics and reacting flows, computational fluid dynamics, and experimental design and testing.

The mission of the ESPL is to advance the fundamental understanding of fuel cell and battery systems, enable industrial engineers to overcome these challenges and accelerate the commercialization of the advanced energy systems. To accomplish the ambitious goal, the ESPL is expanding by establishing state-of-the-art experimental and computational facilities as well as employing individual talents. In addition to active research, the ESPL is heavily utilized for training the next generation of leaders in fuel cell and battery technologies..



ESPL CFD simulation lab in Inha University, Korea



*ESPL Fabrication/test lab in
Inha University, Korea*



*High performance computing
cluster in CFD simulation lab*



Eco-Smart Power Lab

2N 265A (CFD Simulation Lab), 2N279(Fabrication/Test Lab)

Department of Mechanical Engineering, Inha University

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Green Technology Center

Founded in 2012 by the government of the Republic of Korea, Green Technology Center (GTC) is a government affiliated organization based in Seoul. We conduct high-quality research in the field of green technology R&D policies in order to counteract the climate change and the exhaustion of natural resources.

Our vision is to become a think-tank for the transformation of green technology and a bridge-builder for global green technology development.

Our mission is to lead green technology innovation and create new growth engine for the future. GTC, as Korea's gateway for global green technology cooperation, provides practical policy recommendations in three major areas:

- Green Technology R&D Policy Planning
- Global Green Technology Networking & Cooperation
- Green Technology Foresight for Sustainable Future

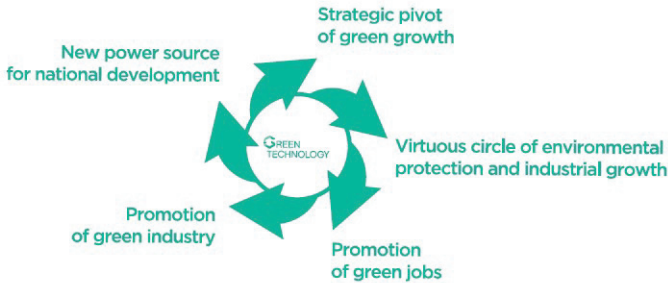
Through our research in these three major areas, GTC plans to support efficient diffusion of green technology and green growth strategies, and we strive to become the most accessible communication channel between the users and suppliers of green technology. We plan to achieve our mission by expanding the scope and depth of our activities, which includes assisting developing countries, networking with developed countries and establishing a system for advanced technology development.

As a global research center, GTC has established strategic partnerships with international organizations such as UNESCAP, UNIDO, UNDP, World Bank, etc., and has participated in various international projects.



*GTC-UNDP
Joint Workshop
on Equitable
Energy Access
(WEEA)*

The importance of Green Technology



Playing a significant role in diffusing Green Technology



*Mekong Development Cooperation
GTCK –GGGI-Vietnam*

Green Technology Center

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Membrane Laboratory (Professor Young Moo Lee) **Department of Energy Engineering, Hanyang University**

Membrane Laboratory(Department of Energy Engineering, Hanyang Univ.) has focused on the development of functionalized polymer materials and versatile membranes for energy conversion and energy harvesting system as well as carbon capture & sequestration.

Various research activities on the newly designed polymer structures and novel membrane fabrication method have been achieved with global industry partners and notable research institutes. For polymer electrolyte membrane fuel cell, our group has studied various types of aromatic hydrocarbon polymers with orderly distributed ion conductive channels in nano-size to improve the electrochemical performances as well as dimensional stabilities.

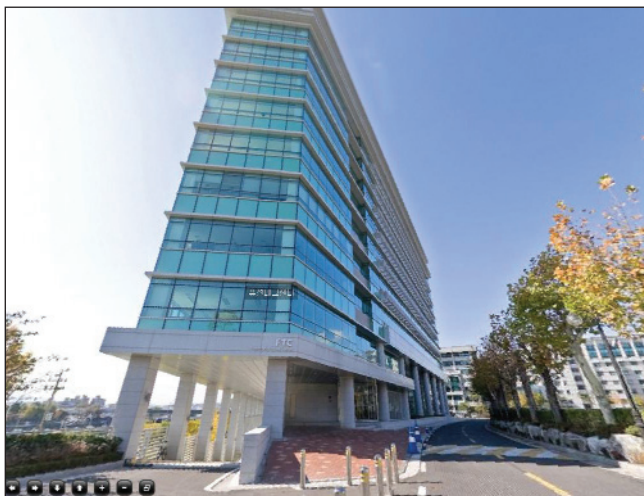
On the other hand, thermally rearranged (TR) polymers, tuned with hour-glass-shaped subnano-sized cavities have been invented and improved in collaboration with international partners (CSIRO, CSIC). TR hollow fibers are also being commercialized with Air Products. The current membrane technology enlarges the membrane application areas toward the energy harvesting membrane technology, high efficient desalination and pre- and post combustion CCS.



*Hanyang
University*



한양대학교
HANYANG UNIVERSITY



Fusion Technology Center

Membrane Laboratory (Professor. Young Moo Lee)

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Fax: (+02) 2291 5982

E-mail: ymlee@hanyang.ac.kr

Web: <http://mbl.hanyang.ac.kr>



Hugreen Power Inc.

Hugreen Power Inc. is a specialized manufacturer leading the industry with its innovative technology in the portable and mobile fuel cell with a capacity ranging from 200W~7KW. All products from Hugreen Power Inc. operated by a liquid fuel-based integrated chemical hydride hydrogen generator which is one of the key technologies are not only excellent and safe in the storage quality with a high hydrogen storage density and easy to handle and operate but also energy-efficient eco-friendly ones.

More than all, we could make it lighter and more compact as the components of the hydrogen generator are all integrated into one.

Differently with existing fossil fuel based power generation systems and other fuel cell systems using reformer, which have the problems of noise, heat, environment and operating time, Hugreen Power uses our utmost efforts for the value realization and commercialization as true future-oriented renewable energy, which can be used diversely such as for motive power sources or power source for all kinds of devices throughout the fields in society from household use up to industrial and military use, stationary or mobile generator, APU, etc.



HP-200FCS (200W Fuel Cell Power System)



Hugreen Power Inc.

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Rep. of Korea
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Fax: +82-32-202-3303,
E-mail: kang@hugreenpower.com
Web: <http://www.hugreenpower.com>



Hyundai Motor Company

Established in 1967, Hyundai Motor Co. has grown into the Hyundai Motor Group, with more than two dozen auto-related subsidiaries and affiliates. Hyundai Motor -- which has six manufacturing bases outside of South Korea including the U.S., China, India, Russia, Turkey and the Czech Republic -- sold 4.06 million vehicles globally in 2011.

Hyundai Motor, which employs over 80,000 worldwide, offers a full line-up of products including small to large passenger vehicles, SUVs and commercial vehicles.

Further information about Hyundai Motor and its products is available at www.hyundai.com.



Hyundai Motor Company
www.hyundai.com



KIST (Korea Institute of Science and Technology) Fuel Cell Research Center

Founded in 1966, KIST is a premier multi disciplinary research institute in Korea. The Fuel Cell Research Center, for the last 24 years, has been actively conducting research and development for fuel cells.

The main objective of the Center is to acquire core competencies in fuel cell technology in order to transfer technologies to domestic companies to establish the fuel cell industry in the near future.

The members of the Center work diligently to develop core technology of fuel cell components to improve performance, to enhance life and to reduce the cost of fuel cell for transportation and distributed power generation. In addition, the Center works to develop technologies related to hydrogen generation and storage for fuel cells and innovative water electrolysis technology.

Besides preparative labs and extensive analytical equipment for ex-situ testing, the Center operates about 20 PEMFC test stands.



KIST Fuel Cell Research Center – PEMFC Test lab

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The PEMFC team in KIST

KIST, Fuel Cell Research Center

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Web: http://eng.kist.re.kr/kist_eng/?sub_num=591



Kolon industries, inc.

Description of business area and product for Danish companies;
Since the first nylon production in Korea in 1957, KOLON Industries, Inc. is developing and manufacturing chemical and materials. Focusing on the four major business divisions, namely, industrial materials, chemical, films/electronic materials, and fashion, the company has become a leader in each industry. The part of membrane in industrial materials, which are used in water treatment and energy devices such as fuel cell.

- **Membrane humidifier and reinforced PEM for fuel cell**
- **Membrane and membrane module for water treatment**

As the change of environment and depletion of natural resources, it is impossible to maintain green growth without the support of eco-friendly materials. KOLON Industries, Inc. leads the material development in the area of waste water treatment and pre-process of sea water desalination. Moreover, by the starting of the fuel cell applications, we have been expanded development for the various areas like fuel cell humidifier and reinforced polymer electrolyte membrane.

Ecomate® : Membrane for fuel cell applications

Membrane Humidifier

Ecomate®-H

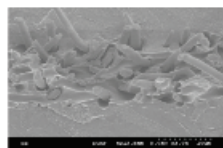


Nanofiber-reinforced membrane

Ecomate®-M



[Nano-web]



Kolon industries, inc.

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Korea

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Korea Institute of Energy Research

The Korea Institute of Energy Research (KIER) is a leading research institute with a focus on energy technology R&D under the Korean Ministry of Science, ICT and Future Planning. The KIER's R&D areas cover almost every form of energy technology except unclear power from renewables, energy efficiency and materials to CO₂ reduction technology such as Carbon Capture and Storage (CCS) and clean fossil fuel technology.

The KIER was established in 1977. For the past 36 years, it has been growing steadily and with the green growth vision of the Korean government, it has recently show rapid development as well as some remarkable results such as the highest records and technology transfers to companies. Currently it has been in forefront of energy technology innovation that can create future jobs and growth, greatly contributing to the energy security of the country.



Solar panel research at the KIER, Korea



Wind power research at Jeju Global Research Center, KIER's research site in Jeju Island

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LG Chem Research Park

Fuel cells using hydrogen as an energy source generate highly efficient electricity and produce only pure water. Many advanced countries are competing in Fuel Cell R&D to create new renewable industries.

Corporate R&D, Future Technology Research Center's goal is to commercialize polymer membrane based MEA (Membrane Electrode Assembly), a key component of automotive fuel cells, household fuel cells, and mobile fuel cells for electronic devices. Utmost efforts are being put into developing the core technology underpinning MEA and related materials.



LG Chem Research Park **Vision**

Introduce Proud Vision of LG Chem Research Park



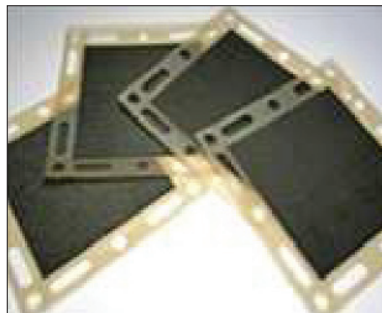
To be a World-Class research Center
Known for **Unique New Technologies**
and **Customer Centered R&D**

Unique New Technology

Technologies superior to competitions in price and function
Intelligent technologies for customer needs
Technologies in tune with customer values

Customer Centered R&D

Provide materials and technologies that support customer's growth
A research institute known and trusted by customers

**LG Chem Research Park**

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Nano Catalysis & Materials Laboratory (NCML)

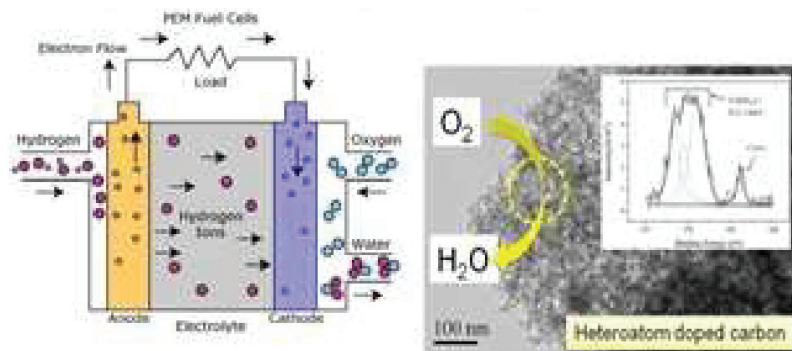
In Nano Catalysis & Materials Laboratory (NCML), research on Fuel cell, artificial photosynthesis, transparent conduction oxide material, and CZTSSe thin film solar cell are on-going. Among those areas, the Fuel Cell is the main research area in NCML.

In fuel cells, especially in polymer electrolyte membrane fuel cell (PEMFC), the electrochemical reaction between hydrogen and oxygen produces water, converting the chemical energy into electrical energy.

Due to the high rate of energy conversion efficiency, high power density, small amount of emission, and low operating temperature, fuel cell is noted as one of the potential alternative energy sources for the future.

However, high price of platinum, which is used as cathode catalyst in PEMFC, hinders the commercialization of PEMFC.

Therefore, NCML is developing and investigating on non-Pt, especially carbon-based cathode catalyst, which can be applied to the real PEMFC system



*Schematic picture of the PEMFC (left)
and the picture of carbon-based cathode catalyst (right)*



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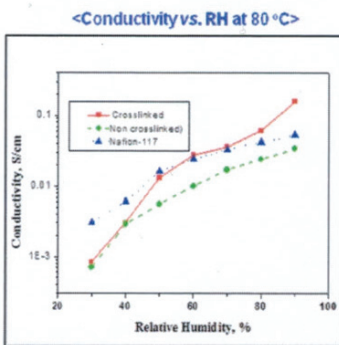
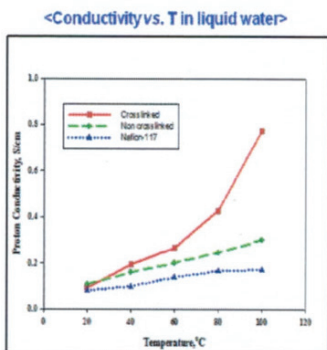
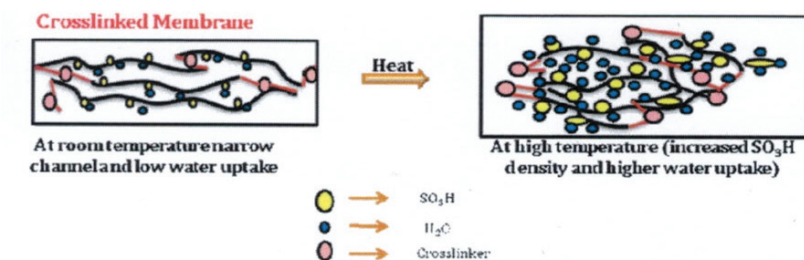


Incheon National University

Our group (OMS Lab) is focussed on the development of novel polymer electrolytes for PEMFC, DMFC and AEMFC.

The key of our research is to use the crosslinking (both chemical and physical) to produce very stable polymer systems. In order to minimize the reduction in ion (proton or hydroxide) conductivity, we have applied 'terminal-crosslinking', 'self-crosslinking' and 'self-aggregating'.

The polymer electrolyte membranes developed by these concepts showed promising results and we continue to develop new polymer electrolytes for fuel cell applications.



Concept of terminal crosslinking (above) and its proton conductivity, together with membrane picture (below)

Organic Material Synthesis Laboratory

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Samsung Advanced Institute of Technology

Samsung Advanced Institute of Technology (SAIT) is developing membrane electrode assemblies (MEAs) and stack for high temperature (HT) PEM fuel cells.

SAIT is Samsung Group's central R&D organization, established in 1987 as the incubator for cutting-edge technologies. SAIT has been focusing on researching core technologies that would create new business opportunities and concentrating on the development of new products. SAIT's research fields consist of future IT, new materials & device, bio, and energy.

The energy research areas include battery (EV/ESS battery and flexible battery) and fuel cell technology (DMFC and HT PEMFC). The high temperature PEMFC research is conducted to develop high performance MEAs and durable stacks for residential fuel cell systems.

SAIT also functions as the Chief Technology Officer (CTO) for the Samsung group including Samsung Electronics, establishing the group's overall R&D outlook and strategy, and also work to enhance the science educational environment in the community since 2000.



Front view of Samsung Advanced Institute of Technology, Yongin-si, Korea



**SAMSUNG ADVANCED
INSTITUTE OF TECHNOLOGY**

Samsung Advanced Institute of Technology

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Sangmyung University

Sangmyung University was first established as Sangmyung Academy for Higher Learning for the Young. The goal was to educate and produce national leaders in 1937 amid Japanese occupation of the Korean Peninsula.

Sooner after, Sangmyung Academy transitioned into Sangmyung Women's College of Education (1965), Sangmyung Women's University (1986), and reborn as Sangmyung University in 1996 by re-establishing itself into a co-educational institution.

The current system is designed to adapt to change and continually expand educational opportunities.



A whole view of Sangmyung University (Cheonan Campus)

**Global
Dynamic**



상명대학교
SANGMYUNG UNIVERSITY

Sangmyung University

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Electronic material laboratory in Yonsei University

Description of research fields and target for EML in Yonsei University; Electronic Material Lab. is developing and manufacturing Membranes for high temperature PEM fuel cells.

Various types of membranes based on polybenzimidazole are synthesized using organic-inorganic hybrid technology.

Development and optimization of novel organic/inorganic hybrid membranes with high proton conductivity and durability.

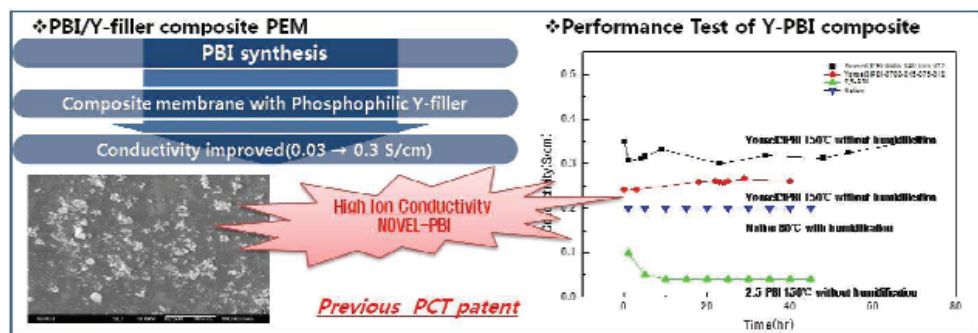
Membrane Electrode Assembly (MEA) for high temperature PEM fuel cells.

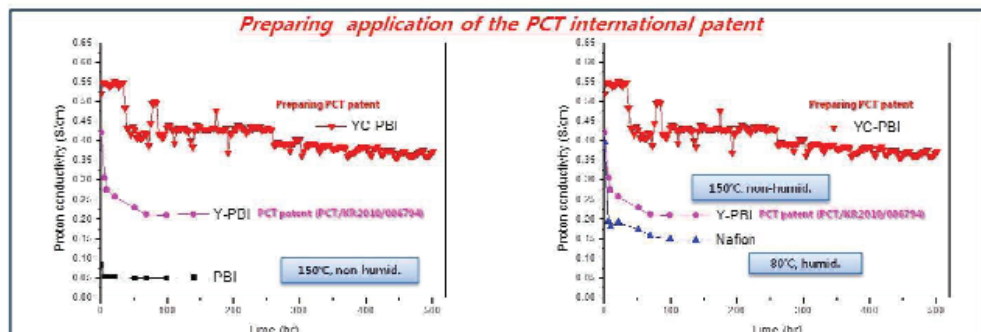
Core technologies to manufacture Proton Exchange Membranes (PEMs) are secured by holding several domestic and foreign patents.

Electronic Material Lab. holds world class performance of PEMs using these key technologies.

Electronic Material Laboratory in Yonsei University has worked and cooperated with several partners which lead the PEM fuel cells research and application field in the world.

Those contribute the enhancement of national competitiveness as well as suggest the solution for global energy problem.





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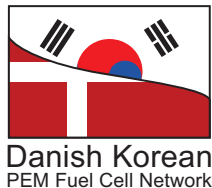
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Notes

Notes

Danish Korean PEM Fuel Cell Workshop

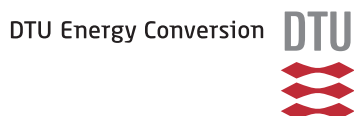


The workshop was financed by a grant from International Network Programme of Danish Agency for Science Technology and Innovation.



Danish Agency for Science
Technology and Innovation
Ministry of Science, Innovation
and Higher Education

It was held 18-19 November 2013 at Korea Institute of Science and Technology in Seoul.



The organizing Committee was:

Jens Oluf Jensen,
DTU Energy Conversion (DK)

Dirk Henkensmeier,
KIST (KR)

Hans Aage Hjuler,
Danish Power Systems (DK)

Jin Soo Park,
Sangmyung University (KR)

Lars N. Cleemann,
DTU Energy Conversion (DK)



With kind support and endorsement from the Embassy of Denmark in Seoul.

