Clean Energy News

USF UNIVERSITY OF SOUTH FLORIDA

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Florida Energy Summit

U.S. dependence on oil, particularly foreign oil, carries significant economic and security risks. There are also a number of other threats to the security of the infrastructure and continuity of the energy supplies, including, catastrophic events such as hurricanes, global terrorism and potential global climate change. Therefore it is important to create a resilient energy infrastructure in Florida and the nation. The federal administration is assessing the nations' vulnerability to a range of outside threats and considering steps needed to develop a more secure energy future — but local and state efforts will also be necessary to ensure a secure and clean energy future.

Creating a resilient energy infrastructure is the goal of the Florida Energy Summit which will bring together leaders from the energy industry, research community and policy makers to prioritize crucial issues and plans of action. The summit is scheduled for May 30, near the USF Tampa campus.

Proactively led by industry leaders, the Summit's objective is "*To establish a forum to discuss actions needed to establish Florida's energy supply and security needs in the 21st century; prioritize R & D and policy needs for the physical security of the energy infrastructure; and continuity of clean energy supplies, including solar energy, biofuels, hydrogen, clean coal technologies, alternative transportation technologies, distributed generation technologies and nuclear power.*"

The Summit will include a select group of leaders from the energy industry, academia and policy makers. Confirmed participants include: TECO Energy, Progress Energy, U.S. Department of Homeland Security, U.S. Department of Energy, ASME ITI, Gulfstream Pipeline, Florida Reliability Coordinating Council, Florida Municipal Power Agency, Florida Department of Transportation, Florida Gas Transmission, Orlando Utilities Commission, Seminole Electric, Lakeland Electric, Florida Department of Environmental Protection, and the Tampa Port Authority.

Sessions will include both national and state perspectives on the power and transportation sectors including conventional and alternative fuels. The breakout meetings will consider the issues brought out in the Plenary Sessions, prioritize the top issues and develop plans of action for R&D and policy needs. The summit will also prioritize the proactive steps the industry will take for a sustainable energy future for Florida

The Summit is being planned by a Steering Committee chaired by John Ramil, President of TECO. The Steering Committee consists of Chuck Black (TECO), Yogi Goswami (USF-CERC), Rich Midula (Seminole Electric), Ed Mierzejewski (USF-CUTR), George Moore (USF-CERC), Steve Reich (USF-CUTR) and Lee Stefanakos (USF-CERC). Actively involved in coordinating and birthing this Summit are George Moore and Yogi Goswami. Moore, who for many years worked within industry at Florida Power Corporation (now Progress Energy), is now a senior researcher at the Clean Energy Research Center (CERC). Goswami, an expert in the field of renewable energy engineering, is the past President of the International Solar Energy Society (ISES) and is currently co-director of CERC.

Clean Energy is Green Energy

Big Ideas.
Big Opportunities.

University of South Florida

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Who is the Clean Energy Research Center?

Lee Stefanakos, Director

As an integral part of the University of South Florida's (USF) expanding international research focus, the Clean Energy Research Center (CERC) investigates critical issues in finding alternative renewable energy solutions for the world.

CERC's mission is to develop, evaluate and promote commercialization of new environmentally clean energy sources and systems. These goals of technological and environmental improvement are within our grasp through multi-disciplinary research, technical and infrastructure development and information transfer.

Vigorous experimentation is underway into hydrogen production and storage, fuel cells, solar energy conversion and conservation and biomass to meet the growing needs of the electric power utilities and transportation sectors.

Our strategy focuses on accelerating the path of scientific innovations to the market by investigating technological barriers impacting the nation's energy goals. The thrust of this strategic direction is born from the interdisciplinary resources at USF.

CERC actively involves researchers from various USF colleges, along with international collaborators. The technological expertise within CERC's research group embraces varied concepts including the existing energy infrastructure, to creating new paradigms in energy production, storage and distribution.

Harnessing the sun for our renewable energy solution.


Yogi Goswami, Co-Director

We are also actively engaged in developing students who will be the future world leaders in advancing energy technology. This is a process of cultivating interdisciplinary engineering applications-oriented research. CERC affiliated faculty offer courses in solar energy, energy conversion and materials science, implementing core course work into energy related examples. These courses are available to students at both the undergraduate and graduate levels through the Departments of Chemical, Electrical and Mechanical Engineering.

Radio Spreads the Word

Spreading the word about renewable energy is as important as the research which furthers the science. The CERC regularly interacts with the community both locally and statewide.

Assistant Director Matt Smith is a frequent guest on Tampa radio station 88.5 WMNF's "Sustainable Living" talk show hosted by Rob Lorei and Jon Butts, discussing current options and trends in clean energy and answering questions from the public. This radio show reaches a diverse audience of up to 5,000 listeners.


Matt Smith, Asst. Director

A first-rate researcher, Smith is able to describe the complicated world of renewable energy engineering to the public with accuracy leavened by his approachable personality.

"I am aware of recent events in the local energy community, and have knowledge of most of the major issues involved with the critical time period we face with energy challenges," Smith explained. "I stay in touch with current tax credits and rebates associated with current alternative energy products," he said.

Tampa Bay listeners phoned in questions during the radio shows. "We had good call-ins during the radio show," Smith said. "I saw the desire from people to become informed and they seemed to want clean energy activities to be a priority in the community," he reflected.

Smith enjoys reaching out to the public. "Its very rewarding and worthwhile to be able to communicate with interested people. This is very important to the community and the public is generally very involved," he explained.

CERC also provides tours of the labs to interested folks including K-12 grades, and takes an active role in Engineering Expos which showcase current research activities to engineering students at the University of South Florida.

The Directors' View

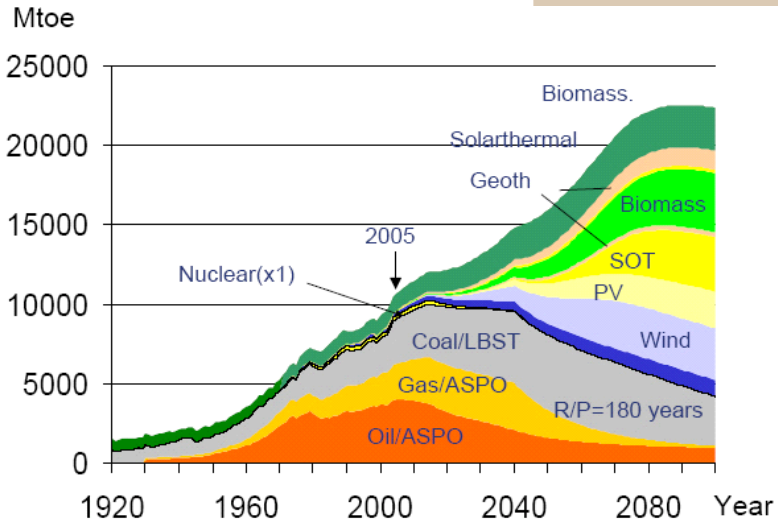
Lee Stefanakos and Yogi Goswami

Global warming is a reality. "Retreating glaciers, stronger hurricanes, hotter summers, thinner polar bears: the ominous harbingers of global warming are driving companies and governments to work toward an unprecedented change in the historical pattern of fossil-fuel use" [Scientific American – Special issue – September 2006].

Almost seven billion tons of carbon is released every year to the atmosphere in the form of carbon dioxide (CO_2) from burning coal, oil and natural gas. Dramatic changes in policies and the patterns of energy use will be required to curtail the exponential increase of CO_2 production.

At present, 53 million barrels a day of petroleum (about 2.23 trillion gallons a day) are used by consumers for transportation. The contribution by the transportation sector to carbon emission and air pollution is staggering.

The above picture becomes even more complicated and disturbing when considering the limited supply of fossil fuels and the dramatic increase in energy consumption by countries like China and India possessing almost two thirds of the earth's population.



Source: LBST Alternative World Energy Outlook 2005

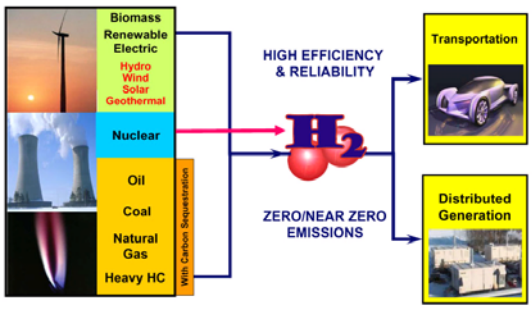
Using less energy is the fastest and least expensive way of reducing carbon emissions and pollution. However, the development of a comprehensive higher efficiency strategy must be accompanied by the use of alternatives based on renewable energies.

Our efforts in the Clean Energy Research Center (CERC) at the University of South Florida are primarily directed in the development of technologies that can use renewable energy for reducing the use of fossil fuels and cleaning of the environment. Florida has no indigenous supply of fossil fuels. However, Florida does have abundant solar and biomass resources. Solar energy can be used for heating, cooling and electrical power, and biofuels and hydrogen provide us an alternative approach to transportation. A combined approach of increasing the solar and biomass resources can mitigate fossil fuel dependency, improve our energy security, improve the environment and provide an opportunity for substantial economic growth. However, achieving this objective will require substantial research effort at CERC and other research institutions.

Global warming is a reality.

CERC researchers and students have been conducting research on energy efficiency, solar thermal power and cooling, thin film photovoltaics, antenna energy conversion, hydrogen production from water and biomass via thermochemical and photoelectrochemical means, hydrogen storage in complex metal hydrides, and fuel cells. In addition research is also being carried out in solar water desalination. CERC is also at the forefront of environmental research in developing advanced photocatalytic processes for clean up of water and air. These research efforts are sponsored by a number of private and government organizations.

Finally, security of our energy supplies, power plants and infrastructure such as power distribution and pipelines has assumed utmost importance in the present age of global terrorism. CERC is planning to hold the first Energy Security Summit for the State of Florida. The energy security topic will be covered in more detail in the next newsletter.

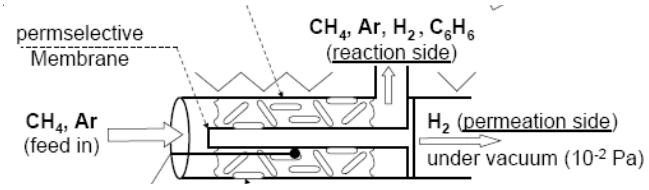


Hydrogen is the simplest, most abundant gas in the atmosphere with the potential to be a great source of energy. Hydrogen's uses are similar to other fuels currently creating heat or power. When hydrogen is used in a fuel cell, it does not emit any air pollution, only pure water and heat. Hydrogen offers the possibility, if harnessed by using clean and safe methods, of moving us toward a cleaner and more secure energy future.

Renewable sources of energy – photovoltaic solar cells, wind, small sustainable hydropower, geothermal and even wave power – are technologies available today that are increasingly being used to produce electricity. That electricity can be used, in a process called electrolysis, to split water into hydrogen and oxygen.

Once produced, the hydrogen can be used to generate electricity directly as a fuel, or stored. Storage is the key to making renewable energy economically viable. That's because when renewable energy is harnessed to produce electricity, the electricity flows immediately. The Green Energy Coalition puts it this way – if the sun isn't shining or the wind isn't blowing, or the water isn't flowing, electricity can't be generated. But, if some of the electricity being generated is used to extract hydrogen from water, which can then be stored for later use, society will have a more continuous supply of power.

Novel Membrane Catalytic Reactor to Produce Hydrogen



Fuel cells are one of the most common ways to convert hydrogen into useful energy. Think of them as energy conversion devices. The fuel cell works similarly to a battery that never goes bad. When hydrogen is added to the fuel cell, electricity is generated and used to power cars, businesses, and homes. Hydrogen and fuel cell technologies have the potential to solve many of the major energy, security and environmental challenges that face America today—dependence on petroleum imports, poor air quality, and greenhouse gas emissions.

Portable, low thermal budget, on-site hydrogen production will be required for fuel cells in a consumer market. Hydrogen production can be accomplished using novel catalytic partial oxidation techniques of various feed-stocks such as biomass, landfill gas and bio-diesel, as well as various petroleum derivatives.


John Wolan

Developing such a novel catalytic membrane reactor to produce hydrogen is being tackled by Chemical Engineering Professor John Wolan. This particular project is especially riveting for Wolan, because of the target of zero greenhouse gas emissions.

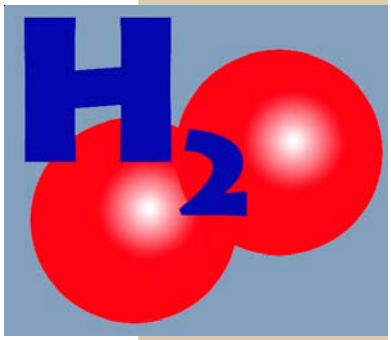
"I was asked by NASA to develop a hydrogen production process using a local feedstock without creating ANY greenhouse gases!" Wolan stressed. "We have developed a novel membrane reactor and catalytic system that converts natural gas to only hydrogen and benzene...and no greenhouse gasses!" he explained.

A NASA grant has supported the research project. Wolan enjoys his work in developing sustainable, environmentally benign energy sources. His research specialties include reacting systems, advanced electronic materials and applications, surface science, and reactor design.

Wolan also serves as a Graduate Advisor. "We all have gifts and talents; I enjoy working with the students on such an important worldwide issue," he said.

Hydrogen Production, Storage and Conversion

Three more hydrogen projects at the CERC focus on production, storage and conversion through fuel cells. These research projects are funded by grants by the U.S. DOE and NASA, which support a team of five researchers. Tackling this multifaceted and difficult task is team research scientist, Dr. Sesha Srinivasan.



Solar Hydrogen: The cleanest way to produce hydrogen is by using sunlight to directly split water into hydrogen and oxygen. Multi-junction cell technology developed by the photovoltaic industry is being used for photo-electrochemical light harvesting systems that generate sufficient voltage to split water and are stable in a water/electrolyte environment.

Improving the efficiency of hydrogen production through photochemical/ photocatalytic processes, and development of novel semiconductor hetero-junction catalysts is vitally important, explained Srinivasan. The Photocatalytic activity of these semiconductor oxide materials requires R+D into synthesis and characterization. Based on these factors, he developed a nanocomposite TiO_2 (Anatase) sensitized with Cadmium Sulfide. These novel nanocomposite heterogeneous photocatalysts will impact the world by developing efficient visible light photocatalysis applications, Srinivasan reflected.

Hydrogen Storage: Currently hydrogen is stored as a high-pressure compressed gas or as a cryogenic liquid. Compressed hydrogen gas tanks will likely be used in early hydrogen-powered vehicles and will need to meet cost and packaging requirements to play a role in the transition to a hydrogen economy. Cost-effective tanks will be required for both solid state or liquid chemical storage and will need to conform to space limitations, as well as effectively dealing with heat management during fueingl.

Dr. Srinivasan is pursuing the development of light weight hydrogen storage systems bearing alkali/alkaline complex materials. The chemical or mechano-chemical formulations of nano-scale transition metal complex hydrides have already been carried out, he explained.

Hydrogen Conversion: All hydrogen conversion technologies are more efficient than that of conventional fossil fuels. Hydrogen, as an energy carrier, can be converted into useful forms of energy for internal combustion engines; combustion with pure oxygen to generate steam; catalytic combustion to generate heat; electrochemical conversion to electricity; and, metal hydride conversions.

U.S. DOE hydrogen storage capacity goals involve designing nano-composite conducting polymer materials with 6 wt.%. "Recently, I proposed a new thermally activated boro-hydride complex system with sorption properties at low temperatures for on-board fuel cell vehicles," Srinivasan described. "I am also developing lithium amides/hydrides for reversible hydrogen storage capacity," he explained.


Sesha Srinivasan

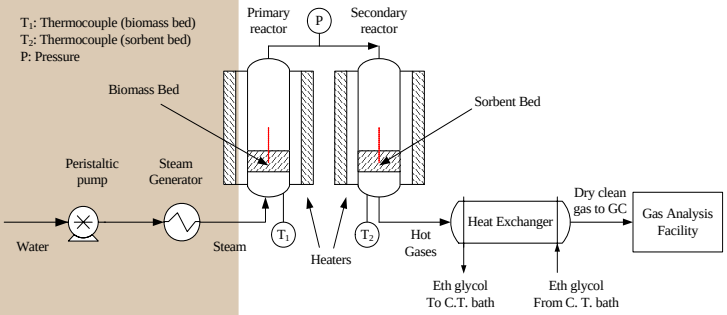
For the fuel cell and hydrogen production project, Srinivasan was involved in the characterization of solid electrolyte materials by differential scanning calorimetry, X-ray diffraction and scanning electron microscopy.

Srinivasan explained that the hydrogen storage materials developed by CERC will have high volumetric and gravimetric hydrogen densities that can address the US DOE and FreedomCAR technical targets. "The results emerging from these material research will definitely impact our energy security and the environment and will lead to a cleaner, sustainable earth," materials scientist Srinivasan reflected.

Green Hydrogen Production from Biomass

Biomass is a renewable resource for producing hydrogen. Thermochemical biomass gasification has been identified as a potential method for producing renewable hydrogen. Recently it has been shown that the addition of small quantities of CO_2-absorbing media during the steam methane reforming (SMR) process has the potential to significantly increase the hydrogen yield. During the process calcium oxide becomes saturated and is converted into calcium carbonate, which is regenerated in a separate reactor. Since biomass gasification is in some ways similar to methane reforming (biomass steam gasification produces a syn gas mixture rich in hydrogen and carbon-monoxide as produced in SMR), the concept can be applied to biomass steam gasification as well.

The present research identifies a novel method of producing renewable hydrogen from resources which are abundantly found in south eastern USA. The agro-industry would be one of the industries that can benefit from this research, in particular, the citrus industry which can br abundantly found in Florida. The biomass feeds used are those commonly found in north Florida and south Georgia such as pine bark and citrus waste.The sorbent enhanced biomass gasification process can also have implications with other industries (such as cement kiln and lime) where the spent sorbent can be effectively utilized.



Doctoral student Madhukar Mahishi determined during his dissertation research that the hydrogen yield at 500°C in the presence of sorbent more than doubled as compared to the no sorbent case. At 600°C, the hydrogen yield increased by almost 48% and the overall gas yield increased by 62%.

Mahishi enjoys his work because it dovetails with his concerns for the developing world. "My research addresses energy issues which is important to developing countries around the world," Mahishi said. "This investigation of renewable hydrogen production is very important from an environmental point of view as most of the hydrogen produced in the US today is mainly from natural gas," he explained.

Energy Systems for Robotic Applications


Kimon Valvavanis

Improving the runtime of their robotic ground vehicles, the Unmanned Systems Lab (UML) is a vibrant hub of research activity. Using the state of the art in power generation and storage, UML aims to significantly increase the endurance of both ground and aerial vehicles for traffic monitoring, border patrol, security and surveillance.

Computer Science engineering professor, Kimon Valavanis is director of the UML, which designs, builds and prototypes small unmanned systems. Of acute interest are control system design and vision, swarm formation control, and networking and communications.

Deducing the reasons for the ATRV-Jrs low endurance problems, the team is currently upgrading its power storage from NiCd batteries to a hybrid system utilizing a DMFC and Li-Ion batteries. Results indicate an increase in runtime for the ATRV-Jr. ground vehicle from an hour to about 10 hours.

"A parallel task of this project is to retrofit the ATRV-Jr with a landing platform that will allow a significant increase in the range of our unmanned helicopters. Currently two different designs are being evaluated and construction of a prototype is scheduled to commence within a month," explained Valavanis.

The UML is an internationally recognized academic and research facility where students are exposed to both basic theoretical and applied research and development. Currently the Unmanned Systems Lab has over 15 graduate students. Funding comes from various sources including the Hillsborough County, the Army Research Lab and SPAWAR.

Photovoltaic Thin Film Technology

Optimizing thin film solar cell structures for maximum performance and reliability is the research focus for Profs. Chris Ferekides and Don Morel. As Ferekides puts it, "We are developing highly efficient and cost effective solar cells for the production of cost competitive electricity."

To do this, they use several deposition systems and other processing and characterization equipment to fabricate and analyze CdTe, CdZnTe, CIGS and CdSe thin film solar cells.


Chris Ferekides

The CERC research has fabricated some of the most efficient thin film solar cells in the world. Its the "making things" that intrigues Ferekides because of the potential for helping the world. "We get to make real working devices that could potentially be the solution to the Earths energy needs," he reflected. Ferekides, a native of Cyprus, is a professor of Electrical Engineering.

This effort is sponsored by the National Renewable Energy Laboratory (NREL) and has achieved world-class results in a competitive field. The project currently supports 3 graduate students.

Photocatalysts for Efficient Operation under Visible and Solar Irradiation

Photocatalytic air disinfection destroys airborne hazardous microorganisms. The biggest danger from biohazards, such as anthrax, arises when they become airborne and spread through building ventilation systems. A photocatalytic disinfection technology developed by Prof. Yogi Goswami effectively provides a solution while drastic measures such as fumigation do not.

Chemical Engineer and Ramil Professor, Goswami stresses that more work needs to be done to ensure the technologys effectiveness against bioterrorism. Reducing the time needed for complete oxidation to a fraction of a second is vital. Incorporated with HEPA and electrostatic air filters, it will provide a complete solution to removing and neutralizing biohazards from indoor air.

A focus of the CERC research team is modifying the electronic properties of semiconductor-based photocatalysis to destroy environmentally hazardous compounds that are found in waste water or in air.

CERC Research Scientist Nikolai Kislov is tackling this project. Focusing a systematic study into thermochemical changes of nanoparticulate Titanium Dioxide (TiO_2) for the destruction of organic compounds in both an aqueous solution and vapor phase, Kislov described.


Nikolai Kislov

Intense study is being directed to several aspects of the link between photocatalytic activity and selectivity of the thermochemically ammonia-treated TiO_2 (its effectiveness in photocatalytic degradation of organic compounds.), and its physical and optical properties.

The aim of the work is to obtain information about tailoring the surface, and the structural and compositional properties of TiO_2 by variation of the thermochemical treatment parameters (ammonia gas flow, furnace temperature, and treatment duration) in order to obtain catalysts with a defined photocatalytic activity and/or selectivity, which can operate effectively under visible and/or solar irradiation.

This research into the next generation of photocatalysts will have a profound impact on the world, Chemical Engineer Kislov reflected, as it has so many applications in purification of water and air contaminated with organic and microbiological contaminants, generating non-polluting power resources and reduction or stabilization of CO_2.

"These are vital areas for urban, economic, environmental and industrial developments not only in the United States but in the whole world," Kislov stressed. "It gives me some kind of the satisfaction that my work is important for the society."

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Honors and Awards

- Ms. Barbara Graham received the 2006-2007 Outstanding Staff Award from the University of South Florida, for her continuing excellence in coordinating all publication services for the Clean Energy Research Center, as well as managing the "Solar Energy" journal, an international renewable energy technical journal, published by the International Solar Energy Society (ISES). She received her award at a ceremony held in May 2007.
- Dr. Sesha Srinivasan received an award for his Invited Talk in the special Genesis Symposium "Planet Earth – Energy and Environment Security" at the 94th Indian Science Congress, Annamalai University, Chidambaram, Tamil Nadu, India, January 03-07, 2007.
- Dr. Yogi Goswami delivered opening Plenary Lectures and was honored at the International Renewable Energy Conference in Chiba, Japan (Oct.2006); the ISES Latin American Regional Congress, Buenos Aires, Argentina (Oct. 2006); and the ISES Arab Regional Solar Energy Congress in the Kingdom of Bahrain (Nov. 2006. He also delivered a Keynote Lecture at the Material Research Society Symposium in Cancun, Mexico (Aug. 2006).
- "*eNewsletter: Systems, Man, and Cybernetics Society*" of the International Electronics and Electrical Engineers Society ran a story about the CERC , June 2006. http://www.ieeesmc.org/Newsletter/June2006/index.php
- Undergraduates Amanda Gannon and Aaron Black won second place at the 2006 Florida American Vacuum Symposium (FLAVS) held at the University of Central Florida in Orlando, for their presentation "Nanocomposite ß-type Zeolite Applications for Polymer Electrolyte Membrane Fuel Cells" based on research done in Dr. John Wolan's applied surface science lab. The win is important to Gannon and Black. "Placing in a conference with 50+ peers validates our work especially since it was the first conference either of us had attended," Gannon reflected.
- Prof. Yogi Goswami was appointed the USF John and Naida Ramil professor of Chemical Engineering during 2005. Previously he had served as director of the Univ. Floridas Solar Energy and Energy Conversion Laboratory for 15 years.

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International Collaboration


Deepali Nimbalkar

CERC regularly hosts research scientists as Fulbright Scholars. During 2006 Dr. Deepali Nimbalkar from Vasantdada Sugar Institute, Pune, Maharashtra, India conducted fundamental research into photocatalytic detoxification of polluted water; such research will aid in the remediation of effluent water from sugar cane processing. During 2007, Dr. Takhir Razykov from the Uzbek Academy of Sciences, Tashkent, Uzbekistan conducted research into thin film photovoltaics as part of continuing studies into cost effective production of high efficiency PV cells for eventual commercialization.


Takhir Razykov

Globalization Speakers Series 2007

The USF Patel Center for Global Solutions and the Clean Energy Research Center co-hosted Dr. Anil K. Rajvanshi as the Patel Globalization Speaker, March 21 on the USF Tampa campus. Rajvanshi spoke on "Energy for the Rural Poor: Challenges for the Global Community". He is the director of the Nimbalkar Agricultural Research Institute (NARI) in Phaltan, Maharashtra, India. For more than 25 years, NARI has applied sophisticated science and technology to solve the problems faced by rural peoples in the areas of energy, water, pollution, and income generation, broadly based on renewable energy in environmentally sound ways.

Books

■ Goswami, D.Y., (Editor-in-Chief), Advances in Solar Energy: An Annual Review of Research and Development. Volume 17, James + James/Earthscan, London, UK (for the American Solar Energy Society), March 2007.

■ Goswami, D.Y. and F. Kreith (Co-Editors-in-Chief): Handbook of Energy Efficiency and Renewable Energy; CRC Press, Boca Raton, FL, April 2007.

Book Chapters

■ Stefanakos, E., Goswami, D.Y., Srinivasan S., and Wolan, J. Hydrogen Energy Chapter in the "Handbook of Environmentally Conscious Power Generation" John Wiley & Sons, April 2007.

■ Wolan, J.T., "Review of Nanoporous Templates for Large Defect Reduction in SiC and GaN, Nanocatalysis, Magnetic Clusters, and Biotechnology", in Catalysis Applications of Porous SiC, CRC Press, Boca Raton, FL, January 2007.

Refereed Journal Articles

■ Fawcett, T.J., Reyes, M., Spetz, A.L., Saddow, S.E. and Wolan, J.T., 2006. "Thermal detection mechanism of SiC based resistive gas sensors," *Applied Physics Letters* 89, 182102.

■ Kim, S., Ghirlanda, S., Adams, C., Bethala, B., Sambandam, S., and Bhansali, S., 2006, "Design, Fabrication and Thermal Characterization of a Magnetocaloric Microcooler," *International Journal of Energy Research*, 31, 6/7, 717-727.

■ Krishnan, S. Bhansali, S., B., Buckle, K. and Stefanakos, E. 2006, "Fabrication and Characterization of Thin-Film Metal-Insulator-Metal Diode for use in Rectenna as Infrared Detector", Materials Research Society Symposium Proc. Vol. 935, p. K03-18.

■ Martin, C., and Goswami, D.Y. 2006, "Effectiveness of Cooling Production with a Combined Power and Cooling Thermodynamic Cycle," *Journal of Applied Thermal Engineering*, 26/5-6, 576-582.

■ Reyes, M., Waits, M., Harvey, S., Shishkin, Y., Geil, B., Wolan, J.T. and S.E. Saddow, 2006, "Growth of 3C-SiC on Si Molds for MEMS Applications," *Materials Science Forum*, Vols. 527-529, pp. 307.

■ Sadrameli, S.M., and Goswami, D.Y., 2007, "Optimum operating conditions for a combined power and cooling thermodynamic cycle" *Applied Energy*, 84, 254-265.

■ Sagüés, A.A., Wolan, J.T., De Fex, A. and Fawcett, T.J., 2006, "Impedance behavior of nanoporous SiC," *Electrochimica Acta*, 51/8-9, 1656-1663.

■ Srinivasan, S. Wade, J. and Stefanakos, E. 2006 "Synthesis and Characterization of Photocatalytic TiO2-$ZnFe_2O_4$ Nanoparticles, Journal of Nanonomaterials, Vol. 2006, Article 45712, pp. 1-4.

■ Srinivasan, S.S., Wade, J., Stefanakos, E.K., and Goswami, D.Y., 2006, "Synergistic effects of sulfation and co-doping on the visible light photocatalysis of TiO_2,"*Journal of Alloys and Compounds*, 424 (1-2), 322-326.

■ Vijayaraghavan, S., and Goswami, D. Y., 2006, "A Combined Power and Cooling Cycle Modified to Improve Resource Utilization Efficiency Using a Distillation Stage." *Energy: The International Journal*, 31/8-9, 1177-1196.

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CERC is already ranked among the nations elite research centers and with every year we continue to improve. Your financial contributions supplement state and grant funding, and make an enormous difference in our efforts to further renewable energy research and improve our infrastructure. All gifts are tax deductible. If you have any gift/tax questions please contact Edward Kominowski, Director of the USF's College of Engineering Development Office at (813) 974-9896. We hope that you will help the CERC and in so doing, aid the USA's transition to a renewable energy future. Thank you for your generous contribution to the USF CERC!

Lee Stefanakos and Yogi Goswami, Directors, CERC

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