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RESEARCH PROJECTS

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ADVANCED ENERGY™

Research and Technology Center

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PROGRAMS AND PROJECTS AT THE ADVANCED ENERGY CENTER™

New York is the fourth largest consumer of electricity among the fifty states and has the second highest energy rates. Developing solutions to cost and supply problems of this magnitude will not only serve the needs of our state but our nation as well. These goals could be reached by increasing supply while reducing dependence on volatile and foreign sources of fossil fuels and creating new technology products that will enter the stream of global commerce and produce economic returns. Today, the rapidly increasing demand from the growing economic powerhouses in South Asia and the Far East coupled with the negative impact of fossil fuels on global climate have pushed energy R&D to the forefront. It is difficult, however, for the industrial energy sector to undertake high-risk, large-scale research due to its thin profit margin and aggressive competition. The Advanced Energy Center™, which is located at Stony Brook University (SBU) and serves a number of institutions including Brookhaven National Laboratory (BNL), City University of New York, SUNY Farmingdale, SUNY Maritime, NYU-Polytechnic University, Rensselaer Polytechnic Institute (RPI), Syracuse University, CCNY, and the New York Institute of Technology (among others), represents a unique opportunity to take a national lead in the development of clean technology, alternative and renewable energy technologies, as well as energy conservation. Investigators at Stony Brook and BNL have embarked on cutting edge research across a broad spectrum of these new opportunities with the theme of "reliable, affordable, and environmentally sound energy for America's future. This publication describes currently funded research programs and projects on smart grid and hydrogen fuel energy for America's future, batteries and fuel storage, photovoltaic cells, nanotechnology based catalysis, improved and highly efficient combustion processes, efficiencies of conventional energy, monitoring of gases and pollutants, energy policy, advanced energy efficient transportation and other energy-related programs.

As diverse as these efforts are, an overarching theme is the application of nanoscience and nanotechnology to overcome critical barriers. New properties being discovered in familiar materials present many scientific questions, but they also offer the promise of new, more efficient and cost-effective solutions. Advanced Energy Center™ projects involve new generations of students, imbuing them with the knowledge, skills, and awareness of the broader societal implications and economics of energy research and supplies the growing national demand for energy-centric science and engineering graduates. SBU is listed among the top 150 universities in the world and has among its faculty recipients of both the National Medal of Science and the National Medal of Innovation and Technology. It leads the 65 campuses SUNY system in earning competitively-awarded federal research funds and is the origin of the only drugs produced by any SUNY campus that have been approved by the FDA. Brookhaven National Laboratory has a history of outstanding scientific achievement that spans more than six decades, and led to seven Nobel Prizes. Its leadership role is achieved by positioning the Lab's user facilities: the National Synchrotron Light Source II (NSLS-II), Relativistic Heavy Ion Collider (RHIC), and the Center for Functional Nanomaterials (CFN) - in continued leadership positions working in teams with universities and industries. Over the last five years, SBU and BNL have been the SUNY leader in technology transfer, whether measured by licensing fees, invention disclosures, issued patents, or executed licenses. The campuses have a "cradle to Fortune 500" suite of economic development programs, from R&D collaboration to the nurturing of new enterprises in its incubator facilities. The projects described here are a modest representation of the depth and breadth of our commitment to the research disciplines that bear on energy research. Much more needs to be done and our faculty colleagues are rising to these challenges. We invite you to join us!

Dr. Yacov Shamash
Vice President for Economic Development
Dean, College of Engineering
and Applied Sciences
Stony Brook University



Dr. David O. Conover
Vice President for Research
Stony Brook University



Dr. Doon Gibbs
Laboratory Director
Brookhaven National Laboratory



THE ADVANCED ENERGY CENTER™

The **Advanced Energy Center™** (aertc.org) engages with energy-based institutes, laboratories, and programs throughout the country. Our LEED platinum facility at the Stony Brook Research and Development Park supports eight major research and training centers: Advanced Energy Training Institute (AETI), Center for BioEnergy Research and Development (CBERD), Center for Emergent Superconductivity (CES), Center for Mesoscale Transport Properties (m2M), NYSERDA Clean Energy Business Incubation Program (CEBIP), New York Energy Policy Institute (NYEPI), New York State Smart Grid Consortium (NYSSGC), and the Thermomechanical & Imaging Nanoscale Characterization (ThINC). Each of these centers harnesses an expert team of researchers, educators and investigators dedicated to pursuing advanced energy solutions. As the founding organization of the New York State Smart Grid Consortium (NYSSGC), we also work closely with the NYSSGC in bringing together business and government leaders, policy makers and researchers in developing innovative programs to deploy smart-grid technology.

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ADVANCED ENERGY™

TRAINING INSTITUTE

AT STONY BROOK UNIVERSITY



Ms. Patricia Malone

Stony Brook University, Center for Corporate Education (CCE), brings its expertise in professional and industry certification to the Advanced Energy Training Institute (AETI) which includes new and innovative programs in energy and sustainability, ranging from sustainable project and business management skills to green building, energy efficiency, power and smart power. Working with core partners, such as the U.S. Green Building Council (USGBC, USGBC-LI), and the Advanced Energy Center partners including NYSERDA, PSEG, NYPA, National Grid, IBM and others, the Advanced Energy Training Institute is identifying new credentialing venues, linking and clustering certification programs, conducting focus groups and engaging state-wide agencies and partners to create a platform for honest credential brokering in sustainability and smart energy.

COURSE SAMPLING

LEED TRAINING

Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), provides a suite of standards for environmentally sustainable construction. LEED Certification is the nationally accepted benchmark for the design, construction and operation of high performance buildings.

LEED ACCREDITATION (GA & AP)

LEED Green Associate (GA) Study Group course prepares participants for the rigors of the LEED GA Exam. LEED GA is the first step in becoming a LEED Accredited Professional (AP). LEED AP Study Group course is also offered.

ASSOCIATION OF ENERGY ENGINEERS (AEE)

CERTIFIED ENERGY MANAGER (CEM)

AND CERTIFIED ENERGY AUDITOR (CEA)

AETI has partnered with NYSERDA to offer CEM and CEA exam preparation training both in New York City at the Manhattan Campus and on Long Island.

AEE Certified Energy Manager

This special 5-day seminar provides an in-depth, comprehensive learning and problem-solving forum for those who want a broader understanding of the latest energy cost reduction techniques and strategies. The program begins by examining the basic fundamentals within all key areas of energy management. From there, the instructors systematically move to a "working level knowledge of the specific principles and techniques needed to really get the job done. The participant gains the knowledge and confidence it takes to effectively apply state-of-the-art principles of energy management, and to achieve control over energy costs in their organization(s) — whether they are responsible for managing a single facility or developing an energy management program for multiple corporate facilities, government buildings, etc. AEE's most requested program, this seminar has been completed by thousands of professionals since its inception in 1994.

CORE PARTNER

AETI Executive Director:

Ms. Patricia Malone

Lead: Stony Brook University

AEE Certified Energy Auditor

This focused, fast-paced 3-day instructional program is designed both to expand the student's knowledge in the energy auditing field, and to serve as a preparatory vehicle for the examination required to achieve AEE's Certified Energy Auditor (CEA) credential. Participants gain the fundamental knowledge needed to evaluate how energy is being used in a facility, and to identify where consumption can be reduced, covering useful calculation methods and practical examples. The instructor will emphasize effective auditing basics while putting them in the context of the "big picture and the bottom line. The CEA examination will be administered on the morning of the day following the seminar – to all qualified participants. Additional AEE workshops include:

- Certified Water Efficiency Professional (CWEP)
- Energy Efficiency Practitioner (EEP)

Smart Grid Workshops

The smart grid promises to increase the efficiency of today's electric system and save billions of kilowatt-hours each year. The Smart Grid applies information technology, tools and techniques so the grid runs more efficiently. The current electric grid is inefficient for meeting today's demands. When customers know how much energy they use, usage will reduce. Today's demands on energy created the need for alternative solutions to our electric system which is over a century old. Upgrades are necessary to traditional power plants ~ Smart Grid will increase energy efficiency in a smart, lower-carbon way!

- Security Issues in the Smart Grid
- Educate & Incentivize Consumers to Save Energy
- Smart Grid Modeling
- Wireless Networking for Smart Grid
- Smart Grid Optimization - How The Grid Becomes Smart
- Visualization of Smart Meter Data
- Business Opportunities in Smart Grid Security
- Wireless Networking for the Smart Grid

NYSERDA Small Commercial Energy Auditor Training

Course materials in final review, coming soon.

Stony Brook University Funded

CONTACT INFORMATION

Ms. Patricia Malone
AETI Executive Director
Stony Brook University
Email: sbucet@stonybrook.edu
www.stonybrook.edu/cet

PARTNERS

The image contains a grid of logos for various partners. Row 1: Advanced Energy Training Institute (Stony Brook University), Research and Technology Center (Stony Brook University). Row 2: Project Management Institute, Center for Corporate Education (Stony Brook University). Row 3: NYSERDA (Energy. Innovation. Solutions.), NYU Stern MIBA. Row 4: New York Power Authority, PSEG (We make things work for you.). Row 5: Syracuse COE (Center of Excellence), Center of Excellence (Wireless and Information Technology, Stony Brook University). Row 6: University at Buffalo (The State University of New York Millard Fillmore College), 35 Years of Achievement AEE.



Center for BioEnergy Research and Development



Dr. Devinder Mahajan

The Center for BioEnergy Research and Development's (CBERD) mission is to conduct collaborative research focused on delivering technology solutions that enable widespread commercialization of biofuels and bi-products and to assist government and industry in achieving the national priority of augmenting our petroleum-based economy with renewable energy, chemicals and biomaterials. We are a multi-Industry/University Cooperative Research Center (I/UCRC) for Bioenergy Research and Development (CBERD).

The center comprises five universities, and is focused on making transformative discoveries to enable the lignocellulosic fats and oil based bio-industries meet the challenges set forth by the US President, federal and state agencies and the American public. Research is highly consistent with federal agency roadmaps. Our vision is to be a vibrant research community and a lead contributor of science and technology to meet the nation's bioenergy goals. We will achieve this vision by setting forward thinking goals, achieving excellence in collaborative research, attracting best in-class researchers, engaging active participation from industrial partners, nurturing an environment of innovation and cooperation, producing highly qualified professionals at the baccalaureate, masters, and doctoral levels, and excel in technology transfer.

CBERD holds two Industrial Advisory Board (IAB) meetings each year with sponsor industries that guide research in their areas of need. All sponsoring industries are members of the IAB. Research projects involve members of the faculty of each participating university, and graduate students at the master's and doctoral level. Collaborative research is leveraged through the I/UCRC concept, which has long-standing success with companies and industries throughout the world. CBERD is supported by the National Science Foundation (NSF), and member industries. NSF evaluators monitor all center activities and regularly attend the IAB meetings. Currently, there are seven research foci in CBERD. These areas are dynamic in that they change from time to time depending upon the research interests of our supporting industries, the Industrial Advisory Board, CBERD's Strategic Plan and CBERD's Research Roadmap.

Focus areas are:

- 1) Feedstock agronomy and supply
- 2) Feedstock breeding and genomics
- 3) Bioprocessing microbes and enzymes
- 4) Biomass processing
- 5) New platform technologies
- 6) Modeling and Process lifecycle analysis
- 7) End-use and product development

CORE INSTITUTIONS

CBERD Director: Dr. Duane Abata

Lead: South Dakota School of Mines

Local: Stony Brook University

Site Director: Dr. Devinder Mahajan

FRAMEWORK AND STRUCTURE



Funded by National Science Foundation (NSF) and Membership Partners



CONTACT INFORMATION

Dr. Devinder Mahajan
NSF-CBERD Site Director
Jefferson Science Fellow, U.S. Department of State
Stony Brook University
Email: Devinder.Mahajan@stonybrook.edu
www.aerc.org/cberd

CES

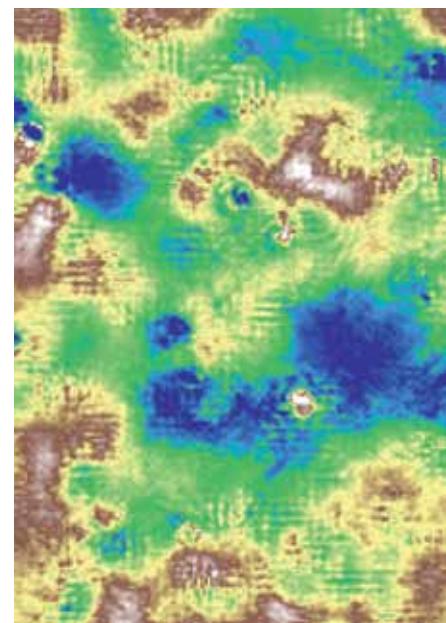
Center for Emergent Superconductivity



Dr. Peter D. Johnson

As U.S. electrical energy consumption continues to grow, the nation's electrical power transmission grid faces fundamental structural challenges of capacity, reliability and efficiency if it is to meet the needs of the 21st century. Electricity demand will grow by 50% in the U.S. and 100% globally by 2030, with nearly all of that growth in cities and suburbs where the overhead power lines and underground cables are nearly saturated. Power delivery and control solutions based on superconductors can solve these crises with demonstrated higher current carrying capacities over conventional cables, self-healing current limiting capabilities and substantial increases in efficiency. However, fundamental material challenges remain that must be addressed in order for superconductivity to have a broad impact on the electrical grid.

The objective of the Center for Emergent Superconductivity (CES) – an Energy Frontier Research Center funded by the U.S. Department of Energy Office of Basic Energy Sciences – is to explore fundamental research issues which will overcome key barriers leading to the viable application of high temperature/high current superconductivity by enabling the design of superconducting materials with optimal physical and critical properties which facilitate a superconducting power grid as soon as feasible in the 21th century. Thus, our most profound challenge is to understand the fundamental mechanisms of high-temperature and high-current superconductivity sufficiently to direct discovery of new or improved families of materials with higher critical temperatures and currents.



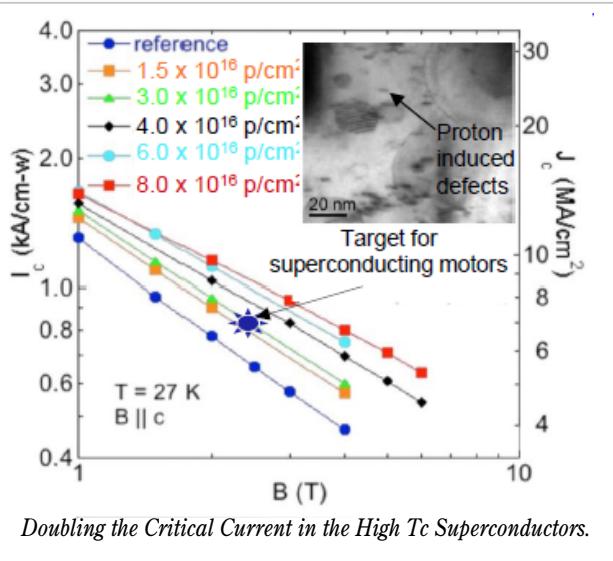
An image of the interference pattern made by wave-like electron pairs in a high-temperature, iron-based superconductor as measured using a phase-sensitive scanning tunneling microscope.

CORE INSTITUTION

Brookhaven National Laboratory

Executive Director:

Dr. Peter D. Johnson



The Center brings together 16 PIs with strong records of accomplishment and demonstrated records of collaboration from three world leading research institutions in correlated electron superconductivity. The latter include Brookhaven National Laboratory, Argonne National Laboratory and the University of Illinois at Urbana-Champaign. The Director of the Center is Dr. Peter D. Johnson, Chair of the Condensed Matter Physics & Materials Science Department at Brookhaven National Laboratory, and a Fellow of the American Association for the Advancement of Science. Through their Center interactions, the PIs pursue three grand challenges: finding new strongly correlated superconducting materials, understanding the mechanisms leading to strong correlation and high temperature superconductivity, and controlling vortex matter to raise the current carrying performance of superconductors.

Funded by the Department of Energy (DOE)



PARTNERS

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Corporate Education
and Training

CONTACT INFORMATION

Dr. Peter D. Johnson
CES Executive Director
Brookhaven National Laboratory
Email: pdj@bnl.gov
www.aertc/ces



Dr. Esther Takeuchi



Dr. Amy Marschilok

Center for Mesoscale Transport Properties (m2M): a DOE Energy Frontier Research Center. At its essence, energy is the sum of heat and work: $\Delta E = q + w$. As such, the ultimate goal for any energy storage system is to maximize useful work (w) and minimize the generation of waste heat (q). During the operation of an energy storage system, ions and electrons are transported over multiple size domains where the sum of these processes leads to complex physics. Resistance evolves over time due to phase changes in the solids and changes in the composition and structure of the interfaces. These complicating factors must be considered to derive the full panoply of information needed for rational design and predictive modeling of materials useful in energy storage systems. While inefficiency can be approached at the macro level, emphasizing bulk parameters and bulk methods cannot fully interrogate or address the inherent heterogeneity of ion and electron flux contributing to the local resistance within an electrode and at the interfaces. In order to develop the capability to predict and ultimately control energy storage systems, these inefficiencies must be understood not just as a bulk property (heat), but rather as localized resistance at the molecular to mesoscale (m2M) levels.

The mission of the Center is to understand and provide control of transport properties in complex battery systems with respect to multiple length scales, from molecular to mesoscale (m2M); to minimize heat and maximize work of electrical energy storage devices. The goal of the m2M Center is to enable deliberate design of materials and components to achieve higher performing, longer life, and safer energy storage systems through acquisition of new fundamental knowledge about ion and electron transport and electron transfer properties of energy relevant materials, over multiple length scales, across interfaces and over time. The expected research outcomes are that the Center will provide the conceptual approaches to predict materials properties, processing outcomes, and functional characteristics which determine conduction and electron transfer properties, including the complexities of interfaces and time. The information gained will enable design of materials and systems to bridge the gap between theoretical energy content and functional energy delivery.

CORE INSTITUTIONS

m2M Director:

Dr. Esther Takeuchi

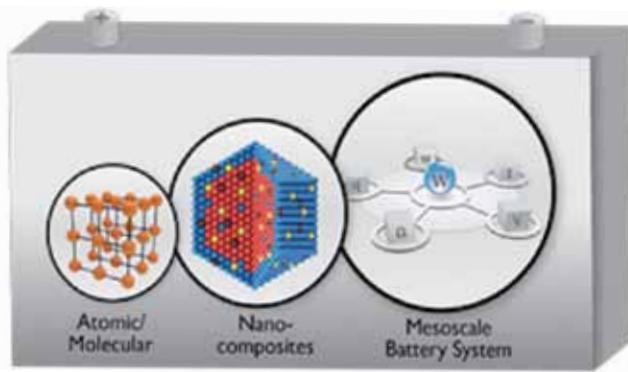
SUNY Distinguished Professor

Materials Science and Engineering, Chemistry

Stony Brook University

Chief Scientist, Global and Regional Solutions

Brookhaven National Laboratory



Funded by the Department of Energy (DOE).
New York State Energy Research and Development Authority (NYSERDA)
Empire State Development's Division of Science, Technology and Innovation (NYSTAR)

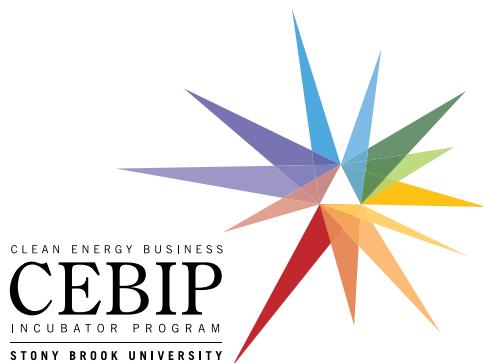
PARTNERS



CONTACT INFORMATION

Dr. Esther Takeuchi
m2m EFRC Director
Stony Brook University
Email: esther.takeuchi@stonybrook.edu

Dr. Amy Marschilok
m2m Center Operations Officer
Stony Brook University
Email: amy.marschilok@stonybrook.edu



Dr. Anil Dhundale



Bryan Berry

Photo by Jeanne Neville



David Hamilton

CORE INSTITUTION

CEBIP Executive Director:

Dr. Anil Dhundale

Lead Institution:

Stony Brook University

Project Manager, Clean Energy

Research and Market Development:

Bryan Berry

NYSERDA

The Clean Energy Business Incubator Program (CEBIP) provides assistance and resources for developers of renewable and clean energy technologies. By mentoring entrepreneurs CEBIP helps them establish successful enterprises to bring their technologies to market. Bringing an innovation to market can be a difficult process requiring technical and business guidance, successful acquisition of funding, and continuing to retain a competitive advantage.

CEBIP's goal is to incubate "green technologies by helping to develop and commercialize them, and to create and sustain growth companies. CEBIP's aim is the creation of high-paying cleantech jobs and industry within New York State that addresses current and future clean energy needs. CEBIP seeks to address many key needs of an early-stage, energy-based technology business, which is especially critical in today's rapidly-changing marketplace. We have assembled an unsurpassed team of partners and access to unparalleled resources to maximize prospects of startups and new business ventures.

The problem of energy cost and supply is the pre-eminent economic challenge for New York State. As the fourth greatest energy user among the fifty states, with the second highest electricity costs, New York State has a double incentive to address this problem. New York State's net consumption is estimated to cost \$60 billion dollars, or 6.6% of the gross state product, and clean energy solutions hold promise for state-based companies. Solutions must critically lower the cost of energy production in the state, and also become products that will enter the worldwide stream of commerce and bring financial rewards, thereby providing good jobs for New Yorkers and tax revenues for the state.

Enormous investments in basic research at Long Island's research institutes will continue to yield early stage technologies that need feasibility testing, decisions on how and when to enter the commercial development pathway, and securing financing. CEBIP has assembled an unsurpassed

team of partners to maximize prospects of start-ups and young ventures augmented by our participation in the Clean Energy Innovation Collaborative with a single point of continuing contact for clients to call on these resources as needed.

CEBIP has brought some of Long Island's leading industry experts together to provide guidance and direction to our clients. The CEBIP Advisory Board is comprised of business leaders and clean energy experts that have real-world experience and can offer invaluable advice. The CEBIP Management Team, with extensive industry knowledge and access to a wealth of resources, is an excellent source point for the clean energy entrepreneur. In addition, CEBIP can tap into the invaluable knowledge and experience of faculty and staff both at Stony Brook University and Brookhaven National Laboratory. We also have the capability of accessing the NYSERDA funded Entrepreneurs in Residence Initiative, which can bring like-minded individuals together for brainstorming and networking.

CEBIP has access to the vast professional services and technological resources that Long Island has to offer. The Small Business Development Center at Stony Brook, which is one of twenty-three campus-based regional Small Business Development Centers within New York State, brings together the resources of the University, the private sector and government at all levels to assist entrepreneurs, business and industry in the solution of their problems, leading to increased productivity and profitability. CEBIP also can team with the Long Island Angel Network (LIAN) to help with obtaining new business venture start-up capital. CEBIP clients will also have access to Stony Brook University research facilities:

- Center for Advanced Technology in Sensor Systems (SensorCAT) for technical and business expertise, rapid prototyping & fabrication facilities and financial co-sponsorship.
- The Strategic Partnership for Industrial Resurgence (SPIR) utilizes the extensive engineering resources of the SUNY system to help local industry compete more effectively.

- Center for Biotechnology offers leading experts in biorenewable energy.
- Stony Brook Office of Technology Licensing and Industry Relations for patents and IP Technology Transfer.
- The Advanced Energy Research and Technology Center (AERTC) is the leader in advanced energy technology research within New York State.

CEBIP has also developed a physical space component of the commercialization road map with a shared space for CEBIP clients. This shared office or lab space (Innovation Forum @ LIHTI or Innovation Forum Lab @ LIHTI) provides CEBIP clients access to both office and lab space at a desk/bench level. CEBIP anticipates that this shared space concept will help start-ups raise funding and then transition to larger and dedicated facilities of their own.

Outside of Stony Brook University, CEBIP clients will also have access to Brookhaven National Laboratory (BNL) resources, which has a staff of approximately 3,000 scientists, engineers, technicians and support staff and over 4,000 guest researchers annually. BNL's role for the DOE is to produce excellent science and advanced technology with the cooperation, support and appropriate involvement of our scientific and local communities.

Long Island has very active and vocal clean energy related advocates. CEBIP has fostered relationships with these advocates, which will allow our clients exciting and high level networking opportunities. In addition, the Advanced Energy Training Institute (AETI) offers Clean Energy Strategy Sessions to give entrepreneurs an opportunity to network with experienced industry leaders.

CEBIP is fully committed to helping clean energy technology companies bridge the gap between invention and market using the expertise, business acumen and technological resources of our management team, Advisory Board and extensive partners. We will continuously work towards the development of a successful clean energy economy on Long Island, with the ultimate goal of creating new jobs and having a strong economic impact here in New York.

CEBIP operates directly under the direction of the Long Island High Technology Incubator (LIHTI). LIHTI is a non-profit organization dedicated to helping new technologically-innovative companies to grow by providing them with a variety of support resources and services. CEBIP is financially supported by the New York State Energy Research and Development Agency (NYSERDA). NYSERDA strives to facilitate change through the widespread development and use of innovative technologies to improve the State's energy, economic and environmental wellbeing.

Funded by New York State Energy Research and Development Authority (NYSERDA)



CONTACT INFORMATION

*Dr. Anil Dhundale
CEBIP Executive Director
Stony Brook University
Email: anil.dhundale@stonybrook.edu
www.aetc.org/cebip*

*David C. Hamilton
Director, Business Development
Email: david.hamilton@stonybrook.edu*

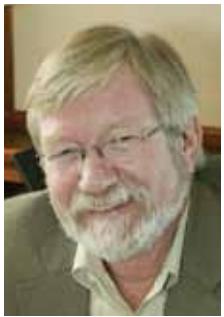
PARTNERS

Supported by:



New York Energy Policy Institute

AT STONY BROOK UNIVERSITY



Dr. Gerald Stokes, BNL



Dr. Guodong Sun, SBU

New York Energy Policy Institute (NYEPI) is a state-wide consortium of public and private universities and national laboratory. It was established to advise policymaking on energy issues important to the State. Stony Brook University (SBU) was designated by the New York State Energy Research and Development Authority (NYSERDA), under the direction of Governor David Paterson, to lead NYEPI. The Institute is housed in the Advanced Energy Center (aerc.org) located at the Stony Brook University Research and Development Park, with initial support from NYSERDA.

The consortium includes Stony Brook University, Binghamton University, Brookhaven National Lab (BNL), City University of New York (CUNY), Clarkson University, Columbia University, Cornell University, Hudson Valley Community College, Morrisville State College, Polytechnic Institute of New York University (NYU-Poly), Rensselaer Polytechnic Institute (RPI), SUNY College of Environmental Science and Forestry (ESF), Syracuse University (SU), University at Albany, University at Buffalo, University of Rochester, and Pace University. These institutions have many of the nation's leading energy experts on their faculty in areas ranging from science and engineering to social science, business administration, and public policy. NYEPI brings together the best and brightest minds in the energy fields to help solidify New York State's standing as a leader in energy policy research and analysis.

The consortium's long-term goal is to develop a strong, dynamic, and networked community that conducts energy policy research and advises policymakers.

NYEPI is led by a board comprised of energy experts, public-policy practitioners, and business and government leaders; and operates through a President, an Executive Director, and three hubs based at its core institutions (Stony Brook University, Rensselaer Polytechnic Institute, and Syracuse University). Each of the three hubs will serve as a regional center of NYEPI. Professors Gerald Stokes and Guodong Sun, both from SBU's Department of Technology and Society, serve as its President and Executive Director, respectively.

NYEPI focuses on five targeted programs:

- 1) providing rapid response policy analysis and advising
- 2) conducting longer-term energy policy research
- 3) serving as an academic, energy information and research clearinghouse
- 4) creating and maintaining a database of energy experts
- 5) conducting policy workshops and briefings to policymakers on key current and emerging energy issues

CORE INSTITUTIONS

Stony Brook University

Rensselaer Polytechnic Institute

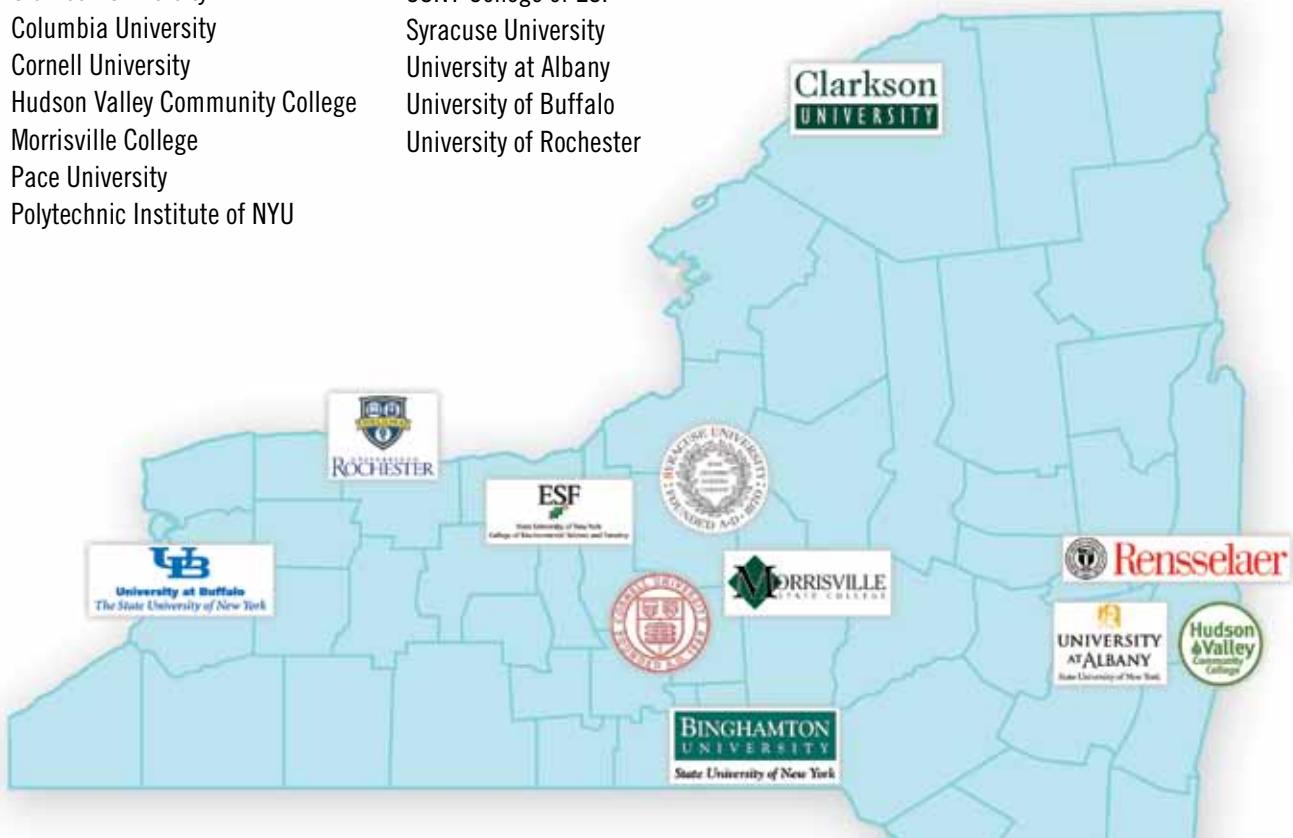
Syracuse University



PARTNER INSTITUTIONS

Binghamton University
Brookhaven National Laboratory
City University of New York
Clarkson University
Columbia University
Cornell University
Hudson Valley Community College
Morrisville College
Pace University
Polytechnic Institute of NYU

Rensselaer Polytechnic Institute
Stony Brook University
SUNY College of ESF
Syracuse University
University at Albany
University of Buffalo
University of Rochester



Funded by New York State Energy Research and Development Authority (NYSERDA), and Contracting Agencies



CONTACT INFORMATION

Dr. Guodong Sun
Executive Director
Stony Brook University
Email: guodong.sun@stonybrook.edu
<http://www.aertc.org/nyepi>





Robert B. Catell



James T. Gallagher



Nancy Doon

The AERTC is a founding member and strategic partner in the New York State Smart Grid Consortium (Consortium). The Consortium is a unique public-private partnership that brings together the world's leading utilities, technology providers, policy makers and research institutions to identify opportunities that promote the modernization of the grid in New York State. To accelerate the adoption of new technologies, regulation and market mechanisms, the Consortium seeks to facilitate collaboration among the various stakeholders within the State.

The primary mission of the Consortium is to continuously advocate for smart grid implementation by both the public and private sector. While agnostic with respect to specific technologies, the Consortium is committed to educating the public and assisting regulators, policy makers and investors in assessing the potential benefits of technology and the appropriate extent of the commitment by New York's utilities, technology providers, educational institutions, research laboratories and public agencies to the deployment of advanced energy technology.

The Consortium is currently focused on the following priority initiatives:

1) Actively support the New York Public Service Commission's (PSC) Reforming the Energy Vision (REV) proceeding.

The Consortium is an active party in the New York State Department of Public Service Commission's Reforming the Energy Vision (REV) proceeding. The New York State Public Service Commission (PSC) commenced its REV initiative to reform New York State's energy industry and regulatory practices. This initiative will lead to regulatory changes that promote more efficient use of energy, deeper penetration of renewable energy resources such as wind and solar, along with wider deployment of "distributed energy resources such as microgrids, on-site power supplies and storage. It will also promote greater use of advanced energy management products to enhance demand elasticity and efficiencies. These changes, in turn, will empower customers by allowing them more choice in how they manage and consume electric energy.

2) Support the implementation of Innovative Smart Grid Projects across New York State.

Through active engagement with its members, the Consortium is advancing projects that will demonstrate innovative smart grid technologies and the benefits that would be provided through substantial grid modernization deployment. The short-term emphasis of this effort includes the exploration of the feasibility of "showcase microgrid demonstration projects. In addition, the Consortium is providing guidance on community-based projects that will reduce costs, promote clean energy and enhance reliability and resiliency.

CORE INSTITUTION

NYSSGC Chairman:
Robert B. Catell

A consortium of leading utility,
industrial, academic and
research organizations.

3) Identify research and best practices in Smart Grid Deployments in New York State and the rest of the world to facilitate shared learning.

Working closely with its member universities, the Consortium is preparing an inventory of research capabilities related to grid modernization currently underway in New York. The results of this effort will lead to a second phase that will (a) showcase the innovative research underway at New York's universities and research institutions, (b) identify any gaps where additional research is desirable, and (c) organize, promote and publicize these capabilities to relevant stakeholders. To promote smart grid international collaborations, the Consortium is an active member of the Advisory Board of the European Commission's GRID4EU and also participated in the launch of Denmark's GreenTech Center, a smart grid laboratory designed to encourage research, education and innovation in emerging smart grid technologies.

For more information, please visit our website:
www.nyssmartgrid.com

CONTACT INFORMATION

Mr. Robert B. Catell
NYSSGC Chairman
rcatell@nyssmartgrid.com

Mr. James T. Gallagher
NYSSGC Executive Director
jgallagher@nyssmartgrid.com

Ms. Nancy Doon
NYSSGC Director of Environmental Services
[ndoон@nyssmartgrid.com](mailto:ndoon@nyssmartgrid.com)

PARTNERS





ThINC

THERMOMECHANICAL & IMAGING NANOSCALE CHARACTERIZATION

AT STONY BROOK UNIVERSITY



Dr. Miriam Rafailovich

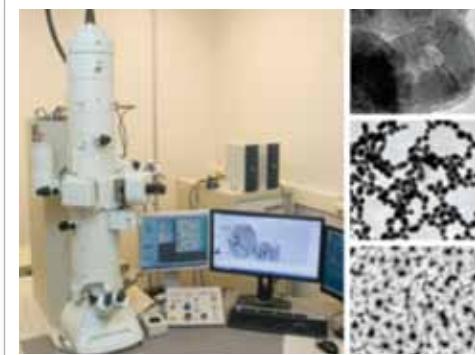
The Thermalmechanical and Imaging Nanoscale Characterization (ThINC) is a core facility of the Advanced Energy Center™ (AERTC). It is dedicated to establishing partnerships between Stony Brook University and industrial laboratories for enabling cutting-edge research in nanoscience.

The facility combines cutting edge instrumentation, with two full time scientists, who are available to teach and guide users in their use and finding the best approach to understanding their needs in nanotechnology. If needed, the scientists will then guide the users in drafting proposals for using additional instrumentation available at the BNL-CFN. Our facility opens doors to regional industry and students, providing them with educational resources allowing them to explore, innovate, and go further into the world of nanotechnology.

COMPREHENSIVE SERVICE IMAGING

TRANSMISSION ELECTRON MICROSCOPE (TEM) JEOL JEM 1400

- Suitable for materials science, polymer and biological applications
- Features available: Cryotomography, STEM, EDS for elemental identification
- Accel. Vol.: 40~120kV
- Magnification: x5,000~2,000,000/x120~4,000



TEM images: (top) Graphitized carbon, showing a distance between graphene layers of approximately 3.4Å; (middle) Synthesized gold nanoparticles, with average size ~40 nm; (bottom) P3HT/ PCDTBT blend polymer thin film



Dr. Chung-Chueh



Dr. Ying Liu

SCANNING PROBE MICROSCOPE WITH HYSITRON ATTACHMENT

Bruker Dimension ICON

- Nanomechanics/ nanoindentation
- Nanoelectrical characterization
- Imaging in fluid
- Heating and cooling stages
- Contact, Tapping and ScanAsyst modes



Scanning probe microscope images: (left) 3D image of photoresist imprinted patterns on silicon wafer scanning by Contact mode; 2D image of organic photovoltaic polymeric solar cell (PMMA/P3HT/PCBM) scanning by Peakforce TUNA mode, showing the topography (middle) and conductive current (right) measurement

CORE INSTITUTION

Stony Brook University

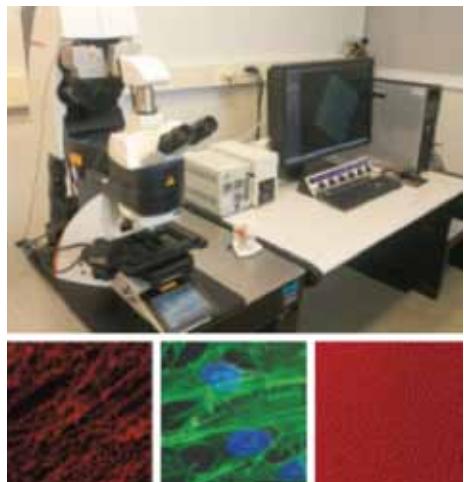
Dr. Miriam Rafailovich

Chief Scientist, AERTC

UPRIGHT CONFOCAL MICROSCOPE

Leica TCS SP8X

- Upright geometry suitable for materials science applications with opaque samples or substrates
- Immersion lenses permit imaging of submerged samples
- GaAsP hybrid detection system (HyD)
- White light laser 470~670 nm, and UV laser 405 nm
- Tokai Hit stage incubator providing 37°C and 5% CO₂ (live cell imaging)



Confocal microscope images: (left) Organic photovoltaic polymer MEH-PPV electrospun fibers; (middle) Dental pulp stem cells grown on polyisoprene thin film treated with micro-sized beads taken together by incident (fluorescence) and transmitted (DIC) lights. Stained with Alex Flour Phalloidin 488 (actin filaments) and DAPI (nuclei); (right) Organic photovoltaic polymer P3HT blended with PMMA

THERMOMECHANICAL CHARACTERIZATION

THERMOMECHANICAL CHARACTERIZATION

- Dynamic Mechanical Analysis (DMA, TA Q800): Temp. range: -145~600°C
- Differential Scanning Calorimetry (DSC, TA Q2000): Temp. range: -90~550°C
- Thermal Gravimetric Analysis (TGA, TA Q50): Temp. range: Ambient +5~1000°C
- Thermal Conductivity Meter (DTC300): Temp. range: -20~300°C

Thermal conductivity range: 0.1~40 W/m.K



SPECTROSCOPIC ELLIPSOMETRY

Horiba UVISEL FUV

- Spectral range from 190 to 880 nm; thin film thickness from 1Å to 30µm
- Nanometer film thickness determination with multi-film and interface capabilities

EM SAMPLE PREPARATION

Leica EM UC7 with Cryo Attachment

- High-quality ultramicrotome for precise room temperature and cryo sectioning (-15~-185°C)
- Prepare excellent quality semi-thin and ultra-thin sections, as well as the perfectly smooth surfaces for light, electron and atomic force microscopy examination
- Diamond and glass knives available
- Ideal for elastomers, polymers and organic photovoltaics
- Well suited for biological samples, either embedded or lyophilized

SAMPLE PREPARATION

SAMPLE PREPARATION

- 6-ft. chemical fume hood
- Photoresist spinner

CONTACT INFORMATION

Dr. Miriam Rafailovich

Chief Scientist, AERTC

Email: miriam.rafailovich@stonybrook.edu

Dr. Chung-Chueh Chang (Simon)

Instrumentation Scientist, AERTC

Email: chung-chueh.chang@stonybrook.edu

Dr. Ying Liu

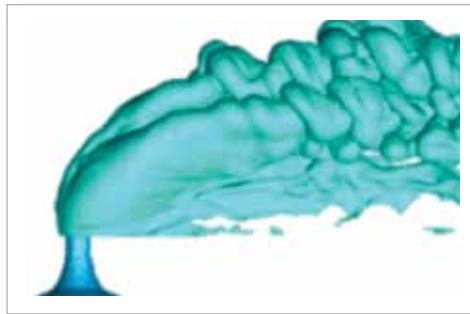
Industrial Project Scientist, AERTC

Email: ying.liu.1@stonybrook.edu

Volume Visualization of Porous Rocks

PI: Arie Kaufman, SBU

The visualization of volumetric data has aided many scientific disciplines ranging from geophysics to the biomedical sciences. We developed the VolVis, a comprehensive, diversified, easy to use, extensible, high performance and portable volume visualization system. Specific energy related applications include volume rendering for analyzing the pore space in three- (and two-) dimensional X-ray computed microtomographic (XCMT) images (e.g., from the Light Source at BNL) of rocks. With appropriate images it can be used to analyze fluid partitioning in the pore space, for applications of ground water contaminants, and for oil distributions. VolVis was licensed to Exxon Production Research Company in Houston, TX for visualization of oil exploration. (NSF, Exxon, DOE).



Visual Simulation of Thermal Fluid Dynamics in a Pressurized Water Reactor

PI: Arie Kaufman, SBU

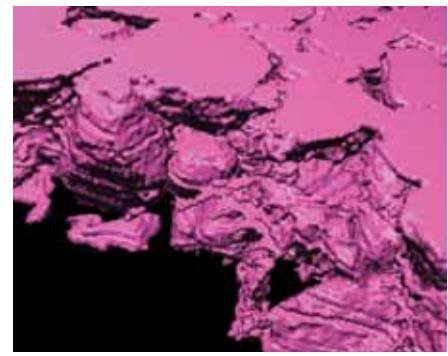
We developed a simulation and visualization system for the critical application of analyzing the thermal fluid dynamics inside a pressurized water reactor of a nuclear power plant when cold water is injected into the reactor vessel for a possible thermal shock to the vessel. We employ a hybrid thermal lattice Boltzmann method (HTLBM), which has the advantages of ease of parallelization and ease of handling complex simulation boundaries. For efficient computation and storage

of the irregular-shaped simulation domain, we classify the domain into nonempty and empty cells and apply a novel packing technique to organize the nonempty cells. This method is implemented on a GPU (graphics processing unit) cluster for acceleration. We demonstrate the formation of cold-water plumes in the reactor vessel. A set of interactive visualization tools, such as side-view slices, 3D volume rendering, thermal layers rendering, and panorama rendering, are provided to collectively visualize the structure and dynamics of the temperature field in the vessel. To the best of our knowledge, this is the first system that combines 3D simulation and visualization for analyzing thermal shock risk in a pressurized water reactor. (NRC, ISL)



Publications:

Zhe Fan, Yu-Chuan Kuo, Ye Zhao, Feng Qiu, Arie Kaufman, and William Arcieri. *Visual Simulation of Thermal Fluid Dynamics in a Pressurized Water Reactor*, *The Visual Computer*, (2008).



Energy Projects:

- Smart grid
- Visual modeling

RESEARCHER PROFILE

Arie E. Kaufman Distinguished Professor and Chair of the Computer Science Department and Distinguished Professor of Radiology

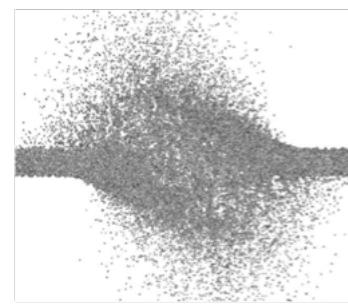
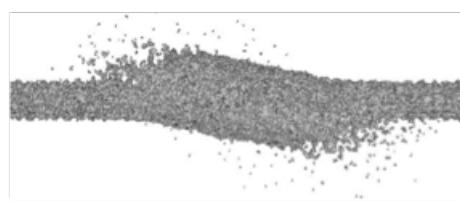
Awards and Honors:

- Long Island Technology Hall of Fame Inductee (2013)
- Fellow, ACM (2009)
- Chief Scientist, Center for Excellence in Wireless and Information Technology (CEWIT) (2007-)
- Innovative Research Award, State of New York (2005)
- IEEE Visualization Career Award (2005)
- Member, European Academy of Science (2002)
- Entrepreneur Award, State of New York (2002)
- Editor-in-Chief, IEEE Transactions on Visualization and Computer Graphics (TVCG) (1995-98)

Simulation of High Power Liquid Mercury Accelerator Targets

PI: Roman Samulyak, SBU

The targetry group of DOE's Muon Accelerator Program (MAP) is exploring the feasibility of high power liquid mercury targets for future particle accelerators. The numerical simulations aim to describe the hydrodynamic response of the target interacting with proton pulses in magnetic fields and provide input for the design of reliable targets. Simulations use FronTier, a multiphysics code with explicit resolution of material interfaces based on front tracking, a smooth particle hydrodynamics code, and a newly developed Lagrangian particle code that significantly improves accuracy of previous particle-based methods. We have performed simulations of liquid mercury jet targets interacting with high power proton beams in magnetic fields. MHD simulations which predicted strong distortion of the jet entering a 15 Tesla solenoid and the reduction of the target efficiency have led to a change of design parameters for the CERN MERIT experiment. Simulation also predicted strong instabilities and cavitation of the mercury jet interacting



Particle-based simulations of mercury jet dispersal after deposition of 4 MW beam of 8 GeV protons. States of the neutrino factory target at 1 ms after the deposition of the proton beam (left), and the muon collider target at 0.35 ms (right) are shown.

with proton pulses at zero magnetic field and a stabilizing effect of the magnetic field. The main conclusion of the targetry program is that liquid mercury jet targets can reliably work in future accelerators and neutron sources up to 8 MW power limit. This research resulted in unique computational tools that will be able to serve as a design tool for future accelerator and neutron source targets. (DOE HEP)



Publications:

- R. Samulyak, H.C. Chen, H. Kirk, K. McDonald, *Simulation of high-power mercury jet targets for neutrino factory and muon collider*, Proceedings of PAC2013, Pasadena, CA USA, paper TUPBA09.
- R. Samulyak, W. Bo, X. Li, K. McDonald, H. Kirk, *Computational algorithms for multiphase magnetohydrodynamics and applications*, Condensed Matter Physics, 13 (2010), No 4, 43402: 1 - 12.

Modeling of Advanced Powertrains

PI: Sotirios Mamalis, SBU

The automotive industry is constantly facing the challenge of improving vehicle fuel economy and reducing emissions without sacrificing performance. Novel combustion concepts, such as Homogeneous Charge Compression Ignition (HCCI) and Spark-Assisted Compression Ignition (SACI), as well as recent advances in engine technology (e.g. variable valve actuation) and electrical components (e.g. batteries) offer the promise of dramatic gains in vehicle fuel economy. In order to take full advantage of these new technologies, howev-

er, it is important to enhance our fundamental understanding of the combustion processes, while addressing the increased complexity of the engine and vehicle systems. For this purpose, we use models of varying complexity and fidelity to aid the development of advanced engines and evaluate the potential overall fuel economy improvements at the vehicle level. More specifically, CFD models with detailed chemical kinetics are used to investigate basic aspects of HCCI and SACI combustion and understand the effects of combustion phasing and engine load/speed on burn rates and combustion efficiency. The knowledge gained from the fundamental CFD studies is then used to develop system level models that can aid in the design of the engine system, compo-

ment matching and controls development. Finally, the engine system model is employed to generate engine fuel consumption maps that can be incorporated in vehicle level simulations for assessing the overall fuel economy gains of conventional and hybrid vehicles over a given drive-cycle. (SBU)



Publication:

- Mamalis, S., Babajimopoulos, A., Guralp, O., Najt, P. M., & Assanis, D. (2014). *The interaction between compression ratio, boosting and variable valve actuation for high load homogeneous charge compression ignition: A modeling study*. International Journal of Engine Research, June 2014, 15 (4), 460-470.

Seismic Data Visualization for Oil Exploration

PI: Arie Kaufman, SBU

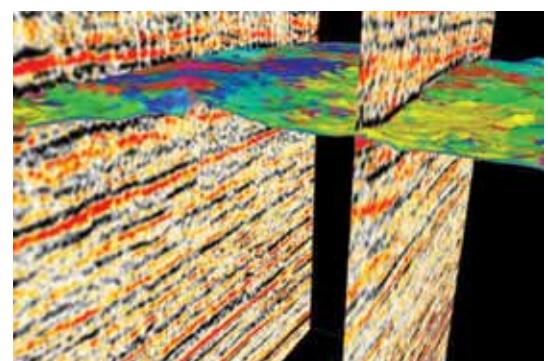
We have developed a visualization cluster system for assisting geophysicists with the task of locating potential oil and gas wells utilizing seismic data in conjunction with other geophysical data. Visualization of terabytes of multiple volumes along with geometric models requires coordination of massive distributed memory on a large scale machine, such as a cluster. We configured the Stony Brook Visual Computing Cluster consisting of 66 dual-processor compute nodes, with 66 GPUs and 34 VolumePro volume rendering boards. We have been able to use our cluster to visualize multi-channel volumes mixed with geometric data on a multi-gigabyte scale using cluster technology, image composition, and hardware assisted volume rendering. Interactive input

from the user includes viewpoint, cut planes, transfer functions, and other viewing parameters. To facilitate the work of a geophysicist, we register and fuse multiple volumes from a variety of sources into an interactive visualization. (NSF, Terarecon, IBM, HP)



Publications:

- S. Frank and A. Kaufman. *Dependency graph approach to load balancing distributed volume visualization*. The Visual Computer (2009).
- S. Frank and A. Kaufman. *Out-of-core and dynamic programming for data distribution on a volume visualization cluster*. Computer Graphics Forum (2009).

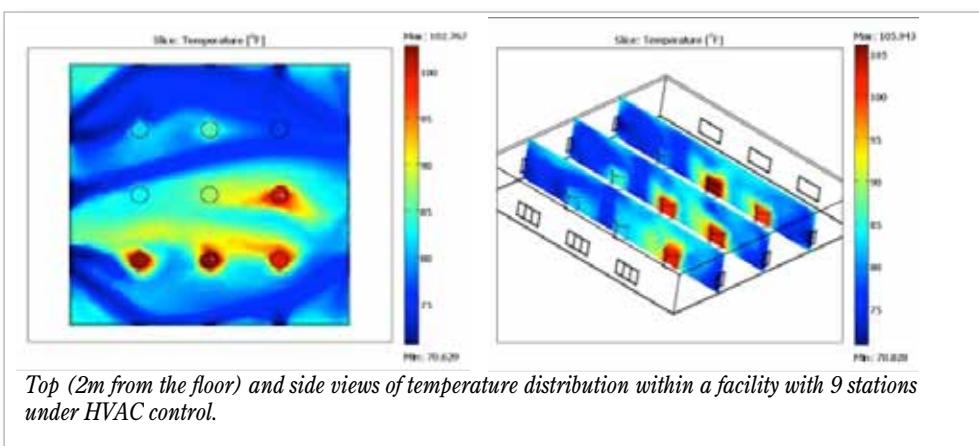


Transformation of the seismic information to unified analysis of potential reserves with the help of 3D technology

Energy Efficiency Performance Indicators for a Production Line

PI: Qing Chang, SBU

Modern manufacturing facilities lack the proper indicators to truly capture energy performance of a production line. Our work creates new energy efficiency performance indicators, which separates usable energy from energy waste to give floor managers the ability to easily see which machines are running efficiently. These indicators differ from current performance measures because they utilize real time data and do not simply just use energy per part, which does not always correctly identify the energy waste in a system. We use these indicators in conjunction with energy savings opportunities to optimize the energy efficiency of the overall production system. (GM)



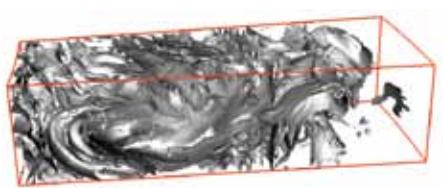
Top (2m from the floor) and side views of temperature distribution within a facility with 9 stations under HVAC control.

Publications:

- Q. Chang, G. Xiao, S. Biller, et. al, *Energy Saving Opportunity Analysis of Automotive Serial Production Systems*. IEEE Transaction on Automation Science and Engineering DOI: 10.1109/TASE.2012.2210874, 2012.

- M. Brundage, Q. Chang, S. Wang, S. Feng, G. Xiao, and J. Arinez. *Energy Savings Opportunities and Energy Efficiency Performance Indicators for a Serial Production Line*. APMS 2013 International Advances in Production Management Systems (2013).





Interface from a front tracking simulation of two-phase turbulent Taylor-Couette mixing flow in a spatial annular sector domain extracted from the geometry of a centrifugal contactor device used in solvent extraction processes of nuclear spent fuel reprocessing.



Thermal Flow Modeling and Visualization

PIs: Arie Kaufman and Klaus Mueller, SBU

We employ the Lattice Boltzmann Method (LBM) for simulation and visualization of flow with thermal effects. LBM discretizes the microphysics of local interactions and can handle very complex boundary conditions, such as porous regions, urban canyons, curved walls, indoors, datacenters and dynamic boundaries of moving objects or material, as well as thermal effects. We introduce a heat transfer model between the heat source objects and the flow environment. We simulate the thermal flow dynamics by a hybrid thermal Lattice Boltzmann model (HTLBM). Due to its discrete nature, LBM computational pattern is easily parallelizable. We have accelerated LBM on commodity graphics processing units (GPUs), achieving real-time on a single GPU or on a GPU cluster. Primary applications of fast HTLBM are in air and ground contamination, thermal modeling of cooling and heating of buildings, especially advanced cooling for datacenters and modeling heating oil and electricity usages. (NSF, DHS, NASA)



Publication:

Y. Zhao, Y. Han, Z. Fan, F. Qiu, Y. Kuo, A. Kaufman and K. Mueller. *Visual Simulation of Heat Shimmering and Mirage*. IEEE Transactions on Visualization and Computer Graphics, 13, 1, (2007) pages 179-189.

Damage Tolerant 3-D Periodic Interpenetrating Phase Composites with Enhanced Mechanical Performance

PI: Lifeng Wang, SBU

The research objective of this project is to study high-performance polymer periodic interpenetrating phase composites (IPCs) with enhanced mechanical properties (including stiffness, strength, impact resistance, toughness, energy dissipation and damage tolerance) through an integrated approach combining design, fabrication, analysis and experiment. Geometries based on triply periodic minimal surfaces and 3-D microtrusses will be used to optimally design microstructures of the proposed IPCs and 3-D direct-write printing technologies will be employed to fabricate them. Analytical and computational micromechanics models will be developed to simulate the IPCs and various tests will be conducted to characterize the fabricated IPCs and to validate the proposed models. It is anticipated that the findings of this proposed research will provide guidelines for engineering and tailoring IPCs to achieve optimized properties. (NSF)



Computational Evaluation of New Concept of Magneto-Inertial Fusion

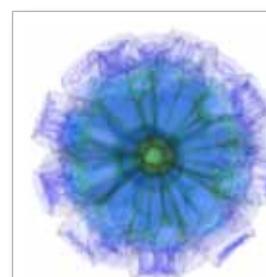
PI: Roman Samulyak, SBU

In the Plasma-Jet driven Magneto-Inertial Fusion (PJMF) concept, a plasma liner (formed by the merger of a large number of radial, highly supersonic plasma jets) implodes on a magnetized plasma target and compresses it to conditions of the fusion ignition. By avoiding major difficulties associated with both the traditional laser driven inertial confinement fusion and solid liner driven MTF, the plasma-liner driven magneto-inertial fusion potentially provides a low-cost and fast R&D path towards the demonstration of practical fusion energy. Front tracking technologies have been used for the computational evaluations of the PJMF concept. Simulations demonstrated the successful formation of the plasma liner by the merger of plasma jets and estimated the uniformity and thermodynamic state of the liner. The uniformity of the liner is critical for the reduction of Rayleigh-Taylor instabilities in the target while maintaining a high Mach number in the liner is necessary to achieve high target compression rates. Our simulations quantified the influence of oblique shock waves on the liner formation and the role of atomic processes in improving the liner quality and target compression rates. They have also investigated processes leading to target instabilities, deconfinement time and verified theoretical scaling laws. Simulations support experimental effort at Los Alamos National Laboratory. (DOE FES)



Publications:

- H. Kim, L. Zhang, R. Samulyak, P. Parks, *On the structure of plasma liners for plasma jet induced magnetoinertial fusion*, Phys. Plasmas 20, 022704 (2013).
- H. Kim, R. Samulyak, L. Zhang, P. Parks, *Influence of atomic processes on the implosion of plasma liners*, Physics of Plasmas, 19:082711, 2012.
- R. Samulyak, P. Parks, L. Wu, *Spherically symmetric simulation of plasma liner driven magnetoinertial fusion*, Physics of Plasmas, 17 (2010), 092702.



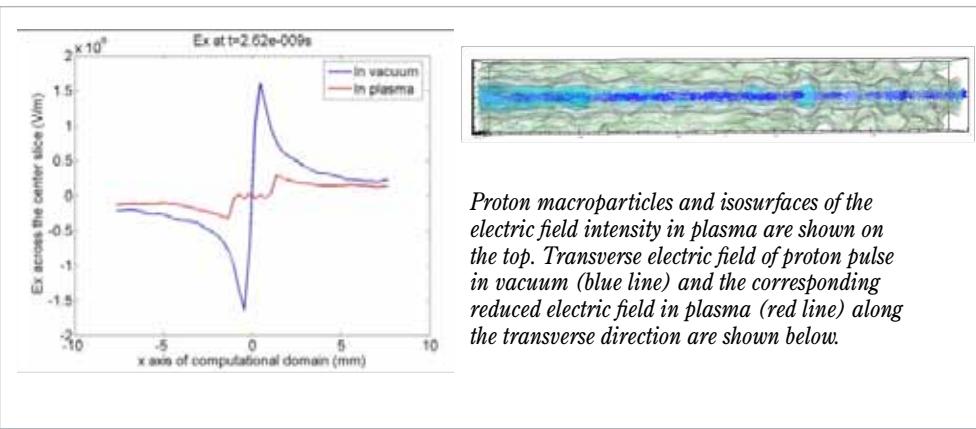
Frontier simulation of the formation and implosion of plasma liner formed at conditions relevant to Los Alamos experiment.

Simulation of Advanced Coherent Electron Cooling and Beam-Beam Effects

PI: Roman Samulyak, SBU

The new BNL LDRD project, led by V. Litvinenko (SBU-Physics Department and BNL-CAD), focuses on theoretical, computational and experimental studies of the newly proposed method of Advanced Coherent electron Cooling (ACeC or Micro-Bunching e-Cooling). This approach promises to be superior to any of the current cooling schemes or proposed ones and has a capability to greatly increase the intensity frontier of future particle accelerators. The simulation program, led by R. Samulyak, will achieve proof-of-principles simulations of advanced coherent electron cooling for e-RHIC, address the efficiency of ACeC and fundamental questions of the dynamics of short electron bunches. In particular, the important problem of the reduction of shot noise. High fidelity numerical simulations will aid theoretical and experimental work at CAD. We will also perform computational evaluation of methods for plasma suppression of beam-beam effects in RHIC. In particular, we will simulate electromagnetic fields in plasma created by highly relativistic, colliding proton beams

and optimize plasma parameters that lead to the most efficient suppression of beam-beam effects. We will also study the generation of plasma in RHIC by the proton beam ionization of neutral gases. If the beam-generated plasma proves to be of insufficient density, models for external plasma discharges will be used. On the applied mathematics side, the research will result in the development of new computational models and fast algorithms that will combine in a state-of-art software for the simulation of electrodynamics of particles and fields optimized for modern architecture supercomputers. Such a code will increase research capabilities at BNL. The developed software will also be applicable to numerous high-priority BNL applications such as electron gun, energy recovering linac, aspects of the muon ionization cooling such as the interaction of muons with plasma in absorbers, and advanced laser / wakefield methods for the acceleration of hadron beams. (BNL LDRD)



Integrated Production Line and HVAC System

PI: Qing Chang, SBU

We have created an integrated thermal and production system model to optimize energy and monetary savings in a manufacturing plant. Utilizing simulation methods, we have combined the two largest energy consumers in a manufacturing facility; the production line and the HVAC system. By joining these two systems, we created an overall control scheme to coordinate shut offs of certain machines without any throughput loss on the production line. These timed shut offs are called opportunity windows. The opportunity windows for the production line are synced with the peak periods of energy demand for the HVAC system to optimize the energy cost savings. (GM)



Publications:

M. Brundage, Q. Chang, D. Chen, and V. Yu. *Energy Savings Opportunities of an Integrated Facility and Production Line*. Proceedings of ASME 2013 Manufacturing Science and Engineering Conference (2013).

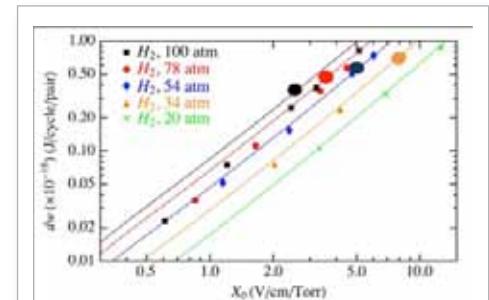
M. Brundage, Q. Chang, Y. Li, G. Xiao, and J. Arinez. *Energy Efficiency Management of an Integrated Serial Production Line and HVAC System*. 9th IEEE International Conference of Automation Science and Engineering (2013).

Simulation of Muon Ionization Cooling Devices

PI: Roman Samulyak, SBU

The aim of this project is to develop novel mathematical models, highly scalable software for modern supercomputers and perform simulations of muon cooling devices in support of the DOE Muon Accelerator Program. Understanding of the interaction of muon beams with plasma in muon cooling devices is important for the optimization of the muon cooling process. A dense hydrogen gas-filled radio-frequency (RF) cavity has been proposed for muon beam phase space cooling and acceleration. An important issue in high-pressure gas-filled radio-frequency (HPRF) cavity is an RF power loading due to beam-induced plasma. Incident particle beam interacts with dense hydrogen gas and causes a significant ionization level. Due to high frequency of collisions with neutrals, electrons reach equilibrium within picosecond time scale and move by the instantaneous external electric field. These charged particles, mainly electrons, absorb power of the electromagnetic field in the cavity. Thus, subsequent bunches following the first one will experience a reduced external field. This external field drop effect is strengthened by the repetitive beam inflow. The recombination process mitigates the side effects of plasma loading. In order to intensify the

electron-capture process, electronegative gas is used in cavity. Atomic processes are critical for the performance of the cooling device and should be modeled accurately in simulations. The aim of the current simulation program is the development of mathematical and numerical models and parallel software for the simulation of processes occurring in gas-filled RF cavities. A parallel electromagnetic particle-in-cell code with atomic physics, called SPACE, has been developed at Stony Brook University / BNL. It implements the finite difference time domain method, new mathematical models and numerical algorithms for the interaction of high-energy beams with neutral gas and plasmas. In particular, a novel algorithm dealing with repetitive beam is developed and implemented. Our simulations have achieved good agreement with HPRF experiments performed at Fermi National Accelerator Laboratory. The experimentally verified code is being used for the prediction of new muon cooling regimes that are not achievable by current experimental devices. (DOE HEP)



SPACE code simulation of plasma loading of high-pressure hydrogen gas filled RF-cavity at Fermi National Accelerator Laboratory. Comparison of simulation results (large circles), theoretical calculations (solid lines), and experiments (small dots) are shown.

Publications:

- K. Yu, R. Samulyak, M. Chung, A. Tollestrup, K. Yonehara, *Modeling and simulation of beam-induced plasma in muon cooling devices*, IPAC-2014, Paper MOPME043.
- R. Samulyak, H.C. Chen, H. Kirk., K. McDonald, *Simulation of high-power mercury jet targets for neutrino factory and muon collider*, Proc. NA-PAC 2013, paper TUPBA09.
- R. Samulyak, K. Yu, M. Chung, A. Tollestrup, K. Yonehara, R. D. Ryne, *Algorithms for self-consistent simulations of beam-induced plasma in muon cooling devices*, Proc. NA-PAC 2013, paper MOPBA06.

Visual Interface to Aid Energy Aware Layout and Use of Smart Spaces, Buildings, Offices and Industry Facilities

Pls: Arie Kaufman and Klaus Mueller, SBU



We will devise an approximate but fairly accurate simulation framework to model heat, cooling, lighting and the like and show these profiles as a heat map on walls and floors of smart spaces. These maps could then be used for energy-aware room layouts, utilization and possibly also solar panel placement. We will

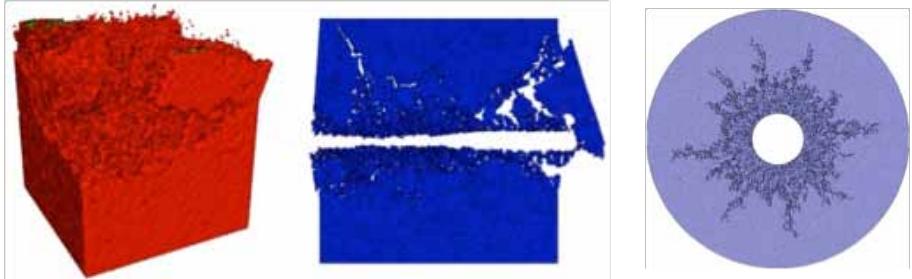
further model the light and heat exposure from exterior sources such as the sun to augment the map. (IBM, NY)



New Computational Models for Brittle Fracture

PIs: Roman Samulyak and Xiangmin Jiao, SBU

The goal of this project is to develop accurate mathematical models, parallel software, and to perform numerical studies of brittle fracture capable of supporting practical engineering design relevant to the DoD mission. We have developed a mass conservative brittle fracture algorithm and scalable parallel software based on the energy minimization of elastic networks. The application of this algorithm to fundamental and engineering problems has led to numerous improvements of the description of underlying physics and numerical performance. In particular, the model was successful in the study of failure waives which are characterized by the bifurcation of failure waive fronts, e.g. the transformation of the envelop of completely disintegrated (communited) zones into radial cracks. Unfortunately, the applicability of our brittle fracture method was limited by its compatibility with established engineering codes for solid dynamics, which are primarily based on finite element methods. In our current ARO-supported project, we are focusing on the adaptation of the brittle fracture method to the finite element framework in 2D and 3D, thus extending capabilities of finite element methods for the description of fracture dynamics. While the core of our new method is still based on energy minimization, our new code is based on a simplified version of the ALE (Arbitrary Lagrangian Eulerian) formulation to allow large displacement and arbitrary mesh motion, coupled with a weighted least squares formulation to calculate nodal strains and mesh adaptivity to improve accuracy and stability. The adoption of the finite



Three-dimensional numerical simulation of brittle fracture of stretched beam (left), and two-dimensional simulation of failure waives (middle and right).

element method allows the new software to be interoperable with standard FEM codes widely used for material studies. The new approach also improves the accuracy of simulation of real materials. Our project pursues the development of a prototype code for FEM-based description of complex fracture regimes and a proof-of-concept verification and validation program. (Army Research Office)



Publication:

H. Wei, R. Samulyak, *Mass-conservative network model for brittle fracture*, J. Coupled Syst. Multiscale Dyn., Vol. 2 (2014), No 2, p. 2330.

RESEARCHER PROFILE



Energy Projects:

- Modeling and Simulations
- High Energy Physics and Particle Accelerators
- Nuclear Fusion
- Fluid Dynamics and Magnetohydrodynamics

Roman Samulyak, Professor, Department of Applied Mathematics and Statistics, Stony Brook University, and Scientist, Computational Science Center, Brookhaven National Laboratories.

Research Interests:

Mathematical modeling and development of numerical algorithms for complex multiphase systems involving fluid dynamics, magnetohydrodynamics, relativistic particles and electromagnetic fields, and solid dynamics with fracture, and applications to supercomputer simulations of processes in particle accelerators, high energy density matter, and nuclear fusion and fission devices.

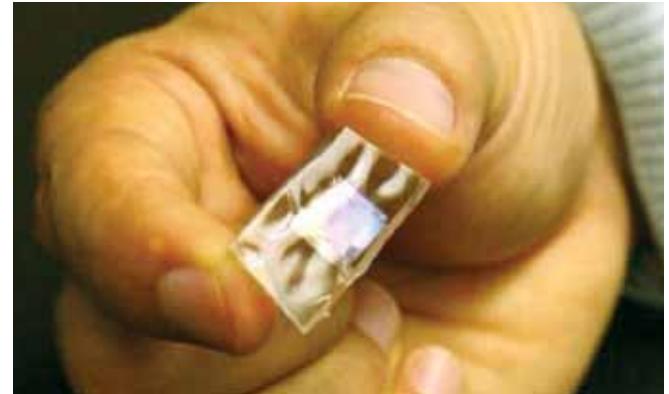
Smart Composites for Energy Harvesting

PI: T. A. Venkatesh, SBU

Smart piezoelectric materials, by virtue of their coupled electromechanical characteristics, have been recognized for their potential utility in many applications as sensors and actuators, from medical ultrasound devices for prenatal care, micro/nano-positioners for atomic force microscopes and sonar hydrophones to non-destructive testers and inkjet print heads. Considerable research efforts in the past years have resulted in the development of several monolithic piezoelectric materials such as, lead zirconate titanate (PZT) and barium titanate, with enhanced coupled properties. However, despite the enhancement of their piezoelectric properties, monolithic piezoelectric materials generally exhibit certain limitations. For example, they are mechanically brittle as most of the piezoelectric materials are ceramic-type materials; their functionality is generally unidirectional as the poling characteristics of the piezoelectric material allow them to sense or actuate in one direction (i.e., in the dominant poled direction) only. Because of these limitations, the range of applicability of monolithic piezoelectric materials is

limited. A composites approach to piezoelectric materials can potentially overcome the limitations of monolithic piezoelectric materials. The overall objectives of our research efforts are:

- 1) To obtain a comprehensive understanding of the fundamental properties of smart piezoelectric composites.
- 2) To design novel smart materials based devices and structures for sensing and actuating functions as well as for energy harvesting applications. (NSF)



Promising new piezoelectric materials can be used in energy harvesting applications.

Publications:

C. Marcheselli and T. A. Venkatesh. *Electromechanical Response of Piezoelectric Composites with Hollow Fibers*, Applied Physics Letters, (2009).

R. Kar-Gupta and T. A. Venkatesh. *Electromechanical Response of Piezoelectric Composites: Effects of Geometric Connectivity and Grain-size*, Acta Materialia, (2009).

Advanced Materials for Energy Generators and Energy Converters

PI: T. A. Venkatesh, SBU

Within the current context of an energy critical economy and environment, there is considerable interest in identifying and enhancing the efficiency and reliability of energy generators such as land based turbines and energy converters such as aircraft jet-engines. In such turbine or engine structures, it is usually uncommon for complete structures to be created as a single unit from a monolithic material. Functionality of design and economies of scale invariably mandate the creation of several subparts that are subsequently assembled. In the process of integration, contact

between similar or dissimilar materials is naturally unavoidable. When contacts such as dovetail joints of turbine blades are subjected to dynamic loading or vibrations, localized damage originating at the contact locations could result in catastrophic structural failure. Detection of such damage is often difficult as the damage is usually hidden under the contact geometry and is not easily amenable for inspection. Hence, there is a tremendous need to better understand the origin and progress of material damage under such localized, dynamic contact conditions and design op-

timal materials to mitigate such damage processes and enhance the life and reliability of such energy generators/converters. (NSF)



Publications:

H. Lan and T. A. Venkatesh. *On the Uniqueness and Sensitivity Issues in Determining the Elastic and Plastic Properties of Power-law Hardening Materials through Sharp and Spherical Indentation*, Philosophical Magazine, 87, (2007), 4671-4729.

H. Lan and T. A. Venkatesh. *On the Sensitivity Characteristics in the Determination of the Elastic and Plastic Properties of Materials through Multiple Indentation*, Journal of Materials Research, 22, (2007), 1043-1063.

Silicon Carbide Electronics for Electrical Energy Generation, Storage and Utilization

PI: Michael Dudley, SBU

Silicon carbide (SiC) is a wide bandgap semiconductor with exceptional physical properties that make it highly suitable for electronic and optoelectronic devices operating under high temperature, high power, high frequency and/or strong radiation conditions. SiC-based electronics and sensors can operate in hostile environments (600°C) where conventional silicon-based electronics (limited to 350°C) cannot function. Performance gains from SiC's exceptional properties offer economically large performance benefits to the aircraft, automotive, communications, power and spacecraft industries. Complete realization of the potential of such SiC-based devices will directly impact the need for materials capable of operating under extreme environments, improve electrical energy storage and efficient solid state lighting; three critical areas identified by the Department of Energy for addressing future energy requirements. Over the past 15 years, our research group has worked on a number of sponsored projects devoted to control and elimination of defects that degrade the performance and reliability of SiC power devices through understanding the fundamental nature and behavior of defects, their influence on material properties and their effect on device performance. Availing the advanced characteriza-

tion facilities at SBU and BNL and working in close collaboration with crystal growth, process modeling and device fabrication groups, considerable reduction in crystal defects and near elimination of micropipes, a "killer defect," as well as capability of growing large substrates has been achieved. We continue to develop novel approaches to enable wide scale adoption of SiC to pressing energy technologies (DOE, DOD, NSF, NASA).



Publications:

- M. Dudley, J. Bai, X. Huang, W. M. Vetter, G. Dhanaraj, B. Raghethamachar, "Synchrotron white beam X-ray topography, transmission electron microscopy and high-resolution X-ray diffraction studies of defects and strain relaxation processes in wide band gap semiconductor crystals and thin films," *Mater. Sci. Semicond. Proc.* (2006), 9(1-3), 315-322.
 G. Dhanaraj, X. R. Huang, M. Dudley, V. Prasad, R.-H. Ma, "Silicon carbide crystals. Part I. Growth and characterization," *Crystal Growth Technology* (2003), 181-232, Springer-Verlag, Berlin, Germany.
 Q.-S. Chen, V. Prasad, H. Zhang, M. Dudley, "Silicon carbide crystals. Part II. Process physics and modeling," *Crystal Growth Technology* (2003), 233-269, Springer-Verlag, Berlin, Germany.

Free Cooling of Data Centers

*PIs: Tom Butcher, SBU and BNL,
Jon Longtin, William Worek, SBU*

Modern data centers can contain hundreds or thousands of computer servers that produce considerable heat. These machines, however, can often be comfortably run with ambient room temperatures upwards of 90 to 100°F or more. At the same time, considerable electrical energy is consumed by maintaining the room at traditional temperatures of 68 to 72°F. This project is directed at implementing an evaporative cooler for data center cooling. By using evaporative cooling rather than traditional expansion cooling, HVAC energy loads can be reduced substantially while still providing an adequate ambient environment for the computers within the data center. The project involves installing a modern, high-efficiency evaporative cooler on



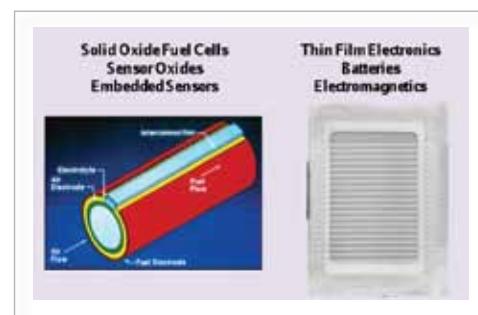
a data center in southern California, and then monitoring energy use compared to the traditional HVAC equipment currently installed. This project is led by Brookhaven National Laboratory, with Stony Brook University as a partner. (DOD ESTCP)

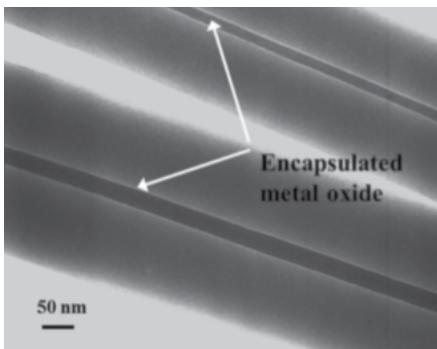


PFI: Partnership for Innovation in Thermally Sprayed Systems: Enabling New Applications Through Advanced Processing Science

PIs: Sanjay Sampath, Chris Weyant, T.A. Venkatesh, Yacov Shamash, SBU, and Srikanth Gopalan, Boston University

This NSF-funded Partnerships for Innovation (PFI) project brings together a small business-academia innovation team to capitalize on emergent opportunities in thermal spray (TS) deposition of functional oxides for applications in high temperature sensing and electrical energy conversion systems. The common goal amongst the PFI projects involves understanding the process-material-functional property relationships in TS functional oxides. This will be accomplished through advanced TS particle diagnostics and models, process maps and advanced characterization. Concurrent consideration of business issues (value-proposition analysis) will be incorporated via stage gage models. The broader impacts are numerous. Successful consideration of TS in sensors and energy systems will enable wide ranging opportunities in thick film devices, mesoscale electronics, photocatalytic surfaces etc. It has the potential to bring down manufacturing costs and provide scaling for fuel cell and batteries enabling their wide spread utilization. (NSF)





TEM image of as spun nanofibers showing metal oxide nanorods encapsulated within polymer

Tailored Nanoceramics Through Electrospinning for Energy Applications

PI: Perena Gouma, SBU

Mo₃ and W₃ nanoceramics were synthesized by understanding the effects of precursor parameters on the electrospinning process. Polymer based composites with molybdenum and Tungsten oxides were synthesized by varying the polarity of electrospinning process and the structures were studied upon thermal treatment. The nanostructures obtained were in the form of nanowires, nanotubes and nanogrids; the formation of these nanostructures could be related to their initial solution parameters. The formation of nanowires was due to the encapsulation of the metal oxide into a core-shell polymer matrix; a reverse configuration of polymer being encapsulated by metal oxide was observed by reversing the polarity of the process which led to the formation of nanotubes upon thermal treatment. The formation of nanogrids was due to immiscibility of the metal oxide particles into the polymer solution.

The nanostructure obtained find applications in the field of energy generation. Mo₃ and W₃ have band gap of 2.82eV and 2.76eV respectively and they tend to be good candidates for applications in solar cells. Mo₃ have also been used as anodes for Li-ion batteries where the higher surface area to volume ratio of nanowires and nanotubes results in higher charge capacity. (NSF)



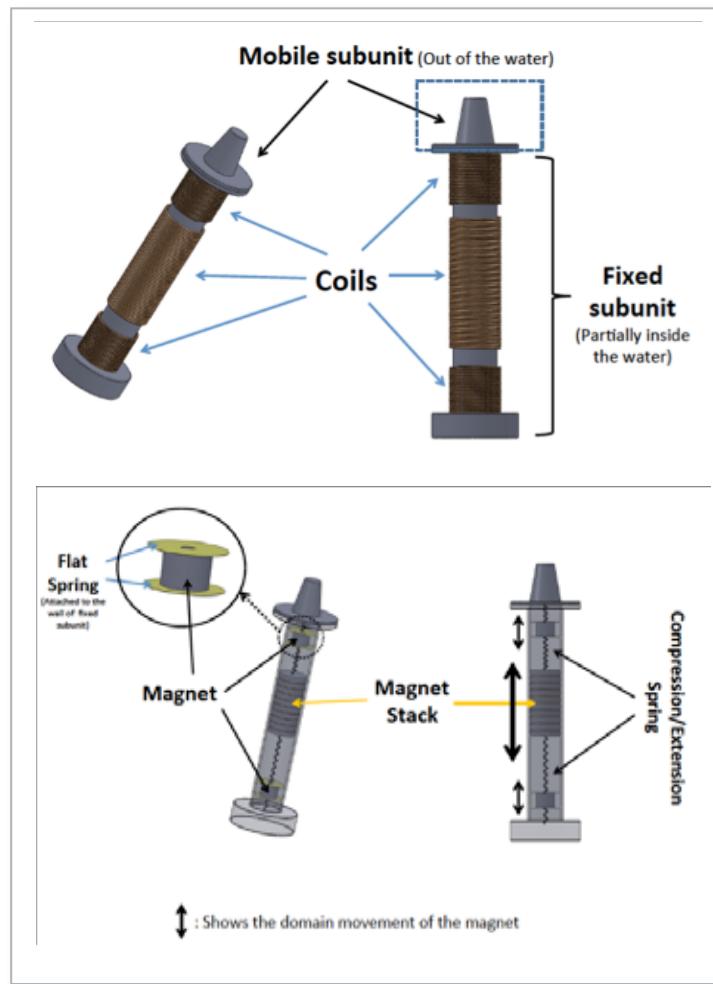
Ocean Wave Energy Harvesting: A Triple Axial Linear Generator

PI: Ya Wang, SBU

Providing a tremendous and remarkably untapped source of energy, random ocean waves and currents have a natural aptitude for energy scavenging. The benefits associated with the use of this technology are as follows: the highest energy density among renewable energy sources, minimal negative environmental effects, and maximized daily energy production in comparison to other alternative energies (e.g. solar energy). This project seeks to manufacture an axial linear generator, which may be used to convert the energy of low fre-

quency ocean waves into electrical energy. The new design of this energy converter contains three linear generators to effectively improve the energy-producing efficiency and output power of the device. In the United States alone, the potential for harvested energy from ocean waves is estimated to be 255 TWh per year, i.e. 6% of the total energy demand in the U.S. (Energystics, Ltd.)

Energystics, Ltd.

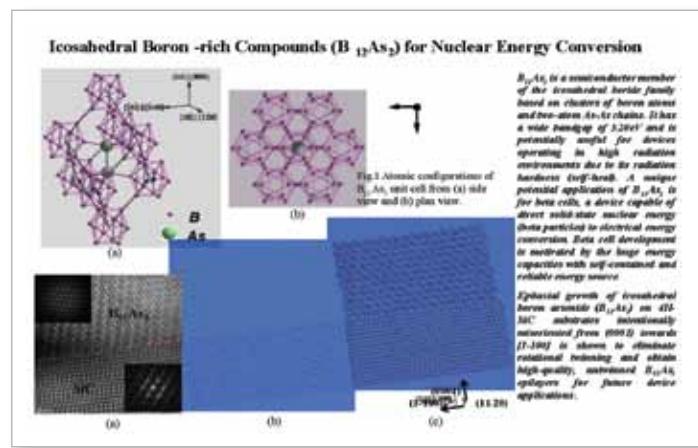


Icosahedral Boron-rich Compounds for Nuclear Energy Conversion

PI: Michael Dudley, SBU

Icosahedral boron-rich compound semiconductors such as boron arsenide ($B_{12}As_2$), boron carbide (B_4C), boron phosphide ($B_{12}P_2$) are stable refractory materials that display distinctive electrical transport and radiation hardness properties that is related to their unusual atomic structure and bonding. This family of borides are of interest for radiation hard, high temperature and high power electronic devices. Of particular interest is the development of novel energy conversion devices where the unusual strength of the icosahedral structure and its self healing properties can be exploited for the direct conversion of nuclear radiation to electricity. Such beta cells function similar to solar cells where beta particles emitted by a radioactive source is employed in place of solar radiation. In collaboration with Kansas State University and University of Bris-

tol, UK, a comprehensive program has been established to characterize the fundamental properties and study the relationship between the processing, structure, composition, and properties of these boride semiconductors, so their potential applications as beta cells as well as thermoelectric converters and neutron detectors may be realized (NSF Materials World Network).



Publications:

- H. Chen, G. Wang, M. Dudley, Z. Xu, J. H. Edgar, T. Batten, M. Kuball, L. Zhang and Y. Zhu, *Single-crystalline $B_{12}As_2$ on m -plane (1100) 15R-SiC*, *Appl. Phys. Lett.*, 92 (2008) 231917.
H. Chen, G. Wang, M. Dudley, L. Zhang, L. Wu, Y. Zhu, Z. Xu, J. H. Edgar and M. Kuball, *Defect structures in $B_{12}As_2$ epitaxial layers grown on (0001) 6H-SiC*, *J. Appl. Phys.*, 103 (2008) 123508.

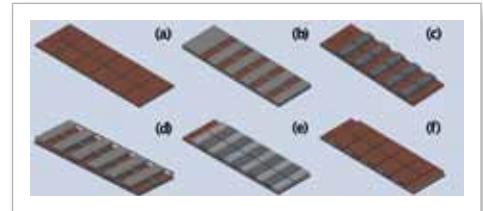
Innovative Approach for Low-Cost High-Volume ThermoElectric Device Manufacture

PIs: Jon Longtin, and David Hwang, SBU

Vehicle transportation is responsible for 65% of the annual oil consumption in New York State, yet less than 30% of the fuel energy is converted into mechanical power in a vehicle, with the balance lost as waste heat. Significant progress has been made in the past ten years to recover vehicle waste for electricity production by using solid state thermoelectric (TE) devices, with 5–10% fuel savings reported. Despite the promise of thermoelectric materials, however, the high-volume manufacturing of TE devices represents a severe bottleneck for widespread adoption of such devices for commercial applications on vehicles and in industrial settings. In this project, we are developing concepts for an innovative manufacturing solution to overcome these technical bottlenecks and to develop marketable, cost-effective TE generators (TEGs) by directly fabricating the functional TE layers onto exhaust

pipes in a rapid, economical, and industrially scalable manner.

The approach is based on recent progress developed by our team at SBU to develop TEGs fabricated directly onto exhaust and waste-heat components. The technology is based on thermal spray and laser micromachining for non-equilibrium material synthesis of bulk materials (filled skutterudites and magnesium silicides), thermal spray direct write of thick films and laser micromachining for feature patterning to fabricate TEGs directly onto waste heat components. In contrast to traditional state-of-art TEG technologies based on prefabricated modules, our manufacturing process will eliminate epoxy binding and mechanical clamping and thus can significantly increase the durability of the TEG, while reducing manufacturing cost and energy use. Such direct-integrated



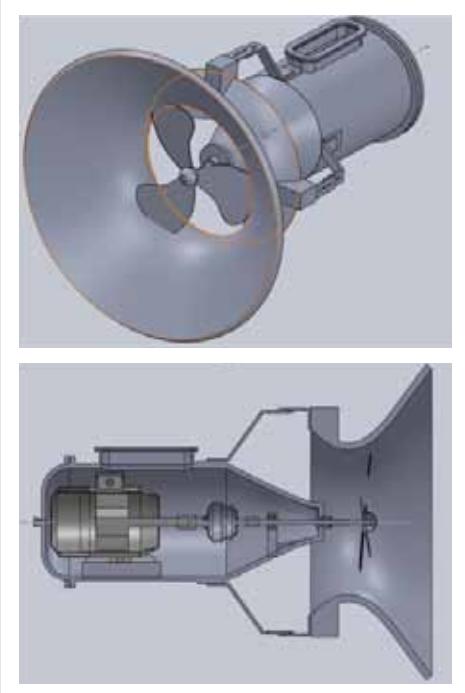
TEGs can also reduce the time of material synthesis and device processing from weeks to hours or less through its inherently scalable manufacturing process. Our developments can also be extended to other applications, such as electricity power plants (fossil and nuclear), diesel locomotive engines and ship engines. The project includes a series of inter-related manufacturing tasks that will be explored over a 12-month period. (NYSERDA)

nyserda
Energy. Innovation. Solutions.

Vertical Axis Hydroelectric Power Harvesting

PI: Ya Wang, SBU

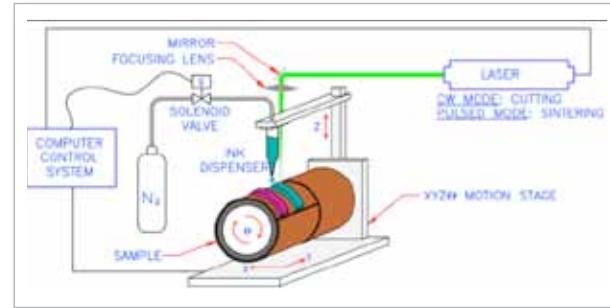
This project is developing a new class of low-head hydroelectric power with already measured efficiencies of 55% at 1 kilowatt and 61% at 5 kilowatts (see graph below). Its ideal application is within a piping system, a USA market of likely municipal 12.684 gigawatts (based on calculations of District Meter Areas and population), but its design principles can be put to use in the 40 GW of low-head hydro identified in topic 18a and regular hydro as well. By providing a complete system in a package in which the water is concentrated into the enclosure of a pipe or conduit, it has the potential to be fish-friendly by use of a filter and to be less costly in terms of money and space. In addition, it may enable better control of efficiency. We therefore have a system that is responsive to the subtopic, and offers best-in-kind access to markets beyond those considered in the 40 GW. (Flower Turbine Inc.)



Integrated Additive Manufacturing and Laser Micromachining to Fabricate Thermoelectric Devices Directly onto Waste-Heat Components

PIs: Jon Longtin and David Hwang, SBU

The emphasis of this feasibility study is to develop concepts to fabricate thermoelectric generators directly onto engineering components using additive manufacturing. The approach takes an innovative variation of additive manufacturing, called Laser-Sintered Ink Dispensing (LSID), to deposit thermoelectric materials in paste form under robotic control onto arbitrarily shaped surfaces. LSID eliminates epoxy binding and mechanical clamping and thus can increase the durability of the TEG, while reducing manufacturing cost and energy use. A laser is then used to sinter the paste into a rugged solid form. The laser can also provide material removal, allowing for a single, integrated system capable of additive and subtractive manufacturing. The program will build on our previous experience using additive manufac-



turing and laser micro-machining for thermo-electric device fabrication. LSID is inherently scalable and the technical findings in the proposed research can be extended to other applications, such as power plants (fossil and nuclear), diesel locomotive engines, and ship engines. (NYSERDA)

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Energy Innovation Solutions

RESEARCHER PROFILE



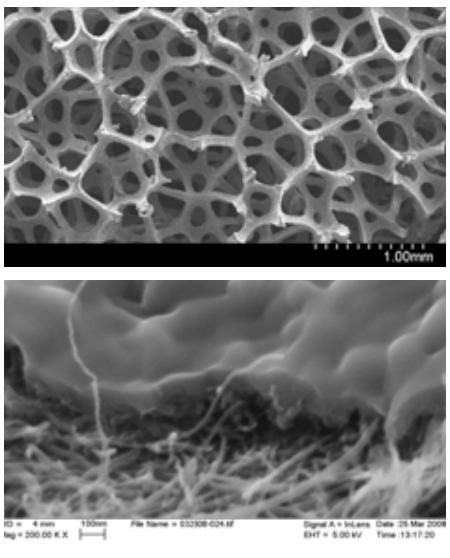
Energy Projects:

- Energy Harvesting
- Sustainable Nanomaterials
- Sensors, and Actuators

Ya Wang, Assistant Professor, Department of Mechanical Engineering, Stony Brook University

Awards and Honors:

- ASME, SPIE Smart Structures/ NDE Conference Session Chair, 2014
- ASME, IDETC Conference Session Chair, 2014
- ASME, SPIE Smart Structures/ NDE Conference Session Chair, 2013
- ASME SMASIS Best Hardware Competition Award 2012
- ASME, SPIE Smart Structures/ NDE Conference Session Chair, 2012
- ASME, SPIE, AIAA member, 2007 - date



High Performance Supercapacitors Based on Carbon Nanomaterials

Pl: Vladimir Samuilov, SBU

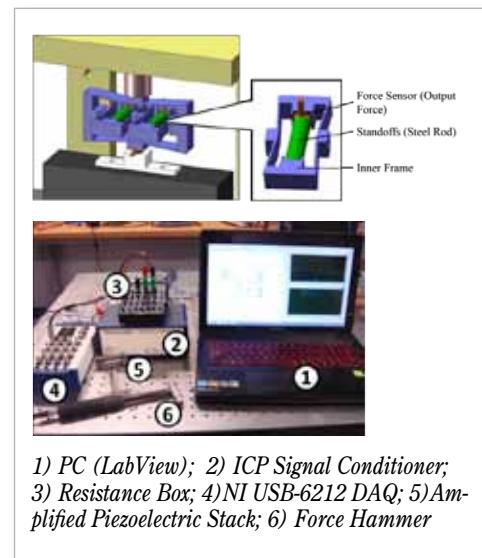
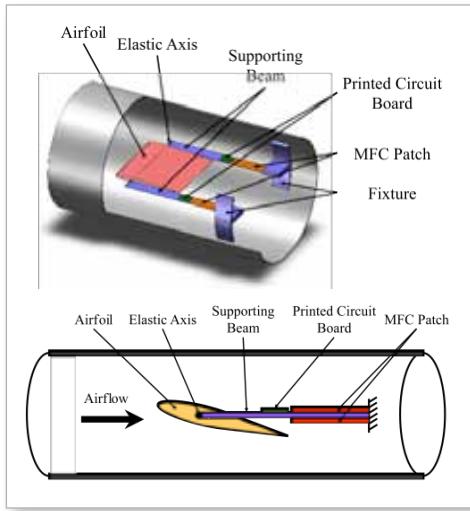
Supercapacitors exhibit great potential as high-performance energy sources for a large variety of potential applications, ranging from consumer electronics through wearable optoelectronics to hybrid electric vehicles. This research project focuses on carbon nanomaterials, especially carbon nanotube films, graphene oxide and 3-D graphene, due to their high specific surface area, excellent electrical and mechanical properties. We have developed a simple approach to lower the equivalent series resistance by fabricating electrodes of arbitrary thickness using a highly concentrated solution of carbon nanotubes and reduced graphene oxide based composites. Besides the problem of increasing the capacitance, the minimization of the loss tangent (dissipation factor) is marginal for the future development of the supercapacitors. This means not only a very well developed surface area of the electrodes, but the role of the good quality of the porous separator and the electrolyte are very important. Our project addresses these factors as well. (SBU, BNL, Graphene Labs, Lomiko)



Hybrid Piezoelectric and Electrodynamic Energy Harvester

Pl: Ya Wang, SBU

In recent years, the studies on piezoelectric energy harvesting have extended to harvesting energy from the aeroelastic vibration of airfoil systems, known as piezoaeroelastic energy harvesting. This project aims at developing a hybrid piezoelectric and electrodynamic energy harvester to provide a self-sufficient power supply for smart air-conditioning damper controllers. The unique design of this hybrid harvester involves two flexural bimorph piezoelectric cantilever beams with a rigid airfoil tip mass of plunge and pitch degrees of freedom. The chord direction of the airfoil tip mass is designed to be along with the airflow direction to avoid aerodynamic interruption. The span direction is designed to be along with the width direction of the air duct to have as larger a span length as possible. Electric energy is induced near flutter speed via piezoelectric transducers under combined aerodynamic (plunge and pitch motion) and vibrational loads of duct airflows. (DOT)



High Power Density Portable Piezoelectric Energy Harvesters

Pl: Ya Wang, SBU

Piezoelectric multilayer stacks, a vibration-to-electric energy conversion mechanism, have been used for energy harvesting from ambient vibration source in recent years. The main problem of using the piezoelectric stacks for energy harvesting is that the low amount of energy is harvested under direct loading conditions due to the high stiffness of the piezoelectric stacks. The objective of this project is to investigate and develop a high-efficiency light-weight portable piezoelectric energy harvester, capable of harnessing several watts of electricity from the backpack motion or dynamic stepping force, 100-1000 times more than the state-of-the-arts piezoelectric harvesters, to meet the critical power demand for soldier's electronic devices. Such a piezoelectric energy harvester can be a stand-alone device that sits at the bottom of a regular backpack under the load or acts as a convenient electrical source when the soldier steps on or presses it. (ONR and SUNY Sustainability Program)



Publication:

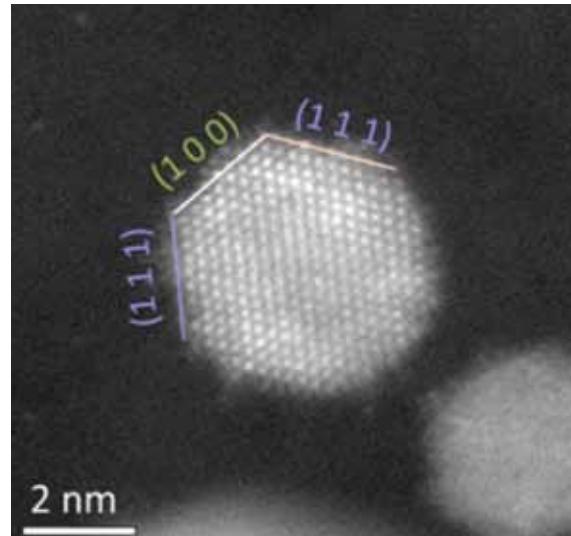
Wang, Y., Chen, W., and Guzman, P., 2014, *A new amplified stack energy harvester: design, modeling, and experiment*, Journal of Intelligent Material Systems and Structures, In Publication.

Structure and Function in Electrocatalysis of Reactions for Direct Energy Conversion

PI: Radoslav Adzic, BNL

Our work will continue studies of platinum monolayer electrocatalysts, their electronic and structural properties to address the long-lasting challenge of shifting the reaction to potentials close to the thermodynamic reversible values. Selective adsorption of fluorinated chain molecules will be used to decrease the H₂O activity on Pt, increase the O₂ concentration and splitting the O-O bond ("dry cave" effect). Onion-structured nanoparticles with new cores of multiple metal layers can facilitate reaching this goal, as indicated by our DFT calculations. A broad study of enhanced kinetics and reaction mechanisms of the oxidation of alcohols (methanol, ethanol) on Pt monolayers under tensile strain will be intensified. Modifications of Pt surfaces will be studied to achieve CO₂ reduction beyond COH or CO species at Hads potential, which is 0.8 V smaller overpotential than that of other catalysts. Studies of ordering at the core-shell

interface to increase stability and activity of electrocatalysts will be continued, as well as the design of the micro-reactor for electron microscopy studies of catalysts. Nitrating non-noble components of core-shell catalysts will be explored to increase their catalytic activity and stability. By kinetic modeling and computational methods, we will obtain deeper insight into the kinetics and mechanisms of the O₂ reduction reaction and alcohol oxidation. The success of this work will greatly contribute to resolving the major problems of electrocatalysis. (DOE)



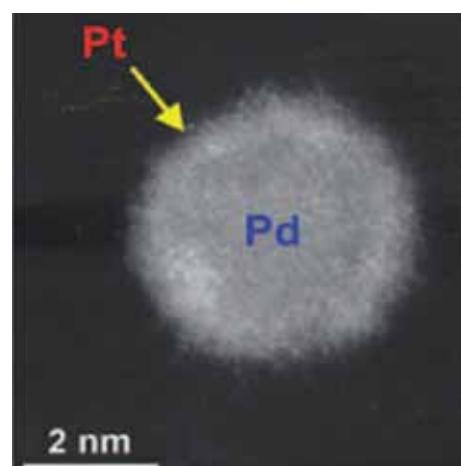
High resolution image of a platinum monolayer on faceted palladium nanoparticle catalyst for oxygen reduction at fuel cell cathodes

Contiguous Platinum Monolayer Oxygen Reduction Electrocatalysts on High-Stability Low-Cost Supports

PI: Radoslav Adzic, BNL

The research program will focus on increasing activity and durability of the catalysts, reducing the PGM contents, and simplifying scale up syntheses. Pt monolayer deposited on nanoparticles of selected size, composition, structure and shapes including nanowires and nanorods containing very small or no PGM metals. New concepts and methodologies in designing core-shell catalysts will be studied. These include: 1) electrodeposition for catalysts syntheses to obtain several types of core shell catalysts including W -Ni alloys, yttrium and other refractory metals and 2) hetero-layered core structure, for tuning the effect of core on a Pt monolayer shell. The latter will be obtained from non-aqueous solvents, as well

as underpotential deposition (UPD) of several reactive metal monolayers. Improving stability of cores will be accomplished using ordered intermetallics and nitrated non-noble metal cores. We will explore graphene oxide as support for a Pt monolayer or core nanoparticles. We will also address the Grand Challenge in Electrocatalysis, i.e. approaching with the hydrogen / oxygen fuel cells.1.23V. (DOE)



Platinum monolayer on palladium nanoparticle catalyst for oxygen reduction at fuel cell cathodes



Effective Cleaning of the Mexican Gulf Oil Spill by Ceramic Nano-catalysts

PI: Perena Gouma, SBU

Stony Brook researchers have synthesized novel self-supported 3D ceramic nano-catalysts (nanogrids) for the decomposition of oil in water using solar energy. Oil constituents can be carcinogenic and do not decompose (biodegrade) on their own. The ceramic nanogrids will be used for the fast and efficient remediation of medium crude oil in salt water, as is the case for the oil spill in the Mexican Gulf that is dangerous to polluting the shoreline. The oil will break down to carbon dioxide, water, and water-soluble organics because of the interaction of the nanogrids with the sunlight. These ceramic nanogrids are prepared by the synergy of two processes: a) the electrostatic spinning of non-woven mats of polymer fibers on metal foils; and b) a heat-treatment allowing the metal to diffuse into the polymer fibers taking on their shape and to further oxidize forming the nanogrid structure. Sunlight will activate the nanogrids to catalyze the breaking down of oil constituents, such as benzene, to environmentally benign chemicals, thus facilitating economic, fast, and effective water remediation. (NSF)



Publication:

J. Lee and P.I. Gouma, *Tailored 3D CuO Nanogrid Formation*, *Journal of Nanomaterials*, Volume 2011 (2011), Article ID 863631.

Nanomaterials for Clean Energy Applications

PI: Gary Halada, SBU

To truly understand interaction between the environment and natural and human-made materials, it is essential to understand reactions at the nanoscale. It is at this level, from single molecules to ultrathin films on surfaces, that structural and chemical transformations first occur which affect critical environmental processes, such as corrosion of advanced alloys, association of hazardous waste with soil or buildings and transformation of radioactive materials by microbes. Likewise, by exploring the electron transfer processes which occur at the surface of catalytic nanoparticles and the nature of the association of organic molecules with the surface of nanoparticles, we can design new, safe and inexpensive processes for forming nanomaterials for energy and biomedical applications. To accomplish these goals, we build interdisciplinary partnerships within the University, with other colleges and research groups, with industry and with Brookhaven National Laboratory. The current focus areas of our research include:

- 1) Development of a 'green' electrochemical method for synthesizing robust catalytic metal nanoparticles and nanocomposite surfaces for energy and biomedical applications (patent pending).
- 2) Development of novel radioactive cleanup technologies which take advantage of the ability of polysaccharide-based composites

to capture and retain radionuclides and other toxic metal ions.

- 3) Characterizing the interaction of toxic metals with biomacromolecules to better understand the nature and fate of mixed waste. We also recognize the critical need to help build the next generation of researchers and engineers in nanotechnology for energy and other areas of strategic national need.

Hence, through the support provided by the National Science Foundation and the College of Engineering and Applied Sciences, we have created the Nanotechnology Studies program. This program involves faculty from multiple departments at the University to provide a research-intensive, multidisciplinary minor for undergraduates from all academic majors to learn about the science and real-world applications of nanotechnology. A Research Experience for Undergraduates (REU) site in 'Nanotechnology for Energy, Health and the Environment,' which operates in conjunction with the program, has so far supported the research experiences and professional development of more than 40 undergraduates from 18 institutions. By creating these opportunities, we hope to help build a research community and workforce to apply nanoscale technologies in energy and other critical areas. (DOE, NSF)





Laser-based High Efficiency Separation of Rare Earth Materials

PI: David J. Hwang, SBU

Rare-earth materials have strategic importance for the advanced devices in a variety of sectors including optoelectronic devices and electric/hybrid vehicles. Recently, extracting these elements from ores in a cost-effective and environmentally benign method become critically important due to bottleneck in its supply chain and has been recognized as national crisis in terms of high technology business and security. Laser processing can be the breakthrough to this end since laser beam is able to volatilize the material and/or introduce photochemical effects to increase both the yield and selectivity of separation and extraction processes. Since the laser separation method corresponds to solvent-free, dry process, it can bypass chemical use and waste disposal issues. Based on the preliminary evaluation of the technical feasibility by conducting parametric studies of a model material system using various processing parameters, current focus of the project is in demonstrating stable and high throughput processing towards pilot level system. (KITECH, Korea)



Publications:

- [1] K.T. Kang, J.Y. Hwang, D.J. Hwang, *Laser-based high efficiency separation of rare earth materials*, KITECH-US Industrial Technology R&D Collaboration Forum, US-Korea Conference on Science, Technology and Entrepreneurship, NJ, USA (2013).
- [2] Y.S. Rho, D. Hwang, K.T. Kang, *Laser ablation of rare earth material containing glass and investigation of stoichiometry change*, Submitted to Journal of Applied Physics (2014).

Novel Nanomaterials and Nanostructures for Air and Water Quality Control

PI: Alexander Orlov, SBU

Development of nanoscale materials and products has become a major area of investment on a global scale with substantial number of products already on the market in this size range. Novel applications of nanoparticles in medicine, cosmetics, personal care products, materials science, energy production, information storage and electronics are just a few examples of the significant progress made in this field. For a long time the primary motivation in developing the nanoproducts had little to do with environmental applications. However, recent developments have led to the creation of a new area – environmental nanotechnology. Water pollution control, groundwater remediation and air quality control are all set to benefit from the latest advances in development of nanomaterials-based membranes, absorbents and catalysts. Our group is focused on utilizing the unique properties of such materials for both water and air quality control.

- 1) Development of nanoparticle modified catalysts for a complete degradation of pollutants in both air and water
- 2) Development of high surface area materials (such as mesoporous molecular sieves) for oxidation of Volatile Organic Compounds (VOCs)
- 3) Development of light-activated catalysts for indoor air quality applications



Publications:

- Orlov, A., Klinowski, J.K. *Oxidation of VOCs by SBA-15 mesoporous molecular sieves modified with manganese*, *Chemosphere*, 74, (2009), 344-348.
- Orlov, A., Jefferson, D., Tikhov, M., Lambert, R. M. *Enhancement of MTBE photocatalytic degradation by modification of TiO2 with gold nanoparticles*, *Catalysis Communications*, 8, (2007), 821-824.

Long Island Climate Resilience Index

PI: Guodong Sun, SB

This project develops an index framework, Climate Resilience Index (CRI), that assesses the resiliency characteristics (e.g., robustness, redundancy, resourcefulness), and resiliency performance (e.g., response, and recovery) to future climate extremes of five subsystems: the economic, environmental, governance, infrastructure, and social. By comparing the change in CRI, it can measure the impacts of infrastructure investment on community vulnerabilities. In the first Phase, we will apply this index framework to the infrastructure subsystem of Long Island. But the framework is designed so that it can be applied to all the five subsystems of New York State or one of its regions (e.g., Long Island, New York City, or up state). (HUD)

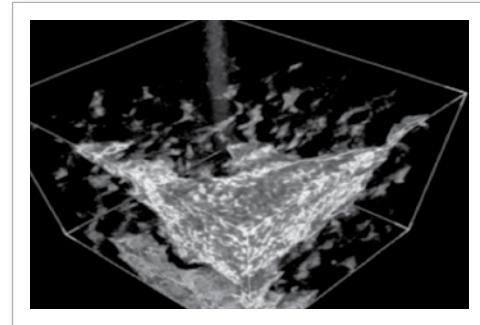


Sediment-hosted Macro Formation Mimics and Imaging Methane Hydrate Growth at Microscale Using Computed Tomography: Potential Implication in Climate Change

PIs: Devinder Mahajan, Prasad Kerkar, Tadanori Koga, Keith Jones and Miriam Rafailovich, BNL and SBU

Sequestering CO₂ as hydrates in geological formations is of interest to cap CO₂ levels in the atmosphere. To make the sequestration process more cost efficient, an idea was proposed to store CO₂ as hydrates while simultaneously extracting valuable energy fuel CH₄ from naturally existing CH₄ hydrate reservoirs beneath the ocean floor and permafrost. Currently, work is focusing to develop further understanding of hydrate formation at the micro scale. X-ray computed micromicrography (CMT) holds potential for revealing reservoir topologies and intricate oil or gas frameworks since it is a non-invasive, non-destructive tool that gives an accurate map of X-ray absorption variation within a sample. An X-ray CMT technique at the beamline X2B, National Synchrotron Light Source (NSLS) and Brookhaven National Laboratory (BNL) is be-

ing used to image the replacement of methane hydrates hosted in porous media with CO₂. The focus will be on establishing the effect of mass transfer area and gas-liquid volume ratio on hydrate saturation. The scope of work includes a set of experiments to study CH₄ release from CH₄ hydrates by injection of gaseous CO₂ in the CO₂ hydrate stability regime. The accompanying changes in pore water, capillary effects and host sediment stiffness are some of the issues to establish. The host sediment stiffness is probably one of the crucial parameters to establish to ensure seafloor stability. A successful outcome of the proposed effort is a pathway to supplant our energy supply by extracting CH₄ from hydrates while simultaneously sequestering CO₂ to offset its release into the atmosphere. (SBU, BNL)



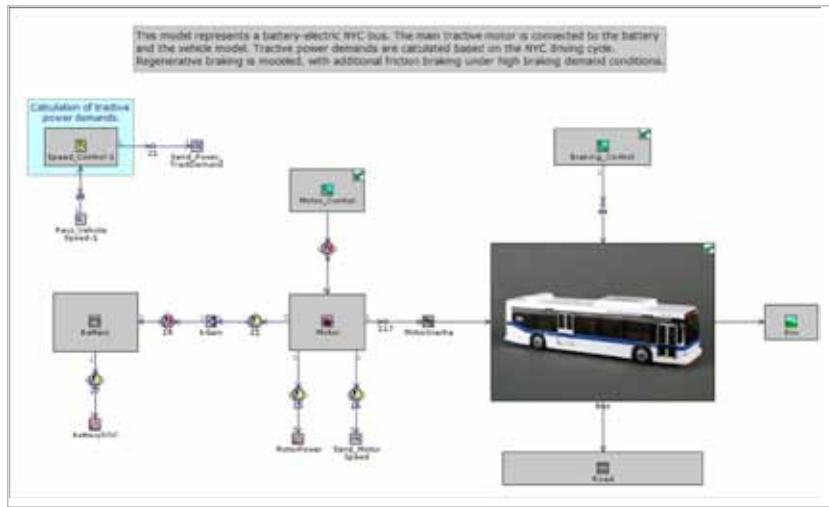
Publication:

P. Kerkar, KW. Jones, R. Kleinberg, W.B. Lindquist, S. Tomov, F. Huan and D. Mahajan, 2009. *Direct observations of three dimensional growth of hydrates hosted in porous media.* Appl. Phys. Lett. 95: 024102.

Design Optimization of Electric Buses for MTA New York City Fleets

PI: Sotirios Mamalis, SBU

In an effort to reduce petroleum consumption and gaseous emissions, MTA is interested in replacing current diesel and hybrid diesel-electric buses with electric ones. It is expected that by utilizing electric buses, MTA can reduce its carbon footprint as well as suppress operating and maintenance costs. Stony Brook University is partnering with Unique Technical Services LLC to provide to MTA optimized designs for different New York City routes. Electric bus design is based on data collection from existing buses, simulation and analysis, as well as prototype construction and testing. Optimal designs



account for battery pack sizing, traction motor and drivetrain selection, and auxiliary systems use. (UTS, NYSERDA, MTA)

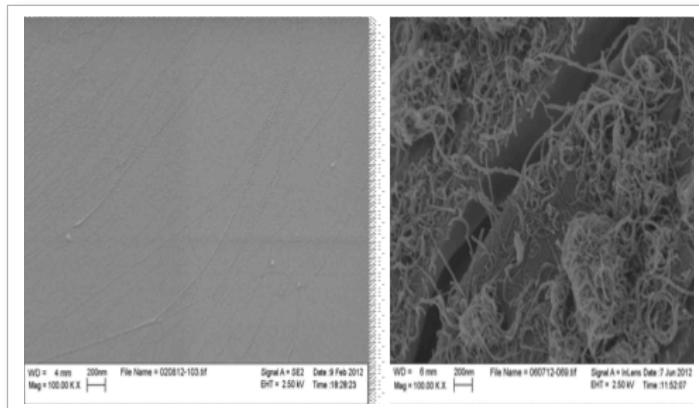


Developing a New Generation of Sustainable Polymer Nanocomposites for Energy and Consumer Applications While Addressing Consumer Safety Issues

PI: Alexander Orlov, SBU

Producing a new generation of polymer nanocomposite materials can revolutionize transportation and energy issues by delivering superior performance (mechanical, thermal and others) while reducing weight and environmental impact. However, there is also a concern from the consumer point of view about safety of nanomaterials. This research program addresses

both aspects in a holistic way. Firstly, we develop new approaches in incorporating more sustainable nanomaterials into polymers to achieve an outstanding performance in various industrial applications. Secondly, we develop novel methods in studying stability and toxicity of encapsulated nanomaterials leading to better design strategies for nanocomposites. (NSF)



Publication:

Ging, J., Tejerina-Anton, R., Ramakrishnan, G., Nielsen, M., Murphy, K., Gorham, J., Nguyen, T., Orlov, A. *Development of a conceptual framework for evaluation of nanomaterials release from nanocomposites: environmental and toxicological implications*, Science of Total Environment, 473-474, 9-19, 2014.

Creating Self-cleaning Air Purifying Surfaces for Urban and Energy Applications

PI: Alexander Orlov, SBU

Creating nanostructured surfaces, which can remain self-cleaning and air purifying, is now becoming a reality. In this project, which involves industrial collaboration with the NY based company, we work on testing performance of catalytic coatings, which can potentially transform urban environment by making it cleaner, more energy efficient. It can also improve public health by removing numerous air pollutants. In addition, it can also create self-cleaning solar cells, which has the potentially to substantially improve their efficiencies. The coatings have already been applied on numerous buildings both in Europe and the US. (DOT)



Cleaning Environmental Contamination by Utilizing Novel Membranes, Adsorbents and Catalysts

PI: Alexander Orlov, SBU

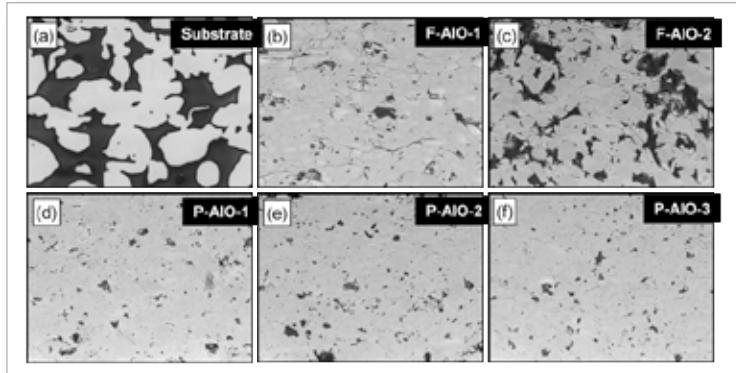
Understanding environmental impact of materials and using materials to minimize environmental impact are two important aspects of materials science to solve environmental challenges of this century. In this project we use several approaches in removing pollutants from gas and liquid phases. We create a new generation of porous materials to serve as adsorbent and catalysts support to eliminate various pollutants from environmental media. In addition, we work on new generation of ceramic membranes, which can filter out various dangerous contaminants from drinking and waste water. Finally, we work on us-

ing photocatalysts to transform hazardous materials into non-toxic ones. (NSF)



Publication:

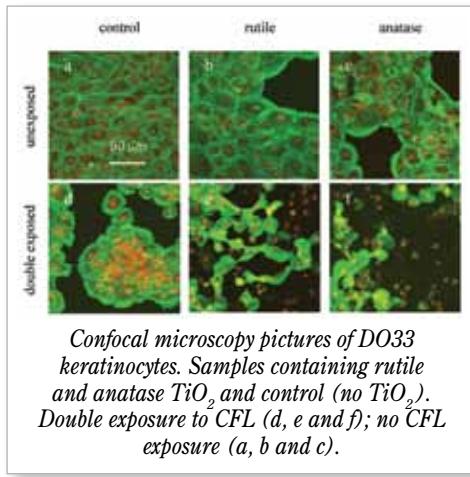
Zhao, S., Su, D., Che, J., Orlov, A. *Photocatalytic properties of TiO₂ supported on SBA-15 mesoporous materials with large pores and short channels*, Materials Letters, 65, 3354–3357, 2011.



TiO₂ in Combination with Energy Saving Compact Fluorescent Light Bulbs Exposure May Cause Skin Cells Damage

Pls: Miriam Rafailovich, Tatsiana Mironava, Michael Hadjigyrou and Marcia Simon, SBU

Compact fluorescent light (CFL) bulbs are gaining in popularity since they use less energy. However, CFL exposure was found to promote adverse skin conditions. The CFL bulb exposure and combination of CFL irradiation with TiO₂ nanoparticles, common ingredient of skin care products, has been investigated on human skin cells. The ultra-violet light outcome from the different CFL bulbs was measured and used for dermal fibroblasts and keratinocytes irradiation. Cells exposed to the CFL exhibited a decrease in the proliferation rates, collagen contraction ability and increase in migration and ROS. Selected nanoparticle dosage had no effect on cell function in the absence of CFL exposure whereas cells containing anatase died after just a single CFL dose. Cells containing rutile were completely destroyed following a second



dose. That indicates potential damage to skin tissue upon exposure to CFL lighting and that TiO₂ nanoparticles may exacerbate the damage. (NSF)



RESEARCHER PROFILE



Alexander Orlov, Associate Professor, Material Science and Engineering Department, Stony Brook University. Associate Professor, Consortium for Interdisciplinary Environmental Research, Stony Brook University. Affiliate Professor, Chemistry Department, Stony Brook University. Affiliate Professor, Institute for Advanced Computational Science, Stony Brook University.

Awards and Honors:

- National Academy of Science Kavli Fellow, US, 2014
- National Science Foundation CAREER Award, US, 2013
- National Academy of Engineering (NAE) U.S. Frontiers of Engineering, 2013
- Fellow, Royal Society of Chemistry, UK, 2012
- National Endowment for Science, Technology and the Arts CRUCIBLE Award, UK, 2005

Energy Projects:

- Sustainable Hydrogen Production
- Clean Fuel Production
- Sustainable Polymer Nanocomposites
- Ceramic Membranes

Environmental Fate of Pollutants

PI: Alexander Orlov, SBU

The nature of contaminant interactions with mineral surfaces is of primary importance for understanding the fate of those contaminants in the environment. It is also of critical importance for designing the technically feasible remediation strategies, which will protect environmental quality and human health. Our research includes studies of interactions of environmental pollutants, such as chlorinated hydrocarbons, with mineral surfaces using a range of spectroscopic techniques, such as XPS, DRIFTS, Raman and IR spectroscopy, synchrotron based NEXAFS and others. These techniques can provide valuable information on molecular structure and chemical properties of contaminant interactions with environmental interfaces. We are also interested in studying the interactions of combustion related pollutants, such as SO₂ and NO₂ with naturally occurring or anthropogenically produced mineral aerosols. The interactions of SO₂, NO₂ and mineral surfaces are the emerging issue in the prediction of air quality in newly-developed industrial nations, particularly China where dust concentrations often exceed 150 µg/m³. The formation of sulfates and nitrates on particulates is also central to quantification of the radiative impact of these emissions. (NSF)



Publications:

- Orlov, A., Watson, D., Williams, F., Tihov, M., Lambert, R. M. *Interactions of 4-chlorophenol with TiO₂ polycrystalline surfaces: study of environmental interfaces by NEXAFS, XPS and UPS*, Langmuir, 23, (2007) 9551-9554.
 Gustafsson, R. J., Orlov, A., Griffiths, P. T., Cox, R.A., Lambert, R. M. *Reduction of NO₂ to nitrous acid on illuminated titanium dioxide aerosol surfaces: implications for photocatalysis and atmospheric chemistry*, Chemical Communications, 37, (2006), 3936-3938.

Catalysis for the Generation of Fuels

PIs: Mike White, SBU and BNL
and Jose Rodriguez, BNL

We have been working on aspects of fuel generation for the hydrogen economy. A key step in the production of hydrogen involves the use of steam to convert carbon monoxide obtained from natural gas or biomass into hydrogen and carbon dioxide by a catalytic process known as the water-gas-shift (WGS) reaction. The WGS process is energy intensive and Rodriguez and White are investigating novel materials that have high catalytic activity at reaction temperatures lower than that possible with today's best commercial catalysts. The new catalysts are composed of small metallic nanoparticles (Au or Cu) supported on a reducible metal oxide (CeO_2 , TiO_2) with each component playing a unique but synergistic role in the WGS process. Work performed at BNL has shown that the active phase of these materials corresponds to metallic Au or Cu and not the metal oxides as previously proposed. The use of ceria (CeO_2) was also shown to yield the most active WGS catalysts, which is partly due to the ease in which oxygen atoms can be removed from the surface of the catalyst. Continuing studies are focused on understanding more about the influence of particle size and reaction conditions on catalyst activity, the unusual activity of Au nanoparticles and the development of an atomic scale mechanism for the WGS reaction process. (BNL)



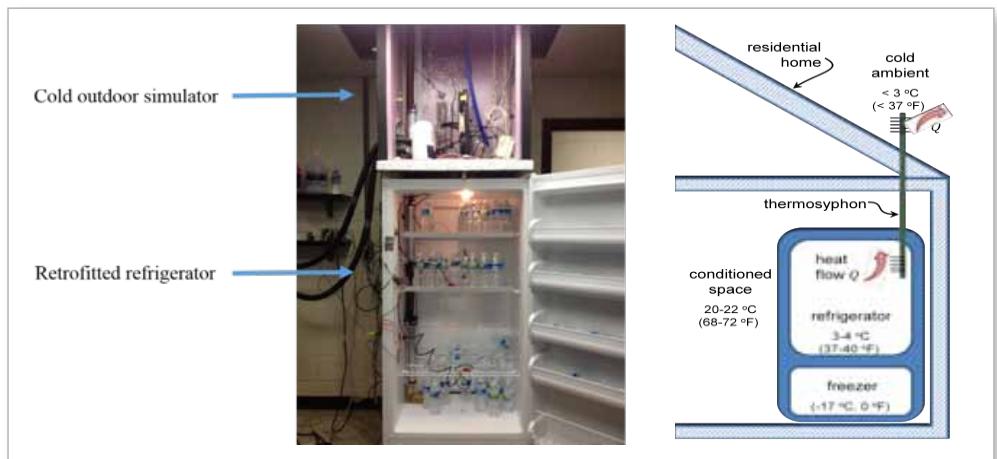
High Efficient Refrigerator Using Cool Outside Temperatures

PI: Jon Longtin, SBU

U.S. households consume >150 billion (B) kWh of electricity per year for residential refrigerators. In many parts of the U.S., however, the outside temperature falls below the 37–40 °F refrigerated-space temperature for several months out of the year, particularly in the northern half of the country. A natural choice is to use the low outside temperatures for cooling to reduce electricity usage for residential refrigerators. This project uses thermosyphons to provide a low-resistance heat transfer path from the refrigerated space to the cold outside. A thermosyphon is simple in construct and design, consisting of a hollow tube that has been evacuated and filled with a working fluid. The tube is oriented vertically and heat is added at the bottom of the device in the evaporator, vaporizing the working fluid and causing it to rise to the top of the device. Heat is removed in the condenser at the top of the device, causing the vapor to condense onto the pipe wall. The liquid flows back down the sides to the evaporator by gravity. The thermosyphon has several key features that make it ideally suited for improving residential and commercial refrigeration applications:

- Minimal temperature difference: since the device uses the latent heat of phase change, significant heat flows can occur with a very small temperature difference (3-4 °F) across the device, making it behave much like a thermal superconductor.
- Heat transfer in one direction only: the thermosyphon is the thermal equivalent of an electrical diode or fluid check valve. Heat only flows when the bottom region of the device is hotter than the top, due to the fact that there is no working fluid under normal conditions in the top of the device. Thus, when the outside temperature is warmer than the refrigerator space, the device simply stops working; heat will not flow back into the refrigerated space. No other control is needed.

A testbed is now being developed to test a residential refrigerator unit with a simulated cold-climate ambient. (DOE MaxTech, BNL Seed Grant, USB)



Exploring Unique Properties of Sub-nanometer Metal Particles to Produce Hydrogen from Water and Sunlight

PI: Alexander Orlov, SBU

Developing sustainable methods of hydrogen production can have significant environmental and energy efficiency benefits. A potentially viable way forward is to produce hydrogen from water by combining solar energy and heterogeneous catalysts. Our group has discovered that sub-nm metal particles can provide an enormous enhancement in photocatalytic hydrogen production under visible light. We have observed 35-50 times increase in activity for hydrogen production due to the presence of the metal clusters. The first-principles calculations of unsupported clusters indicated that there is a substantial difference in both shape and electronic properties between a function of cluster charge and surface composition conducted by our collaborator Dr. Yan Li at BNL. We believe that that our results are the first ever demonstrations of the remarkable potential of these small clusters for sustainable hydrogen production. (SBU)



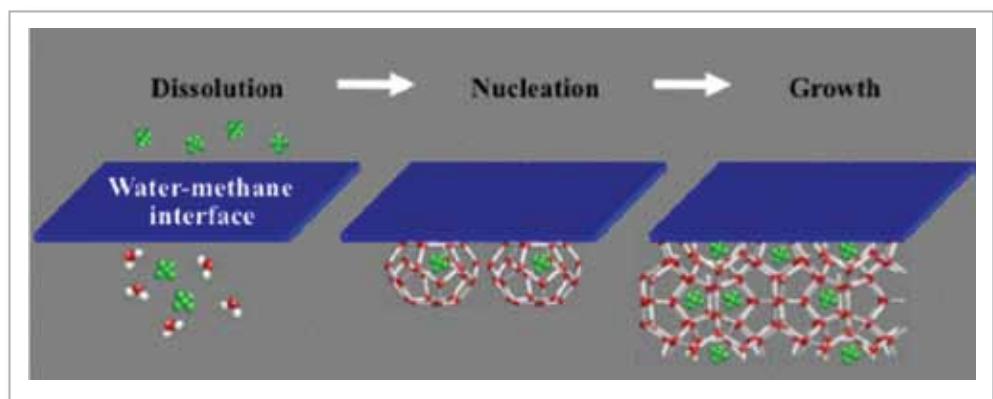
Publication:

Shen, P., Zhao, S., Su, D., Li, Y., Orlov, A. *Outstanding activity of sub-nm Au clusters for photocatalytic hydrogen production*, Applied Catalysis B: Environmental, 2012.



Photocatalysis for Solar Fuel Generation

PIs: Peter Khalifah and Mike White,
SBU and BNL



We are at the center of a thrust to develop materials that can harness the sun's energy for the efficient production of hydrogen fuel via solar water splitting ($2 H_2O + \text{light} - 2 H_2 + O_2$). The pressing challenge is to use visible light efficiently (>50% of terrestrial solar energy) to drive this photoelectrolysis reaction. Random material searches have resulted in the discovery of a handful of promising materials, which can utilize visible light to split water, but with very low overall efficiencies. Higher efficiencies can only be achieved with better materials and a better understanding of light-driven water splitting mechanisms. A joint SBU-BNL team has been assembled to tackle these challenges comprehensively. Prof. Khalifah will coordinate the effort to synthesize perfect surfaces (crystals and thin films) of complex oxide-based materials, while Prof. White will coordinate studies of the molecular reactions that occur at these surfaces. The synthesis efforts will integrate Stony Brook's J. Parise

(Geosciences), A. Oganov (Geosciences) and M. Dawber (Physics) together with BNL researchers J. Rodriguez (Chemistry), I. Bozovic (CMPMS), G. Gu (CMPMS), and W. Han (CFN). Characterization efforts at SBU will include A. Orlov (MSE), M. Fernandez-Serra (Physics), P. Stephens (Physics) and Lars Ehm (Geosciences/NSLS) while those at BNL revolve around the efforts of E. Fujita (Chemistry), S. Lymar (Chemistry), J. Muckerman (Chemistry), M. Newton (Chemistry), and M. Hybertsen (CFN). With these high quality samples and these detailed characterization efforts, it will be possible to achieve a more fundamental understanding of the relationship between the optical and transport properties of the bulk material and the effectiveness of water splitting reactions at its surface. (BNL)

BROOKHAVEN
NATIONAL LABORATORY

Theory and Computation for Semiconductor Catalysis and Solar Water Splitting

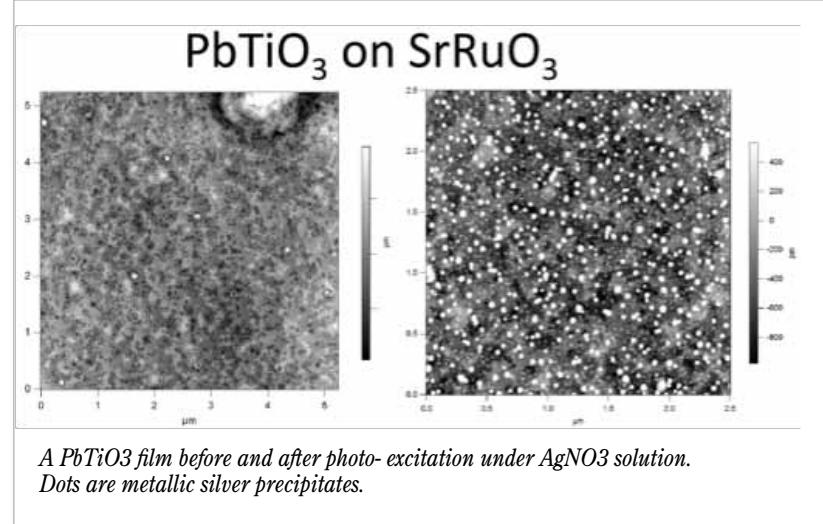
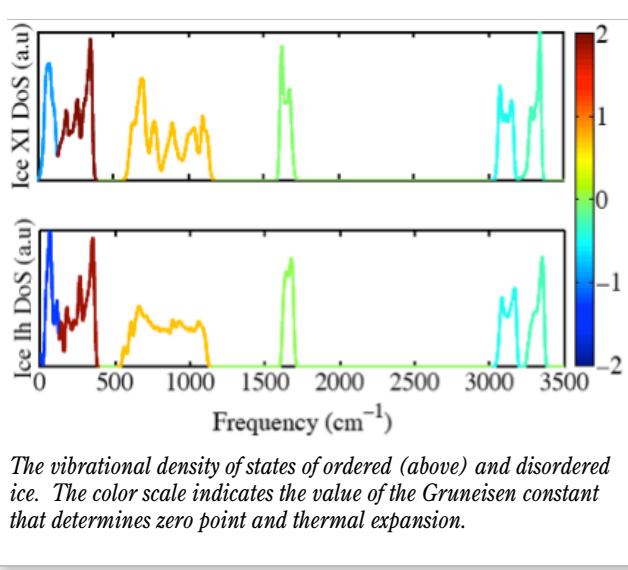
PI: Philip B. Allen, SBU

The aim is to improve theoretical understanding of processes by which solar energy can be captured at catalytic interfaces (e.g. the semi-conducting GaN/water interface) to drive the reaction $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$. Computation (primarily density functional theory) provides the method to simulate processes and to interact with experiment. This work also trains physics graduate students working at the interface between physics and chemistry. Our chosen material for study is the wurtzite-structure alloy of GaN with ZnO, apparently stable over the full concentration range x of $\text{Ga}_{1-x}\text{Zn}_x\text{N}_{1-x}\text{O}_x$. We study the structure and thermodynamics of the clean and the wet surfaces of this alloy. We ask how alloying affects the photo-absorption spectrum and carrier mobility. We study bulk and surface carrier traps and their importance for photo-catalysis. We generalize the USPEX evolutionary structure-predicting algorithms in order to predict thermodynamically relevant surface and interface structures. We study the perovskite-structure polar materials of the $\text{CaTiO}_3/\text{SrTiO}_3/\text{BaTiO}_3$ family. Their interfaces with water offer new ways to tune the photochemistry. We study pure wa-

ter and ice in order to improve the microscopic density-functional description (including van der Waals interactions) and to quantify the importance of quantizing the high energy vibrations (particularly the OH stretch.) We study thermal conductivity of these materials.

Example 1: Photocatalysis on perovskite superlattice surfaces. A graduate student, Benjamin Bein, funded by this project, works with Prof. M. Dawber growing ferroelectric films of PbTiO_3 and testing for photocatalytic activity using aqueous AgNO_3 solution. Weak ultraviolet illumination is used for a short time. The photo-holes cause water oxidation ($2\text{H}_2\text{O} + 4\text{h}^+ \rightarrow 4\text{H}^+ + \text{O}_2$) on the PbTiO_3 /water interface. The photo-electrons reduce the Ag^+ ions, which deposit as hemispheres of metallic silver on the PbTiO_3 surface. The volume of Ag deposited then measures the efficiency of oxidation. It is apparent that PbTiO_3 works well as a water oxidation catalyst under ultraviolet light. The value of this is, (1) band gap tuning by multilayering and alloying may enable visible light to be used. (2) Biasing the ferroelectric may tune the catalytic efficiency.

Example 2: Nuclear quantum effects in ice and water. The goal is to understand how quantized nuclear motions of the protons in water alter the physics, and in particular, the photochemistry. We previously explained the mechanism of the anomalous isotope shift of the lattice constant of ice, namely, D_2O ice has a larger lattice constant than H_2O ice. This happens because compressing the OH--O distance softens the covalent OH bond while strengthening the non-covalent H--O hydrogen bond. This softens the OH stretch frequency and makes the lattice prefer to shrink to maximize the advantage of reduced zero-point energy. Most crystals expand to reduce zero-point energy. The reversed sign anomaly is a specific signature of H-bonding, and gives both a nice monitor of zero-point effects and a computational challenge to test our ability to compute hydrogen-bonding. (DOE)



Economics and Economic Impacts of Offshore Wind Energy in Long Island

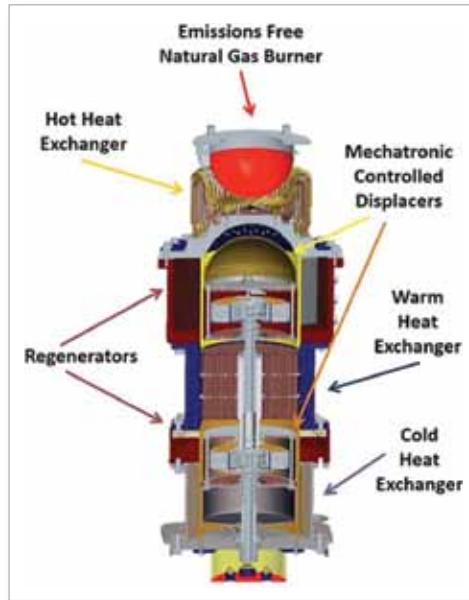
PI: Guodong Sun, SBU

Long Island is one of the regions with the highest energy costs. It is also close to several offshore wind sites with enormous potentials. They can bring major benefits to Long Island. New York Energy Policy Institute (NYEPI) conducts two assessments of offshore wind power in these contexts on Long Island. The first assessment is to evaluate the cost effectiveness of offshore wind power for Long Island's rate-payers relative to that of other new sources of energy. The second assessment is to quantify the economic development benefits for Long Island associated with offshore wind. (Funded by Deepwater Wind)

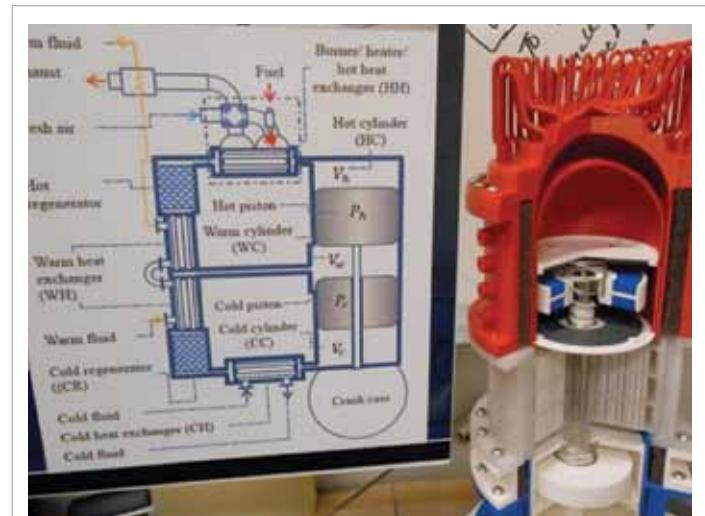


Analysis and Design of Heat Exchangers for a Vuilleumier Natural-Gas Driven Heat Pump

PI: Jon Longtin, SBU



Heat pumps represent an attractive means for residential heating. By moving heat from outside to inside the house, rather than producing heat directly by burning a fuel, heat pumps can result in significant energy costs. This project focuses on the design and analysis of heat-driven heat pump based on the Vuilleumier thermodynamic cycle. The device is driven by natural gas, oil or propane for residential home heating. The device can deliver 160% or more of the fuel consumed as heat to the home, in contrast to even the most efficient traditional heating systems that have a maximum value of 95%. This project focuses on the design of the heat exchangers for a next-generation Vuilleumier heat pump, as well as



modeling the overall thermal and mechanical device operation. (ThermoLift/DOE/NYSERDA)

Forced Flow Convective Baseboard for High Efficiency Energy Delivery

PIs: Tom Butcher, SBU and BNL,
Jon Longtin, SBU

This research project explores the feasibility of integrating a forced-air supply for common baseboard radiators to dramatically improve their performance when supplied with low-temperature water. This offers the potential to improve the annual efficiency of condensing boilers, solar thermal systems and hydronic heat pumps. While some concepts for fan-assisted radiators have been identified, they are expensive and noisy. This concept will allow market introduction of a low-cost product by program partner Slant/Fin Corp., the largest residential baseboard manufacturer in the U.S. The design envisioned involves a small air flow that injects air upward into the bottom section of a baseboard, inducing a larger flow of room air through the baseboard fins. The concept can be compared with some chilled beam designs and is also used



in the popular Dyson bladeless fans that recently came onto the market. The primary focus is on a new product, but the application to retrofit to existing baseboard will also be explored. The intended use is for heating but exploratory studies tests are planned to evaluate the technology for cooling applications as well. Minimum fan power

requirements will be identified and the potential for self-powering with heat from the hydronic loop will be explored in this research project. Project partners include Brookhaven National Laboratory (program lead) and Slant/Fin, Inc. (NYSERDA)

nyserda
Energy. Innovation. Solutions.

RESEARCHER PROFILE



Jon P. Longtin, Professor, Department of Mechanical Engineering and Visiting Scientist, Brookhaven National Laboratory

Awards and Honors:

- Licensed Professional Engineer in NY State (2012)
- Brookhaven Inventors Award for issued US Patents (2010 & 2011)
- R&D 100 Award for technology developed at SBU (2007)
- Licensed Innovation Award for technology licensed by a company (2005)
- Excellence in Teaching Award, SBU (1998)
- NSF Presidential Early Career Award for Scientists and Engineers (PECASE) (1997)

Energy Projects:

- Advanced Heating/Cooling
- Thermoelectric Power Generation
- Sensing, Diagnostics, and Data Analysis
- Natural Gas Monitoring and Storage

Electroactive Smart Air-Conditioner Vent Registers (eSAVER) for Improved Personal Comfort and Reduced Electricity Consumption

PI: Ya Wang , SBU

This project will develop an active air conditioning vent capable of modulating airflow distribution, velocity and temperature to create localized thermal envelopes around building occupants. SUNY Stony Brook's smart vent will modulate the airflow using an array of electro-active polymer tubes that are individually controlled to create a localized curtain of air to suit the occupant's heating or cooling needs. The team estimates this will result in upwards of 30% energy savings through directed localization of existing building heating/cooling output. (DOE)



Photovoltaic Cells

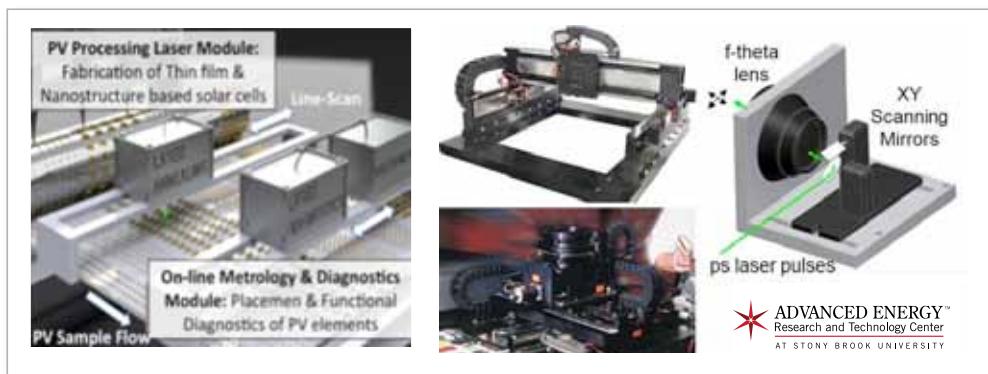
PI: Charles M. Fortmann, SBU

We have recently developed a detailed description of electronic transport in Dye-type solar cells. Dye-type solar cells based upon inexpensive layers of titanium oxide, electrolyte and organic dyes offer one of the best possibilities for meeting the need for vast areas of efficient solar cells in order to address the world's energy needs. The lack of a theoretical framework has stymied attempts to optimize this type of solar cells and exacerbated the venture capital's uncertainty in the push to develop a dye-type solar cell industry. Our approach may enable the Stony Brook group to leapfrog earlier efforts and help launch an era of industrialized dye-type solar photovoltaic energy. Our group is also investigating spectral modification for enhanced solar cell performance. All solar cells perform especially well over a narrow range of photon wavelengths. However, the solar spectrum is composed of a wide range of photon wavelengths. Even the best photovoltaic solar cells use only a portion of the solar spectrum. We are developing layers that could be used with a variety of solar cell types to help convert the solar spectrum to one that better matches the solar cell performance envelope. (Solar Physics Inc.)

[Solar Physics Inc.](#)

Publications:

- S. G. Chawda, J. A. Mawyn, G. P. Halada, C. R. Clayton, C.M. Fortmann. *Phononic Engineered Materials and Devices*, J. Non-Cryst. Solids, 354, (2008), 2548-2551.
- J. A. Mawyn, S. G. Chawda, G. P. Halada, C. R. Clayton, C. M. Fortmann. *Substrate Engineering for High Efficiency Thin Film Solar Cells*, J. Non-Cryst. Solids, 354, (2008), 2492-2494.



Laser-assisted Photovoltaic Manufacturing and Diagnostics

PI: David J. Hwang, SBU

Practical challenge in utilizing renewable solar energy is reducing the cost per watt and simultaneously improving conversion efficiency to compete with current fossil fuel technology. Our research has been focused on the development of laser-assisted current & next generation photovoltaic (PV) manufacturing and diagnostics technologies. Examples include back contact formation and edge isolation for bulk based PV's, advanced laser scribing and spectroscopic in-situ thickness monitoring for thin film based PV's and building integrated PV's, surface treatment of stainless steel substrate for cost-effective and flexible PV's, and direct synthesis of multi-bandgap nanomaterials of superior crystallinity and nanoscale surface structuring to achieve improved light trapping and photocurrent conversion efficiency for nanostructure based PV's and low-cost solid state lightening devices. Enhanced laser-induced field in nanostructures provides great selectivity in functionalizing arbitrary nanomaterials system and forming heterostructures in conjunction with the cost-effective scalable PV nanomanufacturing system development. The advanced diagnostics on light interaction with various PV elements have been demonstrated

through the near-field scanning optical microscopy (NSOM) technology and electron microscopes (SEM/TEM) coupled with pulsed laser illumination, offering nanometric/atomic spatial and sub-ps temporal resolutions. The laser-assisted manufacturing and diagnostics systems existing in Solar PV Laboratory, AERTC are compatible with wide range of PV and display systems at production compatible scale. (Yuco Optics and Yuco Photonics in NY State, Appliflex Inc, University of Utah, Posteel in Korea, Yeungnam University in Korea, Korea Institute of Science and Technology, Tokyo Institute of Technology)



Publications:

- T.W. Kim, D.J. Hwang et al., *Comparison of multilayer laser scribing of thin film solar cells with femto, pico and nanosecond pulse durations*, Proc. SPIE, 7409, 7409-10 (2009).
- [2] D.J. Hwang et al., *Nanoscale Laser Processing and Diagnostics*, Applied Physics A, 96(2), 289 (2009).
- [3] H. Pan, D.J. Hwang et al., *High-Throughput Near-field Optical Nanoprocessing of Solution Deposited Nanoparticles*, Small, Vol. 6, pp. 1812–1821 (2010).

Thin Film Solar Cells with Tunable Transparency

PIs: T. A. Venkatesh, SBU and Mircea Cotlet, BNL

Solar technologies are currently based on conventional solar cells made out of inorganic materials like silicon which are generally opaque. Organic semiconducting materials, including conjugated polymers, have been investigated as potential replacement materials for solar cells. Conjugated polymer-based organic photovoltaic solar cells have several attractive features such as being made of inexpensive materials by cost-effective processing methods like printing techniques, dip or spin casting, requiring low amounts of active material (around 100 nm thick layer) and being light weight and mechanically flexible. However, even at thicknesses of around 100 nm, these continuous thin films also tend to be quite opaque, restricting their application for integrated photovoltaics such as power-generating windows. In order to obtain transparent solar cells, recent efforts have focused on reducing the thickness of the active layer to less than 100 nm, which improves the transparency but drastically reduces the conversion efficiency of the solar cells. Hence, the overall objective of our research effort is to develop conjugated polymer based thin films with a novel micro-porous structure as active materials for solar cells with tunable transparency and good photovoltaic properties. (DOE)



Improvement in Manufacturing Process of mc-Si for Photovoltaic Solar Cells

PI: Michael Dudley, SBU

Solar energy technologies remain at the forefront of efforts to developing clean, reliable, renewable energy technologies. Rapidly increasing demand and concomitant silicon shortage have placed enormous importance on the yield of silicon-based photovoltaic solar cell production. Cast multicrystalline silicon (mc-Si) is the material of choice on account of its low production cost and comparable efficiency to crystalline silicon (c-Si). Working with BP Solar, we have focused on improving material quality and yield of mc-Si PV modules by evaluating the material at each stage of the manufacturing process. This includes the casting of multicrystalline ingots, bandsawing of ingots into bricks, wiresawing of the bricks into wafers and the cleaning, etching, passivation and printing of wafers. Synchrotron radiation-based techniques (at BNL), in conjunction with optical and electron microscopy are employed to carry out these studies. Through these studies, critical problems such as cracking and bowing of wafers that lead to loss of material and thus severely limit yield are being addressed. Novel characterization techniques being developed during the course of this project are being applied to other materials in energy related as well as other fields (NREL/DOE via BP Solar).



Developing Self-cleaning Glass for Solar Panels

PI: Alexander Orlov, SBU

The solar photovoltaics (PV) industry is experiencing a significant global growth. According to the European Photovoltaic Industry Association, the global PV capacity rose from 39.7 GW at the end of 2010 to more than 68 GW at the end of 2011. Capturing this growth in the US in general and in the NY State in particular can bring tremendous opportunities for energy independence, job creations and economic competitiveness. Increasing electricity output from the solar panels, even by few percents, can translate into billions of dollars in savings.

Developing self-cleaning solar panels can have a transformative impact on PV industry. Solar panel surface contamination (soiling) results in significant decrease in output and/or increase in maintenance costs. Some studies shown a decrease in solar cells output by 4 – 10 % on average in the first year of operation due to soiling. For example, the US based Solar Electric Power Association (SEPA) found that photovoltaic electricity output can decline by about 10% during the first year of operation due to accumulation of dirt, dust and other residues.

The project our group is currently working on can help to increase the PV output via two transformative solutions fitted within the supply chain:

- 1) coating solar panel glass before solar panel assembly to introduce self-cleaning properties;
- 2) treating the existing solar panels already installed in NYS to make them self-cleaning.

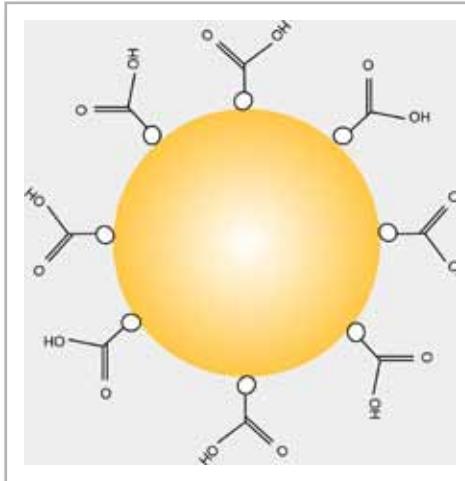
This novel approach can be tremendously beneficial in increasing energy efficiency of the existing and future PVs installations. (SBU)



Enhancing the Power Output of Polymer Electrolyte Membrane Fuel Cells (PEMFC) Through the Deposition of Monolayer Gold Nanoparticle Platelets onto Nafion® Membranes

PI: Miriam Rafailovich, SBU

In our experiment, thiol-functionalized spherical gold nanoparticles (around 2nm in diameter) were synthesized through the two-phase method developed by Brust et al. When a solution containing these particles was spread at the air/water interface, X-ray reflectivity and EXAFS spectroscopy indicated the formation of platelet shaped particles. Langmuir-Blodgett (LB) trough was then used to deposit monolayer of these platelet shaped gold nanoparticles onto the surface of Nafion® membrane. Up to 80% enhancement for output power of a single cell and 33% enhancement for three stacked cells were found after applying the modified Nafion® membrane on PEMFC. Effects of gold nanoparticles are studied by varying the surface pressure (to deposit gold nanoparticles onto membrane) and gases at cathode side. Cyclic voltammetry and oxygen reduction reaction activity will be



measured to further investigate the activity of this kind of gold nanoparticles. (NSF)



Nanoparticle Enhancement of Polymer Electrolyte Membrane Fuel Cell Power Output

PI: Miriam Rafailovich, SBU

PEM fuel cell technology is one of the most promising future alternative energy sources because it has relatively low-operating temperature, high-power density, quick response and pollution-free operation. However, its relatively low power output compared to that of its price has prevented it from many practical applications. Nanoparticles have been widely known to possess catalytic capabilities. Some predicted that gold nanoparticles that are platelet shaped and have direct contact to the substrate to be the “perfect catalysts, if they could actually be produced. We found that under the optimal flow rate of 0.1 SCFH, the addition of nanoparticles resulted in a more than 500% increase in the power output of the fuel cell. One major limitation of the current PEM technology is the reduction of power as the current is increased past a maximal value. Nanoparticle enhanced PEM membranes do not seem to have that limitation and no current maximum has yet been determined. Hence, the actual power enhancement at high current loads could actually be far greater than the quoted value. Further research is in progress to determine this limit and the specific catalytic reaction which is responsible for this increase. This advancement represents a major step in the production of PEM cells for commercial high power applications. (NSF-MRSEC)



Developing and Investigating the Chemical and Mechanical Aspect of Cu/Zeolite Catalysts for Selective Catalytic Reduction of NOx by NH₃ (NH₃-SCR)

P.I: Tae Jin Kim, SBU

Stringent environmental regulations of the greenhouse gases, such as NOx, emissions have driven extensive research in new and advanced functional materials. Recently, US Environmental Protection Agency (EPA) and Department of Transportation's National Highway Traffic Safety Administration (NHTSA) passed new regulations on fuel economy and emission standards. The enforced standards are 20mg/mile for NOx emission. NOx (NO and NO₂) are exhausts from automobiles (especially diesel cars, 95% NO and 5% NO₂) and stationary sources, such as power plants, during combustion of fossil fuels. Due to high activation energy barrier (364 kJ/mol) conversion of NO into non-toxic gases such as nitrogen and water, is very difficult even if the reaction is thermodynamically favorable ($\Delta G = -86$ kJ/mol). Thus, to decrease the activation energy, advanced heterogeneous catalysts design and different NO decomposition reaction pathways (selective catalytic reduction (SCR) and lean NOx trap (LNT)) should be developed. Zeolite supported catalysts (e.g., Fe- or Cu-ZSM5, SSZ-13, BEA, Y) and mesoporous materials (SBA15) are currently being used and have been extensively investigated for diesel car applications.

Our group has designed and constructed an apparatus to conduct a preliminary study of the SCR of NOx with standard zeolites (MFI, FAU, MOR and CHA) and supported zeolite catalysts. Based on the pore size, dimensionality, number of membered ring and oxidation state of surface species (Cu or Fe), we hypothesized significant differences in the conversion of NO and products selectivity during the SCR reactions. In addition to the zeolite structures, because water concentrations are critically affected on the catalyst deactivation, we also considered water vapor in an apparatus. Figure 1 (above) shows a schematic and installed system of the NOx treatment SCR reaction. To measure the converted gas products, FTIR spectrometer, which combined with a spectroscopic gas cell, has been used. Our research

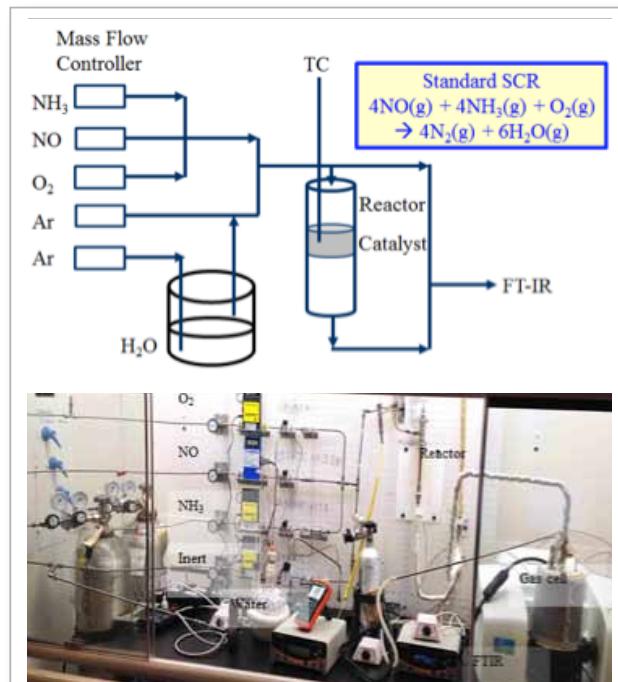


Figure 1. Schematic diagram of NH₃/SCR system

team has tested standard zeolite catalysts using the FTIR spectroscopic techniques and obtained very low (<10% NO conversion) catalytic activity, which was similar to previous reports. Using the Cu-SSZ-13, however, the maximum NO and NH₃ conversion shows of 91% and 90% respectively at 300°C. (Figure 2) This result suggested that our group successfully designed and constructed a set-up that could be used for the investigation of the SCR of NO with NH₃ and will continue to be used for further studies. Future studies to continue this work include further development of catalysts with several synthesis methods and analysis of intermediate species via the Operando study under a wider reaction temperature ranges. (SBU)

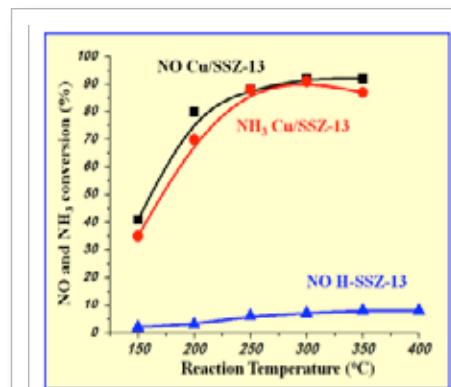


Figure 2. NO conversion versus temperature for Cu-SSZ-13 (square, black) and H-SSZ-13 (triangle, blue) catalysts. NH₃ conversion versus temperature for Cu-SSZ-13 (circle, red) is also shown.



Application of Nanometer and Sub-nanometer Particles for Clean Fuel Production

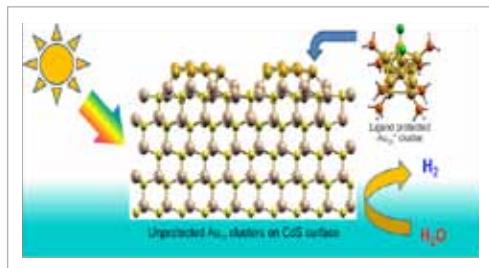
PI: Alexander Orlov, SBU

Nanotechnology can potentially resolve many energy challenges. By tuning the size of materials used in energy production, it is possible to achieve breakthrough in their performance. In addition, it is possible to employ a bottom up approach, whereby building nanoparticles from few atoms to hundreds of atoms we can create new catalysts with unprecedented performance. In this project we are using new approaches in creating a new generation of nanomaterials with sizes ranging from nanometers to sub-nanometers. They have achieved several orders of magnitude better performance than the traditional catalysts used for sustainable energy production. (NSF)



Publication:

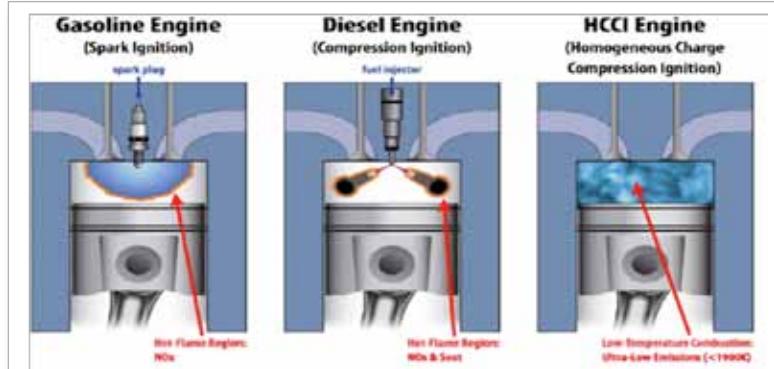
Shen, P., Zhao, S., Su, D., Li, Y., Orlov, A. *Outstanding activity of sub-nm Au clusters for photocatalytic hydrogen production*, Applied Catalysis B: Environmental, 25, 153-160, 2012.



Low Temperature Combustion (LTC)

PI: Sotirios Mamalis, SBU

Low Temperature Combustion (LTC) engines have the potential to provide solutions to continuously evolving fuel economy and emissions regulations. By increasing compression ratio, boost and diluting through air or exhaust gas recirculation, researchers have created novel concepts such as HCCI, RCCI and SACI. These engine concepts can achieve high combustion and thermal efficiencies while keeping cylinder temperatures low for NOx formation prevention. Research at the Internal Combustion Engines laboratory focuses on addressing some of the key challenges associated with advanced combustion engines, such as limited operating range, high pressure rise rates and instability. Addressing these issues will enable widespread adoption of advanced combustion engines by a range of light-duty to heavy-duty vehicles. (SBU)



Publication:

Mamalis, S., Babajimopoulos, A., Assanis, D., & Borgnakke, C. (2014). *A Modeling Framework for Second Law Analysis of Low Temperature Combustion Engines*. International Journal of Engine Research, September 2014, 15 (6), 641-653.

RESEARCHER PROFILE



Energy Projects:

- Advanced / Low Temperature Combustion
- Internal Combustion Engines
- Alternative Fuels

Research Focus:

- Advanced combustion and in-cylinder emissions control
- Computational Fluid Dynamics (CFD) simulations
- Single-cylinder engine experimental testing
- Low temperature combustion in free-piston engines,
- Lean natural gas combustion for medium-duty engines
- Sub-grid model development for CFD software

Development of Cost-Effective Technology for Biogas Purification

PI: David Tonjes and Devinder Mahajan, SBU

Biogas, primarily a mixture of CH₄, CO₂, N₂, H₂S, is a renewable source of methane (CH₄). Bio-methane extraction from biogas to make it pipeline-quality gas is of interest to electric utilities because renewable gas counts as CO₂-net neutral fuel and qualifies for carbon credits. This proposed study is focused on developing an economical method to produce clean methane from landfill gas. Our ongoing collaboration with the USDA-ARS center in Florence, South Carolina on biomass pyrolysis shows that the availability of biochar from pyrolysis could be an opportunity to remove unwanted elements that form biogas produced from landfills. The recovered bio-methane could potentially displace about 10% of the imported natural gas



used to produce electricity on Long Island. (Town of Brookhaven, NSF-CBERD)



Publication:
S. Patel, D. Tonjes, D. Mahajan. *Biogas Potential on Long Island, New York: A Quantification Study*. J. Renew. Sustain. Energy. 3, 043118 (2011); doi:10.1063/1.3614443

Development of a Flex Bio-Plant: Microemulsion-based Production of Bio-methanol and Bio-butanol from Biomass-derived Synthesis Gas

PIs: Devinder Mahajan, SBU, Scott Turn, U Hawaii, and Ponisseril Somasundaran, Columbia University

The slurry-phase MoS₂ catalyzed process to produce mixed alcohols shows that the system operates as a 4-phase system (catalyst/solvent/aqueous/gas) limiting mass transfer to produce mixed alcohols in low yields. The ongoing work envisions a microemulsion system in which the dispersed oil phase in water medium functions as a reservoir of nano-containers for the MoS₂ catalyzed reactions. The CO₂ in syngas, present in supercritical state under operating temperature and pressure, itself acts as the dispersed oil phase and is solubilized in a water medium using non-ionic surfactants. This would substantially enhance alcohol production rates through higher catalyst /gaseous reactant contact in the oil phase and excellent heat management through the dispersion medium. Also,

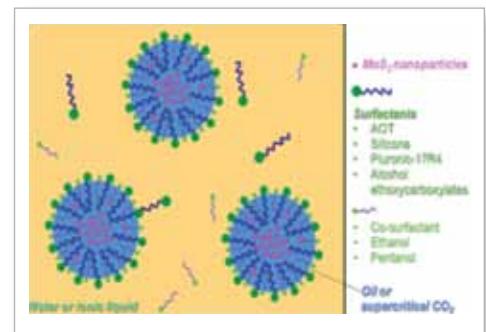
selective partitioning of heavier products in to the oil phase helps in reducing the downstream fractionation load of mixed alcohols. The proposed partnership brings together expertise of two NSF centers: the Center for Advanced Studies in Novel Surfactants (ASNS) is formulating MoS₂ containing microemulsions that can be stable under operating temperatures and pressures and CBERD is conducting tests to evaluate the prepared microemulsions for mixed alcohols. A successful system would achieve the CO conversion per pass from < 20% to > 50% making this pathway a potential commercial process. (NSF-CBERD, US ARMY)

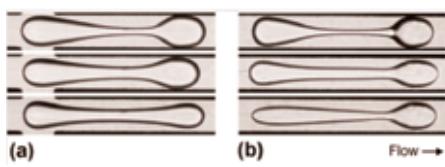


Technical and Evaluation Analysis of Advanced Strategies for the Energy Valorization of Biomass

PI: Devinder Mahajan, SBU

A nine-country (Spain, UK, France, Greece, Chile, China, Japan, Canada and USA) consortium, led by the Universidad Politécnica de Madrid (UPM), Spain, has been awarded four-year funding of €302,000 by the European Commission (EC) under the Marie Curie International Research Staff Exchange Scheme (Marie Curie IRSES). NSF is providing funding to the U.S. PI to interface with the EC consortium on a developing joint program in biomass conversion into fuels and chemicals. The key deliverables are personnel exchange and joint proposal development. (NSF)





Flow induced deformation of high-viscosity droplets translating in microchannels

Microflow of Highly Viscous Fluids: Mixing and Dissolution Processes

PI: Thomas Cubaud, SBU

We experimentally study viscous multiphase flows in transparent high-pressure microfluidic devices. Nanofabrication techniques allow for constructing complex flow geometries that can mimic fluidic networks encountered in nature, such as in trees, blood vessels, and porous rocks. Motivated by the development of techniques for controlling the structural and rheological properties of multi-fluid dispersions, research focus is on transport, diffusion, and capillary phenomena, including lubrication, droplet coalescence, and emulsification processes between low- and high-viscosity fluids at the microscale. A wide range of fluids is investigated, including those important to the energy sector, such as heavy oils, ethanol, and carbon dioxide to potentially discover new pathways for enhanced petroleum manipulations, continuous bio-fuel synthesis, and sequestration of greenhouse gases in porous networks. (NSF)



Publications:

- T. Cubaud, *Deformation and breakup of high-viscosity droplets with symmetric microfluidic cross flows*, Phys. Rev. E, 80, 026307 (2009).
- S. Darvishi and T. Cubaud, *Lubrication of highly viscous core-annular flows in microfluidic chambers*, J. Fluids Eng., 113, 031203 (2011).
- T. Cubaud, B.M. Jose, and S. Darvishi, *Folded micro-threads: Role of viscosity and interfacial tension*, Phys. Fluids, 23, 042002 (2011).
- R. Sun and T. Cubaud, *Dissolution of carbon dioxide bubbles and microfluidic multiphase flows*, Lab Chip, 11, 2924 (2011).

Heat Dissipation in Polymer Nanocomposites: Effect of Filler Size and Shape

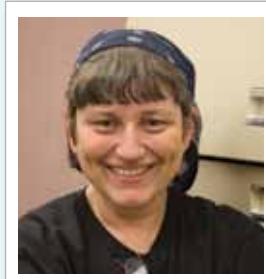
PIs: Miriam Rafailovich and Dilip Gersappe, SBU

In an effort to reduce the flammability of commonly used polymers with and create more fire safe materials, research is being done on the use of flame retardants within polymers. To date, not much is known about the physics and dynamics of this process. Simulating heat propagation in polymer nanocomposite systems may guide experimental flame retardant---and other thermal materials science---research. Using the lattice Boltzmann method (LBM), a model is developed in both two and three dimensions to simulate heat diffusion initiated by a finite heat pulse in a

multiphase system comprised of a polymer matrix and flame retardant nanocomposite fillers. By varying the volume fraction of the fillers, along with their thermal diffusivity, heat capacity and thermal boundary resistance with respect to the polymer, heat transfer in polymer composites is studied. We also vary the size, shape and thermal conductivity of the nanofillers to study the effect on heat dissipation and the time to ignition. (NSF)



RESEARCHER PROFILE



Energy Projects:

- Bioenergy and Biofuels
- Photovoltaic and Fuel Cells
- Combustion
- Nanotoxicology
- Environmental Sustainability

Miriam Rafailovich, Distinguished Professor, Undergraduate Program Co-Director (CME), Department of Materials Science and Engineering, AERTC Chief Scientist.

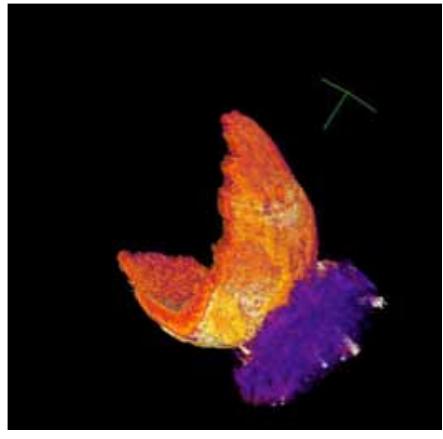
Awards and Honors:

- Lady Davis Fellowship
- Long Island Technology Hall of Fame Inductee
- SUNY Chancellors Award for Research in Science, Engineering, and Medicine (2007)
- Fellow, American Physical Society
- Siemens Foundation Recognition Award as Outstanding Mentor for the Westinghouse, Competition in Math, Science, and Technology

Turning Waste into Fuels, Soil Additives and Improved Construction Materials

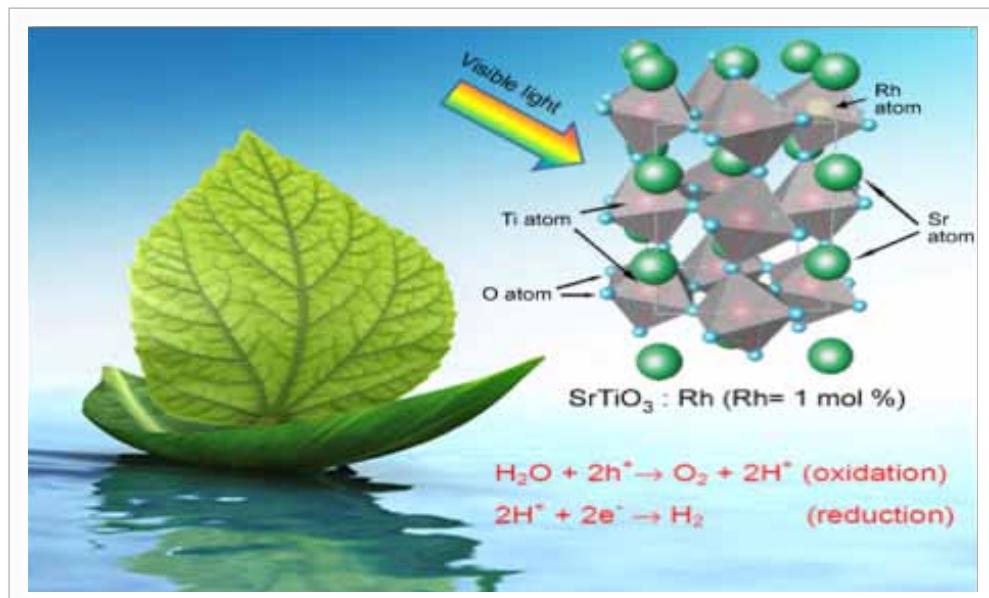
PI: Alexander Orlov, SBU

This project is focused on several innovative approaches on utilizing waste biomass to produce biofuels while using the byproducts of the process as soil improvement additive. We have utilized a synchrotron radiation source to understand the mechanisms of biomass pyrolysis by conducting X-ray tomography studies. We have also collaborated with USDA to understand how this technology can be used to improve soil quality, decrease pesticide runoff and reduce water requirements for crop irrigation. In addition to biomass utilization, we are exploring the innovative concept of using waste concrete to achieve removal of air pollutants from power station. This breakthrough technology employs a recently discovered chemistry of waste concrete, where we demonstrated how to achieve a complete removal of NOx and SOx, which are priority air pollutants originating from power stations held responsible for health problems of millions of people worldwide. (DOT)



New Biomimetic Materials to Produce Hydrogen from Water

PI: Alexander Orlov, SBU



The future of clean hydrogen fuel based economy relies on producing hydrogen in a sustainable way. Currently, most of hydrogen is produced from fossil fuels and therefore cannot be considered sustainable. This project utilizes composite catalysts to combine light and water to synthesize sustainable hydrogen. We use some of the most innovative characterization techniques at Brookhaven National Lab, which are combined with theoretical modeling and experimental systems to produce novel catalysts with performance close to DOE targets for water splitting. This project is funded by the White House Office of Science Materials Genome Initiative, which fosters close integration of theoretical methods with experiments to come up with novel materials with breakthrough performance. This collaborative proj-

ect with Prof. John Parise (Geosciences) and Prof. Artem Oganov (Geosciences) is supported by the NSF grant "High-Pressure Synthesis of Novel Oxynitride Photocatalysts Directed by Theory and In Situ Scattering. (NSF)



Publication:

Dharmagunawardhane, N., Woerner, H., Wu, Q., Huang, H., Chen, X., Orlov, A., Khalifah, P., Parise, J. *Photocatalytic hydrogen evolution using nanocrystalline gallium oxynitride spinel*, Journal of Materials Chemistry A, 2014, 2, 19247.

Developing Moderate Heterogeneous Catalytic Routs for the Conversion of Furan Derivatives into Chemicals and Liquid Hydrocarbon Fuels

P.I: Tae Jin Kim, SBU

The energy consumption data provides that global energy production and consumption rely heavily on coal for electrical power and oil for transportation fuels. However, concerns with depletion of fossil fuels, especially petroleum oil, fluctuating petroleum oil prices and environmental and political problems have led our society to search for renewable and sustainable energy sources, such as solar, wind, hydroelectric and biomass. Among them, biomass is the only source of carbon and liquid biofuels/chemicals that are considered carbon neutral since CO_2 is consumed by biomass regrowth. We fully analyzed the structure information of different biomass resources and standard lignocellulose compositions using the FTIR spectroscopic. (Figure 1) The investigated samples are considered as potential lignocellulosic resources for future biofuels production and biochemicals. To apply these resources as a new material, it is very important to understand a revolution of functional group during the catalytic and thermal decomposition reaction. We can successfully assign most fingerprint and functional group regions in the obtained infrared spectra and use them for further treated samples structure analysis. We have also investigated new chemical reaction pathways to produce a cost-effective biomass derived fuel and chemical. (Figure 2) We hypothesized that furfuryl alcohol oligomers can be used as an additive in fuel blending components and biodegradable plastics. In figure 2, Furfuryl alcohol (FA; $\text{C}_5\text{H}_6\text{O}_2$), which is industrially produced through conversion of furfural ($\text{C}_5\text{H}_4\text{O}_2$) derived from a selective dehydration of xylose ($\text{C}_5\text{H}_{10}\text{O}_5$), is one of the most important furan derivatives. Based on the preliminary experimental results, we expect several impacts on the current technology for the current biomass conversion reaction

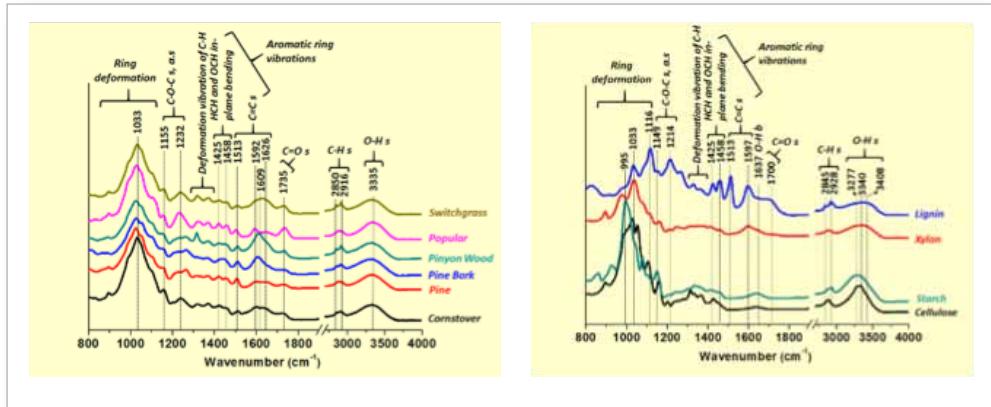


Figure 1. Infrared spectra of standard biomass resources.

into chemicals and fuels.

1. Improved and developed catalysts will provide alternative ways to produce important chemicals and fuels from biomass derived furan derivatives.
2. Optimize the best formula with easy commercialization of the biofuel technology will decrease the dependence on traditional fossil fuel.
3. In addition to catalytic activity and selectivity investigation, in situ or Operando technique will provide the relationship between the heterogeneous catalysts structure and catalytic activity. (SBU)

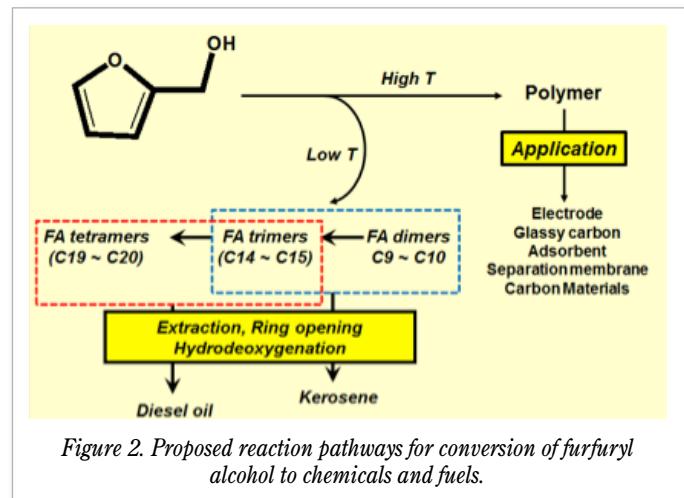


Figure 2. Proposed reaction pathways for conversion of furfuryl alcohol to chemicals and fuels.

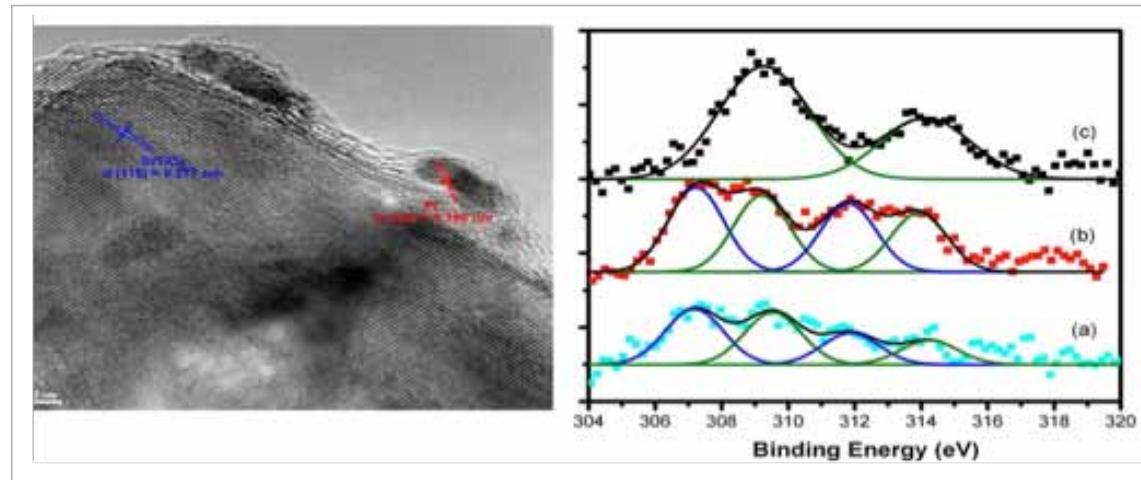
Publications:

- T. Kim, J. Jeong, M. Rahman, E. Zhu, D. Mahajan, Characterizations of Furfuryl Alcohol Oligomer/Polymerization Catalyzed by Homogeneous and Heterogeneous Acid Catalysts KJCE, (2014) Accepted.
 T. Kim Biomass-based Nanocomposites and Mesoporous Materials J. Nanotech Smart Materials (2014) 1-2.



Development of Novel Materials for CO₂ Conversions into Fuels

PI: Alexander Orlov, SBU



In this project, we are working to achieve a breakthrough and paradigm shift in how CO₂, a greenhouse gas, can be used to produce fuels. Nature achieves those conversions via photosynthesis by combining light, CO₂, and very sophisticated biochemistry. However, the

quantum efficiency of this process is rather low. In our project we mimic the natural photosynthetic processes by using inorganic catalysts with the eventual goal to make it more efficient than the naturally occurring processes. (NSF)



Publication:

Shen, P., Lofaro, J.C., Worner, W., White, M.G., Orlov, A. *Photocatalytic activity of hydrogen evolution over Rh doped SrTiO₃, prepared by polymerizable complex method*, Chemical Engineering Journal, 223, 200–208, 2013.

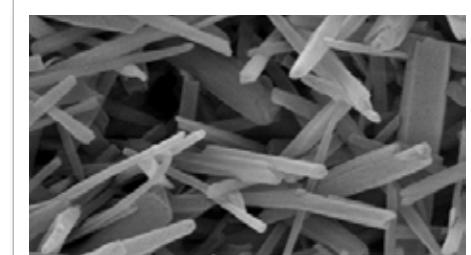
Engineering Flame Retardant Biodegradable Nanocomposites

PIs: Miriam Rafailovich and Chad Korach, SBU

Starch-based polymer blends can be a promising class of biodegradable nanocomposites. Despite their benefits, starch-based nanocomposites with thermoplastic polymers can be very brittle when sufficient amounts are added to obtain flame retardant properties. We have recently developed a new class of nanoparticles where resorcinol diphenyl phosphates (RDP) is used to modify the surface energy, allowing the particles to be easily dispersed within polymer matrices using melt blending. RDP modified starch and RDP modified clays, especially RDP-Halloysite Clay

tubes, can be extruded together with the biodegradable polymers, Ecoflex and polylactic acid (PLA) to produce flame retardant nanocomposites which can pass the UL-94-V0 test. Since the total amount of added particles is less than 10%, embrittlement is minimized. Nanomechanical measurements of the chars remaining, after cone calorimetric measurements, indicate that maintaining flexibility of the chars may be an additional factor in achieving good flame retardant properties. (NORA, BNL)

BROOKHAVEN
NATIONAL LABORATORY



Biomass Derived Furan/Furan Derivatives' Biofuel Products over Heterogeneous Catalysts

PI: Tae Jin Kim, SBU

Chemicals and fuels derived from lignocellulosic biomass are currently attracting attention and will serve as renewable source of carbon containing molecules. Although lignocellulose is one of the cheapest and abundant forms of biomass, due to its higher oxygen content, it is difficult to directly convert into transportation fuels. Mineral acids, such as H₂SO₄ and HCl, have been used to convert lignocellulose and furan derivatives into fuels and chemicals. However, due to the difficulty of catalyst separation and corrosion of reactor, the replacement of homogeneous catalyst to reusable heterogeneous solid catalyst is desirable. In addition to a heterogeneous catalyst development, it would require new catalytic route to improve the efficiency for conversion of biomass to fuels and chemicals. Our research group has been developing a novel pathway for Bio-kerosene and Bio-diesel oil from the biomass derived oxygenated chemicals; 1) Biomass-derived Furan Derivatives' Oligomer/Polymerization reaction 2) Hydrodeoxygenation (HDO) of Biomass Derived Oxygenates and Oligomers. In order to analyze the products, we have been using the most advanced spectroscopic techniques (in situ Raman, FT-IR and UV-vis) and analytical instruments (GC and GC/MS). We will continuously investigate and determine the product distributions of furan derivatives dimers (C9-C10) and trimer (C10-C15), and employed density functional theory to provide a qualitative confirmation of the experimentally observed oligomer distribution trends. (SBU)



Stony Brook
University

The overall objectives of our current research projects are:

- To produce biodiesel from furanic oligomers.
- To develop a novel heterogeneous catalysts which avoid a separation issue from product.
- To provide catalyst surface structure evolution and intermediate species by using the spectroscopic techniques.
- To develop thermochemistry and reaction mechanism based on the density functional theory (DFT) calculation (collaboration team: Argonne National Laboratory Theory Team).

Publications:

Taejin Kim, R.S. Assary, R.E. Pauls, C.L. Marshall, L.A. Curtiss, P.C. Stair, *Thermodynamics and Reaction Pathways of Furfuryl Alcohol Oligomer Formation*, Catal. Commun., 46 (2014) 66-70.

Taejin Kim, R.S. Assary, Hacksung Kim, C.L. Marshall, D.J. Gosztola, L.A. Curtiss, P.C. Stair, *Effects of solvent on the furfuryl alcohol polymerization reaction: UV Raman spectroscopy study*, Catal. Today 205 (2013) 60-66.

Taejin Kim, R.S. Assary, C.L. Marshall, D.J. Gosztola, L.A. Curtiss, P.C. Stair, *Studies of the Raman Spectra of Cyclic and Acyclic Molecules: Combination and Prediction Spectrum Methods*, Chemical Physics Letters, 531 (2012) 210-215.

Taejin Kim, R.S. Assary, C.L. Marshall, D.J. Gosztola, L.A. Curtiss, P.C. Stair, *Acid-Catalyzed Furfuryl Alcohol Polymerization: Characterizations of Molecular Structure and Thermodynamic Properties*, ChemCatChem, 3 (2011) 1451-1458.

Biogas Management for Power and Transportation Fuels Production

PI: Devinder Mahajan, SBU

In July 2013, the NSF funded Center for Bio-energy Research and Development (CBERD) at SBU signed an agreement with Tongji University, China to jointly develop technologies to economically convert biogas from landfills and other sources to transportation fuels. For Long Island, it is an attractive option to replace imported diesel and gasoline. The Partnership will design effective systems for generation and management of biogas from solid waste facilities. The project will use a suite of technologies tested by CBERD at the Town of Brookhaven landfill, including upcoming gas-to-liquid conversion technologies to produce fungible liquid fuels. The follow-up tests will be conducted at the Shanghai Laogang landfill in Shanghai, one of the largest landfills in China. The project will be monitored by the joint EcoPartnership secretariat and the project progress will be reported annually during at an event during the high-profile U.S.-China Strategic and Economic Dialog (S&ED), hosted by the U.S. Department of State.

U.S. – China Strategic and Economic Dialog
A U.S. Department Of State Initiative



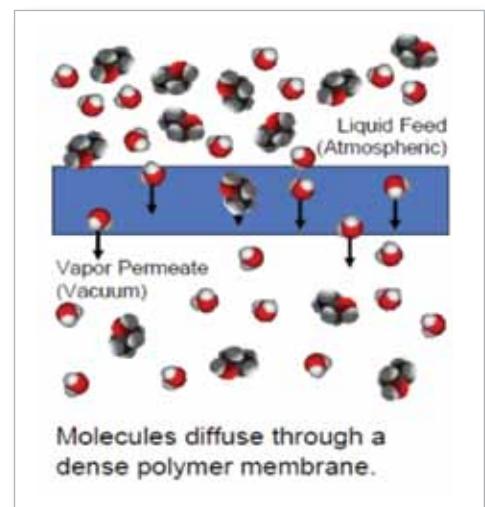
ECOPARTNERSHIPS



Upgrading of Biomass-derived Bio-oil to Drop-In Replacement Renewable Hydrocarbon Fuels

PI: D. Mahajan, SBU and BNL

One of the pathways for biomass conversion of interest is pyrolysis that offers feedstock densification at the source, making it economical to transport the otherwise wet feedstock. However, the dense bio-oil (or pyrolysis oil) requires further processing to make it usable as transportation or power generation fuels. Previous and several ongoing studies, reported in literature, focus on bio-oil production via either slow or fast pyrolysis. In the latter method, the residence time is kept to a fraction of a second to minimize undesirable biochar and gaseous products while enhancing the bio-oil yield. The detailed characterization of bio-oils is reported. Several companies are conducting studies to develop a catalyst system capable of economical processing of renewable hydrocarbon fuels from bio-oils. The focus is to eliminate O in bio-oil as CO₂ or H₂O in the product slate while facilitating catalytic production of hydrocarbon fuels of interest, namely diesel. (USDA-ARS, NSF- CBERD, US ARMY)



Ethanol-Water Separation Using Pervaporation Membrane

PIs: B. Hsiao, B. Chu and D. Mahajan, SBU



Publication:

K. Cantrell, K. S. Ro, M. Anjom, D. Mahajan, and P. G. Hunt, 2007. *Integration of Livestock Waste Treatment and Energy Production*, Ind. Eng. Chem. Res., 46(26) 8918-27.

RESEARCHER PROFILE



Eugene A. Feinberg, Distinguished Professor, Department of Applied Mathematics and Statistics.

Awards and Honors:

- Fellow of INFORMS (2011)
- SUNY Distinguished Professor (2012)
- IEEE Charles Hirsh Award (2012) for developing and implementing on Long Island, electric load forecasting methods and smart grid technologies
- Honorary Doctor, Institute of Applied System Analysis, National Technical University of Ukraine (2011)
- SBU Director of DOE Smart Grid Regional Demonstration Project: Long Island, Smart Energy Corridor (2010 – 2015)

Energy Projects

- Smart Grid
- Electric Load Modeling and Forecasting
- Modeling and Optimization of Electric Power Transmission and Distribution

New breakthroughs on thin-film nanofibrous composite (TFNC) membranes for water purification, including the use of ultra-fine cellulose nanofibers (diameter ~ 5 nm) and the development of multiple-jet electrospinning technology (nanofiber diameter 100 - 300 nm), have provided promising pathways in the filtration field. The non-woven structure has interconnected pores and very large surface-to-volume ratio, while the ease of surface modifications for cellulose can open up interesting leads for many biomedical and industrial applications. This membrane technology is being developed for pervaporation in ethanol synthesis by fermentation process to separate alcohol and water in a much more-energy efficient manner, which is the focus of this study. It is known that the cost of dehydrated ethanol by azeotropic distillation is about twice higher than that of the pervaporation technique. The increase in membrane permeation rate can yield further energy reduction benefit.(NSF- CBERD)

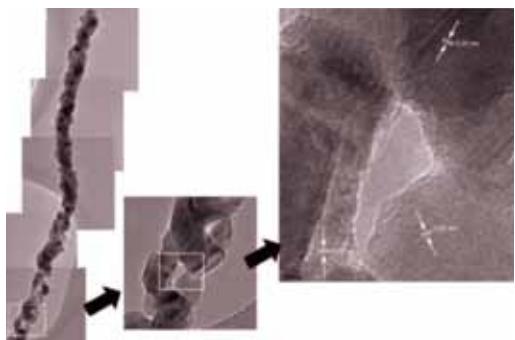


Patent:

B. Hsiao, B. Chu, D. Mahajan and T-M Yeh. *Polymeric Nanofibrous Composite Membranes for Energy Efficient Ethanol Dehydration* U.S. Patent Application, filed: October 2011.

Synthesis of Tailored 3D CuO Nanogrid for Lithium-ion Battery Applications

PI: Perena Gouma, SBU



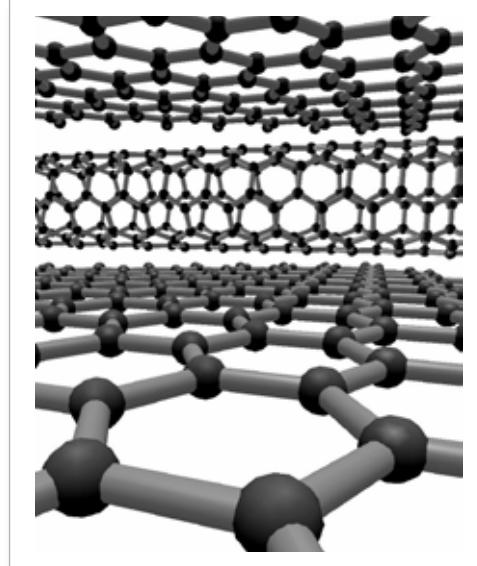
3D CuO nanogrids have been synthesized by direct thermal oxidation of composite substrates consisting of a Cu mesh and polyvinylpyrrolidone (PVP) nanofibers deposited on it by electrospinning. The CuO nanostructures composed of networks of continuous, self-supported, 3-D particles, crystals and nanorods providing increased surface area, porosity and extensive open networks. Scanning electron microscopy

(SEM), high-resolution transmission electron microscopy (HRTEM) and UV-Visible absorption spectroscopy analysis of the thermally treated samples reveal that a unique 3D CuO nanostructure occurs by Cu diffusion within the PVP nanowires covering the copper substrate and upon the subsequent oxidation of this metallic core once the polymer is removed. The average diameter of the CuO grains is 30 nm and the calculated band gap energy is 1.33eV. The high reversible capacity and good cycle stability of the unique 3D CuO nanogrids electrode makes it very promising for lithium battery applications. (NSF)



Publication:

J. Lee and P.I. Gouma, *Tailored 3D CuO Nanogrid Formation*, J. Nanomaterials, 2011 (<http://www.hindawi.com/journals/jnm/2011/863631.html>).



Carbon Nanomaterials for High Performance Supercapacitors

PI: Vladimir Samuilov, SBU

Our research focuses on carbon nanomaterials for supercapacitors as high-performance energy storage devices for a large variety of potential applications from consumer electronics through wearable optoelectronics to hybrid electric vehicles. Nanocarbons come in a wide variety of forms and their properties are very dependent on their structures and morphology. The effort here will focus on fabrication of different forms of hybrid films of nanocarbon, like carbon nanotubes, 3-D graphene and reduced graphene oxide. The combination of these forms of nanocarbon increases the electrode specific surface area and provides excellent electrical and mechanical properties. We have developed a simple approach to lower the equivalent series resistance of supercapacitors by fabricating electrodes using highly concentrated solutions of carbon nanotubes and reduced graphene oxide based composites. (SUNY RF, Local Industry, Sensor CAT)

Types of Government Supports in Energy Technology Innovation: The Case of Li-ion Battery Technologies

PI: Guodong Sun, SBU

The objective of this study is to understand the impacts of different types of government supports (e.g. government championship, technological support and financial aid) on technology innovation process. Lithium-ion (Li-ion) battery technology has experienced significant progress in recent years. Especially for the application on electric vehicle, Li-ion battery is considered as one of the most promising technologies. In addition to enormous efforts by the private firms, governments have also invested heavily in this area, notably in several countries including the

United States. It is an excellent case to examine. To what extent and how, government support contributes to the progress of advanced energy technologies? We are surveying the project managers or principle investigators of about 700 Li-ion battery R&D projects that have received supports from federal government. A value of this research is that its findings can be used to improve government R&D policy. (SBU)



Workload-Aware Storage Architectures for Optimal Performance and Energy Efficiency

PIs: Erez Zadok and Arie Kaufman, SBU

The most significant performance and energy bottlenecks in a computer are often caused by the storage system because the gap between storage device and CPU speeds is greater than in any other part of the machine. Big data and new storage media only make things worse because today's systems are still optimized for legacy workloads and hard disks. The teams at Stony Brook University, Harvard University and Harvey Mudd College have shown that large systems are poorly optimized, resulting in waste that increases computing costs, slows scientific progress and jeopardizes the nation's energy independence. First, the team is examining modern workloads running on a variety of platforms, including individual computers, large compute farms and a next-generation infrastructure, such as Stony Brook's Reality Deck, a massive gigapixel visualization facility. These workloads produce combined performance and energy traces that are being released to the community. Second, the team is applying techniques such as statistical feature extraction, Hidden Markov Modeling, data-mining and conditional likelihood maximization to analyze these data sets and traces. The Reality Deck is used to visualize the resulting multi-dimensional performance/energy data sets. The team's analyses reveal fundamental phenomena and principles that inform future designs. Third, the findings from the first two efforts are being combined to develop new storage architectures that best balance performance and energy under different workloads when used with modern devices, such as solid-state drives (SSDs), phase-change memories, etc. The designs leverage the team's work on storage-optimized algorithms, multi-tier storage and new optimized data structures. (NSF)



Design and Thermal Analysis of Adsorption-Based Natural Gas Storage Vessels

PIs: Jon Longtin and William Worek, SBU

The dramatic reduction in natural gas prices in the recent past has made it an extremely attractive fuel source for residential use. However, for residents not currently on natural gas the cost required to connect to the gas utility distribution system can be extremely cost prohibitive. This project aims to develop a natural-gas storage technology using adsorption to store the gas in container at a moderate pressure of several atmospheres. A novel adsorption medium is employed within the tank that is highly effective and inexpensive. The container will be located at the residence and filled as needed by a supply vehicle. The filling process however, generates considerable heat as the gas undergoes the adsorption process. This heat must be effectively removed in order to fill the tank in as short a time as possible. This project focuses on the thermal analysis and design of tank structures that will provide adequate cooling during the natural gas



filling process to minimize the fill time and develop safe and robust, cost-effective pressure vessel designs that provide the required capacity. (Energetek, Inc.)

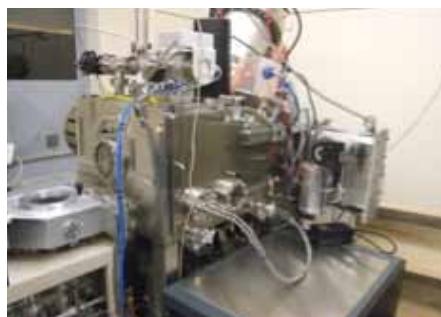


Nanomaterials and Nanostructures for Energy Storage Applications

PI: Vladimir Samuilov, SBU

We have developed a number of technologies for nanomaterials: Carbon Nanotube and Graphene 2-D and 3-D structures, metal and dielectric thin films deposition and processing (amorphous C, diamond-like carbon, Si, SiC, different metals), CVD, thermal, plasma deposition and etching. These technologies are used in energy storage applications (batteries and supercapacitors) and nano- and bio-sensors. We also developed state-of-the-art testing facilities for sensors and electrical energy storage systems.

We are open for collaboration with the members of the Advanced Energy Center interested in these applications of the nanomaterials for energy storage and sensors. (Sensor CAT)

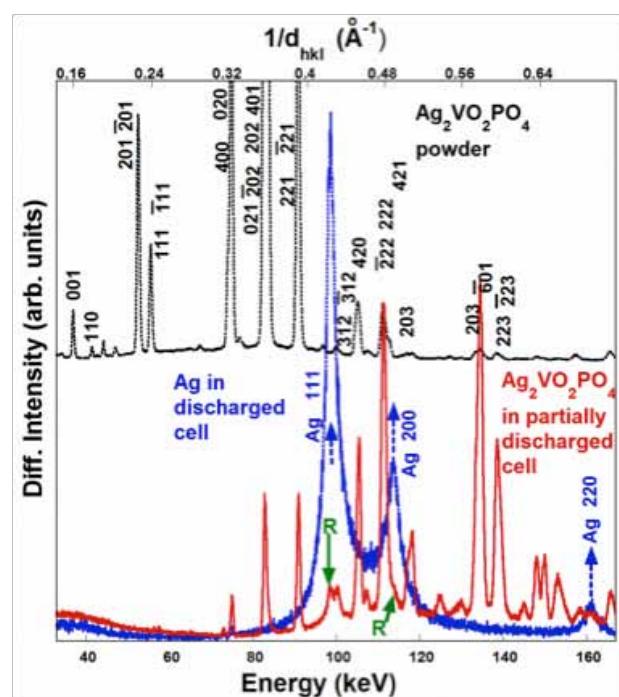


In-situ and In-operando Analysis of Energy Storage Materials

PIs: Esther S. Takeuchi, SBU and BNL,
Kenneth J. Takeuchi and
Amy C. Marschilok, SBU

In situ methods can allow direct interrogation of a battery electrode in its native environment, without exposure of the surfaces to ambient air, moisture and other reactive and deleterious substances. In operando analysis can illuminate changes occurring within a battery material under real use conditions. Such measurements require an understanding of the use conditions of the battery coupled with the ability to collect the data under controlled environments.

For example, crystallographic in situ analysis of electroactive material can provide insight into the material reduction mechanism with the confidence that no structural change or decomposition occurred as a result of material removal from the cell or post-processing. At the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory, the formation of silver metal from the reduction of $\text{Ag}_2\text{VO}_2\text{PO}_4$ can be clearly observed at the electrode–electrolyte interface within a lithium– $\text{Ag}_2\text{VO}_2\text{PO}_4$ electrochemical cell, where the progression of the reduction reaction through the thickness of the cathode can be monitored. This insight amplifies the point that full understanding of an electrochemical reaction in an active battery requires knowledge of the material status as



a function of location within the cathode as well as the overall properties of the cathode material. (DOE)



Publication:

Takeuchi, Esther S.; Marschilok, Amy C.; Takeuchi, Kenneth J.; Ignatov, Alexander; Zhong, Zhong; Croft, Mark. *Energy dispersive X-ray diffraction of lithium–silver vanadium phosphorous oxide cells: in situ cathode depth profiling of an electrochemical reduction–displacement reaction*. *Energy and Environmental Science*. 2013, 6, 1465–1470.

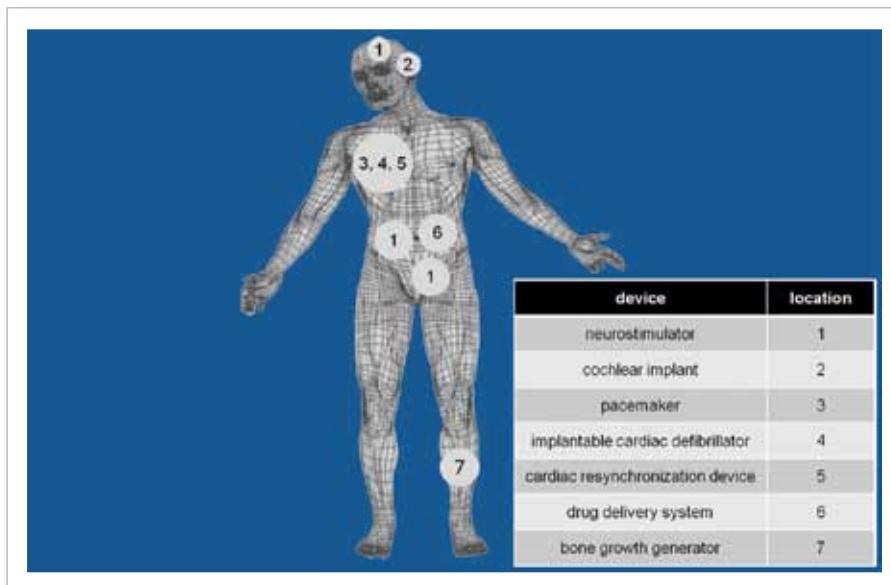
Improved Batteries for Implantable Cardiac Defibrillators

PIs: Esther S. Takeuchi, SBU and BNL,
and Kenneth J. Takeuchi and
Amy C. Marschilok, SBU

There is an ever growing demand for implantable cardiac defibrillators (ICDs), with over 100,000 devices implanted in 2004, and dramatic increases anticipated over the next decade due to expanded indications and coverage by Medicare. The growing level of acceptance of these life-saving devices has increased the desire for improved ICD function. The lifetime of the average ICD patient after implant has increased to 10 years while the average device lifetime is around 5 years. Thus, most patients require additional surgeries to replace their original device, resulting in both clinical risk and cost.

The overall project goal is to solve this discrepancy with fundamental science by demonstrating new superior cathode materials that could be used to extend the life and improve the consistency of ICD batteries. The proposed project has three specific objectives:

- 1) develop a new class of improved battery materials for ICD applications,
- 2) test the materials in experimental batteries under simulated use schemes mimicking ICD function, and



- 3) compare the key characteristics of long term stability, energy delivery, and energy content with the current battery benchmark technology. (NIH)



RESEARCHER PROFILE



Esther Takeuchi, SUNY Distinguished Professor, Department of Materials Science and Engineering, Department of Chemistry; Director, m2M Energy Frontier Research Center; member of the National Inventors Hall of Fame; serves a joint appointment at SBU and BNL.

Awards and Honors:

- Charter Member, National Academy of Innovation (2013)
- E.V. Murphree Award, American Chemical Society (2013)
- National Inventors Hall of Fame (2011)
- Recipient of National Medal of Technology and Innovation presented by President Barack Obama (2009)
- Astellas USA Foundation Award (2008)
- SUNY Distinguished Professor (2009)
- National Academy of Engineering (2004)
- 140 issued US Patents

Energy Projects:

- Energy storage
- Portable power sources
- Micro-power sources

Publications:

Esther S. Takeuchi, Amy C. Marschilok, Kevin Tazil, Eric S. Kozarsky, Shali Zhu, Kenneth J. Takeuchi. *Electrochemical reduction of silver vanadium phosphorous oxide, Ag₂V₂P₂O₄: The formation of electrically conductive metallic silver nanoparticles*. Chemistry of Materials. 2009, 21(20), 4934-4939. PubMed ID: 20161435.

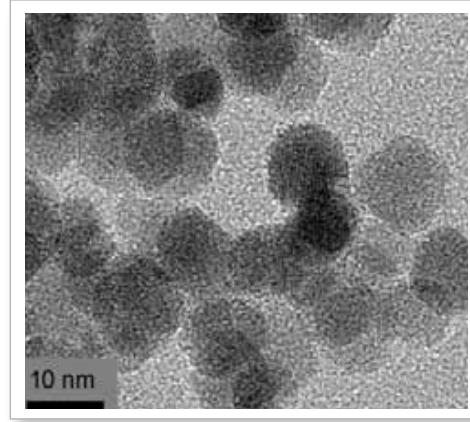
Amy C. Marschilok, Eric S. Kozarsky, Kevin Tazil, Shali Zhu, Kenneth J. Takeuchi, Esther S. Takeuchi. *Electrochemical reduction of silver vanadium phosphorous oxide, Ag₂V₂P₂O₄: Silver metal deposition and associated increase in electrical conductivity*. Journal of Power Sources. 2010, 195(19), 6839-6846. PubMed ID: 20657813.

Young Jin Kim, Chia-Ying Lee, Amy C. Marschilok, Kenneth J. Takeuchi, Esther S. Takeuchi. *Ag_xV₂P₂O₄: A demonstration of the dependence of battery-related electrochemical properties of silver vanadium phosphorous oxides on Ag/V ratios*. Journal of Power Sources. 2011, 196(6), 3325-3330. PubMed ID: 21318071.

David C. Bock, Amy C. Marschilok, Kenneth J. Takeuchi, Esther S. Takeuchi. *Batteries used to power implantable biomedical devices*. Electrochimica Acta. 2012, available online. <http://dx.doi.org/10.1016/j.electacta.2012.03.057>.

New Materials for Stationary Grid-Scale Energy Storage

PIs: Esther S. Takeuchi, SBU and BNL,
and Kenneth J. Takeuchi and
Amy C. Marschilok, SBU



The vast majority of recent battery research investment has focused on the important problem

of electrical energy storage for transportation applications. The successes of these investments and electric vehicle development will shift substantial transportation energy demand from oil-supplied to grid-supplied, and will consequently put even further stress on the already over-stressed electrical grid. This vision requires the development of new battery chemistries and materials for stationary electrical energy storage applications with enhanced cycling, deep discharge capabilities, safety and low cost. This represents a major research challenge and opportunity. The key to battery-based stationary electrical energy solutions will be in new chemistries and new materials with enhanced properties for the stationary application including high energy density, deep cycling, long cycle life,

safety and low cost. Specifically, our group will focus on synthesis, characterization and electrochemistry of low cost environmentally friendly anode materials. The elements to be used are naturally abundant, with lower cost and less environmental impact than many electrode materials in common use today. The overall objective of this work is development of novel anode materials for low cost large scale secondary batteries. Collaboration with Brookhaven National Laboratory will be leveraged to enable utilization of advanced synchrotron and electron tools to characterize the novel electrical energy storage materials. (NYSERDA)

nyserda
Energy Innovation, Solutions

Novel Materials Yielding High Energy, High Power, and Improved Reversibility

PIs: Esther S. Takeuchi, SBU and BNL,
and Kenneth J. Takeuchi and
Amy C. Marschilok, SBU

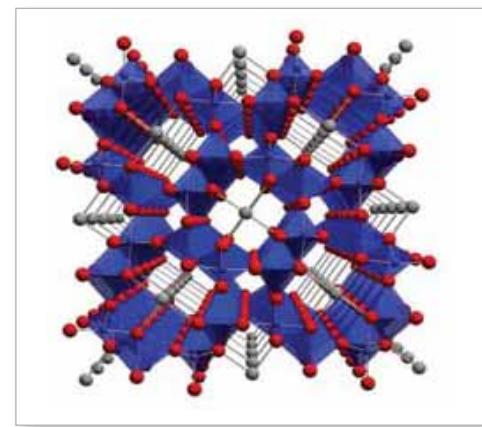
This project will provide mechanistic insight and fundamentally advance the three key performance metrics for energy storage: energy density, power delivery and reversibility. These goals will be realized through development and study of a new class of energy storage materials. The project materials will provide opportunity for a multifold improvement in theoretical energy density over state of the art energy storage materials. A challenge to successful implementation of high-stability cathode materials for energy storage is overcoming their typically low electronic conductivity. The novel materials studied here will form in-situ conductive metallic networks, providing a materials design approach that will enable use of nanomaterials and enhance energy density. One metal ion of the material is reduced to the metallic state and will provide an in-situ conductive network, which will enable the use of small particles by minimizing the inter-particle

contact resistance. This should provide high power to enhance the discharge and charge rates possible. Additionally, this family of compounds will provide multiple electron transfers per formula unit to yield high energy content. Finally, these materials should facilitate the opportunity for enhanced electrochemical reversibility since the host superstructure will provide ion transfer channels that allow facile ion movement. (DOE)



Publications:

- Zhu, Shali; Marschilok, Amy C.; Lee, Chia-Ying; Takeuchi, Esther S.; Takeuchi, Kenneth J. *Synthesis and Electrochemistry of Silver Hollandite*. *Electrochemical and Solid State Letters*. 2010, 13(8), A98-A100.
- Lee, Chia-Ying; Marschilok, Amy C.; Subramanian, Aditya; Takeuchi, Kenneth J.; Takeuchi, Esther S. *Synthesis and characterization of sodium vanadium oxide gels: The effects of water (n) and sodium (x) content on the electrochemistry of $\text{Na}_x\text{V}_2\text{O}_5\text{-}n\text{H}_2\text{O}$* . *Phys. Chem. Chem. Phys.*, 2011, 13,



18047–18054.

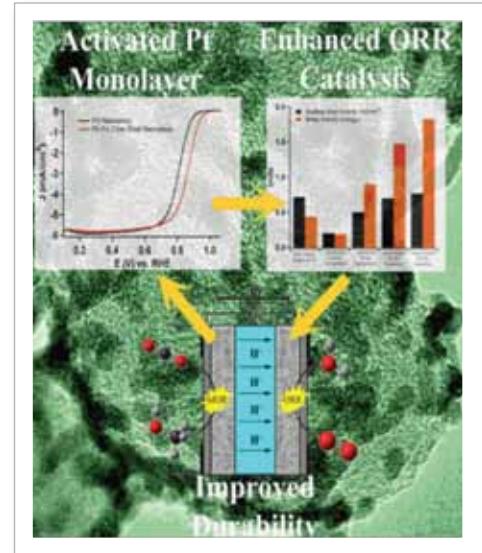
Farley, Katie E.; Marschilok, Amy C.; Takeuchi, Esther S.; Takeuchi, Kenneth J. *Synthesis and electrochemistry of silver ferrite*. *Electrochemical and Solid State Letters*. 2012, 15, A23-A27.

Nanostructures for Fuel Cell Applications

PI: Stanislaus Wong, SBU and BNL

Our group has recently prepared ultrathin (i.e. < 2nm) Pt nanowires (NWs) and Pt monolayer shell ~ ultrathin Pd NW core (Pt ~ Pd) catalysts with high electrocatalytic performance for fuel cell applications. On the basis of prior theoretical work performed, we have prepared highly exfoliated ultrathin Pt NWs with diameters of ~1 nm, utilizing an ambient wet technique coupled with a novel acid treatment step. Indeed, the treated NWs displayed a greatly enhanced size-dependent ORR specific activity of 1.45 mA/cm², which was more than 4-fold and 7-fold higher than that of our submicron Pt nanotubes and commercial Pt nanoparticles respectively. More recently, we have prepared ultrathin Pd NWs with diameters of ~ 2 nm supported on Vulcan carbon and suitably removed surfactant in a novel 2-step treatment process, combining both wet and electrochemical methods. Subsequently, the

desired hierarchical Pt~Pd core-shell NWs were obtained by electrodepositing a monolayer of Pt atoms onto the surface of the Pd nanowire cores. The Pt~Pd nanowire catalyst displayed outstanding surface area, Pt mass and Pt group metal (PGM) mass activities of 0.77 mA/cm², 1.83 A/mgPt, and 0.55 A/mg_{PGM} respectively, representing significant enhancements over commercial Pt NPs and even analogous core-shell Pt~Pd nanoparticle catalysts. This example not only highlights the outstanding intrinsic activity of ultrathin one-dimensional NW catalysts, but also demonstrates that these NW systems can maintain excellent enhancements in mass and specific activities as compared with nanoparticles. (DOE)



Multifunctional Cathode Additives for Li-S Battery Technology

PIs: Hong Gan, BNL
Esther Takeuchi, SBU

Li-S battery technology will be developed as a low-cost, high energy density alternative to current state of the art Li-ion battery technology. The Multifunctional Cathode Additives (MFCA) concept will address important challenges currently faced by the Li-S system by (1) improving cathode electronic conductivity, (2) providing excess lithium source, (3) reducing polysulfide dissolution in electrolyte. Successful development of Li-S battery incorporating the MFCA approach will enable low-cost, high energy density battery technology relevant for PEV application. (DOE)

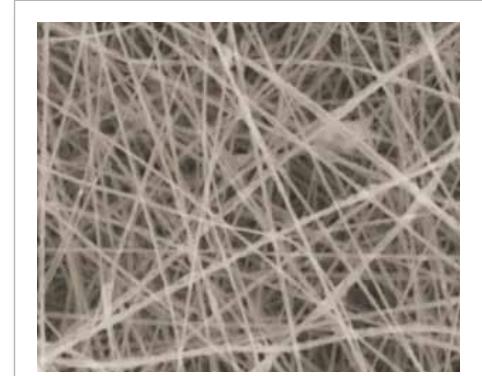


Energy Applications of Polyaniline Nanofibers

PI: Perera Gouma, SBU

Conductive polymers have been found to store or release an electrical charge by a reversible oxidation-reduction in a wide potential range. These materials have great potential because the amount of charge storage by redox reaction compared with conventional electrical double layer is theoretically high. Our research has focused at producing polyaniline nanofibers by means of the electrospinning method. The charge capacity of polyaniline nanofiber is expected to increase dramatically due to the increased surface area offered by the three-dimensional fiber-network structure. (Hitachi Chemical)

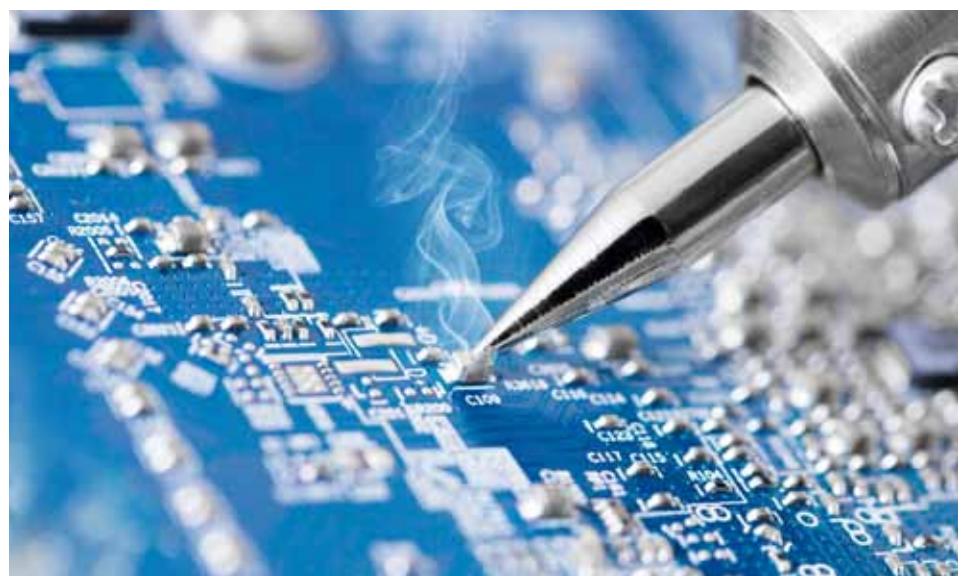
Hitachi Chemical



Extremely Low-Power Hybrid Silicon/Nanoelectronic Circuits

PI: Konstantin Likharev, SBU

We have proposed a new approach (dubbed “CMOL”) to the reduction of power consumption in microelectronics. In this approach, a silicon chip is augmented by a simple add-on nanowire circuit (“crossbar”), with two-terminal nanodevices formed at each cross point. (Reliable fabrication of nanodevices of the required “programmable diode functionality” has already been demonstrated by electronic industry in the context of their memory applications.) The crossbar is connected to the semiconductor transistor base via a pin-based interface distributed all over the chip area. Our simulations have shown that digital CMOL circuits may reduce power consumption of semiconductor chips by at least two orders of magnitude (at the same performance) and thus, contribute very significantly to energy conservation. Our plans include experimental demonstration within the next few years of the first operational CMOL chips. (AFOSR, MARCO, NSF)



Long Island Energy Roadmap

PI: Guodong Sun, SBU



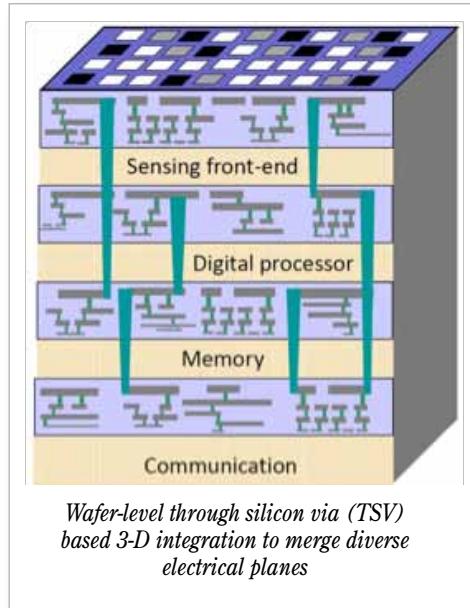
New York Energy Policy Institute is organizing a study on the long-term energy roadmap for Long Island. The roadmap takes a holistic view and approach, integrating different technologies (both emerging and existing) focusing on the economic vitality of Long Island, with an underlying assumption that Long Island is moving towards a low carbon, sustainable and more resilient energy future. The final product will include actionable policy recommendations in delivering the vision. (SBU, National Grid)



Design Methodologies for Low Power 3-D Integrated Circuits

PI: Emre Salman, SBU

Power consumption has become the fundamental barrier to further expanding the capabilities of modern integrated systems. Thus, energy efficiency has emerged as a critical challenge for many applications ranging from low power mobile/embedded chips to high performance data centers. Three-dimensional (3-D) integration has received considerable attention in the past decade to alleviate this issue. The primary objective of this research is to develop a reliable framework to facilitate highly heterogeneous and tightly coupled 3-D systems-on-chip (SoCs) for substantially complex applications where plug-and-play based approaches are not sufficient. This objective is achieved by simultaneously enhancing three interdependent design constraints of critical importance to this framework: power, signal and sensing integrity. The proposed circuit-level and physical-level design and analysis methodologies will serve as a novel framework to produce highly heterogeneous, low power yet robust 3D SoCs. (NSF)



Energy System Transitions

PI: Kathleen Araújo, SBU

To date, understanding of the complex conditions in energy system change has typically been derived from industry-based learning or case studies of a single technology across numerous locations. The multivariate analysis of this study evaluates a range of technologies and countries for a period of roughly four decades to extend insight on systemic influences and interdependencies. Conversions are mapped at regional and country levels, highlighting better practices, as well as varying roles of government, industry and other actors. Integrated assessments consider infrastructure, resources, costs and socio-political considerations to inform industrial planning and policy. (SBU, MIT, Harvard)

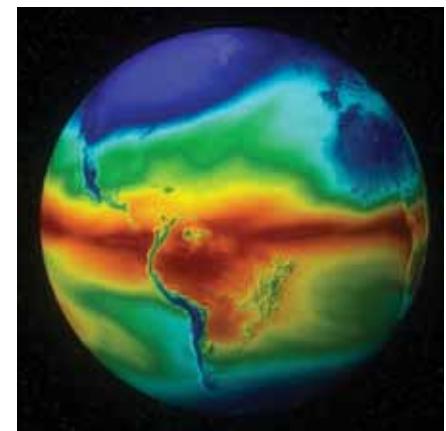


MIT
Massachusetts Institute of Technology



Araújo, K. (2014). *The Emerging Field of Energy Transitions: Progress, Challenges, and Opportunities*, Energy Research and Social Science, 1:1

Photo courtesy of CDOE/NREL



RESEARCHER PROFILE



Kathy Araújo, Assistant Professor, Department of Technology and Society, College of Engineering and Applied Sciences, Stony Brook University

Awards and Honors:

- Fellow, Managing the Atom - Harvard (2013-2014)
- Fellow, Science, Technology and Public Policy - Harvard (2012-2014)
- Fellow, Martin Sustainability - MIT (2009-2010)
- Fellow, Presidential - MIT (2007-2008)

Energy Projects:

- Energy-environmental systems change
- International nuclear safety
- Diffusion of science and technology
- Sustainability-security of the national power system

Nuclear Safety Post-Fukushima

PI: Kathleen Araújo, SBU

Events associated with the Fukushima nuclear accident in 2011 highlighted beyond design-basis deficiencies in nuclear safety. Analysis focuses on regulatory differences associated with back-up power and water, filtered vents and command and control protocols/operator independence in major nuclear countries. Explicitly codified requirements, mandates embedded in compliance reviews, as well as deployment by public actors/contractors are considered. The robustness of post-accident response is tested against factors such as country level industrialization, local technology maturity and the level of nuclear technology/services trade. (SBU, Harvard)



Photo courtesy of CDOE/NREL

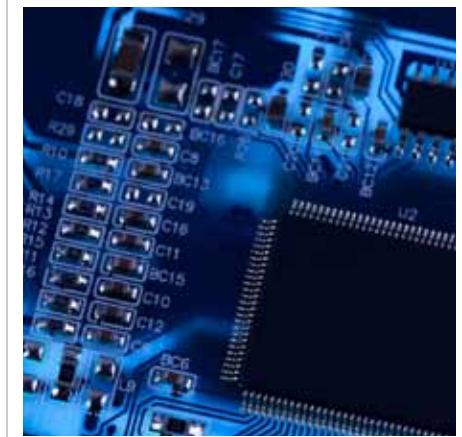


Low Power Clocking Methodologies for Nanoscale CMOS Circuits

PI: Emre Salman, SBU

Existing methodologies to reduce power dissipation either trade performance or utilize the available (positive) timing slack. Sacrificing performance to achieve low power is feasible only for a small set of applications. Alternatively, exploiting the available slack to reduce power dissipation significantly increases the number of critical paths, making the circuit more susceptible to static and dynamic variations. This research aims to significantly reduce power consumption by focusing on the global and local clock distribution networks within a synchronous IC, while maintaining the same performance. The primary objective is to develop a novel low voltage clocking methodology that guarantees nearly same performance as full voltage operation, robust

to both dynamic and static variations and can be automated to produce the optimum operating conditions. Simultaneously satisfying these three conditions will enable us to reliably and automatically apply the proposed low voltage clocking technique to industrial synchronous circuits with an expected overall power reduction of up to 35%. (Semiconductor Research Corporation)



TPP: Small: NFS4Sec: An Extensible Security Layer for Network Storage

PIs: Erez Zadok and Radu Sion, SBU

The Network File System (NFS) is a popular method for computers to access files across networks. The latest major version of this IETF protocol, version 4, is widely accepted and includes numerous new features to improve security, performance and usability when used over wide-area networks. However, the NFSv4's security focus is on network-wide encryption (ensuring that user data cannot be intercepted) and user authentication (ensuring that only legitimate users can access their files). It does not address end-to-end data security (i.e., persistently stored data), data integrity (malicious or benign data corruptions) and more. This project extends NFSv4 with a security layer that allows one to develop mul-

tiples, composable plugin modules to enhance the protocol's security. This layer allows for interception of protocol requests between clients and servers to perform various useful security functions such as:

- logging access to files by users and hosts, useful for regulatory compliance reports and audits
- inspecting files for malware patterns and automatically quarantining them
- verifying the integrity of long-lived files against malicious changes (e.g., Trojan intrusions) and benign but serious ones (e.g., storage media degradation and hardware corruptions)

- detecting denial-of-service attempts and ensuring quality-of-service to legitimate users through load-balancing and redirection; automatic snapshotting and logging to allow for forensic analysis and recovery from failures and intrusions.

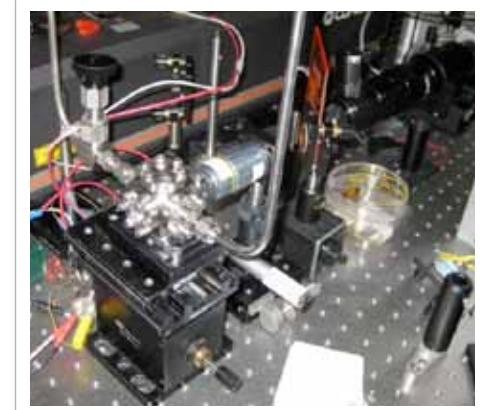
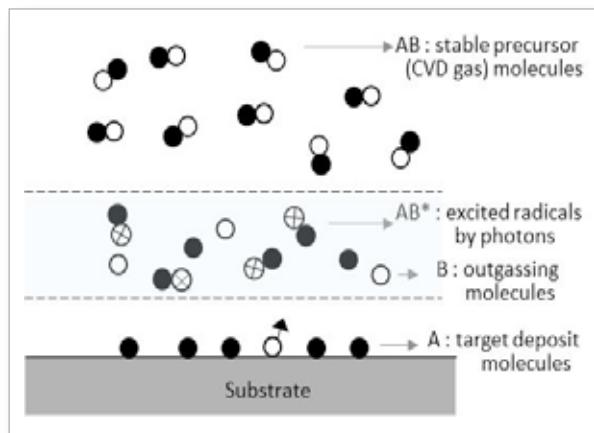
In a cloud-based era, where more data lives longer and is accessed over wide-area insecure networks, this project helps elevate the level of security of every user's data files. (NSF)



Laser-assisted Chemical Vapor Deposition of Passivation Layers for Organic Devices

PI: David J. Hwang, SBU

Organic electronic devices must be protected from water and moisture, which can react with both organic and inorganic active layers and degrade performance. Traditional thin passivation layer deposition techniques are still suffering from excessive deposition temperature or unwanted damage in the underlying organic layers. Another alternative, the atomic layer deposition, allows the lower temperature but it is not suitable due to extremely low deposition rate. We attempt to address the aforementioned limitation of conventional passivation techniques by developing a new laser-assisted chemical vapor deposition technology by decomposing precursor gas molecules with high selectivity, strictly avoiding disturbance of the sensitive organic devices. (Korean Government Agency for Industrial technology, Electronic Display Industrial Research Association of Korea)



Publications:

- D.J. Hwang, S.G. Ryu, and C.P. Grigoropoulos, Nanotechnology, 22, 385303 (2011)
D.J. Hwang, S.G. Ryu, E.P. Kim, C.P. Grigoropoulos, and C. Carraro, Applied Physics Letters, 99, 123109 (2011)

An Efficient, Versatile, Scalable, and Portable Storage System for Scientific Data Containers

PIs: Erez Zadok, Michael Bender and Robert Johnson, SBU

Scientific Bigdata sets are becoming too large and complex to fit in RAM, forcing scientific applications to perform a lot of slow disk and network I/O. This growth also makes scientific data more vulnerable to corruptions due to crashes and human errors. This project will use recent results from algorithms, database and storage research to improve the performance and reliability of standard scientific data formats. This will make scientific research cheaper, faster, more reliable and more reproducible. The Hierarchical Data Format (HDF5) standard is a container format for scientific data. It allows scientists to define and store complex data structures inside HDF5 files. Unfortunately, the current standard forces users to store all data objects and their meta-data properties inside one large physical file; this mix hinders meta-data-specific optimizations. The current storage also uses data-structures that scale poorly for large data. Lastly, the current model lacks snapshot support, important for recovery from errors. A new HDF5 release allows users to create more versatile storage plugins to control storage policies on each object and attribute. This project is developing support for snapshots in HDF5, designing new data structures and algorithms to scale HDF5 data access on modern storage devices to Bigdata. The project is designing several new HDF5 drivers: mapping objects to a Linux file system; storing objects in a database; and accessing data objects on remote Web servers. These improvements are evaluated using large-scale visualization applications with Bigdata, stemming from real-world scientific computations. (NSF)



Automatic Optimal Phase Balancing Algorithms for Electric Utilities

PIs: Thomas Robertazzi, and Steve Skiena, SBU

The majority of electric power systems utilize feeders that carry three phases of alternating current/voltage. Electric utilities and providers of electric power distribution systems seek to have approximately equal loads on each phase, for several reasons:

1. Phase unbalance can limit the amount of power transferred on a feeder, as one phase may reach its maximum carrying capacity (measured in amperes, i.e. ampacity) while the other two phases remain underutilized and unable to carry their full, or even nearly their full, amount of current.
2. Poor utilization of the existing power distribution network may result in unnecessary feeder expansion and upgrades, which raises costs.
3. Phase unbalance can lead to severe voltage drops in the feeders and preventive breaker/relay tripping when one phase nears its maximum ampacity. The restoration of such feeders involves time and money.

Phase balancing aims to reduce the unbalance of loads by shifting them from overused to underutilized phases. The performance of an initially well-balanced network deteriorates with time, as loads increase, decrease and are added or removed from each phase. Phase balance changes substantially during the course of the day due to



Figure 1: The phase unbalance index, which measures the amount of unbalance between phases, versus the number of tap changes for the dynamic programming, simulated annealing and greedy algorithms using actual feeder data. The more negative the log of the PUI, the better the phase balance.

the substantial variation of load on each phase of a feeder.

We have developed novel dynamic programming algorithms to make recommendations to utilities on the best strategies for phase balancing. We have tested our algorithms on actual utility data under the LIPA/DOE Smart Grid project at Stony Brook. We have found significant cost savings thru the use of our algorithms. Extrapolated to the entire United States, the savings could be as high as 250 million dollars a year. This work is patent pending. (DOE)



Enhanced Power System Operation and Control

PI: Eugene Feinberg, SBU

This project investigates and implements numerical algorithms and high performance computing software for solving power-flow, state-estimation and system-stability control problems for electric transmission grids. The

main objective is to develop solution methods that are 10 to 100 times faster than the solution times achieved in current control system implementations. (NYSERDA, NYPA)



Adaptive Runtime Verification and Recovery for Mission-Critical Software

PIs: Scott Smolka, Scott Stoller and Erez Zadok, SBU

Runtime verification (RV) refers to the use of lightweight yet powerful formal techniques to monitor, analyze and guide the execution of programs at run-time. RV is becoming increasingly important for at least two reasons. First, software systems are becoming more complex and more adaptive, making it difficult to statically understand all of their possible behaviors. This is especially true of mission-critical software on autonomous, unmanned vehicles where completion of mission goals depends upon adaptive responses to changing conditions. Thus, RV plays a valuable role in helping users monitor and understand system behavior during testing, debugging and deployment. Second, to increase the reliability of complex adaptive software, RV must monitor and analyze the behavior of the software, its environment and their interaction, in order to trigger adaptive responses when necessary. To fill these needs, RV itself must become more flexible and adaptive and it must be equipped with a recovery framework that will help ensure mission completion in the face of runtime violations. We are developing Adaptive

Runtime Verification and Recovery (Arrive), a novel extension of runtime verification, in which the runtime verification itself is adaptive. Arrive dynamically allocates more runtime-verification resources to high-criticality monitored objects, thereby increasing the probability of detecting property violations within a given overhead budget. Moreover, when a violation is imminent, Arrive takes adaptive and possibly preemptive action in response, thereby ensuring recovery. We are investigating three related aspects of Arrive: overhead control, incomplete monitoring and predictive analysis. We are developing a Simplex architecture for cyber-physical systems by extending Simplex to monitor the software state, as well as the physical-plant state. We are evaluating the performance and utility of the Arrive framework through significant case studies, including the runtime monitoring of the command-and-control and energy-management infrastructure of a fleet of UAVs. (NASA JPL)



Quantitative Musings on the Feasibility of Smartphone Clouds

PIs: Radu Sion

In 2011, Google's data centers alone were consuming the equivalent electricity sufficient to power up 200,000 homes. Energy is a top 3 data center operating cost component. "Fully burdened power" (consumption+distribution) constitutes upwards of 30% of a large data center operating costs. This is why, at scale, ideas of deploying low-power ARM architectures or even large numbers of extremely "wimpy nodes" seem increasingly appealing. Skeptics, on the other hand, maintain that we cannot get more than what we pay for and no free lunches can be had. In this white paper, we explore these theses and provide insights into the power-performance tradeoff at scale for ARM architectures. We quantify the cost/performance ratio precisely enough to allow for a broader conclusion. We then offer an intuition as to why this may still hold in 2030. (NSF)



Laser-assisted Manufacturing of Multiscale Super-Insulation Material

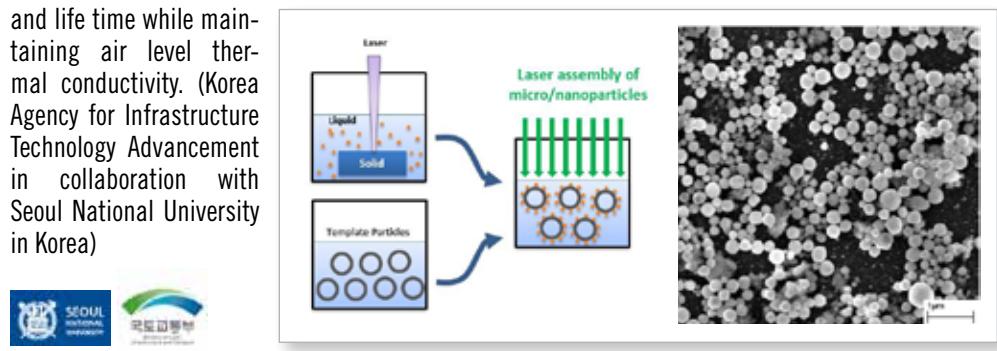
PI: David J. Hwang, SBU

As a route towards energy-efficiency and zero emissions in the building sector, development of super insulating materials is an important task. Nano insulation materials have been accepted as the most promising candidate due to both fundamental merits for insulation (e.g. nano-contact interfaces, intrinsic vacuum effect) and practical advantages for manufacturing to use as building materials. Current study is focused on developing a new technology to realize multi-scale micro/nano scale composite structures assisted by laser-assisted manufacturing techniques ranging from production of unit insulating particles to improvement of mechanical connectivity for enhanced structural robustness

and life time while maintaining air level thermal conductivity. (Korea Agency for Infrastructure Technology Advancement in collaboration with Seoul National University in Korea)

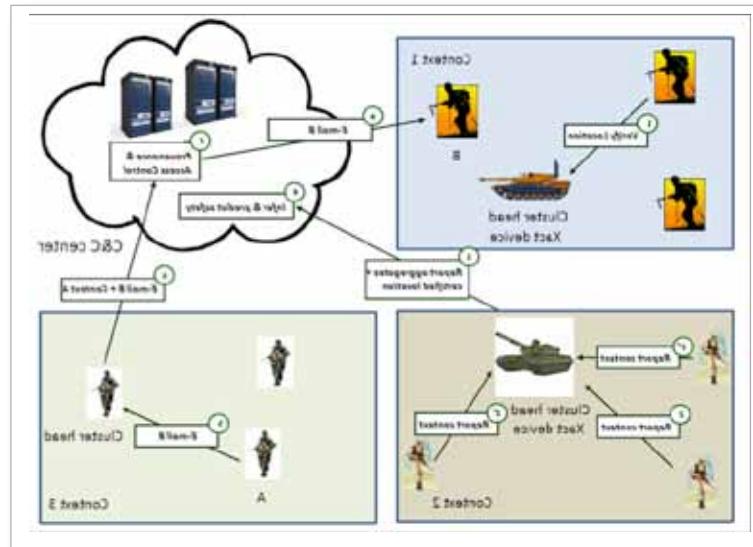


Publications:
M.T. Lee, D.J. Hwang, et al, International Journal of Hydrogen Energy, 34(4), 1835-1843 (2009)



MCloud: Secure Provenance for Mobile Cloud Users

PIs: Radu Sion, SBU and Bogdan Carbunar, FIU



Defense, intelligence and other government agencies are increasingly sharing diverse applications, data and hardware platforms

to capture a single team member's device to inject incorrect information and corrupt the

of varying degrees of mobility, as well as outsourcing their computation and data storage to cloud providers. For example, suppose the commander of a deployed team needs to prepare a report based on information received from his teammates. Since the information aggregated in the report comes from different sources, an adversary needs

report. Furthermore, the commander may copy excerpts of the report into an email intended for approved team members but accidentally include an unauthorized recipient.

The goal of this proposal is to address two critical challenges. The first challenge is to track data, its contexts and its changes, as it flows across multiple mobile and back-end systems and principals for security and regulatory compliance (e.g., ensuring documents derived from classified data stay classified, or tracking the history of intelligence and other data used for decision-making). The second challenge is to enforce security policies uniformly across a large set of principals, compute environments and applications. (ARMY)

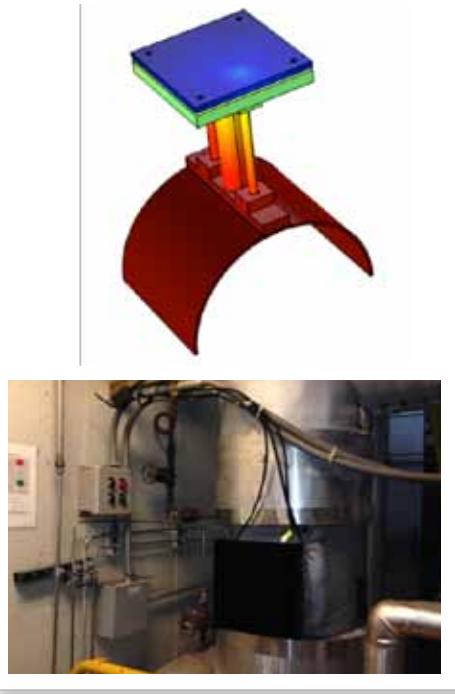


Thermoelectrically Driven Sensing for Nuclear Power Plants

PIs: Jon Longtin, David Hwang, SBU, Lei Zuo, Virginia Tech, Minking Chyu, U.Pitt

Catastrophic events such as that at Fukushima have raised new awareness for robust, reliable sensing and data feedback during catastrophic events. This project is developing thermoelectrically driven wireless sensing packages for nuclear power plants. In the event of a major incident in which all other forms of power to the plant are unavailable, intrinsic heat from the reactor components is used to produce electricity using thermoelectric generators. This energy is stored and then used to drive a sensor network to monitor key parameters such as temperature, pressure, radiation, flow rates, water levels, etc. The project involves the thermal design of the system, the sensor and electronics packaging, the wireless interfacing, power management

and developing designing protection for the sensor package once attached to the component. Excess electrical energy can be stored by a battery and used for actuation as well. For example to open or close a valve, pressure vessel vent, drain, or other critical component that requires power to maximize plant safety. Innovative thermal technologies such as heat pipes and high-performance heatsinks are used to maximize electricity production. The Calpine power plant on campus has generously allowed us to install a prototype design on the main steam line to campus in October 2014, which has been operating successfully since installation. (DOE NEUP)



Evaluation of the Bureau of Energy Resources (ENR) Unconventional Gas Technical Engagement Program (UGTEP)

PI: Devinder Mahajan

The Department of State's Bureau of Energy Resources (ENR) works across the U.S. Government to engage traditional energy exporters and emerging economies in a coordinated effort to boost international energy security and provide advice to steer the world's energy mix toward a more sustainable path. ENR is engaged with other countries through the Unconventional Gas Technical Engagement Program (UGTEP). The purpose of this evaluation is to review the current performance and effectiveness of the Unconventional Gas Technical Engagement Program (UGTEP) and make recommendations that will increase the effectiveness of future programming. (DOS)



DIMMer: A Case for Turning Off DIMMs in Clouds

PIs: Radu Sion, Michael Ferdman, SBU

Lack of energy proportionality in server systems results in significant waste of energy when operating at low utilization, a common scenario in today's data centers. We propose DIMMer, an approach to eliminate the idle power consumption of unused system components, motivated by two key observations. First, even in their lowest-power states, the power consumption of server components remains significant. Second, unused components can be powered off entirely without sacrificing server availability. We demonstrate that unused memory capacity can be powered off, eliminating the energy waste of

self-refresh for unallocated memory, while still allowing for all capacity to be available on a moment's notice. Similarly, only one CPU socket must remain powered on, allowing unused CPUs and attached memory to be powered off entirely. The DIMMer vision can improve energy proportionality and achieve energy savings. Using a Google cluster trace, as well as in-house experiments, we estimate up to 50% savings on DRAM and 18.8% on CPU background energy. (NSF)



EcoHadoop: A Cost-Efficient Data and Task Co-Scheduler for MapReduce

PI: Radu Sion, SBU

We introduce a new energy cost-efficient data and task co-scheduler for MapReduce in a cloud environment. By using linear programming to simultaneously co-schedule data and tasks, LiPS helps to achieve minimized dollar cost globally. We evaluated LiPS both analytically and on Amazon EC2 with significant results. LiPS saved up to 81% of the actual dollar costs when compared with both the Hadoop default and the more performant delay scheduler, while also allowing users to fine-tune the cost-performance tradeoff. LiPS presents today's most cost-efficient scheduler and should be deployed when constraints on overall makespan are flexible. (NSF)



Smart Meter Security Testing

PI: Rob Johnson, SBU

We will perform security evaluations of smart grid devices. Evaluations will include (1) black box testing, i.e. feeding random or malformed inputs to the devices and observing whether they handle the inputs correctly, crash, or otherwise misbehave; and (2) manual evaluation, i.e. testing functionality on correct inputs and verifying that no dangerous functions, such as debugging interfaces, are present in production versions of the devices. (DOE)



Analytics Framework for Understanding Household Energy Consumption

PI: Klaus Mueller, SBU

The introduction and gradual popularity of energy consumption monitoring devices, commonly known as smart-meters, has provided us with an opportunity of capturing and understanding household energy. Our interface provides various visualizations in which users can interactively explore their energy use profiles. They can select and compare different time segments of their profiles and show them in context of local weather (obtained from a weather service), social activities (obtained from a calendar) and the use of their household devices (obtained from the user via a visual user interface). Our visual interface aggregates all this information into a modern multi-faceted information visualization framework that can be interactively manipulated to allow users to learn where, when and how energy was consumed. Once the sources of adverse energy consumption have been identified, users can employ the historical data to play out differ-



ent use behaviors and see the effect on energy use, as well as the size of the energy bill. They can also use the software to predict future or replay past energy consumptions with changed habits, devices and their settings. The insight gained can then lead to positive energy-use behavioral changes by the consumer, which is of benefit to everyone involved. (NSF)



Dynamic Islanding as an Accelerant for Grid Restoration and Enhancement to Reliability

PIs: Guodong Sun, SBU and Hyungseon Oh, UB

Dynamic islanding, the creation of ad hoc microgrids, is an innovative approach to mitigate the impacts of grid outages on customer power supply through the utilization and dispatch of distributed energy resources (DERs), including both generation and storage. There is growing interest in dynamic islanding after recent hurricanes and winter storms. Funded by a seed grant from SUNY 4E Network, New York Energy Policy Institute is organizing a workshop to convene leading experts from SUNY schools and beyond

to engage in in-depth discussions on dynamic islanding. This workshop will discuss the topics including thier roles, potentials and technological/economic/policy challenges in implementing dynamic microgrid and policy changes required to test, demonstrate and eventually deploy this approach. (SUNY RF)



Smarter Electric Grid Research, Innovation, Development, Demonstration, Deployment Center (SGRID3)

PIs: Robert Johnson and Erez Zadok, SBU

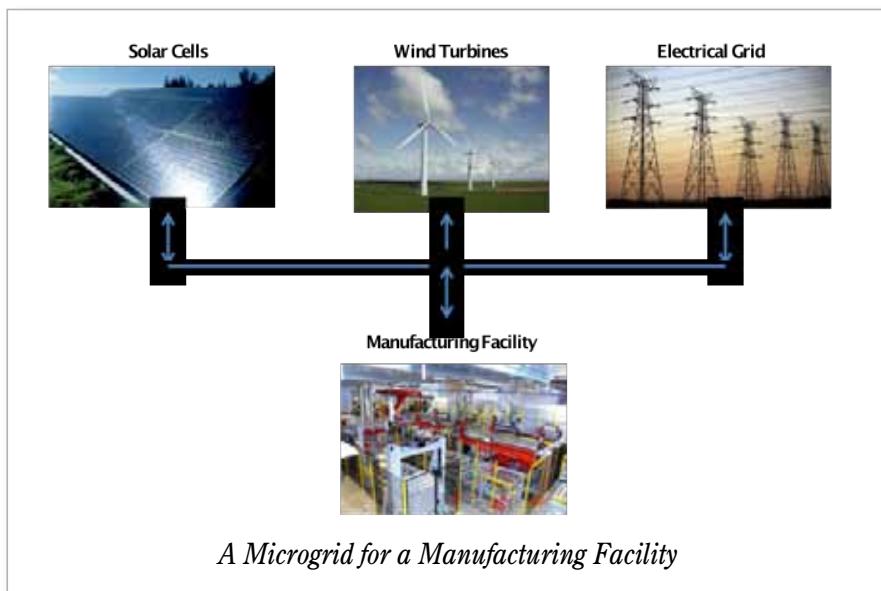
Smart Grids collect vital data about system operation, energy production and use, information flow, user activity and much more. This data must be secured and preserved for decades. In this project, we will investigate techniques to store this data securely using, for example, strong encryption while re-encrypting periodically to keep up with technology trends. We will include policies for data access such that only authorized users can access the data they require. In addition, we will include immutable methods to record and log all accesses (e.g., provenance) such that it would be possible to determine which user(s) accessed which data and when (this is useful for forensics and mitigating the “insider problem”). All data and logs will be replicated securely across several geographically distributed locations (we propose to use CEWIT in New York and CEWIT-Korea as two sample sites). Further, we will develop techniques to resist Denial-of-Service (DoS) attacks by detecting sudden spikes in unexpected activity, logging them, throttling them and possibly blocking such connections. Our development platform will utilize the Network File System (NFS) version 4.1 protocol, a data storage protocol suitable for wide-area (e.g., cloud storage), secure, replicated data access. (BNL)

BROOKHAVEN
NATIONAL LABORATORY

Automated Microgrid Control Scheme

PI: Qing Chang, SBU

Our work looks to create an automated control scheme for a microgrid that is either islanded or connected to the electrical grid. This algorithm will optimize the overall electrical usage in the system to save the most energy cost. The system will consist of multiple renewable energy sources including wind turbines, solar cells, etc. We will use simulation models to model the microgrid, as well as building a working system in our laboratory to test and refine our algorithm. A deterministic model, which treats loads and power as constant parameters, as well as a probabilistic model will be built. The probabilistic model will treat the load and power as random variables. This control scheme will be used in the manufacturing environment to reduce the facility's dependence on the grid and to save energy costs. (Nextek)



Electrical Grid Monitor System (EGMS) Based on Modern Sensor, Communication and Computational Technologies

PIs: Serge Luryi and Michael Gouzman, SBU

Based on the proprietary technology (provisional patent), three main components are to be developed:

1. Inexpensive, robust, and non-intrusive sensors for current and voltage
2. The communication network
3. The information processing and visualization system (SBU)



Automated Smart Grid Security Monitoring and Mitigation

PI: Rob Johnson, SBU

Stony Brook is developing software "sensors" that can be embedded into the programs running on Smart Grid devices. These sensors can detect new attacks spreading through the network and automatically alert other smart grid devices of the attacks. The other devices can then take steps to protect themselves from the attack. This technology can prevent the unconstrained spread of worms on the smart grid. (DOE)



Software Security for Smart Grid Devices

PI: Rob Johnson, SBU

We will create tools to find, and in some cases automatically fix, security bugs in smart grid software. These tools will help find buffer overflows, SQL injection bugs, format string bugs and similar security-critical vulnerabilities. (DOE)





Smart Grid Android Manager

PI: Radu Sion, SBU

The Mobile Smart Energy Manager is an Android/iPhone based Energy Manager that runs on smart phones and tablets. It will connect to local autonomous micro-grid information gateways and components (such as solar panel relays), the macrogrid operators and utility companies' portals, smart home components and the internet to provide real-time energy-related information, debit and consumption data, billing and the ability to manage smart-home devices in real-time on-demand. The Mobile Smart Energy Manager will also allow a unified user control platform for the integration of various

external smart grid data processing and visualization plugins. Examples of such plugins include: 1) big data analytics visualization of micro-grid and macro-grid energy data, 2) connectivity conduit to external data sources and 3) visual devices, such as the reality deck display and the SCADA smart grid control center, 4) networking plugins to interface with any additional custom wireless protocols designed as part of the SGRID3 project. (DOE)



RESEARCHER PROFILE



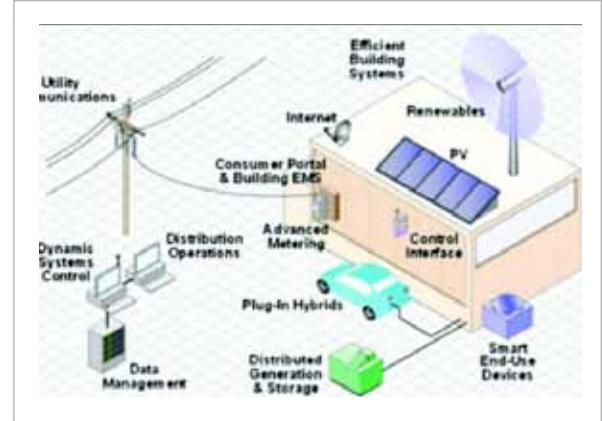
Qing Zhang, Assistant Professor
Department of Mechanical Engineering

Awards and Honors:

- National Science Foundation Fellowship CAREER Award (2014)
- General Motors Boss Kettering Awards (2008, 2006, 2005)
- General Motors R&D Center The Charles L. McCuen Special Achievement Awards (2008, 2006 and 2005)

Energy Projects:

- Battery Manufacturing System Efficiency Improvement
- Manufacturing System Energy Management
- Integrated Micro-grid and Production System



Smart Grid Regional Demonstration: Long Island Smart Energy Corridor

PIs: Eugene Feinberg, Samir Das, Rob Johnson, Ari Kaufman, Klaus Mueller and Erez Zadok, SBU

This is a joint project with Long Island Power Authority and Farmingdale College. The goal is to create a Smart Energy Corridor along Route 110 on Long Island. The project demonstrates the integration of a suite of Smart Grid technologies on the distribution and consumer systems, such as smart meters, distribution automation, distributed energy resources and electric vehicle charging stations.

The project also includes testing cybersecurity systems, using Smart Grid technologies to enhance efficiency and reliability of the distribution network identifying optimal combinations of features to encourage consumer participation and educating the public about the tools and techniques available with the Smart Grid. (DOE)



An Interactive User Interface for the Smart Grid

PI: Arie Kaufman and Klaus Mueller, SBU

In the traditional system, customers just purchase the energy from suppliers and consume it. However, smart grid is two-way communication channel between suppliers and consumers. The roles of consumers are to reduce their total consumption and shift their usage to off-peak time. However, it is difficult to encourage consumers to change their behavior with simple visualization. In this project, we have developed an interactive system to help customers gain better understanding of their energy consumption. In our system, since customers hardly understand their energy consumption of their own electric devices, customers could configure their own virtual house with electric devices to estimate their current energy consumption. Customers could choose what kind of devices they have by dragging and dropping an electric device into their virtual house. Customers can easily select a specific model of each device. Our system also provides a tool to analyze their energy consumption pattern in order to control their energy usage efficiently. Given their total energy consumption from their smart meters, it shows their daily, weekly and monthly energy usage patterns. In addition, it enables customers to predict their energy consumption once they replace their current electric devices with new ones. (DOE)



Resilience Benefits of Distributed Energy Resources

PI: Guodong Sun, SBU

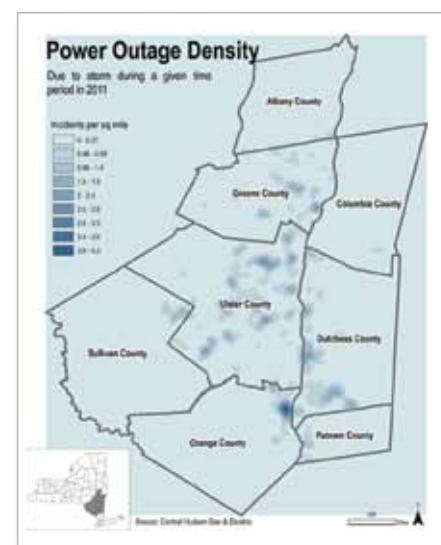
Severe weather events can cause large-scale power outage for extended periods. Enabled by dynamic islanding technology, distributed energy resources (DERs), including combined heat and power (CHP) and plug-in hybrid electric vehicle (PHEV), have large potential for accelerating the restoration process and for mitigating the impacts on critical facilities (hospitals, fire stations, police stations, telecommunication facilities, et al), households and businesses that are beyond the designated service territories of CHPs and PHEV-owners' houses. The objective of this study is to understand the resilience benefits of DER-powered dynamic microgrid. This study starts with an assessment of the arbitrage value of PHEVs to owners. It is followed with a study on the cost of electricity from CHP and PHEVs, as emergency generators, in a microgrid formed through dynamic islanding. (SBU)

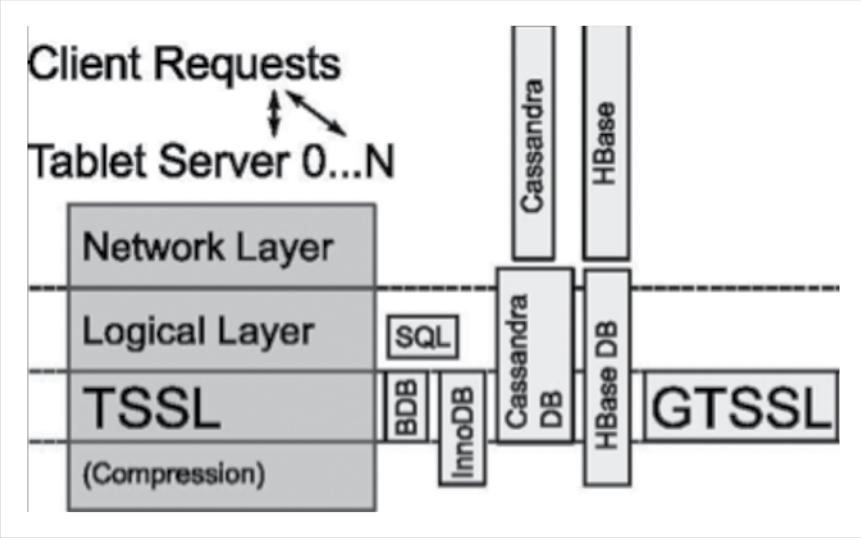


Impacts of Severe Weather Events on the Carrying Capacity of Distribution Grid

PI: Guodong Sun, Sung Gheel Jang, SBU and Martin Schoonen, BNL

The devastation caused by severe weather events (e.g., Hurricanes Sandy and Irene) raised awareness of the potential of climate change to exacerbate weather hazards such as hurricanes, Nor'easters, severe winter weather and flash floods. The storms caused substantial damage to the energy infrastructure. This project examines the performance of the electric distribution system and areas of vulnerability revealed by Hurricane Sandy, including interactions between electric power and water bodies (flooding and surge). The project will identify system improvements to increase resiliency, which may include reinforcing substations against flooding, microgrids, combined heat and power, distributed generation, smart grid technologies and energy storage. (HUD)





Smart Grid Trace Data Analytics and Synthesis

PI: Erez Zadok, SBU

We are collecting large traces from actual nodes in a smart grid, analyzing them to extract the main features and then producing tools and techniques to synthetically generate simulated smart-grid data that is as accurate as the original. This allows us to avoid privacy issues, avoid the need to disseminate large traces and yet be able to experiment with much larger-scale smart-grids (i.e., using Long Island smart-grid data, we could simulate a state-wide or even nation-wide smart-grid data).

I/O traces are good sources of information about real-world workload. Replaying such traces is often used to reproduce the most realistic system behavior possible, however, traces tend to be large, hard to use and share, and inflexible in representing more than the exact system conditions at the point the traces were captured. Often, researchers are not interested in the precise details stored in a bulky

trace but rather in some statistical properties found in the traces; properties that affect their system's behavior under load.

We designed and built a system that (1) extracts many desired properties from a large block I/O trace, (2) builds a statistical model of the trace's salient characteristics, (3) converts the model into a concise description in the language of one or more synthetic load generators and (4) can accurately replay the models in these load generators. Our system is modular and extensible. We experimented with several traces of varying types and sizes. Our concise models are 4--6% of the original trace size, and our modeling and replay accuracy are over 90%. (IBM, NY; EMC & Data Domain, NJ; Google, NY)



Smart Grid Data De-Duplication

PI: Erez Zadok, SBU

Smart-Grid data is likely to be massive and arrive from millions of homes nation-wide. We are developing custom data deduplication techniques to eliminate most redundancy in the data. This allows the data to be more easily disseminated, stored and backed up. Traditional backup systems can get as much as a 40-60x size reduction from customer dedup techniques (much better than traditional local compression).

Deduplication is a popular component of modern storage systems with a wide variety of approaches. Unlike traditional storage systems, deduplication performance depends on data content as well as access patterns and meta-data characteristics. Most datasets that have been used to evaluate deduplication systems are either unrepresentative or unavailable due to privacy issues, preventing easy comparison of competing algorithms. Understanding how both content and meta-data evolve is critical to the realistic evaluation of deduplication systems.

We developed a generic model of file system changes based on properties measured on terabytes of real, diverse storage systems. Our model plugs into a generic framework for emulating file system changes. Building on observations from specific environments, the model can generate an initial file system followed by ongoing modifications that emulate the distribution of duplicates and file sizes, realistic changes to existing files and file system growth.

In our experiments we were able to generate a 4TB dataset within 13 hours on a machine with a single disk drive. The relative error of emulated parameters depends on the model size but remains within 15% of real-world observations. (NetApp, CT; EMC & Data Domain, NJ)



Smart Grid Data Security Policy Enforcement, Non-Repudiation, and Privacy

PI: Erez Zadok, SBU

In conjunction with anonymization of smart-grid data, we are developing appropriate security policy enforcement mechanisms that allow users to access only the data they should have access to, based on their role or security clearance. We will ensure that all access is logged securely in a non-repudiable manner, and generate period reports for Security Officers to review. Our model aims at security and simplicity. We define four security roles: Security Officer, Network Administrator, Data Administrator and User. The security officer is able to create and revoke all other users. The Network Administrator is in charge of configuring the networking aspects of the system, such as firewalling, IP addresses and DNS. The Data Administrator can create regular Users and cryptographically protected volumes, called CryptoShares. These CryptoShares can be accessed by various protocols such as SFTP and Samba: physical data is always encrypted. Every action in the CryptoShares is logged and encrypted. Automatic reports are generated periodically about all actions that took place; administrators can generate such reports manually at any time, store them securely off-site, as well as email them. (Packet General Networks, NY-LI)



Smart Grid National Energy Control Center

PIs: Arie Kaufman and Klaus Mueller, SBU

We will develop new visualization and interaction paradigms, using the RealityDeck, for the SCADA system of the future. The RealityDeck is an immersive Giga-pixel display wrapping around a room of size 40' x 30' x 11' high, containing 416 LCD display screens driven by an 70 graphics processing unit (GPU) cluster that rivals the performance of modern supercomputers. The RealityDeck will fully immerse visitors in 1.5 billion pixels of information, approaching the visual acuity of the human eye. It will allow national energy grid analysts to manage the smart grid's large, multi-variate data, maintain a comprehensive view of the nation's complex energy infrastructure, quickly react to emerging prices or problems and take preventive measures before they arise. (NSF, NGC).



Smart Grid in Smart Buildings

PIs: Arie Kaufman and Klaus Mueller, SBU

A smarter building enables building owners and tenants to make better decisions about the building's energy use through a user interface and often lets them rely on the building to "make" those decisions itself. The latter is supported by numerous sensors which pepper the building and monitor everything from motion and temperature to humidity, precipitation, occupancy and light. The sensors, the computational infrastructure and the user interface work in tandem to create a smarter building. (IBM, NY).



RESEARCHER PROFILE



Energy Projects:

- Smart Grid Security
- Trace Analytics
- Data Deduplication

Erez Zadok, Associate Professor, Computer Science Department, College of Engineering and Applied Sciences, Stony Brook University, Co-Chair of IT Operations Committee

Awards and Honors:

- NetApp Faculty awards in 2009 and 2011
- LISTnet's "Top 20 techies of Long Island award, 2009
- Chancellor's Award for Excellence in Teaching, State University of New York (SUNY), 2007-2008
- IBM Faculty Awards: 2006 and 2008
- NSF CAREER award, 2002

Ambient Visualization of Smart Appliance and Generator Activities

Pls: Arie Kaufman and Klaus Mueller, SBU

Casual users often have little literacy to read and are even phobic to plots and graphs, which makes these users less inclined to explore their use of energy. This project would devise a framework that illustrates energy conception and current use by ways of artistic modification of digital photos and artwork displayed on WiFi connected popular digital photo frames, decorative wall-mounted displays, computer wallpapers, smart phone displays and others. (DOE)



Visual Interfaces to Support Smart Grid Analytics

Pls: Klaus Mueller and Erez Zadok, SBU

Smart grid data analytics typically involves multivariate data in which relationships are difficult to discern without an interactive visual interface. This project would build on a currently unfunded research collaboration between Mueller and Zadok and devise such a visual framework and suite specifically for smart grid data analytics. (IBM, NY; EMC, MA; Google, NY)



Using Crowd-sourcing to Optimize Smart Grid Visualization Methods and Paradigms for Popular Use

Pls: Arie Kaufman and Klaus Mueller, SBU

Mainstream users often have little literacy to read plots and graphs, which makes these users less inclined to explore their use of energy. In order to test what visualization paradigms can lead to better energy use, awareness and behavior, we have been integrating the various visualization methods to be tested into an online game environment. When participating in the game, users must optimize their energy use in a given virtual household using a subset of the visualizations tested. The hypothesis is that once a large number of users play the game, those who achieve the best results most likely used the best visualizations to monitor their energy consumption. For optimal impact, we decided to create a Facebook-resident game since it offers a high penetration factor. Our game also allows users

to purchase more energy-efficient household devices, given a certain budget and personal preferences. We have a database for (electric household) items used in the game, where we store energy-related specifications but also other product-specific data, such as price, performance, dimensions, a picture and others. A visual selection interface for household items can then be used to pick the most suitable device for the virtual household. In fact, the virtual household could even mimic the user's own household and so the game and its outcome also represent good practical value for the user. (DOE)



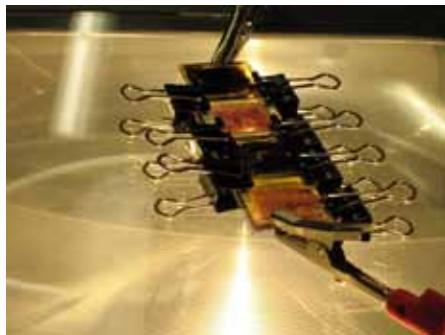
The Long Island Alternative Energy Consortium

liaec.aertc.org

The Long Island Alternative Energy Consortium is a cooperative effort by seven public and private colleges and universities (Stony Brook University, Farmingdale State College, SUNY Old Westbury, SUNY Maritime, New York Institute of Technology, Suffolk County Community College and Nassau Community College), working with public entities (including Brookhaven National Laboratory) and private companies, to ensure that students get the education and training they need to work in the emerging and rapidly evolving industries of renewable and alternative energies.

This collaboration is the beginning of a broad interdisciplinary focus on energy and related issues for a variety of career paths. The ultimate goal is to boost the Long Island economy and contribute infrastructure jobs in the energy sector.

ESTeP – A newly developed minor in energy science, technology and policy (ESTeP) will provide students with the skills to analyze energy policy decisions, follow the dynamics of various energy markets and understand how to use and manage emergent energy technologies. Students from underrepresented populations and nontraditional students, such as veterans or those seeking new careers, are among the demographics the minor targets.



Undergraduate class project on nanocrystalline dye solar cells at SBU.

Academic Program Development – faculty at these colleges will work closely with each other and with industry and government representatives to enhance existing or develop new, academic programs for students interested in working in businesses that design, industrialize, distribute or assess alternative energy for the benefit of Long Island, New York State and the nation as a whole.

Cross Registration – students attending one of the participating colleges and universities will be able to register for courses related to renewable and alternative energy technology and development. Students can choose courses that suit their personal career goals and reflect the diverse capabilities of six outstanding institutions while graduating from their registered institution.

Lectures and Conferences – in order to facilitate the discovery and understanding of key issues in the field, the Consortium will sponsor a series of lectures and conferences relating to sustainable and alternate energy, bringing in experts to interact with students, faculty, government agencies and private companies.

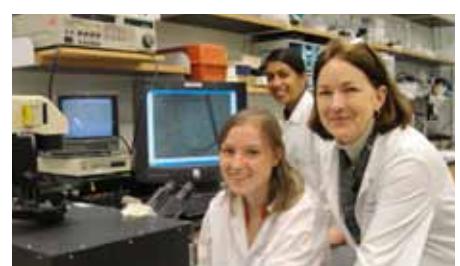
Internships – companies, government agencies, colleges and universities will collaborate to enable students to acquire meaningful, job-related work experiences on Long Island, earn academic credit and develop skills, insight and experience that will guide their future careers.

Job Fairs – one aspect of the Consortium's efforts will be to develop a marketplace where Long Island businesses can find well-prepared students to work in Long Island's emerging energy sector through job fairs, college and university placement offices and faculty/internship referrals.



Collaborative Research – the Consortium will link Long Island's world class college and university resources in basic and applied research to business and government communities in order to bring innovative solutions to their impending energy problems.

For information, contact:
Dr. Gary Halada
Department of Materials Science
and Engineering, Stony Brook University
gary.halada@stonybrook.edu



Research experiences for undergraduates

EDUCATION AND OUTREACH

The Advanced Energy Conference Series: A History of Growth and Success

Individuals Attending

	2007	2008	2009	2010	2011	2012*	2013	2014
Attendees	270	960	1080	1441	443	1640	1662	684

Individuals Presenting

	2007	2008	2009	2010	2011	2012*	2013	2014
Presenters	21	136	192	232	123	342	369	129

Corporate/Organizational Participation

	2007	2008	2009	2010	2011	2012*	2013	2014
Represented	100	375	466	533	214	237	254	403
Exhibit Booths	18	47	67	114	49	90	130	54

Academic Participation

	2007	2008	2009	2010	2011	2012*	2013	2014
College/Universities Represented	6	17	31	37	25	31	72	29
Posters Presented	8	36	48	59	37	60	96	30

*Advanced Energy 2012 canceled due to Hurricane Sandy (estimated)



2007



2009



2008



2009



2009



2010

EDUCATION AND OUTREACH



2010



2010



2011



2010



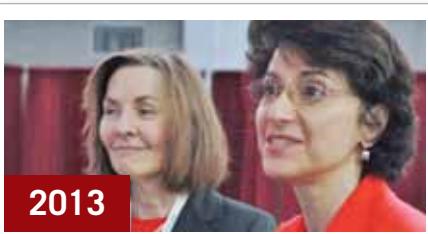
2011



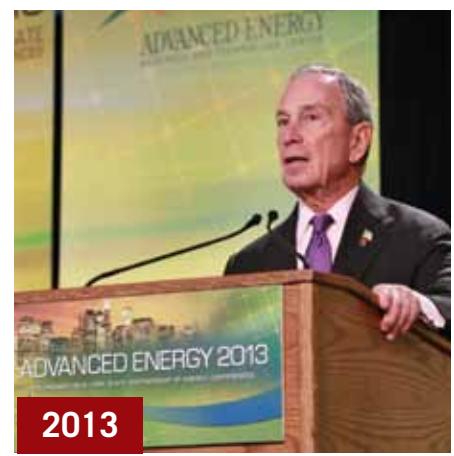
2012



2011



2013



2013



2014



2014

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RESEARCHERS

Adzic, Radoslav
Brookhaven National Laboratory
adzic@bnl.gov

Allen, Philip
Physics and Astronomy
Stony Brook University
philip.allen@stonybrook.edu

Araujo, Kathleen
Technology and Society
Stony Brook University
kathleen.araujo@stonybrook.edu

Bender, Michael
Computer Science
Stony Brook University
bender@cs.stonybrook.edu

Butcher, Thomas
Brookhaven National Laboratory
butcher@bnl.gov

Carbunar, Bogdan
Florida International University
carbunar@cs.fiu.edu

Chang, Qing
Mechanical Engineering
Stony Brook University
qing.chang@stonybrook.edu

Chu, Benjamin
Chemistry
Stony Brook University
Benjamin.Chu@stonybrook.edu

Chyu, Minking K.
University of Pittsburgh
mkchyu@pitt.edu

Cotlet, Mircea
Brookhaven National Laboratory
cotlet@bnl.gov

Cubaud, Thomas
Mechanical Engineering
Stony Brook University
Thomas.Cubaud@stonybrook.edu

Dudley, Michael
Materials Science and Engineering
Stony Brook University
michael.dudley@stonybrook.edu

Feinberg, Eugene
Applied Mathematics and Statistics
Stony Brook University
eugene.feinberg@stonybrook.edu

Ferdman, Michael
Computer Science
Stony Brook University
mferdman@cs.stonybrook.edu

Fortman, Charles M.
Materials Science and Engineering
Stony Brook University
charles.fortmann@stonybrook.edu

Gan, Hong
Brookhaven National Laboratory
hgan@bnl.gov

Gersappe, Dilip
Materials Science and Engineering
Stony Brook University
Dilip.Gersappe@stonybrook.edu

Gopalan, Srikanth
Mechanical Engineering
Boston University
sgopalan@bu.edu

Gouma, Perena
Materials Science and Engineering
Stony Brook University
Pelagia-Irene.Gouma@stonybrook.edu

Gouzman, Mikhail
Electrical Engineering
Stony Brook University
mikhail.gouzman@stonybrook.edu
radu.grosu@stonybrook.edu

Hadjigyrou, Michael
Biomedical Engineering
Stony Brook University
Michael.Hadjigyrou@stonybrook.edu

Halada, Gary
Materials Science and Engineering
Stony Brook University
gary.halada@stonybrook.edu

Hsiao, Benjamin
Chemistry
Stony Brook University
Benjamin.Hsiao@stonybrook.edu

Huang, Peisen
Mechanical Engineering
Stony Brook University
peisen.huang@stonybrook.edu

Hwang, David J.
Mechanical Engineering
Stony Brook University
David.Hwang@stonybrook.edu

Jang, Sung Gheel
Sustainability Studies Program
Stony Brook University
sunggheel.jang@stonybrook.edu

Jiao, Xiangmin
Applied Mathematics and Statistics
Stony Brook University
xiangmin.jiao@stonybrook.edu

Johnson, Robert
Computer Science
Stony Brook University
rob@cs.stonybrook.edu

Jones, Keith
Applied Mathematics and Statistics
Stony Brook University
Brookhaven National Laboratory
kwj@bnl.gov

Kaufman, Arie
Computer Science
Stony Brook University
Arie.Kaufman@stonybrook.edu

Kerkar, Prasad
Materials Science and Engineering
Stony Brook University
pkerkar@ic.sunysb.edu

Khalifah, Peter
Chemistry
Stony Brook University
Brookhaven National Laboratory
peter.khalifah@stonybrook.edu

Kim, Tae Jin
Chemical and Molecular Engineering
Stony Brook University
taejin.kim@sunysb.edu

Koga, Tadanori
Materials Science and Engineering
Stony Brook University
tadanori.koga@stonybrook.edu

Korach, Chad S.
Mechanical Engineering
Stony Brook University
chad.korach@stonybrook.edu

Likharev, Konstantin
Physics and Astronomy
Stony Brook University
konstantin.likharev@stonybrook.edu

Longtin, Jon
Mechanical Engineering
Stony Brook University
Jon.Longtin@stonybrook.edu

Luryi, Serge
Electrical and Computer Engineering
Stony Brook University
serge.luryi@stonybrook.edu

Ma, Xiaosong
North Carolina State University
ma@csc.ncsu.edu

Mahajan, Devinder
Materials Science and Engineering
Stony Brook University
Brookhaven National Laboratory
devinder.mahajan@stonybrook.edu

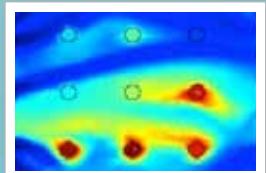
RESEARCHERS

Mamalis, Sotirios Mechanical Engineering Stony Brook University sotirios.mamalis@stonybrook.edu	Schoonan, Martin Geosciences Stony Brook University martin.schoonan@stonybrook.edu	Turn, Scott University of Hawaii sturn@hawaii.edu
Marschilok, Amy C. Materials Science and Engineering Stony Brook University Amy.Marschilok@stonybrook.edu	Shamash, Yacov VP, Economic Development Stony Brook University Yacov.Shamash@stonybrook.edu	Venkatesh, T. A. Materials Science and Engineering Stony Brook University t.venkatesh@stonybrook.edu
Mironova, Tatsiana Materials Science and Engineering Stony Brook University tatsiana.mironava@sunysb.edu	Simon, Marcia Oral Biology and Pathology Stony Brook University Marcia.Simon@stonybrook.edu	Wang, Lifeng Mechanical Engineering Stony Brook University Lifeng.Wang@stonybrook.edu
Mueller, Klaus Computer Science Stony Brook University klaus.mueller@stonybrook.edu	Sion, Radu Computer Science Stony Brook University radu.sion@stonybrook.edu	Wang, Xin Electrical Engineering Stony Brook University xin.wang.1@stonybrook.edu
Oh, Hyungseon University at Buffalo hs01@buffalo.edu	Skiena, Steve Computer Science Stony Brook University skiena@cs.sunysb.edu	Wang, Ya Mechanical Engineering Stony Brook University ya.s.wang@stonybrook.edu
Orlov, Alexander Materials Science and Engineering Stony Brook University alexander.orlov@stonybrook.edu	Smolka, Scott A. Computer Science Stony Brook University scott.smolka@stonybrook.edu	Weyant, Christopher Materials Science and Engineering Stony Brook University christopher.weyant@stonybrook.edu
Rafailovich, Miriam Materials Science and Engineering Stony Brook University miriam.rafailovich@stonybrook.edu	Somasundaran, P. Columbia University ps24@columbia.edu	White, Michael Chemistry Stony Brook University Brookhaven National Laboratory michael.white@stonybrook.edu
Robertazzi, Thomas Electrical and Computer Engineering Stony Brook University thomas.robertazzi@stonybrook.edu	Sun, Guodong Technology and Society Stony Brook University guodong.sun@stonybrook.edu	Wong, Stanislaus Chemistry Stony Brook University Brookhaven National Laboratory stanislaus.wong@stonybrook.edu
Rodriguez, Jose Brookhaven National Laboratory rodriguez@bnl.gov	Stoller, Scott Computer Science Stony Brook University scott.stoller@stonybrook.edu	Wong, Teng-fong Geosciences Stony Brook University teng-fong.wong@stonybrook.edu
Salman, Emre Electrical and Computer Engineering Stony Brook University emre.salman@stonybrook.edu	Takeuchi, Esther S. Materials Science and Engineering Stony Brook University e.takeuchi@stonybrook.edu	Worek, William Mechanical Engineering Stony Brook University william.worek@stonybrook.edu
Sampath, Sanjay Materials Science and Engineering Stony Brook University Sanjay.Sampath@stonybrook.edu	Takeuchi, Kenneth J. Chemistry Stony Brook University Kenneth.Takeuchi.1@stonybrook.edu	Zadok, Erez Computer Science Stony Brook University erez.zadok@stonybrook.edu
Samuilov, Vladimir Materials Science and Engineering Stony Brook University vladimir.samuilov@stonybrook.edu	Tonjes, David Technology and Society Stony Brook University David.Tonjes@stonybrook.edu	Zhou, Yu Mechanical Engineering Stony Brook University yu.zhou.1@stonybrook.edu
Samulyak, Roman Applied Mathematics and Statistics Stony Brook University Brookhaven National Laboratory roman.samulyak@stonybrook.edu	Trojanowski, Rebecca Brookhaven National Laboratory trojanowski@bnl.gov	Zuo, Lei Virginia Tech leizuo@vt.edu



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— Dr. Yacov Shamash
Vice President for Economic Development
Dean, College of Engineering and
Applied Sciences
Stony Brook University



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