THE NATIONAL ACADEMIES

RESEARCH ASSOCIATESHIP PROGRAMS

The Postdoc

Autumn 2013

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NRC Sr. Associate Award

Dr. Bopaiah Cheppudira, NRC Senior Research Associate, Battlefield Pain Management group at **USAISR**, Fort Sam Houston, San Antonio, TX, received poster presentation award at the recently concluded 2013 Military Health System Research Symposium (MHSRS) at Fort Lauderdale, Florida (August 11th to 15th).

continued on page 16

https://ccc.amedd.army.mil/conferences/index.jspx

Col. Dallas Hack (right), director of the Combat Casualty Care Research Program of the U.S. Army Medical Research and Materiel Command, stands with winners of the 2013 Military Health System Research Symposium poster awards. (Photo by USAMRMC public affairs). Dr. Cheppudira, NRC Sr. Associate, second from left.

MHSRS 2013 Award Winners Announced

The 2013 Military Health System Research Symposium Poster Awards were presented on Thursday, August 15, in Fort Lauderdale, Fla., by Col. Dallas Hack, director of the Combat Casualty Care Research Program of the U.S. Army Medical Research and Materiel Command.

GOLD: Dennis Filips – "Evaluation of the iTClamp 50 in a Human Cadaver Model of Severe Compressible Bleeding"

SILVER: Philip DeNicolo – "A Comparison of Dental Disease and Non-Battle Injury Rates of Soldiers in CONUS, Iraq, and Afghanistan"

BRONZE: Melissa Gibbons – Development of a Test Methodology and Modeling Algorithm to Study Material Effects on Blast Lung Injury Using the Normalized Work Method"

HONORABLE MENTION CERTIFICATES:

- H. David Humes – "Immunomodulation with a Selective Cytopheretic Device (SCD) Reduces Acute Brain Injury (ABI) from Intracerebral Hemorrhage (ICH)"
- Phil Rye – "Prevention and Disruption of Multispecies Biofilm Formation and Improved Healing Outcome Using OligoG in a Reproducible Porcine Burn Wound Model"
- **Bopaiah Cheppudira – "Peripheral Antinociceptive Effects of mu-opioid Agonists in a Carrageenan-induced Inflammatory Pain Model"**
- Kenton Gregory – "Treatment of Extremity Compartment Syndrome Using a Multi-Dose Treatment Regimen of Autologous Bone Marrow Mononuclear Cells in Swine"
- Meghan Samberg – "Effect of Platelet Incorporation within Human Plasma Gels on Human Adipose-derived Stem Cell Differentiation"
- Joan Cmarik – "Enhancing Fielded Products"
- Greggory Housler – "Department of Defense Programmatic Overview of Chest Seal Performance"

Congratulations to the winners!

"The Postdoc" newsletter which highlights research and activities of NRC Associates is available in print and on our website: http://sites.nationalacademies.org/PGA/RAP/PGA_047804. Newsletter manager: Suzanne White (swhite@nas.edu)

NATIONAL RESEARCH COUNCIL
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NRCs among 13 honored — Navy's Top Scientist & Engineer Awards

RADM Matthew Klunder, Chief of Naval Research, and CAPT Anthony Ferrari, NRL Commanding Officer, present the award to NRC (former or current) Associates Drs. Anthony Hutcheson, Lee Mitchell, Bernard Phlips, Dr. Eric Wulf, NRL's Space Science Division.

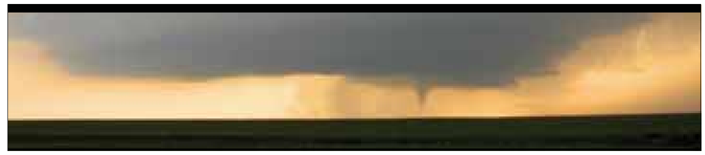
13 US Naval Research Laboratory (NRL) scientists and engineers representing six NRL research divisions were recognized with the prestigious Dr. Delores M. Etter Top Scientist and Engineer of the Year award. The award ceremony was held at NRL on September 5th, with RADM Matthew Klunder, Chief of Naval Research; Dr. John Montgomery, NRL Director of Research; and CAPT Anthony Ferrari, NRL Commanding Officer, presenting the awards. This annual award is sponsored by the Assistant Secretary of the Navy for Research, Development and Acquisition. Former Assistant Secretary of the Navy, Delores Etter established the awards in 2006 to recognize scientists and engineers who have made significant contributions to their fields and to the fleet. **http://www.nrl.navy.mil/media/news-releases/2013/nrl-researchers-honored-with-navys-top-scientist-and-engineer-hash.cOh1mWRY.dpuf**

SuperMISTI Team - Dr. Bernard Phlips, NRC Adviser, and Drs Eric Wulf, Lee Mitchell, and . Anthony Hutcheson all former NRC Associates are recognized for developing and demonstrating the SuperMISTI instrument, which is state-of-the-art in the detection of radiological/nuclear weapons of mass destruction from large standoff distances by passive detection methods. SuperMISTI combines cryogenic detectors that precisely identify the radiation threat with a gamma ray imaging system for source localization. In the July 2012 maritime test program, the self-contained, transportable system demonstrated accurate detection, identification and localization of simulated radiological/nuclear threats in various maritime scenarios at standoff distances out to 300 meters. As an intelligence-cued resource, quickly deployed to a target of interest, it can provide the Department of Navy high sensitivity, accurate information on suspected illicit transport of radiological/nuclear threat materials with dramatically reduced chance of false positive alarms and much larger standoff distances over existing detection capabilities.

RADM Matthew Klunder, Chief of Naval Research, presents the award to Dr. Gary Vora, NRL former NRC Associate and current NRC Adviser

Dr. Gary Vora, former NRC Associate and now NRC Adviser, is recognized for initiating and leading NRL's basic research efforts in the microbiological sciences. In 2012, these efforts resulted in development of the first model bacterial system that can be rationally genetically engineered for sensing, synthesis and decontamination applications in marine environments, integrated biomolecular analyses of ship hull biofouling communities and a comprehensive, single assay tool capable of surveying emerging antibiotic resistance trends and influencing therapeutic treatment decisions: a technology that has been transitioned for use by U.S. Naval Medical Research Units, tri-service and academic collaborators to protect civilian and military populations from multidrug resistant bacterial pathogens. Overall, Dr. Vora has established NRL as a tri-service leader in systems and synthetic biology and a recognized laboratory in the scientific community at-large by developing a set of systems biology methods and tools that facilitate our understanding of how marine bacteria function on the biomolecular level and enable the rational design and construction of genetically engineered sensing and bioremediation bacterial constructs Navy/ Department of Defense relevant applications. As experimental pipelines such as this exist for only a handful of bacterial systems, his efforts have placed the NRL in an enviable position with respect to the nascent fields of systems and synthetic biology. His leadership has allowed NRL to develop a new core competency and necessary research infrastructure that is critical for in-house research and development efforts and for the evaluation of synthetic biology-derived materials from commercial entities: an ability that is not only central to the next century of biotechnology but one that has already been exploited by the Department of Navy in the form of microbially-generated drop-in liquid biofuels.

Weather conditions were ideal for tornado that slammed Oklahoma



The powerful twister that hit Moore was a result of the right atmospheric conditions, as well as bad luck: It was the third time since 1999 that the town has been struck by a powerful tornado. The city of Moore, Okla., was struck by a devastating tornado Monday because all the familiar ingredients were in place to spawn such a massive storm. It was also a victim of simple bad luck. At least twice before in recent years, in 1999 and 2003, destructive twisters have struck the Oklahoma City suburb. Experts said they knew of no scientific reason why Moore became a target yet again.

"If I gave you 1,000 darts and blindfolded you, and you threw the darts, some would cluster together," said **Robin Tanamachi, a NRC Research Associate at the National Severe Storms Laboratory in nearby Norman, Oklahoma**.

"That's, I think, what's happening here. It's a random statistical fluke. Moore has been unlucky."

Scientists sifting through the tornado's wreckage Tuesday said it made perfect sense that a killer storm would emerge in this part of the Plains at this time of year. Warm, humid air from the Gulf of Mexico combines there with dry air from the Rockies, generating swirling winds that can spawn massive thunderstorms — and twisters, when conditions are right. Oklahoma sits squarely in a region that has earned the nickname Tornado Alley.

Meteorologists in the National Weather Service's forecast office in Norman have upgraded Monday's storm from an EF-4 to an EF-5 intensity rating — the highest severity a tornado can achieve on the Enhanced Fujita Scale, which rates tornado strength by assessing the damage a twister inflicts. Conditions were ripe for a storm that day, with plenty of warm, moist air near the ground and temperatures that dropped unusually rapidly as elevations increased, said Howard Bluestein, a tornado researcher at the University of Oklahoma in Norman.

The twister was estimated to have followed a path nearly 20 miles long, remaining on the ground for about 50 minutes. Most tornadoes are over within 10 minutes. Bluestein called Moore's string of bad luck "remarkable."

Early readings of radar collected in the area also painted a picture of a particularly devastating storm, researchers said. Kevin Knupp, an atmospheric scientist at the University of Alabama in Huntsville, used radar to watch the tornado develop in real time from his office. Observing the signal with a graduate student, Knupp estimated that the twister spewed debris across a path two miles wide. He said another dissipating storm in the area may have caused a surge in momentum in low-level air, which in turn could have fed the circulation of the powerful twister.

Tanamachi, who specializes in using radar to build computer simulations of severe storms, said that the Newcastle-Moore tornado, as the weather service refers to it, intensified unusually rapidly. On Monday, she was stationed about five miles south of the tornado's eventual path when radar signals indicated that a super-cell thunderstorm was beginning to develop. Scanning the storm every 60 to 90 seconds and paying attention to details like the size of water droplets, she was able to tell that it was still in an early stage and was "ingesting moist air," which is a common fuel source for a tornado.

Tanamachi said she was surprised by the speed with which the tornado emerged.

Dr. Tanamachi earned her Bachelor of Science (B.S.) degree in in Atmospheric and Oceanic Science at University of Wisconsin at Madison in 2001. She continued her educational career by earning her Master of Science (M.S.) in 2004 and her Doctor of Philosophy (Ph.D.) in 2011, both at the University of Oklahoma.

She analyzed data collected by mobile Doppler radars, using these data to re-create storms and tornadoes inside of a computer. She models the complex air flows in and around tornadoes, and studies how they change with time. She is curious to learn what causes tornadoes to form, but also what causes them to change shape, strengthen, weaken, and finally decay. She spends her day doing computer programming, making graphics, and writing. A few times a year, she travels to scientific conferences to share her findings with other scientists. During the spring (tornado season), she may spend a few days to a few weeks on the road with mobile Doppler radar teams, collecting data in severe storms. The group hopes to catch storms in the act of producing tornadoes and collect data while this is happening. Scientific storm chasing is a difficult task that requires a lot of patience and skill. Mathematics, physics, and computer science are a must for anyone wanting to do severe storms research as a career.

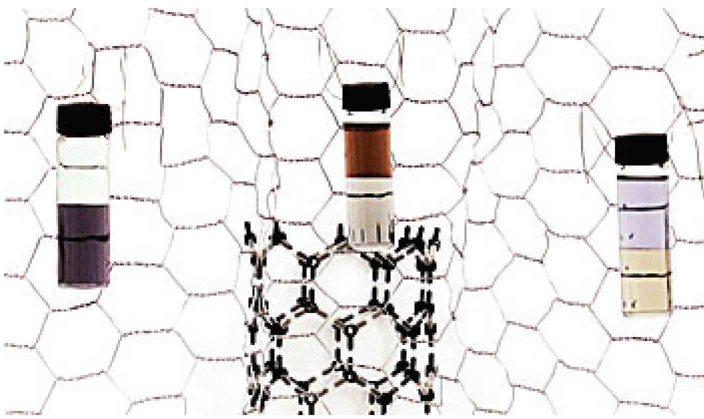
Dr. Robin Tanamachi, NRC Associate at NOAA

Shaking Things Up: Researchers propose new 'old' way to purify carbon nanotubes

National Institute of Standards and Technology

An old, somewhat passé, trick used to purify protein samples based on their affinity for water has found new fans at the National Institute of Standards and Technology (NIST), where materials scientists are using it to divvy up solutions of carbon nanotubes, separating the metallic nanotubes from semiconductors. They say it's a fast, easy and cheap way to produce high-purity samples of carbon nanotubes for use in nanoscale electronics and many other applications.

Carbon nanotubes are formed from rolled-up sheets of carbon atoms arranged in a hexagonal pattern resembling chicken wire. One of the amazing features of nanotubes is that, depending on just how the sheet rolls up, a quality called chirality, the resulting tube can behave either like a semiconductor, with various properties, or like a metal, with electrical conductance up to 10 times better than copper.



Three examples of partitioning carbon nanotubes in liquid phases. Left: nanotubes partitioned by diameter. Smaller diameters, on the bottom, appear purple. Center: partitioned between semiconductors (amber, top) and metals. Right: A sample with different diameter range partitioned between metals (yellow) and semiconductors. Color differences are due to differences in electronic structure.
Credit: Baum/NIST

One big issue in creating commercially viable electronics based on nanotubes is being able to efficiently sort out the kind you want. Thinking about how to do this, **Dr. Constantine Khripin, NRC Associate at NIST** brought up the subject of biochemists and so-called "two-phase liquid extraction."

"Biologists used this to separate proteins, even viruses," says Khripin, ***"It's an old technique, it was popular in the 70s, but then HPLC [high-performance liquid chromatography] replaced a lot of those techniques. People use HPLC to partition carbon nanotubes as well***," he says, "***but it's less successful. HPLC divides things by exploiting differences in the mobility of the desired molecules as they travel small columns loaded with tiny spheres, but carbon nanotubes tend to stick to the spheres, reducing yield and eventually clogging the equipment."***

The concept of liquid extraction is relatively straightforward. You make a mixture in water of two polymers that you've selected to be just slightly different in their "hydrophobicity," or tendency to mix with water. Add in your sample of stuff to be separated, stir vigorously and wait. The polymer solutions will gradually separate into two distinct portions or "phases," the lighter one on top. And they'll bring along with them those molecules in your sample that share a similar degree of hydrophobicity.

It turns out that this works pretty well with nanotubes because of differences in their electronic structure—the semiconductor forms, for example, are more hydrophobic than the metallic forms. It's not perfect, of course, but a few sequential separations ends up with a sample where the undesired forms are essentially undetectable.

Be honest. It's not that easy. ***"No,"*** agrees, Khripin, ***ople tried this before and it didn't work. The breakthrough to realize that you need a very subtle difference between the phases. The difference in hydrophobity between nanotubes y, tiny, tiny."*** But you can engineer that with careful addi- of salts and surfactants.

"This technique uses some vials and a bench-top centri- worth a couple hundred dollars, and it takes under a min- ' observes team member Jeffrey Fagan. ***"The other tech- es people use require an HPLC on the order of $50,000 the yields are relatively low, or an ultracentrifuge that takes 20 hours to separate out the different metals from semi- luctors, and it's tricky and cumbersome."***

"The nanotube metrology project at NIST has been around for a quite a number of years," says senior team member Ming Zheng. ***"It has been a constant interest of ours to develop new ways to separate nanotubes, cheaper ways, that industry can use in the development of nanoelectronics and other applications. We really think we have a method here that fits all the criteria that people are looking for. It's easy, it's scalable, it's high resolution—all the good attributes put together."***

Read more about Constantine on the NIST / Khripin website: http://www.nist.gov/mml/msed/complex_fluids/ckhripin.cfm

Dr. Constantine Khripin, NRC Associate at NIST, June 2011-June 2013

2013 APS Award for Outstanding Thesis Research

Dr. Michael Foss-Feig, NRC Associate at NIST

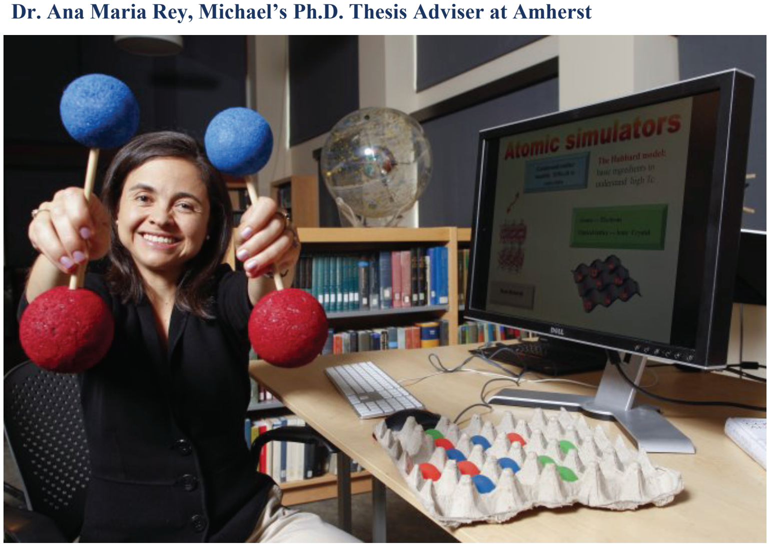
Dr. Foss-Feig received the 2013 American Physical Society Award for Outstanding Doctoral Thesis Research in Atomic, Molecular, or Optical Physics. Michael's Ph.D. thesis, "Quantum simulation of many-body physics with neutral atoms, molecules, and ions," was completed at the University of Colorado in 2012. Michael's **NRC postdoctoral research at the National Institue of Standards and Technology (NIST)** is on the theory of ultracold atoms and molecules, in the group of **Charles Clark, a former NRC Postdoctoral Research Associate**.

Outstanding Doctoral Thesis Research in Atomic, Molecular, or Optical Physics:
http://www.aps.org/programs/honors/dissertation/amo.cfm

Michael Foss Feig:
http://www.aps.org/programs/honors/prizes/prizerecipient.cfm?last_nm=Foss-Feig&first_nm=Michael&year=2013

Michael Foss-Feig was born and raised in Connecticut, and graduated from Farmington High School in 2002. In 2006 he received his bachelor's degree with honors from Amherst College, where he worked under the supervision of Jonathan Friedman studying macroscopic tunneling phenomena in single-molecule magnets. He then moved on to the University of Colorado, becoming a research assistant in the group of Ana Maria Rey at JILA in 2009. His research at JILA pertained to a variety of topics in theoretical many-body physics, with a focus on exploiting the novel properties of alkaline-earth atoms, trapped ions, and polar molecules to explore interesting and/or poorly understood physics at experimentally relevant temperatures. Since graduating in 2012, he has moved back to the east-coast as a National Research Council postdoctoral fellow, working under the supervision of Charles Clark and splitting his time between the National Institute of Standards and Technology and the Joint Quantum Institute

Dr. Ana Maria Rey, Michael's Ph.D. Thesis Adviser at Amherst



Michael's Ph.D. Thesis Adviser at Amherst was Ana Maria Rey, a theoretical physicist and a fellow of JILA, a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology. This September 2013, she was named a winner of a 2013 MacArthur Fellowship, commonly known as the "genius grant."

Rey also is an assistant research professor in the CU-Boulder Department of Physics. She teaches undergraduate and graduate classes. Rey is the eighth CU-Boulder faculty member to win the prestigious award from the John D. and Catherine T. MacArthur Foundation of Chicago as well as the fourth physics faculty member and third JILA fellow. Rey, 36, was one of 24 recipients of the 2013 "no-strings attached" funding. She will receive $625,000 paid out over five years.

"It is a great honor for me to be a MacArthur fellow and to receive such great recognition of my work," Rey said. ***"I want to thank JILA, NIST, CU-Boulder and the outstanding group of colleagues, collaborators and students who have allowed and helped me to accomplish the research I have done."***

The MacArthur Foundation selection committee cited Rey as an ***"atomic physicist advancing our ability to simulate, manipulate, and control novel states of matter through fundamental conceptual research on ultra-cold atoms." We congratulate Professor Rey on this exciting award, and, we also congratulate our faculty, whose ranks now include five Nobel laureates and eight MacArthur Fellowship winners," said CU-Boulder Chancellor Philip P. DiStefano. "I believe Professor Rey's work is emblematic of the research, innovation, and discovery at CU-Boulder, a body of work and a collection of great minds that is unmatched anywhere in the Rocky Mountain region and few places around the nation."***

Tom O'Brian, chief of the NIST Quantum Physics Division and Rey's supervisor, said, ***"Ana Maria has rapidly established herself as one of the world's top young theoretical physicists. She has a special ability to make very practical applications of theory to key experiments. Ana Maria has been crucial to the success of such world-leading NIST/JILA programs as ultracold molecules, dramatic improvements in optical lattice clocks, and use of cold atom systems and trapped ion systems for quantum simulations."***

At JILA, Rey works with ultracold atoms and molecules that are trapped in an "optical lattice," a series of shallow wells constructed of laser light. Atoms that are loaded into an optical lattice behave similarly to electrons in a solid crystal structure. But while it's difficult to change the properties of a solid crystal, the properties of an optical lattice—which essentially acts as a "light crystal"—are highly controllable, allowing Rey to explore a whole range of phenomena that would be nearly impossible to study in a solid crystal system.

Ultimately, Rey hopes her research will lead to the ability to engineer materials with unique characteristics such as superfluids—liquids that appear to move without regard for gravity or surface tension—and quantum magnets—individual atoms that act like tiny bar magnets.

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Rey began studying physics at the Universidad de los Andes in Bogota, Colombia, where she received a Bachelor of Science degree in 1999. She came to the United States to continue her studies, earning a doctorate in physics from the University of Maryland, College Park in 2004. Before coming to JILA in 2008, Rey was a postdoctoral fellow at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and a postdoctoral researcher at NIST in Gaithersburg, Md.

Previous CU-Boulder faculty members who have won a MacArthur Fellowship include David Hawkins of philosophy in 1981, Charles Archambeau of physics in 1988, Patricia Limerick of history in 1995, Margaret Murnane of physics and JILA in 2000, Norman Pace of molecular, cellular and developmental biology in 2001, Daniel Jurafsky of linguistics and the Institute of Cognitive Science in 2002 and Deborah Jin of JILA, NIST and physics in 2003.

"Everyone at JILA is extremely proud of Ana Maria Rey's accomplishments and wholeheartedly congratulate her for this prestigious MacArthur Fellowship," said JILA Chair Murray Holland. ***"She has an incredibly quick mind for physics and is one of the truly creative and ingenious scientists of her time, while also being a wonderful teacher and mentor to both undergraduate and graduate students. This is a great honor for Ana Maria, and a tremendous recognition of the important research programs in JILA and NIST."***

"Rey is a highly effective mentor for an unusually large group of graduate students and postdoctoral fellows given the early stage of her career", O'Brian said. One of Dr. Rey's recent graduate students, **Michael Foss-Feig,** (NRC Postdoctoral Research Associate above) won the prestigious 2013 Best Thesis Award of the American Physical Society's Division of Atomic, Molecular and Optical Physics. Rey herself won the same award in 2005 as a graduate student at the University of Maryland.

On Sept. 24, in another honor, the American Physical Society named Rey the winner of the 2014 Maria Goeppert Mayer Award, which recognizes outstanding achievements by a woman physicist in her early career:
Additional information on Rey is available on the Web at http://www.macfound.org/fellows/901 and http://jila-amo.colorado.edu/science/profiles/ana-maria-rey.

NRC Associateship Program Scientists Push & Pull Droplets with Graphene

Dr. Sandra Hernandez,
NRC Associate at NRL

Scientists at the **U.S. Naval Research Laboratory (NRL), including Dr. Sandra Hernandez, NRC Associate,** have moved liquid droplets using long chemical gradients formed on graphene. The change in concentration of either fluorine or oxygen formed using a simple plasma-based process either pushes or pulls droplets of water or nerve agent simulant across the surface. This new achievement offers potential applications ranging from electronics to mechanical resonators to bio/chemical sensors.

NRL scientists have shown that it is possible to create a chemical gradient on graphene, which pushes or pulls small drops of liquid. Gradients in the wettability of a material are widely found in nature, such as the famous lotus-leaf effect or in spider webs. Researchers who study these effects have found that to be useful, the gradient must be especially smooth without defects that can snag the water droplet. The effect has been achieved before with large molecules or polymers but not with graphene—a layer of carbon only a single atom thick. The chemical flexibility of that carbon enabled both oxygen and fluorine gradients to be created. The mechanical strength of graphene means that these graphene backed chemical gradients could be transferred to many different surfaces. Combined, these advantages provide potential breakthroughs in device design for applications ranging from microfluidics to sensing. The research appears in the June 25, 2013, issue of the journal ACS Nano [DOI: 10.1021/nn401274e].

Creating the chemical gradients requires a delicate touch. While graphene is a robust material, it is still only an atom thick—a too-energetic reaction can rip it apart. The ideal solution was to use an NRL-patented plasma processing technology that can produce the necessary wafer-scale chemical patterns when combined with a physical mask. Here, the mask was a canopy that hung over the graphene, but only partially protected it from the plasma. Moving the canopy higher or making it longer creates different gradients, which are clean and smooth without any additional processing steps.

"The beauty of this approach is the ability to rapidly produce chemical gradients of a desired scale or build arrays of multiple gradients over large surface areas. This combination is very desirable when one considers the large-scale fabrication of devices," said Scott Walton, NRC Adviser and head of the Plasma Applications Section at NRL, and NRC Adviser. ***"An interesting property of graphene is that it can be transferred to many different substrates,"*** notes co-author Paul Sheehan, NRC Adviser in NRL's Chemistry Division. ***"In principle, one could create this chemical gradient on many different substrates, something which has been hard to date."***

The research team produced and tested two different chemical gradients and then tested them using two liquids, water and dimethyl-methylphosphonate (a nerve agent simulant). For both liquids, a gradient of oxygen functional groups pulled the liquid drops towards increasing oxygen concentration. A fluorine gradient did just the opposite, pushing the droplet towards decreasing fluorine. The direction of motion is broadly attributed to shifts in the surface energy on the functionalized surfaces.

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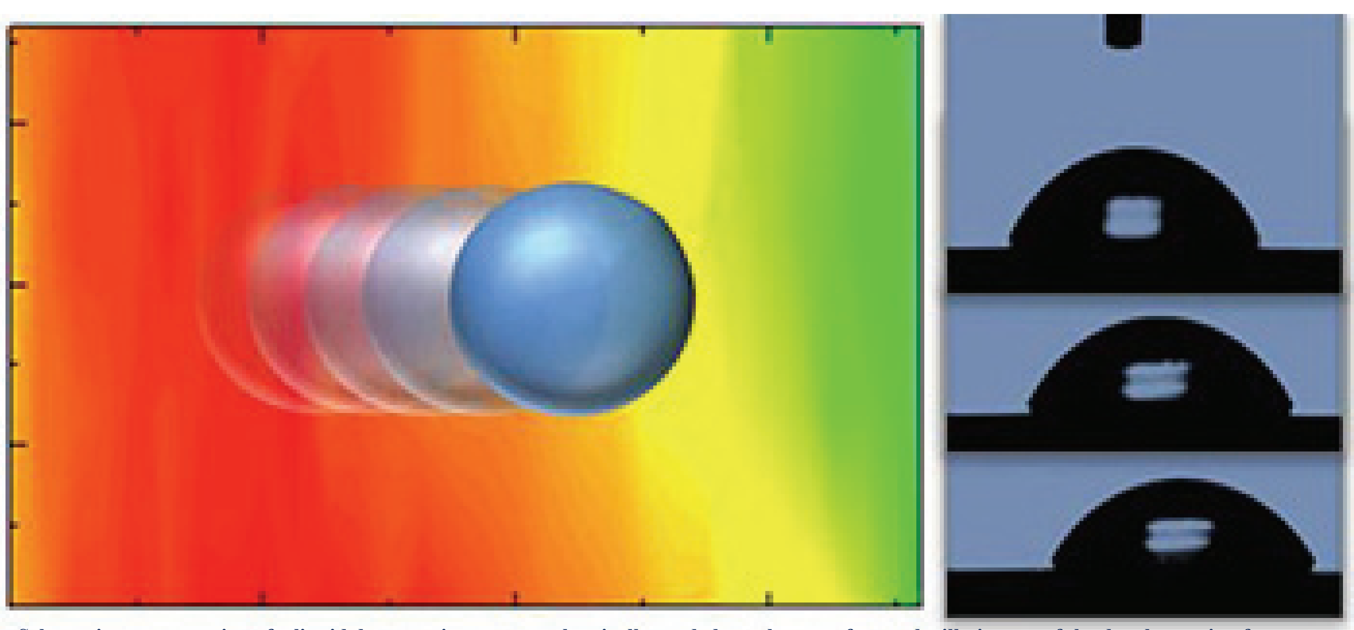

Schematic representation of a liquid drop moving across a chemically graded graphene surface and still pictures of the droplet motion for water on an oxygen gradient

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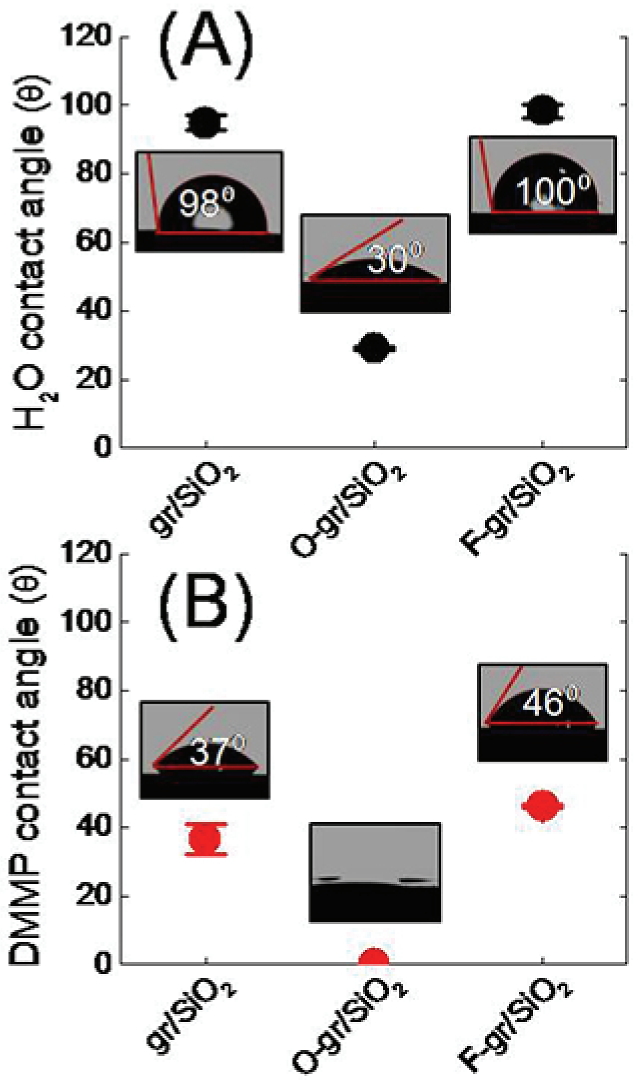

This graph shows the contact angles of 1 µL drops of (A) water and (B) dimethylmethylphosphonate (a nerve agent simulant) on pristine and chemically modified graphene surfaces. (Photo: U.S. Naval Ressearch Laboratory)

Looking forward, the group believes the chemical gradients could be used to propel smaller droplets and perhaps even single molecules. The ability to move liquids or adsorbates across the surface provides additional capabilities in device design for applications ranging from microfluidics to chemical sensing. ***"Well-controlled surface modifications provide the ability to manipulate the material attributes locally, individually addressing the sensory and transducing components of a hybrid material, which offer a range of opportunities in a variety of applications,"*** says **Sandra Hernandez, the NRC-NRL postdoctoral Research Associate** who designed, fabricated, and characterized the gradients. ***"You can imagine these films helping to decontaminate a building or clothes by pulling the agent towards an absorber or a catalyst that breaks them down," adds Dr. Sheehan. "Alternately, it could act like a radar dish for a sensor by pulling all the agents in a large area towards a small, low power sensor."***

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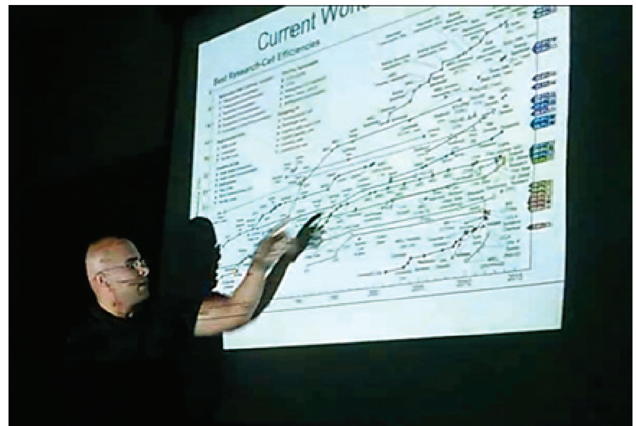
The research is a collaboration among scientists in the Plasma Physics, Chemistry, and Electronics Science & Technology Divisions at the Naval Research Laboratory and the Defense Threat Reduction Agency. Members of the research team include many NRC Advisers and Associates: Drs. Charlee J. C. Bennett, Chad E. Junkermeier, Stanislav D. Tsoi, Francisco J. Bezares, Rory Stine, Jeremy T. Robinson, Evgeniya H. Lock, David R. Boris, Brian D. Pate, Joshua D. Caldwell, and Thomas L. Reinecke.

NRC Associate lectures at PUCMM, Dominican Republic

Dr. Diogenes Placencia, NRC Associate at NRL Division of Electronics Science & Technology gave a lecture at PUCMM University (Pontificia Universidad Catolica Madre y Maestra) in Santiago, Dominican Republic, (August 29th, 2013), on Molecular Electronic Interfaces and their Applications in Solar Energy.

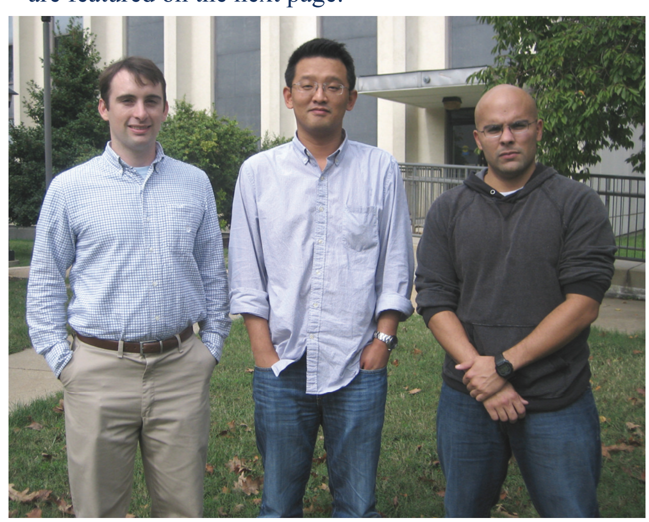
Video: https://copy.com/ryQXZb91IksV ; https://copy.com/gBEHa6lvZ10l ; https://copy.com/p7GL7cCAlzLG

Audio: https://copy.com/nVOLQfUvvIEp



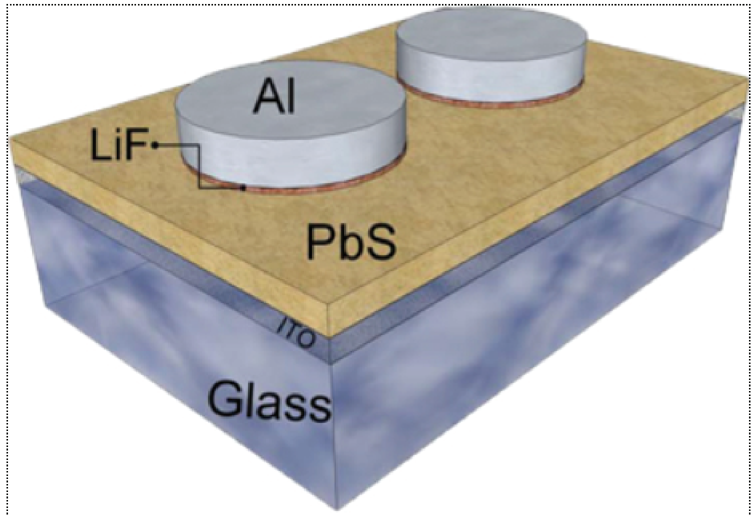
Dr. Diogenes Placencia, NRC Associate at NRL, Diogenes Placencia (shown above) discusses the current state of solar energy technology in the U.S. with students and Professors at PUCMM in Santiago, Dominican Republic.

Drs. Diogenes Placencia, Woojun Yoon, and Troy Townsend, NRC Postdoctoral Research Associates at the U.S. Naval Research Laboratory (NRL), and other NRL research scientists and engineers, as NRC Advisers, in the Electronics Science and Technology Division are featured on the next page.



NRL NRC Research Associates (left to right): Dr.TroyTownsend – Chemistry Division, Dr. Woojun Yoon – Electronics S&T, and Dr/ Diogenes (Dio) Placencia – Electronics S&T) collaborate on various research projects involving semiconducting quantum dots, and their application in next generation photovoltaic technologies.

NRCs achieve highest open-circuit voltage for quantum dot solar cells



Schematic of metal-lead sulfide quantum dot Schottky junction solar cells (glass/ITO/PbS QDs/LiF/Al). Novel Schottky junction solar cells developed at NRL are capable of achieving the highest open-circuit voltages ever reported for colloidal QD based solar cells.

http://www.nrl.navy.mil/media/news-releases/2013/nrl-achieves-highest-open-circuit-voltage-for-quantum-dot-solar-cells#sthash.FNNM1c2d.dpuf

They have demonstrated the highest recorded open-circuit voltages for quantum dot solar cells to date. Using colloidal lead sulfide (PbS) nanocrystal quantum dot (QD) substances, researchers achieved an open-circuit voltage (VOC) of 692 millivolts (mV) using the QD bandgap of a 1.4 electron volt (eV) in QD solar cell under one-sun illumination

Schematic of metal-lead sulfide quantum dot Schottky junction solar cells (glass/ITO/PbS QDs/LiF/Al). Novel Schottky junction solar cells developed at NRL are capable of achieving the highest open-circuit voltages ever reported for colloidal QD based solar cells.

"These results clearly demonstrate that there is a tremendous opportunity for improvement of open-circuit voltages greater than one volt by using smaller QDs in QD solar cells," said **Dr. Woojun Yoon, NRC Associate in NRL Solid State Devices Branch**. ***"Solution processability coupled with the potential for multiple exciton generation processes make nanocrystal quantum dots promising candidates for third generation low-cost and high-efficiency photovoltaics."***

Despite this remarkable potential for high photocurrent generation, the achievable open-circuit voltage is fundamentally limited due to non-radiative recombination processes in QD solar cells. To overcome this boundary, NRL researchers have reengineered molecular passivation in metal-QD Schottky junction (unidirectional metal to semiconductor junction) solar cells capable of achieving the highest open-circuit voltages ever reported for colloidal QD based solar cells. Experimental results demonstrate that improving the passivation of the PbS QD surface through tailored annealing of QD and metal-QD interface using lithium fluoride (LiF) passivation with an optimized LiF thickness.

This proves critical for reducing dark current densities by passivating localized traps in the PbS QD surface and metal-QD interface close to the junction, therefore minimizing non-radiative recombination processes in the cells. Over the last decade, Department of Defense (DoD) analyses and the department's recent FY12 Strategic Sustainability Performance Plan, has cited the military's fossil fuel dependence as a strategic risk and identified renewable energy and energy efficiency investments as key mitigation measures. Research at NRL is committed to supporting the goals and mission of the DoD by providing basic and applied research toward mission-ready renewable and sustainable energy technologies that include hybrid fuels and fuel cells, photovoltaics, and carbon-neutral biological microorganisms.

Making Inorganic Solar Cells with Air-brush Spray

There is currently a tremendous amount of interest in the solution processing of inorganic materials. Low cost, large area deposition of inorganic materials could revolutionize the fabrication of solar cells, LEDs, and photodetectors. The use of inorganic nanocrystals to form these structures is an attractive route as the ligand shell that surrounds the inorganic core allows them to be manipulated and deposited using organic solvents. The most common methods currently used for film formation are spin coating and dip coating, which provide uniform thin films but limit the geometry of the substrate used in the process. The same nanocrystal solutions used in these procedures can also be sprayed using an airbrush, enabling larger areas and multiple substrates to be covered much more rapidly. The trade-off is the roughness and uniformity of the film, both of which can be substantially higher. Reporting their findings in a recent online edition of *ACS Applied Materials & Interfaces* ("Inorganic Photovoltaic Devices Fabricated Using Nanocrystal Spray Deposition"), researchers have now attempted to quantify these differences for a single-layer solar cell structure, and found the main difference to be a reduction in the open circuit voltage of the device. SEM images of the top surface of the deposited films following deposition and sintering, showing CdTe spin coated and CdTe spray coated.

"Our work was motivated by a desire to coat larger substrate areas more efficiently," **Edward Foos, former NRC Associate and currently a research scientists in the Materials Synthesis and Processing Section of the Chemistry Division at the NRL, and first author of the paper, tells Nanowerk. *"Our initial work indicated that if the layers were thick enough to cover the substrate completely and avoid pinhole formation that would lead to shorting of the device, then the increased surface roughness might be tolerable."* He adds that this is the first time the impact of this surface roughness on the performance characteristics has been directly compared for these types of devices. The team prepared single-layer Schottky-barrier solar cells using spray deposition of inorganic (CdTe) nanocrystals with an airbrush. The spray deposition results in a rougher film morphology that manifests itself as a 2 orders of magnitude higher saturation current density compared to spin coating. *"We're currently working to improve the spray coating process to improve the layer uniformity,"* says Foos.**

"If the surface roughness can be reduced, then the overall device performance should increase." **The team is confident that further optimization of the spray process to reduce this surface roughness and limit the Voc suppression should be possible and eventually lead to comparable performances between the two deposition techniques. *"Importantly"* Foos points out, *"the spray-coating process enables larger areas to be covered more efficiently, reducing waste of the active layer components, while enabling deposition on asymmetric substrates. These advantages should be of substantial interest as inorganic nanocrystal-based solar cells become increasingly competitive as third-generation devices."* The team's next step will be the fabrication of more complex device architectures that incorporate multiple solution processed layers. These structures will have an even smaller tolerance for variation. In addition, the deposition chemistry used must not interfere with the material applied in the previous step.**

http://www.nanowerk.com/spotlight/spotid=32458.php#ixzz2hdqUDeCL

An Atomic Clock with 10–18 Instability

Atomic clocks have been instrumental in science and technology, leading to innovations such as global positioning, advanced communications, and tests of fundamental constant variation. Timekeeping precision at 1 part in 10^{18} enables new timing applications in relativistic geodesy, enhanced Earth- and space-based navigation and telescopy, and new tests of physics beyond the standard model. Here, we describe the development and operation of two optical lattice clocks, both using spin-polarized, ultracold atomic ytterbium. A measurement comparing these systems demonstrates an unprecedented atomic clock instability of 1.6×10^{-18} after only 7 hours of averaging.

Quantum mechanical absorbers such as atoms serve as the best available time and frequency references: They are isolatable, possess well-defined transition frequencies, and exist in abundant identical copies. With more than 50 years of development, clocks based on microwave oscillators referenced to atomic transitions now define the Système International (SI) second and play central roles in network synchronization, global positioning systems, and tests of fundamental physics (*1*, *2*). Under development worldwide, optical clocks oscillate 10^5 times faster than their microwave predecessors, dividing time into finer intervals (*3*). Although microwave clocks such as the Cs fountain have demonstrated time and frequency measurements of a few parts in 10^{16} (*4*, *5*), optical clocks now measure with a precision of 1 part in 10^{17} (*6*–*9*).

A clock's instability specifies how its ticking fluctuates over time, a characteristic generally quantified by the Allan deviation (*10*). No time or frequency standard can make measurements better than the statistical precision set by its instability. Further, a clock's systematic uncertainty is often constrained by its long-term instability. For these reasons, and because many timing applications require only exquisite instability, the instability represents perhaps the most important property of an atomic standard.

In pursuit of lower instability, an optical lattice clock uses a stabilized laser referenced to many (10^3 to 10^6) alkaline earth (or similar) atoms confined in an optical standing wave. Alignment of the clock interrogation laser along the direction of tight lattice confinement eliminates most Doppler and motional effects while probing the ultranarrow-band electronic clock transition. These atoms are interrogated simultaneously, improving the atomic detection signal-to-noise ratio and, thus, instability, which is limited fundamentally by quantum projection noise (QPN) (*11*).

Like other cycled atomic clocks, the lattice clock suffers from a technical noise source known as the Dick effect, arising when an oscillator's noise is periodically sampled (*12*, *13*). Cavity-stabilized lasers with low thermal noise have reduced the Dick effect, enabling clock instability below 10^{-15} at short times (*14*). Recently, an uncorrelated comparison of two strontium lattice clocks revealed clock instability of 3×10^{-16} at short times, averaging to 1×10^{-17} in 1000 s (*8*) or, in another case, reaching the 10^{-17} level in 20,000 s (*9*). Here, by comparing two independent optical lattice clocks using ultracold ^{171}Yb, we demonstrate a clock instability of 1.6×10^{-18} in 25,000 s.

Both clock systems, referred to here as Yb-1 and Yb-2, independently cool and collect ^{171}Yb atoms from thermal beams into magneto-optical traps [see Fig. 1 and (*15*)]. Two stages of laser cooling, first on the strong $^1S_0$-$^1P_1$ cycling transition at 399 nm, followed by the weaker $^1S_0$-$^3P_1$ intercombination transition at 556 nm, reduce the atomic temperature from 800 K to 10 μK. Each cold atom sample is then loaded into an optical lattice with ~$300E_r$ trap depth (E_r/k_B = 100 nK; E_r, recoil energy; k_B, Boltzmann's constant) formed by retroreflecting ~600 mW of laser power, fixed at the "magic" wavelength $\lambda_m \approx$ 759 nm (*16*) by a reference cavity. At λ_m, both electronic states of the clock transition are Stark-shifted equally (*17*, *18*). For the measurements described here, ~5000 atoms captured by each lattice are then optically pumped to one of the two ground-state spin projections $m_F = \pm 1/2$ using the $^1S_0$-$^3P_1$ transition. After this state preparation, applying a 140-ms-long π pulse of 578-nm light resonant with the $^1S_0$-$^3P_0$ clock transition yields the spectroscopic line shape shown in Fig. 1C, with a Fourier-limited linewidth of 6 Hz.

Experimental clock cycles alternately interrogate both m_F spin states canceling first-order Zeeman and vector Stark shifts. The optical local oscillator (LO) is an ultrastable laser servo-locked to a high-finesse optical cavity (*14*) and is shared by both Yb systems. Light is frequency-shifted into resonance with the clock transition of each atomic system by independent acousto-optic modulators (AOMs). Resonance is detected by monitoring the $^1S_0$ ground-state population (N_g) and $^3P_0$ excited-state population (N_e). A laser cycles ground-state atoms on the $^1S_0$-$^1P_1$ transition while a photomultiplier tube (PMT) collects the fluorescence, giving a measure of N_g. After 5 to 10 ms of cycling, these atoms are laser-heated out of the lattice. At this point, N_e is optically pumped to the lowest-lying $^3D_1$ state, which decays back to the ground state. The $^1S_0$-$^1P_1$ transition is cycled again, now measuring N_e. Combining these measurements yields a normalized mean excitation $N_e/(N_e + N_g)$. During spectroscopy, special attention was paid to eliminating residual Stark shifts stemming from amplified spontaneous emission of the lattice lasers, eliminating residual Doppler effects from mechanical vibrations of the apparatus correlated with the experimental cycle, and controlling the cold collision shift due to atomic interactions within the lattice (*19*).

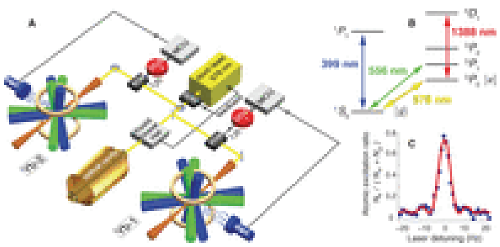


Fig. 1Experimental realization of the Yb optical lattice clocks (A) Laser light at 578 nm is prestabilized to an isolated, high-finesse optical cavity using Pound-Drever-Hall detection and electronic feedback to an AOM and laser piezoelectric transducer. Fibers deliver stabilized laser light to the Yb-1 and Yb-2 systems. Resonance with the atomic transition is detected by observing atomic fluorescence collected onto a PMT. The fluorescence signal is digitized and processed by a microcontroller unit (MCU), which computes a correction frequency, $f_{1,2}(t)$. This correction frequency is applied to the relevant AOM by way of a direct digital synthesizer (DDS) and locks the laser frequency onto resonance with the clock transition. (B) Relevant Yb atomic energy levels and transitions, including laser-cooling transitions (399 and 556 nm), the clock transition (578 nm), and the optical-pumping transition used for excited-state detection (1388 nm). (C) A single-scan, normalized excitation spectrum of the $^1S_0$-$^3P_0$ clock transition in ^{171}Yb with 140-ms Rabi spectroscopy time; the red line is a free-parameter sinc^2 function fit.

By measuring the normalized excitation while modulating the clock laser frequency by ±3 Hz, an error signal is computed for each Yb system. Subsequently, independent microprocessors provide a digital frequency correction $f_{1,2}(t)$ at time t to their respective AOMs, thereby maintaining resonance on the line center. In this way, though derived from the same LO, the individual laser frequencies for Yb-1 and Yb-2 are decoupled and are instead determined by their respective atomic samples (for all but the shortest time scales). The frequency correction signals $f_{1,2}(t)$ are shown in Fig. 2A for a 5000-s interval.

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Special Insert: enlargements of Figs. #1 & #2

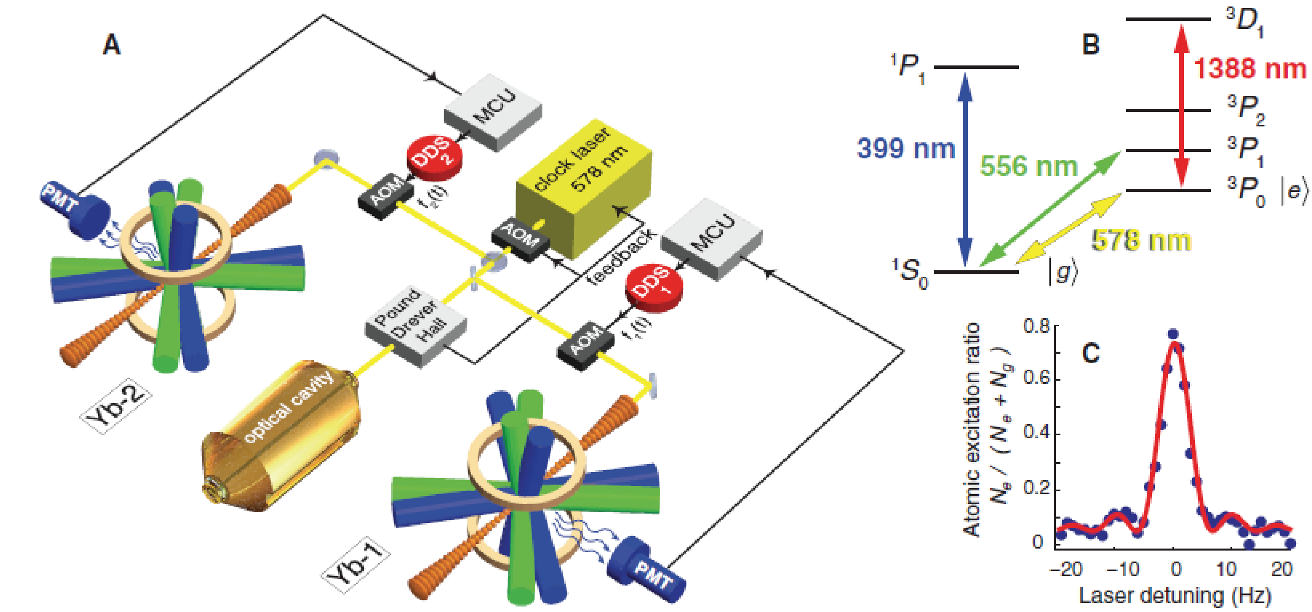

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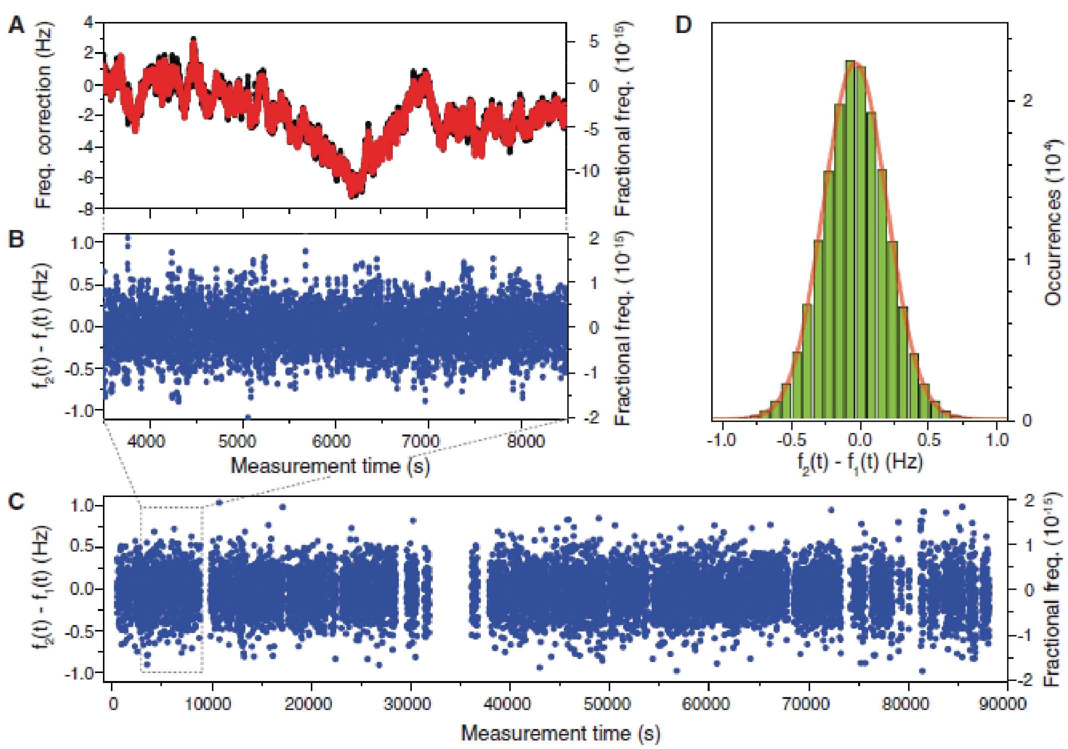
Fig. 2. Frequency comparison between the Yb optical lattice clocks. (A) Correction frequencies, $f_{1,2}(t)$, are shown in red and black. Dominant LO fluctuations are due to the cavity and are, thus, common to the atomic systems. **(B)** Frequency difference, $f_2(t) - f_1(t)$, between the two Yb clock systems for a 5000-s interval. **(C)** Data set $f_2(t) - f_1(t)$ over a 90,000-s interval. Gaps represent data rejected before data analysis due to servo unlocks. **(D)** Histogram of all data and a Gaussian fit ($\chi_r^2 = 0.9996$).



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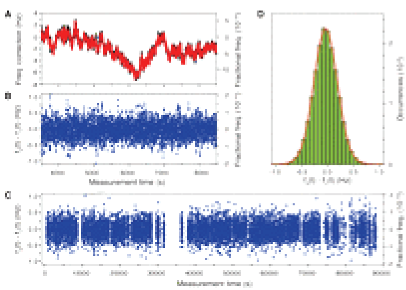
Because the experimental cycles for each clock system are unsynchronized and have different durations, $f_{1,2}(t)$ signals are interpolated to a common time base and subtracted to compute the frequency difference between Yb-1 and Yb-2, as shown in Fig. 2, B to D. Measurements such as these were repeated several times for intervals of ~15,000 s, demonstrating a clock instability reaching 4×10^{-18} at 7500 s. While collecting data over a 90,000-s interval, we observed the instability curve in Fig. 3, shown as the total Allan deviation for a single Yb clock. Before data analysis, ~25% of the attempted measurement time was excluded due to laser unlocks and auxiliary servo failures (*15*). Each clock servo had an attack time of a few seconds, evidenced by the instability bump near 3 s. At averaging times τ = 1 to 5 s, the instability is comparable to previous measurements (*14*) of the free-running laser system, and at long times, the instability averages down like white frequency noise as $\sim 3.2 \times 10^{-16}/\sqrt{\tau}$ (for τ in seconds), reaching 1.6×10^{-18} at 25,000 s.



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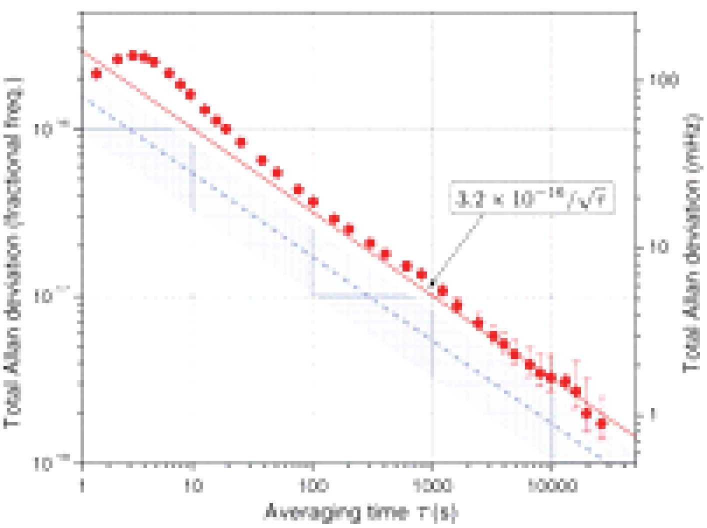

Fig. 3Measured instability of a Yb optical lattice clock.

Total Allan deviation of a single Yb clock, $[f_2(t) - f_1(t)]/\sqrt{2}$ (red circles), and its white-frequency-noise asymptote of $3.2 \times 10^{-16}/\sqrt{\tau}$ (red solid line). The blue dashed line represents the estimated combined instability contributions from the Dick effect $(1.4 \times 10^{-16}/\sqrt{\tau})$ and QPN $(1 \times 10^{-16}/\sqrt{\tau})$; the shaded region denotes uncertainty in these estimates. Error bars indicate 1σ confidence intervals.

Also shown in Fig. 3 is an estimate of the combined instability contribution (blue dashed line) from the Dick effect and QPN (shaded region denotes the uncertainty of the estimate). These contributions must be reduced if 10^{-18} instability is desired at time scales under 100 s. Substantial reductions of QPN are possible with the use of higher atom numbers and longer interrogation times.

Further stabilization of the optical LO will continue to reduce the Dick effect, by both lowering the laser frequency noise down-converted in the Dick process and allowing increased spectroscopy times for higher duty cycles. Improved LOs will use optical cavities exhibiting reduced Brownian thermal-mechanical noise by exploiting cryogenic operation (*20*), crystalline optical coatings (*21*), longer cavities, or other techniques (*14*). Figure 4 demonstrates the advantage of improving the present LO, with four times less laser frequency noise and four times longer interrogation time (corresponding to a short-term laser instability of ~5×10^{-17}). The red dotted line gives the Dick instability, whereas the black dashed line indicates the QPN limit, assuming a moderate 50,000 atom number.

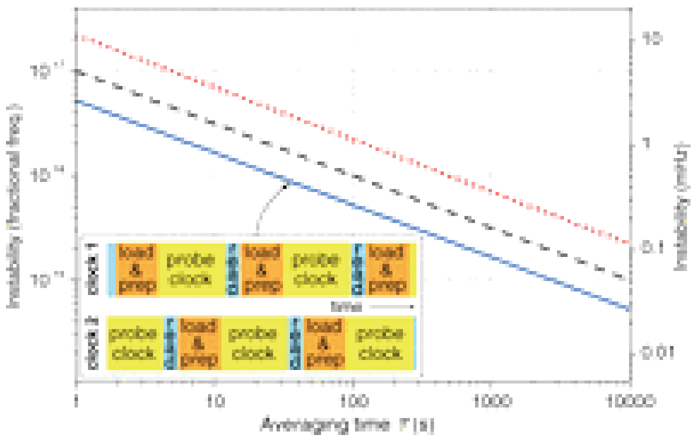

Fig. 4 Calculated instability limits toward the goal of 1×10^{-18} in 100 s. The Dick limit (red dotted line) is reduced by using a hypothetical LO four times as stable as the LO used in our experiment. The QPN limit is shown under the same conditions (black dashed line), assuming 50,000 atoms. The inset illustrates an interleaved interrogation of two atomic systems, allowing continuous monitoring of the LO for suppression of the Dick effect. Dead times from atomic preparation or readout in one system are synchronized with clock interrogation in the second system. The solid blue line indicates the suppressed Dick instability in the interleaved interroga-

Noting that the calculated Dick effect remains several times higher than the QPN limit, we consider an alternative idea first proposed for microwave ion clocks: interleaved interrogation of two atomic systems (*13*). By monitoring the LO laser frequency at all times with interleaved atomic systems, the aliasing problem at the heart of the Dick effect can be highly suppressed. The solid blue line in Fig. 4 illustrates the potential of a simple interleaved clock interrogation using Ramsey spectroscopy. Even with the present LO, the Dick effect is decreased well below the QPN limit afforded by a much-improved LO (black dashed line). In this case, spin squeezing of the atomic sample could reduce the final instability beyond the standard quantum limit set by QPN (*22*). The two-system, interleaved technique requires spectroscopy times that last one half or more of the total experimental cycle. By extending the Yb clock Ramsey spectroscopy time to >250 ms, we achieved a 50% duty cycle for each system, demonstrating the feasibility of this technique. Further suppression of the Dick effect can be achieved with the use of a more selective interleaving scheme. Duty cycles ≥50% can also be realized with the aid of nondestructive state detection (*23*).

Another important property of a clock is its accuracy, which results from uncertainty in systematic effects that alter a standard's periodicity from its natural, unperturbed state. In 2009, we completed a systematic analysis of Yb-1 at the 3×10^{-16} uncertainty level (*16*). Since then, we reduced the dominant uncertainty due to the blackbody Stark effect by one order of magnitude (*24*). With its recent construction, Yb-2 has not yet been systematically evaluated.

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The fact that the instability reaches the 10^{-18} level indicates that key systematic effects (e.g., the blackbody Stark effect, atomic collisions, lattice light shifts) on each system are well controlled over the relevant time scales. The mean frequency difference in Fig. 2 was $\langle f_2(t) - f_1(t)\rangle = -30$ mHz, which is within the Yb-1 uncertainty at 10^{-16}. Systematic effects on each system can now be efficiently characterized beyond the 10^{-17} level. With continued progress, we envision 10^{-18} instability in only 100 s and long-term instability well below 10^{-18}.

Clock measurement at the 10^{-18} level can be used to resolve spatial and temporal fluctuations equivalent to 1 cm of elevation in Earth's gravitational field (25–28), offering a new tool for geodesy, hydrology, geology, and climate change studies. Space-based implementations can probe alternative gravitational theories, e.g., by measuring red-shift deviations from general relativity with a precision that is three orders of magnitude higher than the present level (28). Though present-day temporal and spatial variation of fundamental constants is known to be small (6, 29, 30), 10^{-18}-level clock measurements can offer tighter constraints. Finally, timekeeping improvements can benefit navigation systems, telescope array synchronization (e.g., very-long-baseline interferometry), secure communication, and interferometry and can possibly lead to a redefinition of the SI second (9).

Dr. Kyle Beloy, NRC Associate at NIST

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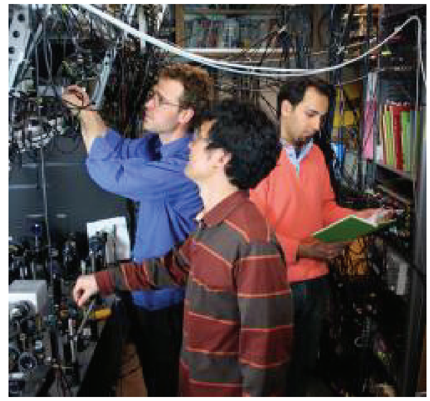

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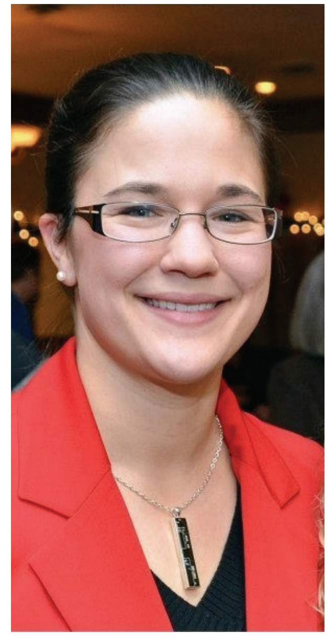
Utilizing sol-gel nanoparticles in concrete curing to improve surfaces



Dr. Jessica Silva, NRC Associate with Dr. Jack Youtcheff, NRC Advisor, FHWA Turner-Fairbank Highway Research Center

Proper curing is a vital post treatment to constructing durable concrete pavements as water loss by evaporation through exposed surfaces can result in mechanical or chemical deficiencies in the final surface of the concrete product.(1, 2) The large exposed surfaces present in the scale of roadway construction, primarily limit the practitioner to the use of Membrane Forming Curing Compounds (MFCCs). These membranes form a physical barrier to the migration of water during the crucial first few hours after concrete placement.(3) Although these materials are widely used, application methods can slow the process and the use of some materials still result in poorly cured concrete. Furthermore, these membranes degrade after environmental exposure and provide little or moderate protection of the concrete surface at later stages of the pavement's service life.

Inorganic membrane forming curing compounds (IMFCCs) are being researched as a new class of curing compounds that may address many of the shortcomings of the current organic compounds. IMFCCs are prepared from metal-oxide materials via sol-gel methods to form nanoparticles. These nanoparticles can react with the concrete surface and form durable coatings and hydration products that may impart beneficial characteristics to the roadway beyond initial curing improvements.

The main objective of this research is to determine if and how IMFCC materials will improve the surface of concrete. They either prevent evaporation from the surface of freshly poured concrete surfaces or react to create an improved layer. In order to better understand if the IMFCCs function to improve the concrete surface several mechanical tests will be conducted including evaporation, absorption, scaling, and chloride penetration.

Through this project, eight different sol-gel IMFFCs were tested; this has been narrowed to three which included SiO_2, SiO_2 combined with TiO_2 (SiO_2/TiO_2), and newly developed silica-aluminate (Si/Al). These water based materials are usually very dilute and have consequently low viscosities. The IMFCCs will be compared to control specimens and two market products, one resin based and one composed of a wax emulsion. The concrete used in this study is produced with ordinary Portland cement (OPC) and either a diabase aggregate or limestone aggregate. Specimens were also created with either Class F fly ash or with Class C fly ash at a 30% replacement of cement by volume.

Typical curing compound application protocols specify that the user apply the material at a rate of 200 ft^2/gal (4.91 m^2/L) after the bleed water has been removed from the cast specimens. It was observed that when using similar rates but applying IMFCC materials with 80% less solids content in comparison to the market products, the IMFCC materials pooled on the surface and were not absorbed by the concrete. It was hypothesized that if the IMFCC could be applied at a later stage when some of the water had been evaporated from the surface, the IMFCC would penetrate and then react to fill the voids that came about from the initial evaporation. This hypothesis prompted the absorption test.

The absorption test (ASTM C 1585) measures the weight of a mortar specimen as water is absorbed through the surface. Older specimens are utilized in this test after they go through a conditioning phase which would allow later application of curing compounds to be tested. If the concrete is dense and well cured then very little water should be absorbed into the surface. If the surface is poorly cured then it will be very porous and allow greater amounts of water into the specimen. To determine if later application of the IMFCC would be effective, three application times were tested, application after the bleed water evaporated as most current materials are applied (0 hours), 6 hours after mixing, and 24 hours after mixing. Two dosage rates were also tested, 3g of IMFCC per specimen or 220 ft^2/gal (the maximum that the surface could hold) and 1.5g per specimen or 110 ft^2/gal (half the previous dosage rate). Delayed application and a higher dosage rate were found to be beneficial to reducing absorption through the surface. Figure 1 depicts the effect of application timing and application rates for specimens utilizing SiO_2 IMFCCs. The values displayed represent the rate of initial absorption and the data show that the higher, level 3 dosage rate provides the least absorption where the low dosage rate appears be independent of application time. Figure 2 shows a comparison of all the types of curing compounds tested. Commercial curing products were tested only as recommended by the manufacturer as it is assumed that would provide the best performance, and therefore delayed application data was not collected. *continued on next page*

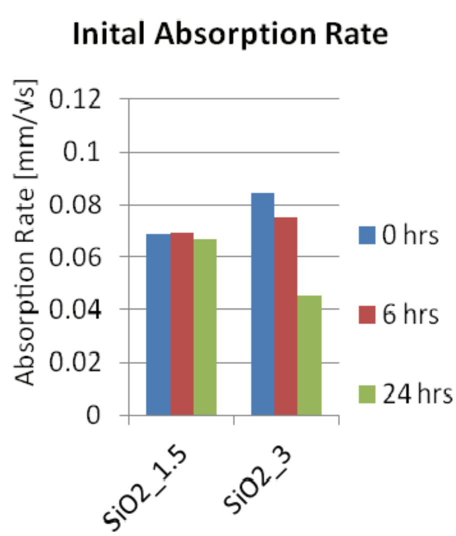


Figure 1 – Initial absorption rate of water through the surface of the specimen. Si_1.5 and Si_3 corresponds to specimens coated with SiO2 IMFCC at a dosage rate of 110 ft^2/gal and 220 ft^2/gal respectively. Using a higher dosage rate and a later application time was most the effective.

Application of the IMFCCs at 24 hours after mixing provided the lowest initial absorption rates indicating an improved surface layer. This supports our hypothesis that IMFFCs should be applied when the surface can accept more liquid, not when the pores are full of water and the nanoparticles are not able to penetrate the surface.

In a related test, chloride penetration was evaluated using ASTM C 1202 to determine if the later application could enhance the blockage of chloride. The concrete field is concerned with chloride penetration because the steel rebar and strand utilized in systems can be corroded by chloride interaction. The same IMFCCs were utilized as in the absorption test, and the IMFFC were applied at a dosage rate of 3g of IMFCC per specimen or 220 ft^2/gal. The results depicted in Figure 3 indicated that applying the IMFCCs at later stages can increase the resistance to chloride penetration when compared to immediate application. This is an expected result based on the reduced absorption seen in the previous tests. The trend however is not totally correlated to a delay in application. As shown, the application at 24 hours in some cases does not outperform the application at 6 hours. Further chloride testing is being conducted to determine the chloride resistance.

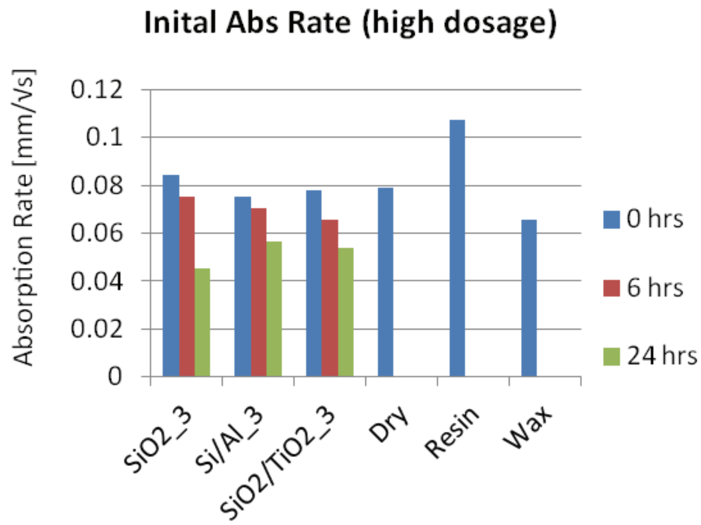
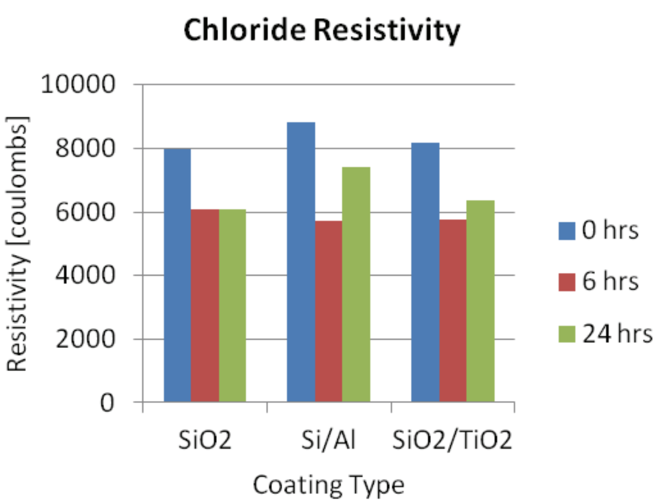


Figure 2 – Similar to Figure 1, this chart compares all of the curing compounds (IMFCCs at a dosage rate of 220 ft^2/gal) and the impact of delayed application. Later application of IMFCCs proved to be an effective procedure.

Figure 3 – Comparison of chloride penetration based the timing of IMFCCs application. Delayed application prevented chloride ingress.



Large concrete specimens were then made to run scaling resistance tests following ASTM C 672. The commercial curing compounds were applied as recommended by the producer after the disappearance of the bleed water. The IMFCCs were applied after 24 hours of mixing. This test protocol requires the specimens be cured for 28 days before testing. Once they have reached maturity, a $CaCl_2$ solution (40g/L) is ponded on the surface and then cycled from freezing to thawing. After 6 cycles the surfaces are evaluated by removing the ponding solution and collecting the scaled surface material to determine how much surface has been degraded. Figure 4 shows one set of specimens made with Class F fly ash. Due to the amount of exposed aggregate it is clear that the IMFCCs improve the resistance to scaling over the control (untreated) surface. Testing is still in progress however certain IMFCCs are showing improved resistance to scaling. A summary of the SiO_2 IMFCC is shown in Figure 5. This chart presents the number of cycles required to scale 100 g of material from the surface of the concrete for the six mix designs tested. In all but one case the IMFCC outperforms the control.

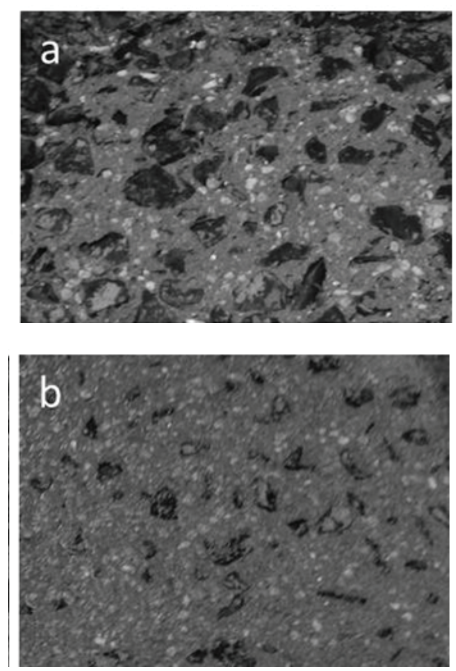


Figure 4
Images show the surface of concrete produced with Fly F and limestone material after ponding $CaCl_2$ for 30 freeze-thaw cycles. Image "a" shows the control specimen while "b" shows a specimen treated with and IMFCC. The IMFCC reduced the scaling

From the initial studies the IMFCCs with the greatest potential for success have been chosen. The application methods have also been defined. After the initial evaluations it seems the IMFCCs have the potential to improve the surface of the concrete and outperform some current market curing compound materials. More testing will be conducted to evaluate the various combinations of materials to obtain a larger scope of these materials' capabilities.

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Figure 5 – The chart reports the number of freeze/thaw cycles until 100g of material has been scaled from the surface of the specimens for the six tested mix designs.

# of freeze/thaw cycles until 100g of surface has scaled						
Mix Design	OPC-Dia	OPC-Lim	FA.F-Dia	FA.F-Lim	FA.C-Dia	FA.C-Lim
Control	54	36	in progress	42	93	24
SiO_2	84	33	in progress	75	104	30

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Dr. Bopaiah Cheppudira, USAISR continued from page 1

ISR researchers attend annual Combat Casualty Care symposium

More than fifty U.S. Army Institute of Surgical Research staff members were among the hundreds of military medical clinicians and scientists to attend the 2013 Military Health System Research Symposium at the Harbor Beach Marriott in Fort Lauderdale, Fla. August 12-15.

During the opening session, Deputy Assistant Secretary of Defense for Force Health Protection and Readiness Dr. David J. Smith welcomed attendees and addressed the value of the 4-day Department of Defense conference, which brings together scientific military, academia, industry leaders and researchers from around the globe to discuss advancements in research and health care developments in the areas of combat casualty care, military operational medicine, clinical and rehabilitative medicine, and military infectious disease programs.

"This really is a mission-essential symposium and it's of critical importance because it provides a forum to address the unique medical needs of our warfighter in a collaborative environment where the (military health system) providers with deployment experience, scientists, academia and industry experts come together to exchange scientific information, drive innovation and ensure continued advancement in military medicine", said Smith.

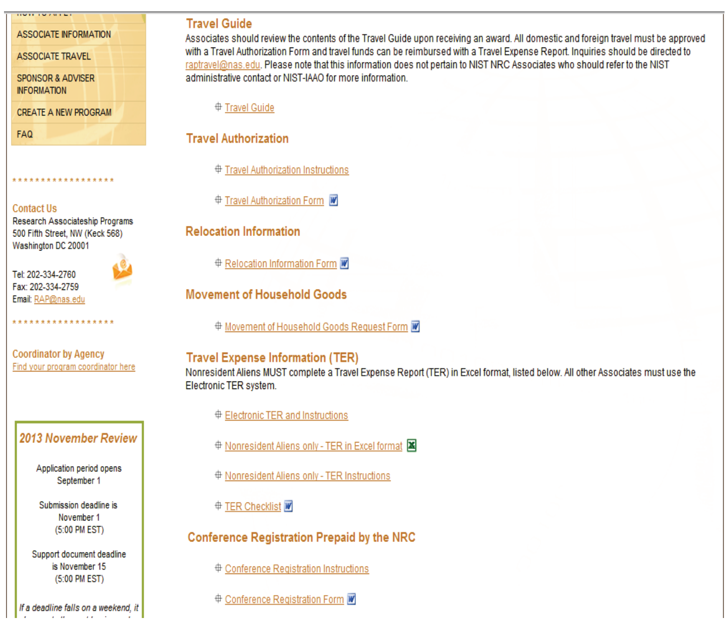
The conference is the careful combination of three previous conferences: the former Advanced Technology Applications for Combat Casualty Care Conference; the Air Force Medical Service Medical Research Symposium; and the Navy Medicine Research Conference. By combining these into one event, the meeting serves as a critical strategy session for leaders to set future milestones for DoD's deployment-related medical research programs, centered on the warfighter's needs.

"Our fighting men and women ask three things from us. Number one is that we give them the best training and the best equipment in the world. Number two is that we give them the best medical treatment in the world, and number three is that we do not leave any American behind," said Congressman John C. Fleming, M.D. ***"Research has led to many health care advancements in combat casualty care during the past decade, but military leaders emphasized that the work doesn't end when troops return home."***

"As combat draws down, military medicine must continue at full pace because we have thousands of beneficiaries with complex, unique physical and mental injuries," said Maj. Gen. Joseph Caravalho Jr., commanding general of the USAMRMC and Fort Detrick. ***"We must not lose momentum."***

During the symposium, some USAISR staff members were recognized for their research. Research Task Area Program Manager for Comprehensive Intensive Care Research Jose Salinas, Ph.D, received the MHSRS Award of Excellence for his leadership of the team which developed and commercialized the Burn Resuscitation Decision Support System-Mobile; Col. (Dr.) Philip DeNicolo, Chief of Regenerative Medicine at the Dental and Trauma Research Detachment was presented an Award of Excellence (Silver Award in the poster presentation); and Bopaiah Cheppudira received an Honorable Mention certificate (poster presentation).

"This award shows how all our team members work together, not just with other organizations at MRMC, but with an outside commercial partner to take this project from concept development, prototyping, and finally into a fully developed and FDA-cleared medical device," said Salinas. ***"This would not have been possible without the full support of the ISR leadership and the MRMC."***



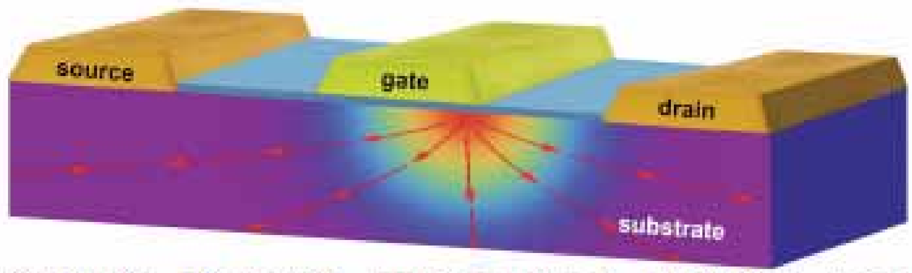
NRC researchers discover novel material for cooling of electronic devices

A team of theoretical physicists at the U.S. Naval Research Laboratory (NRL) and Boston College has identified cubic boron arsenide as a material with an extraordinarily high thermal conductivity and the potential to transfer heat more effectively from electronic devices than diamond, the best-known thermal conductor to date. As microelectronic devices become smaller, faster and more powerful, thermal management is becoming a critical challenge. This work provides new insight into the nature of thermal transport at a quantitative level and predicts a new material, with ultrahigh thermal conductivity, of potential interest for passive cooling applications.

Calculating the thermal conductivity of cubic III-V boron compounds using a predictive first principles approach, the team has found boron arsenide (BAs) to have a remarkable room temperature thermal conductivity, greater than 2,000 Watts per meter per degree Kelvin (>2000 Wm-1K-1). This is comparable to those in diamond and graphite, which are the highest bulk values known.

Unlike metals, where the electrons carry the heat, diamond and boron arsenide are electrical insulators. For the latter type of materials heat is carried by vibrational waves (phonons) of the constituent atoms, and intrinsic resistance to heat flow results from these waves scattering from one another. Diamond is of interest for cooling applications but it is scarce and its synthetic fabrication suffers from slow growth rates, high costs and low quality. However, little progress has been made to date in identifying new high thermally conductive materials.

Historically, fully microscopic, parameter-free computational materials techniques have been more advanced for electronic properties than for thermal transport.



Schematic of thermal management in electronics: Local temperature increases occur as a result of current flow in active regions of devices and can lead to degradation of device performance. Materials with high thermal conductivities are used in heat spreading and sinking to conduct heat from the hot regions. *(U.S. Naval Research Laboratory)*

"In the last few years with contributions from the NRL team, 'ab initio' quantitative techniques have been developed for thermal transport," said **Dr. Thomas L. Reinecke, NRC Adviser** and physicist in the Electronics Science and Technology Division. ***"These techniques open the way to a fuller understanding of the key physical features in thermal transport and to the ability to predict accurately the thermal conductivity of new materials."***

These surprising findings for boron arsenide result from an unusual interplay of certain of its vibrational properties that lie outside of the guidelines commonly used to estimate the thermal conductivity of electrical insulators. These features cause scatterings between vibrational waves to be far less likely than is typical in a certain range of frequencies, which in turn allows large amounts heat to be conducted in this frequency range.

"If these exciting results are verified by experiment, it will open new opportunities for passive cooling applications with boron arsenide, and it would demonstrate the important role that such theoretical work can play in providing guidance to identify new high thermal conductivity materials," Reinecke says.

Thermal conductivity calculations from this group are in good greement with available experimental results for a wide range of materials. The team consisted of **Dr. Lucas Lindsay, NRC Associate at NRL, Dr. Tom Reinecke** and Dr. David Broido at Boston College.

This research, supported in part by the Office of Naval Research (ONR) and the Defense Advanced Research Projects Agency (DAPRA), gives important new insight into the physics of thermal transport in materials, and it illustrates the power of modern computational techniques in making quantitative predictions for materials whose properties have yet to be measured.

Left: Dr. Tom Reinecke, NRC Adviser
Right: Dr. Lucas Lindsay, NRC Associate

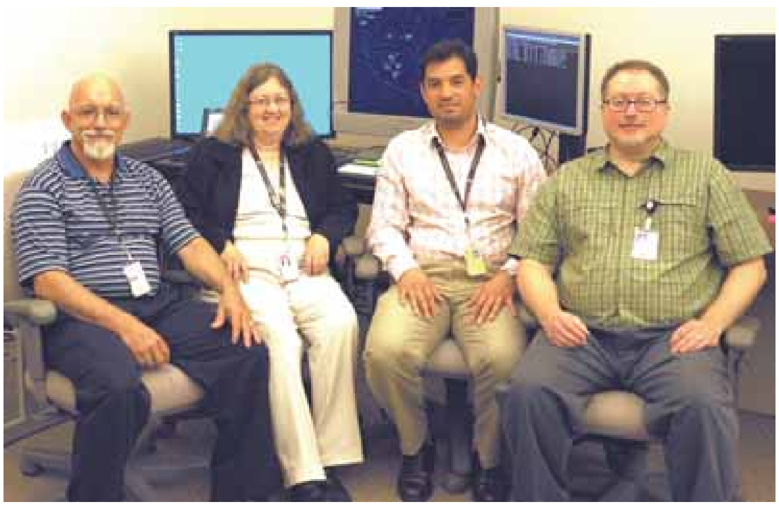
Human Factors Engineering and Air Traffic Control

Dr. Angel Millan, NRC Associate at the Federal Aviation Administration Civil Aerospace Medical Institute (CAMI) in Oklahoma City, Oklahoma. has been working along with Dr. Jerry Crutchfield and Dr. Carol Manning, researchers from the Aerospace Human Factor Research Division (AHFRD), on assessing differences in air traffic controller performance. Dr. Millan's research attempts to understand the impact that changes in air traffic control procedures and equipment have on the cognitive performance of air traffic control specialists.

This research aims at providing designers and policy makers with appropriate requirements to match airspace structure and capacity to controllers' capabilities. In order to increase the number of flights or even properly staff an air traffic control facility, systems have to be designed to help controllers manage constraints imposed by administrative (e.g.: work shifts, restricted areas, altitudes), environmental (e.g.: weather, wind changes) and traffic loads. However, there is no gold standard available for measuring controller performance in these constrained conditions. Additionally individual differences play a significant role in the measurement of controller performance.

Dr. Millan's approach considers the controller as the critical element in the system; therefore he evaluates the usability and performance aspects of human-system interactions using objective and subjective metrics, such as keystrokes, workload ratings, task latencies among others, and tries to map these to a common set of activities. One aspect of the evaluation relies on controllers' subjective estimates of their own workload levels; in other words, controllers use a scale to rate how busy they think they are. However, it is believed that these self-assessment responses are the result of the aggregation of internal cognitive processes and measurements that are influenced by past experience, events, strategies and individual differences. These factors may hamper assessment and evaluation of human performance especially at the micro task level or when research questions demand a more objective measurement. Direct and continuous physiological and cognitive measurements provide more reliable and objective metrics for assessing human capacities and limitations while performing tasks and interacting with systems. However, because the vast majority of tasks in the air traffic control environment, including decision making, are cognitive and therefore unobservable, direct measurements of the human-computer interaction are difficult to obtain.

Nevertheless, the application of neuroscience to the field of ergonomics, giving birth to the term "neuroergonomics," has



Left to right: Dr. Larry Bailey, Dr. Carol Manning, NRC Adviser, Dr. Angel Millan (NRC Associate), Dr. Jerry Crutchfield. Location: Air Traffic Control Advanced Research Simulator (ATCARS) Laboratory at the Aerospace Human Factors Research Division of the Civil Aerospace Medical Institute.

opened a door to explore the use of brain electrical potential as a metric to evaluate human reactions to task loads, complexity and interfaces. The use of technologies such as electroencephalography (EEG), commonly used in the medical field, to collect neurological activity is currently being evaluated by the AHFRD as a tool to continuously and objectively assess human capacities and limitations to perform tasks as well as to infer effectiveness of systems and interfaces.

As part of this line of research, Dr. Millan has been working with Dr. Larry Bailey (AHFRD) in the design of protocols and evaluation of EEG in air traffic control operations. During his tenure, Dr. Millan has had the opportunity to collaborate and participate with researchers from the University of Oklahoma, the FAA Research Development and Human Factors Laboratory (RDHFL) located in Atlantic City, NJ, and the Human Research and Engineering Directorate of the Army Research Laboratory. This collaboration is aimed toward knowledge transfer and implementation of this technology in the air traffic control and human performance research. Continuous recording of brain activity could potentially provide researchers with objective data on controller responses during the interaction with the system.

The analysis of these responses can be translated to specific metrics that can be used to describe levels of engagement, fatigue, effort and workload that influence task performance. Through the use of EEG, Dr. Millan has contributed to advancements in the understanding of how time on task fatigue leads to a reduction in cognitive resources available to controllers. His recent work formed the basis of a session that he organized and presented at the May 4, 2013, Oklahoma and Kansas Judgment and Decision Making Workshop. The session was entitled "A Neuroergonomic Analysis of Air Traffic Controller Performance." This research on human performance and neuroergonomics is leading to the development of new objective metrics for the evaluation of controller performance and ATC interface design, which could translate into reductions in controller training time, hardware maintenance, and operating costs.

Dr. Angel Millan received a bachelor degree in Aeronautical Engineering from the Universidad Nacional Experimental Politécnica de la Fuerza Armada in Venezuela, a Master of Science in Aeronautics (double concentration in aerospace system safety and management) from Embry-Riddle Aeronautical University, Daytona Beach FL and a Ph.D. in Industrial Engineering from the University of Central Florida, Orlando FL. He received an NRC Research Fellowship on 2012 to work on air traffic controller performance and NextGen initiatives with the Aerospace Human Factors Research Division at the Civil Aerospace Medical Institute located in Oklahoma City, OK.

Dr. Stephanie Cole, NRC Associate, ECBC

"Human on a Chip" Stem-Cell Research

Dr. Cole is currently working with a stem cell team under **Dr. Harry Salem, NRC Adviser and Chief Scientist for Life Science at the Edgewood Chemical Biological Center (ECBC).**

"Stephanie has been such a great addition to our team," said Salem. ***"Working with the postdoctoral associates is as much a rewarding experience for me as I hope it is for them. Having someone like Stephanie on the team brings such energy and talent to the work we do."*** Cole joined this program after receiving her undergraduate degree from McDaniel College and her Ph.D. from Johns Hopkins University. She recently sat down with us to tell us more about her experience as a **NRC Associate.**

Stephanie got involved in the NRC's Research Associateship Program when she was completing her Ph.D. She went to the NRC's website and saw that ECBC had interesting research and it seemed like a great place to work. She had an interview and completed a lengthy application, including a ten-page research proposal. It's an extensive process! She was interested in chemistry, biology, studying chemical toxicology, so this provided a unique opportunity to do that. Also, Stephanie and her husband live in Bel Air, and their families are both nearby, so the local aspect was appealing.

Before her senior year in high school, Stephanie did not know what she wanted to do, but knew it wasn't science! She was talked into taking an AP Biology course and the teacher made it so fun. She did pretty well, and it got her hooked. In college, she took more classes, and had a few internships where she got to do research. Stephanie realized she enjoyed doing research and experiments – it felt like a puzzle that she could figure out. So, she decided to pursue that route. It's amazing—one teacher made such a difference in her life.

All of Dr. Salem's team works together to develop the "human on a chip." All of the post docs have been assigned different organs to study independently, with the goal of one day being able to connect them all together. Stephanie has been assigned the liver, so her focus is to create a model for liver metabolism and to study the effects of human metabolism on toxicity using subcultures. A lot of current toxicity studies use animal models, but animals metabolize compounds very differently than humans do. We're working on developing models in vitro, or outside of the body, to test various chemicals. We take liver cells from human cadavers and culture them; they're metabolically active and have been shown to metabolize things the same way as they would in vivo, or inside of the body, so we can have effective experiments that will help us understand how humans metabolize toxins differently from animals.

We look at therapeutics, or ways to treat certain reactions to compounds. But one of the big fields of study is looking at human estimates; based on animal studies we can actually use this type of research to estimate what the human response would be to those compounds. Right now we're just working on the concepts and trying to build up this area of study. There are a lot of different avenues we can take with this area of research.

Dr. Cole spends about 40-50 percent of her time in the lab, planning out experiments with the team. The other portion of her time is mostly spent reading, writing, trying to think of new ideas for projects or different ways we can go with this project and writing research papers. She would like to stay at ECBC if possible and continue with the Army and government research; maybe be a PI in a government lab. This is a nice transition to learn the Army and the environment.

Stephanie honestly admits that one of the most challenging things right now is the budgetary constraints and its affect on funding. As a new postdoc, she wants to get grant writing experience, but in the current climate it can be hard to seek more funding. The good thing, though, is that this field will always be relevant, so she feels like there will be opportunities down the road for that experience.

"With the stem cells and the in vitro toxicity testing, it's been really fun to be at the cutting edge of science", adds Setphanie. ***"I really enjoy attending conferences and meeting others in this field, collaborators we could maybe partner with one day. Knowing our ideas are brand new is very fun and provides a lot of opportunities to write papers and continue to learn more."***

Talk to people—the more people you know, the more you can find out about what you're interested in. See if you can get internships, which provide such great experience, especially in labs. That can also help you figure out if that is the kind of work you really want to pursue.

NRC Associates at ECBC: background-Dr. Crystal Randall, foreground-Dr. Stephanie Cole

Understanding Host-Pathogen Interactions

Dr. Crystal Randall , NRC Associate, ECBC

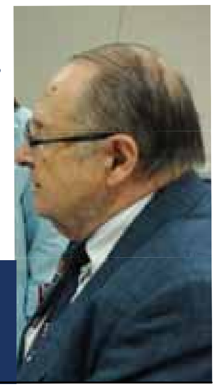
At the time **Dr. Crystal Randall, NRC Associate, ECBC**, earned her Ph.D from the University of Illinois in May 2013, she knew that she wanted to have real-time applications to her science research. When she was offered an Associateship with the NRC Program in June 2013, Crystal was more than willing to pack up her van and make the journey from Illinois to Maryland with her husband, her one-and-a-half year old twins, her dog and cat for an opportunity to work with the Edgewood Chemical Biological Center (ECBC).

"The move was challenging, but NRC made it easy for me to make the trip, "It's a great program and one that I am very happy to be a part of."

Dr. Randall started working at ECBC with the NRC program in June 2013, having always been interested in working for the government since she was an undergraduate. The government appealed to her because it gives the opportunity to do applied research as opposed to basic research. This position gives the opportunity to work on real-world problems and be closer to an end result that can affect change and benefit people. Basic research is still fascinating, but you don't get to interact with a process or product as easily.

Post 9/11, when poxviral diseases began to e identified as a biological threat, universities started receiving funding for research focusing on poxviruses (such as the *molluscum contagiosum poxvirus*), and how they evade host immune responses. In the University of Illinois Department of Microbiology, Dr. Randall's main interest was to understand the host-pathogen interactions. The study of host-pathogen interactions focuses on the interplay between a virus and its host during infection. Viruses have evolved many strategies to circumvent the body's ability to fight infections. Most cells in the human body have defense systems that can detect infection. However, viruses can hide within cells and make proteins that block the cell from detecting infections, thereby making the body's immune system weaker. Crystal's studies focused on how viral proteins interact with and prevent the cell's innate defenses.

There she works on the "Human-on-a-Chip" program along with several of the other postdoctoral researchers at ECBC. They are each focusing on different organ systems with the long-term objective of connecting the four systems through a medium for human predictive toxicity testing. The goal is to them test chemical agent against this system and be able to get a more accurate picture of how the human body reacts to the exposure, thus making it easier to develop countermeasures. Crystal's main focus is on the Lung or Pulmonary Project.



Dr. Harry Salem, ECBC NRC Lab Representative, and NRC Adviser, "Human On a Chip Program.

They grow human lung cells in an air-liquid interface (ALI) cultures. In an ALI culture, the cells are grown on a membrane that is suspended over cell media, so that bottom of the cells are exposed to the media and the top are exposed to the air. This culturing method allows our airway cultures to develop lung-specific characteristics, such as cilia and mucus production. They use a unique exposure system that allows us to expose our airway cultures to aerosolized chemicals. Exposing our cultures in this way allows us to mimic real-world exposure to toxicants in the air. We They then evaluate the cultures before and after exposure to the aerosolized chemicals to learn about the toxicology of each chemical. Testing like this could yield more predictive results on the effects of chemical agents on humans.

Left to right: Drs. Crystal Randall and Stephanie Cole, NRC Associates at EBCB

The biggest challenge of the program will be assessing that the results from our testing is comparable to actual results of a human exposure. The cells take about a month to grow, and do not live long, capturing data quickly is a challenge. Our triumph for this project will be when we develop more predictive tests with which to compare results to previous models, and from which to develop a profile for future exposures.

Dr. Randall's main goal is to develop as a scientist and continue to work on projects where she can be independent and design her own projects. Right now, she really enjoys working for the government and would like to continue doing so. "The government has sophisticated instruments—great to use and make an impact!"

Dr. Joon Park, NRC Senior Associate at AFRL

AFRL NRC Associate Cybersecurity Preceptor in South Korea

The Air Force Research Laboratory (AFRL) under the auspices of the Air Force Office of Scientific Research (AFOSR) was fortunate to have one of its subject matter experts (SMEs) working hand-in-hand with South Korea as it looks to advance its cybersecurity capabilities. This SME acquired his expertise prior to his affiliation with AFRL. In recognition of his knowledge, South Korea's cybersecurity endeavors spurred an invitation to Syracuse University Professor **Dr. Joon Park**. Dr. Park was a **NRC Senior Associate** on a multi-year extended sabbatical in **AFRL's Information Directorate in Rome, NY**. **Dr. Kevin Kwiat of AFRL/RI was his NRC Adviser.** Over the past decades, Dr. Park has been involved with theoretical and practical research and education in information and systems security. He has been integral in establishing Syracuse University as a National Security Agency and Department of Homeland Security-designated Center of Academic Excellence in Information Assurance (IA) both for education and research. He is also the principal investigator for the Department of Defense Information Assurance Scholarship Program at Syracuse University.

Although Dr. Park’s RAP activities primarily aimed to contribute to the Directorate's cyber assurance research and facilitate collaboration with Syracuse University, the broad and in-depth impact in cybersecurity that he achieved as a university professor had already positioned him as a forerunner in the field. During his first year of RAP tenure, Dr. Park’s work at Syracuse University allowed him to create a series of seminars and tutorials for South Korea’s world-class universities and multi-national flagship information technology (IT) companies, such as Korea Advanced Institute of Science and Technology, Yonsei University, Korea Institute of Science and Technology, and Samsung Electronics.

Embracing advanced technology and emphasizing high vigilance are two mindsets that go together in South Korea. With 95% of its households having a permanent Internet connection, the country is leading the world in what it means to be “wired.” This strong measure of progress is blended with apprehension because of South Korea's locale; it is a region of unsurpassed armament. Similarly, cyberspace exhibits the properties of progress and, with the ever-presence of threats, the potential for peril. Unlike kinetic weapons that invoke the fear of immediate physical harm, attacks within cyberspace have an invisible quality; therefore, defending against them is more diffuse. Being a high-profile occupant of cyberspace has meant that South Korea's interests in securing its Internet presence have spanned its government, military, industrial, and civilian sectors. Recently, Dr. Park has played a key role in its efforts.

He leads research seminars in South Korea, which are intended for IA researchers, security administrators, and IT system developers, that explore how to apply information security technologies and approaches to real-life systems and services. Based on the demand by the current technology trends and evolution, Dr. Park presents the evolution of security challenges, potential solutions, and related issues in popular IT services, including cloud computing, online social networking, biometrics, and mission-critical systems.

His IA tutorials cover the principal concepts and approaches in information security for executive decision makers within organizations and general IT practitioners. His comprehensive approach considers not only technical solutions, but also non-technical issues related to information security management, including principal concepts of information security, system vulnerabilities, information security policies, models, mechanisms, and evaluation.

The outcome of Dr. Park's South Korean endeavors exceeded expectations. The goal for his trips was education and dissemination, but he achieved much more. He generated enthusiasm, and enthusiasm can be infectious. As a professor whose primary research and teaching area is information security, he has been trying to share his research outcomes and teaching philosophy so that, ultimately, the cybersecurity knowledge and practice can make a positive impact on the entire society. Dr. Park’s presentations in South Korea were based on work he accomplished prior to his RAP tenure at AFRL, but the spreading of cybersecurity understanding to South Korea has been aligned with AFRL’s interests. Dr. Park's activities follow closely upon AFRL's recent investment in South Korea's Pohang University of Science and Technology. The university completed a research grant through AFOSR's Asian Office of Aerospace Research and Development.

The Pohang University effort entitled "Distributed Detection of Attacks/Intrusions and Prevention of Resource-Starvation Attacks in Mobile Ad Hoc Networks" is aimed squarely at improving mission-based cyber defense; it sought to assure mission-essential functions by preserving scarce battery power during attack avoidance in wireless settings. The research has synergies with AFRL's similar endeavors to adapt concepts from the domain of fault-tolerant computing to achieve information assurance in an in-house, AFOSR-funded effort called “Fault Tolerance for Fight Through (FTFT).” In particular, an AFRL-developed protocol to tolerate attacker-caused faults in mobile wireless units while preserving the units' battery power underscored the complementary nature of threat avoidance and surviving the threat, which was exhibited by the respective Korean and AFRL research.

Dr. Park has provided exemplary support to the FTFT effort through his innovation in creating novel approaches for component survivability at runtime in mission-critical distributed systems. His approaches embrace the early adoption of emerging—yet unproven—technology; the rapid recovery of component failure; and the use of commercial-off-the shelf components. Dr. Park‘s compelling demonstrations of his ideas bring AFRL closer to creating cyberspace foundations that are trusted, resilient, and affordable. Leveraging from the research gains achieved in discovering fight-through schemes, he is addressing trust and privacy issues in online social networks. Today, the

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adoption of online social media and their applications have expanded in kind and size to unprecedented levels and continue to grow at accelerated rates. The creation and deployment of social media is one of the main forces behind the evolution and expansion of the Internet and mobile media. Social media accounts for the majority of Internet traffic while its content comprises the greater part of the daily published multi-media on the Internet. These technologies have a profound impact on society; yet, they can have detrimental outcomes if used maliciously. Inadvertent usage of online social networks may compromise the user's privacy.

Additionally, researchers note that an oppressive regime, for example, could misuse its users' social network to cause a dramatic loss in society's trust of technology. Such a regime could then assert more political control because the loss of trust would undermine the network's ability to form linkages among people. Dr. Park's investigations in the building and maintaining of trust in social networks holds promise for finding a guiding science to better understand the evolution of this technology—a technology that is a microcosm of the Internet and mobile media.

Defense of cyberspace is challenging. The seemingly endless breadth of cyberspace coupled with the technological depth of its composition can divide defensive approaches to be either overarching or highly specific. To abstract away details for the purpose of tractability, overarching approaches can suffer because simplistic models for threats, vulnerabilities, and exploits tend to yield defenses that are too optimistic. Approaches that deal with specific threats, vulnerabilities, and exploits may be more credible, but can quickly lose their meaningfulness as technology changes. Whether approaches are near - or far- term, FTFT's maintains two goals: the ability to survive and the ability to fight-through. Maintaining such a stance requires a healthy dose of skepticism of a technology's ability to be defensible.

Dr. Joon Park, NRC Senior Associate, lecturing at Samsung in South Korea

Dr. Park's tangible recent research contributions to AFRL/RI have been through FTFT; yet, if enthusiasm is indeed infectious, then the FTFT effort, and therefore AFRL/RI, is also a beneficiary of his South Korean experiences.

A primary part of any research is a proper perspective. Dr. Park's infusion of the in-house research, his renewed perspective that embraces advanced technology, and his emphasis on high vigilance is a sound prospect for the future of cybersecurity in South Korea and abroad

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Dr. Kevin A. Kwiat is a Principal Computer Engineer in the Cyber Assurance Branch of the AFRL in Rome, NY where he has worked for 30 years. He received his B.S. in Computer Science, B.A. in Mathematics from Utica College of Syracuse University, as well as his M.S. in Computer Engineering and the Ph.D. in Computer Engineering from Syracuse University. He is an NRC Adviser, acting as a surrogate of the NRC in monitoring his designated research associates and all matters relating to an associate's research program fall under his purview. "Approved for Public Release; Distribution Unlimited: 88ABW-2012-2539, 30-APR-2012"

Meet NRC Associate: Dr. Dingbin Liu, NIH/ NIBIB

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Dingbin obtained his Bachelor of Science at Lanzhou University in China (2006), followed by a M.S. (2009) and a Ph. D. (2012) from the National Center for Nanoscience and Technology of China (NCNST) in physical chemistry while working with Professor Xingyu Jiang on surface chemistry for bioanalysis. In 2012, he joined Dr. Xiaoyuan Chen's group at the National Institute of Biomedical Imaging and Bioengineering where he won the Joint Research Associateship award funded by the Research Associateship Programs of the National Research Council. Dingbin's current research interests focus on development of high-sensitivity nanosensors for biomarker detection.

Selected Publications

Liu D, Wang Z, Jin A, Huang X, Sun X, Wang F, Yan Q, Ge S, Xia N, Niu G, Liu G, Hight Walker A R, Chen X. Acetylcholinesterase-Catalyzed Hydrolysis Allows Ultrasensitive Detection of Pathogens with the Naked Eye. Angew. Chem., Int. Ed. Under revision.

Chen S,† Liu D,† Wang Z, Sun X, Cui D, Chen X. Picomolar detection of mercuric ions by means of gold-silver core-shell nanorods. Nanoscale. 2013; 5: 6731-6735. († contributed equally).

Wang Z, Zhang X, Huang P, Zhao W, Liu D, Nie L, Yue X, Wang S, Ma Y, Kiesewetter D, Niu G, Chen X. Dual-factor triggered fluorogenic nanoprobe for ultrahigh contrast and subdiffraction fluorescence imaging. Biomaterials. 2013; 34: 6194-6201.

Liu D, Huang X, Wang Z, Jin A, Sun X, Zhu L, Wang F, Ma Y, Niu G, Hight Walker AR, Chen X. Gold nanoparticle-based activatable probe for sensing ultralow levels of prostate-specific antigen. ACS Nano. 2013; 25: 5568-5576.

Sun J, Xianyu Y, Li M, Liu W, Zhang L, Liu D, Liu C, Hu G, Jiang X. A microfluidic origami chip for synthesis of functionalized polymeric nanoparticles. Nanoscale. 2013; 5: 5262-5265.

PGA Video Highlights

National Academies—
National Academy of Sciences, Institute of Medicine,
National Academy of Engineering,
National Research Council
Policy & Global Affairs

NRC/RAP Website Highlight

Explore Among 26 Programs | Participating Agencies | http://nrc58.nas.edu/RAPLab10/Opportunity/Programs.aspx

Name	Abbreviation	Reviews
Air Force Research Laboratory	AFRL	All
Armed Forces Radiobiology Research Institute	AFRRI	All
Army Aviation & Missile Research, Development, & Engr Center	AMRDEC	All
U.S. Army Medical Research & Materiel Command	AMRMC	All
U.S. Army Research Laboratory	ARL	All
Army Research Laboratory - U.S. Military Academy	ARL/USMA	All
U.S. Army Research Office	ARO	All
Chemical and Biological Defense Funded Laboratories	CBD	All
U.S. Army Edgewood Chemical Biological Center	ECBC	All
U.S. Environmental Protection Agency	EPA	All
EPA/Faculty Fellowship Program	EPA/FFP	All
FAA-Civil Aerospace Medical Institute	FAA/CAMI	All
Federal Highway Administration	FHWA	All
US Army Corps of Engineers Institute for Water Resources	IWR	All
Naval Marine Mammal Program	MMP	All
National Energy Technology Laboratory	NETL	All
Methane Hydrates Fellowship Program	NETL/MHFP	Feb., Aug.
National Institute of Standards and Technology	NIST	Feb., Aug.
Naval Medical Research Center/Naval Health Research	NMRC/NHRC	All
National Oceanic & Atmospheric Administration	NOAA	All
Naval Postgraduate School	NPS	All
Naval Research Laboratory	NRL	Feb., May, Aug.
U.S.Army Natick Soldier Research, Development & Engr Center	NSRDEC	All
U.S. Army Res, Dev & Eng Com/Armament Res, Dev & Eng Ct	RDEC/ARDEC	All
U.S. Army Research, Development & Engineering Command, NVESD	RDEC/NVESD	All
U.S. Army Criminal Investigation Laboratory	USACIL	All

2014 SCHEDULE

February Review

February 1	Application deadline
February 15	Deadline for supporting documents (transcripts/letter of recommendation)
March 18	Review results finalized
March 25	Review results available to applicants

August Review

August 1	Application deadline
August 15	Deadline for supporting documents (transcripts/letter of recommendation)
Sept 22	Review results finalized
Sept 29	Review results available to applicants

May Review

May 1	Application deadline
May 15	Deadline for supporting documents (transcripts/letter of recommendation)
June 20	Review results finalized
June 27	Review results available to applicants

November Review

Nov 1	Application deadline
Nov 15	Deadline for supporting documents (transcripts/letter of recommendation)
TBD	Review results finalized
TBD	Review results available to applicants

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