DOE Princeton Plasma Physics Laboratory

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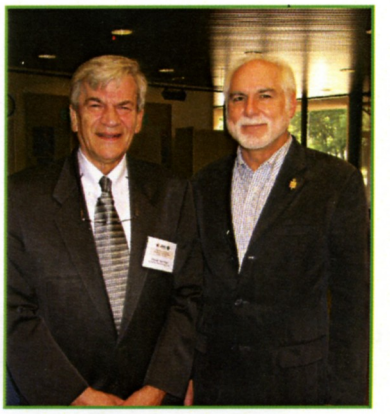
HOTLINE

The Princeton Plasma Physics Laboratory is a United States Department of Energy Facility

Colleagues and Friends Pay Tribute to PPPL's Davidson



Far left, U.S. Rep. Rush Holt (NJ-12) congratulates Princeton University Professor Ronald C. Davidson (right) on 40 years of contributions to plasma physics research and graduate education during a symposium held in Davidson's honor at PPPL. Left, Davidson (left) with UCSD's Fred Driscoll at the Symposium. Driscoll was one of the presenters.

Colleagues, friends, and family from near and far came to PPPL June 11 and 12 to honor Princeton University Professor and former PPPL Director Ronald C. Davidson. The Laboratory hosted the "Symposium on Recent Advances in Plasma Physics" in honor of Davidson's 40 years of plasma physics research and graduate education. The program included scientific talks by researchers from many laboratories, institutions, and universities. During the opening, Rep. Rush Holt offered congratulatory remarks to Davidson and Princeton University Dean of the Faculty David Dobkin presented the welcome. The event included two days of technical talks and a banquet at Frist. ***(More photos on page 2.)***

PPPL Assists in the Development of Artificial Muscle

By Anthony DeMeo

PPPL collaborator Lenore Rasmussen has the gift of serendipity. Two disparate life experiences sparked the polymer chemist's interest in the development of electro-responsive "smart materials" — electrically-driven polymers that are strong and durable enough to act as artificial muscles in prosthetic devices and robotics. Her early experience identifying DNA proteins and an injury suffered by her cousin in a farm accident triggered her interest in the development of the materials. She brings to this work an extensive background in chemistry, biology, and biochemistry.

Rasmussen was using electrophoresis — the movement of suspended particles through a gel under the action of a strong electric field — to separate and identify protein molecules and DNA. "There are little wells in which you put your proteins or DNA samples. You turn on the electricity and watch how they migrate. Different proteins or

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PPPL's Lew Meixler collaborates with Lenore Rasmussen on the plasma treatment of electrodes for smart materials project at PPPL.

Scientific Symposium in Honor of Ronald C. Davidson

Chuan S. Liu, of the University of Maryland, presents to Davidson an embroidered silk cloth from Taiwan, with beautiful images of many children.

At right, Ron Davidson (left) with Rep. Rush Holt.

Symposium photos by Elle Starkman and John Bennevich

Above, Davidson and his family listen to remarks at the Symposium. From left are Davidson, his wife, Jean, son, Ron Jr., daughter Cyndy Premru, niece Arlene Steele, and nephew Rob Davidson.

Top right, PPPL's Nathaniel Fisch, Chair of the Symposium Committee, offers opening remarks. Right, Princeton University Dean of the Faculty David Dobkin welcomes attendees at the Symposium.

Muscle

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DNA fragments will go through the gel at different speeds that depend on their molecular weights. The larger, heavier molecules will have a harder time getting through. One of the wells would contain known proteins for comparison. For DNA, the smaller fragments would move further and longer ones would end up closer to the starting point," explained Rasmussen. But, as fate would have it, one day she made a mistake formulating the gel. "I goofed up mixing stuff together and (as a result) the gel responded to the electricity by contracting — a Eureka moment," she said.

Later, while she was a grad student at Purdue pursuing a degree in biophysics, one of her cousins was spreading hay on a land reclamation project. He slipped and his leg got caught in the hay spreader. His foot was not detached, but much of the muscle and circulation in the calf of his leg were damaged. Initially doctors were not sure he would keep the leg. If gangrene set in, he would have to have it amputated. "I was the scientist and biologist in the family, so they asked if I could go and look at prosthetics to see what was out there in case he needed one. While I really liked what I saw for legs, I really hated what I saw for arms and hands. As it turns out, my cousin's leg healed. He had a lot of recovery and still has a slight limp. But I kept thinking about my experience with the gels in DNA analysis and the need for better prosthetics. So I went on to Virginia Tech partly to get the background in polymer chemistry that I would need to develop artificial muscles," said Rasmussen.

Currently, prosthetics for the arm and hand are not functional unless they utilize three-pronged metal devices that are controlled mechanically. Rasmussen wondered if a prosthetic limb could respond directly to a neural impulse, and whether they could be made more attractive and highly functional. In 2003 she established Ras Labs, LLC, a small,

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Hotline

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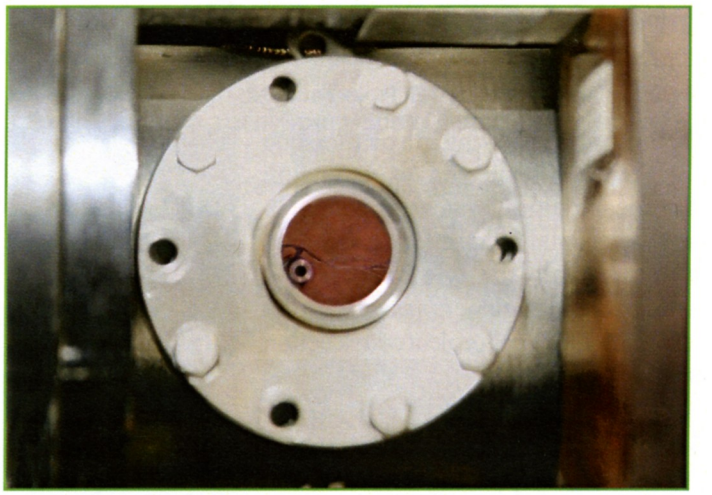
for-profit, innovative research and development laboratory devoted to projects that utilize polymer chemistry, biochemistry, biology and engineering.

Rasmussen envisions artificial muscles, or actuators, that are comprised of an electro-responsive polymer gel (the smart material) containing embedded electrodes, all encased in a flexible coating that acts as a kind of skin. The smart material is cross-linked, meaning that a side bond has been formed between polymer chains to increase strength and toughness. The embedded electrodes serve a dual role: providing the electric stimulus, much like a nerve, and attaching the smart material to a lever, like a tendon attaches muscle tissue to bone. The thin elastomeric coating also serves as a moisture barrier, preventing evaporation and leakage of the electrolyte solution in the polymer, and allowing the actuators to be fully operational anywhere. When the electrodes are energized with direct current, the smart material contracts or expands, depending on the formulation. It then relaxes when the current is turned off, acting much like real muscle tissue responding to a neural impulse from the brain. The goal is for both the electro-responsive smart material and the embedded electrodes to move as a unit, analogous to muscles and nerves moving together.

Rasmussen tested a variety of polymers and found that poly(hydroxyethylmethacrylic acid) — poly(methacrylic acid) cross-linked network gels respond quickly to electricity and have all the other needed properties. But one challenge remained: after repeated cycles, the polymer detached often from the electrodes. However, from her former affiliation with Virginia Tech and with Johnson & Johnson's Ethicon division, Rasmussen recalled that J&J performed plasma sterilization of its medical needles, and then coated them with polymers that allow them to slide more quickly into the patients, reducing discomfort. Plasma treatment not only sterilizes metal, but also improves the adherence of the polymer.

A potential solution was at hand. A colleague put Rasmussen in touch with Lew Meixler, PPPL's Head of Applications Research and Technology Transfer. She met Meixler at a grant-writing seminar at which he presented information on cooperative research opportunities for small businesses at federal labs. Rasmussen's discussions with Meixler resulted in the establishment of a Cooperative Research and Development (CRADA) Agreement last December between PPPL and Ras Labs. The CRADA, with PPPL participants Meixler and Yevgeny Raitses, revolves around PPPL's plasma sterilization equipment, an excellent apparatus in which to treat metal samples with plasma. Different ions are being studied to find a suitable metal and plasma combination that solves the detachment problem.

To date, tests conducted at PPPL are encouraging, resulting in improved bond strengths. Stainless steel and titanium



Wires being treated in the plasma chamber.

metals are being treated with plasma comprised of ions of nitrogen, helium, or hydrogen. Titanium in particular is suitable for use within the body. Oxygen ions derived from synthetic air (for safety) are also used. Ions are driven onto the surface of a 0.5-inch by 1.5-inch metal foil by a 40-volt electric potential for 12 hours. Following treatment, a polymer coating is sandwiched between two pieces of treated foil. The composite is sent to the University of Pennsylvania or to the Princeton Textile Research Institute, which have the capability of performing adhesion tests on the small samples that fit into PPPL's apparatus. A standardized testing apparatus controls the speed and strain with which the composite is peeled apart. Future tests will be conducted with actual wire electrodes treated in the PPPL apparatus.

In addition to identifying a suitable plasma treatment for metals, the tests at PPPL should provide insight into the mechanism responsible for improved adhesion of the polymer. Preliminary studies have shown that the plasma ions rough up the metal surface on a molecular scale and make the surface super clean by removing any oils that might be present. "Right after the peel test we check to see where the break has occurred. If necessary, we use electron microscopy to view the surfaces. If the polymer comes off the metal cleanly, the interface is the problem. If there are patches of the polymer remaining on the metal, then the failure was in the polymer itself — or there could be other things going on," Rasmussen said.

Whatever is learned from the PPPL plasma treatments, Rasmussen will continue her quest for electro-responsive smart materials that can have a profound impact on prosthetics and robotics, with excellent control, dexterity, and durability. If she is successful, a lot of folks may benefit.

"This collaborative effort with Ras Labs is a good example of how a DOE Lab can advance the research of a small business startup. PPPL is helping to improve the metal-polymer interface by plasma treating the actuator electrodes. We hope it will lead to superior electro-responsive actuators that will benefit disabled people," Meixler said. ●

ITER Secondees Prepare for Life in France

By Cindy Ross Lundy, U.S. ITER Project at ORNL

Photo courtesy of ORNL

U.S. secondees assigned to the ITER site in Cadarache are, from left, Idaho National Lab's Ken Sowder, ORNL's Paul Holik, Savannah River Site's Dennis Baker, General Atomics' Remy Gallix, Los Alamos National Lab's Craig Taylor, ORNL's Gary Johnson, High Bridge Associates' Larry Lew, PPPL's Chang Jun and Jerry Sovka of Advanced Technologies.

The charms of living in a picturesque French village and experiencing European culture appear to outweigh any occasional frustrations caused by a more leisurely lifestyle for U.S. ITER scientists and engineers assigned to the international ITER project construction site in Cadarache.

Nine employees affiliated with the U.S. ITER Project have been assigned to the site in the South of France. They are secondees, employed by their home institutions and temporarily seconded to work in Cadarache with the ITER International Fusion Energy Organization. It will build the full-scale experimental device aimed at demonstrating the scientific and technological feasibility of fusion energy.

ITER – Latin for "the way" – involves a scientific collaboration between the United States, China, European Union, India, Japan, Korea and Russia. It is expected to be completed by 2016.

The U.S. ITER Project Office is hosted by Oak Ridge National Laboratory with partner labs PPPL and the Savannah River National Laboratory. The U.S. contributions to ITER project will be accomplished through a collaboration of DOE laboratories, universities and industry.

U.S. ITER "secondees" in Cadarache include Chang Jun of PPPL, a mechanical and electrical engineer. He is involved in computer analysis of the vacuum vessel and other structures and will be working on manufacturing control.

"I speak French and English, so I have adjusted here quite well," he said. "I'm on a very good team, and as a recent secondee, I am working to catch up on the details of the project."

He has two school-age children in Princeton and is working a schedule of three weeks in Cadarache and one week in New Jersey. "My biggest challenges have been the travel and being away from my family. I hope to bring them here as soon as possible to limit the travel time and be able to focus even more fully on our mission," he added.

Gary Johnson of ORNL works closely with Jun. Johnson is no stranger to European assignments, having worked on earlier stages of the ITER project in Germany during the 1990s. He is serving as deputy director general for the ITER tokamak, with responsibility for its design, procurement and construction. This includes the superconducting magnets, vessel systems, blanket and divertor systems, and assembly and remote handling.

Johnson said he enjoys working in an international environment. "Living in Southern France is also very nice. Cadarache is in a beautiful area."

Current professional challenges include helping to build the organization that will finish the design of the tokamak. It involves hiring candidates from all seven ITER parties. The process is time-consuming, he said, but adds that they are making real progress.

Johnson has found eating dinner in France to be a very different experience than in the United States. "Many restaurants don't even open until 7:30 p.m., and then the meal may take more than three hours. This has definitely been an adjustment."

Another secondee, Dennis Baker, spent the previous 34 years of his professional career supporting the Savannah River Site. He has experience in reactor operations support, safety analysis and safety basis development. He helped develop DOE's Magnetic Fusion Safety Standards and was seconded to ITER in the Safety Division in San Diego during the project's engineering design phase. In France, he is in the safety group developing and defending the ITER safety basis.

"This assignment has been an adventure," Baker said. "I have enjoyed the technical work and have already been given assignments with considerable significance. For example, I updated the general ITER confinement strategy and participated in presentations on it to the Safety Working Group of the Design Review Activity and

Spotlight

Name: Chang Jun

Position: Analysis Engineer at PPPL and Vacuum Vessel Analyst at ITER. Jun's mission is to verify and enhance designs by using computer analysis. His work covers mechanical stress analysis and electro-magnetic field analysis, and leads to building better fusion machines.

Quote: "During almost 10 years of service, I have grown to like PPPL more and more because its environment is very professional and the Lab has highly qualified scientists, engineers and staff. I can dive deeply into challenging problems and, through discussions with my colleagues, fly high to see the bigger picture.

I also like the ITER project because it reflects world-wide cooperation, instead of world-wide competition. I applied for an ITER position because I wanted a new challenge, and to continue to develop myself. I received my Ph.D. in France, so if the U.S. is my foster father, France is my uncle. (My 'natural' father is Korea.) I will be back in several years to share my experiences with PPPL'ers."

Other interests: Jun plays tennis and ping-pong, and shares his family's enjoyment of music.

"I have enjoyed many ping-pong games with several PPPL'ers at the Lab. My family members are quite serious about music. My wife plays piano, our high school boy plays cello and drum, and our middle school daughter plays flute and piano. I was a choir conductor for many years, but nobody in our family recognizes my musical sense due to my maladroitness in instruments," Jun says. ●

Chang Jun at the Palais de Chaillot in Paris.

the French Nuclear Regulatory Agency in Paris. "I have also very much enjoyed working with people from other countries and experiencing the culture of the Region of Provence. I have joined a chorale at the Darius Milhaud National Conservatory of Music in Aix en Provence, which has afforded the opportunity to meet many new friends in the area," he added.

Baker said dealing with the bureaucracy long-distance has been a challenge – even though everyone does his or her best to help. "The whole international assignment thing is rather new to me and to my company at Savannah River. I'm also living away from family, and I'm working to get comfortable finding and eating in restaurants, etc. After work, I consider myself a hunter-gatherer, spending my evenings seeking out places to eat or feeling my way through grocery stores studying microwaveable dinners."

Secondee Ken Sowder has been employed by Idaho National Laboratory since 1991 and has provided quality assurance management support to various programs such as ITER, the National Spent Nuclear Fuel Program (Yucca Mountain) and the New Production Reactor Program.

As responsible officer and division head for ITER Quality Assurance, Sowder reports to the deputy director general for Safety and Security and represents ITER and INL on various American Society of Mechanical Engineers and American Society for Quality committees. "In this role, I have really enjoyed working with the many diverse and intelligent people from all over the world brought to this project to support its construction," he said. Living and working in a different culture and language have provided the greatest challenges, he added, along with dealing with relatively expensive living conditions.

Larry Lew has been a project controls engineer on various large-scale civil, nuclear, fossil and transportation construction projects in North America, Japan, Hong Kong and Europe. His ITER responsibilities include coordinating the Planning & Scheduling Working Group to define the scheduling standards and procedures for the international organization and project teams.

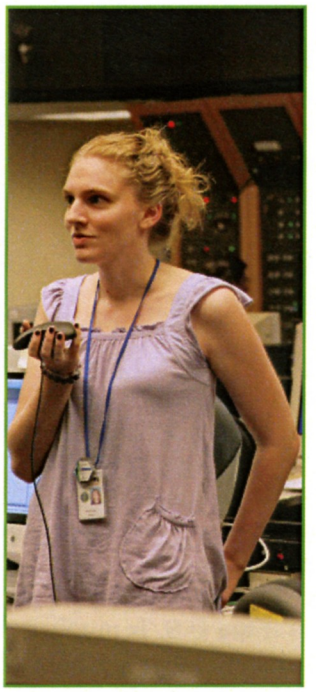
Lew has found much to enjoy in his assignment, including "all the challenges of working on a truly unique project with fascinating people from all parts of the world; daily life in a small village in Provence; and the sites and people of France."

He also is adjusting to marathon restaurant dinners. Additional challenges include ensuring a smooth transition to French life for his children and obtaining an ADSL (asymmetric digital subscriber line) connection, which required seven weeks.

Other U.S. secondees to Cadarache include Remy Gallix, mechanical engineer from General Atomics; Paul Holik, plant system engineer from ORNL; Jerry Sovka, site layout, buildings and assembly group leader from Advanced Technologies; and Craig Taylor, physicist from Los Alamos National Laboratory, who is working on design and integration of tritium exhaust processing. ●

Live From... the PPPL Control Room

At the NSTX Control Room, Princeton graduate student Dave Smith (left) and PPPL Science Education Program Head Andrew Zwicker respond to questions from participants in the "Live From ...PPPL" program on May 31. At left (facing computer) is PPPL physicist Ron Bell. Behind Zwicker is PPPL engineer Tim Stevenson and in the red shirt is PPPL's John Robinson.



Grad student Stephanie Diem fields questions from the students in Teterboro through video conference technology.

Without leaving their school in Teterboro, 60 Bergen County Technical High School physics students took a field trip to the National Spherical Torus Experiment (NSTX) Control Room on May 31. The students participated in "Live From ...PPPL," a program created by PPPL Science Education Head Andrew Zwicker in partnership with the Liberty Science Center.

Virtual Field Trip

The students took a virtual field trip to the control room at PPPL through the innovative program. Using video conference technology, Nancy Butnick, Director of Online Education at Liberty Science Center, connected them with scientists, engineers, and support staff in the control room while fusion experiments were being performed. Students spoke directly to those involved in fusion research. A TV monitor in the control room showed PPPL participants the students in the school's auditorium while the students viewed the control room from a large screen in the school's auditorium. Those speaking from either end used a hand-held microphone.

"The 'Live From ...PPPL' program is a unique opportunity to expand an innovative program," said Zwicker. "Students were able to learn about the design of the fusion reactor, observe the real-time run of a fusion experiment, analyze data sets, and discuss the applications of this work with scientists. They also found out about paths to careers in plasma physics and engineering."

Princeton University graduate students Dave Smith, Stephanie Diem, and Patrick Ross, NSTX physicist Steve Paul, NSTX engineer Tim Stevenson, and Zwicker answered questions from the students about plasma physics, heating fusion-grade plasmas, and NSTX operations. They also talked to the high school students about the experiments occurring that day.

The virtual field trip was part two of the program. A week earlier, Zwicker conducted a workshop at the school, guiding the students through hands-on demonstrations using plasma balls, fluorescent lights, and the PPPL interactive web site to teach the science behind plasma, the fourth state of matter.

"Feedback from the students was extremely enthusiastic and the 60-minute program was expanded to 90 minutes due to the volume of questions asked by the students," said Zwicker, noting that the prototype program was part of an ongoing collaboration between the Liberty Science Center and PPPL. "A funding proposal will be written this summer to expand the program to bring real-time fusion research directly to museum visitors during NSTX operations in Fiscal Year 2008." ●

PPPL Noted for Safety

The Laboratory received the following four awards for safety performance during 2006 at the 79th Annual Governor's Occupational Safety and Health Awards Program on April 24:

PPPL – Recognition Award for having a low incidence of away-from-work lost time injury and illness cases.

NCSX Project – Division of Public Safety Award for working two consecutive years with no away-from-work lost time injury and illness cases.

NSTX Project – Commissioner's Continued Excellence Award for working six consecutive years without an away-from-work lost time injury and illness case.

Plasma Science and Technology Department – Citation of Merit Award for working throughout the year with no away-from-work lost time injury and illness cases. ●

PPPL Technology Transfer Head Lew Meixler (middle) accepts the safety awards on behalf of the Lab from state representatives.

Safety First!

Foley Honored as Mentor

Jill Foley received the U.S. Department of Energy's Outstanding Mentor 2006 Award this month. PPPL Deputy Director Rich Hawryluk (left) presented the award to Foley prior to Foley giving a lecture to undergraduate students participating in the PPPL Science Education Summer Programs. The citation for Foley stated: "In recognition of your dedication as a mentor. For your willingness to share knowledge and to inspire and instill confidence in the next generation of scientists and engineers by setting high expectations, seeking creative solutions, and immersing inquisitive minds in the world of science."

A former graduate student at PPPL who received a Ph.D. from Princeton University in 2005, Foley served as a mentor to National Undergraduate Fellowship (NUF), Science Undergraduate Laboratory Internship, and high school students for the past several years. She also has been a member of the NUF Selection Committee for three years. She conducts research for Nova Photonics, Inc., from an office in PPPL's L-wing. Congratulations, Jill! ●

DOE Job Postings

Deputy for Programs, Office of Science
http://www.usajobs.gov
Announcement Number: SES-SC-HQ-013 (kd)

Associate Director, Office of Science for Biological and Environmental Research
http://www.usajobs.gov
Announcement Number: SES-SC-HQ-014 (kd)

PPPL Firefighters Battle Plainsboro Blaze

PPPL firefighters provided an initial attack line while responding to a five-alarm fire on May 25 at the Princeton Meadows Shopping Center in Plainsboro. The fire, which began in a bakery at the shopping center, damaged many businesses. No employees or shoppers at the center were reported injured in the fire, but some firefighters were treated for dehydration and heat exhaustion.

The PPPL Emergency Services Unit was the second engine company to arrive on the fire ground. "Our unit was dispatched to a mutual aid assignment," said PPPL Site Protection Head John Bavlish. "It was then directed to conduct roof operations. This required our firefighters to open a trench in a very complicated roof structure in extreme heat and smoke conditions."

The operation was designed to stop the spread of fire to other stores within the complex. The PPPL firefighters were evacuated from the roof shortly after completing the task because the roof had become unsafe. It eventually collapsed.

PPPL and Plainsboro Township firefighters conduct roof operations while responding to the May 25 fire at the Princeton Meadows Shopping Center.

The Lab's firefighters made up one group of about 20 responding groups. "The Lab sent eight firefighters to the scene throughout the course of the event. They conducted various fire attack and support tasks," Bavlish said.

One PPPL firefighter was transported to the Princeton Medical Center by the PPPL ambulance because he was dizzy and had double vision. These symptoms were caused by dehydration from the extreme heat and job assignment at the scene. The firefighter was released late the same day and returned to work on May 28. Two other township firefighters were treated at the scene for heat exhaustion and released. In addition to critical fire fighting support, PPPL provided ice and bottled water to many of the responding departments, as well as to the Plainsboro Ambulance.

Doug Vorp, Deputy Chief of the Plainsboro Fire Department, stated, "It's times like this that the Fire Company is very appreciative of the working relationship that they enjoy with PPPL. They have come to rely on PPPL to provide dedicated, diligent and professional staff to assist with emergencies in Plainsboro. The actions of PPPL's personnel at this incident were truly a testament to their dedication and professionalism." ●

Area firefighters work at the scene.

"The actions of PPPL's personnel at this incident were truly a testament to their dedication and professionalism."

— Doug Vorp