Defense Science *Quarterly*

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Message from the Director
Chris Deeney, Defense Science Division

It's hard to believe it's been a year since we published our first issue of the Defense Science Quarterly. I would like to express my appreciation to all the authors who have submitted articles and to the production staff. If you are interested in submitting an article for a future quarterly newsletter, please see the Comments section at the end of the newsletter.

We've had another productive quarter in the world of Defense Science. Before discussing the content of this newsletter, I want to affirm how proud I am of this organization and the work we do. This was brought home at the recent JASON study of the National Boost Initiative in La Jolla, California. Clearly, Boost is a grand scientific challenge and you could tell that Dr. Lars Bildston, the study lead, and the team were engaged and enjoyed digging into the details of this topic. The JASON members were very complimentary of both the overall level of work and the laboratory-wide team effort addressing this issue. As one might expect from such an accomplished group, they had some very good suggestions of topics to look at and they asked several interesting and pertinent questions to challenge previous conventional wisdom. The National Nuclear Security Administration (NNSA) laboratory teams were credits to their institutions and I want to thank them.

Key individuals to thank are Dr. Robert Hanrahan (NNSA) for coordinating the study, and Dr. Frank Graziani (LLNL), Dr. Maurice Sheppard (LANL), and Dr. Tom Mehlhorn (SNL), the laboratory leads. More results of the study will follow once the JASON report is complete.

Some of the key issues for Boost included materials, hydrodynamics, and nuclear physics research. Many of these are conducted at the Los Alamos Neutron Science Center (LANSCE) facility at Los Alamos National Laboratory (LANL). A number of the past quarterly newsletters have included the significant contributions of LANSCE to stockpile stewardship. The LANSCE capabilities will be key to achieving our deliverables in the Predictive Capability Framework, but as LANSCE has aged, we are worried that many systems are obsolete and spares are very limited. NNSA is pursuing a LANSCE refurbishment to extend its life, and the article in this quarterly newsletter describes why the refurbishment is needed and what needs to be done.

Another big facility at LANL is the Dual Axis Radiographic Hydrodynamics Test (DARHT), and in this newsletter we discuss the successful completion of the DARHT 2nd Axis, which includes the DARHT team demonstrating four x-ray pulses that exceeded all the specifications for the project. However, after project completion, the very powerful beam in DARHT ablated beam dump materials so there will be some down time for cleaning the cells. This will delay our first planned hydro experiment. DARHT is state-of-the-art pulsed power at energy levels that only a few nations can build and operate. However, the pulsed power in key stewardship facilities like DARHT, Z, PHOENIX, FXR, NIF and OMEGA are all built on fundamental knowledge and computational tools. This pulsed power base has a broader application than just stockpile stewardship, so as a departure, we have included an article on how such technologies are used by others, the Federal Aviation Administration and the Bureau of Mines, to address issues in diverse areas. [For more information on Work for Others and Laboratory Directed Research and Development projects, contact Ms. Jamileh Soudah at NNSA, jamileh.soudah@nnsa.doe.gov.] Such applications are a testimony to the capabilities of our labs. Other testaments to the quality of our work are publications, international presentations and our fellowship program, all highlighted in this quarterly newsletter.

Derivative Applications of Pulsed Power Science and Technology

by Larry Schneider, Michele Caldwell, Matthew Higgins, Sandia National Laboratories

Work For Others programs are an important means to maintain the vitality of a science and technology base and to provide exceptional service in the national interest. Capabilities developed for the nuclear weapons complex in electromagnetics and pulsed power sciences led to two significant contributions in 2007 for the Department of Transportation's Federal Aviation Administration (FAA) and the Department of Labor's Mine Safety and Health Administration.

Aircraft Wiring Diagnostic

Detecting and locating insulation defects in wiring systems as complex as commercial aircraft is a non-trivial challenge. Ideally, the diagnostic should be non-destructive, capable of detecting a variety of insulation defects such as cracking, chafing, abrasion, and be able to locate the defect accurately in order to reduce potential inspection and maintenance costs. Complicating this quest is the nature of aircraft wiring systems which are comprised of harnesses containing periodically bound single wires and branching of bundles to different areas on the plane. Insulation defects may also be physically small, resulting in an unmeasurable change in the impedance at the defect site.

Pulse Arrested Spark Discharge (PASD) has been demonstrated to be an effective insulation diagnostic for coaxial cables, twisted shielded pair, and more complex single wire bundles commonly found in aircraft and control and monitor wiring systems [1]. PASD employs a patented low-energy arrested-arc concept and time domain reflectometry techniques to produce a well defined reflection from an insulation defect site. The PASD diagnostic can detect and locate a range of electrical insulation damage in cable/wire bundles with non-uniform impedance profiles and was first demonstrated on electrical wiring systems in 1996 under a Department of Energy (DOE) sponsored Nuclear Energy program. Success during initial development of PASD for the DOE led to a three-year Federal Aviation program with a focus on commercial aircraft wiring systems and a reduction to practice of the PASD technique.

The PASD technique uses a high-voltage (~10kV), low-energy (~mJ), short pulse (~10ns) to induce an electrical spark discharge at the site of an insulation defect (see Figure 1). The PASD pulse can be generated by a compact, battery driven pulser and combined with diagnostics and software processing in a package the size of a briefcase. The pulse energy is similar in magnitude to the static discharge generated when walking across synthetic carpets and is insufficient to damage insulation or the conductors within wiring systems. The discharge occurs from the conductor in the wire under test to an adjacent return path that can be another wire or a ground plane. The development of an arc occurs within a few nanoseconds and produces a momentary short circuit that reflects energy back to the sensors at the injection point. Conventional Time Domain Reflectometry techniques can then be used to accurately locate the defect site. This technique is a direct test of the dielectric strength of the insulation system. Since the PASD voltage is insufficient to break down any significant amount of bulk insulation, only defects which expose the center conductor are identified.

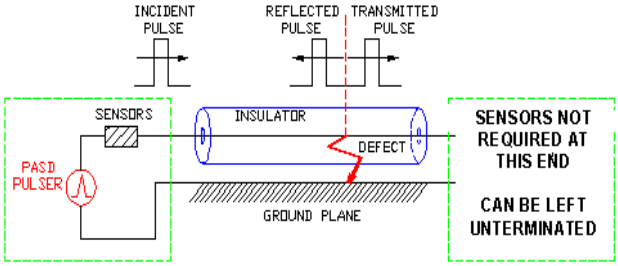


Figure 1. PASD diagnostic concept.

Figure 2 shows example waveforms derived from tests on a coaxial cable with a 0.7 mm hole punched through the dielectric. The inner conductor and outer shield remain fully conductive. The two waveforms deviate at the location of the defect, 78 nanoseconds down the line. In this example, the peak PASD pulse was 9.8 kV at a pulse width of 5ns. The amplitude scale is the voltage measured at the sensor. The location of the change in the two sensor voltage versus time waveforms describes the physical location of the defect site. A simple differencing algorithm can easily locate the change between the two waveforms.

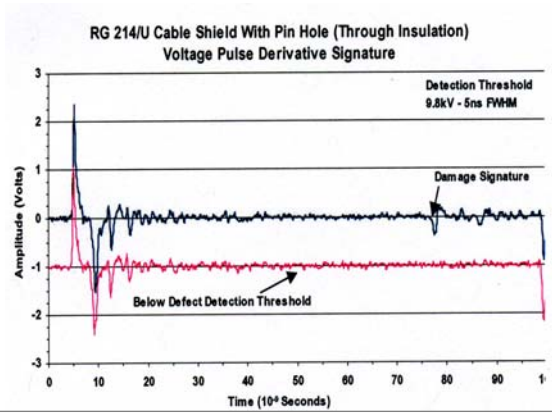


Figure 2. PASD waveforms from a test of a coaxial cable with a pin-hole defect in the insulation. The red line is a low voltage PASD pulse. The upper blue line is the high voltage PASD pulse.

The PASD diagnostic has demonstrated that it can detect and locate chafing, cracking, pin-holes and other breached insulation defects under laboratory conditions and during testing at the FAA's Airworthiness Assurance Center in Albuquerque, New Mexico. These types of defects are documented in the ATSRAC publications *Intrusive Inspection Final Report,* December 2000, and *Aging Transport Systems Task 1 and 2 Final Report,* August 2000, which were comprehensive joint government-manufacturer-operator (industry) studies sponsored by the FAA. PASD's technical capabilities led to a 2007 R&D 100 Award and an Interagency Partnership Award from the Federal Laboratory Consortium. PASD has been commercialized under the trade name of ArcSafe® by Astronics Advanced Electronic Systems (Figure 3).

Figure 3. ArcSafe® with blue-tooth enabled, hand-held monitoring screen. Unit will automatically test a 40-conductor harness.

SAGO Mine Accident Investigation

On January 2, 2006, a methane gas explosion killed 12 miners at the Sago underground coal mine in West Virginia. Although approximately one coal mine explosion per year in the United States is attributable to lightning, evidence has been lacking or controversial at best.

Sandia's requested participation late into the Mine Safety and Health Administration's (MSHA) accident investigation led to the first-ever demonstration of the ability of lightning to propagate energy deep within a mine without the presence of conductive paths [2]. Under the right conditions, this energy can then be available to generate an ignition source for underground explosions. This ground breaking work led the MSHA in 2007 to cite lightning as the likely cause of this accident and set in motion changes in mining operations to prevent similar occurrences in the future [3].

Lightning was quickly considered a possible cause of the accident due to eyewitness accounts detailing strong thunderstorm activity above the mine at the time of the blast. Even more incriminating were the simultaneous recordings of cloud-to-ground lightning in the vicinity of the surface above the mine, a spike in carbon monoxide inside the mine (indicating an explosion), and seismic activity created by the blast. While the circumstantial evidence was strong, there was no credible scientific explanation of how lightning energy could propagate into an abandoned sealed area 100 meters underground.

Sandia provided the MSHA with solid scientific evidence produced through systematic field measurements, analyses and modeling. A rapid response Sandia team spent ten days at the Sago mine site making measurements to characterize the propagation of electromagnetic energy directly through the earth and through metallic penetrations into the mine (Figure 4).

Figure 4. Investigators prepare sensitive electro-magnetic diagnostics and antennas in preparation for measurements deep within the SAGO mine.

Both indirect lightning (free-field propagation through the earth) and direct coupling into the mine through conducting penetrations were evaluated through sophisticated, highly sensitive measurements. A surface lightning stroke or cloud-to-cloud stroke were shown to be capable of coupling sufficient energy onto an abandoned pump cable in the sealed area to cause electrical arcing in an enriched methane gas environment. These field measurements were also supported by analytical models and simulations (Figure 5). Predicted voltage induced in the pump cable for a 100 kA stroke near the surface above the tunnel is shown in Figure 6 on the next page.

As tunnels are sealed and abandoned in the future, electrical cabling will be removed to eliminate potential antenna structures from coupling electromagnetic energy into the often methane filled volumes.

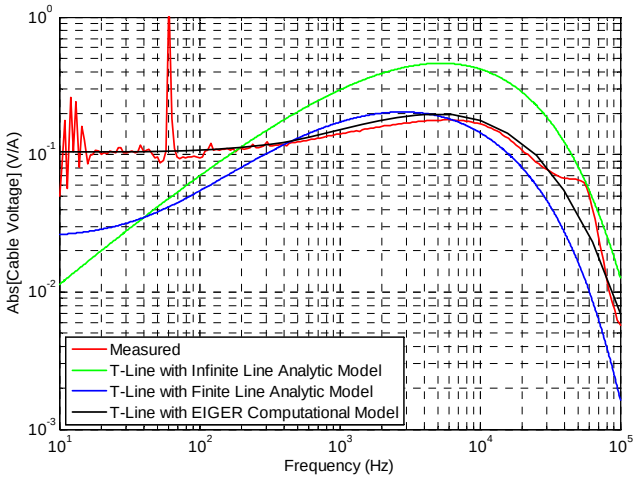


Figure 5. Induced voltage on the pump cable per unit surface stroke current as a function of frequency. The measured waveform (red) is in excellent agreement with EIGER electromagnetic model results (black).

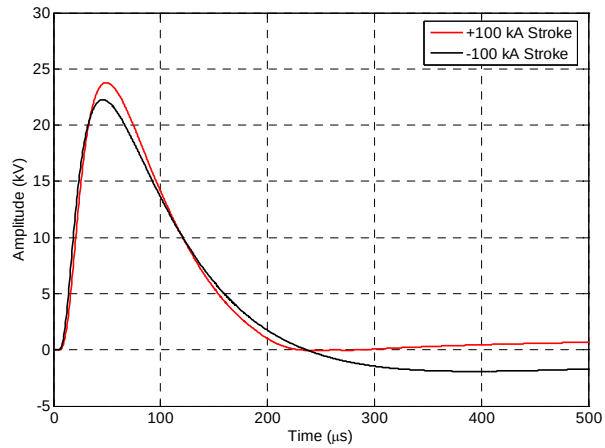


Figure 6. Induced voltage on an abandoned 120 m pump cable due to a hypothetical positive and negative 100kA lightning stroke 100 m above the sealed area.

[1] M. A. Dinallo, L. X Schneider, "Pulsed arrested spark discharge diagnostic technique for the location of defects in aging wiring systems", *Sandia Labs Report*, SAND2001-3225.
[2] M. B. Higgins, M. E. Morris, "Measurement and modeling of transfer functions for lightning coupling into the SAGO mine", *Sandia Labs Report*, SAND2006-7976.
[3] Report of Investigation – Fatal Underground Coal Mine Explosion, Sago Mine, Upshur County, West Virginia, January 2, 2007. ID No. 46-08791, Mine Safety and Health Administration.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

LANSCE-R Means More Beam for National Security Research

by Alan Hurd, Kurt Schoenberg, Kevin Jones, John Erickson, Jim Rhyne, Rich Scheffield, Eric Pitcher, and Peter Prince, LANL

For over thirty years, users of the Los Alamos Neutron Science Center (LANSCE) have been doing groundbreaking weapons research using protons and neutrons. The LANSCE accelerator was the first megawatt-class proton accelerator, and with its current five experimental areas LANSCE remains on the forefront of neutron and proton-based research. At the heart of LANSCE is a drift-tube LINAC in which protons, dressed (H-) or undressed (H+) with electrons, surf on a radio-frequency wave on their way to speed-of-light 800 million electron volts. At that final energy, protons can penetrate deep into a heavy metal, whether it is a tungsten spallation target to make neutrons or a part in an explosive dynamic experiment undergoing radiography.

Operated as a national user facility, LANSCE's users win beam time at the experimental areas through competitive review of their proposals, which includes programmatic considerations in the case of national security science. Once won, beam time is used to study nuclear physics at the Weapons Neutron Research Center (WNR), materials at the Lujan Center, fundamentals of the neutron at the Ultra-Cold Neutron (UCN) Facility, and shock waves in explosively driven objects at the Proton Radiography Station (pRad). Medical isotopes produced at the Isotope Production Facility (IPF) save lives in research hospitals around the country. LANSCE provides the weapons complex with access to world-class instruments and world-class staff to help study the world's knottiest problems.

Like a fine wine, LANSCE has arguably gotten better with age: there are now more experiments done per year, including national security research, than ever before. Maintaining the pace is increasingly costly as components accumulate wear and tear, or fall behind the technology curve. The LANSCE Refurbishment (LANSCE-R) Project will abate a bow wave of long overdue replacements and updates to the accelerator to assure reliable beam for user-driven science beyond 2025.

With CD-1 expected early in 2009, the LANSCE-R Project will replace troublesome RF elements, control systems, magnets, power supplies, vacuum components...all the failing parts that typically bring the beam down during a

run cycle. A substantial fraction of the radio-frequency power systems will be replaced with modern equipment. LANSCE-R also proposes a complete refurbishment of the original accelerator control and timing systems, replaces a substantial number of obsolete diagnostic devices, and modernizes other ancillary systems including a large fraction of the vacuum ion pump and magnet power supplies, fabrication of spare drift tubes and refurbishment of the linac water cooling system.

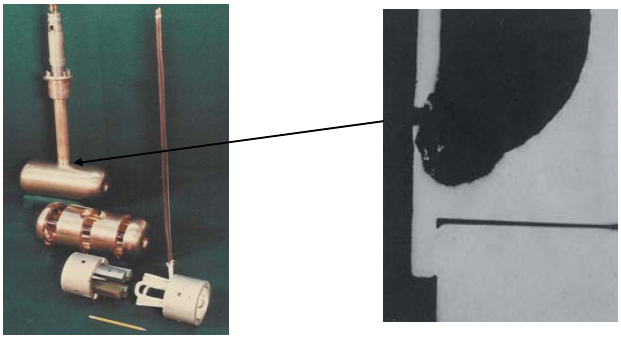


Figure 1. Drift tube LINAC has experienced failures and had visual evidence of erosion along the DTL's length.

By 2015, LANSCE will have been restored to megawatt operation at 120 proton pulses per second, a level of power last achieved in 1998. In recent years, LANSCE has run at 60 pulses per second, 40 to WNR and 20 to Lujan Center, to extend the lives of scarce klystron power amplifiers and to conserve energy. This practice has hampered science done at WNR, where nuclear cross section measurements and radiation effects experiments for the weapons program often require full 100 Hz operation. LANSCE-R will restore WNR's muscle while serving Lujan Center users at their accustomed 20 Hz.

The restoration and life extension of LANSCE is a prerequisite to new, exciting science enabled by other upgrades. The Enhanced Lujan Project proposed to Basic Energy Sciences will establish "world-class" competitive neutron scattering instruments on each of its fourteen materials research flight paths. Many of these instruments will be utilized by defense programs researchers. The high power proton beam will serve the Materials Test Station, Nuclear Energy's new experimental area where materials can be irradiated and improved for fusion energy and next-generation fission environments. Daring new accelerator-driven experiments are being considered as part of MaRIE, LANL's conceptual signature facility of the future.

The improvements brought by LANSCE-R will provide more beam to users to fulfill NNSA missions. In addition to restored power, a new state-of-the-art control system should allow beam tune recovery in a fraction of the time taken now, which will recover otherwise lost beam time. Reliable beam delivery, currently dipping below 80% for some areas, will stabilize. Even though the five-year LANSCE-R project involves delicate RF systems engineering at times, the schedule ensures 125 days (3000 hours) of production beam per year throughout the project for user science.

The LANSCE-R Project is an ambitious project to refurbish key elements of the LANSCE accelerator that are becoming obsolete or nearing end-of-life. It opens the door to exciting new facility developments that promise to lead Los Alamos National Laboratory into the next two decades. In future articles, we will describe the current and future science done at WNR, pRad, Lujan Center, UCN, IPF, MTS, and other LANSCE areas.

Figure 2. Aging vacuum systems are becoming more of an accelerator downtime issue. Pumps, power supplies, valves, and diagnostics are beyond service lifetime or are inadequate to control and monitor system.

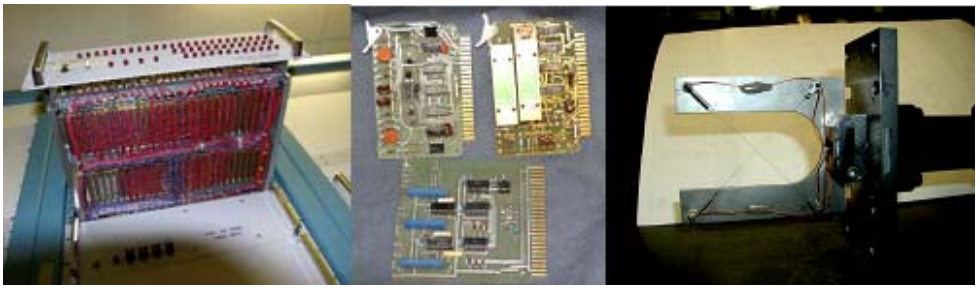


Figure 3. Beam diagnostics and controls, currently rife with ancient VAXes, wire-wrap components (left), obsolete chips (center), and old beam-position monitors will be replaced in favor of state-of-the-art electronics.

Dual Axis Radiographic Hydrodynamics Test (DARHT) 2nd Axis Completed and Put into Operation by Shah Jaghoory, NNSA

It was a success!

Thanks to the tireless efforts of the Los Alamos National Laboratory's (LANL) project team, DARHT 2nd Axis Commissioning and Refurbishment Project is complete and the 2nd Axis has now been put into operation. As was reported in the August 2007 issue of the *Defense Science Quarterly*, completion of DARHT 2nd Axis represents a substantial leap forward in linear induction accelerator technology. The DARHT facility will be the only facility in the world that will provide orthogonal multi-pulse x-radiography capability, which is essential to ensuring the continued safety and reliability of the stockpile under a "zero-yield" test ban.

DARHT 2nd Axis Full Energy Commissioning was completed in August 2007. During the full commissioning phase, the project team again successfully delivered four pulses at energy and dose levels higher than the established goals. Sample results are shown in Figure 1 below.

After the full energy commissioning was completed, the 2nd Axis underwent a series of rigorous readiness tests. These tests included the Management Self Assessment conducting by the project team, followed up by the Accelerator Readiness Review (ARR) that is required by the Department of Energy Order 420.2B *Safety of Accelerator Facilities.* The ARR was conducted by an independent LANL team and observed by a federal team. Corrective Actions were prepared for closing-out all Pre-Start Findings before the NNSA Authorizing Official approved the start of operations to allow integration of the 2nd Axis with the 1st Axis.

After receiving the above authorization, NNSA convened its Energy Systems Acquisition Advisory Board-Equivalent (ESAAB-EQ) to review results of all tests that were required and performed during the project life. The ESAAB-EQ was chaired by the Deputy Administrator for Defense Programs as the 2nd Axis Project Acquisition Executive. The LANL Project Manager and his staff presented results of the tests to the ESAAB-EQ members. Upon recommendations of the ESAAB-EQ members, the Acquisition Executive approved Critical Decision 4 for the project on May 16, 2008, a month earlier than the baseline schedule. In addition, when all cost accounts are closed out by November 2008, the project is expected to have been completed within the approved budget.

Upon the receipt of Critical Decision 4, DARHT 2nd Axis was transferred to LANL program staff to allow the planned integration of the two axes. The integration of the two axes will be achieved after a Contractor Readiness Assessment is completed. The first hydrotest using both axes is scheduled for the latter part of FY 2008.

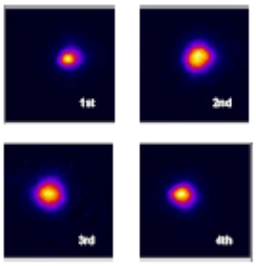
When Bob Smolen, the Deputy Administrator for Defense Programs, approved Critical Decision 4 for the project, he recognized and congratulated both the federal and LANL project and program staff for the successful completion of the project.

For background information refer to the *Defense Science Quarterly* August 2007 Newsletter.

DARHT Update – July 29

During the firing of DARHT for the experiment, a miscommunication resulted in the beam being delivered to the beam dump without being defocused. A 2 kA, 17 MeV beam rapidly vaporized some of the graphite beam dump that requires clean up. This will likely delay the first planned hydro experiments. When the lessons learned are complete, we will have a better understanding of what improvements to procedures and engineering features will be required. LANL has commissioned an independent review.

	Energy (MeV)	Current (kA)	Pulse length (µs)	Spot size (mm-FWHM)	# x-ray pulses
Goals	18	2	1.6	1.25	4
Delivered	17-18	2.1	1.5-1.6	<1.25	4



	1st Pulse (Rad)	2nd Pulse (Rad)	3rd Pulse (Rad)	4th Pulse (Rad)
Goals	100	100	100	300
Delivered	170	185	170	445

Figure 1. Full Energy Commissioning Results showing four pulses, energy levels achievement and dose level.

Annual Symposium of the Stewardship Science Graduate Fellowship (SSGF) Program

by Mike Kreisler, NNSA

For several years, the NNSA's Advanced Simulation and Computing Division has partnered with the Office of Science in sponsoring the Computational Science Graduate Fellowship (CSGF) program for students engaged in research utilizing high performance computing. Roughly three years ago, the NNSA's Office of Defense Science launched the SSGF Program to encourage the training of scientists by providing financial support to talented students who enter a period of study and research in designated areas of stewardship science, including experimental work.

The annual symposium for the SSGF Program was held in conjunction with the CSGF Program on June 16-19, 2008, at the Washington Court Hotel in Washington, DC. The competition to obtain one of these prestigious fellowships is extremely strong and as a result these programs fund truly outstanding graduate students at many of the best universities in the country. In addition to completing the necessary course and dissertation work to obtain their PhD's, each fellow has to spend at least 12 weeks at one of the Department of Energy or NNSA laboratories working on a project with laboratory scientists. This experience often encourages these superb students to seek employment at the laboratories. In the SSGF program, the emphasis is on three particular areas of research: low energy nuclear physics, materials under extreme conditions, and high energy density physics.

David Crandall gave opening remarks at the symposium

The symposium featured presentations by students, a student poster session, a poster session by the laboratories, and award presentations. Barbara Helland (Office of Science) and David Crandall (NNSA) gave the opening welcome addresses. Presentation sessions were moderated by George Seweryniak and Lali Chatteriee (Office of Science) and Mike Kreisler (NNSA). Kim Yates (NNSA) introduced the laboratory poster session. Steve Goodrum, NNSA's Assistant Deputy Administrator for Science, Engineering and Production Programs along with Mike Kreisler introduced the student poster session. After the poster session, many students reported that they were very impressed by the remarks made by Mr. Goodrum, especially his interest in and support of science. They also were excited that he took the time to stay after his remarks to interact with a very large number of the students presenting posters.

SSGF Fellow Angelo Signoracci discusses his poster with Steve Goodrum

Since the SSGF program is relatively new, there were no SSGF student talks although there were several outstanding talks by 4th year CSGF fellows. The SSGF poster session included the following: Laura Berzak (Princeton University)– "Magnetic Diagnostics for the Lithium Tokamak experiment (LTX)"; Krystle Catalli (MIT)–"The Effect of Fe-3+ on the Equations of State of Mg-Silicate Perovskite and Post-Perovskite"; Forrest Doss (University of Michigan)–"Radiating Shock Experiments on the Omega Laser"; Paul Ellison (UC Berkeley)—"Investigating a New Production Reaction and Purification Procedure for Americium-240"; Matthew Gomez (University of Michigan)—"Z-Pinch Contact Resistance Studies"; Miguel Morales (University of Illinois, Urbana-Champaign)—"Ab-initio Simulations of Hydrogen and Helium at High Pressure Using Quantum Monte Carlo"; Angelo Signoracci (Michigan State University)—"Isospin Effects in A=32 Nuclei"; and Dylan Spaulding (UC Berkeley)–"University Use of NIF for Planetary Science".

The Symposium was superbly organized by Krell Institute which administers the fellowship programs for NNSA and the Office of Science.

Mike Kreisler introduced student poster session

Publication Highlights by Brad Wallin

In this section we highlight recent publications in high-impact scientific journals of research supported by the NNSA Science Campaigns.

"Origin of morphotropic phase boundaries in ferroelectrics," M. Ahart et. al., *Nature*, 451, 545 (2008)

A piezoelectric material is one that generates a voltage in response to a mechanical strain (and vice versa). The most useful piezoelectric materials display a transition region in their composition phase diagrams, known as a morphotropic phase boundary, where the crystal structure changes abruptly and the electromechanical properties are maximal. As a result, modern piezoelectric materials for technological applications are usually complex, engineered, solid solutions which complicate their manufacture as well as introducing complexity in the study of the microscopic origins of their properties. Even a pure compound, in this case lead titanate, can display a morphotropic phase boundary under pressure. The results are consistent with first principles theoretical predictions, but show a richer phase diagram than anticipated; moreover, the predicted electromechanical coupling at the transition is larger than any known. For the zero temperature theoretical computations to be consistent with the room-temperature data requires low-temperature phase transitions. Cryogenic high pressure in situ Raman and synchrotron powder X-ray diffraction experiments were performed at the Advanced Photon Source to explore the theoretical predictions. Results showed that the high electromechanical coupling in solid solutions with lead titanate is due to tuning of the high-pressure morphotropic phase boundary in pure lead titanate to ambient pressure. It was also determined that complex microstructures or compositions are not necessary to obtain strong piezoelectricity. This opens the door to the possible discovery of high-performance, pure compound electromechanical materials, which could greatly decrease costs and expand the utility of piezoelectric materials.

"Cubic Zirconia as a dynamic compression window," D.H. Dolan and T. Ao, *Applied Physics Letters*, 93, 021908 (2008)

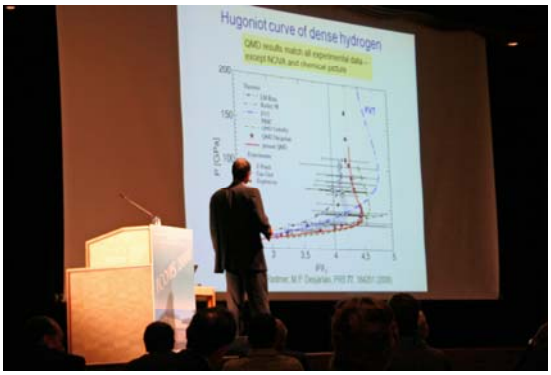
A fundamental limitation in dynamic compression research is the availability of transparent window materials. To serve as a window, a material must remain transparent under extreme pressures and exhibit a simple mechanical response. Single crystal sapphire and lithium fluoride are standard shock compression windows, but additional materials are needed for greater experimental flexibility. Single crystal cubic zirconia is a potentially useful window, as it is known to be transparent in the visible to mid-infrared spectrum and has similar mechanical impedance and hardness as sapphire. Cubic zirconia has different surface properties than sapphire, which could help distinguish surface and bulk nucleation effects; it also has a lower thermal conductivity which may be useful for static preheat experiments. This work uses symmetric impact experiments to characterize the elastic response of <100> cubic zirconia crystals under shock wave compression. Elastic response was determined from the apparent velocity structure upon free surface release and the preservation of light passing through the compressed sample. The Hugoniot and window correction were determined below 9 GPa, and the estimated elastic limit was found to be near 10 GPa. These results indicate that cubic zirconia can serve as a useful alternate to sapphire in dynamic compression experiments that demand alternate surface chemistry or low thermal conductivity.

"X-Ray Diffuse Scattering Measurements of Nucleation Dynamics at Femtosecond Resolution," A. M. Lindberg et. al., Physical Review Letters, 100, 135502 (2008)

The liquid state of matter can be both supercooled below its freezing point and superheated above its boiling point. Although these are non-equilibrium states, their lifetime is longer than typical laboratory observation times and they are thus classified as meta-stable, stuck in a local minimum of the free energy. Despite their apparent stability, these systems exhibit localized fluctuations, corresponding to nuclei of the lower energy phase which rapidly form and dissolve, a process for which there exists a critical size for stable growth of the equilibrium phase, typically of nanoscale dimensions (depending on the degree of superheating). When the transition does occur, it occurs rapidly, as is familiar to anyone who has observed the catastrophic boiling that suddenly occurs in superheated liquid water. The development of ultrafast, atomic-scale sensitive techniques enables one to capture these transient, intermediate states, which under current laboratory methods, may spontaneously transform to lower energy stable states on inaccessible time scales. This work describes diffuse x-ray scattering measurements in which the structural dynamics of the liquid state and the subsequent ablation process are directly measured with sub-picosecond resolution. An InSb bulk single crystalline sample was pulsed with a 50 fs, 800 nm laser pulse at a fluence of 75mJ/cm^2. Following this excitation, a transient liquid state of high compressibility characterized by large amplitude density fluctuations is observed and the buildup of these fluctuations is measured in real time. Small-angle scattering measurements reveal snapshots of the spontaneous nucleation of nanoscale voids within a metastable liquid and support theoretical predictions of the ablation process.

ICOPS 2008

The annual IEEE International Conference on Plasma Science (ICOPS) was held in Karlsruhe, Germany, June 15-19, 2008. This meeting usually occurs in the U.S. or Canada. It was the second time that the ICOPS meeting has occurred outside of North America, and over 500 people attended from 50 countries. The NNSA community was well represented, especially in the area of High Energy Density Physics. Speakers discussed ITER and the French version of NIF (Laser MegaJoule). As mentioned in earlier issues of our newsletter, the NNSA community conducts mission relevant science in a world class fashion. This was highlighted at ICOPS in the plenary talk by Professor Redmer, University of Rostock. In his presentation, he discussed how the planetary science community has updated models of the giant planets based on state-of-the art data and models. Many of the models were generated by the NNSA community, and almost all of the data was produced by us. The photo below shows Professor Redmer discussing the high-pressure hugoniot hydrogen data taken on NNSA gas gun, pulsed power and laser facilities. Diamond cell work conducted by our CDAC academic center was also mentioned.



Highlights and Awards

USMA cadets receive achievement award for internship work at Sandia

On May 1, United States Military Academy (USMA) cadets Brian Czarnecki and James Johnson each received the prestigious Phi Kappa Phi Scholastic Achievement Award for work they did while at Sandia in June-July 2007 as part of a summer internship program. Only three such awards were earned at USMA this year. Working with Tom Haill, Czarnecki and Johnson used the ALEGRA code to study the feasibility of pulsed power machines to ascertain the strength properties of materials under high pressure. The senior cadets used their Sandia summer research as the starting point for a capstone design project in nuclear engineering at USMA.

US-UK 50th Anniversary Events

July 3, 2008, marked the 50th Anniversary of the Agreement between the Governments of the United States of America and the United Kingdom of Great Britain and Northern Ireland for Cooperation on the Uses of Atomic Energy for Mutual Defense Purposes. Over these fifty years, close cooperation between the two countries has become an accepted and valued practice within our nuclear weapons communities. This occasion was marked on both sides of the Atlantic. In London at the Ministry of Defence (MOD) Main Building, Administrator D'Agostino and senior laboratory representatives attended a reception for the opening of an exhibit celebrating the accomplishments of 50 years of close collaboration. In Washington there were a number of events to mark the anniversary. The Center for Strategic Studies held a workshop -- US-UK Nuclear Cooperation: An Assessment and Future Prospects, the Secretary of Energy opened a smaller version of the MOD exhibit erected in the Forrestal Building, and the Secretary of Energy and Secretary of Defense hosted a reception at the Department of State attended by senior representatives from DOE, DOD, MOD, the laboratories and other long time contributors to the relationship. In addition, the "STOCKTAKE 2008" meeting was held where senior US and UK officials renewed the commitment to collaborate on the use of atomic energy for mutual defense purposes.

SSGF 2008-2009 Awardees

The National Nuclear Security Administration and Krell Institute take pleasure in announcing the Stewardship Science Graduate Fellowship Program awardees for the 2008-2009 academic year: Paul Davis, University of California, Berkeley (Applied Physics); Richard Kraus, University of Cambridge, UK (Physics); Jordan McDonnell, University of Tennessee, Knoxville (Theoretical Physics); Anna Nikiforova, Massachusetts Institute of Technology (Nuclear Engineering); Patrick O'Malley, Rutgers University (Experimental Nuclear Physics). Congratulations to all!

Comments

Questions or comments regarding the *Defense Science Quarterly* should be directed to Terri Batuyong (Terri.Batuyong@nnsa.doe.gov).