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News about the Science Campaign February 2008

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Chris Deeney, Director, Office of Defense Science

The FY 2008 Consolidated Appropriations Act has been signed into law allowing the Science Campaign, along with our partner campaigns, to continue on our path to predictive capabilities for the nuclear explosive package. The Appropriations Act has also given us a new opportunity in the form of the Advanced Certification Campaign. The details of this activity are evolving, but it will certainly be an exciting opportunity to demonstrate the impact of our continually improving science on the certification process. We will be having a workshop in March to define the roadmap for Advanced Certification, so we will probably have an article in the next quarterly to introduce the program.

This quarterly issue has several articles on high pressure materials and hydrodynamic research. We have an excellent suite of capabilities from high accuracy platforms like JASPER, through flexible isentropic drivers with pulsed power to x-ray drives to produce warm dense matter. These articles, along with the paper from OMEGA on their Extended X-ray Absorption Fine Structure Diagnostic, all show the power of coupling advanced diagnostics to our experimental high pressure platforms. High quality data like this is mandatory for us to meet our goals in the Quantification of Margins and Uncertainties (QMU) by enabling code and theory validation. JASPER data is already doing this and upcoming experiments on Z and NIF will have significant impact. As we advance on stewardship, we also maintain the capability to perform an underground test during the moratorium. This becomes especially challenging as we move further from our last tests. In the article by Karla Hagans, we see how the test readiness community is rising to this challenge. Christian Mailhiot challenges the community in a different way in his article – can we use high pressure techniques to create novel materials? New materials, for example, have been discovered with significantly enhanced energy density. This is great science with some potentially exciting future applications if we can synthesize and recover more of these materials. As always, the quality of our science is excellent – it has to be for the mission we serve. This issue concludes with three summaries of high impact journal papers. Doug Drake, who has joined our Office from the Inertial Confinement Fusion Office, has summarized three recent journal articles, two from our ICF colleagues and one from the nuclear physics community, that show the quality of our work in NNSA.

The recent departure of a number of our colleagues from the laboratories and test site is a sad event. I want to thank all of those who have contributed to our programs. Over the years, I have worked on various projects with some of the people who have left. For myself and the science campaign, I want to thank them for their excellent work. As we meet our goals in improving the science for QMU. Please know that we would not have gotten there without your contributions. Our best wishes for your new careers, retirements, and future endeavors. Our own office also experienced a recent retirement: Dr. Bharat Agrawal retired after 27 years with the Government. I want to thank Bharat for his service and Los Alamos and the Department of Defense for acknowledging his contributions to LANSCE and the Joint Munitions Program.

Awards

John Lindl, LLNL, has been awarded the prestigious James Clerk Maxwell Prize for Plasma Physics by the American Physical Society Division of Plasma Physics. His citation reads "for 30 years of continuous plasma physics contributions in high energy density physics and inertial confinement fusion research and scientific management." The prize was established in 1975 to recognize outstanding contributions to the field of plasma physics. Dr. Lindl's work has predominantly been supported by the NNSA Inertial Confinement Fusion Program.

The Modernization of Nuclear Test Specific Techniques with a Focus on the Alpha-can Demonstrations by Karla Hagans, LLNL

The United States has a Presidential Directive Decision to maintain a Test Readiness (TR) program to respond to potential stockpile issues and emerging threats. The TR program has been challenged with programmatic and budgetary constraints over the past several years, but is forging ahead with plans and activities to modernize the program to meet the potential challenges of the future. The following article focuses on some of the activities specific to modern diagnostics that will help evolve the program to a more efficient and capable state.

Programs at the Nevada Test Site (NTS) exercise a number of the core technical competencies required to conduct a nuclear test. By designing and executing sub-critical experiments at the NTS, next generation experimental teams have had the opportunity to predict experimental performance, execute and diagnose experiments, analyze experimental data, and refine the computer models of physical phenomena based on specific experimental results. A vibrant experimental program in Nevada is key to maintaining the ability to execute a nuclear test.

As valuable as the subcritical program is to maintaining Nevada program core competencies, there are a number of key areas that aren't exercised in today's Nevada experimental program. Time scales of the data obtained in a subcritical experiment differ by nearly three orders of magnitude from the time scales relevant for a nuclear test. This difference significantly affects the design and execution of the experiments. In addition, the traditional subcritical program doesn't obtain data in adverse electromagnetic pulse and radiation environments. These measurement techniques, as well as specialized experiment emplacement, neutron generators and containment techniques are key core competencies required to execute a nuclear test.

Most of the nuclear test specific core technologies were developed over 20 years ago. The Test Readiness program is investigating modernizing these legacy techniques to develop a forward-looking and sustainable program. In the process of evaluating these new techniques, we are also developing early- to mid-career personnel with the critical skills needed for executing a nuclear test. Modernization efforts are currently ongoing in a number of areas. These include nuclear test imaging techniques, advanced neutron generator development, radiation detector development, high fidelity analog measurements and development of modern 3-D containment calculational tools. We will highlight one of these Test Readiness modernization activities, the modernization of high fidelity analog measurements through the alpha-can demonstration experiments.

Alpha-can demonstrations: Reaction history, a measurement of criticality as a function of time, is a key nuclear test measurement. The measurement is challenging because it requires 10 orders of magnitude dynamic range, time resolutions in the sub-nanosecond to nanosecond range and precise linearity. To meet these demanding requirements, nuclear test specific instrumentation known as Rossi oscilloscopes were developed in the 1950's. A key feature of this oscilloscope was that linearity information was included in the oscilloscope sweep by sweeping the deflection plate with a sine wave instead of a linear sweep, as in a traditional oscilloscope. Figure 1 below, shows a Rossi oscilloscope record of a dry run pulse showing this sinusoidal sweep. Rossi oscilloscopes were built in DOE facilities specifically for the nuclear test program. While we have ~700 Rossi oscilloscopes on hand, we do not have the capability to manufacture new ones. The Rossi's are vacuum tube-based and most of them are over 20 years old.

Figure 1. A Rossi oscilloscope record. Sweep linearity was calibrated in the trace with a sinusoidal sweep.

To identify and test diagnostic equipment that will one day replace the legacy reaction history equipment, namely the Rossi oscilloscopes, a series of "alpha-can" experiments have been developed. By testing potential replacement technology against the Rossi's while they are still functioning, a direct comparison can be made to ensure continuity with past and future data. Early- to mid-career personnel at NTS, LLNL and LANL collaborated on replacement technology approaches that were evaluated as part of the alpha-can I and II experiment series. These experiments were conducted at NTS at the North Las Vegas Facility in Nevada.

A signal generated from a rising exponential pulser, an alpha-can, was electrically split and recorded by a chain of legacy Rossi oscilloscopes and by several different replacement technologies. Figure 2 shows a simplified block diagram of the alpha-can I experiment. The replacement technologies included high voltage clamps, fiber optic techniques, a diagnostic recording system comprised of 8, 12-bit digitizer channels and a digital alpha technique.

A large amount of data were recorded throughout the experiment, including configurations with different alpha

values and one that used 1 km of high bandwidth cable, to simulate a realistic cable length. The result of the alpha-can I experiments showed that reproducing the capabilities of the Rossi scopes with digitizers looks promising in some regimes, however, work is needed to develop high fidelity, high voltage clamps that enable the full dynamic range to be covered by digitizers without damaging the input amplifiers. Alpha-can II recently investigated these clamps along with other improvements to the alpha-can I measurements. The alpha-can II data will take several months to analyze, and will be evaluated throughout the next fiscal year.

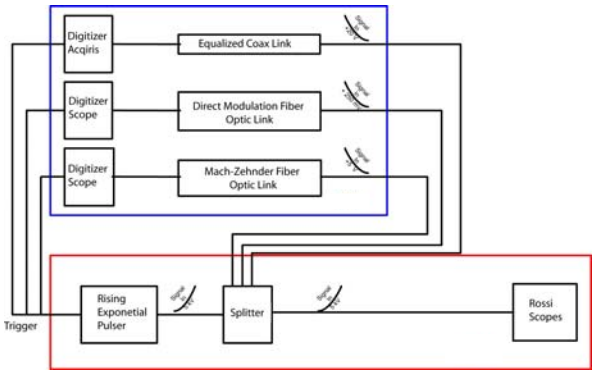

Figure 2. Simplified block diagram of the alpha-can I experiment. Alpha-can I compared various classes of digitizers and fiber optic transmission systems to replace legacy equipment.

Future directions in the Test Readiness Program: The alpha-can demonstrations are one example of our efforts to modernize legacy techniques, both as a way to sustain these techniques and to train early- to mid-career personnel in nuclear test specific requirements. In the future, we will position the Test Readiness investment portfolio to enhance confidence in the nation's predictive modeling capability. This will guide our investment in nuclear test measurement techniques and execution methods. In addition, Test Readiness will continue to invest in nuclear test specific core competencies and leverage the stockpile stewardship mission. Test Readiness activities should be synergistic with ongoing stockpile stewardship activities and we will continue to explore promising opportunities for collaboration.

Monty Wood (LANL) and Don Smith (LLNL) discuss data during the alpha-can II exercise

Since the last nuclear test, the DIVIDER event in 1992, there have been key advances in the understanding of the fundamental physical properties of nuclear weapons.

JASPER Update by Neil Holmes and David Schwoegler

The centerpiece of the Joint Actinide Shock Physics Experimental Research, or JASPER, is a two-stage light gas gun, designed and operated by the Lawrence Livermore National Laboratory within Area 27 at the Nevada Test Site, 75 miles northwest of Las Vegas. Since 2001 JASPER has generated high-precision plutonium data for the nation's Stockpile Stewardship Program. The team also performed an experiment that was part of the Nuclear Counterterrorism Design Support effort.

During FY 2007 the JASPER team accomplished four Hugoniot plutonium experiments that absolutely determine the final pressure, density, and internal energy of Pu when compressed by a strong shock wave. Unique features of JASPER work include experiments that are performed on plutonium; that are successfully contained; and that are highly accurate, with typical uncertainties less than 0.5%. Recent installation of Photonic Doppler Velocimetry diagnostics significantly enhanced our measurements.

JASPER researchers also performed test shots on surrogate materials to successfully validate new gun loading parameters, meeting three divergent goals: 1) velocities down to two km/s, 2) low distortion and tilt of the projectile, and 3) powder loads large enough to ensure post-shot sealing by the piston at the rear of the gun's tapered section. This information is needed for pending experiments to complete the Hugoniot work.

Previously operated as a Radiological Facility since 2001, midway through FY 2007, JASPER was reevaluated by NNSA as a Category 3 Nuclear Facility. While a Documented Safety Analysis is prepared to function within this newly assigned hazard category, JASPER will continue to perform experiments through the end of 2008 under a Justification for Continuing Operation. During that calendar year the team plans to complete up to 18 experiments.

Tenth Shot on Refurbished Z Measures Pressure Drive for Future Experiments

by Marcus Knudson, Jean-Paul Davis, Keith LeChien, Mark Savage, Ray Lemke, Bill Stygar, Guy Donovan, and Mary Ann Sweeney, SNL

The large magnetic fields on Sandia's Z pulsed power facility enable high-pressure isentropic compression and high-velocity flyer plate experiments in support of stockpile stewardship.[1] Z's unique capability to measure dynamic material properties, developed in 1998, has routinely achieved measurement accuracies of a few percent. This capability has been used to answer a long-standing question about the equation of state for deuterium important to weapons and fusion capsules,[2] to address plutonium aging issues, and to constrain the acceptable ignition target design space for beryllium and high-density carbon ablators[3] for the National Ignition Facility. A 14 month upgrade of Z was completed in September 2007 and, before continuing materials experiments, the ability to shape the magnetic pressure pulse on the refurbished machine must be evaluated.

The tenth shot of the refurbished Z (Shot 1775), performed November 14, marked the first step in implementing the new Z as a materials dynamics platform. At a 90 kV charge voltage on the 36 Marx generators, it was the most aggressive test to date, producing a record peak current of 26.4 MA (± 6%) as measured by B-dot monitors located 6 cm upstream of the load at the inner magnetically-insulated transmission line (MITL). The currents at the insulator stack, the outer MITL, and the inner MITL agreed to within 1%, and the intermediate store voltages agreed well with simulations. Based on our early experience on the new Z, a conservative estimate suggests that the improvement in the peak inner-MITL current, compared to the pre-refurbished Z, is about 23%.

Shot 1775 measured the magnetic pressure drive history in the standard long-pulse mode for use with the isentropic compression experiment (ICE) technique, a level 2 milestone for the Inertial Confinement Fusion (ICF) Campaign. The load hardware is shown in Figure 1. A Velocity Interferometry System for Any Reflector (VISAR) measured the time-resolved velocity of the outer surface of a 0.75 mm thick aluminum anode plate. The magnetic pressure drive was deduced by optimizing the magnetic field history in 1-D magnetohydrodynamics (MHD) simulations using the ALEGRA code to reproduce the measured velocity history. Figure 2 shows the magnetic pressure on the driven anode surface. The peak pressure, which depends strongly on load geometry, was about 110 GPa (1.1 Mbar). Electromagnetically self-consistent 2-D ALEGRA simulations, which account for deformation of the load geometry during the pulse, were also performed to unfold the load current history associated with the measured velocity history. Those simulations produced velocity in close agreement with the VISAR data by applying a scale factor of 0.94 (± 2%) to the load B-dot current measurement.

The long-pulse mode characterized initially in shot 1775 is the basis of continuing work to characterize the performance of the refurbished Z under various pulse-shaping configurations (time staggering of laser triggers for gas switches in the pulse forming lines) and develop a new circuit model for Z in preparation for dynamic materials experiments under the Science Campaign (SC). The experiments planned for FY 2008 include measuring the strength of LANL supplied beryllium at stresses greater than 1 Mbar (for the joint SC/ICF level 2 milestone 2888) requalifying the containment chamber on Z (for the SC level 2 milestone 2460) to enable subsequent plutonium experiments at higher pressures than were achievable in FY 2006, and measuring isentropic compression to 4 Mbar in tungsten or tantalum (for the joint ICF/SC level 1 milestone 351 with LANL).

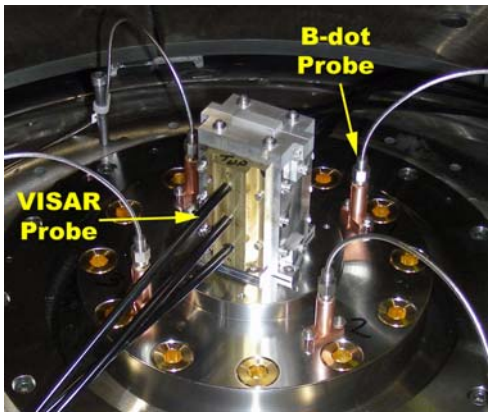

Figure 1. ICE load hardware.

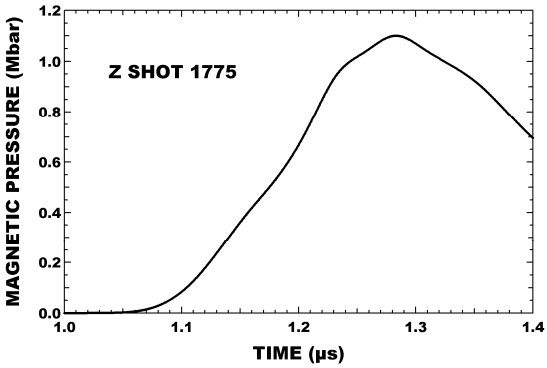

Figure 2. Magnetic pressure on anode surface vs time derived from ALEGRA simulation based on VISAR data.

[1] M.D. Knudson, "Use of the Z Accelerator for Isentropic and Shock Compression Studies," in Shock Wave Science and Technology Reference Library, Springer (Berlin Heidelberg, 2007), Vol. 2, Chapter 1, pp. 1-45.
[2] D. L. Hanson, J. E. Bailey, C. A. Hall, J. R. Asay, C. Deeney, Phys. Rev. B 69, 144209 (2004); M.D. Knudson, et al., Phys. Rev. Lett. 87, 225501 (2001).
[3] M.D. Knudson, Bull. Amer. Phys. Soc. Vol. 51, no. 7, p. 340 (2006).

High Energy Density Research at Los Alamos Examines the Hydrodynamics of Radiatively Heated and Shocked Embedded Layers

by Jonathan Workman

Recent experiments by Los Alamos National Laboratory at the OMEGA laser facility in Rochester, New York, explored the hydrodynamic evolution of embedded layers subject to radiative heating. These experiments, focusing on hydrodynamic evolution, are being used for quantitative validation of 3-D Advanced Simulation and Computing (ASC) calculations of both large- and small-scale hydrodynamic motion. In contrast to traditional shock interaction experiments, the material conditions time dependently evolve before and during the shock interaction process. The complex material and density gradients developed during the heating phase significantly change the shock evolution from what it would be with the initial "as built" profile. Thus far, the types of embedded features fielded include planar disks, rectangular gaps, and most recently single mode sinusoids. This campaign began in 2004 and continues today with significant collaboration from the Atomic Weapons Establishment (AWE). Current efforts have shifted from data collection to analysis and quantitative comparison with simulations.

The laser-based platform described in Figure 1 allows for great flexibility in choice of target type, drive conditions, heating and timing.

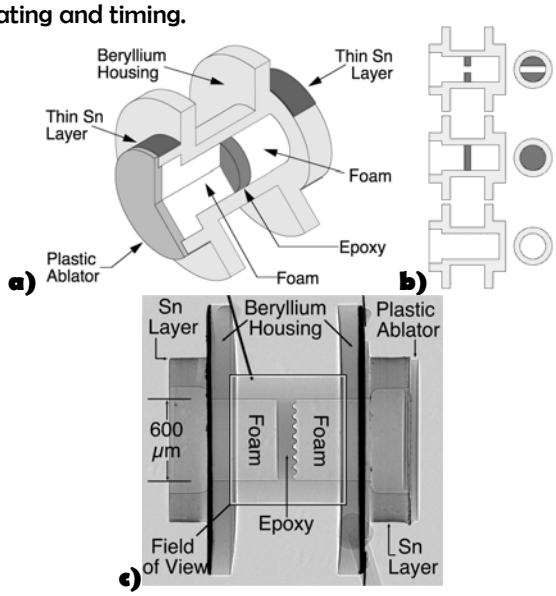

Figure 1. Targets consist of a Be housing with epoxy between 60 mg/cm^3 foam parts. A plastic ablator is used to generate shocks.

Targets consist of a cylindrical beryllium housing that is x-ray transparent and supports the internal components. A 150 μm thick epoxy disk is sandwiched between plastic foam as shown schematically in Figure 1(a). Sn is coated on the Be producing L-shell emission which subsequently heats the target. The shock is generated by laser heating a plastic ablator attached to one end of the target. As shown in Figure 1(b), rectangular features between 18 and 150 μm in height are oriented along the cylinder axis. Figure 1(c) shows an "as built" static characterization radiograph of a single mode sinusoidal target with amplitude and wavelength of 30 and 75 μm respectively. Analysis of heated-only targets reveals the complex density gradients and validates calculations of pre-shock conditions. Figure 2 shows the significant development of density gradients and shocks within 13 ns of heating the targets for several different rectangular gap sizes. The residual gradients from the rarefaction and transmitted shock span an area that is much larger than the original defect size. Density contours are shown in Figure 3 with quantitative comparisons to calculations. There is close agreement in the magnitude of the density perturbations while there appears to be some minor discrepancies in the spatial extent of the perturbations. The experimental results from these types of experiments are used to adjust the treatment of equation of state and x-ray deposition in the calculations required for these warm plasmas.

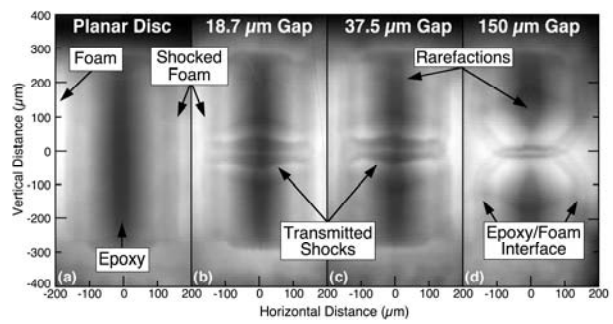

Figure 2. Radiographs of heated targets taken at 13-ns after heating.

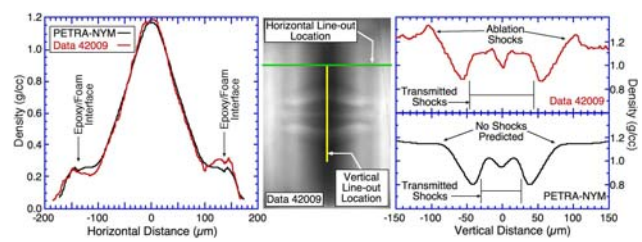

Figure 3. Experimental density profiles of an initial 18-μm gap compared to PETRA-NYM calculations.

Figure 4 shows a qualitative comparison between calculated and experimental data for heated and shocked targets at three different times as the features evolve. It is interesting to note the amount of material moving into the initial gap location and its subsequent evolution driven both by the shock and the initial motion due to heating. Quantifying the amount of material and how it evolves will be included in current analysis and code comparisons.

While data collection for targets with gaps is complete, a second set of data was gathered to measure the effects of radiatively heating single-mode sinusoidal targets. Figure 5 shows recent results from these experiments. The image

on the right is the experimental data while on the left is a simulated radiograph from a full 3-D calculation from the ASC code RAGE. Of interest in the sinusoid data is the phase inversion that occurs in the sinusoid pattern. This phase inversion oscillates in time such that the shock will interact with a time-dependent sinusoidal pattern. This behavior is captured in the RAGE calculations.

The execution and performance of this project represents substantial progress in developing close interactions between experimental and calculational efforts producing critical validation data for ASC codes. Additionally, this work is a strong example of cutting-edge science with significant impact to communities outside of the laboratory environment. The work has withstood strong peer review during international JOWOG conferences and through such avenues as peer reviewed journal publication and an invited talk for the American Physical Society. Close collaborative interactions with AWE have significantly strengthened this effort both from the code side as well as the experimental efforts. The flexible platform used for heating and shocking materials is also under consideration for additional investigations related to materials science, additional hydrodynamic studies, radiation flow and other high energy density related efforts.

The targets used in these experiments were developed, assembled and characterized at Los Alamos National Laboratory with additional parts manufactured by General Atomics.

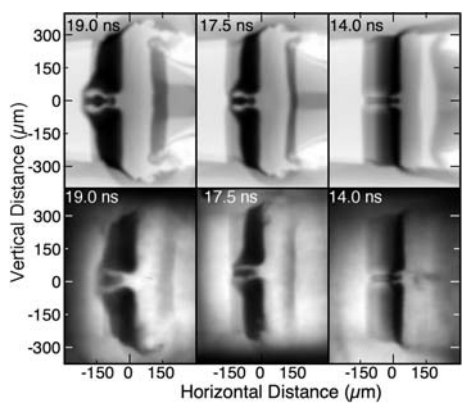

Figure 4. PETRA-NYM calculations (top) and experimental data (bottom) showing shock evolution in a heated 37.5 μm gap target.

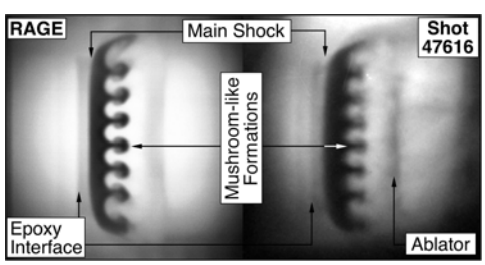

Figure 5. Comparison of 3-D ASC RAGE calculation (left) with experimental data (right) of heated and shocked sinusoid targets.

EXAFS Measurements of Material Properties at High Pressures and Strain Rates by Barukh Yaakobi and David Meyerhofer

The response of materials to shock waves and other high-strain-rate deformations is the subject of intense research. There is particular interest in developing and testing constitutive models that allow continuum hydrodynamic computer codes to simulate plastic flow in the solid state. Such models are important for the study of material strength under high-strain and high-strain-rate conditions. To test such models, the conditions within the compressed samples (such as the amount of compression and temperature) must be measured on a nanosecond time scale.

Extended X-Ray Absorption Fine Structure (EXAFS) can directly measure the bulk properties (as opposed to inferring them from the measured back-surface velocity). EXAFS is a method for measuring the bulk temperature below the melting point, vital for validating constitutive models. EXAFS has been used to demonstrate and study crystal phase transformations on a sub-ns time scale.

The development of EXAFS to study material properties at high pressures and under high strain rate conditions had been the result of a collaboration between the University of Rochester's Laboratory for Laser Energetics (LLE) and Lawrence Livermore National Laboratory (LLNL) lead by Dr. Barukh Yaakobi of LLE.

The key for the successful EXAFS measurements on the OMEGA laser system was the ability to use a large number of beams to implode a backlighter target that produces an intense and smooth x-ray spectrum at photon energies of up to ~10 keV and beyond. Similar experiments are currently being planned for material studies on the National Ignition Facility (NIF).

Early EXAFS experiments at LLE with shocked V, Ti and Fe targets showed the ability to measure the temperature and compression at pressures of ~0.5 Mbar. The hcp-to-α phase transformation in Ti and the bcc-to-hcp phase transformation in Fe were observed on sub-ns timescales.

These measurements have been extended to higher pressures by quasi-isentropic compression, using a two-step target compression (plasma piston). Isentropic compression enables higher pressures to be accessed while keeping the temperature below the melt curve. Preheating in these targets has been studied in detail.

The material properties (e.g., strength) of high-Z metals (in particular, Tantalum and higher Z materials) will be the subject of extensive studies on the NIF, using laser isentropic compression to several Mbar pressures. EXAFS will play an important role in these experiments. The L-shell EXAFS spectrum of Ta (near 10 keV) is currently under investigation on OMEGA. These studies will determine the conditions required for successful observation of Ta L-shell EXAFS on NIF.

Exploiting Extreme Conditions to Create Novel Materials and New States of Matter

by Christian Mailhiot

Large compressions significantly alter the nature of intermolecular interactions, chemical bonding, molecular configurations, and crystal structures and can drive condensed matter systems into new physical and chemical configurations. Thus, high pressure science offers enhanced opportunities to discover new phases (stable and unstable) and to tune materials properties over a wide range of length scales, substantially greater than those achieved by thermal and chemical (composition variations) means at ambient pressures. The *p-T* conditions of interest have resulted in novel states of matter, including three-dimensional (3-D) network structure of polymeric high energy density N, superionic phases of H_2O and NH_3, superconducting ground state fluid H_2, and superhard six-fold stishovite like CO_2. Some of these novel states of matter are likely short-lived and must be investigated by transient measurements.

Covalently-bonded extended phases of molecular solids composed of first- and second-row elements at high pressures are a new class of materials with advanced optical, mechanical and energetic properties (Figure 1). The existence of these extended solids has recently been demonstrated using diamond-anvil cell methods in several systems, including N_2, CO_2, and CO. This new class of materials was predicted to have high energy densities. For example, *ab initio* materials simulations predicted polymeric N_2 (p-N_2) would have the cubic-gauche structure (cg-N) and store three times the energy of the explosive, HMX [C. Mailhiot, L. H. Yang, and A. K. McMahan, *Polymeric Nitrogen, Phys. Rev. B* **46** (1992) 14419] (Figure 2). When a research group synthesized microscopic quantities of p-N_2 at extremely high pressures and temperature, they found that it had the predicted cubic-gauche structure [M. I. Eremets, R. J. Hemley, Ho-kwang Mao and E. Gregoryanz, *Semiconducting Non-Molecular Nitrogen up to 240 GPa and its Low-Pressure Stability, Nature* **411** (2001) 170], however, the extremely small quantities that he could make prevented measuring other predicted novel properties, including its energy content.

Recently, the first experimental evidence was found that these extended low-Z solids are indeed high energy density materials *via* milligram-scale high-pressure synthesis, recovery and characterization of polymeric CO (p-CO) [V. Iota, C. S. Yoo, H. Cynn, *Quartzlike Carbon Dioxide: An Optically Nonlinear Extended Solid at High Pressures and Temperatures, Science* **283** (1999) 1510 – 1513] (Figure 2). Production of this material can readily be scaled up to kilogram or greater quantities. Spectroscopic data reveal that p-CO is a random polymer made of lactonic entities and conjugated carbon-carbon double bonds with an energy content rivaling or exceeding that of HMX. The photographs on the right of Figure 3 show the speed and intensity of energy release from p-CO after fast laser initiation. Solid p-CO explosively decomposes to CO_2 and glassy carbon and may find use as an advanced energetic material.

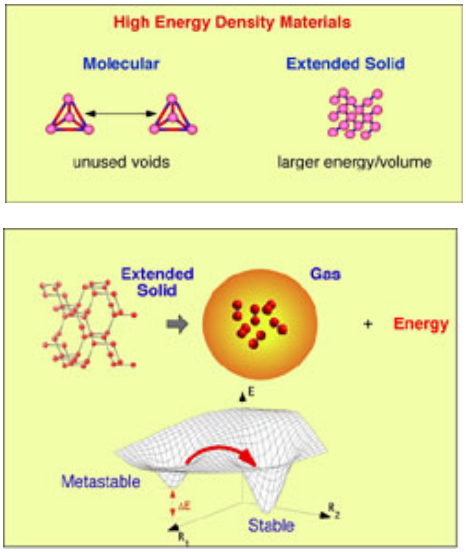

Figure 1. Extended phases of low-Z covalent solids are a new class of high energy density materials (HEDM's): (left) a schematic concept of an HEDM; (right) an example of the energy release reaction.

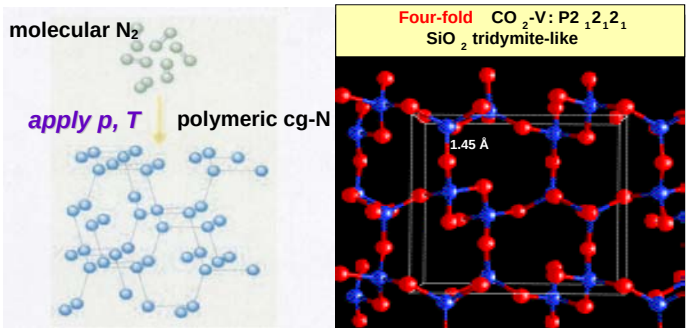

Figure 2: Design and high-pressure/temperature synthesis of novel materials.

Left: Synthesis of polymeric nitrogen from the molecular phase N_2 under high-pressure/temperature conditions.

Right: Synthesis of quartz-like CO from the molecular phase under high-pressure/temperature conditions.

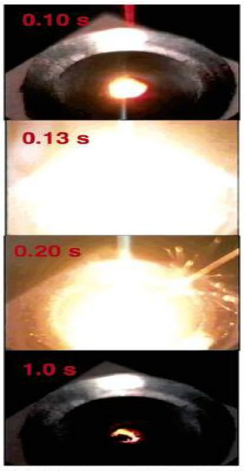

Figure 3. Photomicrographs of a sample of p-CO ignited by a short laser pulse at (top to bottom frame) 0.10, 0.13, 0.20, and 1.0 seconds after ignition. The bright flash of radiation shows that a large energy release occurs within a 0.10-second window about 0.1 second after ignition.

Publication Highlights by Doug Drake

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

Fill-Tube-Induced Mass Perturbations on X-Ray-Driven, Ignition-Scale, Inertial-Confinement-Fusion Capsule Shells and the Implications for Ignition Experiments, G. R. Bennett, et. al., Sandia National Laboratories, Lawrence Livermore National Laboratory, and General Atomics, Physical Review Letters **99**, 205003 (2007)

The first ignition targets fielded on the National Ignition Facility (NIF) will be filled with deuterium/tritium fuel using tubes inserted into the shell material. Although these fill tubes will be tiny (10-20 μm outside diameter, a few μm wall thickness, and a few ng glue mass at the ablator-tube join), they will still have a finite adverse effect on implosion uniformity, and it is necessary to determine whether this effect will result in a significant degradation in target performance. This paper describes experiments performed on Sandia National Laboratories' Z facility with NIF-scale targets designed to isolate the effects of fill tube perturbations during the early stages of capsule implosion. Simulations of the experiments were carried out using the HYDRA radiation-hydrodynamics code, producing results that compared closely with actual measurements. It was determined that fill tube induced perturbations arise from an early-time, but short-lived tube x-ray shadow, rather than direct hydrodynamic mass coupling, and that the effect on NIF ignition target performance is likely to be negligible.

Compensation for Time-Dependent Radiation-Drive Asymmetries in Inertial-Fusion Capsules, S. A. Slutz, R. A. Vesey, and M. C. Herrmann, Sandia National Laboratories (SNL), Physical Review Letters **99**, 175001, (2007)

A major objective of Lawrence Livermore National Laboratory's technical contract for the NOVA laser, portions of which are included in the National Academy of Science's (NAS's) Second Review of the Department of Energy's Inertial Confinement Fusion Program (Sept. 1990), was to "demonstrate our quantitative understanding of the limitations (physics and technology) so that flux uniformities (both instantaneous and time integrated) required for ignition/moderate gain will be achieved on the NOVA Upgrade." This paper attests to the fact that, over a decade later, means of compensating for time-dependent drive asymmetries is still an area of active research. Rather high convergence ratios (initial outer radius of the fuel divided by the radius of the compressed hot spot) will be required to achieve ignition on the National Ignition Facility. This, in turn, will require a high degree of drive symmetry to insure sufficiently precise implosions to avoid such potential results of non-uniform implosion as penetration and quenching of the hot spot by cold target material. Numerous means of achieving the necessary implosion symmetry have been proposed, including precise phasing and locating of the driver beams, radiation shields, and adjustments to the geometry of indirect drive hohlraums. This paper proposes the use of depth variable doping of the capsule ablator to vary the opacity as a means of compensating for asymmetries and achieving uniform implosions. Doping a low Z target shell material such as beryllium or CH with a higher Z material such as gold would have the effect of reducing ablation, and, as a consequence, the drive temperature and pressure. The paper suggests that, by taking advantage of this effect via variable doping of target ablator layers, it should be possible to compensate for P2 radiation asymmetries as high as 20%, with comparable results for higher mode perturbations.

New Levels and a Lifetime Measurement in ^{202}Tl N. Fotiades, R. O. Nelson, and M. Devlin, Los Alamos National Laboratory, J. A. Becker, Lawrence Livermore National Laboratory, Physical Review C **76**, 014302 (2007)

The study of excited states in the thallium isotopes that are located close to the doubly magic ^{208}Pb nucleus is important for comparison with shell-model calculations in this mass region. However, for ^{202}Tl, which is an odd-odd nucleus, no shell model calculations have been so far reported. Moreover, the experimental information on this nucleus is very limited, due mainly to its proximity to the line of stability.

The only information that exists for ^{202}Tl is mostly for low-spin states and was obtained in β-decay measurements and in single-nucleon pickup reactions. This present work studied excited states in ^{202}Tl with up to ~2 MeV excitation energy populated in a (n,2n) reaction on the stable ^{203}Tl isotope. The data were taken using the GEANIE spectrometer and the neutron beam of the Los Alamos Neutron Science Center's WNR facility. The deduced excitation functions combined with $\gamma-\gamma$ coincidence information were used to considerably enrich the low-spin part of the level scheme, which now exhibits similarities to that of the neighboring ^{204}Tl isotope up to at least 0"500 keV excitation energy. Two states, 3.8 keV apart in excitation energy, were observed very close to the previously reported first excited state of ^{202}Tl observed in a (p,d) reaction. The half-life of the previously known 7+ isomer in ^{202}Tl at 950 keV excitation energy was remeasured The 591(3) μs value obtained in the present work differs by ~4% from the 572(7) μs value adopted in the literature.

Comments

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