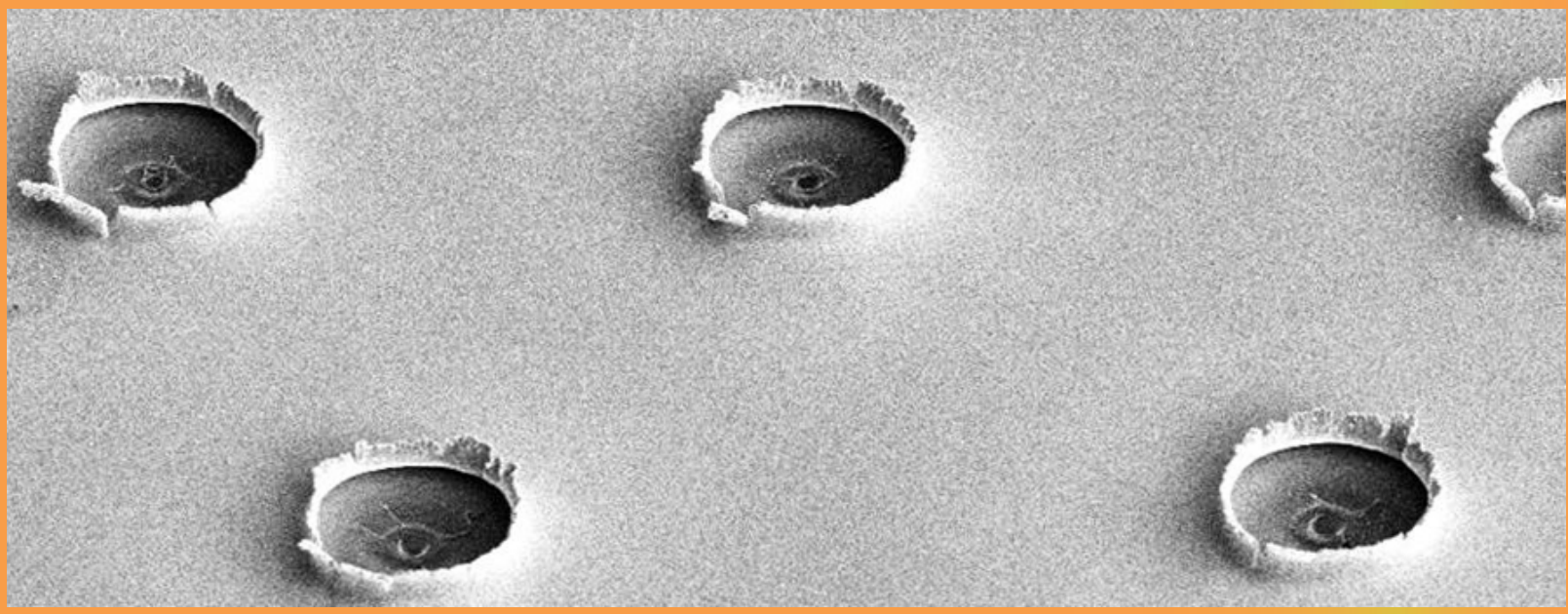
Science and Technology UPDATE

April–June 2014



Science and Technology on a Mission

LLNL-MI-663954

RESEARCHERS WIN PRESTIGIOUS E. O. LAWRENCE AWARD

Two Lawrence Livermore researchers were among the six 2013 E. O. Lawrence Award laureates **named by the Department of Energy** (DOE). The Award, established to honor the memory of **E. O. Lawrence**, recognizes mid-career U.S. scientists and engineers for exceptional contributions in support of DOE and its mission to advance the national, economic, and energy security of the United States.

LLNL seismologist Stephen C. Myers was recognized in the National Security and Nonproliferation category for his work on developing seismic monitoring technologies to locate nuclear explosions. Stephen was cited for his leadership in developing the **Regional Seismic Travel Time Model and Computing Code**, a collaborative effort involving Livermore, Sandia, and Los Alamos National Laboratories and the Air Force Technical Application Center. RSTT improves the accuracy of locating seismic events by using a sophisticated 3-D model of the Earth's crust and upper mantle. Since 2010, RSTT has been used by the Air Force and the Comprehensive Nuclear Test Ban Treaty Organization to monitor nuclear events around the world, including North Korea. Stephen's seismic monitoring work received early support from the LDRD Program, including projects 01-ERD-096 and 05-ERD-019, each of which he worked on as a co-investigator.

Former LLNL scientist Siegfried H. Glenzer, an 18-year Lab veteran who joined the SLAC National Accelerator Laboratory last year, was recognized in the Fusion and Plasma Sciences category for his work on the National Ignition Facility (NIF). He and his collaborators were among the first to perform experiments there, beginning with NIF's early light in 2004 and including full-scale inertial confinement fusion hohlraum experiments from 2008 to 2010. After successfully achieving the required hohlraum radiation temperature and symmetry, they fielded the first implosions with thermonuclear fuel. Siegried's early-stage IFE work was supported by the LDRD program including projects 02-ERD-013, **05-ERI-003**, **08-ERI-002**, and **11-ERD-050**, for all of which he was the principal investigator.

Said LLNL Director William Goldstein, "I am proud of my colleagues and their scientific discoveries. This important award continues to validate the impact Lawrence Livermore researchers have made on the science and technology that enhances our national security." The photo shows Stephen (left) and Siegfried (right) being honored by LLNL Director Goldstein.

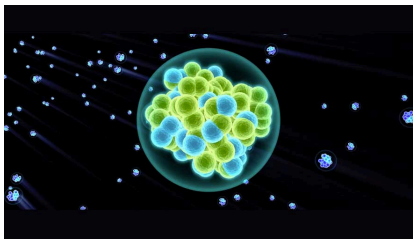
About the Cover

A scanning electron microscopy image of iron subjected to shots from a tabletop-scale titanium–sapphire laser to capture the metal's transition from the alpha to epsilon phase crystal structure (see page 18).

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-7NA27344.

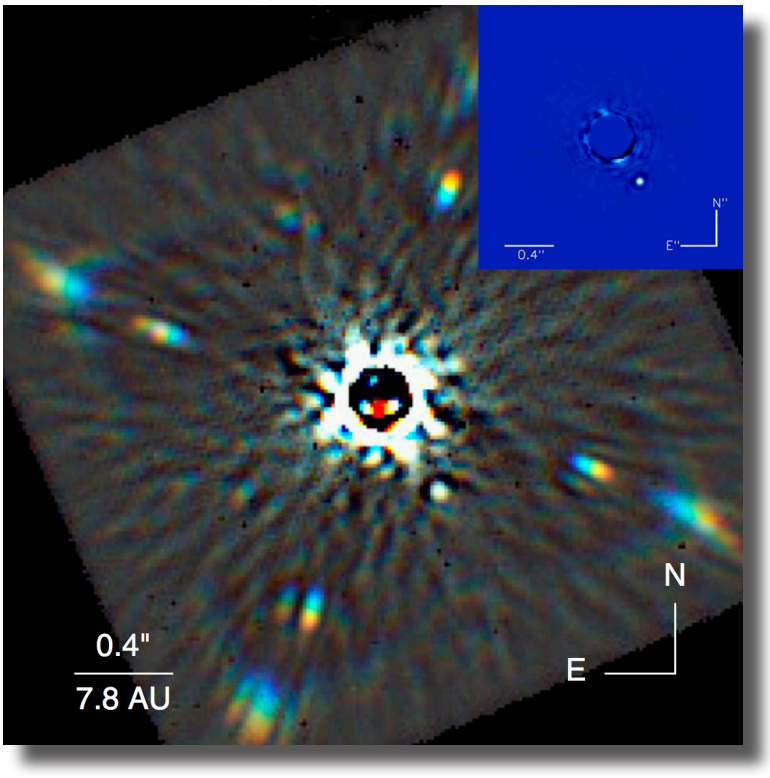
ELEMENT 117—DISCOVERED BY LLNL—CONFIRMED BY INT'L TEAM

The existence of element 117—first discovered by LLNL scientists and their international collaborators in 2010—has been confirmed by a second international team, bringing the element one step closer to being named and officially inducted into the Periodic Table of Elements. A team led by scientists at Germany's GSI Helmholtz Centre for Heavy Ion Research confirmed element 117 (and its decay chain into elements 115 and 113) and **published its findings in a paper in *Physical Review Letters***. The next step is for the International Union of Pure and Applied Chemistry (**IUPAC**) to review the new findings and the original research and decide whether further experiments are needed before officially acknowledging the element's discovery. Upon acceptance, IUPAC would then determine which institution may propose names. Among those participating in the German experiments were Livermore researchers Narek Gharibyan and Dawn Shaughnessy and former postdoc Evgeny Tereshatov. Dawn was also part of the original **U.S.–Russian team that first synthesized element 117**—work that was **supported at Livermore by the LDRD Program**.



EXOPLANET, 63 LIGHT YEARS AWAY, TRACKED WITH GEMINI PLANET IMAGER AND LIVERMORE ADAPTIVE OPTICS

A team of LLNL researchers and international collaborators have tracked the orbit of the exoplanet Beta Pictoris b—located 63 light years from Earth—using the next-generation, high-contrast **adaptive optics system** on the Gemini Planet Imager (GPI). In this achievement, announced in a paper **published in *Proceedings of the National Academy of Sciences***, the team refined their estimate of the planet's orbit by analyzing the two disks around the parent star, Beta Pictoris, finding that the planet is aligned not with the main debris disk but rather with a warped secondary disk. "If Beta Pictoris b is warping the disk," explains Livermore's Lisa Poyneer, a coauthor of the paper, "that helps us see how the planet-forming disk in our own solar system might have evolved long ago." This announcement follows on the **recent unveiling** of the first images from GPI. The adaptive optics technique that captured this first-ever light image of Beta Pictoris b was developed at LLNL with **early support from the Laboratory Directed Research and Development Program**. The figure is a color composite of a GPI image of Beta Pictoris—a single image that visually captured the orbiting planet (at the 5:00 position), as shown more clearly in the combined image (inset).



DEFENSE PROGRAMS AWARDS OF EXCELLENCE PRESENTED

Three teams of Laboratory researchers and others, along with two individual LLNL researchers, have been recognized in the NNSA Defense Programs Awards of Excellence. The awards, which honored work performed in 2012, were presented at LLNL by **Brigadier General James Dawkins**, Principal Assistant Deputy Administrator for Military Application in NNSA Defense Programs. "Thank you for what you do—it's important work," said Dawkins. "You are the backbone of our national security. Never forget that." The teams and individuals are:

Primary Design Code Team—for developing and implementing a new capability that has enabled unprecedented high fidelity in simulations of a wide range of programmatic applications. The capability significantly improves representation of the physics underlying many fine-scale phenomena.

L1 Milestone Team—for developing a cutting-edge uncertainty qualification methodology and using it and science-based models to assess the quality of early-phase hydrodynamic models and to make a prediction of a Los Alamos hydrodynamic experiment. This achievement enabled, for the first time, a systematic analysis of all relevant focused-physics experiments related to early-phase hydrodynamics and how they inform science-based models, clearly describing the weaknesses and strengths of the various models and where improvements need to be made.

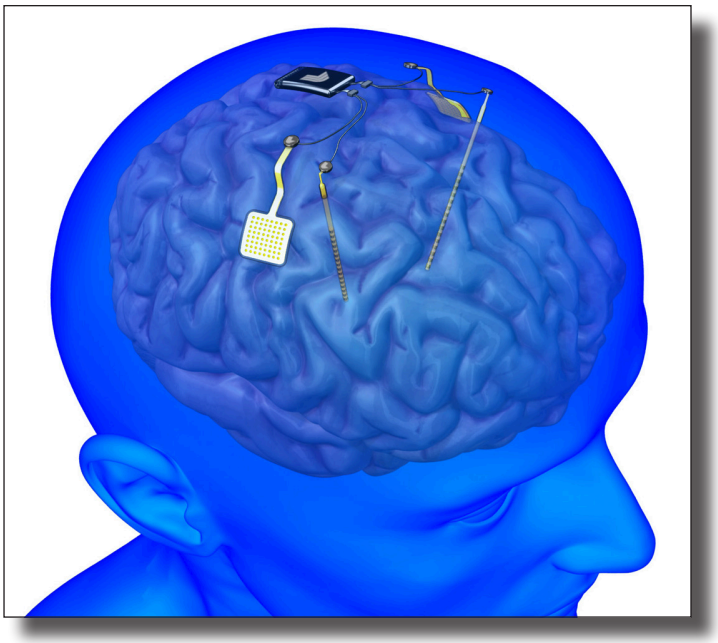
TATB Technical Working Group—for playing a critical role in finalizing a domestic triaminotrinitrobenzene (TATB) production capability and successfully qualifying laboratory- and pilot-scale TATB production through a readiness campaign. The working group is a joint DOE–Department of Defense program to restore a full-scale production capability for a material that is critical to the safety of both conventional and nuclear weapons stockpiles.

Paul Nowak—for developing a three-dimensional computational physics capability that has significantly redefined the simulation approach to nuclear weapon design and assessment, as used in the annual assessment review and on developing options for the future life extension programs.

Wigbert Siekhaus—for developing, over the last three decades, a complete and comprehensive model of the aging behavior of a major component in a nuclear explosive detonation system. His results aided the decision-making process behind the forwarding of a LLNL weapon system for consideration as the warhead in the proposed long-range stand-off (LRSO) weapon.

The photo shows the Primary Design Code Team with Brigadier General James Dawkins (holding plaque) and LLNL's Charles Verdon, LLNL Principal Associate Director for Weapons and Complex Integration (far right).

$5.6 MILLION FROM DARPA FOR NEURAL DEVICE TO TREAT PTSD AND OTHER BRAIN DISORDERS

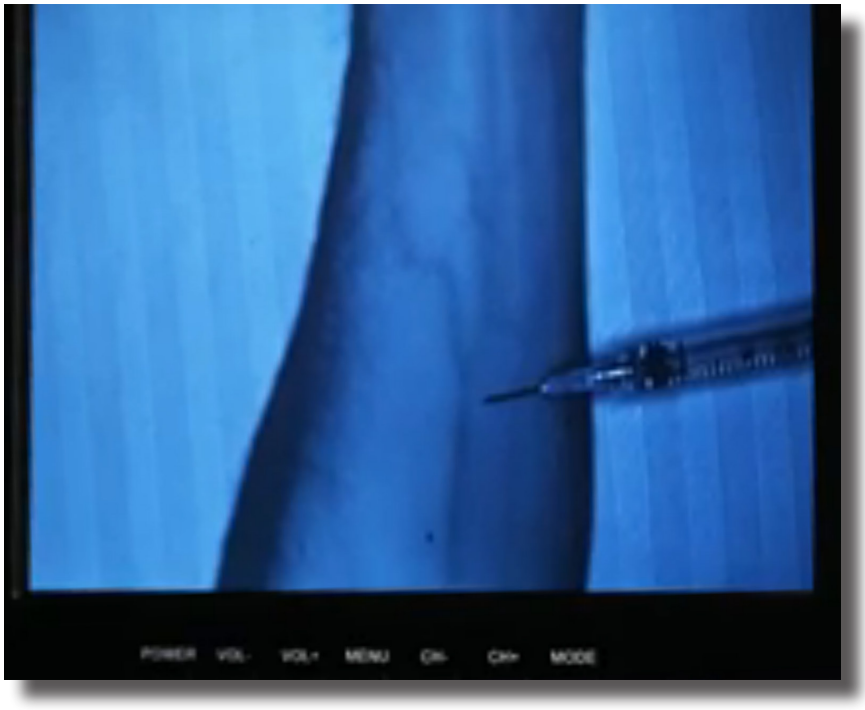


The Laboratory has received $5.6 million from the Defense Advanced Research Projects Agency (**DARPA**) to develop an implantable neural interface with the ability to record and stimulate neurons within the brain, to help doctors better understand and treat conditions such as post-traumatic stress disorder, traumatic brain injury, and chronic pain. The new neural device will be based on technology similar to that in the **R&D 100 Award-winning artificial retina**—the world's first neural interface—which was successfully implanted into blind patients to help partially restore their vision. The new project is part of DARPA's Systems-Based Neurotechnology for Emerging Therapies (**SUBNETS**) Program, which in turn supports the White House's Brain Research through Advancing Innovative Neurotechnologies (**BRAIN**) Initiative, a new effort aimed at revolutionizing our understanding of the human mind and uncovering ways to treat, prevent, and cure brain disorders. The project at LLNL is being led by **Satinderpall Pannu**, whose **team of engineers** aim to build a prototype device in four years. "We are very excited about this project," said Satinderpall. "This is a great opportunity to develop therapies that have the potential to advance health care for our service members, veterans, and the general public." The figure shows where various components of the planned system will be implanted.

REAL-TIME VEIN-IMAGING DEVICE MARKETED

In June, a vein-imaging device containing LLNL technology **debuted on the market** after the Laboratory licensed the technology at the beginning of the year. Developed by Livermore's **Stavros Demos** and released by **Near-Infrared Imaging**, Vein-Eye is a non-contact, near-infrared system that visualizes a patient's veins in real time for medical personnel drawing blood or inserting an intravenous needle into a patient's arm.

An early prototype was sent to a hospital in the Philippines following earthquakes and flooding and used on infants and persons whose veins had collapsed because of dehydration. The device proved a ringing success and is still in use there today.



TEAM WINS ASCR LEADERSHIP COMPUTING CHALLENGE AWARD

Andreas Kemp and colleagues in Lawrence Livermore's Fusion Energy Sciences Program have been selected to receive a 2014 Leadership Computing Challenge award from the DOE Office of Advanced Scientific Computing Research (**ASCR**) for their proposal "Laser-driven relativistic electron beam filamentation in solids." Under the award, Andreas

and his team will be given 30 million hours of central processing unit time on the **Titan Cray XK7** supercomputer at Oak Ridge National Laboratory. The ASCR **Leadership Computing Challenge** is intended to provide large allocations of computing time on leadership-class systems for projects of interest to DOE. The award will allow large-scale simulations of high-energy-density laser physics problems such as gamma-ray bursts and the origin of cosmic rays to support **Andreas's 2012 DOE Early Career Research Program award**. Andreas's colleagues include LLNL researchers **Frederic Perez**, **Bruce Cohen**, Laurent Divol, **Prav Patel**, and University of Nevada–Reno professor **Yasuhiko Sentoku**.

DEIONIZATION TECHNOLOGY FOR WATER PURIFICATION LICENSED

LLNL signed a limited exclusive patent license agreement with EcoWater Systems, LLC, in February for a capacitive deionization technology for residential use. Under the agreement, EcoWater Systems also optioned the technology for water purification for commercial and light industrial applications of up to 5,000 gallons per day. The company plans to begin importing a product from Italy that they have determined overlaps with the LLNL patents. Located in Woodbury, Minnesota, EcoWater is a member of The Marmon Group, a subsidiary of Warren Buffett's Berkshire Hathaway, Inc., and markets to small commercial and residential customers. It is one of the world's largest manufacturers of water treatment system for residential use.

RESEARCHER NAMED OSA SENIOR MEMBER

Livermore's Zhi Liao has been named a senior member of the Optical Society of America (OSA). To qualify for senior membership, individuals must have at least 10 years of significant professional experience since the time of their highest degree and be an active member of the OSA. The designation recognizes experience and professional accomplishments or service within a field that sets the person apart from his or her peers. In the photo, Zhi is demonstrating the principle of total internal reflection using a laser light fountain at a recent Science and Engineering Festival in Washington, D.C.

TWO RECEIVE EARLY-CAREER RESEARCH PROGRAM AWARDS

Todd Gamblin and **Jennifer Pett-Ridge** have been selected by DOE to receive Office of Science Early Career Research Program Awards. The two were selected by the Office of Advanced Scientific Computing Research and the Office of Biological and Environmental Research, respectively. These awards provide $500,000 per year for 5 years to support outstanding scientists early in their careers working in disciplines supported by the DOE Office of Science. This year, 35 awardees were selected from a pool of about 750 applicants; 18 awardees are from universities and 17 from national laboratories.

Todd's project—"Statistical Methods for Exascale Performance Modeling"—will develop scalable statistical models of the adaptive, data-dependent behavior of large-scale scientific simulations, as well as techniques to reduce the complexity of models so they can be easily understood by developers, allowing them to optimize code performance quickly. His project will also use performance models to validate the behavior of so-called "proxy applications" to ensure that they accurately represent the behavior of larger, more complex simulations, so that the applications can take full advantage of the performance of future exascale machines.

Jennifer's project, titled "Microbial Carbon Tranformations in Wet Tropical Soils: The Importance of Redox Fluctuations," will study the effects of changes in soil temperature, moisture, and oxygen availability on the genomic content and function of tropical soil microorganisms in tropical forest soils. These soils store more carbon—in the form of plant litter and decomposed organic matter—than any other terrestrial ecosystem and play a critical role in the production of greenhouse gases, which affect both atmospheric chemistry and climate. By tracking the microbial processes involved with the degradation of organic carbon compounds, this project will increase the accuracy of predictions of whether organic carbon is retained or lost from tropical soil systems in various climate change scenarios.

Todd and Jennifer join the Lab's ten previous award winners: **Yuan Ping in 2013**; **Céline Bonfils, Gianpaolo Carosi, Andreas Kemp, and Jaime Marian in 2012**; Yongqin Jiao, Peter Lindstrom, and Sofia Quaglioni in 2011; and Vlad Soukhanovskii and Greg Bronevetsky in 2010.

SCIENTIST RECEIVES NASA SUPPORT UNDER EARLY-CAREER PROGRAM

Atmospheric scientist Mark Zelinka has been awarded NASA funding under its New Investigator Program in Earth Science. His project, titled "Interactions Among Clouds, Radiation, and Circulation at Mid-latitudes," will receive approximately three months of support per calendar year over a three-year period. Of the 131 proposals that were received, NASA selected 21 for funding. The New Investigator Program in Earth Science is designed to **support outstanding scientific research**, cultivate scientific leadership, and promote career development for scientists and engineers in the early stages of their professional careers. NASA's **Earth Science Division** places particular emphasis on an investigator's ability to promote and increase the use of space-based remote sensing through his or her proposed research.

MANAGER JOINS NASA FORUM ON DIRECTION OF SCIENCE ON INTERNATIONAL SPACE STATION

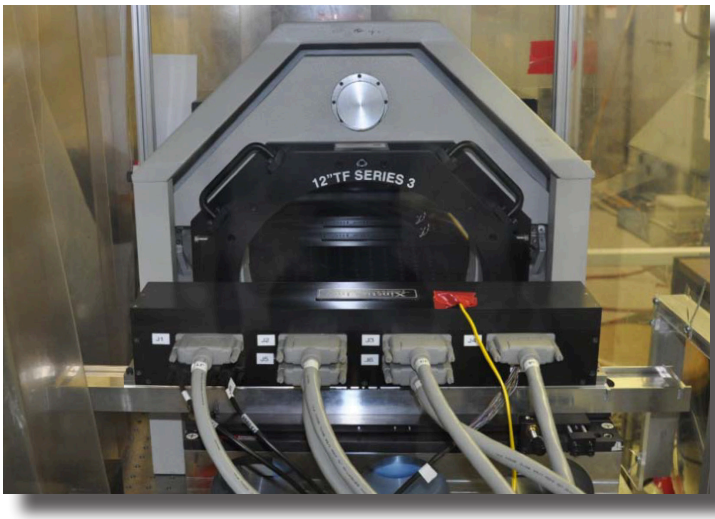
Betsy Cantwell, Livermore's director for economic development, was part of **a panel of experts called by NASA** to discuss the future direction for life and physical sciences aboard the International Space Station (**ISS**). "We took a broad look at what research needed to be done in the physical sciences and the life sciences to underpin the future of space exploration," said Betsy (second from right in the photo). The **videotaped forum**, which was titled ***Destination Station: ISS Science Forum***, emphasized microgravity research to prepare astronauts for long-duration missions farther into the solar system than ever before and provide lasting benefits to life on Earth. The forum included a real-time conversation with NASA astronaut and ISS Expedition 40 crew commander **Steve Swanson** as he and his fellow crewmembers orbited 260 miles above Earth.

TWO TO SERVE ON DOE STRATEGIC PLANNING PANEL FOR FUSION ENERGY

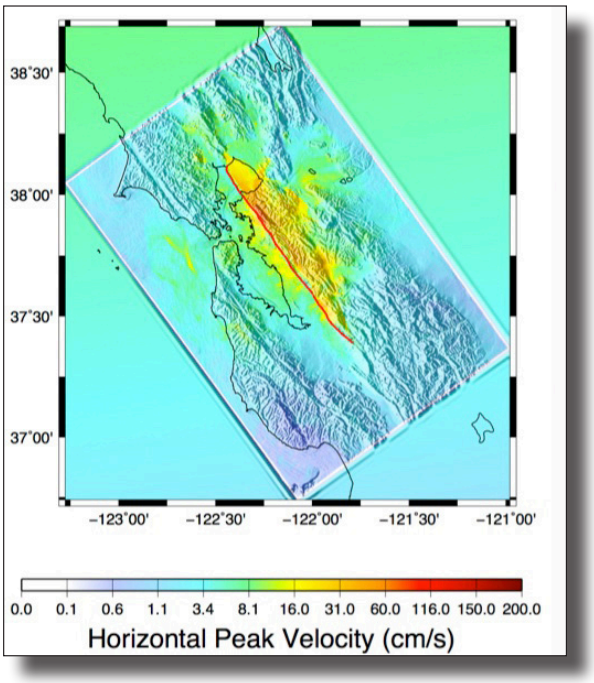
The fiscal 2014 Omnibus Appropriations Act requires DOE to submit a strategic plan for the Office of Fusion Energy Sciences program by January 2015. Accordingly, the DOE Fusion Energy Sciences Advisory Committee (**FESAC**) has formed a **Strategic Planning Panel** to assist DOE Office of Science Acting Director Pat Dehmer with development of this plan. Lawrence Livermore's Don Correll and Susana Reyes have been asked to serve as members of the panel, which will develop recommended strategies under three different future funding scenarios: flat funding, funding with an inflation allowance, and funding with modest growth. The FESAC report is due October 1 this year in order to meet the January 2015 Congressional deadline.

RECORD-SETTING PRECISION IN ADAPTIVE X-RAY OPTICS

Increasingly advanced, high-performance x-ray mirrors are required by today's fourth-generation x-ray light sources, whether free-electron lasers—such as the **Linac Coherent Light Source** or Japan's **SPring-8 Angstrom Free Electron Laser**—or advanced synchrotron sources such as the National Synchrotron Light Source II. Lawrence Livermore, building on its expertise in visible-wavelength adaptive optics and reflective x-ray optics, supported **an LDRD effort led by Lisa Poyneer** to design, fabricate, and test x-ray deformable mirrors (XDMs). Two significant benefits over traditional non-adaptive x-ray optics are believed possible with XDMs: active control, a potentially inexpensive way to achieve a better surface figure than is possible by polishing alone, particularly on long substrates; and the ability to change the figure, allowing for dynamic correction of aberrations in an x-ray beam line. In **a paper published in *Applied Optics***, Lisa and her team describe the 45-cm-long XDM they fabricated using super-polished single-crystal silicon, with 45 actuators along the tangential axis. After assembly, the XDM exhibited a surface height error of just 19 nm. Then, using high-precision visible-light metrology and precise control algorithms, the team actuated the XDM and flattened its entire surface to a controllable figure error of only 0.7 nm—the first subnanometer active flattening of a substrate longer than 15 cm. The photo shows the XDM facing the interferometer in a metrology laboratory.



LARGEST-EVER SW4 SEISMIC SIMULATION ON VULCAN PRESENTED AT ANNUAL MEETING



Livermore's **Anders Petersson** and Bjorn Sjogreen achieved their largest seismic simulation to date using the **SW4 code**, which simulates seismic wave propagation resulting from earthquakes and other energetic events. The team's latest results—**presented** at the recent **annual meeting** of the Seismological Society of America—represent a fourfold increase in frequency. The pair credit this increase in resolution in each space dimension and time to recently developed higher-order numerical methods and to the massive parallelism of the **Vulcan system**, on which their code was run. "Our final obstacle for performing realistic simulations on Vulcan was populating the 55-billion-grid-point mesh with realistic material properties," said Anders. To achieve this goal, he and Bjorn developed a new file format that can be read with the parallel input–output routines previously developed by Bjorn. The SW4 code is used by Laboratory seismologists in geophysical monitoring, among other uses. The figure shows peak ground velocity in a simulated earthquake of magnitude 6.74 on the Hayward fault.

IN HIGH-PROFILE TRIAL OF IVORY DEALER, PROSECUTION TURNS TO LLNL RADIOISOTOPE ANALYSIS

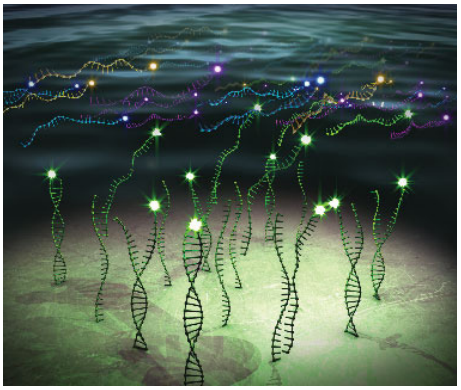
Damning is the word used by National Geographic to describe **LLNL radioisotope analysis submitted as forensic evidence** in the trial of an ivory dealer in Togo. The dealer had claimed to have imported his inventory of ivory prior to 1990, when a global ban on international ivory trade went into effect. Prosecutors sent samples of the ivory to Lawrence Livermore, where radiocarbon dating at the **Center for Accelerator Mass Spectrometry** indicated that the defendant's stockpile "included ivory from elephants killed after 1990 and possibly as recently as 2010." The case is being closely watched in the hopes that a conviction will demonstrate to poachers and ivory traffickers how cutting-edge technology is being marshaled against them.

TELEMETRY DEVELOPED FOR STARTUP'S ADVANCED AUDITORY PROSTHETIC

Lawrence Livermore engineers have successfully developed implantable power telemetry for an advanced auditory prosthetic, completing the first phase of deliverables in the Laboratory's partnership with Bay Area startup **OtoKinetics**. The device is a miniature radio-frequency coil system that can transmit 500 μW of power, and the sponsor will now use this achievement to raise venture and Federal funding for the next step: to further develop a wireless link to transmit data signals. The goal of OtoKinetics is to provide a commercial device that delivers increased performance compared to current cochlear implants to treat deafness. The implantable power telemetry system would enable the device to be powered wirelessly, thus removing the need for implanted batteries or electrical wires penetrating through the skin. Successful commercialization of this technology could help millions of patients worldwide who suffer from hearing loss.

LLNL BIODETECTOR FINDS PATHOGENS IN SOLDIERS' WOUNDS MISSED BY OTHER TECHNOLOGIES

In a three-year study of wounds suffered by U.S. soldiers, researchers at LLNL and four other institutions used the Lawrence Livermore Microbial Detection Array (**LLMDA**) to detect one or more bacterial pathogens in approximately one-third of all wound samples in which no bacteria had been previously detected using the standard culture method. The work **appears in *Journal of Clinical Microbiology***. Said Livermore postdoc and lead author **Nicholas Be**, "The culture-based methods currently being used to measure infection often do not detect bacteria that are difficult to grow in the lab. Better detection methods for microbes that impact the healing process could help surgeons make more informed predictions and decisions for improving patient care." Developed by Livermore scientists, the LLMDA contains 180,000 probes that are capable of detecting, within 24 hours, any previously sequenced bacteria or virus; the current number is about 8,100. One of the key findings made in the study with LLMDA is that certain bacteria common in hospital-related infections, such as *Pseudomonas* species and *Acinetobacter baumannii*, were found associated with wounds that did not heal successfully. One of Nicholas's co-authors, LLNL biologist **Crystal Jaing**, who helped develop LLMDA under **LDRD project 08-SI-002**, believes that the detection array could also have applications in the wider medical world. "Our technology could be helpful to doctors treating burns with large surface areas, people injured by trauma, or people with diabetic ulcers," she said.



$1.2 MILLION FROM EERE TO IMPROVE FUEL STORAGE OF HYDROGEN-POWERED VEHICLES

Livermore's **Brandon Wood** and team, along with colleagues at Georgia Institute of Techology and the University of Michigan, have received $1.2 million in funding from the DOE Office of Energy Efficiency and Renewable Energy to study the use of nanoparticles to help hydrogen-powered vehicles store more hydrogen fuel on board. Brandon and LLNL colleague **Tae Wook Heo** will use multiscale modeling to investigate the kinetics of a high-capacity hydrogen-storage candidate based on magnesium borohydride nanoparticles originally developed for light-duty vehicles. The modeling framework was originally developed by Brandon and Tae Wook under a project (**12-ERD-053**) in the Laboratory Directed Research and Development (**LDRD**) Program. Unlike conventional hydrogen storage tanks, the new tank they seek to develop would be much smaller and would not require the hydrogen to be stored at cryogenic temperatures. This would be accomplished with a new material that absorbs and releases hydrogen readily. "It's like a sponge that absorbs hydrogen in a solid matrix, giving it a much higher density for storage," Brandon said. Magnesium borohydride nanoparticles have a demonstrated high hydrogen storage capacity and reversibility, making them excellent candidates for onboard hydrogen storage.

ENGINEER CHAIRS ASPE TOPICAL MEETING ON ADDITIVE MANUFACTURING

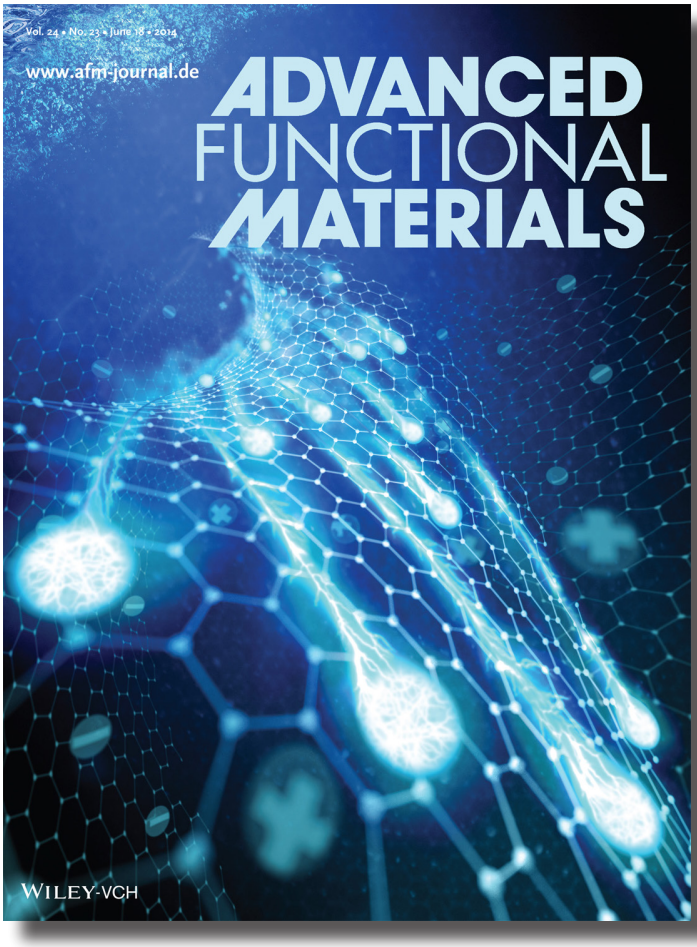
Lawrence Livermore engineer John Taylor chaired the **2014 Spring Topical Meeting** of the American Society for Precision Engineering (**ASPE**), the theme of which was "Dimensional Accuracy and Surface Finish in Additive Manufacturing." Three additional LLNL researchers also served on the meeting's organizing committee. Held in addition to its annual meeting, the ASPE topical meetings are convened annually to focus on a **specific technical topic** in precision engineering more narrowly defined than those of the annual meetings. John's involvement in ASPE events also includes **co-chairing** the 2012 summer topical meeting.

LABORATORY HOSTS 18TH ANNUAL SIGNAL AND IMAGE SCIENCES WORKSHOP

The 18th Annual **Signal and Image Science Workshop** was held on May 21 at the High-Performance Computing Innovation Center, part of the **Livermore Valley Open Campus**. A signature event of the Laboratory's Center for Advanced Signal and Image Sciences (**CASIS**), the annual gathering serves as a showcase for R&D in signal and image sciences at Lawrence Livermore and Sandia National Laboratories. Approximately 100 attendees visited this year's workshop to hear presentations and view posters, with topics that included signal and image processing, pattern analysis, machine learning, controls, and communications, as well as application areas such as geophysics, astronomy, and the biosciences. The keynote speaker was **Pietro Perona**, an electrical engineering professor at Caltech and internationally recognized expert on computational vision. His address, titled "Visipedia—A Distributed Visual System Composed of Machines and People," explored the idea of a visual interface for Wikipedia that could answer visual queries and enable experts to contribute and organize visual knowledge. This year's CASIS workshop was cosponsored by the Oakland–East Bay chapter of the Institute of Electrical and Electronics Engineers **Signal Processing Society**.

MATERIAL WITH DYNAMICALLY CONTROLLABLE CHARGE TRANSPORT

Although materials that change properties in response to changes in surface charge have been known for many years, interest has surged recently with the emergence of interface-dominated bulk materials, such as the recently developed three-dimensional (3D) bulk nanographene. With its ultrahigh surface area and chemical inertness, this material offers new opportunities for exploring surface-charge-modulated physical properties. In **a paper featured on the cover of *Advanced Functional Materials***, Livermore's Juergen Biener, Ted Baumann, and colleagues show that the electrical conductance of centimeter-sized 3D bulk nanographene can be dynamically controlled by changing surface charge density. In fact, a fully reversible change in conductance of up to several hundred percent can be achieved by imposing a potential of less than one volt. The observed change in conductivity can be explained by the electrochemically induced accumulation and depletion of charge carriers, in addition to variation in carrier mobility owing to changes in defect density (resulting from changes in interfacial charge). The team's results open the door to new applications of bulk graphene materials, such as low-voltage, high-power tunable resistors. This work was supported by the Laboratory's LDRD Program under **project 12-ERD-035**—work that was also **featured on the cover of *Advanced Materials*** in 2012.



NIF X-RAY DRIVE MEASUREMENTS REPORTED IN *PHYSICAL REVIEW LETTERS*

Experiments conducted on NIF last year have revealed the source of a discrepancy between simulations and measured ablator implosion velocity, **LLNL researchers and collaborators reported in a *Physical Review Letters paper***. The experiments used ignition-scale cryogenic hohlraums with one end cut off, exposing the hohlraum interior and far laser entrance hole (LEH) directly to views from x-ray spectrometer and x-ray imaging diagnostics. The technique was designed to create a plasma environment as close as possible to the ignition target while allowing for a more complete view of the hohlraum interior, as well as the first-ever direct measurement of the hohlraum x-ray drive from the viewpoint of the target capsule. The researchers said the experiments measured lower capsule drive than with conventional LEH-inferred drive, consistent with slower implosion speeds. "The . . . data demonstrate that the cause of the reduced implosion speed is a deficit in x-ray drive relative to simulations," they report. "The results indicate that it is the model for x-ray production in gas-filled hohlraums and not ablation physics that must be improved to gain predictive capability for indirect-drive ignition experiments." Lead author Stephan MacLaren was joined by LLNL colleagues and collaborators from the United Kingdom's Atomic Weapons Establishment.

NEPTUNIUM KINETICS IN WATER ON COVER OF *INORGANIC CHEMISTRY*

Research conducted by LLNL Lawrence Scholar Adele Panasci, staff scientists **Stephen Harley** and Mavrik Zavarin, and William Casey of UC Davis is **highlighted on the cover of *Inorganic Chemistry***. This team has been using Livermore's unique radiologic and nuclear magnetic resonance capabilities to shed light on the molecular-level structure and kinetics of aqueous chemical complexes of the actinide elements. Such information is critical for safety assessments of nuclear storage facilities, which rely on models to predict how actinide species might migrate through engineered barriers, soil, and groundwater. These models rely on data from experiments to describe the numerous geochemical processes that can affect actinide transport, but the available data are few and far between for most actinides. In the *Inorganic Chemistry* paper, the team re-examined the kinetics of carbonate ligand exchange in a neptunium compound using carbon-13 nuclear magnetic resonance experiments under chemical conditions relevant to nuclear waste storage. They found that the neptunium(VI) ligand exchange mechanisms parallel those of the analogous uranium(VI) complex. Neptunium is of particular interest due to its long half-life (over 2 million years for neptunium-237), high solubility in natural groundwaters, and high radiotoxicity. This work was supported by the Office of Biological and Environmental Research in the DOE Office of Science.

FIRST EVIDENCE THAT HYDROGEN PEROXIDE CAN SEPARATE PLUTONIUM FROM MINERAL SURFACES

In a **paper published in the online edition of *Environmental Science and Technology***, Laboratory scientists **James Begg**, **Mavrik Zavarin**, and **Annie Kersting** show that environmental levels of hydrogen peroxide, a chemical found in natural waters and used in hair treatment, can affect the stability of plutonium adsorbed to goethite, montmorillonite, and quartz across a wide range of pH values. These results provide the first evidence that hydrogen peroxide drives the desorption of plutonium(IV) ions from mineral surfaces.

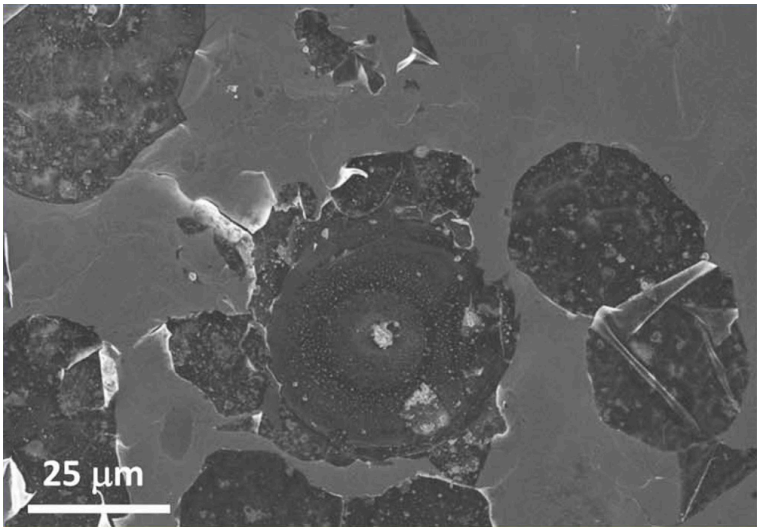
The authors also point out the significance of a reaction between hydrogen peroxide and iron-bearing phases and provide evidence of the ability of that reaction to drive the desorption of plutonium from the mineral surface. This is important because iron-bearing minerals are expected to be strong adsorbers of plutonium in the environment. The team suggests that this reaction pathway, coupled with environmental levels of hydrogen peroxide, may contribute to plutonium mobility in the environment.

NANOSCALE CHEMICAL IMAGING OF ATMOSPHERIC PARTICLES

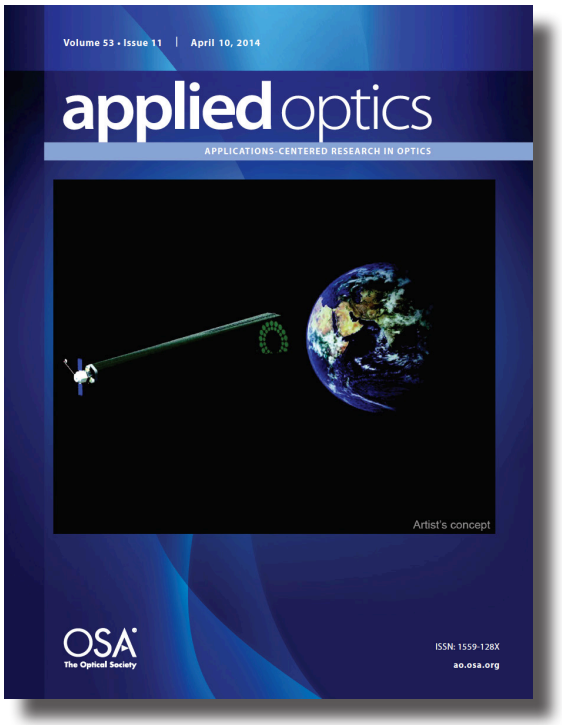
Knowledge of the spatially resolved composition of atmospheric aerosol particles is essential for understanding their origin, evolution, fate, and ultimate impact. In **a paper featured on the cover of *Analytical Methods*** and highlighted by the journal as a "Hot" paper, LLNL chemist Peter Weber and colleagues from the California Department of Public Health and Pacific Northwest National Laboratory document the application of nanometer-scale secondary ion mass spectrometry (nanoSIMS) for the three-dimensional chemical imaging of individual atmospheric particles. The team used nanoSIMS—which can map the nanometer-scale chemical composition of a particle over a broad range of particle sizes—to investigate aerosol particles collected in Mexico City. Particles from an air pollution event were found to vary greatly in composition, suggesting multiple sources. In contrast, background particles were found to be compositionally homogeneous, with elevated concentrations of nitrogen, oxygen, and chlorine on their surfaces, an observation consistent with atmospheric aging of the particles. The results demonstrate the feasibility of the three-dimensional chemical characterization of atmospheric particles and the insight that such information can provide for elucidating their chemical history.

INVITED REVIEW PAPER ON BREAKTHROUGHS IN X-RAY OPTICS

A **special issue** of *IEEE Photonics Journal* devoted to breakthroughs in photonics in 2013 includes **an invited review paper** by **Regina Soufli** on the latest advances in extreme ultraviolet and x-ray optics. The paper highlights recent work by Lawrence Livermore researchers and other groups around the world. These recent developments have been motivated by the availability and demands of new x-ray sources and by the needs of scientific and industrial applications. Among the breakthroughs highlighted are the fabrication, metrology, and mounting technologies for large-area optical substrates with improved figure, roughness, and focusing properties; multilayer coatings optimized layer properties, achieving improved reflectance, stability, and out-of-band suppression; and nanodiffractive optics with improved efficiency and resolution. The figure is a scanning electron microscopy image of a magnesium–silicon carbide multilayer coating suffering advanced atmospheric corrosion, before **development, by a team led by Regina, of an improved version with superior corrosion resistance**.



MOIRE OPTICS ON COVER OF *APPLIED OPTICS*

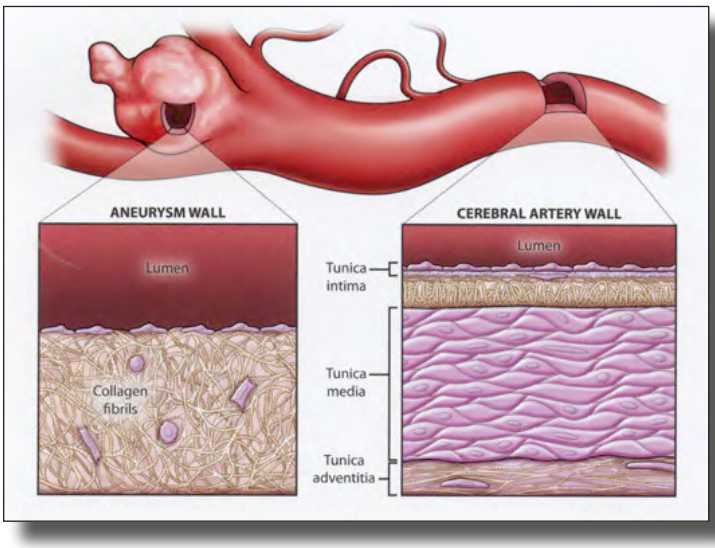


A paper by lead author **Jerry Britten**, LLNL colleagues, and other researchers describing the optics technology being developed for the Defense Advanced Research Projects Agency's (DARPA's) Membrane Optical Imager Realtime Exploitation (**MOIRE**) Program was **featured on the cover of *Applied Optics***. The MOIRE Program—which recently **demonstrated a key capability to DARPA**—seeks to further develop the technology for ultralight, diffractive membrane-based telescopes to provide geosynchronous-orbit Earth observation capabilities. Supported by LLNL, NeXolve Corporation, and Alliant Techsystems, Ball Aerospace has entered the second phase of a MOIRE contract to demonstrate a ground-based telescope utilizing segmented, membrane-diffractive primary lenses. The membrane optic diffractive imager provides increased aperture at lower mass and cost compared to conventional systems, and can enable persistent coverage from geosynchronous orbit. The researchers have demonstrated four-level Fresnel zone lenses in glass with a minimum line width of 1 μm, using a commercial laser photoplotter with overlay writing capability and ion-beam etching for pattern transfer. The etching technology was developed at LLNL.

SIMULATIONS OF ION AND ELECTRON ENERGY DISTRIBUTIONS IN FUSION PLASMAS

In a paper featured on the cover of *Plasma Physics and Controlled Fusion*, a team composed of LLNL's **Andrea Schmidt** and colleagues at MIT, other national labs, and industry **describes fully self-consistent, time-dependent simulations** of ion and electron energy distributions generated by radio frequency waves injected into a Tokamak fusion reactor. These simulations iterate between Fokker-Planck and full-wave electromagnetic field solvers and predict the effect of heating and current drive by externally generated radio frequency waves. Such synthetic diagnostics are used to compare the predicted and measured particle distributions, past calculations used a less computationally intensive ray-tracing–Fokker-Plank approach, which does not account for interference effects from crossing waves and does not properly treat reflections from the plasma cutoff. The full-wave approach was made possible through advanced algorithms that accelerated the full-wave calculation as well as a vector extrapolation method that reduced the number of iterations needed for convergence. In addition, a new decomposition algorithm improved the scaling of the code to parallel processors.

RADIOCARBON DATING UPDATES UNDERSTANDING OF LIFE-THREATENING ANEURYSMS

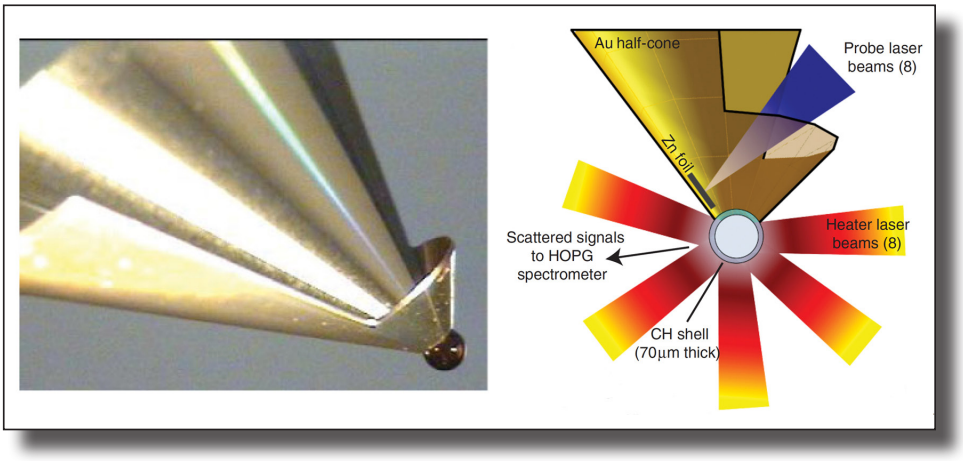


Using radiocarbon dating conducted at Lawrence Livermore's **Center for Center for Accelerator Mass Spectrometry**, researchers determined the age of ruptured and unruptured cerebral aneurysm tissue, focusing on the main structural constituent and protein—collagen type I—and finding them younger than previously thought. This overturns decades of assumptions that unruptured cerebral aneurysms—which pose a life-threatening risk if they burst—rarely undergo structural change after formation, which occurs at the branching of cerebral arteries because of weakness in the arterial wall. The young collagen type I suggests that the bulges alternate between periods of stability and periods of instability, during which they are prone to rupture. The findings **were published in**—and featured on the cover of—the journal *Stroke*. "This research may help doctors to formulate better screening and identification of those people at increased risk of an aneurysm rupture," said Livermore's **Bruce Buchholz**, who was part of the international research team. Roughly 2 to 3 percent of all people have an unruptured cerebral aneurysm, and the death rate from those that rupture is over 35 percent.

The figure shows the location of a typical aneurysm and where the samples were taken, along with a cut-away of an aneurysm wall.

FIRST MEASUREMENT OF CONTINUUM DEPRESSION IN WARM DENSE MATTER WITH XRTS

In a *Physical Review Letters* paper, LLNL researchers and collaborators **present detailed measurements of the electron densities, temperatures, and ionization states of compressed CH shells** in well-characterized compressed matter from spectrally resolved x-ray Thomson scattering (XRTS). The researchers describe both the elastic and inelastic XRTS features for the first time, providing the ionization state with high accuracy. The results accurately show a carbon charge state of 4 at pressures approaching 50 Mbar, resulting in approximately two times greater free electron density than in standard radiation-hydrodynamic modeling of the system. "These results," write the authors, "have important implications for inertial confinement fusion studies where knowledge of the electron density in shock-compressed warm dense matter affects the calculation of hydrodynamic instabilities in the design of capsule implosion experiments." Lawrence Livermore authors include Annie Kritcher and Arthur Pak The figure shows a photo (left) of a cone-in-half-shell target used in the experiment and a schematic diagram (right) of the target geometry and laser beam configuration.

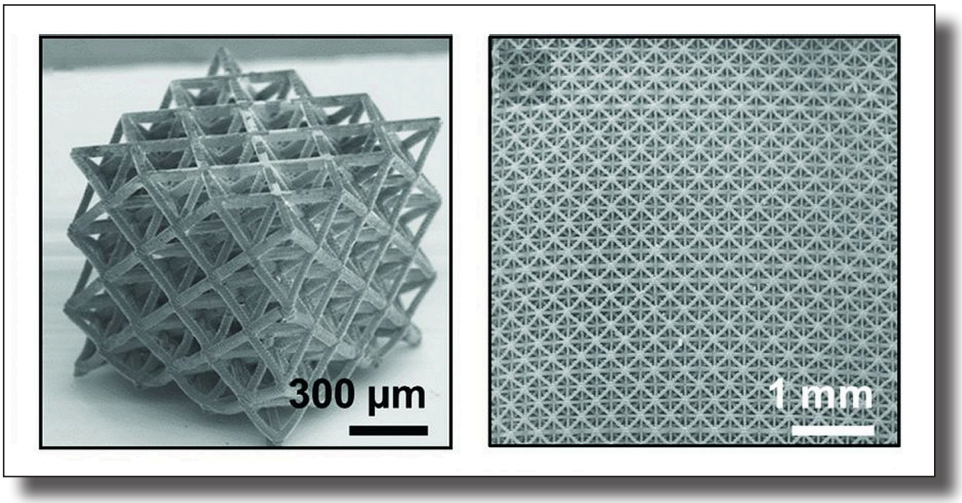


PAPER IN *SCIENCE* SHOWCASES LIVERMORE'S ADDITIVE MANUFACTURING

A team from Lawrence Livermore National Laboratory and the Massachusetts Institute of Technology (MIT) has published a paper in the high-profile journal *Science* **describing its use of additive micro-manufacturing processes** to create micro-architected metamaterials—**engineered materials** with properties not found in nature—that maintain a nearly constant stiffness per unit mass density, even at ultralow density. "These lightweight materials can withstand a load of at least 160,000 times their own weight," said LLNL engineer Xiaoyu Zheng, lead author of the *Science* article. Said Livermore's **Chris Spadaccini**, who led the Livermore–MIT team, "Our micro-architected materials have properties that are governed by their geometric layout at the microscale, as opposed to chemical composition." The basic structural approach is, at a micro-level, a lattice structure in which individual struts stretch in response to an applied load, rather than bending as in a conventional foam material. This engineering strategy has produced exceptionally stiff, strong, and lightweight materials that could someday soon be used in parts and components for aircraft, automobiles, and space vehicles, among other applications. At LLNL, additive manufacturing has long been supported by the LDRD Program (under projects such as **08-ERD-053** and **11-SI-005**). The figure shows (left) octet-truss unit cells packed into a cubic microlattice and (right) a network of such cells comprising a stretch-dominated lattice material.

NEW ENERGY RECORD SET FOR MULTILAYER-COATED MIRRORS

Focusing optics that operate in the soft gamma ray energy range can advance a range of scientific and technological applications that benefit from the large improvements in sensitivity and resolution these optical devices can provide. Multilayer-coated mirrors are an example of a technology that can help achieve this goal and in **a paper published in the online edition of *Optics Express***, LLNL postdoc **Nicolai Brejnholt** and colleagues from LLNL, the Technical University of Denmark, and the European Synchrotron Radiation Facility demonstrate, for the first time, that very short-period multilayer coatings deposited on superpolished substrates operate efficiently above 0.6 MeV; nearly a factor of 2 higher than the previous record (384 KeV) set by this same team. These results demonstrate that the Bragg scattering theory established for multilayer applications as low as 1 eV continues to work well into the gamma ray band, thus opening the door to the possibility of imaging instruments capable of mapping positron–electron annihilation. Work at LLNL was supported by the Laboratory Directed Research and Development Program under **project 13-ERD-048**, whose principal investigator, Marie-Anne Descalle, was a co-author of the *Optics Express* paper.

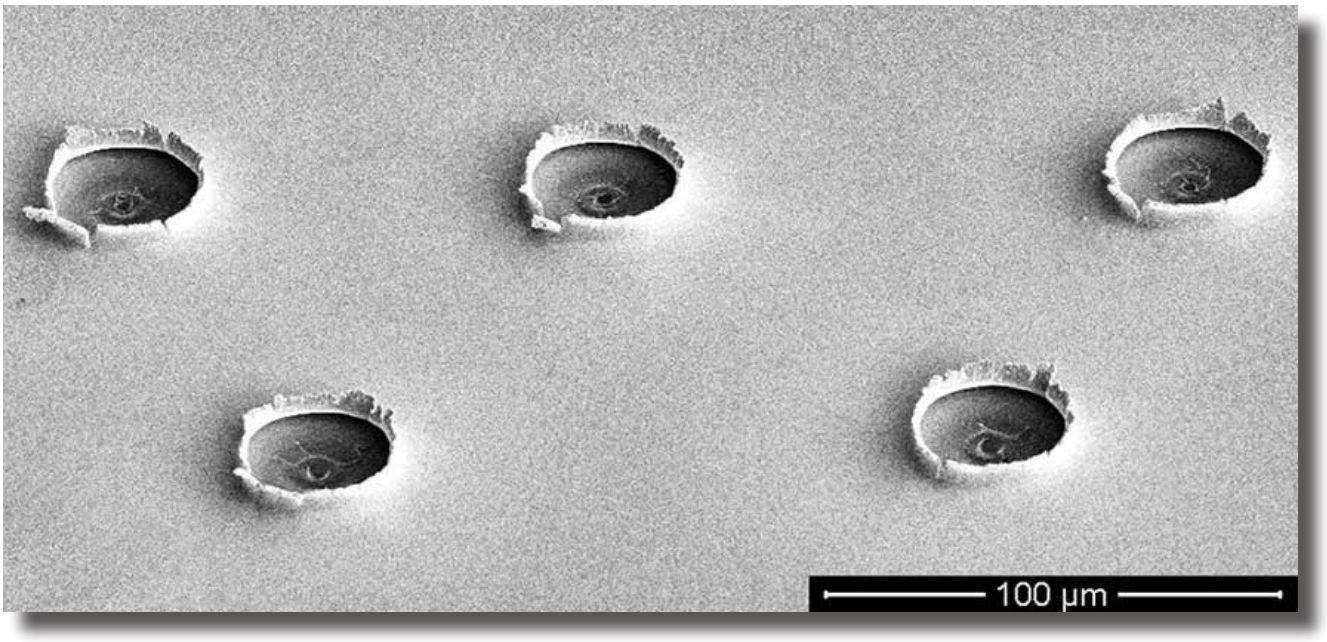


LASER EXPERIMENTS ENHANCE UNDERSTANDING OF IRON'S PHASE TRANSITIONS

In **an article published in the *Journal of Applied Physics***, using an ultrafast, tabletop-scale titanium–sapphire laser system to effect extremely rapid dynamic compression, LLNL researchers have shown that the transition of iron from the alpha to epsilon phase crystal structure can take place in less than 100 trillionths of a second after compression begins. In addition, the team reports that the corresponding deviatoric stress before the transition begins can exceed 3 GPa, while the transition stress itself is up to 25 GPa, nearly twice the value measured at low strain rates. The researchers used their results to propose a systematic variation with loading time of the normal-stress/relative-volume curve followed by iron during rapid compression. "We hope this work will substantially improve our understanding of how polymorphic phase transitions take place under dynamic compression and inspire further interesting experiments and theoretical treatments," said team member **Jonathan Crowhurst**. The figure is a scanning electron microscopy image of a sample of alpha-phase iron subjected to shots from the titanium–sapphire laser.

NEW METRICS ON SHAPE–ENERGY RELATIONSHIP IN FUEL FOR FUSION EXPERIMENTS

During an inertial confinement fusion implosion, the fuel's symmetrical shape must be maintained so that kinetic energy can be efficiently converted into compression and heating of the fuel and hotspot. A recent shape experiment campaign at the National Ignition Facility (NIF) extensively measured the time-dependent shape of implosions, providing insight into low-mode (long-wavelength) swings and their effect on energy yield. In **a *Physics of Plasmas* paper**, lead author Annie Kritcher and her LLNL colleagues demonstrate that the time-dependent shape over the entire implosion correlates with yield reduction from low-mode asymmetries. The team has developed a metric—a function of hotspot shape, fuel areal-density shape, and residual kinetic energy at peak compression—that is well correlated to yield degradation due to low-mode shape perturbations. The work showed that the areal-density shape and residual kinetic energy cannot, in general, be recovered by inducing counter-asymmetries to make the hot core emission symmetric, and that the yield degradation due to low-mode asymmetries correlates to measurements of time-dependent shape throughout the entire implosion, including early-time shock symmetry and in-flight fuel symmetry.

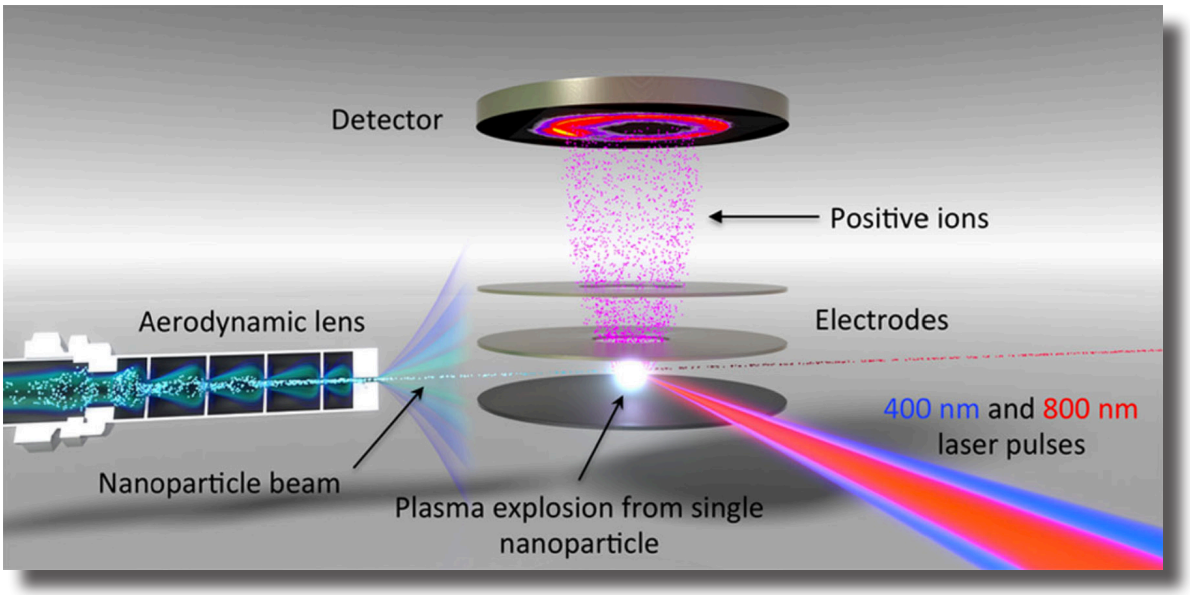


NANOPLASMA SHOCK WAVES OBSERVED FOR FIRST TIME

A team of researchers including LLNL physicists Jim Gaffney, Mark Foord, and Steve Libby has made the first-ever experimental observation of shock waves in nanoplasmas using an apparatus that can image the momentum distribution of individual, isolated 100-nm-scale plasmas. The team describes their results in **a paper published in *Physical Review Letters***. The experiment used a sequence of two laser pulses—one to vaporize an alkali chloride salt nanoparticle into a plasma, and a second to generate the shock wave. Such nanoplasmas have been generated before, but this new work marks the first time that the propagation of a shock wave through the plasma has been observed. The team also found that using a heating pulse prior to the main laser pulse increased the intensity of the shock wave, producing a strong burst of quasi-monoenergetic ions. This approach should allow the study and use of shock phenomena in dense plasmas with tabletop-scale lasers and could ultimately lead to methods for producing ion beams for biomedical uses and provide insights into other shock phenomena, such as shock waves in supernovae. Daniel Hickstein of the University of Colorado and the National Institute of Standards and Technology led the research team, which also included researchers from the U.S. Naval Research Laboratory. The figure shows the apparatus used by the researchers to image the shock waves.

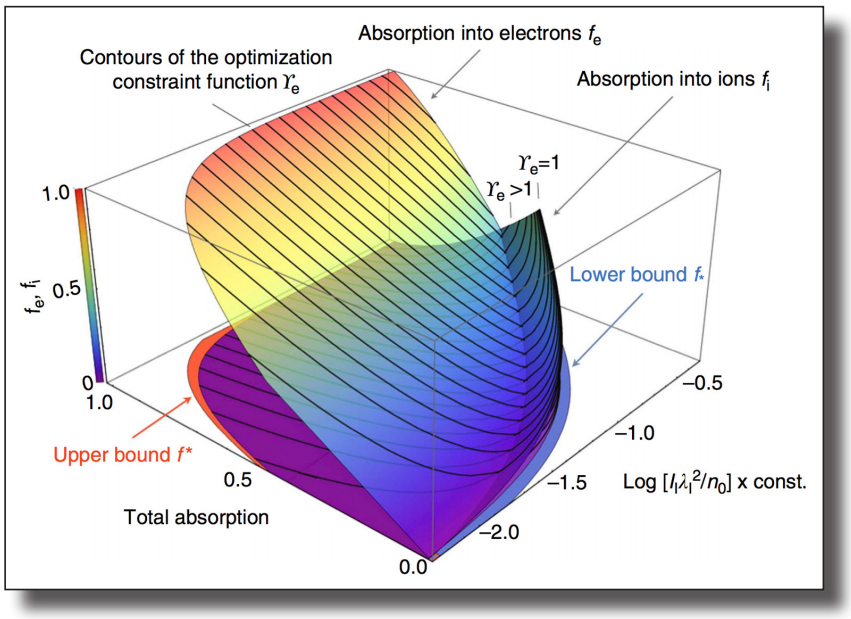
ISOTOPE ANALYSIS IN *SCIENCE* REVEALS REACTION OF ANCIENT ICE TO CHANGING CLIMATE

An international team of researchers used ancient dirt in Greenland—cryogenically frozen for millions of years under nearly two miles of ice—to unravel an important mystery surrounding climate change. Their findings, **published in *Science***, answer the question, How did big ice sheets melt and grow in response to changes in temperature? "Our study," says co-author and former LLNL scientist Dylan Rood, "demonstrates that the ice in the center of the Greenland Ice Sheet has remained stable during the climate variations over the last 2.7 million years. . . . [and] adds to a body of evidence that shows how major ice sheets reacted in the past to warming, providing insights into what they could do again in the future." Using the technology at Livermore's Center for Accelerator Mass Spectrometry (**CAMS**), the researchers analyzed the soil's content of beryllium-10, which is naturally deposited onto Earth's surface after being created in the atmosphere by cosmic rays. The amount of beryllium-10 therefore indicates how long the soil was on Earth's surface before being covered by ice. Said Dylan, "CAMS allows us to count these very rare beryllium-10 atoms, which is analogous to finding the one grain of sand that is different than the rest on a beach."



NEW MODEL BOUNDS ABSORPTION OF PETAWATT LASER LIGHT

For over two decades, the crucial problem of petawatt laser light absorption by dense matter has been intensely studied, both theoretically and experimentally, by a large international community of researchers. Interest is driven by fundamental concerns—the behavior of matter under extreme relativistic conditions—and possible practical application—such as the development of laser electron accelerators, lab astrophysics, and fusion energy. The interaction at the heart of these studies begins with the transfer of laser energy to particles through complex mechanisms. Multiple transfers of energy might follow after that, such as through positron generation. However, because the conditions of illumination are so nonlinear, the problem of initial energy transfer has defied a successful general treatment. Now, in **a paper published in *Nature Communications***, Lawrence Livermore **graduate scholar** Matthew C. Levy and his colleagues from LLNL and Rice University present a new model they have developed for intense laser interactions with dense matter. In the paper they use the model, which is analogous to the Rankine-Hugoniot relations for shockwaves, to reveal the fundamental limits on initial energy transfer. For applications needing to circumvent the absorption bounds they derive, this model will accelerate a shift from solid targets to structured and multilayer targets and lead the development of new materials. The figure represents the new model's bounds on the absorption and subpartitioning of light, showing that as a laser target absorbs more of the laser energy, the energy is predominantly coupled into relativistic electrons.



ULTRAVIOLET SPECTROSCOPY REVEALS PHOTON–ATOM INTERACTION IN STRONG FIELDS

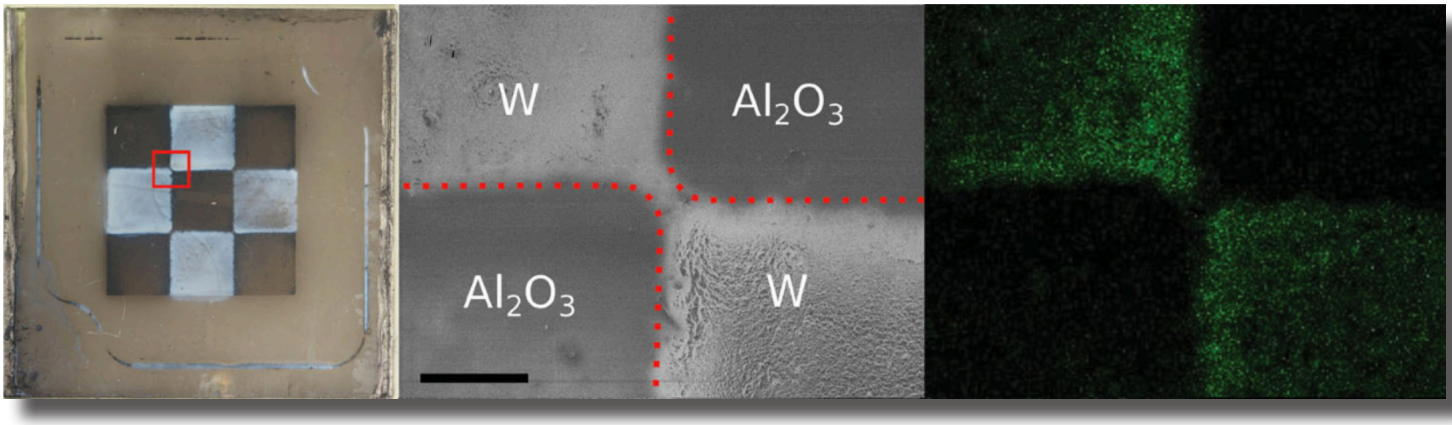
The hyperfine splitting of the atomic 1s ground state is well understood for hydrogen but remains enigmatic for the hydrogenlike ions of high-atomic-number (high-*Z*) elements. Previous attempts to measure the 1s hyperfine splitting of high-*Z* ions have produced values that cannot be easily reconciled with theory, leading to speculation about limits to the predictive power of quantum electrodynamics (QED). Combining measurements of 1s and 2s hyperfine splittings has been shown theoretically to result in a cancellation of uncertainties of various poorly constrained parameters, making an unobscured test of QED effects possible. In **a paper featured as an "Editors' Suggestion" in *Physical Review Letters***, Peter Beiersdorfer and colleagues demonstrate the possibility of using high-resolution ultraviolet spectroscopy to measure 2s hyperfine splitting with an accuracy of 0.001 eV. This is, in principle, sufficient to test the accuracy of QED calculations at a level better than a few percent—more than 20 times better than previously possible. To test their approach, the team used highly charged praseodymium-141 ions, because their energy levels are known well from first-principles calculations and are unaffected by small contributions from QED and nuclear magnetization effects. They obtained excellent agreement with theory, validating their technique and showing that in the near absence of QED and nuclear magnetization effects, theory can correctly treat the hyperfine splitting in high-*Z* atoms.

ADVANCE ENABLES 3-D PRINTING WITH FORMERLY 2-D TECHNIQUE

Electrophoretic deposition (EPD) is a long-established coating technique that can deposit various substances onto a wide range of surfaces but has been limited by its ability to deposit material only across an entire surface and not in specific, precise patterns. Now, researchers at Livermore and UC Santa Cruz have created a technique called light-directed EPD, which uses photoconductive electrodes to dynamically pattern a surface material. Described in **a paper in *Advanced Materials***, this advance allows the buildup of material in targeted areas where the light comes in contact with the photoconductor's surface. Enabling the creation of patterned, multimaterial 3-D composites over large areas with fine resolution, this could soon become a true additive manufacturing technique for creating unique composites, such cellular material with precisely crafted voids for blood vessels in manufactured organs. "This represents a large step in advancing EPD as a method of fabricating complex 3-D patterned composites," said Livermore's Andrew Pascall, lead author of the journal paper. The figure shows (left) a plane view of tungsten (W) and alumina (Al_2O_3) deposited in a pattern, (middle) a scanning electron microscopy image of the region marked with the red square, and (right) an elemental map showing the clean separation of the W and Al_2O_3.

NEUROTOXIN ACTION—AND POSSIBLE ANTIDOTES—REVEALED WITH RADIOCARBON MEASUREMENTS, SIMULATIONS

After numerous incidents of accidental and intentional human poisoning, the rodenticide tetramethylenedisulfotetramine (TETS) was banned worldwide in 1984, but it remains a concern as a chemical threat agent because of its high toxicity and ease of manufacture. The TETS molecule is known to block the action of the neurotransmitter gamma-aminobutyric acid (GABA), but the specific molecular interaction had not been directly established. Now, in **a paper published in *Proceedings of the National Academy of Sciences***, Livermore Laboratory researchers **Bruce Buchholz**, **Timothy Carpenter**, and **Felice Lightstone**, along with colleagues from UC Berkeley and UC Davis, report on using accelerator mass spectrometry—conducted at Livermore's **Center for Accelerator Mass Spectrometry**—and molecular dynamics simulations to characterize the binding of carbon-14-labeled TETS to GABA receptor sites in rat brains. The team also studied the extent to which a variety of compounds known to bind to the GABA receptor sites were able to inhibit the binding of TETS, thus providing guidance on possible antidotes for TETS poisoning. Calculations showed that TETS has an unusual binding interaction with the GABA receptor—knowledge that, together with the experimental binding measurements, should help identify potential antidote molecules that prevent TETS binding or displace it from its binding site.

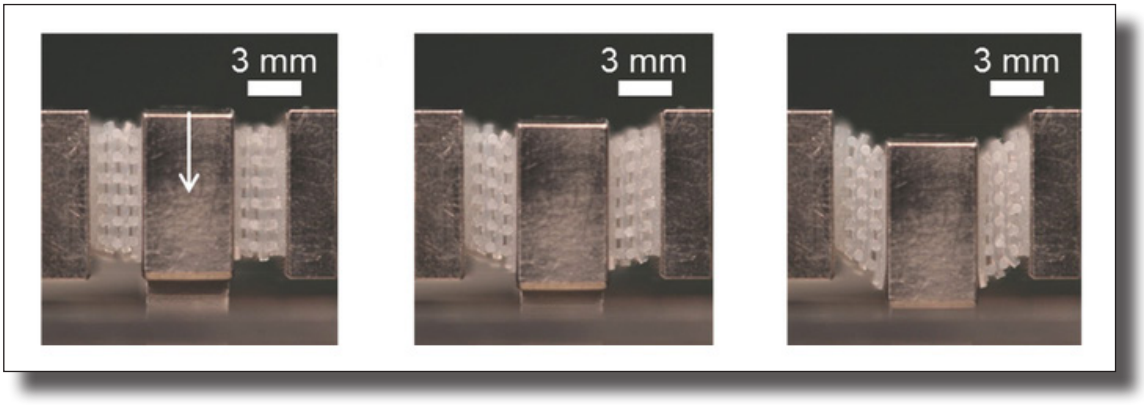


FIRST USE OF ADDITIVE MANUFACTURING TO CREATE FLEXIBLE, STRETCHABLE STRUCTURES

In **a paper published in *Advanced Functional Materials***, lead author Eric Duoss and other LLNL additive manufacturing researchers describe their results in employing direct ink writing (DIW) to create porous, elastomeric architectures with mechanical properties determined by the ordered arrangement of submillimeter struts. According to the team, this work represents the first time that 3D printing has been harnessed to pattern highly flexible, stretchable 3D periodic structures with tailored mechanical properties. The article describes two layouts patterned with direct ink writing, one resembling a "simple cubic" structure and another akin to a "face-centered tetragonal" configuration. The structures exhibit markedly distinct load response with directionally dependent behavior, including negative stiffness. These findings suggest the ability to independently tailor mechanical response in cellular solids with microarchitected design. Such ordered materials, say the authors, may one day replace random foams in mechanical-energy-absorption applications. This work continues to build on foundational efforts enabled by the Laboratory Directed Research and Development Program's **strategic initiative on additive manufacturing**. The photographs illustrate architecture-dependent shear behavior in simple cubic structures with skins assembled in the shear test apparatus with 25% precompression under 0%, 40%, and 110% shear strain (left to right).

WARM DENSE MATTER SEEN IN LASER-INDUCED DKDP CRYSTAL BREAKDOWN

New insights into the formation and evolution of warm dense matter (WDM) have been obtained by LLNL researchers and a colleague through a study of the physical processes that transform a transparent, non-absorbing material into an energy-absorbing plasma. An intermediate state between solids and dense plasmas, WDM is characterized by temperatures ranging from a few tenths to tens of electron volts at densities close to that of a solid, and is the laboratory analogue of astrophysical conditions found in the core of giant planets or induced during high-energy-density conditions such as those of inertial confinement fusion experiments. In a *Journal of Applied Physics* paper, LLNL's Michael Feit and Stavros Demos, with a collaborator from France's Center for Intense Lasers and Applications, **report on experiments and modeling of nanosecond bulk laser damage to deuterated potassium dihydrogen phosphate (DKDP) crystals**. They found that breakdown of the DKDP crystals involved physical conditions associated with the formation of warm dense matter: material at solid density in the presence of high temperatures and high-density plasma and ultrafast phase transitions. Consequently, the system developed during the study "is well adapted to the study of the transition of materials to the warm dense matter state, while avoiding the complicating influences of hydrodynamics and heat diffusion," they write. "This can enable well-controlled experiments and understanding of the material properties during the formation and evolution of warm dense matter."



NEW METHOD TO FABRICATE ULTRATHIN POLYMER FILMS

Thin polymer films are used to suspend fuel-containing capsules in hohlraums used in indirect-drive inertial confinement fusion experiments, and recent results from the National Ignition Facility suggest that the quest for fusion ignition would be aided by thinner films. Now, in **a paper published in *Langmuir***, an LLNL team describes a new method for producing freestanding ultrathin polymer films. Such films are typically fabricated using a "sacrificial" underlayer or overlayer that facilitates removal of the thin film from its deposition substrate, but in their paper, the team shows the direct delamination of extraordinarily thin, large polymer films—as thin as 8 nm and up to 13 cm in diameter—without the need for such sacrificial layers. By modifying the substrate to lower the interfacial energy that resists film–substrate separation, they can achieve the conditions for spontaneous delamination, even for very thin films. The method's robustness, persistence, and self-optimizing nature distinguish it from previously used fabrication methods and make it a potentially scalable process for the fabrication of ultrathin freestanding or transferrable films for numerous other applications, such as filtration, microelectromechanical systems, and tissue engineering. The figure shows a 55-nm-thick polyvinyl formal film mounted on a 13-cm-diameter wire hoop (left), the same film supporting a 9-g watch glass (middle), and a 30-nm-thick film supporting a 4-g plastic ball (right).

NEW, EFFICIENT WAY TO OPTIMIZE PARAMETERS FOR LASER-BASED ADDITIVE MANUFACTURING

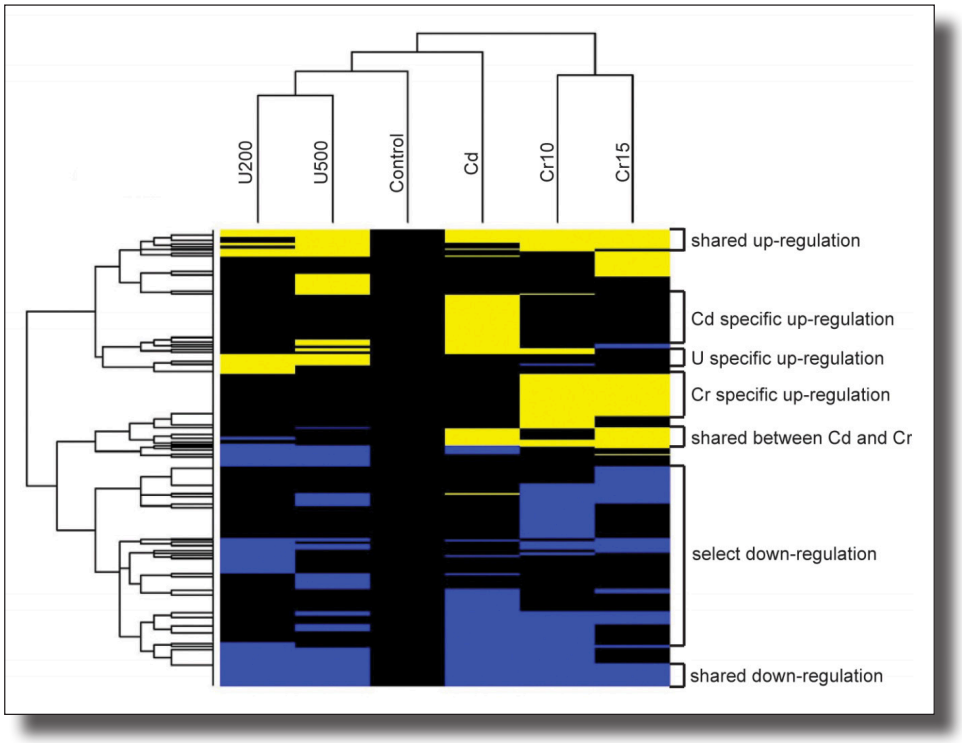
Using simulations and experiments, Lawrence Livermore researchers have developed an approach for efficiently identifying the optimal parameters for printing high-density metal parts using selective laser melting, a form of additive manufacturing in which a part is produced layer by layer using a high-energy laser beam to melt and fuse metal powder particles. In **a paper published in the *International Journal of Advanced Manufacturing Technology***, the team explains how machine parameters can be selected using simple simulations to predict the dimensions of the melt pool—the pool of liquid formed when the laser melts the metallic powder. "We mine the simulation output to identify important . . . parameters and their values such that the resulting melt pools are just deep enough to melt through the powder into the substrate below," said Chandrika Kamath, LLNL researcher and lead author of the paper. "By using the simulations to guide a small number of single-track experiments, we can quickly arrive at parameter values that will likely result in high-density parts." Chandrika and her colleagues are working under LLNL's **Accelerated Certification of Additively Manufactured Metals Initiative**, which is also **supported by the Laboratory Directed Research and Development Program**.

WHOLE-PROTEOME ANALYSIS OF URANIUM-MINERALIZING BACTERIUM

Because of its ability to mineralize uranium(VI) under aerobic conditions, the ubiquitous bacterium *Caulobacter crescentus* holds promise for use in bioremediation applications such as groundwater contamination from nuclear waste storage facilities. In **a paper in the *Journal of Proteome Research***, lead author **Mimi C. Yung**—a postdoctoral researcher at LLNL—and team examine the effect of uranium, chromate, and cadmium on protein levels in *C. crescentus* using a label-free whole-proteome analysis. The results provide insight into how *C. crescentus* is able to resist these heavy metals and what roles specific proteins play in metal detoxification, which might eventually pave the way to more-effective bioremediation strategies for heavy metals. The figure is a heat-map representation of bacterial proteins differentially expressed among five metal treatments compared to a control with no metal, with proteins identified as up-regulated shown in yellow, down-regulated in blue, and nondifferentially expressed in black. This shows that samples from the two uranium treatments and the two chromium treatments were clustered together respectively.

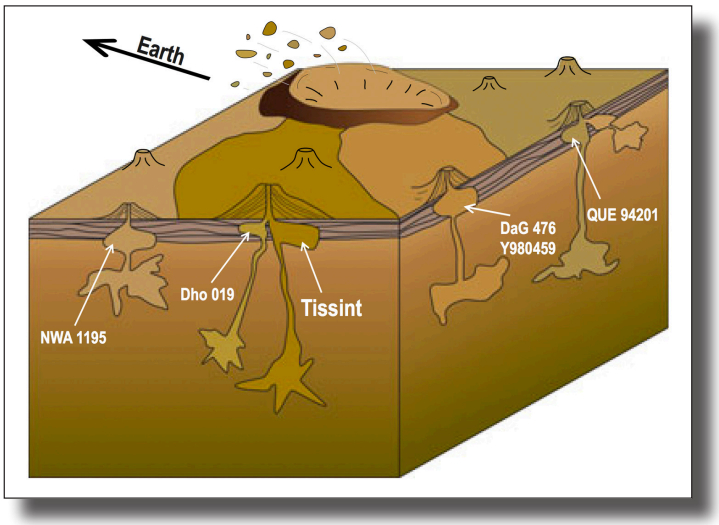
SIMULATIONS OF ACETAMINOPHEN BINDING TO METABOLIC ENZYMES

Livermore researchers Yue Yang, Sergio Wong, and Felice Lightstone **published a paper** titled "Understanding a substrate's product regioselectivity in a family of enzymes: a case study of acetaminophen binding in cytochrome P450s" in the journal *PLoS ONE*. Drug regioselectivity—the preference of one reaction site over another in a chemical reaction—is a key aspect of enzyme catalysis. The team applied large-scale two-dimensional umbrella sampling simulations to characterize acetaminophen binding in the active sites of the family of cytochrome P450 enzymes as a case study to show the different regioselectivity exhibited by a single substrate in comparative enzymes. Results successfully explain the experimentally observed regioselectivity for all five human cytochrome P450 enzymes included in the study, demonstrating that binding events play an important role in determining regioselectivity. Work at LLNL was supported by the Laboratory Directed Research and Development Program under project **12-SI-004**.



MARTIAN METEORITE'S AGE AND CRATER OF ORIGIN DETERMINED WITH ISOTOPIC ANALYSIS

In **a paper published in *Meteoritics & Planetary Science***, lead author and LLNL postdoc **Gregory Brennecka** and team describe their determination that **Tissint**—a Martian meteorite whose fall to Earth was the first in over 50 years to be witnessed—has a crystallization age of 574 ± 20 million years. They describe how isotopic information about Tissint gained using the rubidium–strontium and samarium–neodymium isotopic systems, in addition to other work on other previous samples of Martian meteorites, places significant constraints on the possible source craters for this meteorite and others like it, which provide an opportunity to study various aspects about the red planet's evolution. The authors show that this "pristine new sample from the surface of Mars" is likely derived from a source crater approximately 90 km in diameter and approximately 1 million years old. The figure is a schematic of the proposed source location of Tissint and other depleted shergottites, depicting the volcanic complex from which these samples may have originated as determined from their geochemical and chronologic characteristics.



TWO INVITED PAPERS IN JOURNAL'S SPECIAL ISSUE ON INERTIAL CONFINEMENT FUSION

A **special issue** of *Nuclear Fusion* on inertial confinement fusion included two invited papers by LLNL authors. A **paper describing laser–plasma interactions relevant to fast ignition** was written by Livermore's **Andreas Kemp**, **Frederico Fiuza**, **Prav Patel** and colleagues from the University of Madrid, Hiroshima University, the Instituto Superior Tecnico Lisbon, the University of Nevada, Reno, and UCLA. Covering recent progress toward understanding those intense laser–plasma interactions, the authors describe how increases in computational and modeling capabilities, as well as algorithmic developments, have enhanced the ability of researchers to perform multidimensional particle-in-cell simulations of the interactions at relevant scales. Different numerical modeling approaches and configurations are addressed, providing an overview of the capabilities and their limitations. Finally, the paper compares simulation results with experimental observables.

Another paper **describes ion- and proton-driven schemes for fast ignition**. Authored by LLNL researcher **Mark Foord** and colleagues from LANL, UC San Diego, Universidad Politécnica de Madrid, Technische Universität Darmstadt, and General Atomics, this paper shows that fast ignition by laser-driven ion beams is an attractive alternative that sidesteps present difficulties with laser-driven electron-beam ignition while also leveraging recent progress in generating high-power-density ion beams on existing laser facilities. Although many ion species could be used for ignition, they concentrate on technologically convenient protons or carbon ions. Based on the design studies and increased understanding of the physics of laser-driven ion acceleration, the authors provide laser and ion-generation laser–target design points employing several distinct ion-acceleration mechanisms. The authors also state that many possible paths to success are available with fast ignition based on laser-driven ion beams.

INVITED POSTDOC PAPER ON PARAMETERS AFFECTING ACCURACY OF GROUNDWATER ASSESSMENT

A special issue of *Environment Systems & Decisions* titled "The Value of Information" features **an invited paper** by LLNL postdoctoral researcher **Whitney Trainor-Guitton**. In the paper, she gives three examples of how the value of geophysical data can be estimated for groundwater sustainability problems, such as where remediation or artificial recharge needs to take place—an issue highly relevant to today's water supply questions. To estimate the value of any information, she states, one must estimate the reliability of the technique so that decision-makers can be accurately informed about uncertain parameters that will affect the outcome of their decisions. In the case of groundwater, such parameters are subsurface hydrologic properties. Whitney discusses the challenges of assessing the reliability of geophysical data to assess spatial heterogeneity and other properties in the subsurface.

2D X-RAY RADIOGRAPHY OF IMPLODING NIF CAPSULES

The first-ever 2D radiography experiments of imploding National Ignition Facility ignition-scale capsules at peak velocity were reported **in a *Physical Review Letters* paper,** by Livermore's Ryan Rygg and colleagues. The 2D radiography technique augments previous techniques that provided a partial record of the time-dependent drive symmetry but did not diagnose symmetry from the time of the final shock launch to that of stagnation. The new experimental platform provides shape information during this previously undiagnosed period of the capsule implosion and demonstrated that the shape of hotspot self-emission was sometimes misleading about the symmetry of the surrounding cold shell. These new 2D measurements revealed a previously undetected low-mode asymmetry in the in-flight capsule shell and allowed this asymmetry to be mitigated. Ryan was joined on the paper by LLNL colleagues Ogden S. Jones, John E. Field, **Maria Alejandra Barrios**, and others.

FIRST-EVER MEASUREMENT OF IONIZATION RECOILS IN LIQUID ARGON

Livermore researchers, in collaboration with colleagues at UC Berkeley and Penn State University, have made the first-ever measurement of ionization recoils in liquid argon. Their work, **published in online edition of *Physical Review Letters***, measured the ionization yield of 6.7-keV argon-40 atoms stopping in a liquid argon detector. They obtained an ionization yield of 3.6 to 6.3 (e^-/keV) for applied electric fields in the range of 240 to 2,130 V/cm—results encouraging for applications using liquid argon to search for signals from hypothetical dark matter particle interactions and from coherent elastic neutrino–nucleus scattering.

X-RAY DIFFRACTION TECHNIQUE COUNTS SINGLE PHOTONS IN NOISY ENVIRONMENTS

In a *Review of Scientific Instruments* paper, LLNL researchers and their collaborators **describe a new diagnostic designed to record x-ray diffraction** in low signal-to-noise environments, such as those encountered during laser-driven compression experiments on solid material. When driving samples to terapascal pressures such as those found in planetary interiors, traditional x-ray diffraction techniques are plagued by increased sources of background and noise, as well as a potential reduction in signal. In particular, x-ray noise from the drive plasma itself threatens to rapidly overcome any signal due to diffracted photons as higher pressures are attained. To overcome this challenge, the researchers have developed a technique known as single-photon energy-dispersive x-ray diffraction (SPEDX), which uses charge-coupled device cameras in single-photon

counting mode to directly record the x-rays scattered from a laser-compressed sample. In experiments at LLNL's Jupiter Laser Facility, the researchers demonstrated the ability to record diffraction patterns on nanosecond timescales and to subsequently separate signal from background photon by photon. The SPEDX technique mitigates many of the issues surrounding the use of high-intensity lasers to drive samples to extremes of pressure, allowing for structural information to be obtained in a regime that is currently largely unexplored.

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