LDRD Quarterly Highlights

Mission Agility · Technical Vitality · Workforce Development

FY23 Q4

FEATURED HIGHLIGHTS FOR Q4

Lawrence Livermore National Laboratory

Standing in LLNL's Center for Micro Nano Technology, Nathan Ray holds a marvel of optical engineering, a 5- centimeter metasurface optic with deep, closely spaced surface features that allow for a wide optical bandwidth and a large span of incidence angles for an antireflection layer. (Photo by Jason Laurea/LLNL.)

Advanced masking technology enables applications for metasurfacing optics

Optics researchers at Lawrence Livermore National Laboratory (LLNL) have refined their novel metasurface process to create taller features without increasing feature-to-feature spacing, an advance that unlocks exciting new design possibilities.

"We have refined our process to create metasurfaces that allow for a wide optical bandwidth and a large span of incidence angles for an antireflection layer," said LLNL research scientist Eyal Feigenbaum, the principal investigator. "We can now cover bandwidth range all the way from the ultraviolet to wavelengths larger than

2 microns, which is extraordinary. That wasn't possible with the existing technology."

The result is reported in a new paper, "All-Glass Metasurfaces for Ultra-Broadband and Large Acceptance Angle Antireflectivity: from Ultraviolet to Mid-Infrared." It will be the cover story for the December 2023 issue of *Advanced Optical Materials*. Read more…

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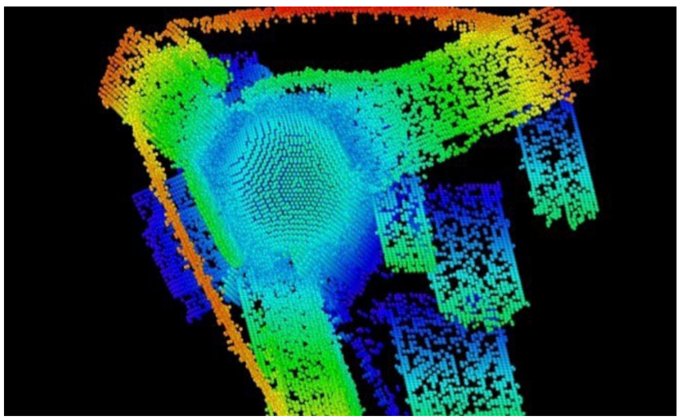

When a diamond undergoes plastic deformation, atomic bonds break and re-form along imperfections called dislocations. Taken from a molecular dynamics simulation, this rendering represents a shocked diamond as a pore collapses under pressure. Each dot represents a defective atom within the diamond's crystalline structure, while the different colors indicate the longitudinal position of the dislocations. (Photo courtesy of LLNL.)

Understanding the plasticity of diamond for improved fusion ignition

Alex Li, a Lawrence Livermore National Laboratory (LLNL) summer student in the Computational Chemistry and Materials Science Summer Institute, recently led a study published in the journal *Matter* to investigate the evolution of plasticity in diamond along different loading orientations and the effects that voids (pores) within the material can have on stresses within the diamond. This team's research was supported by LLNL's Laboratory Directed Research and Development program.

While diamond carbon is one of nature's strongest naturally occurring materials, it is known to undergo irreversible plastic deformation when loaded at high rates. Rob Rudd, LLNL scientist and Li's mentor, notes, "We usually think of diamond as brittle, strong and unyielding until it cleaves. Shocked diamond is different. Alex did a fantastic job working out the complex and unexpected details of the deformation."

The nature of this deformation is important for high-energy-density experiments on high- energy laser systems such as the National Ignition Facility (NIF), as well as for further evolving scientific understanding of carbon-rich exoplanets. At NIF, diamond carbon is used as an ablator and capsule material for producing the extremely high pressures needed to cause nuclear fusion reactions that are being intensively investigated as a source of energy.

In many shock-compression experiments, diamond has shown little to no plastic behavior until reaching extreme pressure and temperature conditions. Because diamond exhibits strong anisotropic behavior — that is, has different properties in different locations, depending on the direction of applied stress — it can be difficult to anticipate how diamond will react under such extremes. Defects present within the diamond capsules that hold the fusion fuel can cause imperfect compression, resulting in a failure to ignite. Read more…

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Sandia National Laboratories

More than a thousand experimental lasers and amplifiers adorn a three-inch, gold-electroplated silicon wafer made at Sandia's Microsystems Engineering, Science and Applications complex. (Photo by Craig Fritz.)

Integrating microscale optical devices on silicon microchips

Sandia has been awarded a patent for its new method of integrating many different materials onto silicon — the same starting material semiconductor fabrication plants use to make microchips. This method enables Sandia to build high-bandwidth, high-speed optical devices, including indium phosphide lasers, lithium niobate modulators, germanium detectors and low-loss acousto-optic isolators — all critical components for high-power optical systems. Building a laser on silicon is a challenging and unusual feat that could extend America's leadership in semiconductor technology. Read more...

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Sandia bioengineer Susan Rempe, left, and chemical engineer Tuan Ho peer through an artistic representation of the chemical structure of a kind of clay. Their team is studying how clay could be used to capture carbon dioxide. (Photo by Craig Fritz.)

Scientists study clay for snatching carbon dioxide from air

Carbon capture and sequestration is the process of capturing excess carbon dioxide from the Earth's atmosphere and storing it deep underground with the aim of reducing the impacts of climate change, such as more frequent severe storms, rising sea levels and increased droughts and wildfires. This carbon dioxide could be captured from fossil-fuel-burning power plants, or other industrial facilities such as cement kilns, or directly from the air, which is more technologically challenging. Carbon capture and sequestration is widely considered one of the least controversial technologies being considered for climate intervention. Read more...

- **Technical Vitality**

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The 2023 experiment robots and UAS.

NNSS interns facilitate SDRD's return to UAS experimentation

Thanks to the Minority Serving institution Partnership Program-Nuclear Security Science and Technology Consortium (MSIPP-NSSTC), Nevada National Security Sites' (NNSS') Site-Directed Research and Development (SDRD) program is resuming unmanned aircraft system (UAS) experimentation. Read more…

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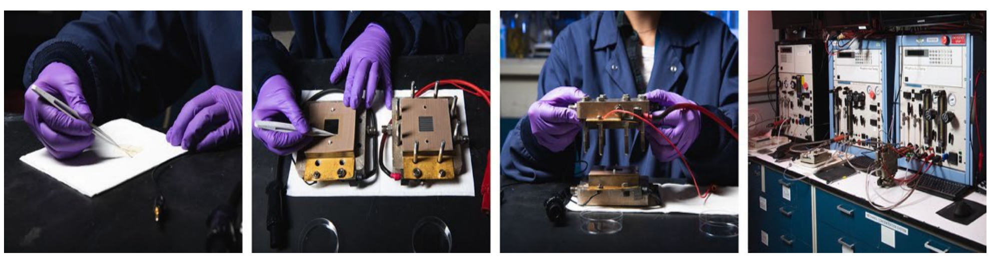
Los Alamos NATIONAL LABORATORY



An experimental fuel cell is assembled sandwich style: (left) the membrane material is transparent and fragile and goes in the middle of the sandwich with the anode beneath and the cathode on top. (Left center) The cathode material is placed on top of the membrane, then (right center) the cathode flow field is placed on top of the cathode and the whole sandwich is bolted tightly together. (Right) The assembled fuel cell is hooked up to a test rig that will measure power output and fuel efficiency. (Photo courtesy of LANL)

Hydrogen on the horizon

For the past nine years, Los Alamos researcher Yu Seung Kim has been developing hydrogen fuel cells that are powerful enough, efficient enough, and durable enough to support the heavy-duty vehicle sector. With semi-trucks emitting more than 80 percent of the greenhouse gases currently released into the atmosphere by diesel engines, Dr. Kim's work could play a large role in helping the United States reach the goal of zero net emissions by 2050. Read more…

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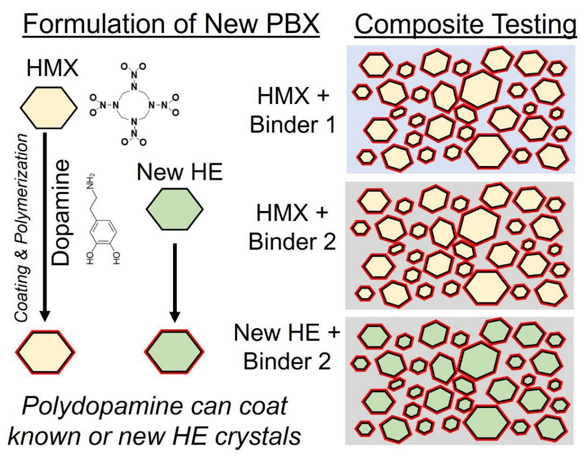

Many thermal and mechanical properties of plastic-bonded explosives are affected or even dominated by the structure and properties of the crystal-polymer interface. Using polydopamine or other adhesion promoters will allow for both tailoring the properties of the formulated composites and enabling new formulations to be manufactured. (HMX: high melting explosive, HE: high explosive.) (Image courtesy of LANL.)

Biologically inspired reinforcement using polydopamine of polymer bound composites

The development of qualified explosive material is both time consuming and expensive. Researcher Matthew Herman is working on a project to rapidly develop new explosives through the use of an interfacial strengthening agent that will reduce the number of experiments needed to predict material behavior, saving both time and money. Recent tests have shown success with a polydopamine coating that is much more resistant to cracking and damage, thereby improving the overall material properties. Read more…

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AMAZING LDRD HIGHLIGHTS

CRYSTAL STRUCTURE USEFUL IN PREDICTING MATERIALS PROPERTIES AT LLNL: New research shows successful ab initio crystal structure prediction of energetic materials > **Mission Agility, Technical Vitality**

PLATFORM TESTS COLORECTAL CANCER THERAPIES IN VITRO: Platform capable of studying CRCLM PDO response to various chemotherapeutic gradients > Mission Agility, Technical Vitality

STERILE NEUTRINO RESEARCH RAMPS UP: LLNL scientists study sterile neutrinos to discover and better understand dark matter > Mission Agility, Technical Vitality

BEYOND THE LIMITS OF HUMAN, SENSOR SIGHT: Sandia-developed software system finds, tracks moving objects as small as a pixel > Mission Agility, Technical Vitality

NEW PLATFORM FOR RADIATION EFFECT STUDIES: Rethinking radiation effects in materials science using the plasma-focused ion beam > Mission Agility, Technical Vitality

INVESTIGATING EXTRACTION USING A CLEAR PROCESS: Exploring how exposure to radiolysis and harsh chemical reagents impact americium-241 extraction chromatography
> Mission Agility, Technical Vitality

This newsletter, published quarterly, features LDRD and SDRD work done by Lawrence Livermore, Los Alamos, Nevada National Security Site and Sandia. To see a PDF with all articles referenced in this newsletter or review past issues, visit NNSA-LDRD.lanl.gov and click on the Quarterly Highlights tab. IM Release #: LLNL-AR-855154.

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