MST e NEWS

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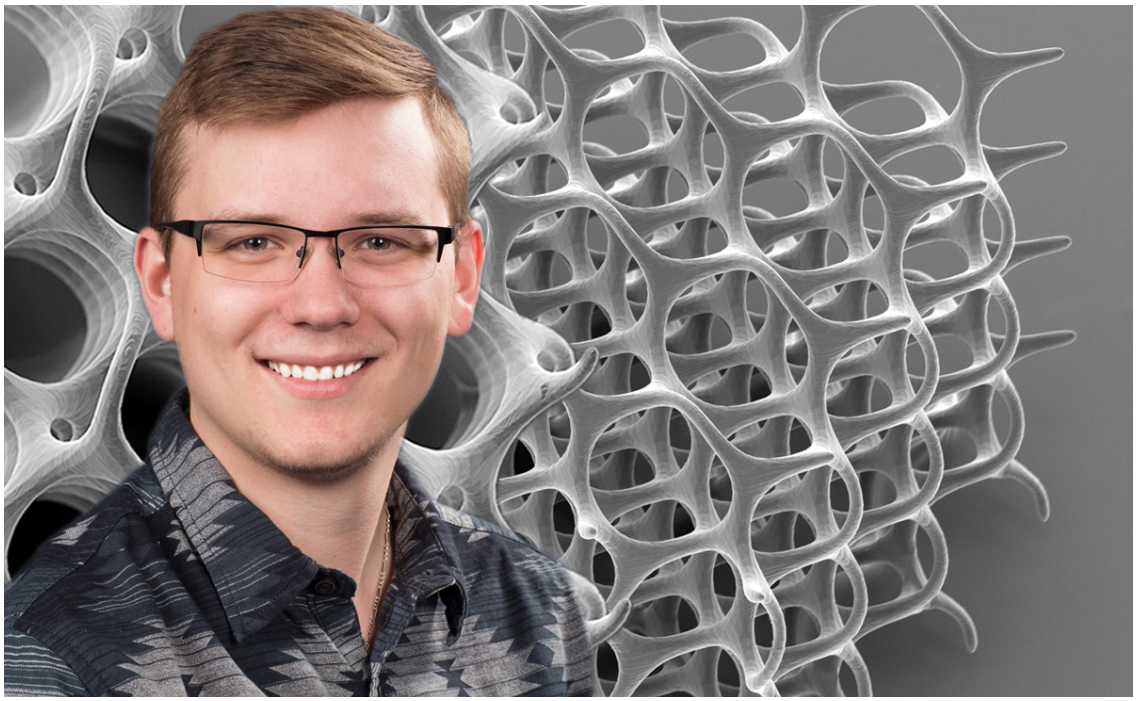
Los Alamos NATIONAL LABORATORY EST. 1943



Matt Herman used two-photon lithography to make a micro gyroid structure (background) for use in studies aimed at understanding how materials respond when subjected to extreme compression.

Matthew Herman

Investigating the material world

By H. Kris Fronzak, ADEPS Communications

Growing up, Matthew Herman explored new worlds through books. He had enrolled at Western Washington University, intent on studying literature and becoming a writer, when a professor suggested he visit the school's engineering department. Herman soon determined that science has, at its core, the same purpose that motivated him to write–problem-solving. He now makes discoveries as an R&D technologist in Engineered Materials (MST-7), applying his affinity for creating and problem-solving to materials with clear, concrete applications, such as additively manufactured microlattice structures and a particle accelerator the size of a shoebox.

> *"We're working with young and exciting technology, applying it to our own needs and starting to understand mechanical responses."*

"We're working with young and exciting technology, applying it to our own needs and starting to understand mechanical responses," Herman said. "Someday we could push the science to the point that Los Alamos would have another tool in its arsenal for designing inertial confinement fusion targets." Such targets are an essential device in the quest for achiev-

continued on page 3

From Jon's desk . . .

> *An important aspect of the initiative is that everyone, regardless of job series, will be given the opportunity to have a mentor.*

In previous editions of "From the desk," both Dave and I have relayed that MST has hired and will continue to hire a large number of individuals due to projected attrition rates and programmatic growth. Our five-year hiring plan, which was initiated in FY17, projected that we would need to hire 87 individuals. Over half of those hires will be performed by the end of this fiscal year. Bringing in this many individuals in a short period presents us with many challenges across the recruiting-hiring-onboarding-training-mentoring-career development process. To address some of these challenges, MST has launched an MST Workforce Development Initiative that includes expectations for managers, team leaders, mentors, and workers to craft career development plans and identify mentor opportunities. The MST Workforce Development Expectations document can be found on the MST Division Resources web page. An important aspect of the initiative is that everyone, regardless of job series, will be given the opportunity to have a mentor. Our expectation to have a mentor will be an "opt-out" expectation. This means that you will have to indicate that you do not wish to have a mentor (students and postdocs are excluded from opting out), otherwise we will do our best to place you with an appropriate mentor. Please stop by my office and share your ideas if you have thoughts or concerns about MST's Workforce Development Initiative.

To prepare for the large number of hires and ensure that we are in position to deliver on current and future mission requirements, MST has initiated several revitalization projects many of which you may already be aware. In the Material Science Complex (MSC), we are refurbishing a large portion of the laboratory and office spaces. The general thought process is to create easily "reconfigurable" laboratory and office spaces with the expectation that this will make us more agile when addressing new mission requirements. In addition, Sigma and MST are in the process of creating a Solidification Laboratory in building 2002 of the MSC. This new capability will provide opportunities for programmatic growth in small-scale casting, solidification science, and advanced manufacturing techniques in an unclassified environment. It is anticipated that new hires from MST and Sigma will use this facility for relevant work while waiting on clearance processing. MST is also planning on refurbishing Trident by creating a Demonstration Scale Nuclear Fuel Prototype Fabrication facility in an effort to strengthen the nuclear fuels capability within MST Division. The design and Class V estimate are complete for the Trident facility upgrade and we are anticipating the funding necessary to proceed with the project. As part of the desire to strengthen the nuclear fuels capability, the Ceramic Nuclear Fuels team in MST-7 will be moving into MST-8. The expectation is that this reorganization will enable better integration of the team members with core nuclear energy program and scientists located in MST-8 and enable more effective management of the capability for MST Division.

Lastly, I would like to thank all of those that are currently engaged in supporting the Materials for the Future Institutional STE Capability Review that is set to take place April 8-11. The review is taking place earlier than in previous years and includes all of the areas of leadership in the Materials for the Future strategy, with the consequence of having significantly shortened deadlines. I really appreciate your willingness to integrate the shortened deadlines with your busy schedules. Again, thank you!

MST Deputy Division Leader Jon Bridgewater

Herman cont.

ing nuclear fusion—or replicating the power of the sun—in a laboratory environment.

Herman was recruited to Los Alamos National Laboratory through a collaborative program with the University of Oregon, where he received his master's degree in polymers and coatings chemistry. As a post-graduate research assistant, he worked with MST-7 scientists to create a correlation spectroscopy technique that reveals the chemical changes that occur in thin polymers during irradiation. He became a Lab staff member in 2017.

To cap off his opening year as Laboratory staff, Herman was the first author in a peer-reviewed article published in *Fusion Science and Technology* (please see page 9 for more detail). The work stems from Laboratory research proving that various microlattices, including those contained inside inertial confinement fusion (ICF) fuel capsules, can be produced at sub-micrometer resolution using two-photon polymerization. This proof of concept means engineers could eventually control target design to additively manufacture targets for ICF experiments.

Herman's position as a technologist calls for the best of his dual education in engineering and chemistry and his skill in determining how best to conduct experiments. He splits his time between MST-7's material science lab and a two-photon lab where researchers fabricate microlattices and study factors that determine how plastics age in weapons-relevant environments. He frequently collaborates with MST-7 modelers to define how each ligament in a material's lattice affects the holistic strength. He describes parts of the job as "trial by fire," as he's often calibrating new technology and commercial systems to fit the group's ultra-specific studies.

Herman is part of a team working on a Laboratory Directed Research and Development (LDRD) project to develop a particle accelerator the size of a shoebox by advanced manufacturing a photonic crystal that functions as a laser-driven accelerator. He is developing resins with specific properties that allow them to withstand the accelerator's operating environment and retain the extremely high resolution of the two-photon manufacturing process, which is required to make parts as complex and as small as the dielectric laser accelerator photonic crystal. If the researchers succeed, the resulting portable device could be used in various national security applications, including war-fighting support, and as a compact medical therapy machine or light source.

"Because of his background, Matt knows the fundamental physics and chemistry of polymers themselves. He can take a novel material with unique properties and use it to actually build structures that this accelerator may need to function," said Robert Gilbertson (MST-7), co-principal investigator for the compact accelerator LDRD project. "There's a strong need for materials engineers across the Lab, and Matt's sharp, very easy to work with, and has a unique skill set. He has a great future ahead of him."

Matt Herman's favorite experiment

What: Performed in situ x-ray tomographic imaging of samples manufactured by two-photon polymerization during compressive loading.

Why: To improve the understanding of how materials deform and fracture during loading in real time.

When: 2017

Where: Argonne National Laboratory's Advanced Photon Source

Who: Matthew Herman, Principal Investigator Brian Patterson, Trevor Shear, Kevin Henderson (Los Alamos National Laboratory); Jason Williams, Nikhilesh Chawla (Arizona State University); Xianghui Xiao, Kamel Fezzaa, and Sun Tao (Argonne National Laboratory)

How: A load cell was constructed that could rotate in order to collect tomographic images during material compression. This allows for the collection of x-ray radiograph data that was reconstructed into three-dimensional renderings of the sample as it is deformed.

The "a-ha" moment: 4,200 radiographs were collected per second during compressive loading of the sample. This allows for the reconstruction of seven full three-dimensional images in that one second that show compressive bending and breaking of the sample's structure. This massive amount of data collected in such a small amount of time allows us to study material three-dimensional mechanical deformation at higher strain rates.

Carlos Tomé receives Postdoctoral Distinguished Mentor Award

Carlos Tomé (Materials Science in Radiation and Dynamics Extremes, MST-8) is a recipient of a Laboratory 2017 Postdoctoral Distinguished Mentor Award. The annual awards recognize the contributions a mentor makes during a postdoctoral researcher's appointment and are presented to those who demonstrate a level of mentoring substantially beyond expectations. Tomé was nominated by previous postdoctoral fellow Arul Kumar Mariyappan and postdoctoral research associates Wei Wen and Hareesh Tummala (all MST-8).

Tomé was recommended for his 20 years of outstanding mentorship, during which he has been dedicated to improving his postdocs' careers by motivating them to become successful and independent researchers. Of the 19 postdocs he previously mentored, 11 are professors in academia, 3 are staff scientists at the Lab, and 3 are research scientists at other research laboratories. According to his nominators, Tomé "is known to accommodate, inspire, and train culturally diverse postdocs. His office doors are always open not only for scientific discussions but also for career developments." He provides his postdocs with the chance to participate in international conferences and supports their future academic and research activity through recommendations and collaborations.

Tomé is known as one of the world's leading experts in the micromechanics of polycrystalline metals. He has a publication record of more than 17,000 citations and is the recipient of the 2016 Cyril Stanley Smith Award from the Minerals, Metals, and Materials Society (TMS) board of directors and the 2016 Khan International Medal of Plasticity. Symposiums have been held in his honor during the 2017 International Plasticity Conference and at the 2011 TMS annual meeting. Material scientists and engineers in academia, national laboratories, and industry use his theories, models, and numerical codes. A Los Alamos Fellow, Tomé has been the principal investigator of a DOE Basic Energy Sciences program on hexagonal materials since 2003.

Other award recipients were Michael Chertkov (Physics of Condensed Matter and Complex Systems, T-4), Andy Sutton (Inorganic, Isotope and Actinide Chemistry, C-IIAC), Jim Ten Cate (Geophysics, EES-17), and Steve Yarbro (National Security Education Center, NSEC). Daniel Livescu (Computational Physics, CCS-2) received the Frank Harlow Distinguished Mentor Award.

Technical contact: Carlos Tomé

Residual stress determination of additively manufactured Ti-6Al-4V 'bridge-shaped' components

Additive manufacturing (AM) of metals brings new possibilities to the production of low-cost industrial applications. One of the main AM processes for the production of metals is the selective laser melting (SLM) process. SLM is based on powder bed fusion technology and uses a high power-density laser to selectively melt and fuse the metallic particles together. During fabrication, the rapid solidification and large thermal gradient cause the formation of unwanted and, in some cases, detrimental residual stresses. For example, high tensile residual stresses at a surface can cause crack initiation and consequent failure of the structure (see Figure 1). Up to now, there has been a limited understanding of the process-structure-property-performance relationship of the AM components. This limitation has a critical impact on the usage of the AM metallic components, while it restrains the unique ability of process models to predict the final behavior of the AM structures.

Lawrence Livermore National Laboratory (LLNL) has developed Diablo, a predictive computational code for residual stresses in AM structures. In an effort to provide valuable experimental validation data for Diablo, a Los Alamos team (Maria Strantza, Bjorn Clausen, and Don Brown, Materials Science in Radiation and Dynamic Extremes, MST-8) performed a residual stress investigation on AM metallic components in collaboration with researchers from the National Institute of Standards and Technology (NIST). In this work, Ti-6Al-4V bridge-shaped specimens were built via SLM using four different scan strategies: continuous scan aligned with x-axis, continuous scan at 45 degrees to x-axis, island scan aligned with x-axis, and island scan at

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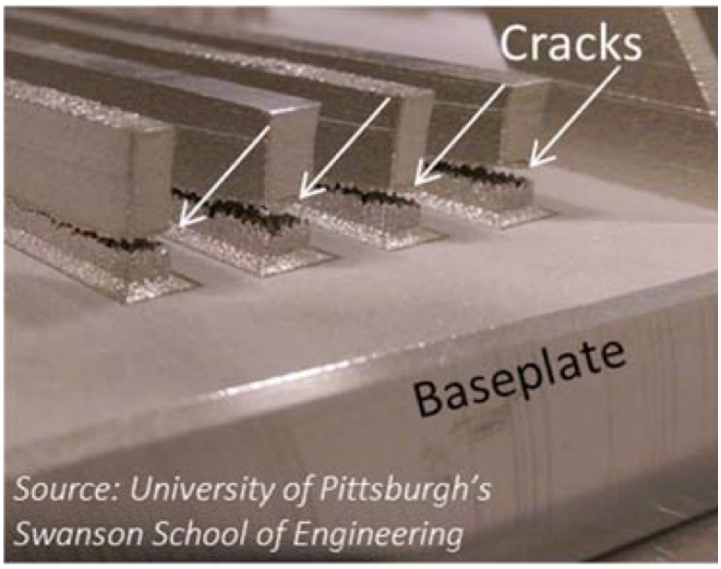

Figure 1: Tensile residual stresses at the external sides of metallic additively manufactured samples compromised the structural integrity of the samples.

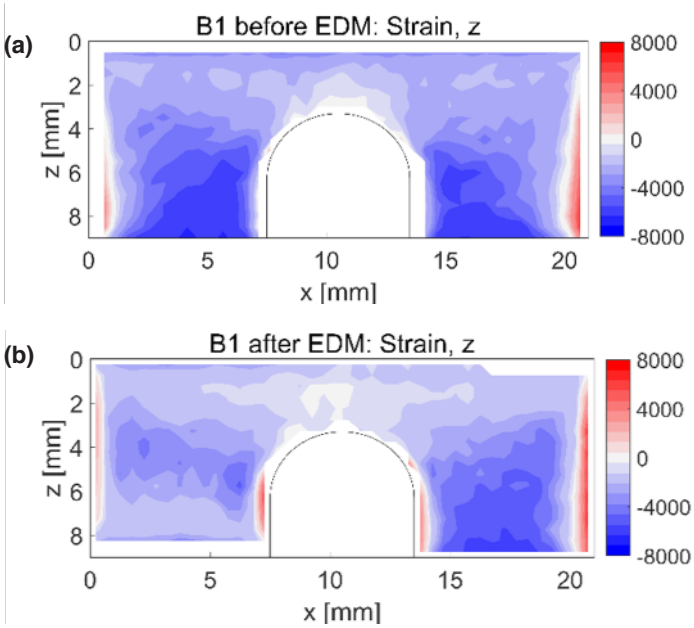

Figure 2: Contour plots of the calculated strain (×10^6) in z direction, which corresponds to the building direction of the additively manufactured Ti-6Al-4V sample. In (a) the sample is still attached on the baseplate and in (b) the left leg of the "bridge" is detached from the baseplate.

Residual cont.

45 degrees to x-axis. A 90-degree rotation in scan orientation was performed after each layer for all four cases. Energy dispersive diffraction measurements (white beam: 35-150 keV) were performed on all four SLM Ti-6Al-4V components at the A2 instrument of the Cornell High Energy Synchrotron Source (CHESS). X-ray diffraction was used to accurately measure lattice parameter and then determine the elastic strains present in these bridges while still attached to the base plate and after one leg had been cut off the base plate. Figure 2 shows the strain on a cross section of one of the bridge-shaped samples before and after cutting of one of the two legs. Relaxation in the cut leg is apparent. In contrast to expectations, the diffraction results showed higher strains present in the bridges built via the island scan strategies, particularly near the edges of the parts. The thermomechanical simulations of these bridge builds exhibited good qualitative agreement with the experimental results. However, the effects of varying scan strategy were not captured with the current modeling technique.

High-energy x-ray light sources such as CHESS provide a novel method to probe the mesoscale, the "middle" scale where imperfections, defects, and "heterogeneities" are critical to controlling a material's macroscopic behaviors and properties. The experiment is an example of science that could be furthered with MaRIE, Los Alamos's proposed Matter-Radiation Interactions in Extremes capability for in situ time-dependent materials science at the mesoscale. MaRIE would allow researchers to observe in real time how the residual stresses develop as the part is built, thus yielding information that could be used to enable design of processes to achieve tailored mechanical properties.

This research is being performed by a Los Alamos team from MST-8 (Brown, Clausen, and Strantza), collaborators from NIST (Lyle Levine and Thien Phan), and collaborators from LLNL (Wayne King, Neil Hodge, and Rishi Ganeriwala). The work was funded by C1 and the Gas Bottle Qualification program and benefited from the use of the A2 beamline at CHESS. The work supports the Lab's Stockpile Stewardship mission area and Materials for the Future science pillar.

Technical contact: Maria Strantza

In situ diffraction measurements of mesoscale features at unprecedented time scales during metal additive manufacturing

Additive manufacturing (AM) is an innovative fabrication and repair technology that can build metallic components in a layer-by-layer manner. Currently, there is a limited understanding of the process-structure-property-performance relationship of metal AM materials, which severely limits the ability of process models to predict the final behavior of the components. This is the prime obstacle to widespread adoption of metal AM components in property-critical applications. Insight into the dynamics of AM processing through in situ measurements is imperative for providing the mesoscale information required to develop physics-based predictive models for properties and performance. With these developed relationships in hand, AM can begin to support Los Alamos's Stockpile Stewardship mission through providing materials with controlled functionality and predictable performance.

The unique capability of the Advanced Photon Source (APS) at Argonne National Laboratory provides the required photon flux and state-of-the-art detector technology to enable in situ AM measurements. Recently, a team of Los Alamos researchers with Lawrence Livermore collaborators performed in situ experiments at APS to capture microstructure evolution information during metallic wire-feed AM process. They successfully obtained phase evolution information during the solidification of Ti-6Al-4V (Ti64) and 304L stainless steel (SS). In the work, metallic wires of SS and Ti64 were deposited onto a base material of SS and Ti64, respectively, using the relatively new cold metal transfer process in an additive configuration. High-energy x-rays (E=71 keV) were used to continuously record diffraction data at 200 Hz with a spot size of 50 µm to capture rapid solidification and microstructure evolution in highly localized areas of the bulk material during the AM process. Capturing data at every 0.005 seconds provided the high temporal resolution at the appropriate length scale (microns) to validate and inform microstructural models and to support LANL's mesoscale

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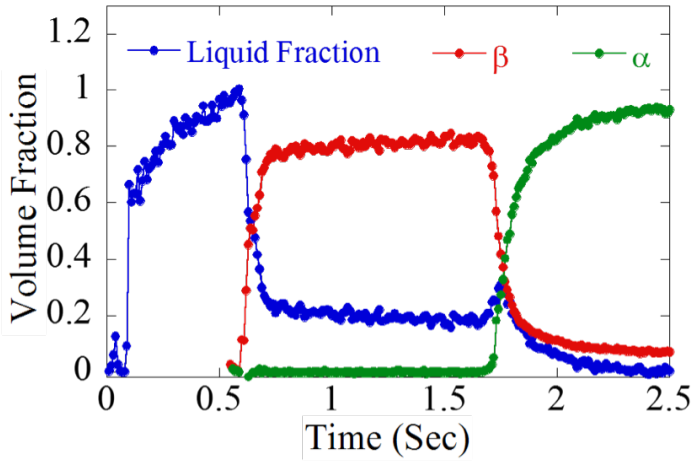
In situ diffraction cont.

strategy. In addition to the high-energy x-rays, high-speed optical images were recorded at frame rates between 2 kHz and 12.5 kHz to complement the diffraction information acquired during the deposition and solidification process.

Two types of experiments were performed while collecting diffraction data and optical imaging data. In the first case, molten beads were deposited in a stationary setup to investigate solidification during additive repair of small surface defects. In the second case, the material was deposited in a linear fashion while collecting data at positions throughout. This experiment simulated AM as a fabrication technology and enabled the researchers to capture the dynamics of the system in the time-critical process of solidification. Coupled diffraction and optical imaging provided both process diagnostic and microstructure evolution information during deposition of material. The figure shows the phase fraction evolution as a function of time for the Ti64 of the first experimental case (repair of small surface defects). The results indicate that beta phase forms first in Ti64 while at the end of the solidification (2-2.5 sec after the deposition) Ti64 mainly consists of alpha phase. Although the transformation was expected, the rate at which the transformation occurred provided the new, needed information to validate models that predicted microstructure based on process parameters. From a performance perspective, the amount and position of the beta phase has a significant impact on the strength and ductility of the overall component, making predictive capability in this area a priority. Developing these predictive capabilities is consistent with the Materials for the Future science pillar goals.

Although the results of these experiments provide information specific to the two alloys, the long-term impact of this project is largely centered on the methodology of using cutting-edge beamline science to capture mesoscale science at temporal and length scales unreachable in the past. Volume fractions of liquid and solid, including different phases that formed during the solidification process, were captured every 0.005 seconds. Limitations in detector and photon flux did not permit measurements of other microstructural parameters, such as texture and elastic strain, without compromising the temporal resolution. Being able to capture phase evolution as well as texture and elastic strain with high temporal resolution would further improve the models that link processing to microstructure. In order to achieve this, however, future facilities like MaRIE coupled with improvements in detector technology are necessary. As AM continues to grow, developing the platforms (MaRIE, APS-U) and tools for in situ experiments that can capture the full range of mesoscale data (phase, texture, strain) during solidification in materials that undergo the rapid cooling rates of AM (10^3 and 10^6 K/s) will be important for the ability to insert components into property critical applications.

This research is being performed by a team from Materials Science in Radiation and Dynamics Extremes (MST-8) (Don



Phase evolution in point deposited Ti64 as a function of time. Note that the alloy initially solidifies as beta before transformation to the alpha phase. Through the use of APS, researchers obtained high time resolution data that shows the rate and time of these phase transformation. This mesoscale information forms the critical data for linking process to microstructure in AM. With this linkage in hand, a future can be envisioned where the amount and locality of the beta phase can be controlled in order to tailor the properties of AM Ti64 and impact the Materials for the Future science pillar.

Brown, Maria Strantza, Reeju Pokharel and Adrian Losko), Sigma Division (Sigma-DO) (John Carpenter [principal investigator] and Jason Cooley), and Materials Synthesis and Integrated Devices (MPA-11) (Erik Watkins), and collaborators from Lawrence Livermore National Laboratory (Ibo Matthews and Nick Calta). The work was funded by a Laboratory Directed Research and Development Exploratory Research Momentum award and benefited from the use of the APS at Argonne National Laboratory, which is funded by the DOE's Office of Basic Energy Sciences.

Technical contact: John Carpenter

Toward a molybdenum-based fuel cladding

Spurred in part by the 2011 Fukushima disaster, efforts to develop enhanced accident-tolerant materials for the nuclear energy industry were funded by the U.S. Department of Energy Fuel Cycle Research & Development Program. Specific priority was placed on the search for durable fuel and cladding materials, the latter being regarded as the most important component for both safety and energy production. Of the various materials pursued for nuclear fuel cladding applications, molybdenum (Mo) was investigated by Los Alamos due to its high melting temperature, high strength, and high creep resistance at elevated temperatures. Such properties are extremely important under accident conditions when flow of cooling medium is interrupted.

The desirable properties of Mo for fuel cladding applications are highly dependent upon purity and microstructure,

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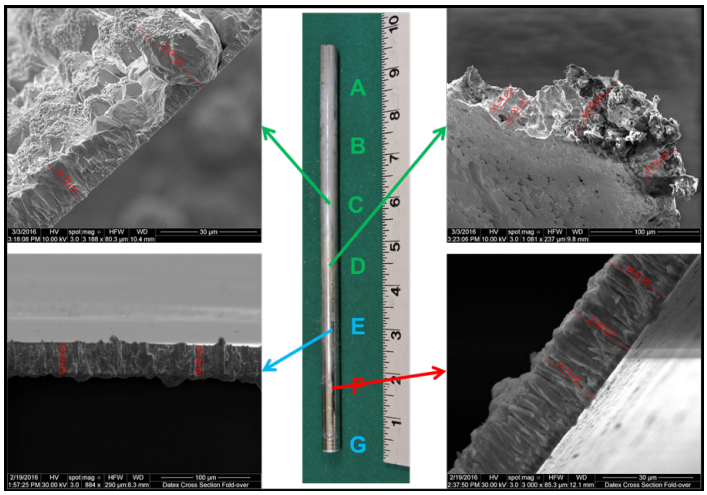


Scanning electron microscopy images of Mo tube wall cross sections from various locations along the tube. The scale given by the ruler is in inches.

Molybdenum-based cont.

which are difficult to control with conventional metallurgical methods. Therefore, chemical vapor deposition techniques were investigated as a means of producing tubes with the desired properties. Freestanding Mo tubes were produced with lengths and wall thickness up to 9.5 inches and exceeding 250 µm, respectively. Characterization of these tubes revealed that the properties of the tubes varied along the length. For example, the wall thickness of the resulting tubes decreased with distance from one end to the other, and the microstructure varied greatly, as shown in the figure above.

Microstructures suitable for the needs of a Mo-based cladding were achieved, albeit only locally with the tubes. It was determined that by reconfiguring the deposition system with a translating mechanism (as has been demonstrated for SiC tubes[1]), a Mo tube with the desired microstructure along its entire length could be produced.

The work was funded by DOE Nuclear Energy Office Fuel Cycle R&D Program (LANL Project Lead Stuart Maloy, Materials Science in Radiation and Dynamics Extremes, MST-8). The study was recently published in *Surface and Coatings Technology*[2]. This work supports the Laboratory's missions related to Energy Security solutions and the Materials for the Future science pillar. Team: M. Beaux, D. Vodnik, R. Peterson, B. Bennett, D. Devlin, and I. Usov (Engineered Materials, MST-7); G. King and S. Maloy (Materials Science in Radiation and Dynamic Extremes, MST-8); J. Salazar and T. Holesinger (Nuclear Materials Science, MST-16).

Technical Contact: Miles Beaux

1) P. Drieux et al., "Experimental Study of the Chemical Vapor Deposition from CH_3SiHCl_2/H_2: Application to the Synthesis of Monolithic SiC Tubes," *Surface and Coatings Technology* **230** (2013).
2) Miles F. Beaux et al., "Chemical Vapor Deposition of Mo Tubes for Fuel Cladding Applications," *Surface and Coatings Technology* **337** (2018).

Prism, building an inclusive workplace

Prism, the Lab's Lesbian, Gay, Bisexual, Transgender, and Queer+ (LGBTQ+) Employee Resource Group, fosters an inclusive workplace culture that supports the LGBTQ+ employee base. Prism provides and promotes LGBTQ+ visibility among staff and with management about current workplace and social issues that affect the LGBTQ+ community. Through networking, educational events, outreach, and more, Prism strives to create a safe space for LGBTQ+ employees while maintaining diversity in thoughts and ideas across the Laboratory. All Lab staff—LGBTQ+ and allies—are welcome to join and support this Employee Resource Group. For more information, see www.lanl.gov/careers/diversity-inclusion/erg/lgbtq/index.php.

Prism's 2018 goals are the following.

- Clear locations of gender neutral bathrooms
- Safe zone and active bystander training
- Professional oSTEM (Out in Science, Technology, Engineering, and Mathematics) chapter
- Fundraising for local LGBTQ+ charities
- Continuing to create an LGBTQ+ friendly work environment

Future events include the upcoming.

- Adrien Lawyer of the Transgender Resource Center of New Mexico will return to present Transgender 101 and Transgender 201
- Santa Fe Pride in June 2018
- oSTEM in November 2018
- Post-It With Pride permanent art installation unveiling at the NNSB
-

Past events include the following.

- Post-It With Pride, June 2017
  www.lanl.gov/discover/news-release-archive/2017/June/0608-lgbtq-art-installation.php
- Adrien Lawyer of the Transgender Resource Center of New Mexico presented Transgender 101, July 2017
  int.lanl.gov/news/news_stories/2017/July/0706-transgender-101.shtml
- Santa Fe Gay Pride Parade, September 2017
  int.lanl.gov/news/news_stories/2017/September/0921-sf-pride-parade-recap.shtml
- oSTEM, November 2017
  int.lanl.gov/employees/diversity/groups/resource-groups/lgbti/chicago-conference.shtml
- Los Alamos Rainbow day, January 2018
  int.lanl.gov/news/news_stories/2018/January/0116-prism-events.shtml

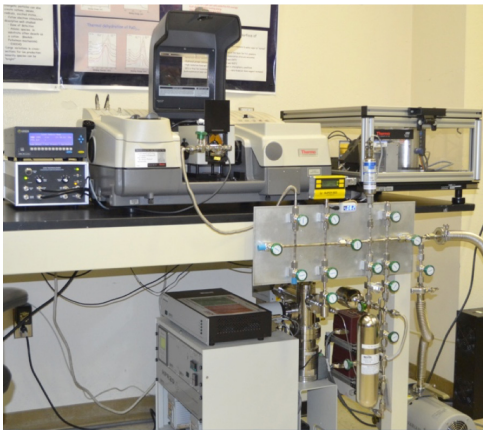
If you are interested in participating in any of the group's meetings or events, please contact prismboard@lanl.gov.

MST researchers present plutonium catalysis research at DOE headquarters

In January, researchers from the Material Science and Technology Division presented recent work on plutonium catalysis experiments at the Department of Energy headquarters in Washington, D.C. The seminar covered research performed at Los Alamos's plutonium surface science laboratory, a collaborative effort between Engineered Materials (MST-7) and Nuclear Materials Science (MST-16) located at the Target Fabrication Facility in TA-35.

The seminar highlighted a surface and gas-phase chemistry study obtained from polarization-modulation infrared reflection-absorption spectroscopy, or PM-IRRAS, a technique that can simultaneously measure the coordination of surface molecules and the gas phase constituents during a heterogeneous catalysis experiment. This PM-IRRAS system is unique in that has been configured to safely accept plutonium metal samples.

The DOE presentation focused on recent PM-IRRAS work that directly studied gas phase chemistry as a plutonium sample was exposed to various atmospheric gases. According to the experiments, vibrational absorption bands consistent with surface carbonates were observed on the plutonium surface in the as-received condition. Subtle changes in the absorption lines showed that the carbonate bands were affected by the various gas exposures. Experiments with isotopically labeled oxygen (^{18}O) also revealed exchange between the gas phase species and the oxygen originating from the thin plutonium surface oxide (^{16}O). This fascinating result reveals the complex and reactive nature of the plutonium surface.



The plutonium surface science laboratory's polarization-modulation infrared reflection-absorption spectroscopy system.

The work was funded by the C1 Primary Assessment Technologies science campaign (LANL program manager Ray Tolar), the Laboratory-Directed Research and Development program, and the National Nuclear Security Administration. The research supports the Laboratory's Stockpile Stewardship mission area and its Materials for the Future science pillar by enabling surface characterization of plutonium.

Thomas J. Venhaus and Joseph D. Anderson (MST-16) presented the work at the seminar, Keri Campbell (Chemical Diagnostics and Engineering, C-CDE) served as a co-author, and Sarah Hernandez (MST-16) and Miles Beaux (MST-7) attended the presentation.

Technical contact: Thomas Venhaus

MST e-NEWS

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To submit news items or for more information, contact Karen Kippen, ADEPS Communications, at 505-606-1822, or adeps-comm@lanl.gov.

For past issues, see www.lanl.gov/org/padste/adeps/mst-e-news.php.

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NNSA National Nuclear Security Administration

Celebrating service

Congratulations to the following MST Division employees celebrating recent service anniversaries:

Raymond Martinez, MST-16	40 years
Don Brown, MST-8	20 years
Claudette Chavez, MST-16	20 years
John Dunwoody, MST-7	15 years
Robert Gilbertson, MST-7	15 years
Amy Ross, MST-16	15 years
Igor Usov, MST-7	15 years
Jianzhong Zhang, MST-8	15 years
Alison Pugmire, MST-7	10 years
Nikolaus Cordes, MST-7	5 years
Stephanie Edwards, MST-7	5 years
Loren Espada Castillo, MST-7	5 years
Arul Kumar Mariyappan, MST-8	5 years

AM technique creates microlattices and capsule walls for ICF targets in a single print

Understanding hydrogen fuel mix in inertial confinement fusion (ICF) capsules is critical to achieving this potential source of virtually limitless, laboratory-generated energy. However, capsules with the precise foam form required for controlling this mix have historically suffered from manufacturing methods that produce a random structure and varying properties from batch to batch.

Recent advances in three-dimensional (3D) printing suggest that this technique can be used to create microlattices and capsule walls in a single print. Using two-photon polymerization (a laser-driven additive manufacturing technique), Los Alamos researchers produced proof-of-concept, submicrometer-resolution microlattices of various structures and a microlattice-containing capsule. The technology allows complete control of the mixing structure, making it suitable to modeling and easily modified for tailored target design.

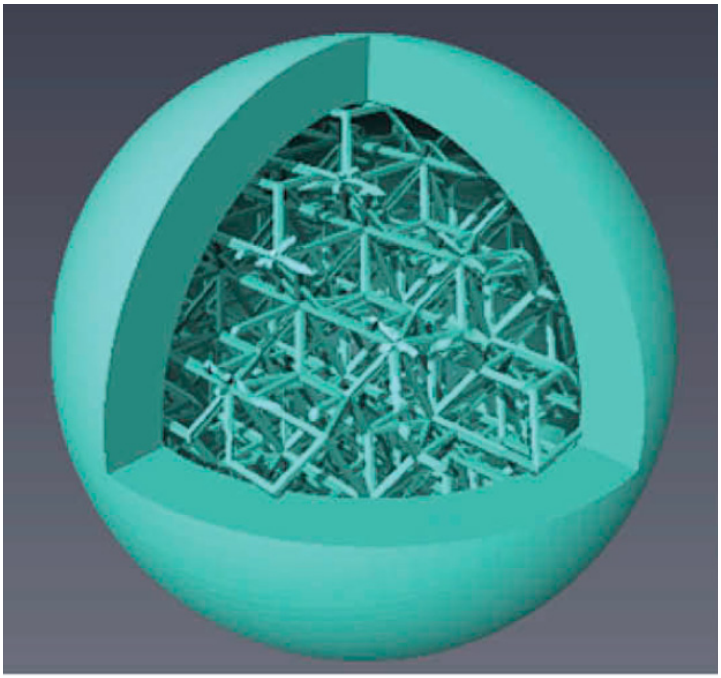
The resulting highly ordered, 3D-printed structures were characterized using electron microscopy and x-ray tomography, which measured void quality and distribution and lattice ligament thickness and spacing within microlattices. Future work, including demonstrations of various foam properties, densities, and the development of other, more applicable resins, will further add tools to the physicists' toolbox for laser experiments.

The work was funded by the Secondary Assessment Technologies science campaign (LANL program manager Melissa Douglas) in support of the Marble campaign. It supports the Laboratory's Nuclear Deterrence and Energy Security mission areas and its Nuclear and Particle Futures science pillar, with a focus on the High Energy Density Plasma and Fluids thrust area. It also supports the Materials for the Future science pillar, in particular the Defects and Interfaces and Extreme Environments science themes by developing methods that further efforts to develop materials with controlled functionality and predictable performance, the core vision of the Lab's materials strategy.

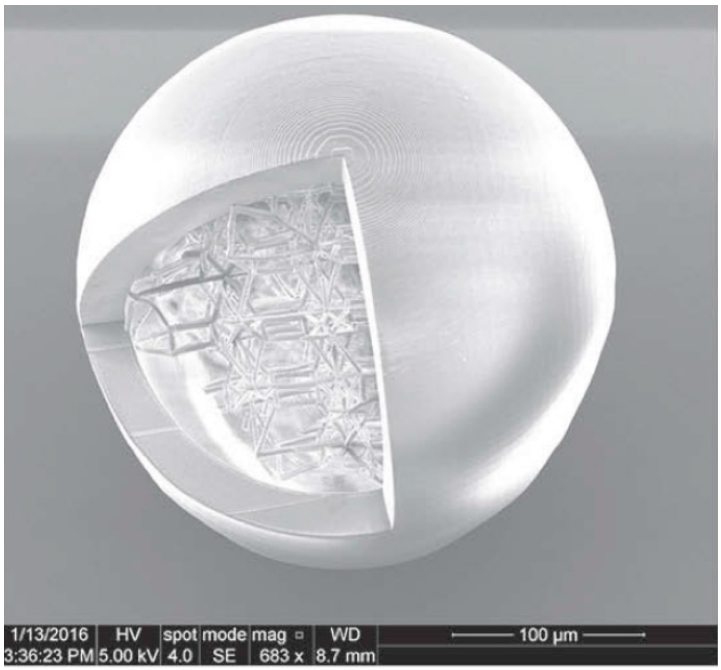
Researchers: Matthew J. Herman, Dominic Peterson, Kevin Henderson, Tana Cardenas, Christopher E. Hamilton, and Brian M. Patterson (Engineered Materials, MST-7); and John Oertel (Plasma Physics, P-24).

Reference: "Lithographic printing via two-photon polymerization of engineered foams," *Fusion Science and Technology* **73** (2017).

Technical contact: Matthew Herman



A CAD rendering (above) and a scanning electron microscopy (SEM) image (below) of a capsule printed with an interior lattice structure. (One-eighth of the surface was not printed for SEM imaging.)



HeadsUP!

Dispose of unneeded chemicals the 'Labpack' way

By Mario Santistevan (MST-DO)

This fall, employees in Materials Science and Technology, Materials Physics and Applications, and Sigma divisions were invited to a presentation by Paul Newberry from the Environmental Protection and Compliance Division's Waste Management Services on using "Labpacks" to dispose of unused and unspent chemicals.

The Associate Directorate for Experimental Physical Sciences has an inventory of more than 30,000 chemicals. Approximately 12,000 of these chemicals are greater than 10 years old. The directorate's Environmental Management System Environmental Action Plan includes using the Labpack process to reduce this inventory.

The main objectives of the Waste Management Services program are

- to enable Los Alamos waste generators to dispose of numerous non-radioactive Labpack-quantity chemicals in a more efficient way using the chemical clean-out model, and
- to assist chemical user groups to better manage unwanted chemical inventory in a compliant and safe manner.

After the presentation, a team in Engineered Materials (MST-7) and another in Nuclear Materials Science (MST-16) decided to pilot the process for the Division.

How Labpack works

The first step is filling out a Labpack inventory spreadsheet, which can be found by searching "WMC Labpack" from the Lab's homepage. After completion, this list is submitted to labpack@lanl.gov for Waste Management Services' review to ensure incompatible chemicals aren't shipped together and that the items on the list meet the requirements of the program.

MST-7 Labpack pilot

In December, MST-7 performed a mass chemical disposal. Employees used the Labpack spreadsheet to inventory unused and unspent chemicals. These chemicals consisted of sealed and partially used containers and unprocessed chemicals. Chemical categories were comprised of acids, flammable liquids, corrosive, bases, and carcinogens, all which originated from past projects and were taking up valuable chemical space in the Target Fabrication Facility and TA-35, SM-0002.

One of the seven chemical cabinets that were removed from building 0213.

A waste container filled with chemicals. These containers were then filled with vermiculite, sealed, and removed.

A barcode system was used to identify the mass and state of content for each chemical container. The data were submitted to the waste management coordinators and scheduled for pickup.

Out of MST-7's 4,469 chemicals, 797 containers were removed, reducing MST-7's chemical inventory by ~16%. The group's goal of reducing risk and making its labs a safer place to work was successful. For more information, contact Michael D. Garcia or Reuben J. Peterson (both MST-7).

This project would not been successful without the help of MST-7 personnel Dominic Peterson, Brian Patterson, Michael D. Garcia, Linda Meincke, Blaine Randolph, and Lola Sandoval; Science & Technology Operations (DESHF-STO) staff Candie Arellano and Alice Trujillo; and Ovide Morin's Waste Management Services team.

continued on next page

HeadsUP! cont.

MST-16 Labpack pilot

MST-16 completed a pilot of the process in December. Its inventory included chemicals left over from a previous project and those transferred to a team leader following a scientist's retirement. An employee consolidated unneeded chemicals from several laboratories and reduced MST-16's inventory by 328 individual containers, 291 of which were disposed of in the Labpack and 37 of which were transferred to another researcher for use in ongoing programmatic work. For more information, contact Michael R. Middlemas (MST-16) or Jon G. Roberson (DESHF-STO).

Sealed containers being removed.

> *With the level of success this program brings, MST, MPA, and Sigma divisions plan to perform more Labpack operations in the future, improving safety and reducing environmental risks posed by excess chemical inventories.*

Photos of a chemical cabinet before and after using the Labpack.

Of the total 1,088 disposed containers, 872 were greater than 10 years old and 410 were categorized as time sensitive. With the level of success this program brings, MST, MPA, and Sigma divisions plan to perform more Labpack operations in the future, improving safety and reducing environmental risks posed by excess chemical inventories. Contact Dianne Wilburn (Materials Science and Technology, Division Office, MST-DO) or your waste management coordinator for further information.

VPP recertification celebration

As part of celebrations held across the Lab recognizing LANL's recertification as a DOE Voluntary Protection Program Star Site, employees at the Los Alamos Neutron Science Center enjoyed light refreshments and the opportunity to receive a commemorative keepsake.

The Laboratory recently celebrated its recertification as a DOE Voluntary Protection Program (VPP) Star Site. Since 2014, Los Alamos National Laboratory has held the title of the largest Department of Energy VPP Star site. Every Laboratory worker's visible contribution and demonstration of ownership and leadership in safety and security made this three-year recertification possible. Only DOE contractors with outstanding safety and health programs are awarded Star recognition, the highest achievement level.