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INSIDE

Photo (far left) by Mick Greenbank, IRM-CAS

Tarik Saleh

At left, Tarik Saleh holds a plutonium rod in a glove box, demonstrating that Los Alamos National Laboratory can perform actinide research on quantities that few places in the world can. He's often on the road sharing his expertise with other national labs, Russia, and Switzerland, traveling with a trusty foldable bicycle in his suitcase.

How a bike junkie became a hotshot in nuclear materials science

By Diana Del Mauro, ADEPS Communications

Inspired in high school by a carbon fiber bicycle, Tarik Saleh attended a university engineering day to learn how to frame a career around this wonder material. "It was really biking that kicked me off into materials science," he said.

With aspirations of inventing advanced bike materials, Saleh immersed himself in materials science and engineering at the Massachusetts Institute of Technology and then the University of California, Berkeley, spending summers machining bike parts, assembling bikes, and hobnobbing with bike companies. In time, though, Saleh realized he might be better off using his degrees in a traditional scientific career (and pocketing the higher pay to feed his obsession).

After earning a PhD Saleh changed course, finding the best of both worlds at Los Alamos National Laboratory. In the Nuclear Materials Science group (MST-16), he studies radiation-damaged materials to understand how their behavior changes over time, laying the groundwork for futuristic power plants and informing the maintenance of nuclear weapons.

> *". . . there's virtually nobody in the United States who can do what we do."*

"It's a really cool job because there's virtually nobody in the United States who can do what we do (with the amount of

continued on page 3

"I have found that there are many similarities between being a high school coach and a LANL manager."

A personal portrait is an occasional feature that offers the opportunity to learn more about MST management. The list of questions contains both serious and fanciful queries; their selection and the answers are of the subject's choosing.

A personal portrait . . .

Current position: MST Division Leader since 2012
Started at LANL: MST-6 postdoc, 1996, studying palladium hydrogen interactions

Your role as a manager…

Why did you want to become an R&D manager?
For me, it was two-fold. First, I have a strong passion for technical leadership of materials science and engineering, particularly in linking processing-structure-property relationships. As an R&D manager I am able to champion this philosophy with our peers and program offices to influence future research and applied engineering directions. Secondly, I experienced frustration as a staff member with LANL bureaucracy and compliance constraints. I felt I could either continue to be frustrated by this or do something about it to help my fellow scientists and myself. Although I was able to try to remove some of the barriers as a scientist working with management, I found that I could be more influential again as an R&D manager.

How you do you start your day?
I usually get up early and exercise by either jogging or riding my bike. I find this to be a good time to reflect and think about what I want to accomplish in a given day. Once the day starts, it is hard to find time to sit back and think.

What is your personal motto?
As an assistant high school basketball coach, I read a lot of material from John Wooden. I have found that there are many similarities between being a high school coach and a LANL manager. Here are two of his quotes that resonate strongly with me:

"Be more concerned with your character than your reputation, because your character is what you really are, while your reputation is merely what others think you are."

"Never make excuses. Your friends don't need them and your foes won't believe them."

Your role as a scientist…

Why did you become a materials scientist?
I've always had a curious and inquisitive nature. When I was young, I loved taking things apart (bikes, lawn motors, and hand tools) to figure out how they worked and putting them together again–well, most of the time. As I grew older I really enjoyed physics and chemistry and understanding why materials behave the way they do. While participating in an engineering career program at Caterpillar as a high-school senior, I fell in love with metallurgy and have continued in this field since.

Describe any kind of research you are doing in addition to your management responsibilities.
I have been performing biochemistry research trying to understand the effect of natural yeast cells on the breakdown of sugars from a variety of roasted barely malts. Yes, I'm a homebrewer and have been for over 20 years. Since I don't have time for much lab work, this has been a way for me to still experiment and have fun.

Your beginnings…

What was the source of your scientific inspiration as a youth?
My father. He often encouraged me to explore the world around me and helped with multiple science projects. I also had two great physics and chemistry teachers in high school, Mr. Pittman and Mr. Ebeling, who always pushed me to do my best and develop the foundations of a strong experimental method.

If you hadn't become a scientist, what other career would you have pursued?
Since I really enjoy making things and doing things with my own hands, probably a contractor/carpenter or mechanic. Depending on how well my biochemistry research goes, perhaps that can be my fallback career after the Lab.

MST Division Leader David Teter

Saleh cont.

plutonium Los Alamos works with)," Saleh said. "There are a handful of places in the world, literally."

Saleh prides himself on being a patient, careful, and skilled experimentalist. Covered head to toe in protective regalia, he manipulates millimeter-size plutonium samples with tweezers in a glove box, following strict safety protocols and federal laws.

Plutonium is a perplexing metal that suffers radiation damage from internal decay, and Saleh plays a leading role in characterizing its behavior—a contribution former mentor Franz Freibert said is "critical to the successful implementation and interpretation of dynamic plutonium experiments," such as large endeavors at the Nevada National Security Site that seek to understand how nuclear weapons parts age and when they must be replaced. Saleh and his colleagues won a large team Distinguished Performance Award in 2009 for these types of R&D efforts.

Lately, he spends more time on nuclear energy fuels and materials, working toward reliable electricity for his daughter's generation. As principal investigator he decides which mechanical tests are done on which samples, then analyzes the results. His expertise is in demand. Switzerland's Paul Scherrer Institute shipped a high-dose fuel cladding material for him to study, and he recently reported his findings in person.

"Tarik has the unique expertise of mechanical testing combined with a knowledge of advanced characterization using neutrons and ultrasonic techniques," said Stuart Maloy (Materials Science in Radiation & Dynamics Extremes, MST-8), who leads nuclear reactor core and structural materials research for the Lab's Advanced Nuclear Energy Program. "He has learned to perform these measurements on highly radioactive materials."

Saleh cycles to work in any kind of weather and packs a folding bicycle for business trips. He owns more than 25 bikes, enters races, blogs about biking, and runs the Tarik Saleh Bike Club, a hobbyist endeavor for like-minded cycling enthusiasts. The road from his dreams to his successful career involved a few detours. He took a five-year break between graduate degrees, toiling in a foundry and in bike shops, and designing accelerator parts at Lawrence Berkeley National Laboratory. A PhD wasn't in his plans, but when he applied for a position in University of Tennessee's materials science department, he heard about a lucrative grant and returned to school.

As he was finishing his PhD, an advisor suggested Los Alamos as his next stop. Here, Saleh found the technical environment he was looking for as well as a biking paradise. "I liked Los Alamos so much I never went back," he said.

Tarik Saleh's Favorite Experiment

What: Mechanical testing of an irradiated steel duct from the Fast Flux Test Facility reactor (Hanford Site in Washington), and subsequent re-irradiation in the BOR-60 research fast reactor at the Russian Institute of Atomic Reactors (RIAR) in Dimitrovgrad, Russia.

When: Sample machining, testing, shipping, and re-irradiation started in 2009 and is ongoing.

Where: Primary materials handling and mechanical testing occurred in Chemistry Metallurgy Research (CMR) Wing 9 hot cells, machining in the Sigma facility, and Babcock & Wilcox Technical Services in Virginia, additional characterization at Los Alamos Neutron Science Center and the Advanced Photon Source at Argonne National Laboratory, and re-irradiation is ongoing in RIAR.

Who: The core LANL team for this international project is Toby Romero (Inorganic Isotope & Actinide Chemistry, C-IIAC), who does the sample handling and testing in CMR hot cells, and Stuart Maloy (MST-8), who provides project oversight and guidance, both critical to my success as PI on this project. Osman Anderoglu (MST-8) does important transmission electron microscopy (TEM) characterization on the irradiated material.

How: We are looking for mechanical properties changes in ferritic-martensitic steels (HT-9 in this case) out to fast neutron spectrum doses of 400 dpa (displacements per atom) and above. This primarily involves small sample tensile testing—a simple test that involves a huge amount of irradiated material handling, machining, shipping, and testing.

The a-ha moment: We can ship irradiated materials to labs in Russia (with the help of our excellent customs and shipping departments and a host of others). Also, HT-9 still retains excellent ductility at doses in excess of 150 dpa.

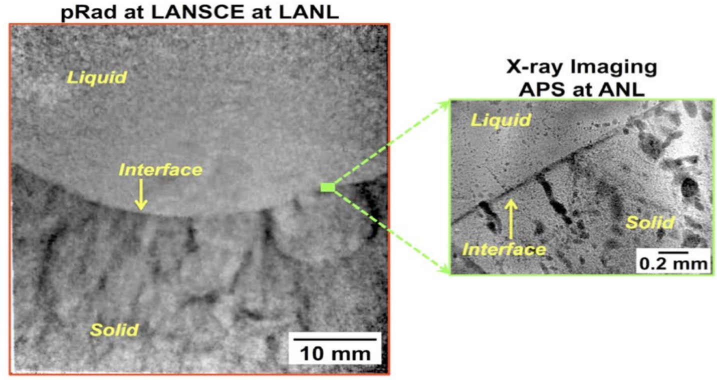
Proton radiography probes metal solidification

For the first time, high-energy protons have been used to image a large metal sample during melting and solidification without destroying the sample. Such real-time imaging will provide the insights needed to control the microstructure of metals and lead to advanced manufacturing processes that fabricate materials with desired properties. Creation of microstructures by design is considered a grand challenge in this field. *Scientific Reports* published the work, and the DOE, Office of Science, Basic Energy Sciences website highlighted the paper at science.energy.gov/bes/highlights/2013/bes-2013-06-a/.

Invented at Los Alamos, modern proton radiography (pRad) penetrates materials with a high-energy proton beam to produce pictures and time-lapse movies of the properties and behavior of materials under a variety of conditions and three-dimensional processes. This method has several advantages compared with x-ray radiography. X-rays are typically used on low-density metals of small volumes (<1 mm3), whereas proton radiography can be used on large samples (>10,000 mm^3). The increase of more than four orders of magnitude in sample size for pRad enables more realistic observations of the metal solidification processes.

In this work, researchers used 800 MeV protons at the Los Alamos Neutron Science Center (LANSCE) and synchrotron x-ray radiography at Argonne National Laboratory's Advanced Photon Source to interrogate solidification in an alloy of aluminum with 10 atomic percent indium additions. This alloy exists as two separate liquid phases before solidification. The scientists monitored the fluid flow and structure evolution in the experiments. The team made the first-ever pRad video sequence of aluminum with 10 atomic percent indium melting and solidification. The minority and majority liquid phases behave similarly to oil droplets in water, except that the denser, indium-rich liquid droplets sink instead of floating in the majority aluminum-rich liquid phase. Understanding the complex motion and coarsening of the indium-rich liquid droplets in the melt may provide a methodology to control how the solidification structure develops and allow improved casting quality.

Manipulation of solidification parameters is crucial for growing single crystals or controlling structure evolution and micro-segregation in a casting, setting the stage for what properties are possible after any downstream processing. Large scale parameters are controlled by casting design, which can include highly engineered melt flow patterns, heat transfer during mold filling, and progression of the solidification reaction. This early processing path determines the overall quality of a casting by influencing the presence of defects and the microscopic phase arrangement – characteristics that persist even after subsequent thermal-mechanical processing. Current methods to design castings incorporate experimental trials with destructive characterization



Protons and x-rays permit nondestructive and direct imaging of metal alloy melting and solidification. The left image demonstrates that protons can be used to examine a large sample volume during solidification, which is relevant for casting. The right inset image highlights a representative sample volume probed using x-rays. The images depict solidification structure development in an aluminum–10 atomic percent indium alloy at different length scales.

techniques and empirical modeling. Post-mortem structure evaluations are typically used to infer what occurred at elevated temperatures, but direct observations of metallic alloy solidification have been limited. Commercially available tools to simulate fluid flow and solidification sequence are generally finite-element based and rely largely on post-processing and empirical relationships to simulate structural outcomes.

Proton microscopy fills a critical gap in the evolving capabilities of dynamic imaging techniques. It enables direct observations of structural outcomes as a function of processing in large volumes of materials. It also affords studies of three-dimensional processes, such as fluid flow encountered during solidification for which thick sections, rather than thin (constrained) sections, better represent processes that occur in actual castings. The real-time monitoring of metallic alloys during processing will permit direct interrogation of responses to parameter changes needed to develop predictive structure evolution models to couple with finite elements. This information will bridge the micro- and macroscale regimes. It will also enable directed synthesis and processing to control structure evolution and the creation of optimal properties during process development.

Reference: "Proton Radiography Peers into Metal Solidification," *Scientific Reports* **3**, 2020 (2013). Los Alamos contributors include principal investigator Amy Clarke, Seth Imhoff, Paul Gibbs, Jason Cooley, Tim Tucker, Kester Clarke, Joel Montalvo, Robert Field, James L. Smith, Thomas Ott, and Martha Barker (Metallurgy, MST-6); Christopher Morris, Brian Hollander, and Fesseha Mariam (Subatomic Physics, P-25); Frank Merrill (Neutron Science and Technology, P-23); Brian Patterson (Polymers and Coatings, MST-7); Dan Thoma, and David Teter (Materials Science and Technology, MST-DO). Collaborators are Wah-Keat Lee

continued on next page

Radiography cont.

(Brookhaven National Laboratory), Kamel Fezzaa, and Alex Deriy (Argonne National Laboratory).

The DOE Office of Science, Basic Energy Sciences Program, through the Early Career Program and the Laboratory Directed Research and Development (LDRD) Program, funded different aspects of the Los Alamos work. The Proton Radiography Facility, a user facility at LANSCE, is sponsored primarily by NNSA Science Campaigns. The DOE Office of Science funds the Advanced Photon Source User facility at Argonne National Laboratory. The work supports LANL's Energy Security mission area and the Materials for the Future and Science of Signatures science pillars.

Technical contact: Amy Clarke

Reverse engineering nuclear waste design

In what *New Scientist* magazine described as an "ambitious" approach to managing nuclear waste, Laboratory researchers are investigating the potential to reverse engineer waste forms to become more stable over time.

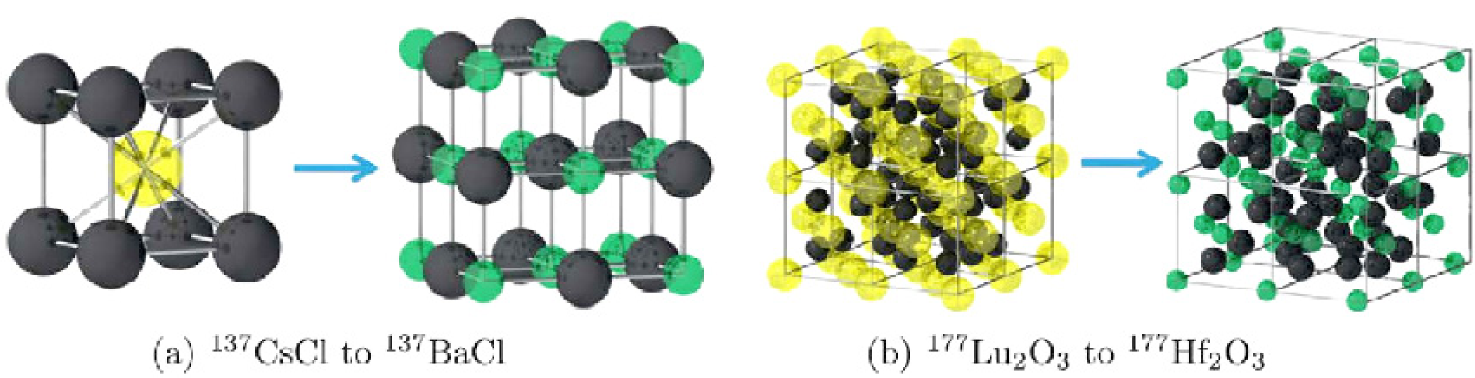
The process was explained in a *New Scientist* article describing a number of possible waste management solutions. The LANL research described is part of the project "Radioparagenesis: Robust Nuclear Waste Form Design and Novel Material Discovery," led by Chris Stanek (Materials Science in Radiation and Dynamic Extremes, MST-8), which aims to answer a fundamental materials science question regarding the impact of daughter product formation on the stability of solids comprised of radioactive isotopes. By answering this question, a predictive capability could be established to design radiation-tolerant and chemically robust nuclear waste forms. This could remove a significant obstacle limiting the expansion of nuclear energy. The project has predicted that transmutation may be a unique synthesis route allowing for the formation of compounds, which are often unconventional (e.g., rocksalt BaCl from the decay of $_{137}$Cs in CsCl), due to the chemical transmutation that occurs during radioactive decay, or "radioparagenesis," as the researchers call the phenomenon. By understanding the chemical evolution a waste form may undergo, more robust waste forms can be designed. Furthermore, the work has also resulted in new computational tools that with greater reliability predict the performance of waste in a repository setting.

The challenge of validating the predictions made is that the "short-lived" fission products of interest from a waste disposal perspective have 30-year half-lives, which would require experiments of 200-year duration. Therefore, the research team developed an accelerated chemical aging approach that relies on synthesis of samples comprised of very short-lived isotopes made by the Lab's Isotope Production Facility at LANSCE. The scientists performed an accelerated aging experiment involving $_{177}Lu_2O_3$, which has a six-day half-life. Although $_{177}$Lu is not a fission product of interest for waste disposal, its decay does mimic that of important fission products $_{137}$Cs and $_{90}$Sr because its daughter product (Hf) is considerably different chemically. To minimize the samples' radioactivity, the team used very small samples and relied on TEM (transmission electron microscopy) characterization. Initial results suggest that transmutation does indeed defy intuition and may result in novel phase formation.

References "Eternal Challenge: Are We Getting Any Closer to Curing Nuclear Energy's Biggest Headache?" *New Scientist* **220**, 2941, 42 (2013). Amanda Mascarelli authored the article. "Accelerated Chemical Aging of Crystalline Nuclear Waste Forms," *Current Opinion in Solid State and Materials Science* **16**, 126 (2012). Researchers include C. R. Stanek and B. P. Uberuaga (MST- 8), B. L. Scott and R.K. Feller (Materials Synthesis and Integrated Devices, MPA-11), and N. A. Marks (Curtin Institute of Technology).

LDRD (Laboratory Directed Research and Development) funded the work, which supports the Lab's Energy Security mission area and Materials for the Future science pillar.

Technical contact: Chris Stanek



Two examples of DFT (density functional theory) predictions of radioparagenesis, where (a) describes the formation of rocksalt BaCl from the decay of $_{137}$Cs in CsCl, and (b) describes the formation of bixbyite Hf_2O_3 from the decay of $_{177}$Lu in Lu_2O_3. In both examples, the yellow atoms refer to the parent atom, green to the daughter, and black to stable lattice anions. The team recently performed the $_{177}Lu_2O_3$ experiment at LANL.

A new class of hierarchically porous metal materials

Nanoporous metal electrodes display diverse applications in catalysis, sensors, and renewable energy systems. While these materials are valued for their large surface area, a necessary trade-off exists between the design of electrodes with exceedingly small pores and restricted mass transport within the porous structure.

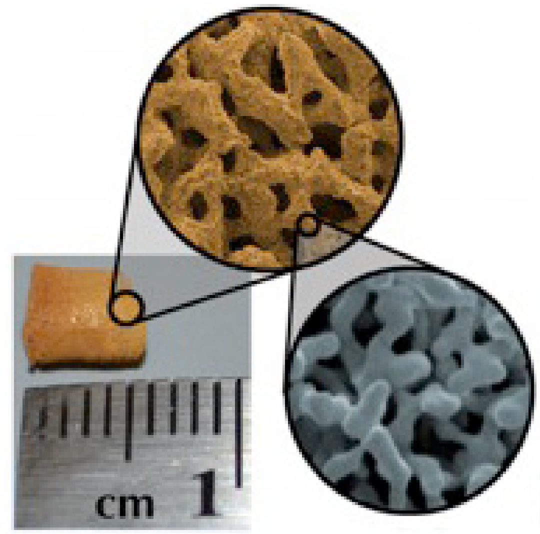
Resolving this paradox is crucial for an array of emerging technologies that require materials with both large surface area and rapid transport capabilities (i.e., supercapacitors, biosensors, and high-performance batteries). LANL researchers have developed a simple method to synthesize three-dimensional porous gold electrodes possessing structural hierarchy on widely separated length scales. They used a recently discovered class of soft materials known as *bijels* (bicontinuous interfacially jammed emulsion gels) for the process. *The Journal of Physical Chemistry Letters* published the research.

The growing diversity of applications for hierarchically porous solids and the need to provide broader access of these materials to the research community through flexible, benchtop materials synthesis techniques motivated the work. Therefore, the team designed the process to eliminate the need for sophisticated laboratory equipment and hazardous chemicals. The researchers developed a straightforward and flexible materials synthesis platform for hierarchically bicontinuity gold materials. The process is based on colloidal bijel templates and a simple combination of nanocasting and chemical dealloying.

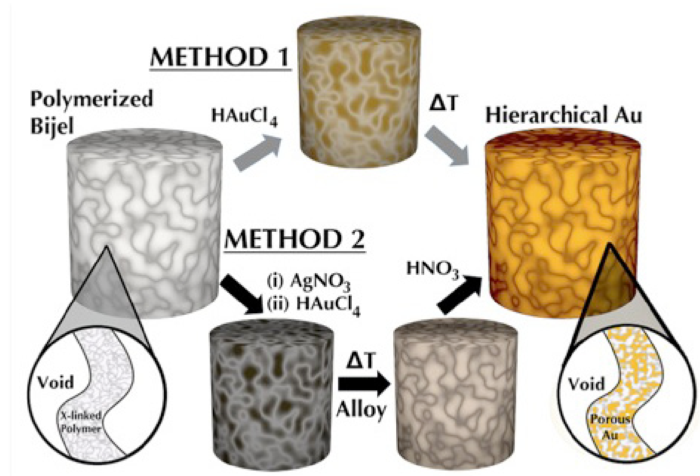
The new method enables the synthesis of hierarchical gold materials on the benchtop. A synergistic combination of nanocasting and chemical dealloying enables a flexible and low-cost synthesis technique where the pore size on both the macro- and mesoscale may be controlled independently. This general approach can offer a new design paradigm for the parallel optimization of surface area and mass transport in porous metal electrodes. Preliminary electrochemical studies demonstrate the promise of these materials as next-generation electrode materials for catalysis, sensing, and energy systems. This behavior can be attributed to confinement of the oxidized species within the hierarchical microstructure of the bijel electrode.

This simple process illustrates, for the first time, the rational design of a functional porous material derived from a colloidal bijel. Although the use of advanced materials based on bijels has been proposed for a number of engineering applications, evidence of their intended chemical functionality has not been shown previously.

On the basis of these results, the LANL team believes that bijels can offer a low-cost and accessible synthesis platform for hierarchically porous metal electrodes with enhanced



Digital and electron microscopy images of hierarchically porous gold materials synthesized using colloidal bijels.



Processing route to hierarchically porous gold monoliths using bijels as templates. Method 1: a nanocasting approach. Method 2: a nanocasting and dealloying approach.

performance for immediate applications in catalysis, separations, and renewable energy systems, where rapid mass transport and high surface area are often simultaneously required. In addition, these foams are useful for radiation transport experiments in NNSA Science Campaigns.

Reference: "Developing Monolithic Nanoporous Gold with Hierarchical Bicontinuity Using Colloidal Bijels," *The Journal of Physical Chemistry Letters **5***, 809 (2014). Researchers include Matthew Lee, Miguel Santiago, Chris Hamilton, and Kim Obrey (MST-7); Navaneetha Subbaiyan (Center for Integrated Nanotechnology, MPA-CINT); and Juan Duque (C-PCS).

NNSA Science Campaign 4 funded the research, which supports the Laboratory's Nuclear Deterrence and Energy Security mission areas and Materials for the Future science pillar.

Technical contacts: Kim Obrey and Matt Lee

MST expertise key to rebuild of Lab's largest VIM furnaces

Personnel from Metallurgy (MST-6) and Nuclear Materials Science (MST-16) have been working together to rebuild the vacuum induction melting (VIM) furnaces E and F located in the Sigma foundry. The largest VIM furnaces at the Laboratory, they are capable of melting up to 2500 kg of uranium.

The furnaces have been general-purpose workhorses for more than 50 years, supporting programs that range from uranium R&D, to pit manufacturing, to declassification of parts.

The rebuilds underway will include a new vacuum chamber and refurbished induction coils on E; fixing water leaks in the cooling system of F; and fresh insulation, bricking, and gasketing on both furnaces. The rebuild includes slight modifications to materials and dimensions to replace materials no longer available and improve the heating and cooling performance.

Fritz Sandoval, Ray Martinez, and Adam Farrow (MST-16) have provided expertise and assistance on radiological work and hot jobs, as well as help in procurements and other aspects. Victor Vargas, Rob Aikin, and Isaac Cordova (MST-6) have provided expertise in uranium and casting work and provided oversight and support. This work is ongoing and expected to integrate into a longer-term infrastructure plan for ensuring the future operability of the Sigma foundry.

Technical contact: Rob Aikin

Sigma's vacuum induction melting furnaces E and F are being refurbished by members of MST, including Isaac Cordova pictured here.

Inset: On the mezzanine around uranium furnace E (left to right), Ray Martinez, Fritz Sandoval, Rebekkah Aguilar (DSESH-STO FOD), and Adam Farrow take turns knocking fire bricks into a drum below for disposal. Wearing respirators as they reached into the furnace with a 25-lb steel rod, they debricked the furnace in order to access the induction coils, which were removed and sent for refurbishment.

MSTeNEWS

Materials Science and Technology

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

To read past issues, see www.lanl.gov/orgs/mst/mst_enews.shtml.

Celebrating service

Congratulations to the following MST Division employees celebrating a service anniversary recently:

Robert Houlton, MST-8	30 years
David Devlin, MST-7	25 years
Kenneth McClellan, MST-8	20 years
Manuel Chavez, MST-7	15 years
Veronica Livescu, MST-8	10 years
Theresa Quintana, MST-7	10 years
Brett Robinson, MST-16	10 years
Joseph Romero, MST-16	10 years
Paul Tobash, MST-16	10 years

HeadsUP! ADEPS Environmental Action Plan for FY14

Environmental management will always be an ongoing effort. Our 2014 Environmental Action Plan addresses our impact on the environment, and outlines steps we can take to reduce our impact and decrease the potential for and severity of any environmental damage.

In keeping with the three-pronged approach established in the recent past, we have focused upon three objectives: Clean the Past; Control the Present; and Create a Sustainable Future. These objectives parallel the LANL institutional objectives, with the targets fine-tuned to fit our Directorate's needs.

Clean the Past: Reduce Environmental Risks from Historical Operations, Legacy and Excess Materials, and Other Conditions Associated with Activities No Longer a Part of Current Operations.

Target 1: Focused inventory on out-of-date peroxide formers to ensure proper testing and potential disposal pathways.
Target 2: Reduce ADEPS surplus equipment, salvaging or recycling wherever appropriate; inventory and work to minimize use of transportainer storage units; reduce total volume of chemical containers; properly disposition unwanted/unneeded office and lab items; properly disposition legacy records and documents.

- Action 1: Reduce, Salvage and Recycle
- Action 2: Transportainer Inventory, Clean-out, and Removal
- Action 3: MST Clean-out of 03-35 (Contingent on available funding)
- Action 4: MST Clean-out of 03-169 (Contingent on available funding)

Control the Present: Control and Reduce Environmental Risks from Current, Ongoing Operations, Missions, and Work Scope.

Target 1: Managers will conduct at least one environmentally-focused MOV in each quarter
Target 2: Perform annual chemical inventories (90% of ChemLog entries inventoried)
Target 3: Communicate environmental objectives to the Directorate
Note: all three targets are assessed on an annual basis.

Create a Sustainable Future: Reduce or Eliminate the Use of SF6 Green House Gas (GHG) by Recycle/Reuse or Replacement Activities.

Target 1: SF6 reduction, elimination, and/or reclamation of this egregious GHG is an institutional environmental goal via the LANL SSP (Site Sustainability Plan).

We need you to turn off lights in offices, conference rooms, hallways, and labs when not in use. Get that leaking faucet/toilet/urinal fixed (contact your Facilities Coordinator). Turn off computer peripherals when not in use. Alter your purchasing habits–Purchase GREEN. Use the blue and green recycling bins. Share chemicals, minimize chemical inventories, purchase safer alternatives, recycle and dispose properly. Salvage all unnecessary or unused (and not needed) equipment. Nominate a deserving colleague for a P2 Award!!

Document, record, and report all significant environmental actions that you take that positively affect the environment. Remember, if it's not recorded, it didn't happen. Please send your environmental action updates to your Division's EAP contact (MPA: Susie Duran at susiew@lanl.gov; MST: Jim Coy at jcoy@lanl.gov; LANSCE: Frances Aull at aull@lanl.gov; P: Steve Glick at sglick@lanl.gov). This will ensure that our Directorate continues to get the recognition it deserves for our environmental efforts.

The plan in greater detail can be found at hsrasweb.lanl.gov/emsdb/print_plan.asp?id=351.


Spring snow, White Rock Canyon