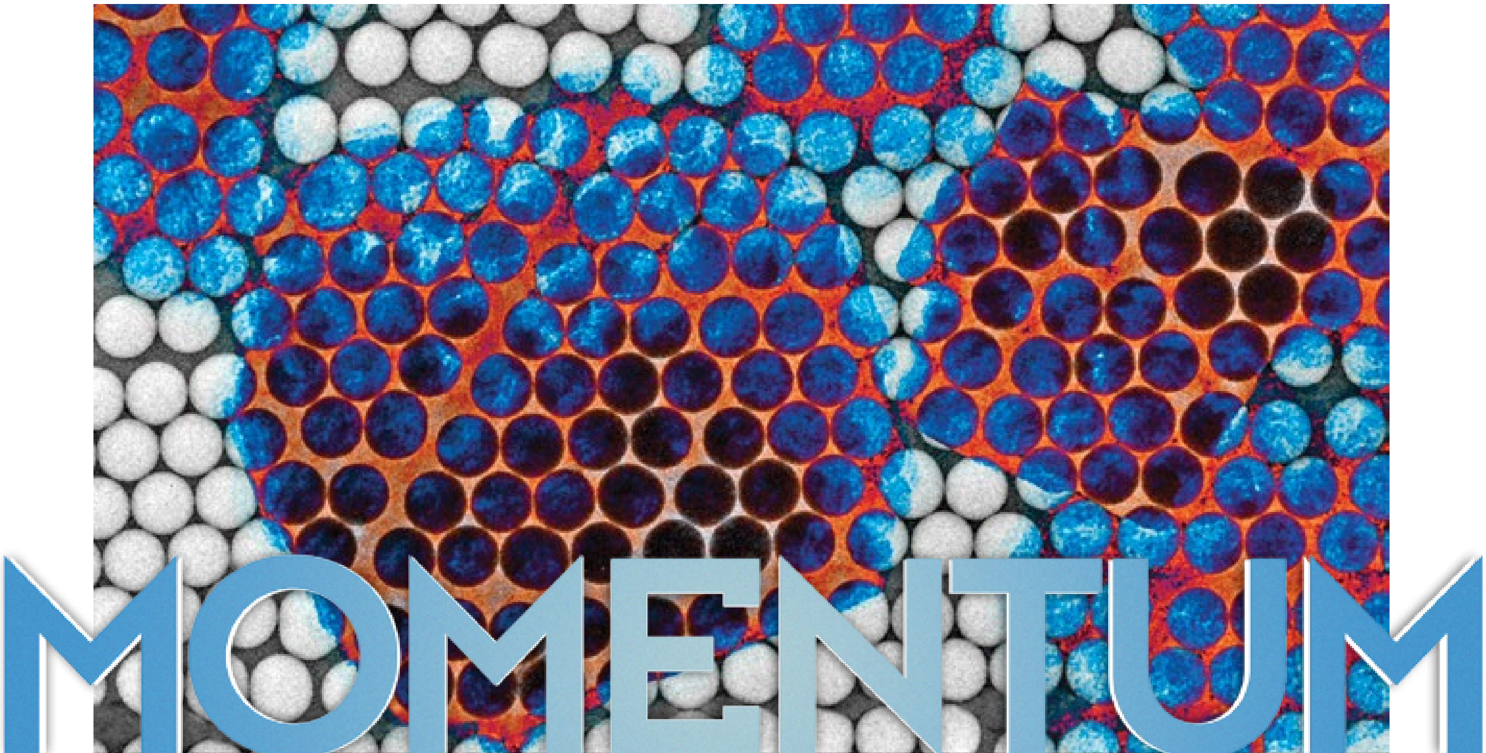
Science & Technology at the Ames Laboratory

inquiry 2016

Issue 2



Sensitive Instrument Facility | Caloricool | Critical Materials Institute | Advanced Manufacturing

CaloriCool™
CALORIC MATERIALS CONSORTIUM

CMI

SIF

AMES LABORATORY
Creating Materials & Energy Solutions
U.S. DEPARTMENT OF ENERGY

inquiry

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Ames Laboratory is a U.S. Department of Energy national laboratory seeking solutions to energy-related problems through the exploration of chemical, engineering, materials and mathematical sciences, and physics. Established in the 1940s with the successful development of the most efficient process to produce high-purity uranium metal for atomic energy, Ames Laboratory now pursues much broader priorities than the materials research that has given the Lab international credibility. Responding to issues of national concern, Ames Laboratory scientists are actively involved in innovative research, science education programs, the development of applied technologies and the quick transfer of such technologies to industry. Uniquely integrated within a university environment, the Lab stimulates creative thought and encourages scientific discovery, providing solutions to complex problems and educating and training tomorrow's scientific talent.

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U.S. DEPARTMENT OF ENERGY | Office of Science

From the Director

Scientists describe momentum as the quantity of motion of a moving body, measured as a product of its mass and velocity. A more general definition might describe it as the forward motion resulting from applying a driving force behind something. By that yardstick, Ames Laboratory has a number of efforts gathering momentum.

Our Sensitive Instrument Facility (SIF) opened its doors this past spring, and a growing number of users are taking advantage of its state-of-the-art microscopy equipment to characterize materials in unprecedented detail. We were delighted to have Energy Secretary Ernest Moniz on hand for the SIF dedication ceremony. Work is now underway to move three additional pieces of research equipment to the space to take full advantage of the building's isolation from outside interference and the proximity to the existing electron microscopes. See what's happening on pages 7-9.

We launched a new research consortium called CaloriCool™ in 2016 with the idea that refrigeration could be radically better—cheaper, cleaner, more precise and energy-efficient—by abandoning vapor-compression technology for something entirely new: a solid-state caloric system. Established under DOE's Energy Materials Network and overseen by the Office of Energy Efficiency and Renewable Energy, CaloriCool brings together national labs, industry, and academia, including Pacific Northwest and Oak Ridge National Laboratories, the University of Maryland, Pennsylvania State University, and Citrine Informatics. And this research team plans to do it—including adoption into manufactured systems and products—within a decade. Read more about it on pages 10-11.

We're also involved in two separate Advanced Manufacturing Office efforts. Iver Anderson's group leads a $5 million effort to improve the production and composition of metal alloy powders used in additive manufacturing, more commonly known as 3D printing. And Matt Kramer, Ryan Ott and Pete Collins will be working with colleagues at the SLAC National Accelerator Laboratory and Lawrence Livermore National Laboratory to characterize what happens with those powders *in situ* as the powders are being laid down, melted, and resolidified during the 3D printing process. Find out more about this work on pages 12-13.

The Critical Materials Institute, a DOE Energy Innovation Hub led by Ames Laboratory, continues to do ground-breaking work to make better use of materials and eliminate the need for materials that are subject to supply disruptions. In its three years of existence, CMI has 47 invention disclosures to its credit and has developed eight new goals for the final two years of its initial five-year funding cycle. You can find out what those efforts are on pages 14-15.

Finally, after an international search, we are pleased to have hired Dimitri Argyriou as chief research officer. A condensed matter physicist, Dimitri comes to the Ames Laboratory from the European Spallation Source, where he served as its Director of Science and Head of Operations Planning.

With all this progress, we look forward to 2017 and the 70th anniversary of the founding of Ames Laboratory. A lot has changed in seven decades, but we are still committed to creating materials and energy solutions.

Adam Schwartz, Director

Jiles named Jefferson Fellow

David Jiles, Palmer Endowed Chair of the Iowa State University Electrical and Computer Engineering department, and Ames Laboratory associate has been named a Jefferson Science Fellow at the U.S. State Department.

The Jefferson Science Fellowship is open to tenured or similarly ranked faculty from U.S. institutions of higher learning who are U.S. citizens. Jefferson Science Fellows spend one year on assignment at the U.S. Department of State or U.S. Agency for International Development as science advisors on foreign policy issues. Assignments are tailored to the needs of the hosting office, while taking into account the Fellows' interests and areas of expertise. As part of their assignments, Jefferson Fellows have the opportunity to travel to U.S. embassies and missions overseas. Following the fellowship year, the Jefferson Science Fellow returns to his/her academic career, but remains available to the U.S. government as an experienced consultant for short-term projects.


David Jiles

Jiles, an Anson Marston Distinguished Professor of Engineering at ISU, is one of 12 Jefferson Fellows named in 2016. His research interests include magnetism and magnetic materials, nonlinear and hysteretic behavior of magnetic materials; magnetoelasticity, magnetostriction, and magnetomechanical effects; development of novel magnetic materials; and biomedical engineering applications, including the development of transcranial magnetic stimulation for noninvasive treatment of brain disorders.

Gordon receives INCITE grant

Ames Laboratory scientist Mark Gordon was awarded a 2016 INCITE grant from the DOE's Office of Science.

The Innovative and Novel Computational Impact on Theory and Experiment, or INCITE, program was created as a primary means for scientists to access the DOE's supercomputers at Argonne and Oak Ridge national laboratories.

The award to Gordon includes 200 million processor hours of computing time on the IBM Blue Gene/Q supercomputer at Argonne National Laboratory. His research team will use the hours to study anions (negatively charged ions) such as chloride, fluoride and bromide in water, as well as ionic liquids and the processes that occur in them.

Canfield awarded APS McGroddy Prize

Professor Paul C. Canfield, a senior scientist at Ames Laboratory, has been awarded the James C. McGroddy Prize for New Materials by the American Physical Society (APS).


Paul Canfield

Canfield, who is also a Distinguished Professor and the Robert Allen Wright Professor of Physics and Astronomy at ISU, was selected for the prize "for development and use of solution growth of single crystalline intermetallic materials to design, discover, and elucidate new heavy fermion, superconducting, magnetic, and quasicrystalline states." He will be awarded the prize, which consists of a certificate and honorarium, at the 2017 APS March meeting in New Orleans.

Bertoni awarded Margaret Butler Fellowship

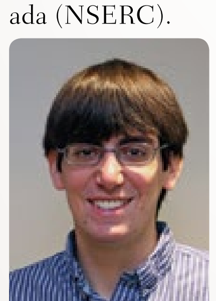
Ames Laboratory and Iowa State University PhD student Colleen Bertoni has been named the recipient of the Margaret Butler Fellowship in Computational Science.


Colleen Bertoni

Bertoni will spend 2017 at the Argonne Leadership Computing Facility (ALCF), a DOE user facility at Argonne National Laboratory. She will work as a post doctoral fellow at the ALCF, where she will advance her quantum chemistry studies of liquid water and ion solvation by employing and optimizing ab initio-based fragmentation methods on the facility's supercomputers.

Perras awarded Banting Fellowship

Frédéric Perras, a post-doctoral researcher at the Ames Laboratory, has been awarded a Banting Fellowship by the Government of Canada and the National Sciences and Engineering Research Council of Canada (NSERC).


Frédéric Perras

Perras joined the Ames Laboratory in 2015 after he was named the Laboratory's first Spedding Fellow, a position created to recognize exceptional research achievements. He conducts research in Ames Laboratory senior scientist Marek Pruski's group, specializing in solid-state NMR spectroscopy, including dynamic nuclear polarization (DNP-NMR).

Anderson inducted into National Academy of Inventors

Ames Laboratory senior metallurgist Iver Anderson was inducted into the National Academy of Inventors (NAI) at a special ceremony in Washington, D.C. at the United States Patent and Trademark Office (USPTO).

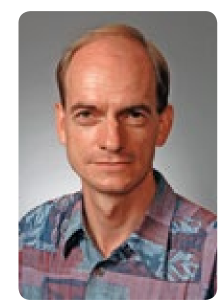

Iver Anderson

The ceremony, which was held as part of the NAI's Fifth Annual Conference, welcomed 168 new Fellows into the academy. Each Fellow was presented with a special trophy, a medal and a rosette pin.

The NAI Fellows Selection Committee credited Anderson for demonstrating a "highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made tangible impact on quality of life, economic development, and welfare of society."

Kreyssig and Yu named APS 2016 Fellows

Ames Laboratory scientists Andreas Kreyssig and Edward Yu were named 2016 Fellows of the American Physical Society (APS).


Andreas Kreyssig

According to APS, Kreyssig was elected for "elucidating the relationships between the structural, magnetic, and superconducting properties of iron-arsenide high-temperature superconductors."

Kreyssig is a physicist in the Laboratory's Division of Materials Science and Engineering, and an adjunct associate professor of physics in the Department of Physics and Astronomy at Iowa State University.

Yu was elected for "his distinguished contributions to the field of efflux transporters, which mediate resistance to a variety of antimicrobials in bacteria, and his research into the crystallography of integral membrane proteins."


Edward Yu

Yu is a professor of Chemistry and of Physics & Astronomy. He was named the John D. Corbett Professor of Chemistry in 2014 and elected as a Fellow of the American Association for the Advancement of Science that same year.

Fox appointed International Francqui Professor Chair

Professor Rodney Fox has been appointed to an International Francqui Professor Chair as part of the Francqui Foundation, based in Belgium. Fox will travel to Belgium for a six-month stay in late 2016 and early 2017. His main host will be the Laboratory for Chemical Technology in Ghent, Belgium.

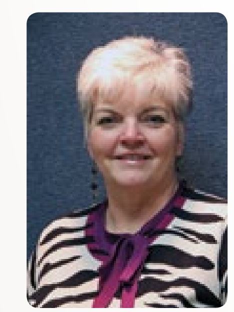

Rodney Fox

The chair is named for Emile Francqui, a Belgian serviceman, politician and business man. He and President Herbert Hoover established the foundation in 1932 to support higher education and research in Belgium.

Fox was also named early this year as recipient of the AIChE Shell Thomas Baron Award in Fluid-Particle Systems. This award recognizes an individual's recent outstanding scientific/technical accomplishment which has made a significant impact in the field of fluid particle systems or in a related field with potential for cross fertilization with relevance to the topics of interest to PTF community.

Covey named FLC Mid-Continent Tech Transfer Professional of the Year

Debra Covey, associate lab director and director of Sponsored Research Administration at Ames Laboratory was named the 2016 Technology Transfer Professional of the Year by the Federal Laboratory Consortium (FLC) Mid-Continent Region.


Debra Covey

The award recognizes the efforts of an FLC laboratory technology transfer professional or team who has demonstrated outstanding work transferring technology in a manner significantly over and above what was called for in the normal course of work.

Covey was recognized for playing a significant role in the institution of the Ames Laboratory-led CaloriCool™ consortium for the discovery and development of environmentally friendly and energy-efficient refrigeration technologies. She is also credited with expanding non-disclosure agreements, intellectual property management, and collaborative R&D agreements that link the members of Ames Laboratory's Critical Materials Institute.

Meet the New CRO

Dimitri N. Argyriou

Dimitri N.Argyriou has been named Chief Research Officer at Ames Laboratory. His appointment follows an extensive international search and became effective January 2017.

In announcing the selection of Argyriou, Ames Laboratory Director Adam Schwartz said, "This is a critical position for Ames Laboratory. Dimitri's proven leadership and experience at leading laboratories around the world provides an excellent opportunity to advance our scientific mission. We welcome Dimitri and look forward to having him on the Ames Laboratory team."

The Chief Research Officer (CRO) is responsible for initiating, developing and supervising Ames Laboratory's scientific divisions, institutes and programs. The CRO formulates and evaluates new initiatives that fall within Ames Laboratory's mission—to create materials, inspire minds to solve problems, and address global challenges—often emphasizing cross-disciplinary collaborations with other DOE national laboratories, academia, and industry.

Argyriou is a condensed matter physicist and comes to the Ames Laboratory from the European Spallation Source (ESS), a $2 billion next-generation neutron spallation source under construction by a partnership of 16 European countries in Lund, Sweden. Argyriou served as its Director of Science and Head of Operations Planning, contributing to the establishment of the ESS organization and securing its funding by leading the effort to define its scientific project scope and delivery by its partners.

An established world-class researcher in electronic and magnetic materials, Argyriou is a fellow of the American Physical Society cited for his work on colossal magnetoresistance manganites, and is a recipient of the Friedrich-Wilhelm-Preis for his work on multiferroics.

As the new leader of research efforts at Ames Laboratory, Argyriou plans to use his experience in management and leadership in science, research, and "big-science" projects to help provide vision for establishing new scientific programs at Ames Laboratory.

"I am humbled and equally excited to join the Ames Laboratory and work with some of the best minds in the area of materials," Argyriou said. "Ames Laboratory is needed now more than ever to solve some of society's tricky problems, and I see a bright future ahead for its research. I am very happy to be part of the Ames team."

Argyriou received his Ph.D. and B.S. degrees in Physics from the University of Technology, Sydney, Australia and his habilitation from Rheinisch-Westfälische Technische Hochschule, Aachen in 2009. He has co-authored over 160 scientific papers in peer-reviewed journals and given numerous invited talks at international conference. He is a main editor at IUCrJ, the International Union of Crystallography. He serves in various scientific advisory roles, including at ISIS, a pulsed spallation neutron and muon source, operated by the Science and Technologics Research Council, UK; and at the Japan Proton Accelerator Research Complex, Japan.

Argyriou has had key collaborations on projects with scientists around the world and has been the recipient of numerous competitive funding proposals throughout his career.

Argyriou replaces former CRO Duane Johnson, who stepped down to pursue research opportunities at Ames Laboratory and Iowa State University.

SENSITIVE INSTRUMENT FACILITY

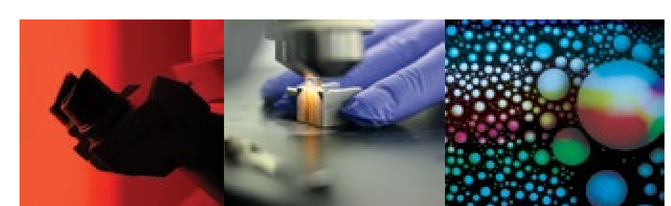
Newly dedicated, expanding capabilities

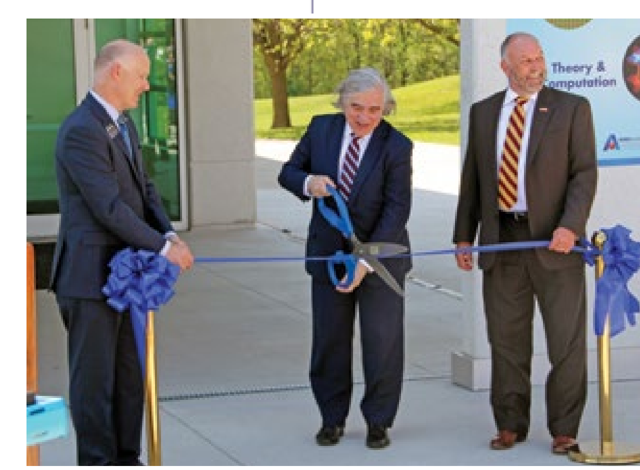
BY KERRY GIBSON

Ames Laboratory's Sensitive Instrument facility, which opened in February and was formally dedicated in 2016, bustles with a steady flow of scientists using its array of high-powered electron microscopes to take an unprecedented, close-up look at all types of materials.

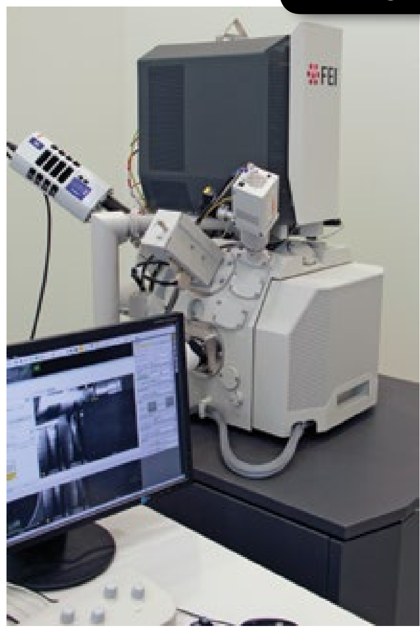
Built with funding from the DOE's Office of Science, the nearly $10 million state-of-the-art facility was designed to shield the sensitive microscopes from outside interference. Two-foot thick concrete floors, including sections mounted on shock absorbing springs and isolated mechanical systems reduce vibration while ¼-inch-thick aluminum wraps some of the instrument bays to prevent electromagnetic interference.

AMES LABORATORY | SIF SENSITIVE INSTRUMENT FACILITY





Energy Secretary Ernest Moniz cuts the ribbon officially opening the Sensitive Instrument Facility on May 6, 2016, with assistance from Ames Laboratory Director Adam Schwartz (left) and Iowa State University President Steven Leath.

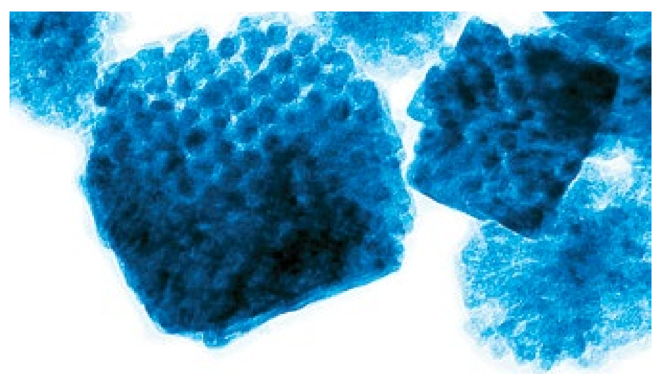


FEI Teneo

FEI Helios

FEI Tecnai

FEI Titan Themis



Through a combination of DOE, Ames Laboratory, and Iowa State University funding, three state-of-the-art electron beam characterization tools worth more than $6 million were purchased and an existing transmission electron microscope was moved and upgraded. The facility houses the following:

FEI Teneo field emission scanning electron microscope with Oxford EDS/EBSD for combined elemental and phase mapping and texture determination.

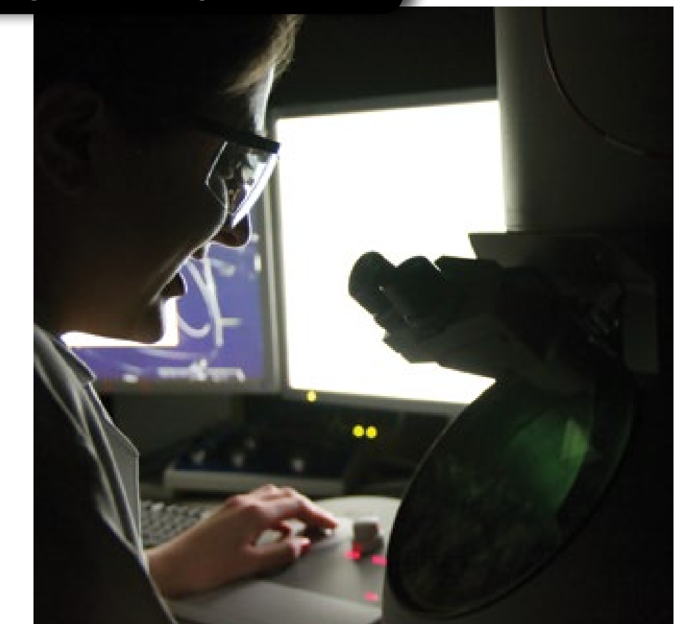
FEI Helios Focus Ion Beam (dual beam) system with easy lift out capabilities for TEM and 3D atom probe sample preparation, auto-slice capability for 3D reconstruction and a multi-chemical deposition system for circuit editing.

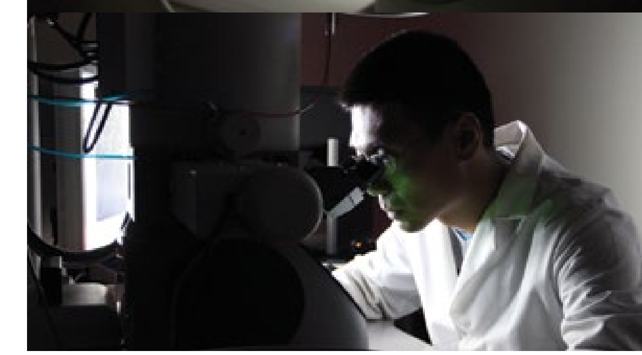
FEI Tecnai G2-F20 scanning transmission electron microscope (STEM) with both EDX and EELS capability.

FEI Titan Themis 300 Cubed probe aberration corrected STEM with Super-X EDX detector, GIF quantum ER system and a Lorentz lens with biprism, which enables rapid, precise navigation from mesoscopic to atomic scale, as well as study of intrinsic magnetic and electric fields.

SENSITIVE INSTRUMENT FACILITY

Kewei Sun uses a microscope in the SIF's wet lab to prepare a sample for observation by one of the facility's electron microscopes.





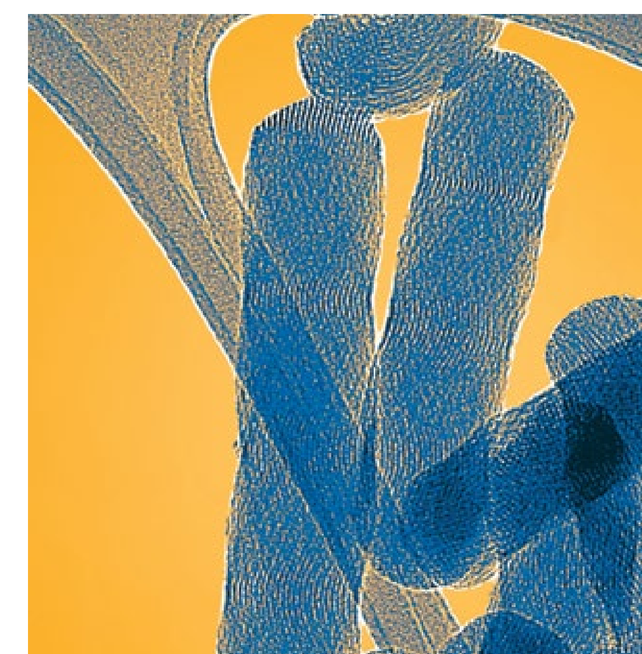
Facility users view material samples through the TECnai scanning transmission electron microscope. The Tecnai was moved from Wilhelm Hall and upgraded for use at the SIF.

Obviously only trained researchers may operate the equipment and so far, 65 individuals have applied for training and 42 have been approved to operate one or more of the machines. All users are Ames Laboratory associates, but they include researchers from a number of departments across the ISU campus.

When the building was built, one large instrument bay at the south end of the building was left empty to allow for future expansion. Work is underway to finish that space to accommodate three pieces of equipment that can also benefit from the building's isolation features and the proximity to the other equipment.

That equipment includes a nitrogen vacancy (NV) centers in diamond magnetoscope used by Ames Laboratory researcher Ruslan Prozorov and his group; a stimulated emission depletion imaging (STED) system developed by Ames Laboratory scientist Emily Smith; and an Extreme Quantum Terahertz nanoscope proposed by Ames Laboratory scientist Jigang Wang.

According to Sarah Wiley, SIF program coordinator, construction should be completed by mid-2017, and the three research groups are expected to be operational by the start of the fall 2017 semester.



Cooler in 10

CaloriCool consortium's goal: game-changing refrigeration technology within a decade

BY LAURA MILLSAPS

Refrigeration has been such an integral part of our everyday lives for so long that we rarely think of it. Our food is fresh and our offices and living rooms temperature-controlled thanks to the vapor-compression technology developed over a century ago, and it is an integral part of medical care, transportation, military defense, and more.

At Ames Laboratory a new research consortium called CaloriCool™ launched in 2016 with the idea that refrigeration could be radically better—cheaper, cleaner, more precise and energy-efficient—by abandoning vapor-compression for something entirely new: a solid-state caloric system. And this research team plans to do it—including adoption into manufactured systems and products—within a decade.

"It's like replacing the incandescent light bulb with an LED bulb; the new technology does the same thing, but in a completely different and much more efficient and sustainable way," said Vitalij Pecharsky, director of CaloriCool. "That's what CaloriCool will do with the refrigeration and heat pumping industries."

The idea that caloric systems could be used as a replacement for traditional refrigeration technology is actually nothing new. For the last 20 years, materials scientists have been searching for compounds that can generate strong cooling effects when cyclically acted upon by magnetic, electric, or mechanical forces—called magnetocaloric, electrocaloric, and elastocaloric materials.

Starting with the discovery of gadolinium-silicon-germanium compounds in Ames in 1997, a few other materials are worth mentioning. These include lanthanum-iron-silicon-hydrides and iron-manganese-silicon-phosphides for magnetocalorics, nickel-titanium for electrocalorics, and selected terpolymers for electrocalorics. But none of those materials have been exactly right for commercialization into any kind of product like a residential refrigerator, or building environmental systems. "This is essentially what

CaloriCool is going after," said Pecharsky, who is also an Iowa State University Anson Marston Distinguished Professor of Materials Science and Engineering and Ames Laboratory faculty scientist. "We know the real obstacle preventing the leap into marketable technology is the lack of affordable, high-performance caloric materials."

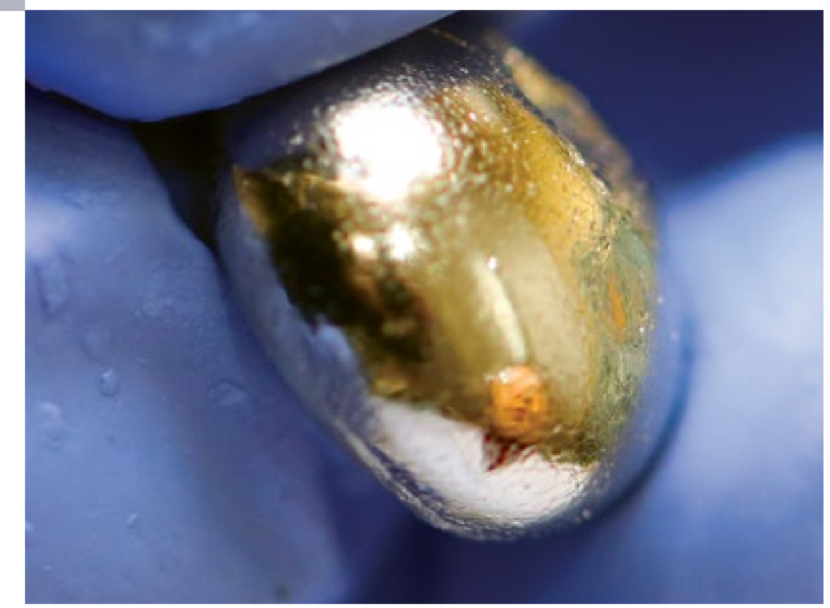
The search has already begun in earnest, led by a team of researchers based in Ames and enhanced by partner teams who represent a range of skills vital to the effort, including

Post-doctoral researcher Yibole Hargen prepares a caloric material sample for evaluation in the laboratory. CaloriCool is searching for a metallic compound that could potentially radically change refrigeration technology as it currently exists.

theoretical analysis, materials design and characterization, engineering design, and technology commercialization.

"We've already identified several classes of caloric materials that look promising, based on a review of the existing scientific literature, and we are creating samples of them for evaluation," said Pecharsky.

Experimental work is going forward while the consortium also assembles an informatics system that will be used as both a database and a computational aid tool to assist in evaluating existing and new materials.



A sample of a caloric compound. Caloric materials demonstrate cooling effects when cyclically acted upon by magnetic, electric, or mechanical forces. Solid state caloric cooling systems could potentially be far more energy-efficient and environmentally friendly than traditional vapor-compression systems.

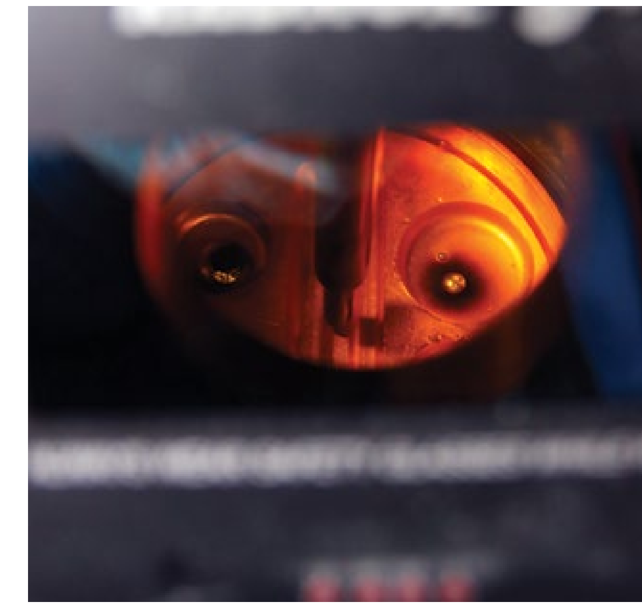
"Within five years, we want CaloriCool to be the authority, the resource for information on caloric materials, part of the national materials genome," Pecharsky said. "That's going to help accelerate commercialization of the technology."

Engineering design members of the group have already traveled to Denmark Technical University to establish collaborations and study existing prototype systems for a test station device being designed and built in 2017 called CaloriSMART—Small-scale, Modular Advanced Research Test-station. The test station will allow researchers to rapidly assess whether new materials have the correct properties, can perform as needed for use in a manufactured device, and use the smallest sample necessary to produce reliable data.

"You could read up on how to go about it, but we decided it was better to send our people and let them get their hands on some of these systems, see how they work, and how we can collaborate with experts to build exactly what we need," said Pecharsky.

All of the research in caloric cooling will go hand-in-hand with an analysis of the economic impacts of the technology, including scale-up, technology transfer, and raw materials availability. CaloriCool's goal is to discover these caloric materials, but they must also be economical, widely available, non-toxic, manufacturable, and create enough energy savings and other benefits that it is attractive to manufacturers and consumers. Early predictions are that caloric cooling systems could result in as much as a 30 percent higher efficiency than currently available vapor-compression products.

"What we are doing is exactly the point of U.S. Department



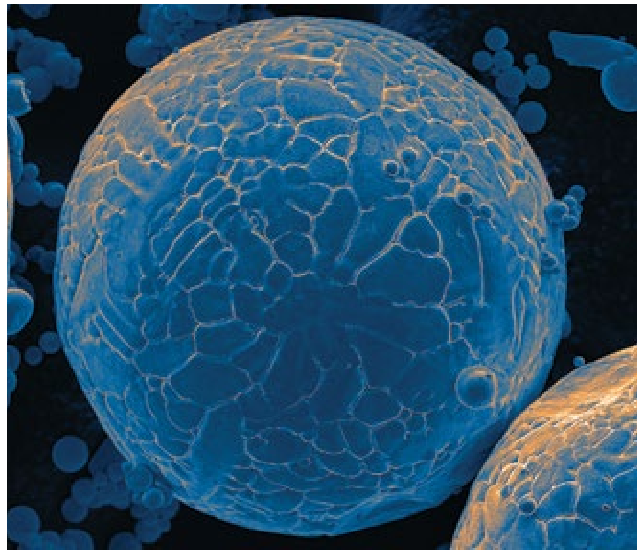
Formation of samples in an arc melt furnace, as shown through its viewport.

of Energy's Energy Materials Network, to really shorten the time frame for materials development to a real, manufactured technology," said Pecharsky. CaloriCool was one of seven consortia established in 2106 under DOE's Energy Materials Network and overseen by the Office of Energy Efficiency and Renewable Energy, specifically to address the need for advanced materials for clean energy technologies. CaloriCool is bringing together national labs, industry, and academia, including Pacific Northwest and Oak Ridge National Laboratories, the University of Maryland, Pennsylvania State University, and Citrine Informatics, all of which have become official partners in 2016. At present, the CaloriCool team is working with several other potential industry partners, which will be announced when negotiations are completed.

"The research has been out there a long time; we just needed a new and more aggressive approach to move it from the laboratory to commercialization," said Pecharsky. "We are quite confident we'll be able to deliver, and that commercial devices will begin to appear in stores and dealerships near you in five to 10 years."

Better Powders Advance Additive Manufacturing

BY LAURA MILLSAPS



A micrograph shows the perfectly spherical shape of powder particles formed by high-pressure gas atomization (HPGA).

Additive manufacturing, also known as 3D printing, has reached a widespread measure of success in manufacturing processes using polymers, or plastics. But the use of metal alloys for additive manufacturing has lagged due to lack of both materials and process development.

Ames Laboratory and Oak Ridge National Laboratory have been awarded $5 million from the U.S. Department of Energy's Advanced Manufacturing Office (AMO) to improve the production and composition of metal alloy powders used in additive manufacturing.

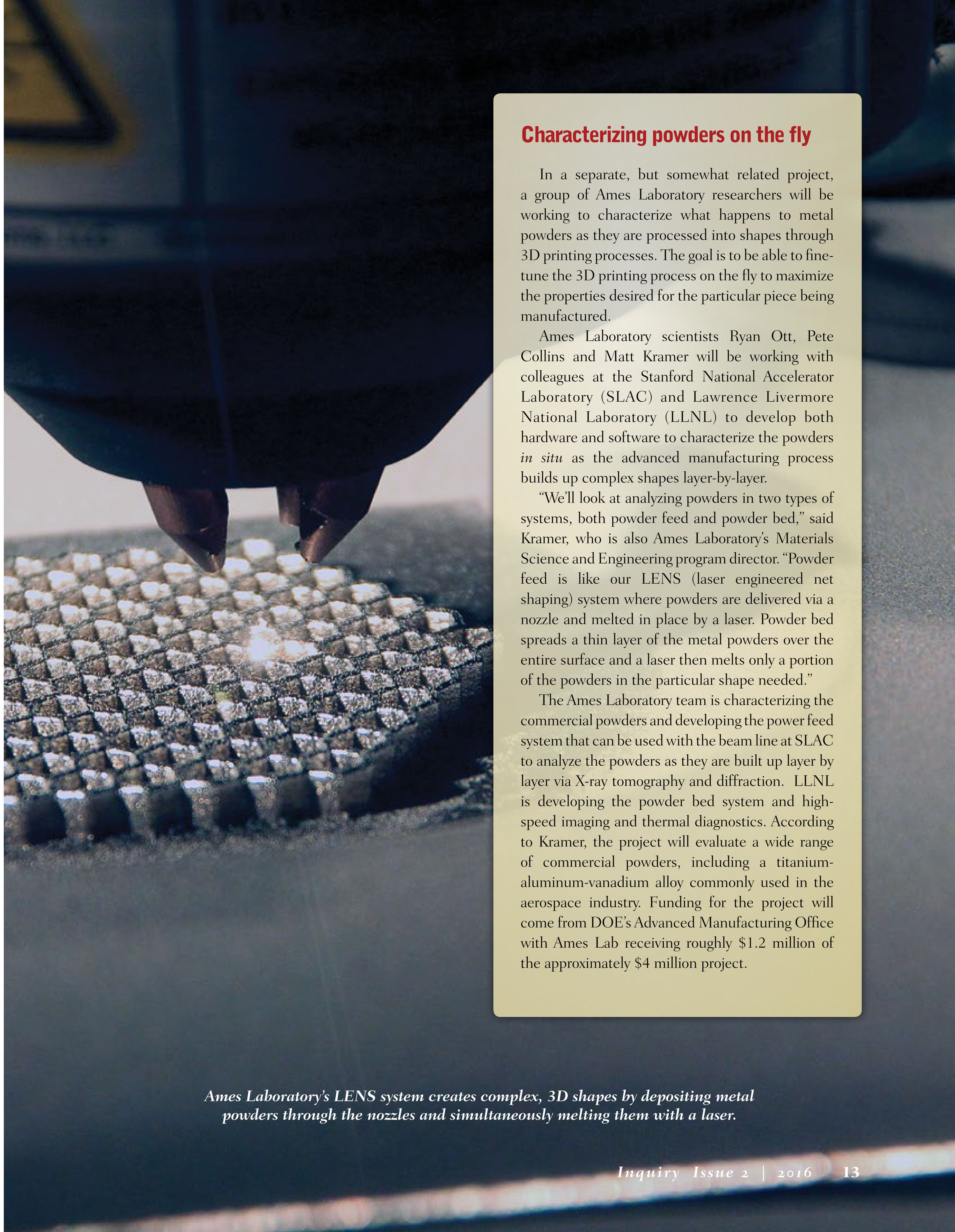
Ames Laboratory scientist Emma White sits at the control panel for one of Ames Laboratory's HPGA systems.

"There's a lot of intense interest focused on additive manufacturing with metal alloys, because there are so many potential applications," said Iver Anderson, project leader and senior metallurgist at Ames Laboratory and adjunct professor of Materials Science and Engineering at Iowa State University. "Industry has demands for prototyping parts, design development, reducing waste of expensive materials, and efficiently producing custom and legacy components for their customers."

Because additive manufacturing uses metal alloy powders as its raw material, the ability to control the properties and quality of those powders becomes paramount to the quality of the final product, and achieving properties equal to cast and machined or, especially, cast/forged and machined parts.

The project will improve powder production by developing advances in a high-pressure gas atomization process pioneered at Ames Laboratory and will design and customize alloys specifically for additive manufacturing processing methods. Modeling and simulation of gas atomization process stages at Ames Laboratory will use a flow simulation code developed by the National Energy Technology Laboratory for part of the work. The experimental gas atomization work and alloy design calculations/verification also will be performed in the powder synthesis facilities at Ames Laboratory. Oak Ridge National Laboratory's Manufacturing Demonstration Facility (ORNL-MDF) will conduct the corresponding additive manufacturing experiments.

"Today, if a manufacturer went to metal powder producers with a shopping list of the alloys and powder specifications they needed for their manufacturing process, they very likely wouldn't find what they want," said Anderson. "The customization capabilities are just not there, and we need to get there. That is going to be the key to commercially competitive additive manufacturing processes."



Characterizing powders on the fly

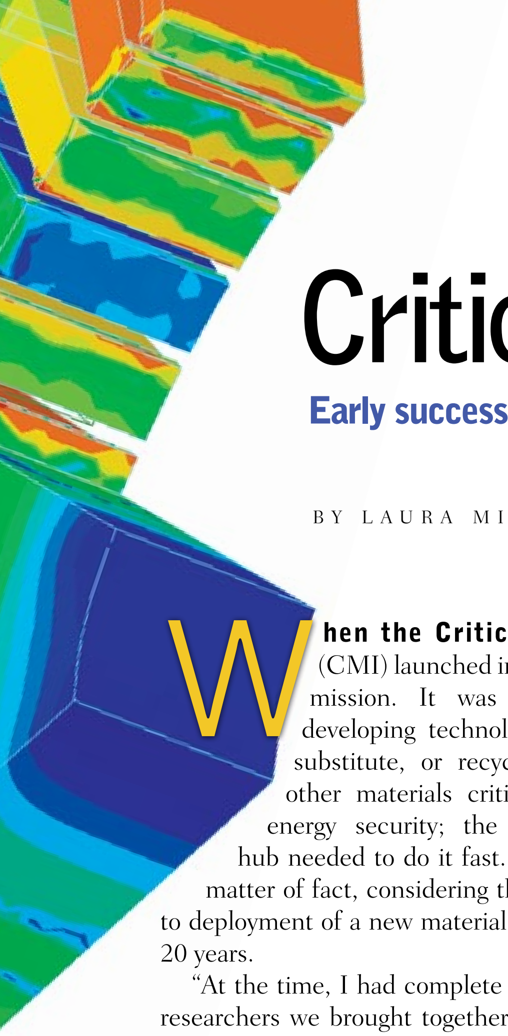
In a separate, but somewhat related project, a group of Ames Laboratory researchers will be working to characterize what happens to metal powders as they are processed into shapes through 3D printing processes. The goal is to be able to fine-tune the 3D printing process on the fly to maximize the properties desired for the particular piece being manufactured.

Ames Laboratory scientists Ryan Ott, Pete Collins and Matt Kramer will be working with colleagues at the Stanford National Accelerator Laboratory (SLAC) and Lawrence Livermore National Laboratory (LLNL) to develop both hardware and software to characterize the powders *in situ* as the advanced manufacturing process builds up complex shapes layer-by-layer.

"We'll look at analyzing powders in two types of systems, both powder feed and powder bed," said Kramer, who is also Ames Laboratory's Materials Science and Engineering program director. "Powder feed is like our LENS (laser engineered net shaping) system where powders are delivered via a nozzle and melted in place by a laser. Powder bed spreads a thin layer of the metal powders over the entire surface and a laser then melts only a portion of the powders in the particular shape needed."

The Ames Laboratory team is characterizing the commercial powders and developing the power feed system that can be used with the beam line at SLAC to analyze the powders as they are built up layer by layer via X-ray tomography and diffraction. LLNL is developing the powder bed system and high-speed imaging and thermal diagnostics. According to Kramer, the project will evaluate a wide range of commercial powders, including a titanium-aluminum-vanadium alloy commonly used in the aerospace industry. Funding for the project will come from DOE's Advanced Manufacturing Office with Ames Lab receiving roughly $1.2 million of the approximately $4 million project.

Ames Laboratory's LENS system creates complex, 3D shapes by depositing metal powders through the nozzles and simultaneously melting them with a laser.



Critical Materials Institute:

Early successes lead to new and bigger challenges

BY LAURA MILLSAPS

When the Critical Materials Institute (CMI) launched in 2013, it had an audacious mission. It was not only charged with developing technologies that could diversify, substitute, or recycle rare-earth metals and other materials critical to the nation's clean energy security; the DOE energy innovation hub needed to do it fast. Mind-bogglingly fast, as a matter of fact, considering that the traditional timeline to deployment of a new material or process is usually 18 to 20 years.

"At the time, I had complete faith in the abilities of the researchers we brought together. They truly were the best and the brightest at what we're doing here," said CMI Director Alex King. "But it was unknown whether we could really work as a team, get sufficient buy-in from industry leaders and move quickly enough to get where we needed to go."

A little over three years, 47 invention disclosures, and multiple industry partnerships later, the hub has been basking in the DOE's and legislators' praise. Part of the secret, King said, is a combination of computational theory, high through-put experimentation, and close collaboration with industry partners.

"A great deal of our progress hinges on deciding what not to do," King said. "Abandoning ideas that are impractical, too time-consuming, too expensive, or of too little interest to industrial partners, who are the people who take the research from the lab bench and actually make it go."

Tom Lograsso, one of four research team leaders at CMI and Ames Laboratory's deputy director, agrees that the right methodology has proven successful, using just one example from his own research team.

"I think we've demonstrated the use of tools that allow us to be highly responsive, and phosphors are my poster child for that," Lograsso said. "We went from having no substitutes to having two green and one red phosphor for long tube fluorescent lighting. We discovered which phosphors have not only the appropriate fundamental properties, but also the manufacturing characteristics that allowed them to be currently in manufactured products. To do this all in slightly more than three years is phenomenal, and we've now got a stretch goal to find red and green phosphors for LED lighting within the next two years."

CMI Critical Materials Institute
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CMI researcher Nerine Cherepy, from Lawrence Livermore National Laboratory, displays phosphors developed to use far less rare-earth oxides than in current fluorescent lighting technology. CMI researchers' next goal is to develop red and green phosphors for LED lighting.

With a just a little under two years left in CMI's 5-year funding cycle, the DOE asked the hub to challenge itself even further, and its researchers responded with eight new, more specific and more challenging goals.

- Produce a neodymium-iron-boron magnet using materials and technologies located entirely within the United States.
- Discover a new permanent magnet that rivals neodymium-iron-boron magnets in performance, using reliably available elements.
- Develop a commercial product based on an aluminum- and cerium-based casting alloy.
- Develop a working, inexpensive, bulk-scale, exchange-coupled spring magnet.
- Design a new permanent-magnet motor with optimized system performance.
- Discover new red and green phosphor candidates suitable for use in LED lamps.
- Demonstrate hard disc drive disassembly rates exceeding 5,000 per day, to speed recovery of magnets for recycling or re-use.
- Scale up the supercritical fluid process for dissolution, separation of dissolved components, and refinement of separated critical elements, from milligram to kilogram quantities.

Of these, King mentioned in particular the challenge of developing an exchange-coupled spring magnet, a theoretical idea in which two different magnets are combined at the nanometer scale that creates a magnet with the best properties of both, rather than just their average. While they've been created in the lab on a small scale, CMI proposes to create ones that could be made on a bulk scale and large enough for applications like motors.

"That's going to be a hard one, no doubt about it, but we believe we have some insight now with our three years of research experience that will help guide us in pursuit of this goal," said King.

Other magnet discoveries remain in this list of goals as well, including new permanent magnets that use less critical materials.

"To find a new magnet that rivals the most powerful magnet is a challenging task; it's been 45 years since NdFeB magnets were discovered," said Lograsso. "If it was easy, we would have had something by now. But we have some promising leads on magnets that may fill a gap between weaker magnets and the most powerful ones, applications where we're currently using stronger magnets than we need to be. We are also working on refining the processing of magnetic materials we already do have, through things like additive manufacturing and magnetic field treatments."

Postdoctoral researcher Helena Khazdozian reviews a technical presentation on permanent magnet motor design. One of CMI's eight research goals aims to integrate permanent magnet development with motor engineering design as a means of optimizing both.

Another notable goal takes CMI in a slightly new direction, designing a new permanent magnet motor.

"We are asking ourselves: if we could make a magnet any shape we want, what kind of motor could we design with it?" said King. "It's a matter of combining magnet design with motor design, instead of treating them as entirely separate challenges."

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"It's taking the design of magnets to the systems level, so it's more of an engineering goal rather than fundamental science, but it's completely in keeping with CMI's goals," said Lograsso.

King and Lograsso both consider the new goals high-risk, but ultimately obtainable.

"We took a hard look at where we've been, and the places we're most likely to cross the finish line in the time left, and from there we developed these more specific goals," said King. "We believe with industry informing our research decisions, we've got the right strategy to meet success."

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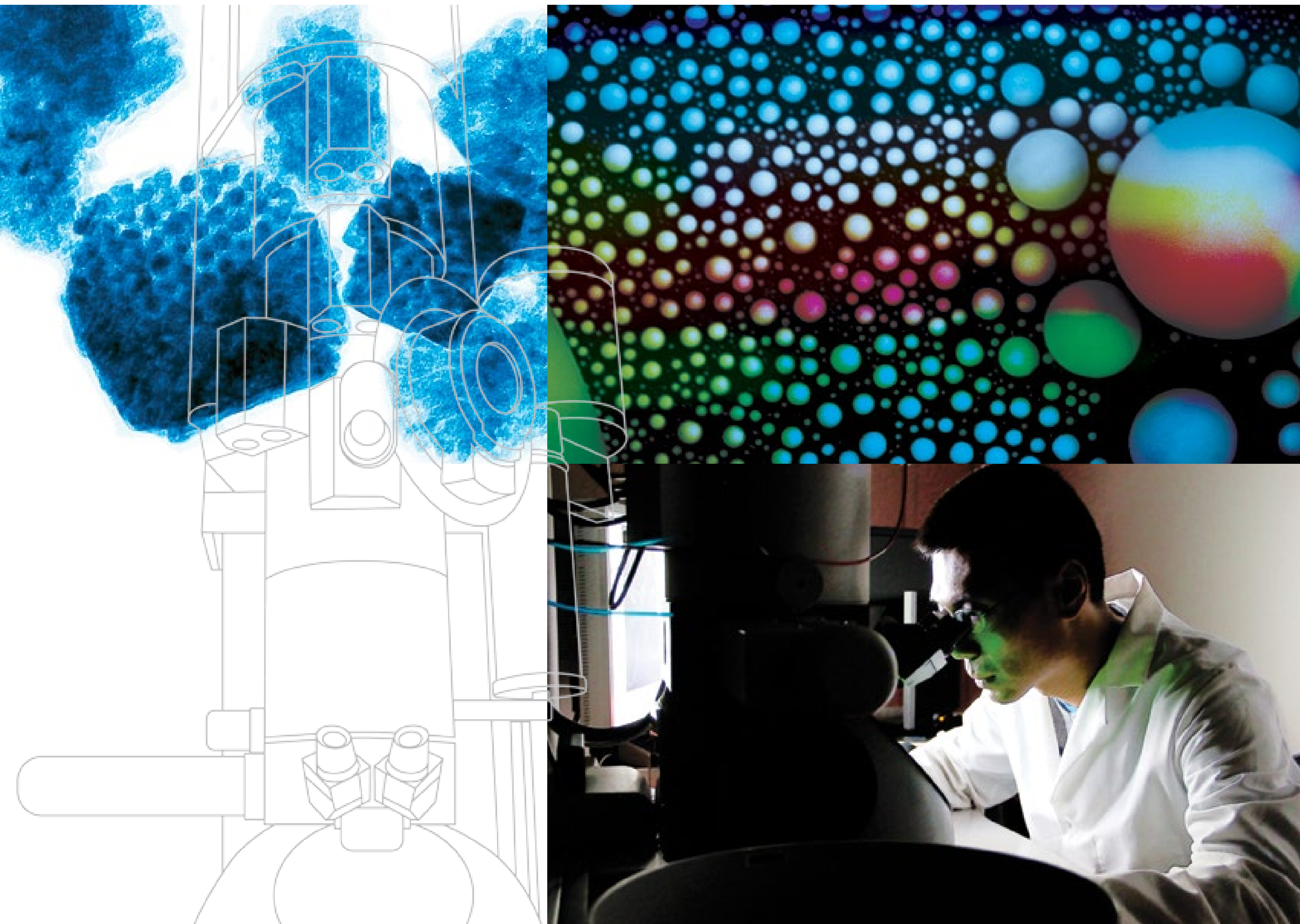

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