Science & Technology at the Ames Laboratory

inquiry

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Issue 1

The Critical Materials Institute is Born

CMI | Critical Materials INSTITUTE

THE Ames Laboratory
Creating Materials & Energy Solutions
U.S. DEPARTMENT OF ENERGY

inquiry

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The 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 Lab 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

The Ames Laboratory in Transition

This is an exciting time for Ames Laboratory! In January, we were notified that we had submitted the "winning" proposal to operate the DOE's latest Energy Innovation Hub that will focus on critical materials. Ames Laboratory and its partners, a combination of national laboratories, university and industrial researchers, are working to launch the Critical Materials Institute, a $120-million, five-year program focused on technologies that will make better use of the materials we have access to, as well as eliminate the need for materials that are subject to supply disruptions.

From its beginning, Ames Lab has focused on developing and processing critical materials. Its six-decade-plus history of working with a group of materials called the rare earths has resulted in expertise that covers the entire materials life cycle. In this issue of Inquiry, we highlight the Critical Materials Institute, what the various partners bring to the table and how the institute will work to advance new materials and technologies to make them available to meet the country's energy needs.

In landing the Critical Materials Institute, Ames Laboratory is experiencing a somewhat unanticipated change in leadership. Ames Laboratory Director Alex King has elected to step down from that position in order to devote his full-time efforts to leading the CMI.

I have been appointed to temporarily serve as Ames Lab's director, and it is an honor to have the opportunity to serve the Lab through this leadership transition period.

Over the past few years, the Lab has seen its scientific programs steadily strengthen as research programs in both fundamental sciences and applied technologies have expanded. The visibility of the Laboratory's research and its scientific impact has increased within DOE and around the world. DOE is addressing Ames Laboratory's need for a building to house our most sensitive scientific instruments.

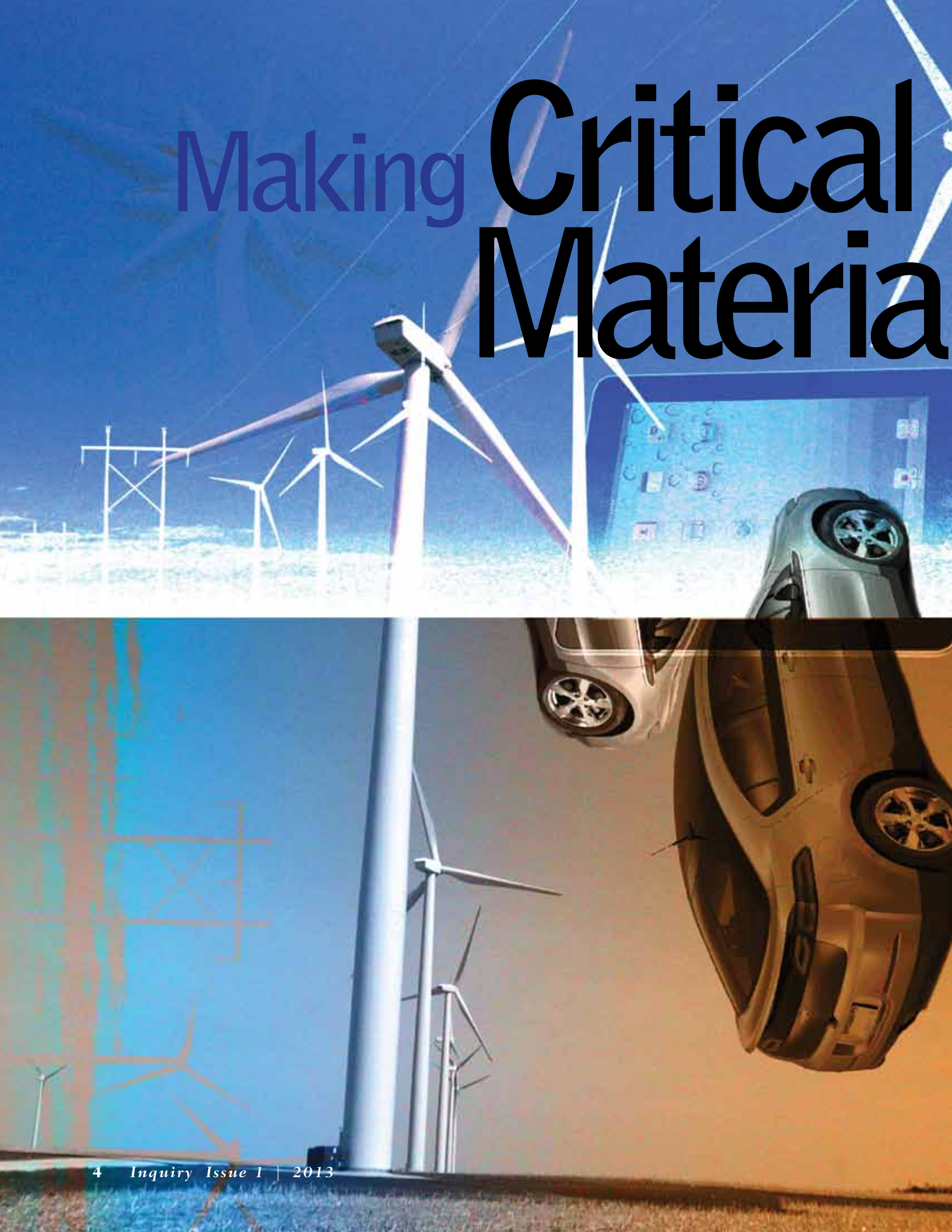
During this transition period, we face several challenges over the next year. First and foremost is the search for and selection of a new laboratory director; second, the launch of the Critical Materials Institute; and third, to maintain the current momentum of our core programs.

> The visibility of the Ames Laboratory's research and its scientific impact has increased within the Department of Energy and around the world.

I will focus my efforts in these areas as well as several other ongoing efforts, including the completion of the Sensitive Instrument Facility; developing plans for the conceptual design of a new building for our computational efforts; and continuation of the acquisition of state-of-the-art characterization equipment, which is essential for Ames Laboratory to continue its scientific leadership in key areas. Clearly, these are exciting times for the Ames Laboratory.

Tom Lograsso, Interim Director

Making Critical Materia



BY KERRY GIBSON

IS Less Vital CMI | Critical Materials Institute

It's not surprising that nearly all of today's advanced technologies rely on equally high-tech materials. Whether it's the cellphone in your pocket, the hybrid car you drive, or the wind farm down the road that generates your electricity, there are certain materials that are critical to making those various technologies work.

It's also a simple truth that most of those critical materials, particularly the rare-earth elements, are currently produced in China. Starting in the 1980s, a combination of accessible raw materials, cheap labor and less stringent environmental controls allowed China to develop a monopoly as the supplier of 95 percent of the world's rare-earth market. However, China is moving from being an exporter of raw materials to using those raw materials itself to produce the finished goods and has reduced rare-earth export quotas in the past two years.

What are Critical Materials?

To address this looming economic threat, the U.S. Department of Energy conducted a study and released the Critical Materials Strategy report in December of 2011. That report examined the role rare earths and other materials play in clean energy technologies, such as wind turbines, electric vehicles, solar cells and energy efficient lighting. The report found that several clean energy technologies use materials, particularly the rare earths dysprosium, neodymium, terbium, europium and yttrium, which are at risk of supply disruptions in the short term, perhaps as early as 2016. The DOE listed these materials as "critical" materials. Two others, lithium and tellurium, were identified as being "near critical" materials.

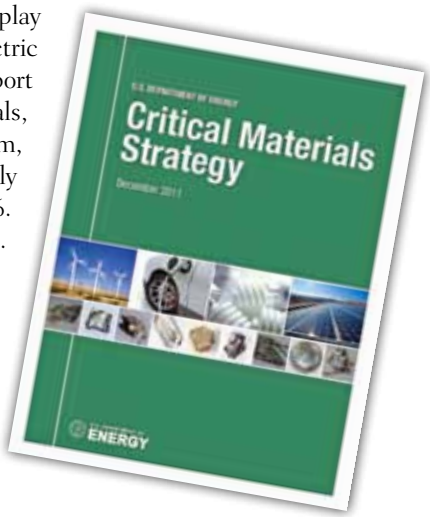
In response to the report's findings, DOE proposed establishing a Critical Materials Energy Innovation Hub in May 2012 "to reduce materials criticality, prevent criticality of new materials that are essential for energy technologies and coordinate research and development across the entire materials lifecycle."

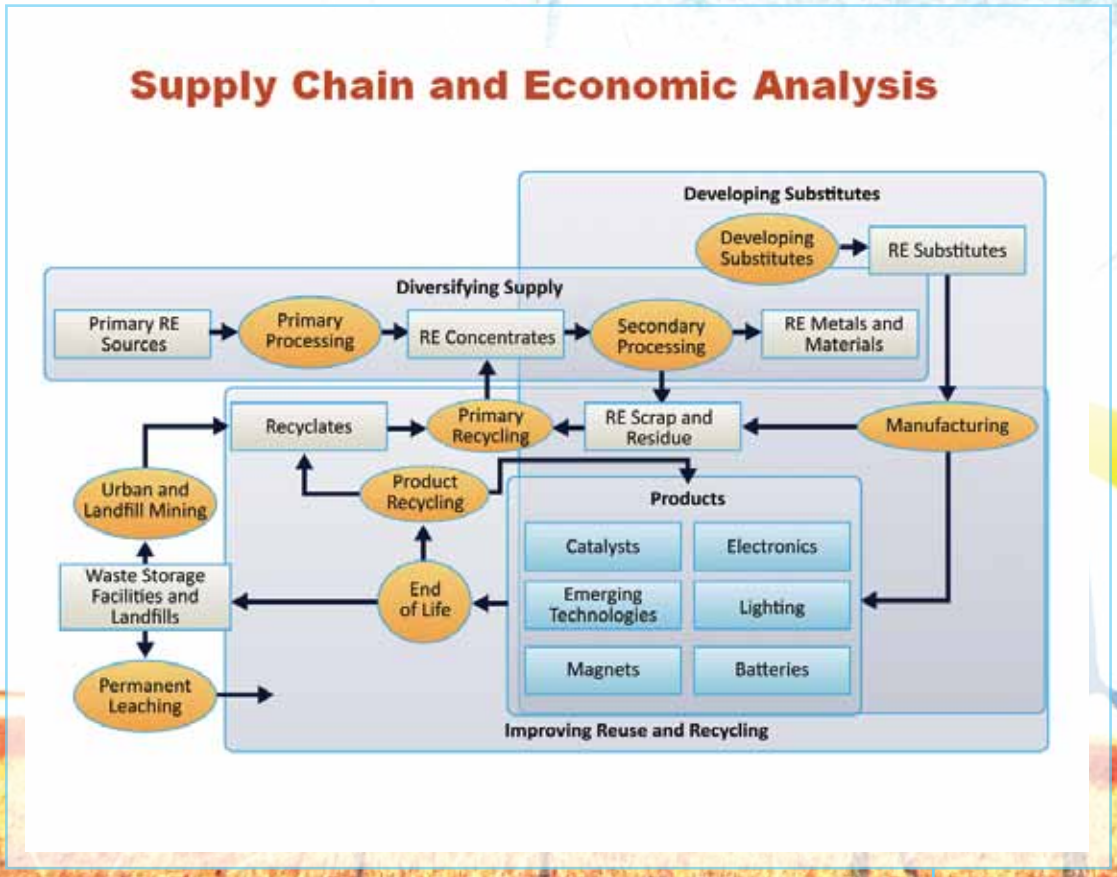
Like the other Innovation Hubs established to address solar energy, improved nuclear reactors, better batteries, and energy-efficient building design, the Critical Materials Hub would be a major integrated research center. Researchers from many different institutions and technical backgrounds would work collaboratively in a team setting modeled after the Manhattan Project.

The CMI is Born

In January, after a competitive grant proposal process, DOE announced that a group led by the Ames Laboratory was selected for this latest innovation hub, receiving $120 million over five years.

Besides the Ames Laboratory, the team includes partners from three other national laboratories – Idaho National Laboratory, Lawrence Livermore National Laboratory and Oak Ridge National Laboratory – and seven universities – Brown University, Colorado School of Mines, Purdue University, Rutgers University, University of California-Davis, Iowa State





University, and Florida Industrial and Phosphate Research Institute. Industry partners include General Electric; OLI Systems Inc.; SpinTek Filtration Inc.; Advanced Recovery,; Cytec Inc.; Molycorp Inc. and Simbol Materials. (See Partner Profiles on page 8).

CMI Director Alex King summarized the job of the Critical Materials Institute as helping the United States avoid the impact of materials criticality by doing four things:

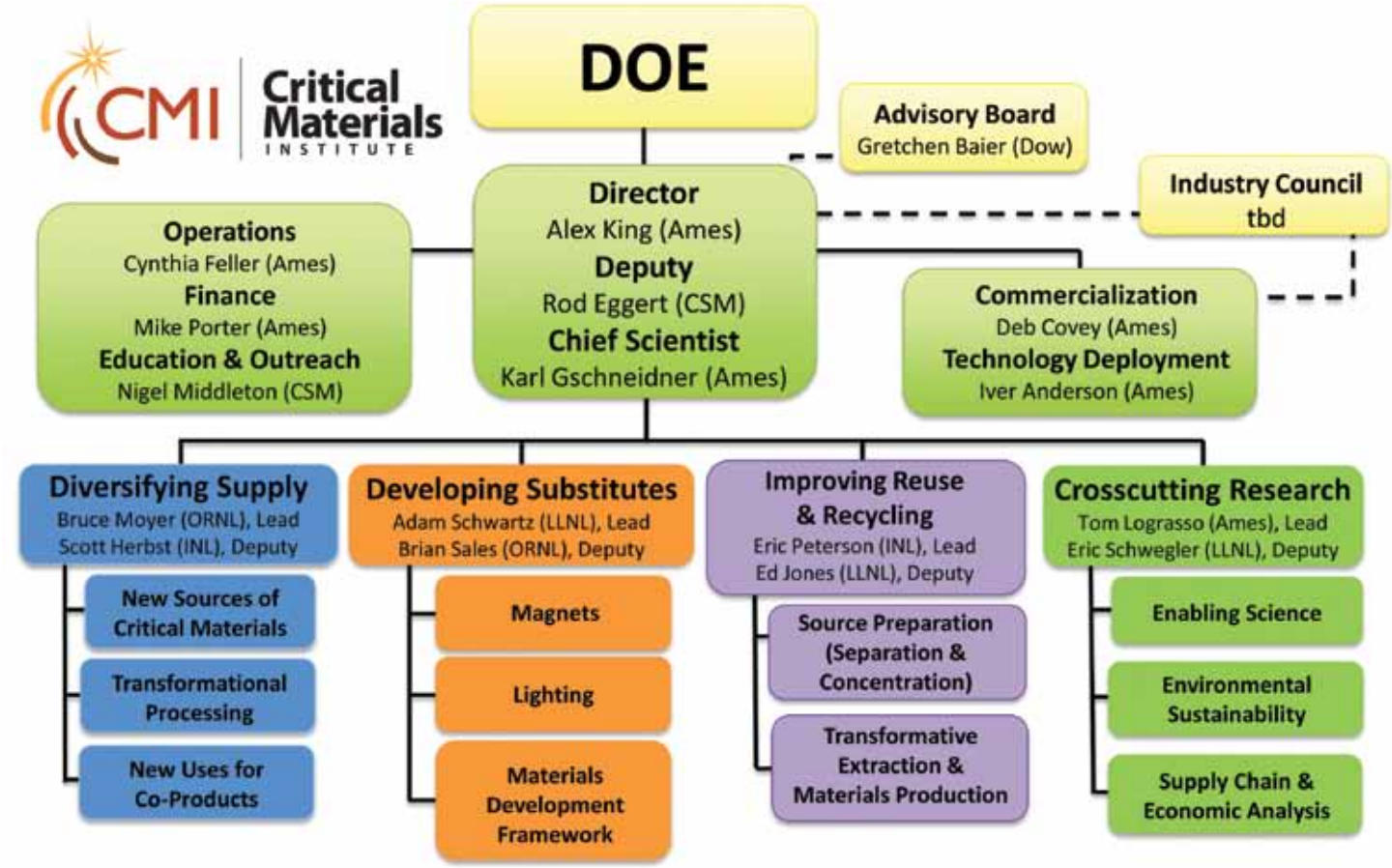
- Diversifying supplies. If one source goes offline, other sources would be available.
- Developing substitute materials that can meet needs without using the materials in use today.
- Developing tools for recycling materials that are needed.
- Forecasting what materials might become critical in the future.

The CMI has research teams in each of those areas. Bruce Moyer, group leader of Oak Ridge National Laboratory's Chemical Separations Group, is heading up the diversification efforts. Adam Schwartz, Condensed Matter Physics Division Leader at Lawrence Livermore National Laboratory, will lead the team search for substitute materials. Recycling efforts will be led by Eric Peterson, who is involved in polymer research and heads the Process Science and Technology Business Line at the Idaho National Laboratory. Ames Laboratory interim director and crystal growth expert Tom Lograsso will lead the crosscutting research team, which includes supply chain and economic forecasting. (Turn to page 12 to hear how each of these leaders expects to address their part of the overall puzzle.)

Think Tank Approach

"We'll be taking a 'think tank' approach to critical materials," King says, "which is a departure from the traditional approach to materials research. We'll be looking at the entire **supply chain** and how each of these areas affects the others and the end result as well as assessing changing needs and market forces."

That includes closer than usual collaboration with the other innovation hubs and research centers throughout the country and the world. Such collaboration is mandated by the Federal Critical Materials Coordination Council, an offshoot of a larger federal government effort aimed at improving the effectiveness of scientific research through dissemination of information and coordination of research efforts.



"Communication, particularly between the various innovation hubs, will be vital," King says. "For example, if the battery technology hub identifies a particular material that's necessary to bring a new, more efficient battery to market, we'll be involved in looking at that material's criticality and how to address those issues. We'll constantly review and shift resources to where we can get the most bang for the buck."

In addition to the teams mentioned, CMI will also have an educational/outreach component, headed up by Nigel Middleton, Colorado School of Mines Senior Vice President for Strategic Enterprises. Chief scientist is Ames Lab senior metallurgist Karl Gschneidner Jr., a recognized international expert on rare earths. Gschneidner's testimony before a House subcommittee in 2010 helped bring attention to the issue of materials criticality (turn to page 15 to read more about Gschneidner).

And helping move technologies or innovations from the lab bench to industry will be Ames Lab's Associate Director for Sponsored Research Administration Debra Covey and Ames Lab senior metallurgist Iver Anderson. Ames Lab has a proven track record as a top producer among the national laboratories in terms of patents and the generation of royalty income. For example, Anderson's lead-free solder formula was patented worldwide by more than 60 companies and generated well over $35 million in royalties.

Ames Lab will also provide general support staff and administration of the Institute will take place in Ames.

"The CMI has a number of different partners, but the Ames Laboratory rose to the leadership position because it is uniquely qualified in the most critical materials of the day," King explains. "The Ames Lab has a six-decade history of working with a group of materials called the rare earths. It has expertise that covers the entire materials life cycle. The CMI protects the current technologies that everybody seems to rely on today, and new technologies that may emerge."

CMI Partner Profiles

Brown University

Brown University will be responsible for chemical synthesis of highly coercive nanomaterials for nanomagnetism studies and for nanomagnetic applications. The Brown researchers have been leading the research efforts in chemical synthesis of monodisperse magnetic nanoparticles and their self-assembly for magnetic applications. They have demonstrated the potential in using their chemical methods to produce highly coercive iron-platinum and samarium-cobalt nanoparticles. CMI support will allow them to continue their search for the right chemical syntheses that can lead to the formation of hard magnetic rare-earth metal based or other new kinds of hard magnetic nanomagnets.

University of California, Davis

Understanding thermodynamic stability and chemical stability is the key to improving the extraction, processing use, and reuse of critical materials. Professor Alexandra Navrotsky and the Peter A. Rock Thermochemistry Laboratory at the University of California, Davis provide world-unique capabilities for measuring the energetics of formation of solid materials including rare-earth and lithium-ore minerals and manufactured ceramics, including materials for batteries and other applications. High-temperature oxide melt solution calorimetry will be used to determine such properties that are crucial to new processes and applications developed by the CMI.

Colorado School of Mines

Founded in 1874, Colorado School of Mines is a small university with some 5,000 students and 300 faculty members. Mines emphasizes engineering and the applied sciences, with a special focus on earth resources, energy, and the environment. Perhaps better known overseas than at home, it is one of the few universities in the world with broad expertise in the exploration, extraction, production, and use of mineral and energy resources. Mines has strengths in mineral processing and extractive metallurgy, recycling, materials characterization, educational programs and outreach, and economic and policy analysis.

Florida Industrial and Phosphate Research

Since its inception in 1978, the Florida Industrial and Phosphate Research (FIPR) Institute has funded/conducted more research on phosphate mining and processing than any other institution in the world, including 110 projects on minerals separation, 122 projects on chemical/metallurgical engineering and 138 projects on public health and the environment related to phosphate mining. FIPR is a leader in comprehensive recovery of energy values from phosphate, such as uranium and rare earths, and in sustainable development of phosphate resources by developing uses for byproduct phosphogypsum and wastes, such as tailings.

Cytec

Cytec Industries Inc. helps the mining industry meet complex metallurgical, economic, safety and environmental challenges through innovative technologies and superior technical service. Cytec delivers leading chemical technologies for solvent extraction, flotation and alumina processing-innovations powered by a history of value creation for its customers. Cytec's understanding of the end users will be a valuable contribution to the development and deployment of new technologies led by CMI. Cytec's major role is to lend its commercialization perspective to support CMI's mission of eliminating the criticality of materials for clean energy technologies.

GE Global Research

GE Global Research works on a wide range of projects in support of all of GE's businesses. The team comprises virtually every technical discipline and works on projects ranging from basic R&D to product engineering to manufacturing scaleup and technology transfer. GE Global Research has a proven record of moving technologies across the "valley of death" and into commercial production. From rare-earth elements to advanced superalloys, critical materials play an essential role in the manufacturing and function of many GE products. As an industrial member of the CMI, GE Global Research looks forward to bringing its technical expertise and experience in transitioning technologies from the lab to the manufacturing plant floor and ultimately to the marketplace to this important challenge.

Idaho National Laboratory

Idaho National Laboratory will lead the recycling and recovery focus — developing better chemical separation methods in collaboration with both the recycling and mining industries. INL will apply its long history of expertise in effectively separating lanthanides from complex mixtures to recycle rare-earth and other critical elements from discarded electronics. The team will develop and test new processing methods that selectively recover critical metals using supercritical fluids, membranes and electrochemical approaches. These advanced separation techniques might also help mining operations by boosting extraction from raw ore.

INL also will work on biological and geochemical approaches to improve extraction of critical elements from ores and waste streams. Finally, INL has significant roles in environmental research related to wastewater processing and in economic analyses of processes developed throughout the CMI.

Oak Ridge National Laboratory

Oak Ridge National Laboratory will use its expertise in separation science, material synthesis, characterization, and process technologies to develop new technologies that result in increased diversity of critical-materials sources. ORNL will help discover more economical processing of ores and minerals, more efficient means of processing pure materials for manufacturing, and find new uses for other, more abundant materials.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory is a national security laboratory with internationally recognized expertise in materials development, characterization and testing, and high-performance computing. LLNL will contribute expertise in validated predictive capabilities, materials synthesis, advanced and in situ characterization and testing, and additive manufacturing. LLNL and its partners will create a permanent magnet with properties equivalent to the best magnets available, but using 20 percent of the rare-earth content, and will develop new phosphors for fluorescent lamps that significantly reduce the content of the least available rare-earth elements. LLNL will also create a quantitative framework for cost-efficient material development that includes a materials design simulator for efficiently prototyping of rare-earth-based alloys.

OLI Systems

OLI Systems is bringing simulation expertise to the CMI. OLI specializes in the prediction of thermodynamic and thermophysical properties of complex systems that contain electrolytes in bulk solutions and at interfaces. OLI software provides accurate simulations of separation processes, corrosion phenomena, oil and gas scaling, and materials synthesis conditions.

OLI's thermodynamic models will be expanded to predict the properties of systems containing rare-earth metals and other critical components in aqueous and nonaqueous environments. OLI Systems will work with other CMI partners to develop customized thermodynamic prediction methodologies to address the simulation needs of CMI.

Rutgers, the State University of New Jersey

The Riman research group at Rutgers, The State University of New Jersey will lead the thermochemistry effort, which includes OLI Systems, UC Davis and various CMI scientists. The objective is to create a validated database of thermodynamic properties, which will be part of a conglomerate that also includes structural, physical and electronic properties compiled by the CMI. Another major objective of this thermodynamics thrust is to translate its relevance to problems being solved by the CMI. To this end, Professor Richard Riman will draw on his extensive background in rare-earth-based materials, solution chemistry, thermodynamics, and translation of experimental research to practical application in industry.

Advanced Recovery Inc.

Advanced Recovery Inc. is a recycling company dedicated to meeting the environmental challenges of the future with a world-class organization. ARI provides recycling services to manufacturers, developers, governments and financial institutions.

Molycorp

Molycorp is one of the world's leading rare earths and rare metals companies, combining a world-class, rare-earth resource at Mountain Pass, Calif., with world-leading ultra-high-purity rare earth and rare metal materials processing capabilities.

Purdue University

Purdue offers educational programs in manufacturing, design and analysis of material lifecycles. Purdue is a leader in advanced manufacturing for critical materials and offered one of the first national courses in critical elements.

Simbol Materials

As a sustainable materials technology company, Simbol Materials brings choice to the clean technology and contemporary industries. Simbol offers a stable and secure source of high-purity materials that are critical for production of high-performing electric vehicle batteries and other energy storage devices. Simbol actively contributes to the advancement of green technologies, including the work of CMI.

SpinTek Systems

SpinTek Systems has over 30 years' experience with membrane filtration systems and over 14 years' experience with rotating membrane systems that it will bring to the CMI. SpinTek is a leader in providing filtration separations for industrial wastewater applications.

CMI Leadership

Alex King

Director, Critical Materials Institute

Professor, Department of Materials Science and Engineering, Iowa State University

What's the potential of the Critical Materials Institute?

There are many different answers to that question. CMI will assure secure supply chains of materials that are essential for clean energy technologies, such as hybrid vehicles, wind turbines, efficient lighting systems, energy storage, etc. It will also boost the supply of expertise in all of the technical areas required to secure those supply chains. It will be an information resource for researchers, industry and policy makers. And it will work to coordinate efforts with other federal programs on critical materials, both within and beyond the Department of Energy. CMI has the potential, through all of these efforts, to ensure that the United States can be a leader in the manufacture of clean energy technologies.

How will the leadership team function?

CMI has an incredibly talented leadership team and some wonderful consultative bodies that have been working together for over two years, first setting out its agenda and then working together very intensely to prepare the proposal that led to the award of the funds for the Hub. Since the selection, we have been joined in our work by several enthusiastic and motivated folks at DOE HQ, too. My role is to ensure that these groups talk to each other, and listen to each other, too, so we make effective decisions about the use of the resources that we control. I have to make sure that the research projects all stay on track, and I also get to be the spokesperson for the group on most occasions. It's challenging, but the directorship of the Ames Lab is probably as good a preparation as there might be for the job. Even with all of those things going for us, we are still going to be making this up as we go along to some extent. We'll see just how flexible we can be.

Rod Eggert

Deputy Director, Critical Materials Institute

Professor and Division Director, Division of Economics and Business, Colorado School of Mines

What's the potential of CMI?

CMI has the potential to accelerate scientific and technical innovation in the area of clean energy technologies. Without solving the challenges of critical materials, development might otherwise be stalled because of fears of the unavailability or price volatility for essential raw critical materials.

How will collaboration among the different areas and partners work?

The most important part of collaboration is communication. We will establish formal mechanisms for communication, as well as informal opportunities through which we hope communication will occur. In addition, crosscutting research on supply chain and economic analysis provides an opportunity for collaboration. This analysis, among other things, will provide the broader context in which to understand technical CMI research, allowing CMI researchers in one area (say, process engineering) to understand how work in another area (say, materials design) fits into a bigger picture.

Karl Gschneidner Jr.

Chief Scientist, Critical Materials Institute

Scientist, Ames Laboratory, and Distinguished Professor, Department of Materials Science and Engineering, Iowa State University

What's the potential of CMI?

The potential of CMI is enormous. Our nation has an immense challenge facing us in getting our rare-earth industry to be competitive with the Chinese and the rest of the world. Other problems we are facing are reducing our reliance on some of the most critical rare earths (for example, dysprosium, terbium and europium), by finding substitutes, or ways to decrease the amount of these elements in applications, such as reducing the amount of dysprosium used in high-strength neodymium-iron-boron magnets.

How will collaboration among the four focus groups help CMI reach its goals?

An interesting type of collaboration will exist between the CMI's Crosscutting Research focus area and the other three focus areas, since most of the information obtained in the Crosscutting Research focus area will be fed into research being carried out in the Diversifying Supply, Developing Substations, and Improving Reuse and Recycling focus areas. Conversely, when information or experimental data are required, scientists in a given focus area will contact the appropriate scientists in the Crosscutting Research area to get the help and information needed.

In addition, collaboration with the scientists at universities or national labs and engineers in industry is critical, especially to keep research on track, because the CMI was funded to ensure that U.S. industry is competitive with the rest of the world and to overcome some of the problems and shortcomings that placed materials in such a critical state. And, of course, the cooperation, joint research, and collaboration with the academic and national laboratory partners will be vital to move CMI forward to reach its goals.

Bruce Moyer

Focus Area Leader in Diversifying Supply, Critical Materials Institute

Group Leader, Chemical Separations Group, Oak Ridge National Laboratory

What will the Diversifying Supply area do?

We'll take a three-pronged approach: enabling the economical processing of new types of ores and minerals; increasing the efficiency of processing ores and conversion to pure materials for manufacturing; and finding new uses for more abundant metals that are co-mineralized with critical elements in ores.

What's the potential of CMI?

CMI really addresses an ongoing problem faced over the ages by human engineering, namely maintaining stable supplies of materials even as demand constantly changes. So, beyond the really cool research we have planned for the next five years, the grander vision of promoting the sustainability of material life cycles will make being a part of CMI most rewarding.

Adam Schwartz

Focus Area Leader in Developing Substitutes, Critical Materials Institute

Division Leader, Condensed Matter Physics, Lawrence Livermore National Laboratory

What will the Developing Substitutes focus area do?

The Developing Substitutes area will develop a substitute permanent magnet that exhibits properties similar to current magnets, but contains less rare-earth elements; create new phosphors that eliminate europium and terbium from fluorescent lamp phosphors; and construct a closely coupled theoretical and experimental framework that accelerates the invention and deployment of new substitute materials at a reduced cost.

What's the potential of CMI?

The CMI has assembled an amazing team with all the qualifications to make great strides toward eliminating the criticality of materials. The rare earths are highest on our priority list at this time. I'm confident that, as a team, we can substantially improve the processing to obtain rare-earth elements more efficiently, reduce the usage of the rare earths through substitute materials, and improve our processes for material reuse and recycling.

Eric Peterson

Focus Area Leader in Improving Reuse and Recycling, Critical Materials Institute

Head, Process Science and Technology Business Line, Idaho National Laboratory

What will the Improving Reuse and Recycling area do?

We will develop efficient approaches to recycling and reuse of critical-element-containing materials that range from electronics and magnets to fluorescent light bulbs. The Improving Reuse and Recycling area initially will address developing efficient approaches to recovery and reuse of rare-earth elements contained in magnets, fluorescent light bulbs, and electronics utilizing novel methods that enhance current approaches to elemental recovery that include solvent extraction, electrochemistry, pyrometallurgy and repurposing of materials.

What's the potential of CMI?

The CMI has huge potential to alter the direction of America's efficient use of resources, beginning with the rare earths and broadening to other materials as their supply chains become stressed. I look forward to both being a part of and leading a component of CMI because of the tremendous intellectual and engineering challenges that it presents, coupled with the opportunity to work with some of America's leading scientists and engineers.

Tom Lograsso

Focus Area Leader in Crosscutting Research, Critical Materials Institute

Interim Director, Ames Laboratory

What will the Crosscutting Research area tackle?

The Crosscutting Research focus area will concentrate on developing computational and experimental tools to assist projects in the other focus areas. These mechanisms will provide basic science tools for material discovery, design, synthesis and processing; methods to mitigate environmental concerns with new processing methods; and economic and supply chain analyses to ensure the solutions under development in the other focus areas are commercially and economically feasible.

What's the potential of CMI?

CMI has the potential to significantly impact the ability of the nation to restore a domestic supply chain for critical materials. A domestic supply is fundamental to our national security, energy security and consumer products industry.

Chief Scientist, Chief Advocate

BY LAURA MILLSAPS

Karl Gschneidner's rare-earth advocacy gathers strength in form of research institute

Karl Gschneidner Jr., chief scientist of the Critical Materials Institute, feels vindicated by the newly created Department of Energy research hub. The CMI will address solutions to domestic shortages of rare-earth materials through a collaboration of academia, national laboratories and industry. It's an idea that Gschneidner has been steadily and vocally promoting the last four years.

"This was government listening and responding," says the senior metallurgist with Ames Laboratory and a 61-year researcher of rare-earth metals. "I jumped for joy when I heard the news about the Hub."

What began as a concern about the rare-earth materials supply for industries that relied on them — automobile, electronics, and defense technologies — emerged as a national energy and defense security challenge. Gschneidner claims no special insider predictions.

"I think awareness, including mine, evolved," Gschneidner says of the issue as it became apparent about four years ago to the western world that China, which produced 97 percent of the world's supply of rare earths, intended to export less and less in order to meet its own internal needs.

"It certainly wasn't a Eureka moment. I wasn't even in on it that early, really, because I'm a researcher. I'm not involved in the production end," he says. "But I remember meeting with some people in Washington who told me 'every single one of our weapons systems depends on rare-earth materials, and take a look at what's happening in China.' It was an eye-opener, I tell you."

Gschneidner started spreading the word and knew public education was foremost. Gschneidner has published 500 research papers over six decades studying a group of metals that most people have never heard of outside of their foggy memories of the periodic table in their high school science textbook.

"Europium, neodymium, gadolinium. The public is mostly unaware that these materials even exist," he explains. "But they use them in their cars, their electronics, and their computers every single day and they don't even know it. Consumers take these things for granted, but I think that is gradually changing with more media coverage of this issue."

Media attention to the issue garnered Gschneidner some high-profile press over the last five years, not only in industry publications like Magnetics Business and Technology, but also in magazines directed at mass audiences like National Geographic and Popular Mechanics.

"I talked to anyone who would listen," Gschneidner says of his message. Finally, in 2010, some of the listeners included members of the U.S. Congress House Subcommittee on Science and Technology. In his testimony, he urged legislators to invest in the scientific research and technology development needed to return the U.S. to rare-earth materials independence. He proposed a research center much like the Critical Materials Institute that emerged, finally, in 2013.

Gschneidner, long a part of the Ames Laboratory's international reputation in materials science, also believes it is the best place for that to happen.

"The Ames Laboratory's heritage in rare-earth metal research had a lot to do with being chosen to lead the Hub. It's certainly the reason why so many other organizations wanted to partner with us in our proposal. But I don't want to give the impression that the DOE simply handed it to us because of our reputation. It was a competitive situation. We will have to prove ourselves, and we will."

Karl Gschneidner Jr.

Gschneidner expects to play an advisory role in shaping the research goals of the Critical Materials Institute, but he declined to make predictions about the next big scientific breakthrough in rare-earth materials and processes.

"All I can tell you about the future is that it's here, now," he says. "It could go this way or that way, but you don't know until you have a breakthrough, and those often come in the most unexpected places. That's the fascination of science."

Gschneidner and other CMI leadership members have plans to make sure those breakthroughs become innovation, through revival of the Rare-earth Information Center, a service and publication of the Ames Laboratory that ceased in 2002.

"What we do at the Critical Materials Institute has to be shared. Basic research can't be left in a void; it needs to go to technical people who can say, 'hey, I can use that for this product or that process.' "

"That's what these research Hubs are for. Some of the projects will be successful. Some won't. But putting research dollars and scientific talent together in one concerted effort, that's going to bring us more progress than otherwise. The CMI is absolutely the best shot we've got."

Lucky Number 7

the Holy Grail of Technology Transfer

BY STEVE KARSJEN

WHEN IT COMES TO SUCCESS, IT SEEMS everyone envisions achieving a 10. But for the Critical Materials Institute, those who handle technology transfer at the Ames Laboratory would say a "seven" is a better barometer of success.

As it turns out, technology transfer success is built on a numbering system originated by NASA and adapted by the Department of Energy as a metric to help laboratories, such as the Ames Lab, universities and companies determine the right time to transition a technology into the marketplace. The system is called technology readiness level or TRL.

Debra Covey, associate laboratory director, and head of the Ames Laboratory's Office of Sponsored Research Administration, says the key TRL number is seven.

"Once a technology has reached a level seven, it's ready to be deployed to industry for prototype demonstration in an operations environment," says Covey. "You've taken it past bench scale and proof of concept to a prototype to be deployed."

That's significant for the CMI because its partners have already identified projects that have the potential to achieve TRL7.

"Some of these projects are at TRL2 or TRL3 right now, and we hope that in the next two to three years we'll see several of them being fast-tracked along to a TRL7 and then into the marketplace, TRL9," Covey says.

Many of the technology transfer concepts the CMI is ushering in are new for Ames Laboratory. For example, this will be the first time the Lab will have its industry partners "pull" technologies into their organizations rather than the Laboratory "push" them out into industry. Covey explains Ames Lab's approach has been to take the basic science research performed at the Lab, capture any intellectual property, and then search for an industry partner interested

> **"In essence, the CMI will be creating its own markets because it's focusing on projects that our partners have identified as addressing commercial needs."**
>
> *- Deb Covey*

> "The end result could be an exceptional payoff in terms of years cut from the research-to-product window."
>
> *- Deb Covey*

in developing it. Using the new model, the potential industry partners will already be in place by virtue of their existing participation in the CMI.

"In essence, the CMI will be creating its own markets because it's focusing on projects that our partners have identified as addressing commercial needs," says Covey.

The end result could be an exceptional payoff in terms of years cut from the research-to-product window. Based on the old model, for example, Covey says it took 10 years for lead-free solder to reach the marketplace. The CMI is hoping its model will reduce the window depending upon the technology.

CMI will also establish a commercialization council that will serve in an advisory capacity, making recommendations regarding intellectual property protection and licensing. This council will consist of technology transfer executives from all 18 team members.

And the Institute will create an affiliateship program, whereby companies, organizations or individuals can pay a membership fee that will allow them to have an earlier look at the research results and some of the new technologies coming out of CMI work. Already, Covey says, over 30 different entities have expressed an interest in potentially partnering with the CMI.

When asked to peer down the road five years and describe the CMI's technology-transfer picture, Covey predicts it will be a bright one, with several projects at TRL7 and the resulting technologies or innovations pulled into one or more companies.

Through this success, she hopes the criticality of certain materials is lessened or eliminated, and that CMI is making significant contributions to helping the Department of Energy accomplish its goals for clean, efficient energy sources.

Sharing the Story of Critical Materials

BY STEVE KARSJEN

It's no surprise that the Colorado School of Mines would be tagged as the partner to coordinate the Critical Materials Institute's education activities. Mines is internationally known for its expertise in resource exploration, extraction, production and utilization, all key focus areas of the CMI, as well as its strong research and education programs.

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"At Mines, we really understand the supply-chain, fundamental science and process engineering involved in going from extraction of ore containing critical minerals to preparing them as specialized feedstock materials for applications in advanced technologies," says Nigel Middleton, senior vice president for Strategic Enterprises at the Colorado School of Mines. "So it's only natural for us to be a leading player in the focus of the CMI and its agenda in education, training and outreach."

Nigel Middleton

Although efforts are in the formative stages, plans for the CMI's education programs and outreach will target three key audiences: students and researchers active within the CMI community, a broader community of scientists outside the CMI, and the public. The industry audience includes "those who are already working in the supply chain." For example, these people might be the target of three- to four-day education courses on topics such as rare-earth materials recycling, processing or upstream discovery as well as economics and evaluation.

The broader community outside the CMI includes students and researchers at government, industrial and academic institutions, including community colleges.

"This is where we spread our wings a bit further," says Barry Martin, who is the director of the Special Programs and Continuing Education (SPACE) office at Mines. Martin says CMI may offer internships for post doctoral researchers, exchange programs where students would work with faculty at other institutions, or distance education courses.

Barry Martin

One such course is the Chemical and Physical Metallurgy of Rare Earths (MSE 457/557X) which is already being offered by CMI partner, Iowa State University. Taught by Vitalij Pecharsky, Ames Lab senior metallurgist and ISU Distinguished Professor in materials science and engineering, the course, which began last year as both an on-campus student course and as a distance education course for researchers and industry representatives around the country, has moved from "experimental" status to being offered every other year beginning in 2014.

> " ... it's only natural for us to be a leading player in the focus of the CMI and its agenda in education, training and outreach."
> — *Nigel Middleton*

"Feedback on the course has been good," says Pecharsky.

Martin says CMI will also focus on educating the public on critical materials issues, mostly because of the political

> “The CMI will also focus on **educating the public** on critical materials issues, mostly because of the **political dynamics of the criticality of rare-earth materials** in this country. So the CMI might propose a lecture series on rare earths, focusing on elevating the **important role critical materials play** in our quality of life.”
>
> — *Barry Martin*

dynamics of the criticality of rare-earth materials in this country. So the CMI might propose a lecture series on rare earths, focusing on “elevating the important role critical materials play in our quality of life.

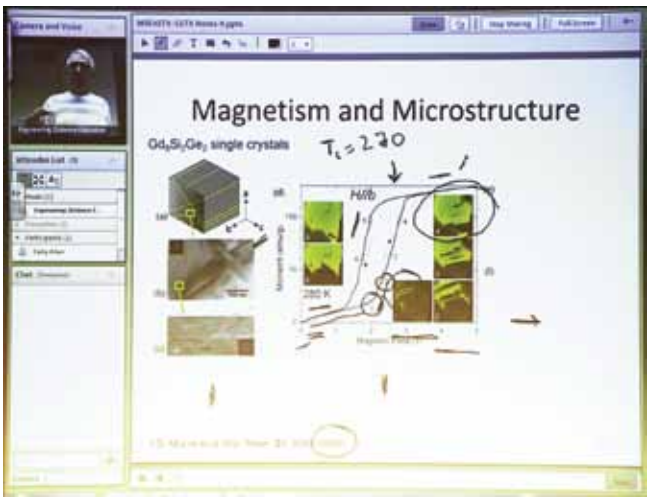
“Mines might even build upon its already-existing and popular Energy Minerals Field Institute and begin offering people opportunities to come to Colorado and participate in field site visits,” he says, adding he could also see working more closely with local governments to identify manufacturing opportunities and, thereby, build a “larger footprint for businesses.”

And looking down the road, Martin says a longer term education vehicle may be STEM (science, technology, engineering and math) efforts for the K-12 community. For example, CMI partners may contribute to curriculum development for teachers and students, or they may develop summer camps and materials’ bowls, which would test high school students’ knowledge in chemistry and metallurgy.

“Through our efforts, we hope to tie everything together and show how research turns into action,” says Martin. “It’s a great opportunity to tell the story of science.”

Vitalij Pecharsky

Pecharsky teaching Chemical and Physical Metallurgy of Rare Earths (MSE 457/557X) *at Iowa State University.*



Pecharsky offers the course both on campus and as a distance education course.

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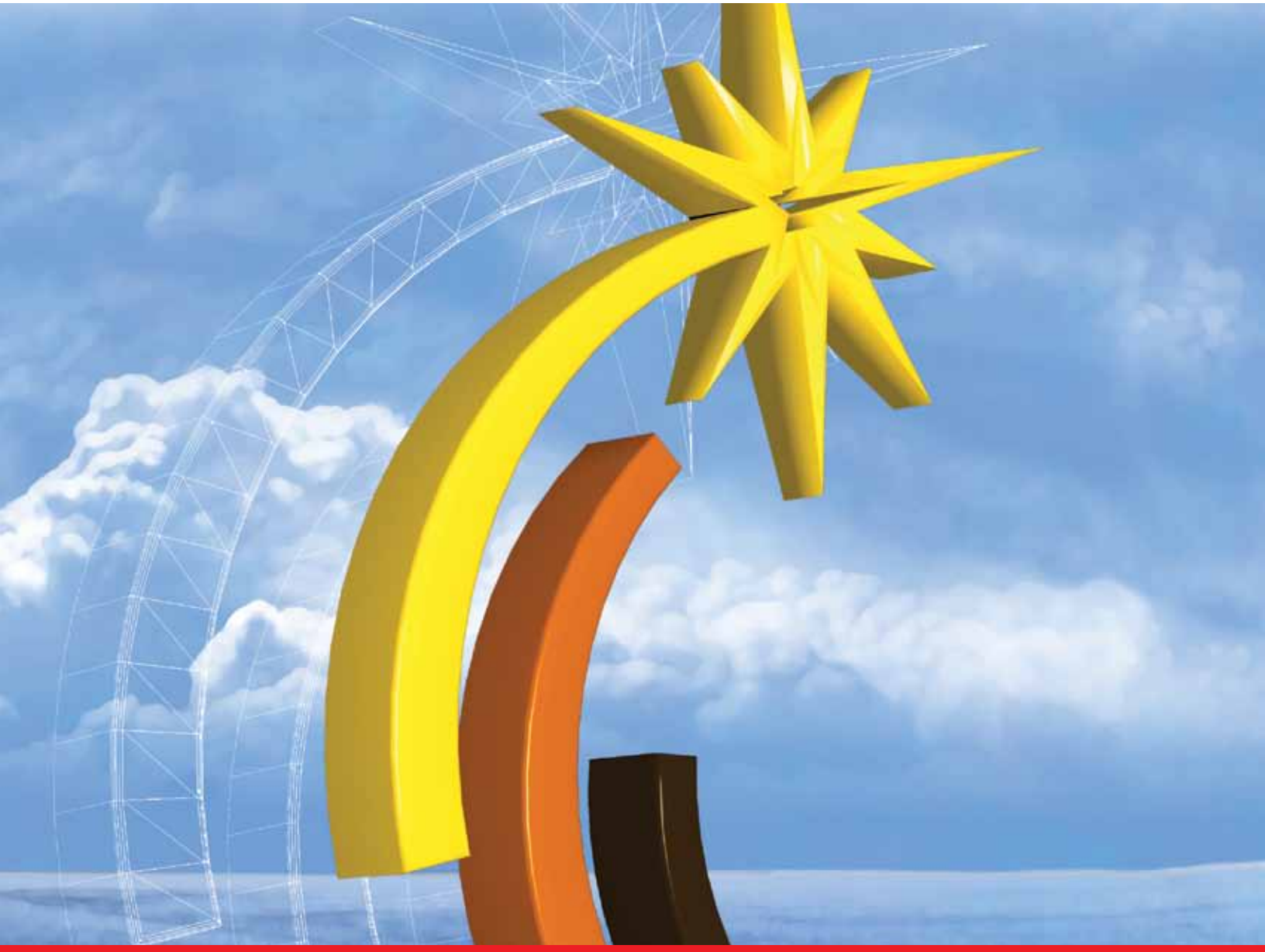

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