ARPA-E WORKSHOP

Rare Earth and Critical Materials

December 6, 2010 in Arlington, VA

Advanced Research Projects Agency-Energy | U.S. Department of Energy
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BACKGROUND

The workshop will consist of five plenary talks and four breakout sessions. The breakout sessions will be run concurrently in groups of two, with focuses on:

Supply / Material processing

Magnets and magnetic systems / motors and generators

Phosphors and general illumination

Catalysts and separators

Experts from across science and engineering will be brought together to identify possible new approaches and pathways to addressing technical challenges in critical materials across these fields.

SUPPLY / MATERIALS PROCESSING

BACKGROUND

Existing availability of rare-earth materials is limited by the processing of these materials into usable form (elemental metal, oxide etc) from known deposits. Existing process technologies are based on acid-alkaline chemical processes followed by solvent extraction to yield elemental species separation. Commercial scale acid-alkaline processes use large quantities of reagents. As a result, environmental and cost considerations for processing rare-earth materials have been prohibitive, particularly in developed nations. Environmental impacts are significant with more tangible costs in developed nations. Pathways to new rare-earth materials processes, which have minimized environmental impacts, are of high interest for discussion and examination in this workshop.

The rare earths are rather challenging to separate chemically as the latent heats of oxide formation are nearly the same between rare-earth elements. Further, solubilities of rare-earth ions in solution and separation coefficients are very similar for most solvents. Rare earths elements may often be separated into light (lanthanum, cerium, neodymium, praseodymium) and heavy (terbium, europium lutetium, gadolinium) elements based on characteristic ores. Light rare-earth element deposits are by far more prevalent. In this workshop and break out session, we are interested in completely new processes and approaches (physical, chemical or biological) to separation and processing, particularly for heavy rare-earth elements of high importance to energy applications.

With the increased demand for neodymium and dysprosium for permanent magnets, new high-selectivity separation technologies are needed. Neodymium has low separation selectivity relative to praseodymium, and dysprosium occurs in very low concentration in most rare-earth ores. New separation technologies might be based on chemical (species specific ionic liquids and solvents), physical (species specific porous membranes) or biological (elementally specific geobacters) means as possible mechanism for processing. New technology pathways to cost effective separation and concentration of neodymium and dysprosium are of high interest for examination in this workshop.

QUESTIONS:

Are there completely new process pathways which may be used, and subsequently scaled, for the processing of rare earths?

Can we leverage the knowledge base from the actinide materials processes realm to the lanthanide / rare-earth materials processes? For example, highly selective processes for the isolation of Americium and for the separation of Thorium from water have been developed. Can the physical and chemical methods used in these heavy-element separation technologies be applied to rare-earths?

Geobacters have been studied over the past few years as microorganisms with metabolisms which chemically interact with compounds and minerals. Can geobacters with strong affinity for specific rare-earth elements be identified and developed in potentially industrially relevant processes?

MAGNETICS

BACKGROUND

Rare earth metals of Neodymium and Dysprosium are of high importance for highest energy product permanent magnets, in the form of $Nd_2Fe_{14}B$ material. Such magnets are of increased use in electric motor and generator applications of the energy sector as the coupling means between torque and electricity. Dysprosium is used in higher Curie temperature permanent magnets and as a result is of increased importance for electric motors, particularly in the transportation sector. In this workshop, magnetics will be addressed from two directions: identification of potential material alternatives at the component level and of potential magnet replacements at the system level. Technologies for either possible technical approach (component or system) are of high interest and possible pathways will be investigated in this workshop.

Nanoscale magnetic material mixtures have been shown to have potential for high-energy product in permanent magnets, with reduced rare earth material content, through spring-exchange coupling of hard and soft magnetic phases in close proximity (< 50nm). ARPA-E has already initiated two projects in this approach: University of Delaware project is focused on aligned nanoscale mixtures of hard and soft magnetic materials; and General Electric project will demonstrate consolidated hard and soft phases of core/shell nanoparticles

In this workshop and breakout session, we are looking for even newer / alternative approaches to reduced rare-earth content permanent magnets in energy systems.

QUESTIONS:

Are there other non-rare earth content magnets which may exhibit high coercivity, particularly as a potential hard-phase in nanoscale composites? For instance PtCo forms very high energy density permanent magnets with no rare-earth content, although the cost is prohibitive. What new magnets might exhibit high coercivity with low rare-earth content?

Alternatively, what are the technical barriers to the use of superconducting magnets in some applications, such as high power wind turbines (>1 MW)?

Are permanent magnets necessary in high energy density electric motors for vehicles and what alternatives exist? For instance, with recent advances in power electronics, can induction or reluctance motorsefficiently couple torque and electric energy at acceptable cost and weight requirements? What technology advances are required to use non-permanent magnet motors in transportation or heavy industrial applications?

PHOSPHORS

BACKGROUND

Rare earth materials are used as both dopant or compositional quantities for phosphors. Terbium, Erbium, Yttrium and Europium are all used as red green and blue phosphors for white lighting. New phosphors are used to downshift UV or blue emission from LEDs to form color corrected white LEDs. Proposed strategies for dealing with reduced rare-earth availability include recycling programs where the phosphors from older tubes form the supply for new high-efficiency lighting.

In this workshop and breakout session, we are most interested in identifying over-the-horizon new technology opportunities for rare-earth free phosphors or alternative mechanisms for generation of high color rendering index white emission for high efficiency general illumination. Technologies which harnessing surface plasmon effects are of high interest.

QUESTIONS:

Are there high-efficiency optical transitions in non-rare-earth materials which can be used as an alternative particularly for new LED or OLED sources of white light? For instance, can size and shape of nanoparticle emitters be manipulated to control color in non-rare-earth phosphors as they are in aqueous environments for biological applications? Can new phosphors be developed which only use rare earths materials in dopant quantities (less than 0.1%)? For downshifted LED or OLED emitters, what technology gaps are there in matching emission wavelength to phosphor absorption to achieve high color rendering index white emission? What are the technology gaps for the emission intensity from multiple wavelength LEDs to be controlled, at a low enough cost, such that the resulting color remains consistent over time, even as individual emitters are subject to degradation?

CATALYSTS AND SEPARATORS

BACKGROUND

Rare earth oxides such as Ceria are used significantly in applications involving oxygen catalysis and transport through ceramic separators. Examples include: Ceria stabilization on Na-Y Zeolite catalysts are used for fluid catalytic cracking in most modern petroleum refining of gasoline for the transportation sector; Ceria (as well as Pt and Rh) form the basis for the 'three-way catalyst' in widespread use for post-combustion catalytic conversion for automobiles; and Ceria is used in yttria-stabilized zirconia (YSZ) separators used for high temperature diffusion electrolyte separators used in chemical processes and fuel cells.

In this workshop and breakout session, we are interested in exploring over-the-horizon new technical solutions which would provide alternatives or completely new pathways, to the use of rare-earth materials in catalysis and separator applications.

QUESTIONS:

Are there alternatives to the high use of rare-earths in fluid catalytic cracking? For instance mesoporous zeolites have been shown to increase both the efficiency and mass transfer rates for fluid catalytic cracking. What are the limits in controlling size and shape to dramatically increase unit process efficiency and throughput? What are the ultimate limits and by what quantitative amount could the process be improved while reducing rare-earth content? In high diffusivity oxygen separators, what other solutions might provide the combination of oxygen permeability and mechanical integrity at high temperatures, without rare-earth or critical materials? Finally, low or reduced dimensional materials such as graphene or nanotubes exhibit interesting catalytic properties, for instance on the edges and on the surfaces. Can these unique structures be developed into new catalyst technologies of significant importance for the energy sector?

BREAKOUT SESSIONS AND PARTICIPANT PREPARATION

Four breakout sessions of 90 minute lengths will be held through the workshop, in two periods of two concurrent sessions. Each participant is has been assigned a recommended breakout session to attend with an open option to attend either session during the second time period. Approximately 10 participants have been assigned to each session.

For the breakout session which a participant has been asked to attend, each participant is asked to prepare an up to 5 minute and 3 PowerPoint slide contribution, intended to spur discussion. Following two 15 minute stage-setting overview presentations, each participant will be asked for their contribution, interspersed with technical dialog between participants. All contributions will be accommodated, to the extent possible.

****** Any presentations created for the workshop should be publicly releasable ******

Private one-on-one sidebar meetings will be held with ARPA-E Program Directors both the night before, Sunday night, and at the conclusion of the day in 15 minute increments in the hotel restaurant area. The purpose of sidebar meetings is to share innovative technology concepts with Program Directors in a more private venue. In order to accommodate travel schedules at the end of the workshop, participants are encouraged to contact Angela Huffaker to schedule a time in advanced of the workshop, or sign up at the time of meeting.

AGENDA

**** Sunday Dec. 5 @ 6pm – Dinner in hotel with side-bar discussions for those arriving early. ****

8:00 AM	Registration / Coffee / Breakfast	
8:15 AM		
8:30 AM	Kick-Off	
8:45 AM	Overview of Day	
9:00 AM	US-Japan Rapporteur	
9:15 AM	US-EU Rapporteur	
9:30 AM	Current State of the Art for Supply	
9:45 AM	Current State of the Art for Applications Talk #1	
10:00 AM	Current State of the Art for Applications Talk #2	
10:15 AM	Break	
10:30 AM	SUPPLY Briefing #1	MAGNETS Briefing #1
10:45 AM	SUPPLY Briefing #2	MAGNETS Briefing #2
11:00 AM	SUPPLY Brainstorming / Dialog	MAGNETS Brainstorming / Dialog
11:15 AM		
11:30 AM		
11:45 AM		
12:00 PM		
12:15 PM	Break for Lunch	
12:30 PM	Keynote	
12:45 PM		
1:00 PM	Break	
1:15 PM	CATALYSTS Briefing #1	PHOSPHORS Briefing #1
1:30 PM	CATALYSTS Briefing #2	PHOSPHORS Briefing #2
1:45 PM	CATALYSTS Brainstorming / Dialog	PHOSPHORS Brainstorming / Dialog
2:00 PM		
2:15 PM		
2:30 PM		
2:45 PM		
3:00 PM	Break	
3:15 PM		
3:30 PM	Report Out	
3:45 PM		
4:00 PM		
4:15 PM		
4:30 PM	Conclusion of Day	
4:45 PM	Adjourn to "No Host" Happy Hour / Dinner (Hotel Bar) Sidebar Discussions with ARPA-E Program Director (On Request)	
5:00 PM		

CONTACT INFORMATION

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