Report on the FY05 ITP Materials Project and Portfolio Peer Review

Overview of the Portfolio

Advanced materials represent one of the most important and urgent technical needs of U.S. industry. The availability of appropriate materials and processing methods is often critical to the successful realization of a new engineering or process concept. Because harsh industrial environments impose severe demands on materials performance, the success or failure of many industrial energy efficiency concepts depends on the selection of suitable materials and fabrication techniques. The eight Industrial Technologies Program (ITP) portfolios – aluminum, chemicals, forest products, glass, metal casting, mining, petroleum refining and steel – all cite materials as high-priority R&D in their technology roadmaps, and all industry technology roadmaps collectively cite at least 10 specific materials-related priorities (Industrial Materials for the Future R&D Priorities, RAND 2001).

The ITP Materials portfolio consists of four subprogram focus areas that address the major crosscutting materials challenges for industrial processing. First, materials limitations to energy efficiency are usually related to inadequate performance or life-time in severe service environments, and the success or failure of many industrial energy efficiency concepts depends on materials selection and fabrication techniques to meet the ever-increasing demands on performance and life. Components wear, corrode, or oxidize in most industrial environments, and process efficiencies are often bounded by what temperatures the equipment and components can withstand. The subprogram focus area **Materials for Degradation Resistance** addresses development of materials and protection systems to enable greater efficiencies and productivity in industrial processing. Second, for energy systems in general, the greatest challenges center on energy loss reduction and recovery. The subprogram focus area **Materials for Energy Systems** is addressing this challenge through development of advanced refractory and insulation materials, and through innovative concepts, such as thin film thermoelectric systems, for waste energy recovery and reuse. Third, separation technologies account for approximately 22% of all in-plant energy use in the United States, and in many instances over 50% of plant operating costs in the chemical industry. Thus, the goal of subprogram focus area **Materials for Separations** is to develop low-energy alternative separations systems for use in the chemicals, petroleum refining, forest products and mining industries. Lastly, limited access to accurate, verified simulations and predictions creates barriers to development and commercialization of new materials and strategies that may offer energy efficiency gains when applied to industrial processes. The subprogram focus area **Thermophysical Databases and Modeling** supports the goals of the other four focus areas in the subprogram by addressing these database and simulation needs. Of particular importance is development of capabilities to simulate and optimize materials performance during high temperature industrial processing and in high wear and corrosion industrial degradation environments.

Portfolio Management

The U.S. Department of Energy sponsors Industrial Materials for the Future (IMF) research and development (R&D) to lead a national effort to research, design, develop, engineer, and test materials needed for energy efficiency improvements in ITP portfolios. ITP awards cost-shared funding for R&D projects through a competitive solicitation process. Projects are performed by collaborative partnerships and must address energy processing in industrial energy manufacturing. In this way, ITP maintains a balanced portfolio of R&D projects that will help realize national goals for energy and the environment. As a priority, DOE fosters high-risk, high-

return R&D with the potential to significantly improve energy efficiency, environmental performance and product yield.

The IMF portfolio seeks to identify, support and nurture promising efforts in materials and processing technologies so they can be demonstrated in industrial applications. Funded activities cover proof of concept, applied research and development, and applications engineering. The Materials portfolio is crosscutting, emphasizing longer-range materials needs common to multiple industries and encouraging multi-industry partnerships.

Purpose of the Portfolio Review

The four focus areas and all related R&D work are reviewed annually at the Project and Portfolio Review Meeting. For this meeting, a panel of independent experts is engaged to review the portfolio, its goals, and consider whether it needs to be rebalanced. The panel also evaluates whether individual projects are reaching the target milestones on schedule and examines the interaction of participants with DOE staff.

The Project and Portfolio Review was designed to:

- Provide an overview of the portfolio strategy and focus areas, and obtain feedback on the overall balance and direction of the portfolio to help guide future DOE planning and solicitations.
- Generate detailed performance evaluations of each project to give the R&D teams constructive feedback on their projects and assist the Department of Energy (DOE) in ongoing project management
- Expose a wide public audience to the ongoing research in the Materials portfolio
- Increase opportunities for networking between the principal investigators and potential research or commercialization partners

The Portfolio Peer Review Process

Prior to the review, seven individuals were asked by the DOE-GO project manager to serve as members of the Review Board for the June, 2005 ITP Materials Portfolio review. All reviewers had a broad-based knowledge of Materials R&D as well as specific expertise in a particular area or areas (e.g., steel metallurgy, corrosion, separations, etc), and experience managing industrial R&D. Four of the reviewers were independent consultants, one a senior executive at the Naval Research Laboratory, one a university faculty member, and one an employee of a forest products company. All individuals were familiar with the Industrial Technologies Program and its mission through previous interactions and with the Program.

The reviewers signed non-disclosure agreements to ensure the confidentiality of information presented on the projects. Each project was evaluated by the reviewers using four major criteria:

- Programmatic Benefits (benefits to DOE and Industry)
- Technical Merit (likelihood of technical success)
- Commercialization Potential (includes knowledge transfer for earlier research stages)
- Overall Project Assessment

The 2005 ITP Materials Project and Portfolio Review meeting was held May 31–June 3 in Chicago, IL. Sixty participants from universities, industry, the national laboratories, and representatives from DOE's ITP Office and the Golden Field Office attended the sessions. During the event, the DOE Materials Technology Manager reviewed the Materials Portfolio strategy and planning with the reviewers and asked for feedback. The principal investigators for the IMF-sponsored projects reported on their progress for the past year and outlined their direction for future activities. The eighteen presentations on active projects from the Materials portfolio were supplemented with six other technical presentations relevant to IMF.

Exhibit 1: Materials Program Projects that Participated in the FY05 Review

Focus Area 1: Degradation-Resistant Materials

Materials Development and Processing

- 1772 Development of cast austenitic stainless steel
- 1790 Advanced tooling alloys for molds and dies
- 16948 Low-temperature surface carburizing of stainless steels

Ultra-Hard Materials

- 1789 New class of ultra-hard borides
- 1795 Novel superhard materials and nano-structured diamond composites
- 1798 Ultrananocrystalline diamond coatings for pump seals
- 16949 Development of bulk nanocrystalline cemented WC for industrial applications

Wear/Corrosion Resistant Materials

- 1762 Stress-assisted corrosion in boiler tubes
- 1791 Advanced composite coatings
- 16941 Development of functionally graded materials for manufacturing tools
- 16942 Structurally integrated coatings for wear and corrosion
- 16944 Development of materials resistant to metal dusting
- 16946 Advanced wear and corrosion resistant systems through laser surface alloying
- 16951 Alkaline-resistant Fe-phosphate glass fibers as concrete reinforcement

Focus Area 2: Thermophysical Databases and Modeling

- 1778 Combinatorial methods for alloy design and optimization
- 1788 Thermochemical models and databases for high temperature materials
- 16950 Prediction of corrosion of advanced materials and fabricated components

Focus Area 3: Materials for Separations

- 1779 Modified zeolites for hydrocarbon separations

Focus Area 4: Materials for Energy Systems

Refractories/Heat Recovery

- 1796 Advanced nanoporous composite materials for industrial heat applications
- 16540 Materials for high-temperature black liquor gasification
- 16940 Materials for industrial heat recovery systems
- 16943 Multifunctional metallic and refractory materials for handling of molten metals
- 16947 Advanced thermoelectric materials for efficient waste heat recovery in process industries

Welding/Joining

- 16945 Advanced integration of multi-scale mechanics and welding process simulation in weld assessment

Over 140 FY2005 R&D Partners:

- 109 Industrial Partners
- 21 Universities
- 9 Laboratories
- 3 Associations

The Portfolio Peer Review Results

After reviewing the focus areas and content of the Materials R&D portfolio, the Review Board offered the following observations and recommendations:

- Saving energy through manufacturing processes and product improvement are implicit in the planning activity, but are not considered explicitly. A strategic look at these two mechanisms may reveal some additional opportunities for R&D investment.
- A stronger strategic vision for the scope and direction of the Materials portfolio would help highlight other rationale for changes in the projects in the Materials portfolio could be articulated.
- The focus area-barrier-pathway framework is helpful in considering individual projects and provides a tool to understand and describe ongoing activities.
- The use of stage gate and go/no-go decisions on projects was endorsed. This will require project contracting officers understand the stage-gate concept and make project awards with the state/gate system built into the funding.
- Consider requiring each project proposal demonstrate completion of a creditable literature search.

- The category of Degradation Resistant Materials currently dominates the portfolio. The portfolio focus could be expanded to consider projects in Refractories, Separations, and Database and Modeling.
    - In the case of a new effort in Separations, the DOE should work closely with the chemicals and petrochemicals industries and require active industrial partners in any proposals.
    - The area of Refractories was strongly endorsed as it was felt that this area could result in some major energy savings.
    - Database and Modeling activities have often pinpointed areas where major energy savings may be possible. DOE should look to other government agencies to see how the emphasis in this program dovetails with other activities.
- Some existing projects appear to have limited cross-cutting benefit in the materials field. Ideally, Materials projects should be aimed at two or more industries and tied closely to the roadmap needs of these industries.
- There should be some standardization of the economic benefits across projects.

The MRB was also asked to rank the focus areas by priority, in the event of budget contraction. The response was as follows: Materials for Energy Systems (in particular Waste Heat Recovery), Materials for Degradation Resistance, Separations. The Review Board felt that, under a diminished budget scenario, Thermophysical Databases and Modeling should be eliminated as a separate focus area.

Program and Project Management Response

In response to the MRB recommendations, the priority order of the focus areas and topic areas has been reassessed. Materials for Energy Systems is the first priority, with particular emphasis given to advanced refractories and advanced materials for waste energy/heat recovery. Materials for Degradation Resistance is second in priority (with and emphasis on novel microstructures and ultra-hard materials), followed by Materials for Separations. These focus areas and corresponding subtopics will continue to be assessed and refined as the ITP strategy and corporate goals are defined.

The focus area-barrier-pathway framework will continue to be improved as the strategic vision for ITP program and for the Materials portfolio comes into clearer focus over the next year. The stage gate approach to portfolio and project management will continue to be implemented for greater risk control and portfolio effectiveness.

A solicitation and lab call have been prepared for FY2007. Proposals were invited to address the priority topic areas, including ultra-hard materials, materials for separations, refractories, materials for waste heat recovery, and thermophysical databases and modeling. The resulting portfolio will be more evenly distributed across the focus areas than previously, though all new projects will require significant industrial participation and cost share. In the area of Materials for Separations, selection of new projects will rely on consideration of the priorities of the ITP chemicals portfolio.