NETL Core Competencies

NATIONAL ENERGY TECHNOLOGY LABORATORY

Materials Engineering & Manufacturing

Design, Synthesis, and Processing of Advanced Materials for Clean Energy Systems

Materials Performance in Real Energy Environments

The components that will keep the next generation of energy systems up and running are unlike the ones on the market today. NETL is designing, producing, and testing the unique materials that can fill that need. To achieve the high efficiencies required to reduce fuel consumption and concomitant emissions, materials must be able to withstand temperatures, pressures, and corrosive conditions more extreme than those found in conventional energy systems. The tools and expertise that NETL has at its disposal make it the premier lab for these materials.

1

Corrosion & Electrochemistry Lab

Materials Performance Corrosion

Understanding materials' response to environmental factors, and using this knowledge for developing new alloys and corrosion protection strategies, is key in enabling advanced power systems and safe utilization of domestic energy resources. The Corrosion and Electrochemistry Laboratory is utilized to quantify, measure, and understand aqueous corrosion. The laboratory has electronic potentiostats/galvanostat meters for conducting electrochemical experiments for measuring corrosion rates using different electrochemical methods, predicting susceptibility to pitting corrosion by determining pitting potential, and determining conditions for corrosion protection. Current research focuses on evaluating the corrosion performance of materials for applications in CO_2 power cycle conditions at lower temperatures representative of balance of plant components; developing advanced electrochemical sensors for monitoring component health in downhole and natural gas transmission pipeline environments; and developing materials and methods for corrosion protection to protect critical infrastructure, including natural gas pipelines.

2

Carbon Capture Materials Synthesis Lab

Materials for CO_2 Capture and Oxegen Carriers

The focus of this research is the analysis, synthesis, and purification of chemical compounds to identify novel, cost-effective materials for carbon capture applications, such as membranes, sorbents, solvents, and catalysts, that when deployed, result in cleaner use and production of fossil fuels.

Development of efficient oxygen carriers is key to the success of chemical looping combustion. The oxygen carrier, usually a metal oxide, transports oxygen to the fuel. An effective carrier will react readily with the fuel, oxidizing methane to carbon dioxide (CO_2) and water, and will fully reoxidize upon contact with oxygen. Reactivity and durability of oxygen carrier materials are significant issues being addressed at NETL. Researchers are striving to meet other criteria for oxygen carriers, including low cost and good availability. Carriers are tested in the NETL pilot-scale 50 kW chemical looping combustion reactor.

3

Metals Melting Facility

Inellegent Alloy Development & Manufacure

NETL maintains a complete alloy development research facility, which includes a unique alloy fabrication laboratory for prototyping alloy manufacturing with capabilities for melting (vacuum induction melting, vacuum arc remelting, electroslag remelting), casting, forging, rolling, and heat-treating materials ranging in size from a few grams to 400 pounds. Because of NETL's scale of alloy production capabilities, NETL's alloy solutions readily translate into industrial practice. In addition to advancing the DOE mission, this capability has been leveraged by other government agencies and private sector partners to provide alloy solutions to materials challenges in the defense, aerospace, and biomedical fields.

4

Materials Characterization Lab

Rare Earth Elements Research

NETL's materials characterization laboratories allow for the analysis of engineered and natural materials from the nanoto macro-scale. At Albany, our petrographic and metallographic capabilities include quantitative microanalysis by electron microprobe, optical microscopy, electron microscopy (scanning and transmission), confocal laser scanning microscopy, and x-ray diffraction. The use of microanalyses combined with image processing visualization techniques allow for the identification and quantification of elements and phases of interest. NETL leverages materials characterization capabilities resident at all three sites. NETL material scientists use these analytical techniques to interrogate the underlying processing-structure-property relationships that govern materials performance and use this information to design better materials.

5

Severe Environment Corrosion Errosion Research Facility

Understanding Corrosion Errosion to Improve Energy System Performance

The Severe Environment Corrosion Erosion Facility is a multi-laboratory, modular facility that allows researchers to examine the performance of materials under a wide variety of corrosion conditions. Researchers can use the facility to conduct experiments at varying temperatures, in pure or mixed-gas environments, and in pure- or mixed- gas/liquid environments. Research conducted at the facility supports NETL's investigations into oxy-fuel combustion, refractory materials stability, and fuels. It also sheds light on how existing power plants can best be upgraded.

6

Solid Oxed Fuel Cell (SOFC) Manufacturing & Test LAb

SOFC Research

The SOFC Manufacturing and Test Lab provides researchers access to fundamental and applied performance data as well as models and simulations that describe the structure, operation, and evolution of SOFCs. The laboratory is equipped to test SOFCs and component materials at temperatures up to 1,000 °C, and under various gas atmospheres and operational conditions. The lab includes conventional SOFC fabrication and analysis devices; an advanced manufacturing electrode infiltration device, a mobile fuel cell test array, and contaminant exposure test facilities.

7

Surface Chemistry & Catalyst Lab

Enineering the Surfaces of Materials Used for Energy Systems

Research in this lab focuses on engineering the surfaces of sorbents, sensors, alloys, and catalysts used in the production of energy and synthetic fuels. The laboratory has instrumentation to image, manipulate, and quantify the chemical and physical interactions occurring on material surfaces, since this interface dictates corrosion resistance, catalytic activity, and sorbent selectivity.

The lab utilizes a variety of atomic-force and scanning tunneling microscopes, which enable researchers to image molecules and atomic structures on surfaces. Other instrumentation (such as X-ray photoelectron spectroscopy, ion scattering spectroscopy, and temperature programmed desorption spectroscopy) allows researchers to probe the composition of surfaces and detect how chemical reactions are impacted.

8

Metals Fabrication Lab

Intellegent Alloy Development & Manufacture

NETL's capability in structural materials research is anchored by its substantial alloy fabrication and performance testing facilities, which deliver high-performance, affordable materials that enable diverse energy technologies. Researchers specialize in the design, fabrication and manufacturing, performance assessment, and performance prediction of heat- and corrosion-resistant alloys. Complementary computational materials research is integrated into these activities to guide alloy development and manufacturing research and to predict materials performance. Research focuses on cost-effective materials for severe stress and corrosive/erosive environments with a service life of 100,000 hours.

9

Mechanical Testing Lab

Performance of Advanced Materials In Severe Surface Environments

Many fossil energy (both coal and oil & gas) systems demand components resist mechanical loads for long durations. The Fracture Mechanics Laboratory allows NETL scientists to determine and understand the mechanical performance of advanced materials and validate alloy design solutions. The laboratory is equipped to test a material's ability to withstand cyclical mechanical loads (fatigue) and resulting crack growth (fatigue crack growth). NETL also has the capability to evaluate a material's ability to withstand static mechanical loads for long periods of time (creep) at elevated temperatures. Fatigue and creep are important considerations in the design of many materials' applications.

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Materials Engineering & Manufacturing

- Corrosion & Electrochemistry Lab – Pittsburgh
- Carbon Capture Materials Synthesis Lab – Pittsburgh
- Metals Melting Facility – Albany
- Materials Characterization Lab – Pittsburgh
- Severe Environment Corrosion Erosion Research Facility – Albany
- Solid Oxide Fuel Cell (SOFC) Manufacturing & Test Lab – Morgantown
- Surface Chemistry & Catalysis Lab – Pittsburgh
- Metals Fabrication Lab – Albany • Mechanical Testing Lab – Albany

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