

MATERIALS ENGINEERING & MANUFACTURING RESEARCH

The Department of Energy's (DOE) National Energy Technology Laboratory's (NETL) Materials Engineering and Manufacturing (MEM) Core Competency Directorate delivers functional and structural materials solutions to enable advanced energy systems and technologies. NETL is internationally recognized for its leadership and ability to design and develop materials for extreme environment applications. NETL uses a one-of-a-kind suite of computational and experimental methods for translating new material-science concepts into practical technologies, and boasts advanced tools and unique facilities, across all materials classes.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL is developing a variety of materials to enable clean power, chemicals, fuels, and other products and meet the nation's goal of net-zero carbon emission by mid-century. NETL has broad materials expertise in:

- Design, development and manufacturing of heat-resistant alloys, corrosion-resistant alloys and environmental barriers needed for hydrogen service and other harsh environments.
- Advanced harsh environment sensors for process monitoring and systems integrity.
- Catalysts for CO₂ conversions.
- Electrochemical materials for solid oxide fuel cells.
- Separation materials for gas (CO₂ capture), solid and liquid separation, including extracting rare earth elements from coal waste by-products (e.g., acid mine drainage and fly ash).
- Producing carbon products from coal waste by-products.
- Solving challenges in CO₂ transport and storage, and methane mitigation

Albany, OR • Anchorage, AK • Morgantown, WV • Pittsburgh, PA • Houston, TX



U.S. DEPARTMENT OF
ENERGY



This research supports NETL's Materials Engineering & Manufacturing competency.

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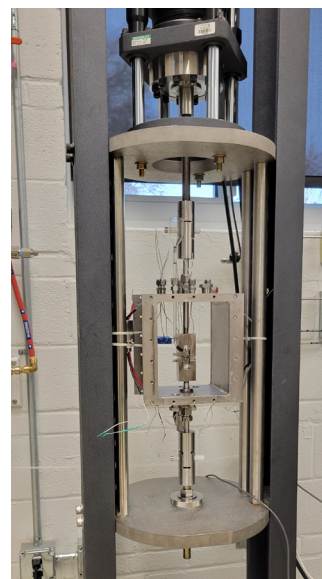
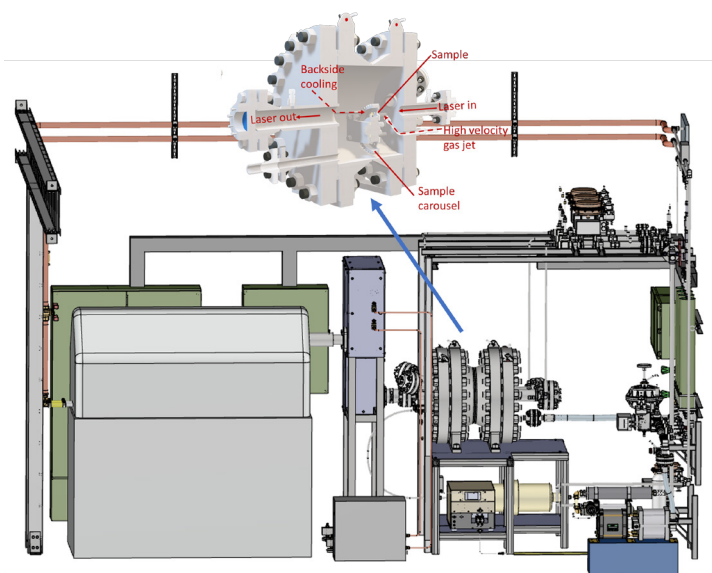
DESIGN & DISCOVERY

NETL harnesses the power of computational modeling with targeted validation experiments to accelerate materials development and deployment. NETL scientists and engineers simulate materials from the atomic scale through the continuum scale to design improved materials. Both commercial software packages and NETL-developed algorithms are used, and the research is conducted in close collaboration with NETL's Computational Science & Engineering and Systems Engineering & Analysis Directorates, and utilizes NETL's supercomputer, JOULE III. Simulations are validated using targeted laboratory experiments that measure the property of merit. High-performance, cost-effective materials identified from these experiments are upscaled and evaluated for further development.

CHARACTERIZATION & PERFORMANCE EVALUATION

NETL qualifies materials concepts by conducting laboratory evaluations at conditions relevant to real-life service. Researchers utilize key facilities and specialized equipment, including the following:

- NETL's Severe Environment Materials Testing Facilities evaluate corrosion and mechanical performance at elevated temperatures, pressures, and in environments that mimic advanced energy systems and subsurface conditions. These laboratories include: (i) Gas turbine simulation rig for long-duration materials testing under realistic temperatures, pressures, gas compositions and velocities, (ii) Controlled environment creep frames which allow investigation of environmental effects on mechanical behavior of materials, (iii) Hydrogen embrittlement frames capable of evaluating fatigue crack growth rates in gaseous hydrogen up to 5000 psi or via electrochemical charging, and (iv) High-pressure and high-temperature materials test vessels that can be pressurized using various gases including H_2 , CO_2 , H_2O , O_2 , and mixtures. NETL's module at the National Carbon Capture Center evaluates carbon capture materials in real flue gas.
- Specialized laboratory reactors test the effectiveness of sensors to operate in the harsh environments associated with advanced energy and resource recovery systems.
- Solid Oxide Fuel Cell (SOFC) Testing Laboratory equipped to test SOFCs and component materials at temperatures of up to 1,000°C, and under various gas atmospheres.
- Controlled environment creep frames which allow for in-situ testing of corrosive gaseous species and concurrent creep damage.
- NETL has a specialized hydrogen embrittlement frame capable of evaluating fatigue crack growth rates in gaseous hydrogen up to 5000 PSI or via electrochemical charging.



Research is conducted in close collaboration with NETL's Energy Conversion Engineering Directorate to evaluate materials in unique NETL energy and chemical conversion reactors, including NETL's Reaction Analysis and Chemical Transformation (ReACT) facility.

SYNTHESIS, PROCESSING, & MANUFACTURING

NETL focuses on innovative methods that readily translate to industrial practices. Chemical synthesis methods are available for the synthesis of polymers, solvents, sorbents, graphene, and nano-materials. Equipment is available to process membranes, hollow fibers, thin-films, ceramics, and fiber-optics, to include high-temperature sapphire fibers. NETL has considerable ingot metallurgy capabilities for manufacturing mission-critical alloys, including air induction melting, vacuum induction melting (up to 300-pound ingots), vacuum arc remelting and electro-slag remelting (with up to 8-inch diameter crucibles). Thermal-mechanical processing equipment is available to convert ingots into plates/sheets and furnaces are utilized for heat-treating alloys.



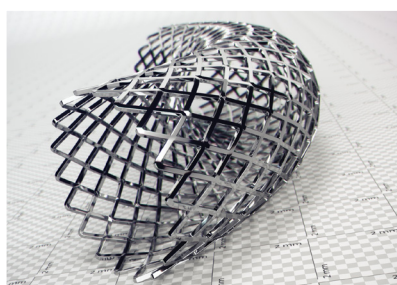
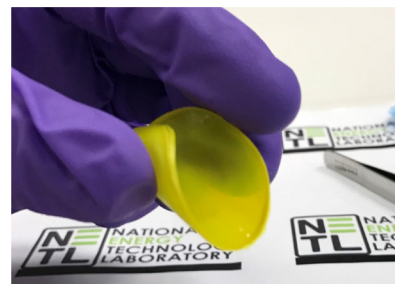
INNOVATION & IMPACT

NETL materials research is responsible for the development, maturation, and deployment of several energy innovations:

- A corrosive-resistant refractory brick used in gasifiers worldwide.
- An award-winning computational heat treatment that enables thick-wall casting of precipitation hardened superalloys, a key to advanced ultra-supercritical steam turbine technology.
- The Basic Immobilized Amine Sorbent (BIAS) family of sorbents, which are low-cost materials for gas and water purification applications.
- Catalysts and electrochemical technologies for conversion of CO₂ into value-added products.
- Cathode infiltration technologies that increase the service lifetime of solid oxide fuel cell systems.
- A method for co-producing single-layer graphene coal liquids directly from coal feedstocks, and thereby creating new high-value markets for coal.

NETL's expertise and capabilities have been leveraged by other sectors, such as power electronics, biomedical, and defense industries. This ultimately promotes advanced technologies, creates domestic jobs, and enhances the overall quality of medical care for American citizens. Examples of NETL's inter-industry synergy include the following:

- World-leading radiopaque alloy for medical coronary stents.
- Multifunctional sorbent technology for contaminant removal in HVAC systems.
- Tunable magnetic alloy for power electronics and power conversion applications.



NETL is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. By leveraging its world-class talent and research facilities, NETL is ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans.

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