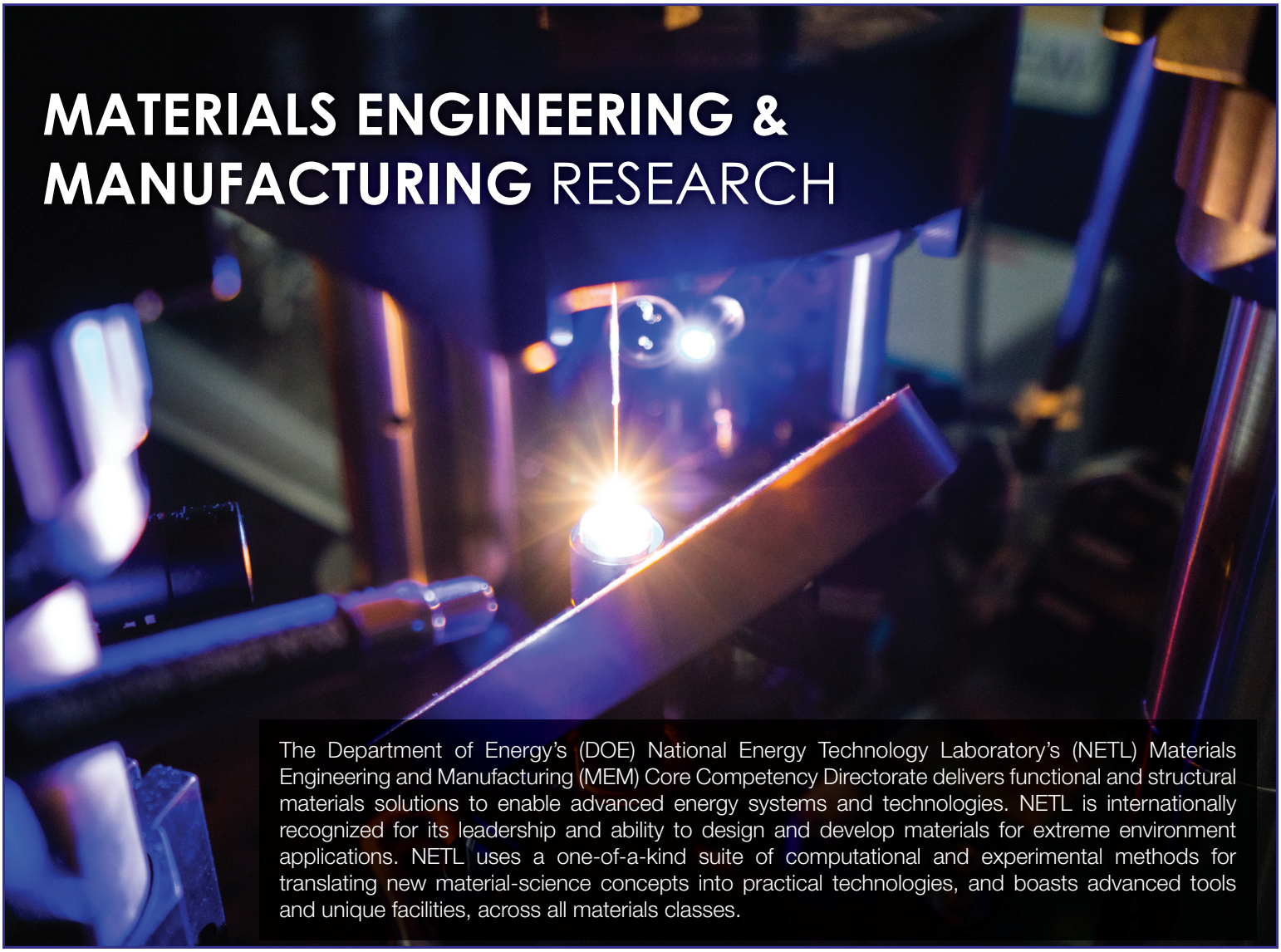
MATERIALS ENGINEERING & MANUFACTURING RESEARCH



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 improve the efficiency and effectiveness of the recovery, transmission, and conversion of domestic fossil energy resources into clean power, chemicals, fuels, and other high-value products. NETL has broad materials expertise in:

- Heat-resistant alloys, corrosion-resistant alloys and environmental barriers for advanced power cycles, drilling, subsurface, and pipeline applications.
- Advanced harsh environment sensors for process monitoring and systems integrity.
- Catalysts for CO_2 conversion; electrochemical materials for solid oxide fuel cells.
- Separation materials for gas (CO_2 capture), solid and liquid separation, including extracting rare earth elements from coal and coal-by products (i.e., fly ash).
- Producing carbon products from coal.

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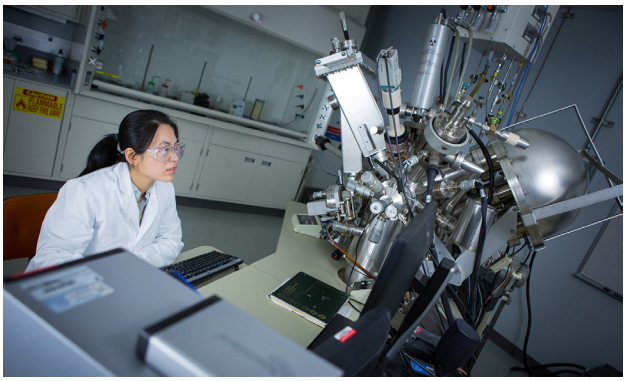
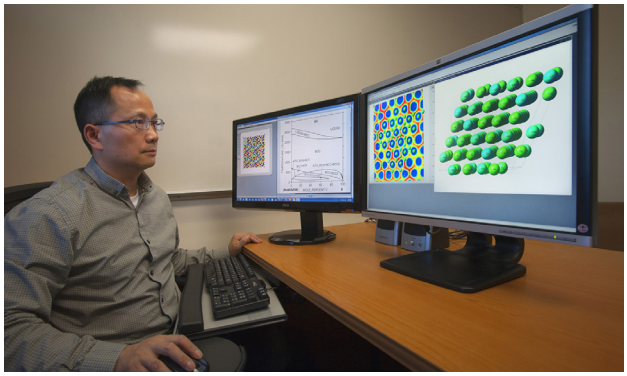
U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

R&D070, October 2019

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 II. 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.



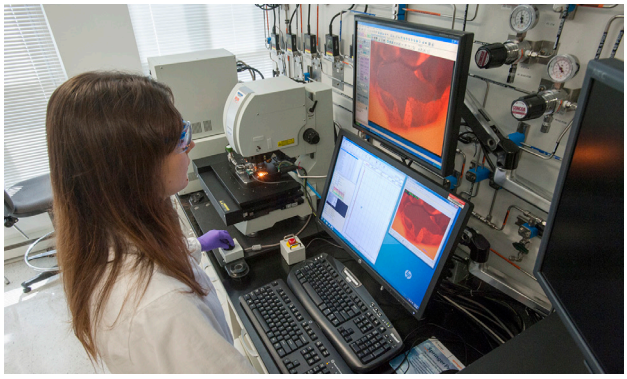


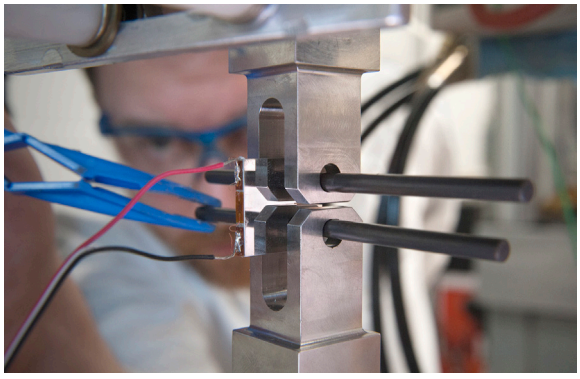
CHARACTERIZATION & PERFORMANCE EVALUATION

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

- NETL's Severe Environment Corrosion-Erosion Research Facility (SECERF) and related laboratories evaluate corrosion and mechanical performance at elevated temperatures, pressures, and in environments that mimic advanced energy (fire- and steam-side corrosion, advanced ultra-supercritical steam, and supercritical CO_2 power cycles) and subsurface conditions.
- NETL's module at the National Carbon Capture Center evaluates carbon capture materials in real flue gas.
- Specialized laboratory reactors test the effectiveness sensors to operate in 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 up to 1,000 °C, and under various gas atmospheres.

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 methods that readily translates 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, fiber-optics (including high-temperature sapphire fibers), and ceramics. 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 Electo-Slag Remelting (with up to 8-inch diameter crucibles). Thermal-mechanical processing equipment is available to convert ingots into plate and sheet and furnaces for heat-treating alloys.

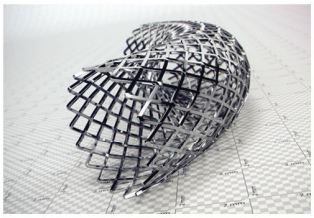
INNOVATION & IMPACT

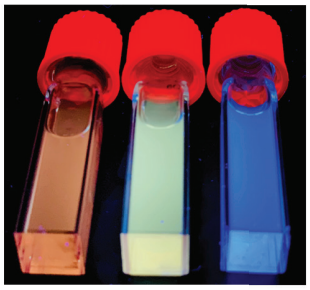
NETL materials research is responsible for the development, maturation, and deployment of several energy innovations:

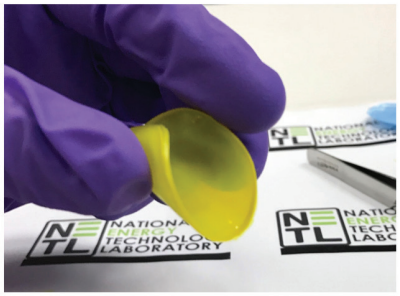
- A corrosive-resistant refractory brick used in nearly every slagging gasifier worldwide.
- An award-winning computational heat treatment that enables thick-wall casting of precipitation hardened superalloys, a key to advanced ultra-supercritical steam turbine technology.
- The Basic Immobilized Amine Sorbent (BIAS) family of sorbents, which are low-cost materials for gas and water purification applications.
- Catalysts and electrochemical technologies for conversion of CO_2 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 in the defense, power electronics, and bio-medical industries to enable advanced technologies, create jobs, and save lives. Examples of our interindustry 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.







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