ADVANCED ENERGY MATERIALS

High nickel superalloy pipe (Inconel 740H™) after extrusion. Photo (2021) is courtesy of Special Metals, a PCC Company.

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NATIONAL ENERGY TECHNOLOGY LABORATORY

The **Advanced Energy Materials Program within the Advanced Energy Systems Research Portfolio** works to characterize, produce and certify advanced alloys and high-performance materials. Materials are key to realizing dispatchable, reliable, high-efficiency power generation. In addition, the program aims to encourage energy growth and use. Materials of interest include those that enable components and equipment to perform in the high-temperature, high-pressure and corrosive environments of advanced energy systems, with specific emphasis on durability, availability and cost.

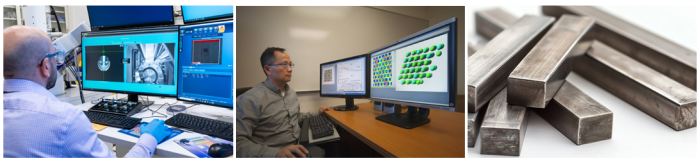
The program also focuses on developing ceramic matrix composites and compatible environmental barrier coatings to enable 70% efficiency. Ceramic matrix composites allow for higher operating temperatures compared to conventional superalloys used in turbines, and thereby ceramic matrix composites can accommodate higher temperatures and potentially increase turbine efficiency. Ceramic matrix composites are reinforced with long fibers and are commonly manufactured by infiltration. Leveraging smart fabrication methods is a key strategy in ceramic matrix composites development and deployment.

PROVIDING INNOVATIVE, COST-EFFECTIVE MATERIALS SOLUTIONS TO ENABLE AFFORDABLE, RELIABLE AND SECURE ENERGY TECHNOLOGIES

The Advanced Energy Materials program focuses on unleashing domestic energy production and use by improving high-temperature power generation technologies, particularly advanced turbines for efficient and low-cost electricity generation from domestic natural gas. While past innovations like advanced welding, ceramic matrix composites/environmental barrier coatings, and the advanced-ultrasupercritical program have aided cycling power plants, current materials and methods still require improvement in durability, operational flexibility and longevity when used in extreme conditions.

Research challenges in advanced energy materials include:

- Understanding materials performance in high-temperature, high-pressure and corrosive hydrocarbon energy environments.
- Developing facilities for testing materials and components under realistic high-temperature, harsh environments.
- Developing advanced manufacturing methods for high-performance materials and computational materials modeling as enabling technologies.
- Reducing new material development time and cost.

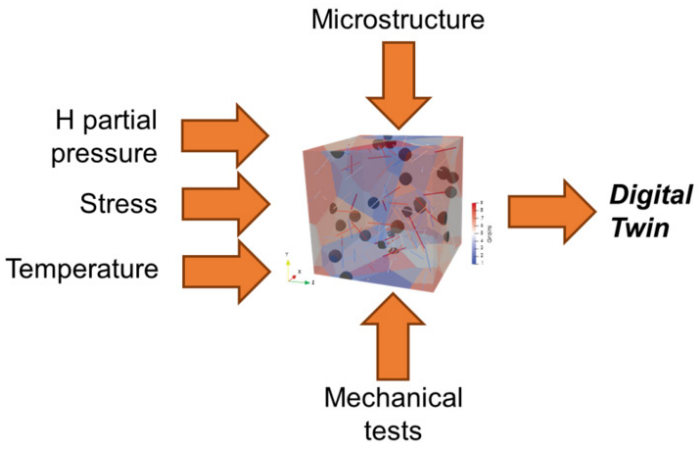


KEY FOCUS AREAS

- Developing and optimizing advanced materials and manufacturing processes using computational materials modeling.
- Refining advanced materials and optimizing manufacturing processes for demanding environments, with a focus on durability, reliability and cost.
- Developing robust joining and welding techniques, demonstrating scalable manufacturing from prototyping to industrialization.
- Integrating emerging advanced manufacturing approaches.
- Continuing programs like eXtremeMAT that develop computational tools to predict the impact of microstructure and alloy chemistry on alloy creep behavior.
- Developing a robust domestic materials supply chain that includes good-paying jobs for the American workforce.
- Developing low-cost, high-performance alloys to increase domestic energy use and production.

HIGH-PERFORMANCE COMPUTING

- **eXtremeMAT — Materials for Extreme Environments:** Current programs like eXtremeMAT have developed computational tools to predict the impact of microstructure and alloy chemistry on alloy creep behavior. These models can be used to accurately predict components' remaining lifespan during service and improve the reliability of energy systems.



- **High-Performance Computing for Materials (HPC4Mtls):** The U.S. Department of Energy's (DOE) Office of Fossil Energy supports the HPC4Mtls program as part of DOE's High-Performance Computing for Energy Innovation initiative. HPC4Mtls accelerates industry discovery, design and development of materials in energy technologies by enabling access to computational capabilities and expertise in the DOE laboratories.

NETL DOE national laboratory dedicated to innovating and accelerating the nation's energy solutions in hydrocarbon, geothermal energy and critical minerals production. With research sites in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL operates as one laboratory to create advanced energy technologies that support DOE's mission and enable affordable, reliable and secure energy to fuel human prosperity.

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