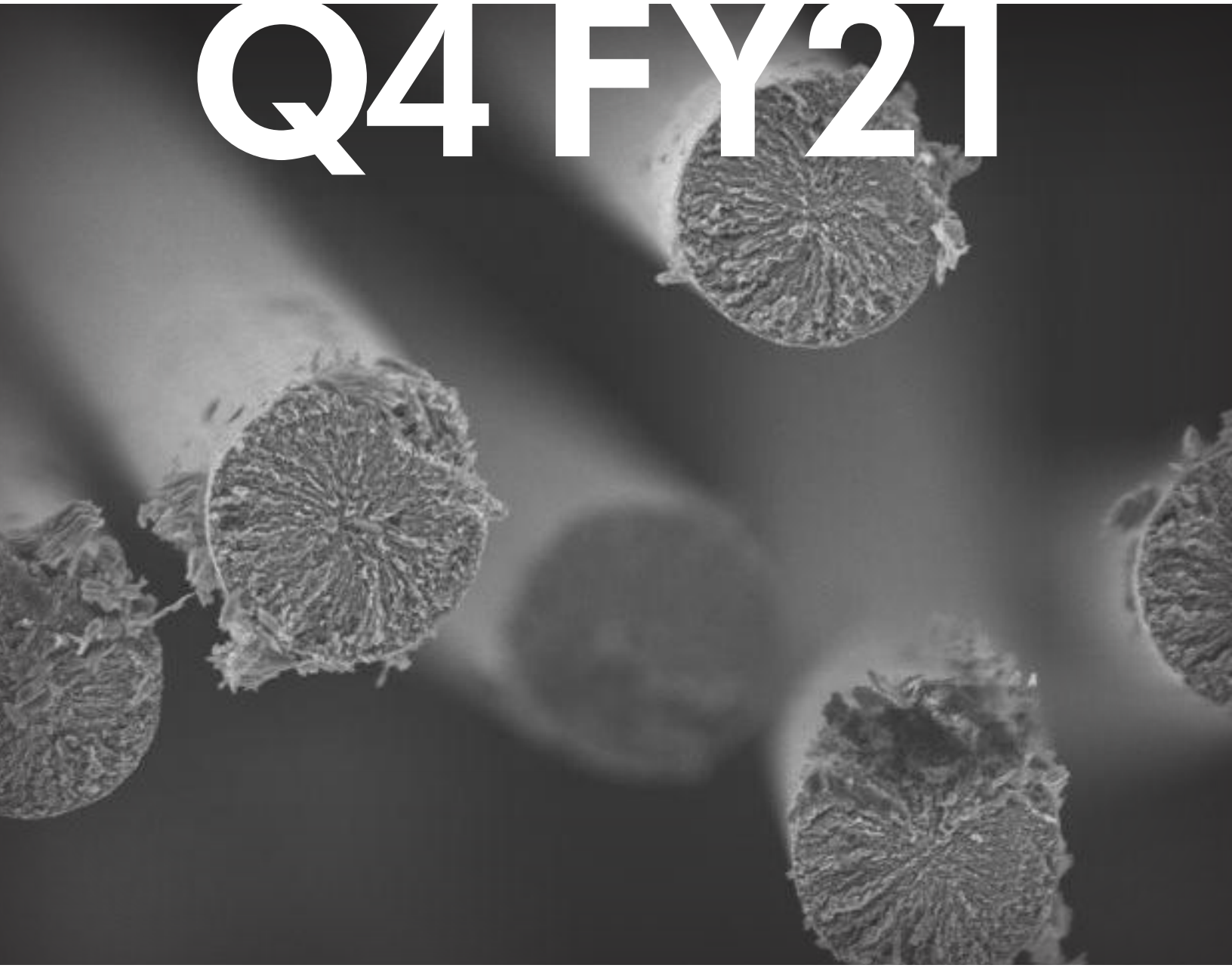
NATIONAL ENERGY TECHNOLOGY LABORATORY

ACCOMPLISHMENTS

Q4 FY21



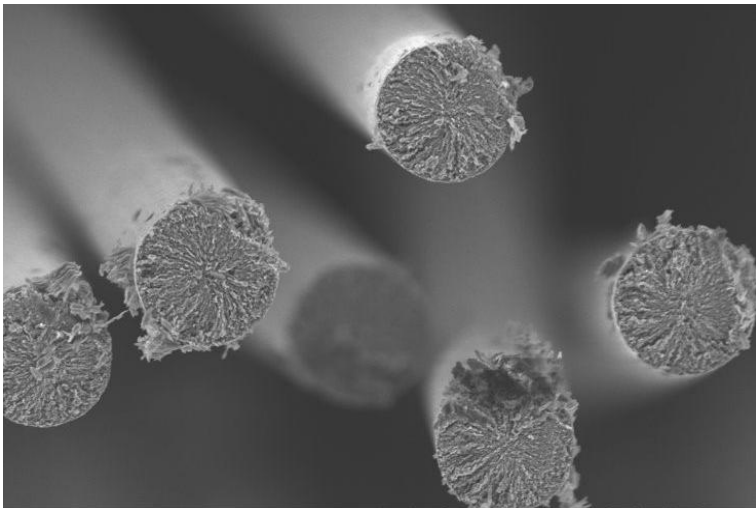
U.S. DEPARTMENT OF ENERGY

NETL ACCOMPLISHMENTS

Quarter 4 – Fiscal Year 2021

NETL COLLABORATION UNLOCKING HIGH-VALUE PRODUCTS FROM CARBON ORE

NETL's project partners Oak Ridge National Laboratory and the University of Kentucky investigated ways to use carbon ore to create high-value products like carbon fiber composites for the aerospace, automotive, wind energy markets and more. The research is helping achieve a key Biden Administration priority of environmental justice by paving the way for new clean manufacturing industries and good-paying jobs in American coal communities. Using advanced multi-scale characterization techniques and high-performance computer modeling, the research team is unlocking the science to enable competitive industrialization of carbon ore-derived carbon fibers and composites.



SOUTHEAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

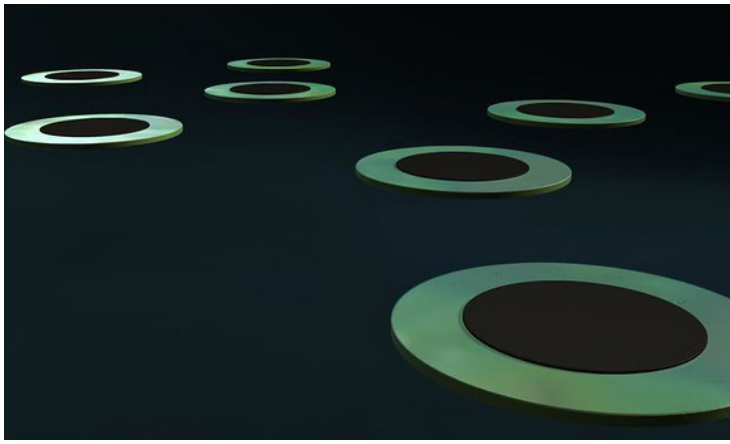
After nearly two decades of collaboration and research, the Southeast Regional Carbon Sequestration Partnership (SECARB) successfully concluded, bringing the country closer to commercial deployment of carbon capture and storage (CCS) technologies. As one of seven Regional Carbon Sequestration Partnerships with oversight from NETL, SECARB was a $130 million program established in 2003 and managed by the Southern States Energy Board with the primary goals of identifying major sources of carbon emissions, characterizing the geology of a 13-state region, determining the most promising options for commercial deployment of carbon dioxide storage technologies in the South, and validating the technology options. Culminating with two large-scale injection tests that laid the foundation for future projects, the efforts undertaken during the SECARB collaboration were crucial stepping stones in building confidence in large-scale carbon dioxide storage.

CO_2 STUDY BY NETL AND PARTNERS HIGHLIGHTED POWER PLANT OXIDATION

NETL researchers, with support from Oregon State University and Pacific Northwest National Laboratory, is exploring how high-temperature carbon dioxide (CO_2) degrades power plant building materials. The team conducted a study titled "Molecular-Scale Investigation of the Oxidation Behavior of Chromia-Forming Alloys in High-Temperature CO_2," which examined how the alloys inside supercritical CO_2 power plants deteriorate as result of increased CO_2 contact. The paper also expressed the need for new materials to build the plants of the future and retrofit the existing fleet. The research could lead to the development of supercritical CO_2 power plants that could help decarbonize the nation's power sector.

NETL PROJECT PARTNERS DEVELOPED A MORE RESILIENT SOLID OXIDE FUEL CELL COMPONENT

In collaboration with researchers from UES Services Inc., the University of Connecticut and the Pacific Northwest National Laboratory, NETL explored high-entropy alloys (HEAs) to replace materials typically used for anode manufacture and overcome long-standing technical barriers to more resilient cause solid oxide fuel cells (SOFC). The research team attempted to mitigate carbon deposits, which can accumulate in the anode and cause SOFCs to fail. Unlike typical alloys like steel, in which small amounts of carbon are added to iron to improve its properties, HEAs generally comprise five or more metals that all contribute significantly to the overall element mix, which results in a more stable structure. This project concluded in September and represents a successful partnership in which a viable solution to a real-world problem was identified and advanced.



NETL ACHIEVED TECHNOLOGICAL MILESTONES IN RARE EARTH ELEMENT SUPPLY CHAIN RESEARCH

NETL's work to develop domestic supply chains of critical minerals and rare earth elements (REEs) from unconventional sources such as carbon ore ash, acid mine drainage and other sources resulted in several milestones in technological applications of sensors and geoscience. The Lab developed a first-of-a-kind "real-time sensor" that cuts the analysis time of REE concentrations in samples from hours to minutes or even seconds. Researchers also developed an unconventional rare-earth and critical mineral model and tool to improve prediction and identification of domestic carbon ore-based resource locations that contain high concentrations of REEs. NETL also performed research and development for screening REE extraction processes and completed two techno-economic analysis screening assessments of NETL-developed extraction pathways to inform process development.

NETL HELPED DEVELOP A RARE EARTH ELEMENT BIOSORPTION REACTOR

NETL partnered with Lawrence Livermore National Laboratory (LLNL), Duke University and the University of Arizona to develop a reactor that will selectively concentrate REEs in an environmentally benign way. Building on bioengineering principles, the LLNL researchers developed a continuous biosorption reactor for REE recovery. The process consists of a two-stage recovery that selectively concentrates scandium, with the remainder of the stream passing through a second biosorption column in which REEs and yttrium are concentrated. Biosorbents bind to REEs in a more environmentally benign way then other conventional separation and recovery methods that rely on toxic acids.

DEVELOPING NET-NEGATIVE HYDROGEN PRODUCTION TECHNOLOGIES

Auburn University, the Electric Power Research Institute, the University of Kentucky Research Foundation and the University of Utah has partnered with NETL to conduct lab-scale investigations into how co-gasification of waste plastics and other diverse waste feedstocks such as biomasses affect gasifier hardware and gasification processes. These investigations are yielding valuable data to inform future upscaling efforts that could provide a pathway to decarbonized energy systems. Advances in gasification of blended and variable feedstocks will enable co-gasification technology to perform reliably and flexibly to produce hydrogen in a net-zero carbon emissions future, and net-negative carbon emission performance could fill an important niche in offsetting difficult to decarbonize industrial sectors.

NETL PLAYED PIVOTAL ROLE IN OBTAINING APPROVAL OF NEW SUPERALLOY FOR TOMORROW'S POWER PLANTS

A new superalloy, developed by Haynes International and tested by a collaborative effort led by NETL, has received American Society of Mechanical Engineers' (ASME) approval for use in the next generation of power plants that will operate with enhanced efficiency and produce fewer greenhouse gas emissions. ASME approval of the superalloy, known as Haynes International H282, provides a new material to withstand aggressive service environments, improve efficiency and extend the life of electricity-producing power plants.

NETL PROJECT PARTNERS HIGHLIGHTED IN JOURNAL

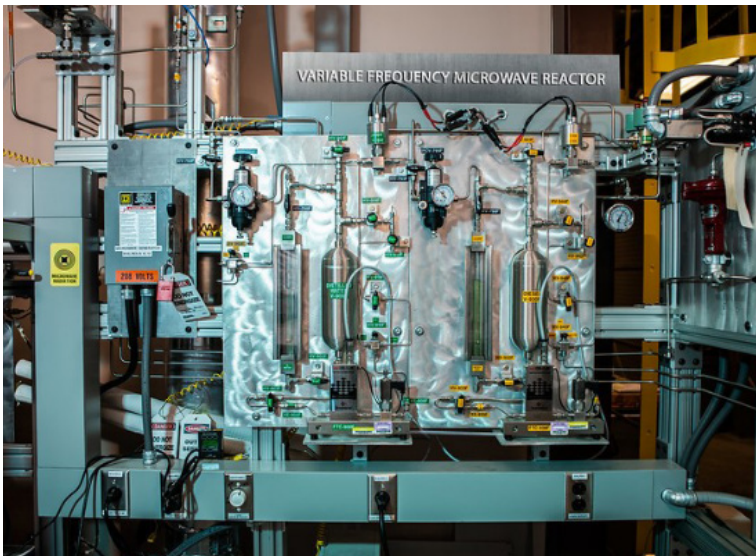
A special July Technical Focus Issue of Materials Evaluation detailed three University-led research and development projects made possible through a partnership with NETL under the Crosscutting Research University Training and Research program, which supports energy research at colleges and universities nationwide, including minority institutions. The special issue featured technical papers describing a robotic inspection tool to evaluate the structural integrity of key components in power plants, developed by Florida International University; a prototype artificial intelligence-enabled robot capable of evaluating and repairing power plant boilers to ensure safer and more affordable energy production, built by the Colorado School of Mines; and a new generation of autonomous robots to monitor and inspect vital energy and civil infrastructure, created by New Mexico State University.

NETL PARTNERED WITH RICE UNIVERSITY TO DEVELOP FLASH GRAPHENE

Rice University partnered with NETL to successfully meet and exceed a key milestone of producing 1 kilogram (kg) of graphene in one day, five months ahead of schedule. The team produced the 1 kg in less than two hours, which exceeded the goal by 20 times. The team studied how an advanced conversion process called flash Joule heating (FJH) can inexpensively produce high-value graphene from carbon ore. Graphene has incredible mechanical and electrical properties, with tensile strength over two hundred times greater than structural steel and electrical conductivity greater than copper. The energy-efficient FJH process can convert almost any carbon-based precursor into quantities of graphene in less than a second.

NETL DEVELOPED MICROWAVE TECHNOLOGY TO PRODUCT LOW-COST HYDROGEN

NETL researchers advanced microwave technology to enable revolutionary changes to the field of reaction chemistry and produce valuable chemicals like hydrogen using less energy and at lower cost. The team is working to unleash the power of microwaves to advance gasification of carbon materials to significantly cut costs and reduce energy requirements while achieving higher yields and greater selectivity of products. Microwaves can rapidly heat reactants to extremely high temperatures without heating the entire reactor volume and achieve desired temperatures quickly, which minimizes startup and shutdown times, saves additional energy and selectively targets the reacting materials. One focus areas in the Lab's gasification research involves transforming carbon ore, biomass or other feedstocks such as waste plastics into gases by reacting the material at high temperatures, without combustion.



NETL RESEARCHER RECEIVED PRESTIGIOUS HISPANIC ENGINEER NATIONAL ACHIEVEMENT AWARD

NETL's José Figueroa, carbon capture team supervisor, received the Great Minds in STEM™ (GMiS) Hispanic Engineer National Achievement Award for advancing projects critical to the success of U.S. decarbonization efforts while serving as an exemplary professional who is helping to ensure a talented and diverse pipeline of researchers for the future. Figueroa manages the implementation of the Lab's approximately $700 million portfolio of active carbon capture research and development projects, with an emphasis on maturing technology from early-concept development to market-ready solutions. In addition, Figueroa promotes diversity at all levels and has worked diligently to inspire future engineers and scientists from various university and underrepresented communities.