

NEW LASER-HEATED PEDESTAL GROWTH CAPABILITY TAKES SENSOR FABRICATION TO A NEW LEVEL

R&D212, May 2024



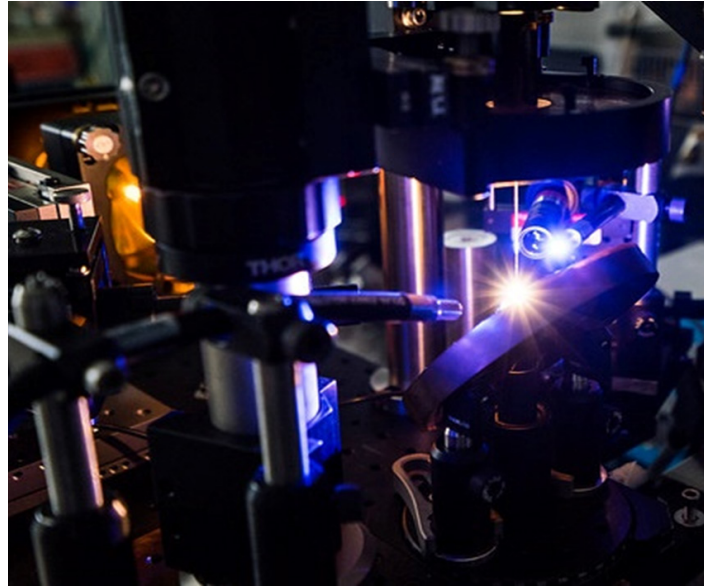
OVERVIEW

Power plant operators must continually monitor conditions in their plants to ensure their equipment is operating safely and efficiently. Researchers on NETL's Sensors and Controls Team can now fabricate optical sensors using single-crystal optical fibers that demonstrate superior properties in comparison to traditional sensors. We accomplish this by using a unique complement of two laser-heated pedestal growth (LHPG) systems. According to NETL researcher Michael Buric, "The new fiber sensors have broader functional temperature ranges, increased durability, and reduced cost. Sensors produced using LHPG will be capable of operating in the high-temperature and harsh environments associated with advanced power systems. Furthermore, these new sensor fibers can be interrogated in a distributed fashion. This ultimately provides sensor data all along the length of the fiber."



It is now possible to engineer an entire energy-generation system with a single optical fiber that maps temperatures or other important parameters in harsh environments. At NETL, some of the world's longest single-crystal fibers have been created, enabling measurements that were previously impossible. These fibers are developed using NETL's novel two stage LHPG process, along with a novel control algorithm that permits the growth of fibers of theoretically infinite length.

U.S. patent number 11,352,712 [Application Number 16/368,425] was granted by the patent office on June 7, 2022. It specifies the new method for controlling fiber growth in a laser-heated pedestal growth system by controlling a laser power output, the pedestal feedstock rate of motion, and the fiber draw rate. The new patented process makes single-crystal fiber easier to grow, and permits the growth of longer fiber lengths than were previously possible. This patent is now available for licensing from NETL.



LHPG is a crystal growth technique that reforms bulk high-temperature-resistant materials, such as sapphire or yttrium aluminum garnet (YAG), into single-crystal optical fibers. The technique produces optical fibers with very high melting temperatures for use as sensor substrates. The LHPG system enables researchers to precisely control crystal growth, and to incorporate novel sensor materials with fiber-substrates during the growth process. The ability to control fabrication parameters along with high-temperature-resistant materials generates optical fiber sensors with improved measurement sensitivity and durability. NETL is now uniquely equipped with two LHPG systems to produce fibers more quickly and with greater functionality. The optical fibers developed at the new facility will be incorporated into fiber sensor assemblies and evaluated for functionality under high temperature and pressure conditions. The materials that demonstrate the most promising performance characteristics will be further evaluated in various sensing configurations.

Optical fiber-based sensors offer distinct advantages including broadband operation and compatibility, and resistance to electromagnetic interference. They also eliminate electrical wires and contacts, which are commonly associated with sensor failure. Additionally, fiber optic sensors are compatible with embedded, remote and distributed sensing technologies.

Innovative process control systems capable of functioning in the extreme environments of conventional and future fossil fuel-based power generation systems will play a key role in improving efficiency while reducing carbon dioxide (CO₂) emissions.

Advanced sensor materials will enable continued use of our coal resources to improve U.S. economic competitiveness while providing global environmental benefits through reduced greenhouse gas emissions. The sensors developed using LHPG could also be applied to process monitoring and control for other energy systems, including solid oxide fuel cells, gas turbines, boilers and oxy-fuel combustion. Other research at NETL is expanding the application of fiber optic-based sensors for use in subsurface monitoring including unconventional, deep and ultra-deepwater oil and gas resource recovery and CO₂ storage.

NETL is a U.S. Department of Energy (DOE) national laboratory dedicated to advancing the nation's energy future by creating innovative solutions that strengthen the security, affordability and reliability of energy systems and natural resources. With laboratories and computational capabilities at research facilities in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL addresses energy challenges through implementing DOE programs across the nation and advancing energy technologies related to fossil fuels. By fostering collaborations and conducting world-class research, NETL strives to strengthen national energy security through energy technology development.

Contacts

Michael Buric

Scientist

Functional Materials Team

Michael.Buric@netl.doe.gov

David Alman

Associate Director

Materials Engineering & Manufacturing Directorate

David.Alman@netl.doe.gov