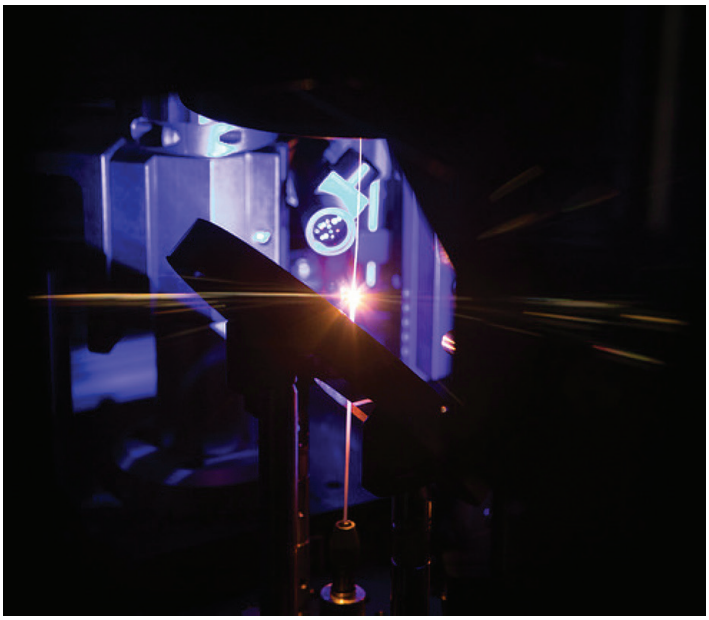
TECHNOLOGY OPPORTUNITY

NOVEL ALGORITHM ENABLES MANUFACTURE OF CONTINUOUS SINGLE-CRYSTAL FIBERS OF INFINITE LENGTH

OPPORTUNITY:

A patent-pending computer-control algorithm invented by the National Energy Technology Laboratory enables the manufacture of single-crystal optical fibers of potentially infinite length, with improved diameter control and faster growth, using a laser-heated pedestal growth (LHPG) system. These fibers can be used to fabricate sensors that can withstand the harsh environments of advanced energy systems. This technology is available for licensing and/or further collaborative research from NETL.



NETL researchers invented a computer-control algorithm that enables the manufacture of single-crystal optical fibers of potentially infinite length using a laser-heated pedestal growth system.

CHALLENGE:

Single-crystal optical fibers made of sapphire and other materials are only commercially available in short lengths of less than 2 meters. Using conventional technologies, length is limited by the finite size of the feedstock pedestal and equipment constraints that prevent supplying more feedstock material without compromising crystal quality. A robust technological solution is needed that allows replacement of the feedstock pedestal with minimum crystal defects and more consistent diameter for long single-crystal fibers. Other algorithms have been studied, but none has offered the ability to produce fibers of arbitrary length.

OVERVIEW:

Advanced fossil energy systems require new, more robust sensing technologies that are compatible with modern control schemes and can withstand harsh environments. Fabricating optical fibers from single-crystal materials like sapphire and yttrium aluminum garnet (YAG) enables the use of fiber-optic technologies in systems where elevated temperatures, extreme pressures, and corrosive substances are commonly found. However, current manufacturing methods limit the length of these fibers due to the finite size of the feedstock material and equipment control constraints.

NETL researchers have developed a continuous control algorithm for producing single-crystal optical fibers in arbitrarily long lengths using an LHPG system. The NETL algorithm enables the use of multiple feedstock pedestals to grow the same long fiber by stopping the growth process to insert a new pedestal as needed. This involves shutting down the laser used to melt the material, inserting the new pedestal, re-initializing the laser to melt the tip of the new pedestal and resuming crystal growth at the same exact diameter. This new algorithm is uniquely effective because it employs an advanced imaging system and several simultaneous and independent proportional, integral, and derivative (PID) controls to enforce a specific set of parameters.

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This novel algorithm permits instantaneous growth of a previously produced fiber, without causing significant crystal defects or changes in the fiber's outer diameter following the pedestal-change procedure. The new algorithm also improves upon previous state-of-the-art technology in diameter control, resulting in fibers with more uniform outer diameters that exhibit lower losses than fibers grown using other methods. Finally, the new algorithm shortens the growth process by enabling production of very thin sapphire fibers from thick pedestal materials in one step, thereby eliminating the need for multiple steps to reduce fiber diameter.

This NETL technology offers numerous advantages over existing technologies for the manufacture of long single-crystal optical fibers, producing a superior product while allowing the growth process to be interrupted as many times as necessary.

ADVANTAGES:

- Allows continuous control of an LHPG system to manufacture single-crystal optical fibers of potentially infinite length.
- Improves upon existing algorithms by simultaneously controlling multiple growth parameters.
- Offers better diameter control to create superior single-crystal fibers.
- Shortens the growth process by eliminating added steps.

APPLICATIONS:

- Control an LHPG system to grow long lengths of single-crystal fibers for a myriad of uses, including:
  - Sensors for harsh environments, such as advanced energy systems.
  - Communications.
  - Materials manufacturing.
- Control an LHPG system to grow fibers or larger crystal structures.

RELATED PATENTS:

U.S. Patent Pending (non-provisional patent application)

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Title: A Laser Heated Pedestal Growth System for Manufacturing Single Crystal Fibers

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