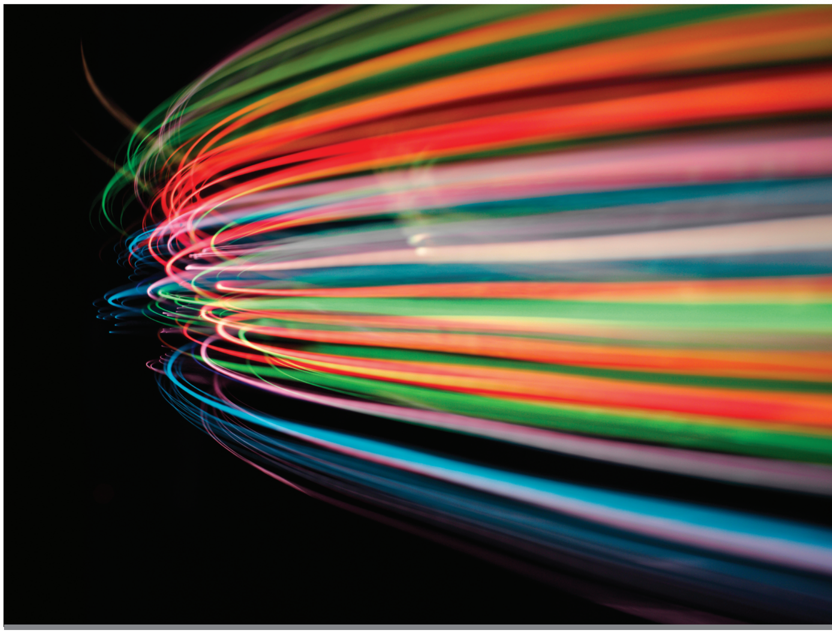

National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Sensors

Compact, Temperature-Tuned OFDR Laser

A reliable, low-cost excitation source for optical frequency domain reflectometry (OFDR)

Fiber optic sensing systems (FOSS) have advantages over conventional sensors including lighter weight, smaller size, improved reliability, and higher accuracy. To date, wavelength division multiplexing (WDM) has perhaps been the most popular fiber optic sensing method. Drawbacks of WDM exist, however, including the importance of fiber Bragg grating (FBG) sensor locations, need for each sensor to have a unique wavelength, and limited number of sensors that can occupy any one data channel (~10). As a result, NASA has focused on OFDR, an alternative FBG interrogation technique based on laser interferometry. OFDR provides advantages over WDM, most notably higher spatial density (up to 1000 FBGs can be multiplexed into a single fiber), and reduced cost per sensor.

During development of an OFDR-based FOSS system, cost and performance-based limitations of traditional excitation sources led NASA to develop a novel, wavelength-swept, solid-state laser tailored to this application.

BENEFITS

- Low cost: NASA's compact, temperature-tuning laser costs roughly one eighth the price of conventional OFDR excitation sources (e.g., external cavity lasers).
- No moving parts: NASA's OFDR excitation source has no moving parts, making it more simple and reliable than external cavity lasers.
- Compact: The laser has a small form factor relative to conventional OFDR excitation sources.

THE TECHNOLOGY

Because OFDR-based fiber interrogation systems rely upon interferometry between sensors with respect to a unique reference length, the excitation source (laser) must lase at a single longitudinal mode (SLM). If the excitation source contains multiple modes, the resulting beat frequency becomes a super-position of the multiple frequencies caused by the modes; as a result, the sensor cannot be accurately defined in the Fourier domain. For OFDR systems with high sensing ranges, a continuous wavelength tunable laser must be used to accommodate the resonant wavelength shift of the fiber sensors due to environmental changes. External cavity lasers (ECLs) have been used due to their narrow linewidth and ability to lase at a SLM with no mode-hopping between steps. However, the mechanical complexity associated with tuning, susceptibility to vibration and shock, and high price point leave much to be desired.

To overcome the limitations of OFDR-based FOSS systems resulting from non-ideal excitation sources, NASA has developed a narrow linewidth solid-state laser based on the Distributed Feedback (DFB) laser. NASA's laser is continuously tuned by manipulating the laser cavity's temperature via a thermal-electric cooler feedback system. This continuous wavelength tuning generates a clean clock signal within an auxiliary interferometer, while the laser simultaneously interrogates multiple FBGs to produce a clean sensing interferometer. A Fourier domain spectrograph is used to show the unique frequency (i.e., location) of each FBG.

While NASA's excitation source provides several performance advantages over conventional lasers used in OFDR, it is also highly compact and one eighth the cost of the ECLs traditionally used as excitation sources in OFDR-based systems. The laser has no moving parts, which also substantially improves system reliability.

Originally developed to demonstrate a low-cost interrogator for liquid level sensing in oil tanks, NASA's compact, temperature-tuned OFDR laser can be applied wherever OFDR-based fiber optic sensing is desirable. Additional applications may include temperature distribution sensing, strain sensing, pressure sensing, and more.

NASA AFRC has strong subject matter expertise in fiber optic sensing systems, and has developed several patented technologies that are available for commercial licensing. For more information about the full portfolio of FOSS technologies, visit: https://technology-afrc.ndc.nasa.gov/featurestory/fiber-optic-sensing

APPLICATIONS

The technology has several potential applications:

- OFDR-based fiber optic sensing systems: This invention was designed to enable OFDR-based fiber optic sensing systems with reduced cost and complexity
- Tank gauging: Monitor liquid level status of cryogenic liquids, oil tanks, and more
- Structural health monitoring: Real-time awareness of structural changes of composites, aerospace structures, turbine blades, and more
- Temperature distribution sensing: Measure temperature conditions in critical locations (e.g., in battery packs of electric vehicle powertrains)
- Pressure sensing: Measuring pressure in hazardous or high temperature environments (e.g., aerospace applications, food processing applications, etc.)

PUBLICATIONS

Patent Pending

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Armstrong Flight Research Center

PO Box 273, M/S 1100
Edwards, CA 93523-0273
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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