Miniature 3D Position-to-Optical Displacement Sensor

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Opportunity

Seeking a licensing and development partner to bring this sensor into commercial production.

Development Stage

Validated in the lab

Intellectual Property

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PROBLEM STATEMENT

Precise displacement measurement underpins many industries, from aerospace and robotics to structural health monitoring. The current standard is the Linear Variable Differential Transformer (LVDT), an electromechanical sensor used for decades in aircraft, nuclear power, servo mechanisms, and process control. LVDTs are reliable, but they are vulnerable to electromagnetic interference, and industry standards cap their accuracy, with the tightest published tolerance at +/-25 μm. A compact sensor is needed that delivers finer resolution and withstands electrically noisy environments.

SOLUTION

Researchers at Missouri University of Science and Technology have developed a miniature optical sensor that measures displacement in three dimensions with micrometer accuracy. It pairs a fiber optic interferometer with a series of gold-coated metasurface resonators patterned onto a mirror. As light travels through the fiber and reflects off the mirror, it creates an interference pattern that tracks movement along the Z axis. At the same time, the wavelength-selective resonators pinpoint movement along the X and Y axes. Three of these fibers can be bundled into a single tri-interferometer package to capture rotational displacement, which is useful for monitoring debonding and delamination at material interfaces. In testing, the sensor measured three-dimensional displacement up to about 450 μm with a maximum error of about 5.4 μm (2.2%).

VALUE PROPOSITION

This sensor delivers about ten times the accuracy of the tightest LVDT standard in a fraction of the size. Because it measures optically rather than electrically, it performs well in environments with electromagnetic interference where LVDTs struggle, including aerospace, robotics, nuclear power, and industrial process control. Its compact form also enables direct embedment in composite materials during manufacturing, supporting real-time structural health monitoring for crack detection, strain measurement, and interface delamination tracking.