A Short-Range Distance Sensor with Exceptional Linearity

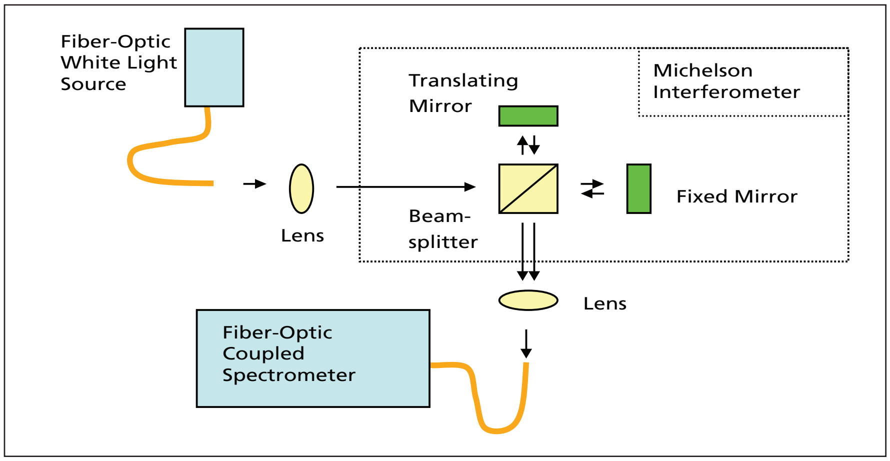
Potential uses exist in the areas of micromachining and nanotechnology.

John F. Kennedy Space Center, Florida

A sensor has been demonstrated that can measure distance over a total range of about 300 microns to an accuracy of about 0.1 nm (resolution of about 0.01 nm). This represents an exceptionally large dynamic range of operation — over 1,000,000. The sensor is optical in nature, and requires the attachment of a mirror to the object whose distance is being measured.

This work resulted from actively developing a white light interferometric system to be used to measure the depths of defects in the Space Shuttle Orbiter windows. The concept was then applied to measuring distance. The concept later expanded to include spectrometer calibration.

In summary, broadband (i.e., white) light is launched into a Michelson interferometer, one mirror of which is fixed and one of which is attached to the object whose distance is to be measured. The light emerging from the interferometer has traveled one of two distances: either the distance to the fixed mirror and back, or the distance to the moving mirror and back. These two light beams mix and produce an interference pattern where some wavelengths interfere constructively and some destructively. Sending this light into a spectrometer allows this interference pattern to be analyzed, yielding the net distance difference between the two paths.



The **Distance Sensor** is based on the wavelength variations of the light transfer through a Michelson interferometer. Collimated white light is launched into an interferometer composed of a fixed mirror and a translating mirror aligned with a beamsplitter. Light reflected from each mirror makes its way to a small spectrometer where the optical intensity can be measured as a function of wavelength.

The unique feature of this distance sensor is its ability to measure accurately distance over a dynamic range of more than one million, the ratio of its range (about 300 microns) to its accuracy (about 0.1 nanometer). Such a large linear operating range is rare and arises here because both amplitude and phase-matching algorithms contribute to the performance. The sensor is limited by the need to attach a mirror of some kind to the object being tracked, and by the fairly small total range, but the exceptional dynamic range should make it of interest.

This work was done by Stephen Simmons and Robert Youngquist of Kennedy Space Center. For more information, contact the Kennedy Space Center Technology Transfer Office at (321) 867-7171. KSC-13382

Miniature Trace Gas Detector Based on Microfabricated Optical Resonators

Ultra-sensitive detection of molecules is available with a modified whispering gallery mode resonator.

NASA's Jet Propulsion Laboratory, Pasadena, California

While a variety of techniques exist to monitor trace gases, methods relying on absorption of laser light are the most commonly used in terrestrial applications. Cavity-enhanced absorption techniques typically use high-reflectivity mirrors to form a resonant cavity, inside of which a sample gas can be analyzed. The effective absorption length is augmented by the cavity's high quality factor, or *Q*, because the light reflects many times between the mirrors. The sensitivity of such mirror-based sensors scales with size, generally making them somewhat bulky in volume. Also, specialized coatings for the high-reflectivity mirrors have limited bandwidth (typically just a few nanometers), and the delicate mirror surfaces can easily be degraded by dust or chemical films.

As a highly sensitive and compact alternative, JPL is developing a novel trace gas sensor based on a monolithic optical resonator structure that has been modified such that a gas sample can be directly injected into the cavity. This device concept combines ultra-high *Q*