Technology Opportunity
Glenn Research Center • Cleveland • Ohio
Technology Transfer & Partnership Office

TOP3–00183

Fiber-Optic Bragg-Grating-Based Sensing

Technology

The National Aeronautics and Space Administration (NASA) seeks to transfer technology for a development of optical sensing systems based on fiber Bragg gratings (FBGs). The optical FBG-based systems permit conducting insitu measurements of pressure, temperature, and other sensing parameters in harsh environments.

Benefits

Fiber-optic technology offers

- Small size and light weight of optical components
- Immunity to electromagnetic interference
- Immunity to chemical agents
- Secure communications
- Signal fidelity and high communication bandwidth
- Bragg gratings are built-in-fiber devices that make the sensors robust
- Fiber Bragg gratings are easily embeddable in materials and structures

Commercial Applications

- Temperature and pressure measurements in harsh environments
- Insitu process monitoring and NDE
- Strain and vibration measurements

Technology Description

FBGs work as filters by selecting a certain portion of the input spectrum of light and reflecting it back as shown in figure 1.

FBGs are manufactured by introducing periodic variations in the refractive index in the longitudinal direction of optical fibers. In order to construct FBGs, optical fibers are doped with photosensitive materials called dopants and exposed to ultraviolet (UV) light with a periodic intensity. The photosensitive dopants change their properties according to the intensity of UV light. This phenomenon is called photorefraction.

The reflected portion of the spectrum depends on the geometry and chemistry of the periodic structure of the grating. Thus, if the geometry or chemistry of the FBG changes due to either environmental changes or induced perturbations the wavelength of the

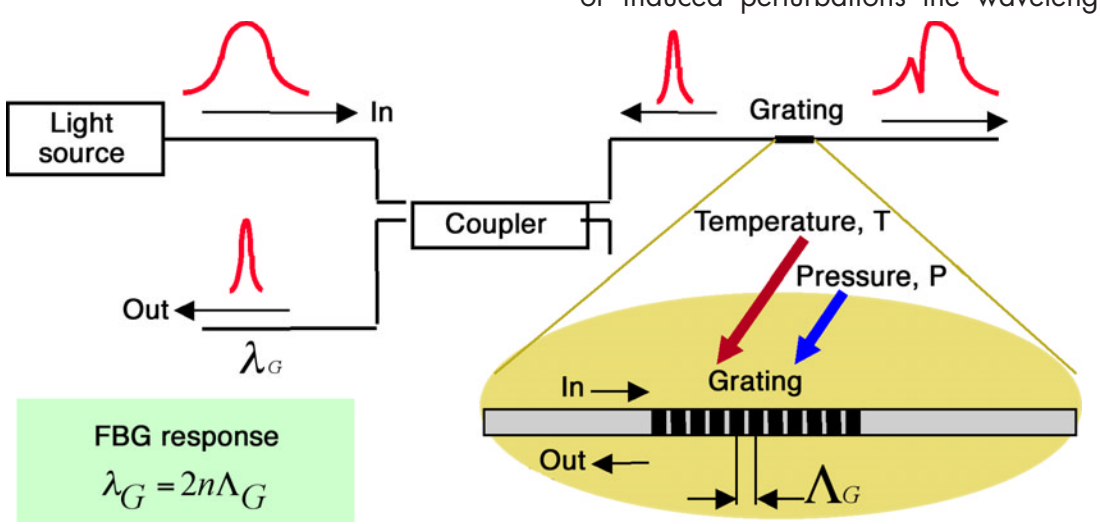

Figure 1.—Principle of operation of fiber Bragg gratings.

reflected light would change accordingly. The property makes FBGs attractive candidates for sensor applications.

Process monitoring

Fiber Bragg gratings have withstood the process of manufacturing of high-temperature polymer matrix composites (PMCs) (300 °C). A PMC plate with the FBG embedded in it is shown in figure 2.

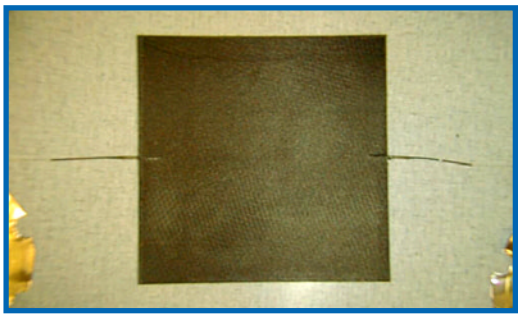

Figure 2.—High-temperature polyamide matrix composite plate with embedded FBG.

Temperature measurements

FBGs have demonstrated the temperature measurement capabilities with less than 1.0 percent error of full scale throughout the entire evaluation temperature range of ambient to 300 °C.

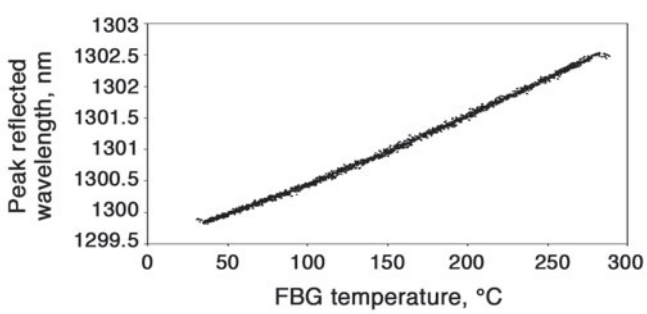

Figure 3.—FBG wavelength temperature dependence through six thermal cycles.

Signal processing

The FBG-based sensing systems require a mechanism or method to convert the Bragg reflected wavelength, which is dependent on the environment or disturbance to a light intensity that could be converted by a light detector into electrical current for subsequent electronic processing.

For processing the Bragg wavelength, we developed two types of unbalanced interferometers (UI), with large and small imbalance. (Imbalance is the optical path difference generated in the interferometer.)

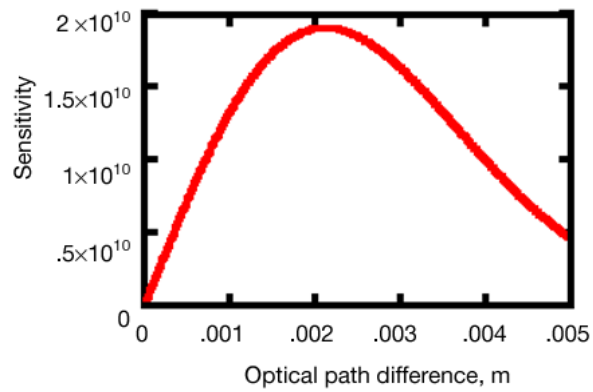

Figure 4.– Sensitivity of UIs with large imbalance to periodic changes in the incident wavelengths.

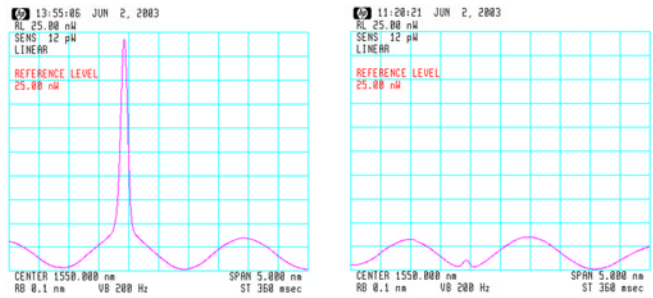

Figure 5.—Signals generated by UIs with small imbalance in response to different Bragg wavelengths.

Options for Commercialization

NASA Glenn Research Center is interested in working with industry and academia to further develop this instrumentation technology.

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References

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Key Words

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