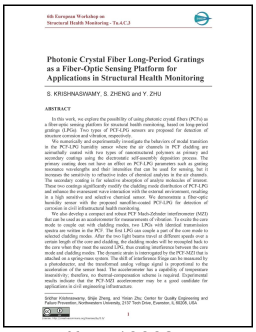
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Photonic Crystal Fiber Long-Period Gratings as a Fiber-Optic Sensing Platform for Applications in Structural Health Monitoring

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ABSTRACT

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In this work, we explore the possibility of using photonic crystal fibers (PCFs) as a fiber-optic sensing platform for structural health monitoring, based on long-period gratings (LPGs). Two types of PCF-LPG sensors are proposed for detection of structure corrosion and vibration, respectively.

We numerically and experimentally investigate the behaviors of modal transition in the PCF-LPG humidity sensor where the air channels in PCF cladding are azimuthally coated with two types of nanostructured polymers as primary and secondary coatings using the electrostatic self-assembly deposition process. The primary coating does not have an effect on PCF-LPG parameters such as grating resonance wavelengths and their intensities that can be used for sensing, but it increases the sensitivity to refractive index of chemical analytes in the air channels. The secondary coating is for selective absorption of analyte molecules of interest. These two coatings significantly modify the cladding mode distribution of PCF-LPG and enhance the evanescent wave interaction with the external environment, resulting in a high sensitive and selective chemical sensor. We demonstrate a fiber-optic humidity sensor with the proposed nanofilm-coated PCF-LPG for detection of corrosion in civil infrastructural health monitoring.

We also develop a compact and robust PCF Mach-Zehnder interferometer (MZI) that can be used as an accelerometer for measurements of vibration. To excite the core mode to couple out with cladding modes, two LPGs with identical transmission spectra are written in the PCF. The first LPG can couple a part of the core mode to selected cladding modes. After the two light beams travel at different speeds over a certain length of the core and cladding, the cladding modes will be recoupled back to the core when they meet the second LPG, thus creating interference between the core mode and cladding modes. The dynamic strain is interrogated by the PCF-MZI that is attached on a spring-mass system. The shift of interference fringe can be measured by a photodetector, and the transformed analog voltage signal is proportional to the acceleration of the sensor head. The accelerometer has a capability of temperature insensitivity; therefore, no thermal-compensation scheme is required. Experimental results indicate that the PCF-MZI accelerometer may be a good candidate for applications in civil engineering infrastructure.

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Содержание