Abstract

Sensors have been an integral part of human life. Various sensor technologies have contributed in their own ways to fulfill specific requirements for aiding human beings. In this context, fiber optic sensors have several advantages such as availability of large number of components from communication industry, small footprint, easy fabrication, and immunity to Electro Magnetic Interference. In the category of fiber optic sensors, Fiber Bragg Gratings (FBGs) have been found to be very useful, because of their high sensitivity, multi-modal sensing ability, large operational bandwidth, and multiplexing capability.

An FBG is a periodic orthogonal perturbation of the refractive index along the longitudinal axis of the core of a single mode optical fiber. The periodic modulation of index of refraction is brought about by exploiting the photosensitivity of a germania- doped silica fiber upon exposure to UV light. FBGs, in the basic form, can sense strain and temperature. However, in recent years, several newer sensing applications of FBGs are being explored and the present thesis is an attempt in this direction.

In this thesis work, Fiber Bragg Grating sensor-based devices have been devised for newer applications in bio-medical and engineering fields. Basically, novel packaging methodologies for FBGs are designed and developed, which transduce the measured parameter to a secondary parameter that can be sensed by the FBG.

In the field of Cardiology, an FBG Pulse Recorder has been developed which has the ability to acquire the radial arterial pulse pressure waveform. It records the beat-to-beat pulse pressure along with the radial arterial diametrical variations. The FBG Pulse Recorder has been employed to measure the blood pressure in conjunction with a sphygmomanometer, using the unique signatures obtained in the radial arterial pulse pressure waveform. By the same methodology, radial arterial compliance, is evaluated. Also, using two FBG Pulse Recorders at the carotid and radial arterial sites the pulse transit time differential is measured which acts as an indicator of variation in systolic blood pressure and pulse wave velocity.

In the field of dentistry, a novel technique for real time dynamic measurement of the maximum individual bite force using Fiber Bragg Grating Bite Force Recorder has been proposed. The results obtained show that bite forces increase along the dental arch and are found to be higher in male than in female. Also, an in-vitro study utilizing the FBG temperature sensor has been carried out to measure the variation of temperature in the pulp chamber during light curing of composite materials.

In the field of seismology, a new methodology for real time dynamic monitoring of seismic vibrations, using a Fiber Bragg Grating Seismic Sensor has been proposed. The validation and field tests are carried out in comparison with a commercial seismometer. Further, the feasibility study for an elephant intrusion monitoring system employing the sensor developed has been put forth.

Furthermore, a displacement device has been devised which converts displacement into strain on a cantilever beam over which the FBG sensor is bonded with the aid of a pivoted arm. This arm provides the necessary mechanical amplification of the displacement by varying the pivot screw position, facilitating tunable sensitivity for the FBG displacement device. Also, the same device has been used for measurement of vibration and with enhanced sensitivity for surface profilometry with a resolution of 175nm.

To summarize, the present thesis demonstrates a comprehensive experimental study which bring out the utility of FBG sensors in variety of challenging applications.