Bragg Gratings in Microstructurated Polymer Optical Fibers

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Fiber optic sensors offer attractive characteristics that make them very suitable and, in some cases, the only viable sensing solution. Some of the key attributes of fiber sensors are:

- Absolute measurement
- Immunity to electromagnetic interference
- Excellent resolution and range
- Passive operation, intrinsically safe
- Water and corrosion resistant
- Rugged, small size and light weight
- Multiplexed in parallel or in series

Despite the many obvious advantages fiber optic sensing struggle with the reputation of being expensive and difficult to handle due to the fibers being very fragile. This limits or delays deployment of new fiber sensing applications.

The Fiber Bragg Grating (FBG) sensor is a short piece of optical fiber with a periodic modulation of the refractive index in the optical fiber. The periodic modulation of refractive index is generated by an interference pattern, and it creates a narrow filter response with peak reflectivity at a wavelength determined by the period of the FBG (see Figure 1).

A broadband light source is used to launch light into the optical fiber towards the FBG, and the FBG will reflect just one wavelength as described above. The

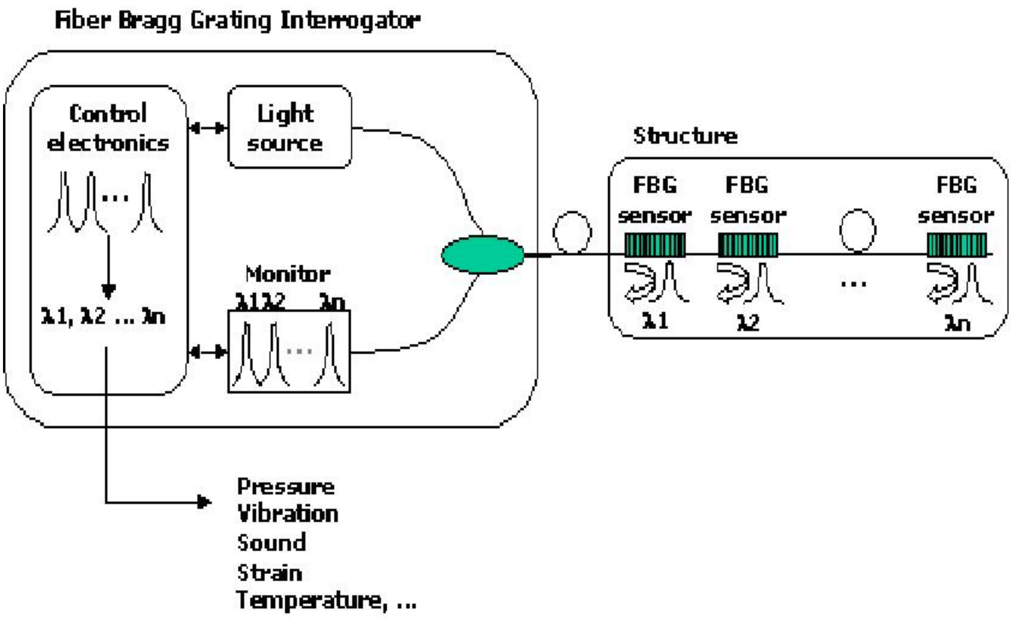

Figure 1: Fiber Bragg Grating sensing system.

remaining wavelengths from the light source will propagate towards the next FBG, which will reflect light at another wavelength, and so on.

When the FBG is mounted on a structure it may be stretched or compressed due to structural changes of the structure. This causes a change in the FBG period, and the peak reflectivity of the FBG is shifted accordingly to $\lambda_i + \Delta\lambda$. Each fiber can contain a multitude of FBG sensors all having different peak reflection wavelength [1].

Determining the peak reflection wavelength and shift in peak wavelength is the basis of FBG sensing, since measurement of the reflected wavelength can be converted to parameters such as vibration, strain, pressure and temperature [2], which again can be converted e.g., to sound (see Figure 2).

In order to convert an audio signal to an optical signal it is necessary the sensor has a fast response to strain. For this reason Polymer Fibers are extremely well suited for strain sensors (due to polymer's Young's modulus that is quite low). Moreover Microstructurated Optical Fibers have the advantage to be endlessy single moded and the possibility to be designed suitably for each application, also in not conventional configurations [3].

The versatility of the Microstructurated Polymer Optical Fibers, together

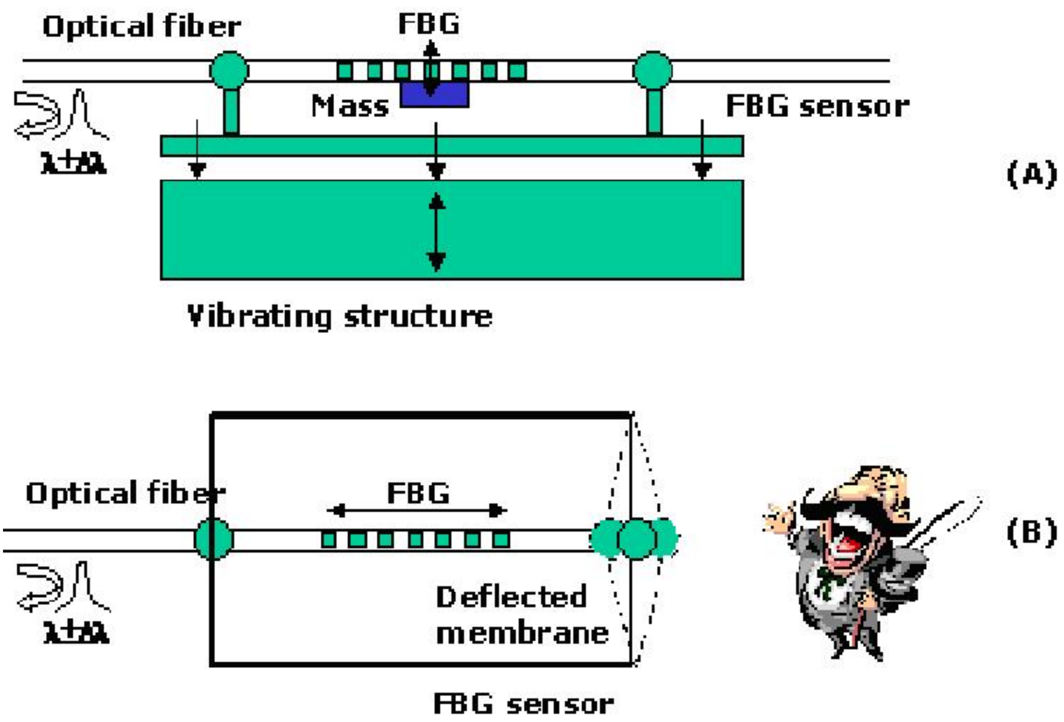

Figure 2: FBG sensor for vibration (A) and pressure/sound (B) measurements.

with the enhanced sensitivity due to the polymers characteristics, and, not least the low cost of polymer fibers give the chance of use sensors based on Bragg gratings written in this kind of fibers in many different fields, one of which could be biosensing.

References

[1] A.D.Kersey, M.A.Davis, H.J.Patrick, M.LeBlanc, K.P.Koo, C.G.Askins, M.A.Putnam, and E.J.Friebele, *Fiber Grating Sensors*, Journal of Lightwave Technology, Vol. 15, No. 8 (1997).

[2] H.B.Liu, H.Y.Liu, G.D.Peng, P.L.Chu, *Strain and Temperature Sensor Using a Combination of Polymer and Silica Fibre Bragg Gratings*, Optics Communications, 219, 139-142 (2003)

[3] M.Large, L.Poladian, G.Barton, M.A. van Eijkelenborg, *Microstructurated Polymer Optical Fibers*, Springer (2008).