LABORATORI NAZIONALI DI FRASCATI
SIS – Pubblicazioni

LNF–03/15 (IR)
10 settembre 2003

RESULTS ON POSITION MONITORING AND DISPLACEMENT (OMEGA-LIKE DEVICE) BY MEANS OF FIBER BRAGG GRATING SENSORS FOR THE BTEV DETECTOR

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Abstract

We propose to use Fiber Bragg Grating sensors for position monitoring of silicon tracking detectors up to a micron precision. We also introduce the concept of a device (the Omega-like device) which, instrumented with FBG sensors, is able to relocate moving structures with a 10 micron precision. We show R&D results including long term stability, resolution, radiation hardness and characterization of Fiber Bragg Grating sensors used to monitor structure deformation, repositioning, and surveying of silicon detectors in High Energy Physics.

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1 INTRODUCTION

FBG sensors are widely used in telecommunication as optical filters. For the first time we have used FBG sensors as optical, low-noise, high-resolution strain gauges to monitor structure deformation, repositioning, and surveying silicon (pixel and microstrips) detectors for HEP experiments at hadron machines. We show R&D results including long term stability, precision, resolution, radiation hardness and characterization.

2 FBG SENSORS

Fiber Bragg Grating (FBG) sensors have been used so far as telecommunication filters, and as optical strain gauges in civil and aerospace engineering [1], and, only recently, in HEP detectors [2]. The BTeV[3] detectors utilize FBG sensors to monitor online the positions of the straw tubes, pixels, and microstrips. The optical fiber is used for monitoring displacements and strains in mechanical structures such as the straw tube-microstrip support presented here. A modulated refractive index along the FBG sensor produces Bragg reflection at a wavelength dependent on the strain in the fiber (Fig.1), permitting real-time monitoring of the support. According to these properties, an FBG sensor is going to be placed in the M0X structure between the Rohacell® foam and the CFRP shell. Sensors will be located in spots of maximal deformation, as predicted by FEA simulation. Figure 2 shows long-term behaviour of FBG sensors while monitoring micron-size displacements, compared to monitoring via microphotographic methods.

3 LONG-TERM STABILITY

The optical fiber is used for monitoring displacements and strains in mechanical structures such as the presented straw tubes-microstrip support. A wavelength selective light diffraction grating (Fig.1) along the FBG sensor is placed in the fiber, and it permits an on-time monitoring of the support. Fig.2 shows long-term behaviour of FBG sensors while monitoring micron-size displacements, compared to monitoring via photographic methods.

4 THE OMEGA-LIKE REPOSITIONING DEVICE

FBG sensors have been also applied to instrument a novel repositioning device with micrometric resolution. The Omega-like device (shown as prototype in Fig.3,4) follows the displacement of the pixel detector designed for the BTeV experiment at the Fermilab Tevatron which, at each accelerator store, has to be moved out and in of the beamline. Fig.5 shows a Finite Element Analysis of the Omega-like device. FBG sensors are located on area of largest strain in order to maximize sensitivity. Preliminary results show how a repositioning precision of about 10microns is reached. Work is in progress to reach the required 3 micron precision.

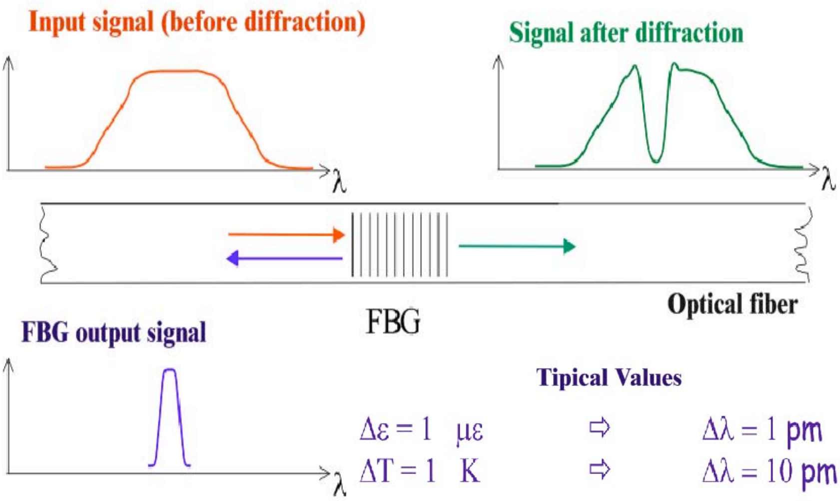

Figure 1. Principle of FBG sensors operation. A laser pulse is injected in the fiber and reflected selectively accoding to the grating pitch. Strain changes the grating pitch thus changing the wavelength of reflected pulse. The sensor is also sensitive to temperature changes.

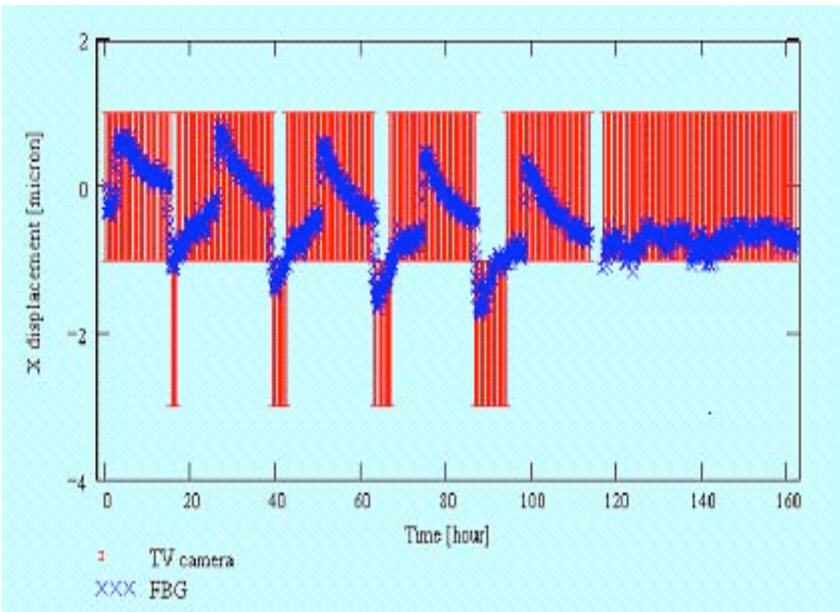

Figure 2. FBG long-term monitoring stability results. FBG output (crosses) is validated by TV camera (bars).

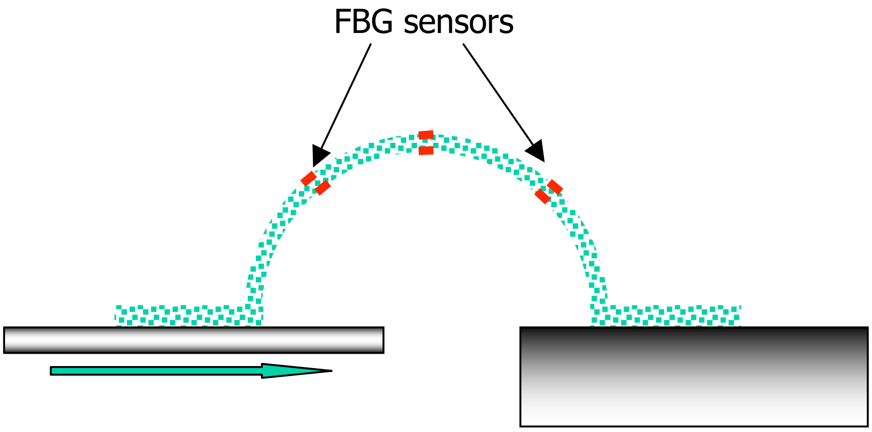

Figure 3. The Omega-like repositioning devices, equipped with FBG sensors, follows the pixel support structure in and out of beam, assuring repositioning accuracy.

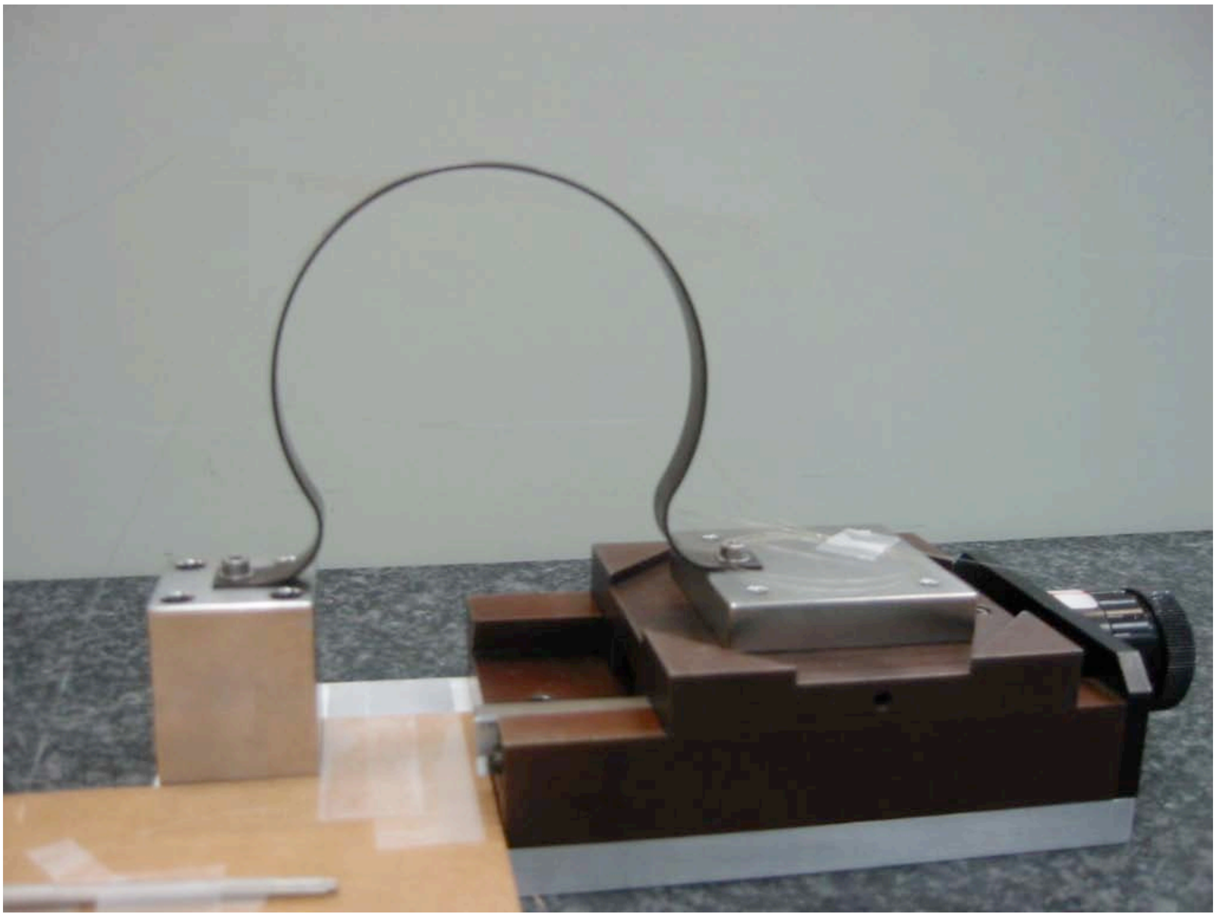

Figure 4. Omega-like prototype in steel.

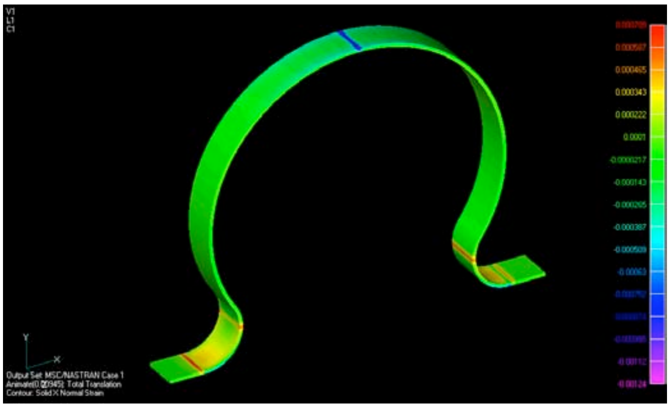

Figure 5. Finite Element Analysis of the Omega-like repositioning system. Sensors are located on the areas of larger mechanical strain in order to maximize sensitivity.

5 CONCLUSIONS

We have used FBG sensors in HEP for the first time as precise, stable, optical devices for micrometric position monitoring of silicon pixel and strips detectors. FBG sensors provide position monitoring with micrometric resolution. We have used sensors to characterize and optimize pixel support structures in Carbon Fiber Reinforced Plastic. Finally, we have proposed a novel device to precisely reposition the pixel detector in and out of the beams at each accelerator store. Preliminary results show a 10micron resolution.

6 REFERENCES

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