Fiber Bragg gratings embedded in 3D-printed patches for sensitivity enhancement of deformation monitoring

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This paper reports a study of a 3D printed patch embedding a fiber Bragg grating. The patch design and fabrication with a 3D printer is described. Finally, sensitivity to temperature and strain are evaluated.
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1. Introduction

In the field of the civil engineering real time and continuous health monitoring of structures are of great interest for the safety evaluation and maintenance of infrastructures allowing for decision-making [1], [2]. To this aim, in the last years, fiber Bragg grating (FBG) technology became very popular due to its intrinsic advantageous peculiarities [3]–[5].

2. Design and fabbrication

In this work FBG has been embedded in a plastic patch, made with 3D printer, in order to enhance its bending sensitivity together with a strengthening the FBG sensor and an increasing the gluing surface improving the strain transfer from the monitored sample. As sensing element, a commercial bare FBG, 10 mm long, have been chosen.

The designed patch, showed in Fig. 1a, has rectangular shape with length of 25 mm to allow to embed, in addition to the FBG, a small part of coated fiber, so that the bare region of the fiber (18 mm long) is completely protected. The selected width is 5 mm to keep small dimension and, at same time, increase the gluing surface. Finally, the chosen thickness is 1.8 mm to ensure the improvement of the bending sensitivity and good device robustness.

The fabrication consists principally of three steps: i) printing of the first half patch, b) positioning of the FBG and c) printing of the second half patch. For the patch printing the so-called fused deposition modeling (FDM) methods was adopted using the Renkforce RF500 3D printer with PLA plastic as printing material.

3. Experimental

In order to experimental test the device, it has been fixed at a metallic bar by means of an acrylate adhesive together with a bare FBG, used as reference.

The bar is 960 mm long, 30 mm wide and 4.2 mm thick while the sensors were positioned 280 mm from one end.

The sensorized bar was placed onto two metallic supports in correspondence of the extremes and subjected to flexural load, as represented in Fig. 1b, loading it with 0 kg, 2 kg, 4 kg, 6 kg (maximum weight) and progressively returned to 0 kg.

The strain trends measured by the sensors are reported in Fig. 1c, where they are observable higher compressive values recorded by the embedded FBG with respect to the bare one. The laboratory temperature remained constant during the test, so no thermal compensation was need.

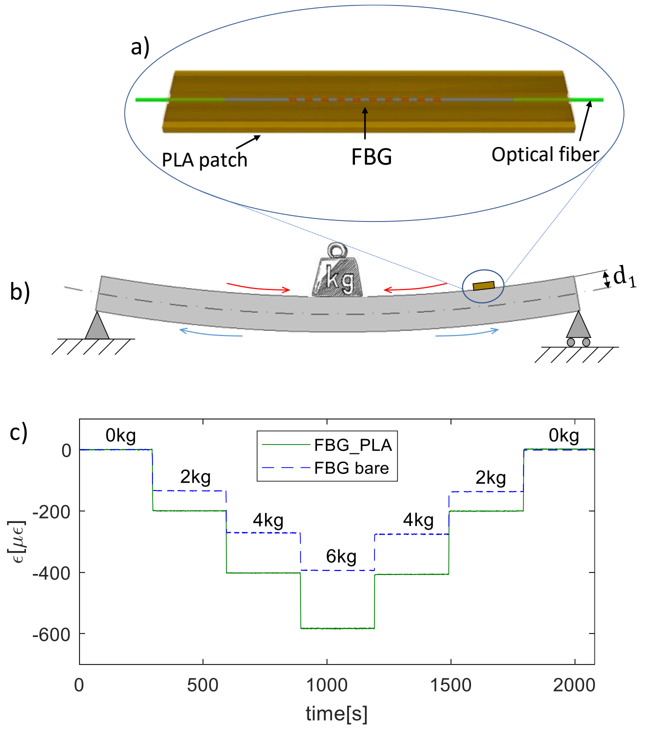

Fig. 1 a) Schematic of the designed device, b) schematic of the bent bar (not in scale) and c) strain trends recorded by the FBGs.

This enhancement in the embedded FBG strain is due to the greater distance d_1 between the neutral axis of the metallic bar and the FBG sensor. In fact, in a bent beam, the longitudinal strain is proportional to the distance from the neutral axis. Then the bending sensitivity increases using our sensing device.

References

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