Bending sensing characteristics of long-period gratings UV-point-by-point induced in non-birefringent fibres

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ABSTRACT

In this work is reported the bending sensing characteristics of a long-period grating produced point-by-point with a 266 nm Nd:YAG laser. Spectral changes of the transducer subjected to bends with curvatures from 0 to 3.13 m^{-1} were investigated. The magnitude of the bend-induced wavelength shift is nonlinear and dependent on the rotation of the cylindrical fibre relative to the bending plane. For each constant bending applied to the grating, the fibre was rotated around its axis in angular steps of 15°, within the angular range from 0 to 180°. An artificial neural network model was applied for identifying the curvatures, resulting in a root-mean-square error of 0.028 m^{-1}.

Keywords: Long-period grating; Bending measurement; Artificial neural network.

1 INTRODUCTION

Long-period gratings (LPGs) constitute a promising transducer technology for direct bend sensing applications. Sensor systems composed by this kind of devices make them suitable in the monitoring of engineering structures such as slabs, bridges, dams and airplanes. The bend-sensitivity of this device can be used to detect changes in the shape of a structure by measuring the attenuation and/or the split of transmission bands[1,2,3,4].

Along the last few years, several works have shown bend sensing applications of LPGs. Patrick et. al.[1] observed that the magnitude of the bend-induced wavelength shift of LPGs induced by UV laser pulses with an amplitude mask, depends on the rotation of the cylindrical fibre relative to the bending plane. However, no correlation was found between the direction of the incident UV light and the fibre angle rotation for which occur the maximum bend sensitivity. In other work Patrick[2] investigated the bend sensitivity of LPGs UV-written in eccentric core fibre (ECF) with a large core offset (14 μm), and demonstrated that a maximum response is obtained when both the centre of the cladding and the core lay in the bending plane. Rathje et. al.[5] showed that the core concentricity error causes asymmetry in the splitting of LPG resonances for different bend directions. Liu et. al.[3] did not observe, in UV-induced LPGs written with an amplitude mask, the rotational dependence of the bend sensitivity, using a normal single-mode B/Ge photosensitive fibre. However, due to the dissimilarity in writing mechanisms, it was found a very strong dependence of the transmission resonances of CO_2-laser-induced LPGs on the orientation of the fibres[6,7,8,9]. Wang and Rao[10] proposed a bend-sensor consisting of one UV-induced LPG, whose bend-sensitivity is independent on the bend-directions, and two LPGs induced by CO_2 laser pulses, whose bend-sensitivities depend strongly on the curved directions. The bend-sensing response of LPGs UV-inscribed in D-shaped fibre has been investigated[11,12] and strong fibre-orientation dependence of the spectral response, when such gratings are subjected to bending at different directions, was observed. Allsop et. al.[13, 14] fabricated LPGs in a standard fibre using a frequency-doubled argon-ion laser and, in a second stage, promoted a modification of the cladding with a femtosecond laser system. This type of sensor showed whether blue or red wavelength shifts, depending on the direction of bending experienced. Devices have also been produced using an elliptical core fibre to study the effects of the cladding modification in the bending sensitivity characteristics[14]. In other work Allsop et. al.[15] produced LPGs in

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