Large Range Torsion Sensor Based on Twin-Core Polymeric Optical Fibre

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Fibre-optic shape sensing is one of the most attractive sensing technologies widely used in various industrial applications, such as structural health monitoring, robotic arm manipulation, vascular catheterisation treatment, etc. and torsion can be considered as an inevitable mechanical characteristic which occurs during measurements. Benefiting from the intrinsic advantages of optical fibres, including immunity to electromagnetic interference, small size, and insensitivity to humidity, a number of optical fibre-based torsion sensors have been demonstrated with the use of fibre Bragg gratings (FBGs), long period gratings (LPGs), and interferometers. Bulk of these fibre-based torsion sensors are designed using silica fibres composed of various structures, e.g., suspended-core fibres, photonic crystal fibres, and multi-core fibres (MCFs). However, the sensitive range of torsion angles is usually limited to 360° because of the high fracture characteristic. In addition, the large Young's modulus and high-level of stiffness of silica fibres restrict their practicality, especially in biomedical sensing scenarios, and the brittle nature of silica fibres introduce potential risks during real applications.

Recently, polymer optical fibre (POF)-based FBGs have raised great research interest in fibre-optic sensing applications [1]. Apart from sharing the merits of silica fibres, POFs possess additional benefits such as high flexibility, biocompatibility, and low stiffness levels. Here, we present the sensing performance of FBGs inscribed in a ZEONEX-based POF, with a twin-core structure for torsion measurement. The twin-core ZEONEX POF has a central and side core arrangement, with core and cladding diameters of ~8 and 160 μm, respectively, and a spacing of ~36 μm between the two cores. FBGs are inscribed in both cores of the twin-core POF using 248 nm excimer laser irradiation with a few pulses. By connecting individual cores from both ends of the fibre, two FBGs inscribed in the central and side cores are monitored simultaneously.

The performance of the torsion sensor is investigated by fixing one end of the fibre while keeping the other end on a fibre rotator. During the twisting process, the stress applied to the cores changes according to their spatial distribution. Using the difference of Bragg wavelength shifts between the two cores, torsion information is retrieved and analyzed accordingly. The test results demonstrate that the POF-based torsion sensor has a higher sensitivity together with a higher torsion angle range up to 720° or even larger without any fibre breakage.

[1] J. Bonefacino, H.-Y. Tam, T. S. Glen, X. Cheng, C.-F. J. Pun, J. Wang, P.-H. Lee, M.-L. V. Tse, and S. T. Boles, *Light: Sci. Appl.* **7**, 3, 2018.