



Fibre Bragg grating sensors have been successfully created in a recent commercial polymer optical fibre material

# a reason to Bragg<sup>★</sup>

A team of researchers from the UK, Denmark and Cyprus report that they can reliably produce fibre Bragg grating (FBG) sensor structures in TOPAS cyclic olefin copolymer microstructured polymer optical fibre (POF). With a temperature response similar to poly (methyl methacrylate) (PMMA) and lower sensitivity to water, these sensors have potential for long-term temperature and strain monitoring.

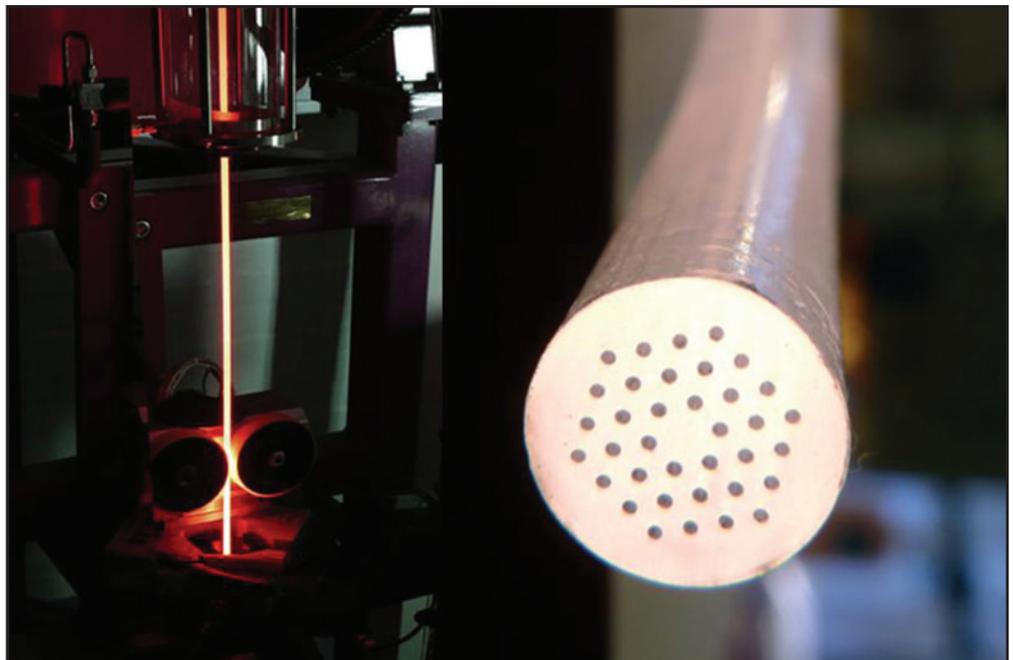
## Robust sensitivity

FBG sensors consist of a periodic modulation of the refractive index along the core of an optical fibre. They reflect light with a wavelength that varies depending on the temperature or strain to which the fibre is subjected. Compared to conventional electronic sensors, FBG sensors have advantages in size, immunity to electromagnetic interference, remote measurement range and the ability to multiplex hundreds of sensors along a single fibre. Silica FBG sensors are an increasingly mature technology serving industries including oil and gas exploration, wind energy generation and structural health monitoring.

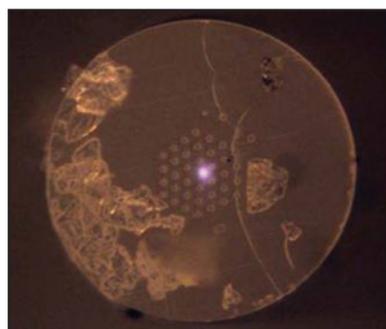
Though less mature, POF has advantages over silica fibre including far higher failure strain and much lower stiffness, useful for both higher-strain applications and the monitoring of compliant materials, where stiffer silica fibre sensors can actually reinforce the material and display artificially low strain values. The majority of POF research is based on PMMA, but these gratings are sensitive to humidity, which is a problem when taking long-term measurements. However, TOPAS fibre contains virtually no water, and so should be insensitive to humidity. Members of this collaboration between Aston University, UK, the Technical University of Denmark (DTU) and Cyprus University of Technology have also shown that TOPAS has interesting properties relating to biosensing that may allow localised grating-based, label-free biosensors to be defined in the fibre.

## A second look

This international team originally obtained evidence of grating inscription and hence photosensitivity in TOPAS fibre several years ago. These early gratings seemed to possess anomalously high temperature sensitivity, but the results were not reproducible. In the intervening years they have developed and refined the fibre production process at DTU to consistently draw good quality fibre to a given specification and in parallel have devel-



ABOVE: Left image: The TOPAS preforms are first drawn down to a cane several millimetres in diameter at the draw tower at DTU. Right image: A cane; this is then inserted into a larger tube and the whole structure is drawn down to fibre  
 RIGHT: Visible light guided by a microstructured polymer optical fibre



oped their grating writing expertise at Aston to cope with microstructured fibres of different sizes and hole geometries. The team has now successfully and reliably inscribed FBGs in TOPAS fibre and they have found that the thermal sensitivity of TOPAS fibre inscribed FBGs is much closer to that of PMMA than their previous results suggested.

## Looking forward

With these results confirmed the team are looking to the next stages of TOPAS FBG sensor development, the first task being to confirm the expected insensitivity to humidity. They also need to characterise the strain and stress response of the sensors, which may prove a complex process as plastics

are usually viscoelastic materials whose behaviour can depend on both the magnitude and rate of strain application as well as temperature. Experience with PMMA also leads them to suspect that the fibre's properties may also depend on both the polymerisation process of the TOPAS preforms and the drawing conditions. They also plan to move their work from the silica-friendly telecommunications band around 1550 nm, where equipment is readily available, to a wavelength of around 850 nm - a more natural wavelength for TOPAS where its fibre loss is an order of magnitude lower.

Alongside this work the team are active in a range of other POF research. They are looking to actually exploit the humidity sensitivity of PMMA for humidity monitoring applications, including monitoring conditions inside rare books for the British Library and monitoring the quantity of water in aviation fuel.

Seeking to exploit the mechanical properties of POF, they are developing the capability to embed POF sensors - and even associated optoelectronics - within flexible structures. The main focus here is on medical applications like in-vivo pressure sensing, exploiting the higher stress sensitivity of POF and providing a potentially safer alternative to glass fibre with regard to fibre breakage within the body.