Distributed Random Lasing Sensors

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Remote sensing using optical fibres has been used for many decades. Starting with Time Domain Reflectometry techniques for the detection of failures and losses in an optical fibre, the field evolved to the use of Fibre Bragg Gratings, exploring the spectral sensitivity of the device to temperature and pressure. While FBGs provide high sensitivity and accurate sensors, this technology requires installation or printing gratings along the fibre. A more versatile technique explores the sensitivity of the phase of the backscattered light to external effects such as temperature or pressure. Phase-OTDR, however involves detection of tiny intensities, which requires sophisticated techniques for phase detection. Overcoming low intensity, multipoint detection and wavelength reuse challenges, a lasing configuration was proposed, in which the remote FBG acts as the far end mirror of an extended cavity synchronously pumped at the resonant roundtrip frequency [1]. This scheme provided fast selection of the desired FBG by simply changing the pump frequency. However, the lack of a full coverage of the optical fibre remained an unsolved problem.

More recently it was shown that any section of a single mode fibre behaves as a fibre grating with random period, providing backscattered light at selected wavelengths [2], which are sensitive to external perturbations thus acting as optical sensors. Hence, the same addressing technique used to select a given FBG in an array can be used now to continuously address any point of the optical fibre. A mode locked random laser is formed, with the far end mirror being the section of fibre addressed by the chosen pump frequency, the length of the scattering section being given by the duration of the optical pulse [3].

Different configurations using the frequency of the synchronous pumping to address a given position along the fibre were proposed, exploring the spectral sensitivity of the Rayleigh Scattering to sense different external perturbations. It will be shown that high sensitivity temperature mapping can be achieved with SOA-based Random Fibre Lasers [4] as well as ultrafast temperature and stress measurements are achieved with a Random Optical Parametric Oscillator configuration using the same synchronous pumping addressing technique [5].

This new class of random lasing sensors will be discussed, opening an avenue to distributed sensing. Exploring different gain media or lasing configurations in these new sensors, further improvements in sensitivity, resolution and time response can be achieved for long range remote sensing, as well as in microscopic and biological applications.

References

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