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Brillouin Distributed Fibre Sensing: State of the Art and Perspectives

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Developed societies require more and more information for their safety and for their economic development. Recent disasters due to landslides, fires in tunnels and collapses of bridges are a source of serious concern on the part of the public which seeks for more safety and for an efficient prevention of these frequent recurrences of dangers.

Sensing in adverse environment and extreme conditions requires dedicated techniques. Quite recent technologies may offer novel valuable solutions and give rise to a strenuous research effort. Optical technologies are an essential actor owing to their tremendous capability to transmit and process a high density of information. Optical fibre is a key component for these technologies and its potential for optical processing and for collecting information as sensing probe is still widely unexplored. The development and the popularity of telecommunications have entirely screened the fact that optical fibres may be efficiently used for sensing purposes.

In this paper we present applications of a novel technique using optical fibres to monitor large structures for safety purpose. The fibre is used as sensing element and can provide distributed measurements of quantities like temperature or strain. In other words a value of temperature and/or strain can be obtained for any point along the fibre. This is made possible by using a nonlinear optical effect in the fibre called Stimulated Brillouin Scattering (SBS).

Optical fibre sensors based on stimulated Brillouin scattering have now clearly demonstrated their excellent capability for long-range distributed strain and temperature measurements. The Brillouin interaction causes the coupling between optical and acoustic waves when a resonance condition is fulfilled. It turns out that this resonance condition is strain and temperature-dependent, so that determining the resonance frequency directly provides a measure of temperature or strain.

The resonance frequency is an intrinsic property of the material that may be observed in any silica fibre. This is very attractive since the bare fibre itself acts as sensing element without any special processing or preparation on the fibre. Standard optical cables may thus be used, resulting in a low-cost sensing element that may be left in the structure. Since the optical effect only depends on the fibre material, it is absolutely stable in time and independent of the instrument. Different measurements performed over a long-term period are thus fully comparable.

The latest developments in this class of sensors will be shown, such as the possibility to measure with a spatial resolution of 10 cm and below, while preserving the full accuracy on the determination of temperature and strain. Illustrative examples of site measurements will be presented and future prospects will be discussed.