

Fibreoptic sensors. Three decades of evolution

[Yu.N. Kul'chin. 'Distributed fiberoptic measuring systems' (Moscow: Fizmatlit, 2001)]

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The use of optical fibres as the susceptible sensors of physical quantities occupies a particular and important place among their various applications. During more than three decades of their developing, fibreoptic sensors have passed through a few stages of evolution: from the simplest point sensors of amplitude type to the distributed measuring networks able to detect the spatial distribution of quantities under study by using neural network technologies in processing of arrayed data. While point and distributed fibreoptic sensors of different types were described in detail in numerous review articles and books, the distributed fibreoptic network is now the subject of intense inquiry, the significant contribution to which was made by Yu.N. Kul'chin and collaborators. This fact attests the actuality of the monograph.

The structure of this book is quite traditional. In the beginning, the fundamental principles of the theory of single-mode and multimode step-index and gradient fibres and polarisation-maintaining fibres are outlined; also sensor components such as the optical isolator, the polarisation controller and the power coupler are described. Then, methods of OTDR as applied to the extended measuring fibre lines with an amplitude signal modulation are discussed.

Chapter 3 is devoted to the design and principle of operation of distributed fibre polarisation sensors. Sensors with time-division multiplexing as well as those with the radiation frequency modulation and coherent multiplexing are discussed there. The author focused much attention on the distributed interferometric sensors of a highest sensitivity, based on single-mode fibre Mach–Zehnder, Michelson, Fabry–Perot and Sangac interferometers, as well as on the single-fibre multimode interferometer, where the processing of speckles of guided modes is used to obtain information. Sensors based on a single-fibre interferometer are inferior to double-arm interferometric sensors in sensitivity (by 10–20 dB), but at the same time have a number of constructional and operational advantages over them. Fibre Bragg gratings are the most important components of fibre communication devices and fibre lasers. Their application in fibreoptic sensors (Chapter 6) provides a high sensitivity and technological effectiveness of these devices. Fibre Bragg

sensors are integrated in extended measuring lines by applying schemes of wavelength-division multi/demultiplexing.

In Chapter 7, the distributed fibre sensors based on Raman and Brillouin scattering are described. Recently, these nonlinear-optical effects (together with four-wave mixing) have started to play the important role in fibre optics. A brief review of intrinsic noises of fibreoptic measuring systems is presented in Chapter 8.

The examples of interesting applications of distributed fibre measuring systems, controlling both man-made and natural objects (objects of composite materials, foundations of dams and bridges, aerospace constructions, mine walls, etc.) are given in Chapter 9. These examples not only demonstrate indubitable advantages of the fibre systems over their electronic analogues but also show some weak points of fibre elements.

The last two chapters (10 and 11) are devoted to distributed fibreoptic measuring networks based on optical coherence tomography and methods of their signal processing. These networks can be successfully used to investigate distributions of both scalar and vector physical quantities. Inasmuch as the photons are the information carriers in fibre networks, the processing of large data arrays should be conducted by using optical neural networks. It is noted that the neural networks of a multilayer-perceptron type, which use holographic coupling matrices, are most promising.

Thus, readers have got the well-written and well-illustrated monograph, which is free from superfluous detailing of the schemes and processes. The author does not attempt to tell everything about every fibre sensor, therefore, the book is quite compact. The impression is slightly spoiled by misprints in text, figures and references. Here and there, the author uses abbreviations more often than it is really needed. Nevertheless, this is undoubtedly interesting and useful book and its publication should be only welcomed.