APPLICATION OF FIBER-OPTICAL MODULATORS AS MEASURING DEVICES IN BIOINFORMATICS RESEARCHES

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***Abstract**: The article is devoted to application of optical devices based on tensosensitive properties of liquid crystals for gathering physical data of biological objects in bioinformatics researches. Graphical results of prototype's test are presented and usage recommendations done.*

***Keywords**: biological researches, measuring devices, fiber optics, liquid crystals.*

***ACM Classification Keywords**: J.3 Life and Medical Sciences – Bioinformatics; C.4 Performance of Systems - Measurement techniques*

Introduction

Bioinformatics, as the science studying informational processes in various biological systems, represents today the integration of huge set of the different databases, algorithms, computing and statistical methods which are intended to decide the problems, arising in molecular biology and experimental genetics during the analysis of the collected knowledge about live beings nature.

The further development of highly-effective biotechnologies is impossible without permanent perfection of the technical toolkit, allowing to obtain primary biological data and to carry out researches of molecule-genetic systems of cells and fabrics. That is why the problem of integration of modern biotechnical tools for gathering of experimental data with up-to-date IT-technologies for their analysis is actual now as never before.

Thereupon application of optical technologies in bioinformatics deserves our special attention. It is well known that the optical devices allows to exclude the erroneous measuring readings caused by external electromagnetic fields which are inevitably imposed to any valuable electric signal from sensors, probes and analyzers involved in process of collecting biological object's information.

All space of the modern world is penetrated both useful and parasitic electromagnetic fields. Effects of different industrial fields, climatic influences, radio noises from various communications, also their combination, fluctuation and interference, is unavailable to the strict mathematical analysis. However they are present in a signal spectrum of any biometric systems, despite of efforts undertaken to their elimination or essential reduction by shielding, filtration, balancing, compensation, equalization, etc.

One of the ways to except these spectrum errors and, thereby, to increase the reliability of the collected information about biological objects, is deployment of optical systems which signals, as the form of optical radiation, are not affected to external electromagnetic fields.

Besides, fields produced by conductivity currents in electric chains of measuring devices placed in tight proximity to studied biological objects inevitably deforms their inwardness. In particular, powerful electrical field can break the electrochemical balance of biological cells. That will lead to incorrect data in especially exact cellular researches. It mostly concerns the measuring tools and sensors invited and applied at the initial stages of development of biotechnologies, for example, the device for immersing of electrodes in a biological fabric [Dzhagupov et al., 1988].

At the present stage of researches it is expedient to replace obsolete electrical tools for gathering biological information with corresponding optical converters such as optical cells which are sensitive to variations of temperature, pressure or chemical composition.

For example, it is possible to get trustworthy information about frequency and filling of live being's pulse by means of optical device represented on the figure 1. This device can also carry out functions of the measuring optical converter of small transversal forces and vibrations. In particular, it can be used as modern replacement for piezoelectrical pulse transeducer introduced in [Dzhagupov et al., 1985]. The basis of device (fig.1) is a tightly closed hollow case 1, filled up by special optical transparent substance 2 with tensosensitive properties. For example, case can be filled by MBBA ("methoxybenziliden-butylamin") also known as Nematic Liquid Crystal (NLC) [Chandrasekar, 1989]. The case 1 equipped with flexible film membrane 3 where convex pelot 4 is placed in the middle for centering and aligning applied forces.

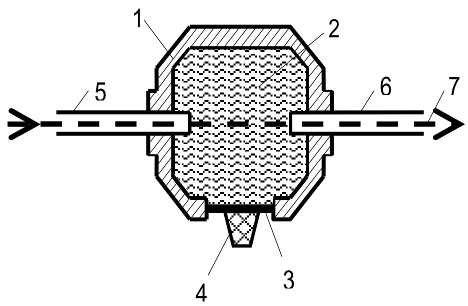

Figure1. Optical sensitive cell for measurement of forces, pressures and vibrations in biological researches

As known, hydrodynamic properties of NLC are similar to properties of isotropic liquids, i.e. for any directions the equation of indissolubility and the Navier-Stocks equation of movement are fair. Therefore, according to theory of elasticity of liquid crystals, any applied outer forces, which dynamical range is matched to membrane's stiffness, will strain liquid crystal molecules that will lead to deviation of NLC optical director due to molecules reorientation.

The variation of optical properties will cause the modulation of NLC polarization angle. Accordingly it will influence to intensity and phase of polarized optical radiation, extending from input fiber-optic light-guide 5 to output fiber light-guide 6 through the optical gap in the case 1 filled the sensitive liquid crystal substance (see fig.1).

Cholesteric Liquid Crystals (ChLC), such as "cholesterilmiristat", can be used also as optical medium for this device. Helical ChLC molecules allow to reflecting an incident light selectively as well as diffraction grating. In this case optical pattern of this device should be changed to reflecting type. At the fixed angles of incident light the pitch P of ChLC molecula's helix can be simply expressed as [Titov et al., 1998]:

$$P = \lambda_{max} / n \tag{1}$$

where λ_{max} is maximum of a wavelength of reflected light, and n is refractive index of a ChLC substance.

If optical vector of ChLC medium substance directed perpendicularly to the membrane and helix pitch P is changing as a function of applied outer force so these varying conditions of interference will lead to variation of a spectral maximum of reflected light beam due to well known optical effect of "selective reflection". That, accordingly, will effect to intensity and a phase of light beam 7, transiting the sensor case 1. For ChLC reflecting medium the position of fiber-optic light-guides 5 and 6 should be changed to axial.

Both examined optical devices are related to optical modulators of a luminous flux. Prototype's test has demonstrated the possibility of its usage for measuring of small force, pressures and vibration. Experimental diagram of the relative value of intensity of through-passing light from LED source as function of mechanical force (or pressure) applied to membrane's pelot 4 is shown on the figure 2.

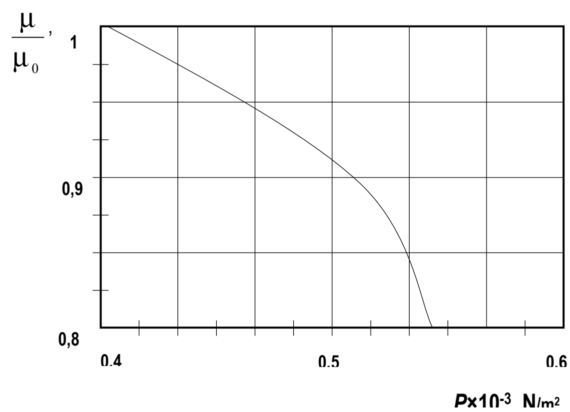

Figure 2. Graph of the relative intensity of through-passing light against the force (pressure) applied to pelot.

Conclusion

Advantages of these offered devices consists of possibility to deploy computing equipment away from explored biological object, as far as necessary, according to length of the used fiber-optic line. That allows complete eliminating any parasitic effect from exterior electromagnetic fields to the gained information.

One more advantage of devices' application consists in the following. Many biological processes, such as functioning of cellular diaphragms, DNA creation, transmission of nervous impulses, muscles contraction, creation of atherosclerotic plaques, proceed with participation of materials and substances which are staying in the "mezo-phase", i.e. they have a property of a liquid crystals [Chandrasekar, 1989]. It means that these materials can be immediately used as sensitive media of the optical transducers. Thus presented application of optical engineering in bioinformation science is not restricted to the considered constructions only.

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