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SEMICONDUCTOR AND LIQUID CRYSTALLINE SENSORS IN THE PROBLEM OF ARTIFICIAL INTELLECT

The interrelation between the peculiarities of artificial intellect model system components' structural self-organization and the possibilities of adaptive dialog human—computer provision is studied. The fractal structure and self-organization of biologically ordered matter are considered to be the basis of signal scaling processes that occur in liquid crystalline—semiconductor contact sensors. It was shown that liquid crystalline structure is the most proper for replication of fractal structure details being always present at the surface of semiconductor wafer and their transfer into bulk of liquid crystal itself. The results obtained by the authors allow to predict the possibility of biomagnetic field registration by means of thin layer fractal structures with internal multiplication of the signal under registration.

1. Organism and Living Cell

The organisms of the higher animals, including human being, are constructed of cells. The cellular associates [1] form various tissues: muscular, connecting, nervous, etc.

The morphologic structures, being formed in organism from various types of tissue are called the organs. Groups of organs, which act in a coordinated manner and are connected anatomically, create the systems of organism, such as nervous one, e. g.

The human organism as the whole could be characterized [2] as the scaling structure with many levels and having fractal properties. One could see the presence of self-similarity on the pictures of aspirating, vascular or nervous systems of human organism.

The fractal type of structure usually makes it real the functioning of all mentioned systems in such a way that that common output has imprinted fractal features as well [3].

Biophysics [4] studies the specific detailes of organic molecules' behavior and properties. They include mainly proteins, aminoacids, sugars and lipids. These types of molecules are predominantly mesomorphic and could self-organize demonstrating liquid crystalline features [5, 6].

All vital processes in human organism are being strictly coordinated and are subordinate to the main goal of the nature — conservation and continuation of the life. General phenomena appropriate to the control processes occurring at all levels of living systems' organization have also the hierarchical character [7] and are studied by bio-cybernetics.

2. Control in Organism. Direct and Reverse Connections

The general sense of control includes [8] such influence of some elements of the system on the other which leads the system to the certain state achieving the certain goals or results.

The term «control» concerning the living organism is very wide and includes the process of organism development, maintenance of the grown organism in the working conditions and repair of some worn out elements.

The most complicated control processes are realized in the central nervous system and in the psychic sphere of human individual.

In the complex biological systems the control process has the specialized part including:

— receptors (sensors) which reflect the state of the system (human being + computer), as we propose, and the incoming information at the level needed for the realization of the following stages of the control process;

— solving part (natural intellect of the human being under investigation + artificial intellect of the computer provided by specialized dialogue software), which is also the part of our original proposal and which could evaluate and/or establish the appropriate level of information exchange;

— effectors (executive elements), realized in our case by means of the specialized software, which generates the control signals and influence directly on the balance of intellectual dialogue.

The operational part of the system information exchange is shown in fig. 1.

The control is based on the exchange of information signals within the components of the system. Each chain of the system elements which serves for signals exchange could be treated as the information channel. These channels create direct and reverse connections.

The type of connections is determined according to the general direction input-output. The direct connection is been realized when the signals are transferred from the input to output end of the system.

The sciences dealing with the processes in living organisms (biochemistry, biophysics and biocybernetics) traditionally present control mechanisms as

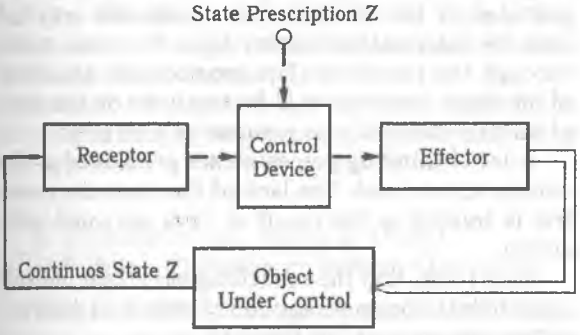

Fig. 1. Scheme of feedback in living organism during perception process

the reverse connection circuits which include the object of the control.

The main scope of exploration of control processes in biological systems becomes the interchange of the control functions between the various levels of nervous system.

The embedded mechanisms of the organism's reaction on the external effects, including problems concerning the intellect's testing and leading to the cardio-vascular system functioning, diffusion velocity correction, metabolic autoregulation, etc. could be measured by the sensorial system and be treated as the objective parameters of the human highest nervous activity.

The control process could be presented by the following steps [1]:

— reception of the information concerning some problem due to be solved through certain interface of the control center (human brain or computer);

— probing of the possible approaches to the problem solution using the existing solutions (personal experience in the field for human or data base for computer);

— choosing of the most appropriate kind of solution;

— realization of the solution chosen.

We propose to use the steps' 2, 3 and 4 realization velocity as a possible quantitative parameters of the intellectual level of information processing.

There is no doubt that almost the same processes take place in the human brain while solving any kind of intellectual problem.

3. Interfaces of Human Organism. Adaptation

Besides, it is well known [9] that the sensing organs of the human organism produces electrical pulses that are, according to Maxwell laws of electromagnetism [10] are always surrounded by electromagnetic waves [11] detectable by the various types of sensors. At this stage, physiological mechanisms of in-coming information in a quite evident manner compress the information. Then the information is being processed at the different levels of nervous system.

The general picture of the world or the problem due to is solved separated and transferred through various nervous fibers gradually being restored to the initial state — the objective image of the problem.

The highest control levels could be represented by the enormous system of information storage, where all the data about the environment (possibly, also intellectual), the current state of the human organism, its needs, etc. The stored information may be of the highest generalized type as well. The most advanced level of the processing system should be treated as the problem image generation at the inner display of human organism.

One of the problems to be solved on the way to the balanced information exchange in the system human-computer is the adaptation problem. At the level of physiological approach, the adaptation means all types of organism's parameters changes which could be reliably attributed to in-coming information deviation.

The adaptation process could be treated in the framework of compartment model with the sources and the sinks of substance and energy as the stage of relaxation to the new state of balance [12].

The characteristic feature of adaptation process is the temporal (for the duration of the relaxation period) change of the metabolic rate.

The active control mechanisms are the first, which react, and, as the result, the transport process is directed to balance achievement between in-coming and out-coming flows of substance and energy.

The time constant of relaxation process induced by the proposed problem solving seems to be the additional parameter of intellectual level evaluation.

The theory of stress induced intellectual reaction of human [13] could be applied to the discussion conducted hereby as well. The situation of intellectual status of human organism under stress resembles the accelerated testing problem in engineering.

The periodical application and removal of the stress could be used in training process of individuals who are going to operate complicated mechanisms under emergent conditions.

4. Psychophysics Problems of the Artificial Intellect

Psychophysics opens the operational field for application and probing of various models of artificial intellect [14]. Multiple functions of human receptors are not described at the appropriate mathematical level now to say nothing of the fact that the senses of human organism are not the intellect itself but only the part of organism's interface.

The mathematical theory of human sensing is urgently needed at the stage of human-computer dialogue's optimization. The elaboration of sensor processes' theory could create a serious foundation of identification theory which, in turn, is the follow-

ing more advanced level of information processing by means of human or artificial intellect.

According to the existing level of artificial intellect understanding [15], the theory of intellect is the scientific discipline which is going to elaborate the mathematical description of human intellect with the scope of its realization using the means of computer science. One can state that such a determination seriously borders the field of exploration of the theory of intellect by the contemporary level of computer science. The determined, discrete and finite processes are the only processes that could be included into the «magic» circle of intellect theory.

In general we can add that the theory of intellect could be determined as the branch of science which studies both human and artificial intellects with the scope of elaboration of specific mathematical approach to the functions of intellect which will make it possible to realize it at the existing level of microprocessor technique development and to make the computer «clever» enough to be able to feel the level of corresponding participant of the dialogue human-computer.

5. The Factors Limiting Modeling of Human Intellect

The character of intellectual activity depends greatly on the conditions in which individual lives and those, in turn, are determined by eventual coincidence of circumstances. The state of organism is also quite eventual.

At last, the intellectual performance as the whole is the process that occurrs by chance. The thoughts that are the combination of temporarily correlated signals emerge spontaneously.

We will try to demonstrate that all the mentioned probabilistic details of thinking process do not contradict the deterministic system of human intellect. Let us assume that human intellect could be represented by determined, discrete and finite system. Then one can easily see that the principal possibility of intellect's description by means of algebra of finite predicates.

It follows that the most common material system that could realize the formules of finite predicates algebra is the finite automate. This imaginative device which clould be modelled by means of the certain and, possibly, very complicated digital computer. In such a way it could be demonstrated that the assumption about determinative, discrete and finite nature of human intellect is quite equivalent to the thesis of principal possibility of artificial representation of the intellect using information processing technique.

Thus the eventuality of the outer space issues signifies only that the signals arrive at the input of the computer that realizes the human intellect's functions quite by chance.

The contradiction between the eventual signals' supply and deterministic way of their processing is overcome in such a way.

The fact that the chance plays significant role in the creative process (the highest level of intellectual activity) demonstrates that human while solving problem uses not only the information that is provided by the intellect in computer-like way but also the information coming from the outer space through the interfaces. The spontaneous character of the ideas' creation could be explained on the basis of human intellect's determinative character.

A lot of thinking processes are proceeded at the subconscious level. The lack of the conscious control is treated as the result of «free personal will» action.

As we see, that the modelling of certain individual intellect does not require the refuse of determinative character of the intellect.

The probabilistic methods could still be applied when we face the case of approximate description of intellectual activity of individual.

But, when we transfer ourselves to the situation of intellects' interaction as in the case of our interest the deterministic approach becomes really unsufficient. Particularly, it is impossible to consider the information exchange process between the individuals.

Seems very realistic to assume that the uniquity of individual intellect is caused by the deterministic chatacter of the interconnections between its components. The difference between individual intellects exhibits through the probabilistic connections between them.

Let us discuss the significance of continuity factor in human intellectual activity. It is stated frequently that continuous processes form the main part of the activity of intellect. This thesis is based on the concept of continuity of physical and chemical processes that occur in human organism, nervous system and brain itself.

It should be noted that this continuity is only imagination because the processes at atomic and molecular levels are of quantum nature. This fact allows us to assume that the intellect could be described mathematically as discretely acting device. It was proved by means of a lot of psychological tests [16] that the appropriate choice of temporal or space quantification step could lead to the image of continuous object creation. The size of this step could serve as well as the quantitative measure of the intellect's interface. The effect of cinema is the best prove of this statement.

The factor of infinity also needs to be tested for the coincidence with the possibility of discrete representation of intellectual processes. Human intellect does not operate with infinite objects but only with special symbols, formulas, sentences and texts. The outstanding mathematician David Gilbert has said [17] that the intellectual activity could be named the «game with symbols». Moreover, this game is conducted according to the certain rules, which present the technique of human thinking. These rules organize the closed system, which could be determined. Gilbert theory's of proof main idea is a

protocol of rules of putting down, comparing and evaluation of the statements.

Another proof of the possibility of infinity of intellect could be provided by algorithmic type of its activity. The theory of intellect faces the problem of solvability through real ability of human intellect and an artificial one as well.

Finally, we can state that the formal description of intellectual processes could be proceeded using the apparatus of discrete mathematics.

6. Biomagnetism. Fields of Direct and Pulse Currents in Human Organism

Magnetic fields induced by electrical currents flowing inside the organism during its vital activities are called biomagnetic ones [18]. Biocurrents emerge as the result of cell electrical activity including muscles and nervous. The electrically active parts of cells are cell membrane.

The processes occurring at membrane interfaces are connected in a bilaterally determined (functional) way with biomagnetic signals.

Thus, knowledge of biomagnetic fields provides the knowledge of state and intensity of the corresponding physiological processes.

The cell membrane has the thickness of about five nanometers and is composed mainly of lipids, which are mesogenic (liquid crystalline) substances [19].

Nernst difference of potentials ΔE_{ion} emerges when the concentration of ions C_0 and C_1 at both sides of half-transparent membrane and could be represented by:

$$\Delta E_{ion} = \frac{k_B T}{e} \ln \frac{C_0}{C_1}. \qquad (1)$$

Taking into account that in the stable state sodium and potassium currents equalize one another, one can obtain:

$$j_K = g_K (V_m - E_K), \qquad (2)$$

$$j_{Na} = g_{Na}(V_m - E_{Na}), \qquad (3)$$

and

$$V_m = \frac{(g_{Na}/g_K)E_{Na} + E_K}{(g_{Na}/g_K)}. \qquad (4)$$

The potential shift could take place when ionic concentration of outer-cell liquid changes. Such is, for example, the reaction of glial cell of human brain on local change of sodium concentration in intercellular space due to neuron activity. It is a slow process taking up to minutes.

Much faster temporal changes of potential with time constant up to milliseconds are caused by membranes penetrateability change.

It should be mentioned specially that the presence of transmembranic potential and even its pulse or gradual change are not accompanied by currents in intercellular space. Electrical currents that flow through the membrane charging and discharging it could be registered only using the electrode placed directly inside the cell.

As the result of transmembranic currents addition, the macroscopic (volume) currents could emerge that flow in intercellular space. This could occur only when membrane surface is charged nonhomogeneously. Such a currents could be detected through extracellular type of registration. Such a monitoring is the scope of the present work and main attention will be paid to this case. Specific macrosopic signals in the cases of correlated membrane polarization non-homogeneity.

The significant difference in the properties of extracellular currents in comparison to intracellular ones is that the first type of currents being detected at macroscopic distances from the cell source exhibit the integral activity of cell groups or that of the organ as a whole.

The effect of these currents could demonstrate itself in two different ways (fig. 2).

The first is the result of the fact that all the organism's tissues are conductors and the potential differences in the range 1...1000 mV arise (fig. 2, a).

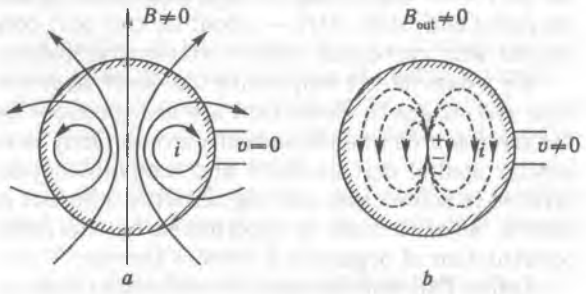

Fig. 2:

a — scheme of inner biomagnetic field structure in conduction media; *b* — scheme of penetrating biomagnetic fields distibution

The second one is more close to the scope of the present paper and is concerned with magnetic fields that come out of physical borders of living organism (fig. 2, b).

The distribution and the oscillation of potentials and magnetic fields are definitely caused by currents' distribution and oscillation inside the physical body of organism.

In the case of the infinite homogeneous medium, one could write the following expressions for the potential $V(\mathbf{r})$ and magnetic field $\mathbf{B}(\mathbf{r})$ caused by the impressed currents $\mathbf{j}^i$:

$$V(\mathbf{r}) = -\frac{1}{4\pi\sigma} \int_v \frac{\nabla \cdot \mathbf{j}^i(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} d^3\mathbf{r}', \qquad (5)$$

$$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int_v \frac{\nabla \cdot \mathbf{j}^i(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} d^3\mathbf{r}', \qquad (6)$$

where σ signifies conductivity of medium.

The real case of human organism could be described by the currents distributed in the ranged space (whole body) divided into the regions with different conductivities (organs). The ranging borders of organs with conductivities σ_1 and σ_2 become in such an approach the sources of secondary im-

pressed currents $\mathbf{k}^i$ which are determined by potential $V(\mathbf{r})$ at the borders:

$$\mathbf{k}^i = -(\sigma_1 - \sigma_2) \cdot V(\mathbf{r}) \cdot \mathbf{n}(\mathbf{r}), \qquad (7)$$

where $\mathbf{n}$ is unit normal vector, which has the properties of delta function while being integrated.

Potentials and fields could be expressed as functions of $\mathbf{j}^i$ and $\mathbf{k}^i$.

One can see that extracting the curl and potential components of $\mathbf{j}^i$ will lead to the following expressions for $V(\mathbf{r})$ and $\mathbf{B}(\mathbf{r})$:

$$V(\mathbf{r}) = -\frac{1}{4\pi\sigma}\int_v \frac{\nabla\cdot\mathbf{j}_p^i(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}d^3\mathbf{r}' - \frac{1}{4\pi\sigma}\int_v \frac{\nabla\cdot\mathbf{k}^i(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}d^3\mathbf{r}', \quad (8)$$

$$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int_v \frac{\nabla\cdot\mathbf{j}_p^i(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}d^3\mathbf{r}' + \frac{\mu_0}{4\pi}\int_v \frac{\nabla\cdot\mathbf{k}^i(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}d^3\mathbf{r}'. \quad (9)$$

It is clear enough that potential $V(\mathbf{r})$ and fields $\mathbf{B}(\mathbf{r})$ carry quite different information about the structure of impressed currents' sources that causes their generation. Potentials $V(\mathbf{r})$ describe the potential part of current connected with membrane surface charging and fields $\mathbf{B}(\mathbf{r})$ — about its curl part connected with correlated inner currents distribution.

We would like to emphasize that electric potentials and magnetic fields that are being caused by the same source (membrane cell currents) may have similar spatial distributions and temporal dependencies in some cases and significantly different in others, what in turn is determined by the inner construction of organism's current sources.

Author [20] worries about the difficulties connected with the division problem of all the impressed currents to initial and secondary ones. However, at the same time he states that the modeling could be provided by means the assumption of medium homogeneity.

The complicated character of the equations (8) and (9) do not allow to understand clearly the difference in information type provided by the signals of electrical and magnetic nature.

The magnetic signal is registered in certain point of space by one sensor and the electrical signal (potential difference) could be measured by pair of electrodes only.

Thus, we see that magnetic sensor reacts to the strong enough (correlated) currents that flow in the region of activity. At the same time, the distribution of weak surface currents influence significantly the distribution of electrical potentials.

The measurement of electrical and magnetic potentials has a complimentary character. The determination of potentials and fields using the known sources distribution is so called direct problem that could be solved precisely and definitely [21, 22].

However, much more significant and useful will be the resolution of the reverse problem — determination of sources' distribution and structure using experimentally registered potentials and magnetic fields. It was shown [23] that this problem has no definite solution. This signifies that electro- and magneto-graphic even registered simultaneously don't comprise the full data set needed for the precise determination of current sources inside living organism.

This difficulty could be dealed with using the assumption of the special model for sources' distribution. One of the assumption of the kind is the heart's electrical vector which is determined as:

$$\mathbf{p} = \int_v \mathbf{j}^i(\mathbf{r}')d^3\mathbf{r}'. \qquad (10)$$

This vector could be determined using the map of measured potentials.

The heart's magnetic vector is introduced quite analogously:

$$\mathbf{m} = \frac{1}{2}\int_v \mathbf{r}' \times \mathbf{j}^i(\mathbf{r}')d^3\mathbf{r}'. \qquad (11)$$

The restoration of magnetic and electrical vectors of any organ of human organism is not a precise solution of the reverse problem.

However, the value of the registered signals and the dynamics of their evolution could support significantly in diagnostics and monitoring of organ's activity. In many cases, they will assist also to make evaluation of the whole organism's activity efficiency.

7. Neuromagnetism and New Directions in Human Brain Exploration

There are many problems before the science that is engaged in human brain exploration. The essence of sensing, the difference between the understandable and non-understandable things and ideas, the nature of memory, function of dreams, etc., are the experimental fundamental problems of intellect theory.

The last two decades are being characterized by the introduction of the most modern physical methods and apparata into research laboratories and neuro-surgical clinics. These are the methods of non-invasive and non-destructive type.

Up to the most recent times, the most informative method of non-invasive type was the electroencephalographic method that allows to registrate the electrical signals' distribution over the head's skin [24]. These potentials are only weak reflection of electrical processes in human brain what is caused by the human cranium structure. Conductive layered structure of cranium significantly diminishes the current densities in comparison with the case of homogeneous conductive medium. Besides, it minimizes the spatial variations of current densities (caused by nervous activity) that makes the picture of signal distribution more monotonous.

It was shown [25] that skin effect does not influence in any way the precision of reverse problem solution in biological bodies of real dimensions.

The magnetic field sensors have certain preferences. They react directly to the currents flowing in human brain and thus spatial distribution and temporal dependence of magneto-encephalographic signals reflect the inner electrical activity of the brain non-corrugated by cranium influence.

Concentric non-homogeneties of spinal liquor, cranium and scalp do not influence in any way on intensity and distribution of magnetic field induced by brain activity and spread to outer space.

Magnetic activity of human brain was registered for the first time by Cohen [26] using regular solenoids. It was very hard to discriminate the useful signal covered by overwhelming noise.

Significant diminuation of the noise level was achieved with the use of superconducting SQUIDS and only after this it become possible to obtain magneto-encephalograms in real time scale.

There is no standard method of taking magneto-encephalogram up to now. Even the first experiments have shown that brain induced magnetic fields have much more fine and thus more informative structure than electrical potentials do.

The recommended density of magnetic sensors distribution has the cell dimensions of 10 *mm* order [18].

Magneto-encephalography differs principally from electro-encephalography in that magnetic field sensors do not require tight contact with the head of the person under test and they could be removed during experiment quite freely.

The most reliable information could be registered only by multi-sensor systems.

8. Sources of Neuro-Magnetic Fields

The grade of brain bio-currents' sources and corresponding magnetic fields detalization depends on the type of interrelation between neuron form, their structure, interaction with other cells, spatial distribution and electrical activity could be reflected in magneto-encephalogram.

The in-brain electrical activity has such a character that in many cases of interest the inducing processes occur in a comparatively small part of the brain. The key model could be represented by current dipole serving as the primary source of magnetic field.

In reality magnetic field induced by current dipole inside sphere differs from that caused by ideal dipole. Precise account was made in [27] where authors present the result in spherical coordinates:

$$H_r = \frac{aP}{4\pi r^3}\frac{\sin\theta\sin\varphi}{\gamma^{3/2}}, \tag{12}$$

$$H_\theta = \frac{P}{4\pi r^2}\frac{\sin\varphi}{\gamma^{3/2}}\left|\frac{\gamma\cos\theta}{\sin^2\theta}\left(\cos\theta - \frac{r}{a} + \frac{r\gamma^{1/2}}{a}\right) - \right.$$

$$\left. - \frac{a}{r}\left(\cos\theta - \frac{a}{r}\right)\right|, \tag{13}$$

$$H_\theta = \frac{P}{4\pi r^2}\frac{\cos\varphi}{\gamma^{3/2}\sin\theta}\left(\frac{r}{a} - \cos\theta - \frac{r\gamma^{1/2}}{a}\right). \tag{14}$$

The definition of the kind is used:

$$\gamma = \left|1 - \frac{2a\cos\theta}{r} + \left(\frac{a}{r}\right)^2\right|. \tag{15}$$

Other types of brain activity that involve large areas of nervous tissue could be represented by system of certain quantity of current dipoles.

There is a lot of experimental evidence [28] indicating that the most intensive source of neuro-magnetic signals is the neocortex of human brain.

The pulse exchange on the short in-cortex distances could not generate sufficient input to neuromagnetic fields because different phases of nervous pulse (spike) will compensate one another while being averaged over large number of axons needed for generation of signal that could be reliably measured.

It is also very unprobable that the relatively low frequency spectrum of magneto-encephalogram could be explained based on magnetic fields induced by propagating spikes.

At least, one-dimensional ordering of brain compartment is also needed for justification of cooperative type of dipole action.

9. Evoked Magnetic Fields and Fields Caused by Events

The task of neuro-magnetic field mapping that could assist in detection of position and orientation of the source may be significantly simplified in the case when the causing process under investigation is reproducible or periodic.

To our deepest regret, spontaneous processes that go on in human brain have no high enough degree of reproducibility.

The situation is totally changed when brain activity has strict cause-consequence relation with the event out of human nervous system. Such type of magnetic fields are called evoked or event related fields.

This type of investigation is much more complicated because the intensity of the signals is 5... 10 times lower than that of spontaneous brain activity.

Phenomena connected with evoked magnetic fields have demonstrated to be very well explained using the model of current dipole.

When the pulse from outer receptor (human interface) comes the cooperating groups of neurons situated in, various brain compartments begin to generate electrical and magnetic signals. Usually some neuron stations are being activated which generate both spikes and gradually changing signals. Signal, which is registered by outer sensors, has the form of decaying wave with superimposed maximums and minimums.

Authors [29] have registered very high degree of signal source localization in brain cortex. The hard fixation of magnetic gradiometer was proposed and special experimental room with no non-homogeneous fields was required as well.

Localized current dipoles were determined quite reliably in the experiments with eye, ear and other stimulated part of human organism's reception system.

10. Liquid Crystals as the Active Media of Weak Magnetic Field Sensors with Inner Amplification of Signal

The state of substance which is, for some compounds, intermediate between hard crystal anisotropic state and isotropic liquid state is called liquid crystalline (LC) phase or mesophase [30]. The main cause of such strange behavior of LC phase lies in special form of its molecules. In many cases, the molecules of LC are elongated in one preferential direction.

There are two large groups of LC compounds differing by the method of mesophase creating:

— thermotropic;

— lyotropic.

The first type of LC could be transferred into mesophase using heating. The phase transition of the first type (with hidden transition heat and step-like change of molecular density) usually accompany such transformation and each specific LC compound has its own temperature range of mesophase existence. This type of LC is represented generally by artificial organic substances.

Second type of LC organizes mesophase at the certain dilution level when the specific ratio between the concentrations of solvent and solute substance. This kind of LC is represented by organic substances of biological nature.

We have shown previously [19, 31—34] that a lot of liquid components of human organism exhibit LC properties, including blood plasma, lipid system, spinal liquor, tear liquid, bile, urine, etc.

It is quite clear that the difference between two types of mesophase forming lies only in the method of intermolecular distance variation.

The dominant orientation of LC molecules is described by vector-director.

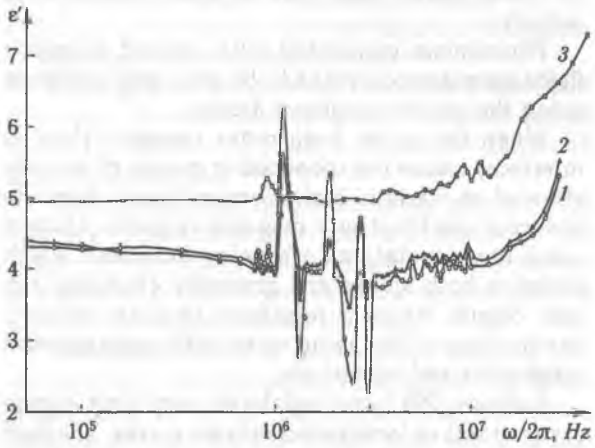

Fig. 3. Dispersion spectrum of real part of complex dielectric permeability:

1 — 27 °C; *2* — 32 °C; *3* — 52 °C ($d = 30$ *mm*)

Degree of orientation homogeneity is presented by order parameter which value lie in the range from zero to one beginning from isotropic liquid to anisotropic crystal.

We have discovered experimentally for the first time[35] the effect of dielectric response of nematic LC stimulated by order parameter's fluctuations. It was known before [36] that planarly oriented nematic LC demonstrates dielectric spectrum of relaxation type and its exploration does not allow to anything more but director fluctuations.

The inclined director orientation gives more degree of freedom and that why we have explored the dielectric spectra of the model nematic MBBA with the initial inclined at 45° director orientation concerning the bordering surfaces.

In fig. 3, one can see the frequency dependence of the real part of complex dielectric permeability measured in thin layer of MBBA at various temperatures. It is obvious from the figure that the specific resonance response of nematic LC occurs only in mesophase existing temperature region.

The components of the resonance dielectric spectra could be represented by the following formulas:

$$\varepsilon'(\omega/\omega_0) = \frac{1-(\omega/\omega_0)^2}{(1-(\omega/\omega_0)^2)^2+\Gamma^2(\omega/\omega_0)^2}, \qquad (16)$$

$$\varepsilon''(\omega/\omega_0) = \frac{\Gamma(\omega/\omega_0)}{(1-(\omega/\omega_0)^2)^2+\Gamma^2(\omega/\omega_0)^2}, \qquad (17)$$

where braking parameter $\Gamma = 2\gamma/\omega_0$ is connected with resonance frequency of damped oscillator. The dielectric responses at the points of resonance are about million times higher than in the case of regular relaxation response.

The frequencies registered in our experiment were at least three orders greater that the known relaxators' frequencies which are caused by director fluctuations. Therefore, the most probable mechanism of resonance spectra arisal could be longitudinal and biaxial fluctuations of order parameter which demonstrate critical behavior near transition isotropic liquid-liquid crystal. In such a way, we have demonstrated the possibility of resonance response of LC thin layer placed between electrodes.

Another our experiment [37] demonstrates $1/f$ noise induced ferro-electric type phase transition in the vicinity of zero frequencies. The dielectric permeability of nematic LC increases at least by five orders of magnitude in comparison to the value measured at higher frequencies (fig. 4).

Two mentioned mechanisms are connected most probably with the effect of domino which demonstrates common motion of oriented molecular clusters in LC layer. According to the well-known fluctuation theory of phase transitions [38], the probability of phase transition is increased incredibly when orientation nucleus is formed at some point situated at domain wall [39].

The combination of all these requirements could be realized in layered system conductor (semiconductor) — liquid crystal. Before making any conclusions, we propose to describe the surface of perfect crystal material available now — silicon wafer.

We have shown experimentally [40] using the lifetime scanning laser microscopy technique that surface under investigation could be described in terms of fractal physics.

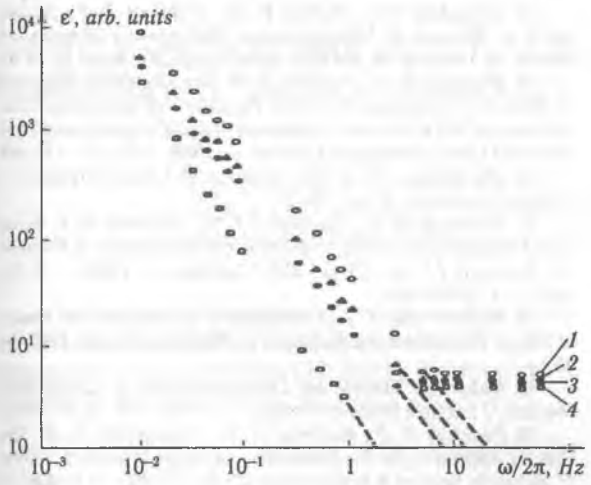

Fig. 4. Frequency dependence of dielectric constant of nematic liquid crystal ZliK-440 for a layer 30/mi thick in lie following fields:

1 — $3{,}3 \cdot 10^5$ *V/m*; *2* — $6{,}5 \cdot 10^5$ *V/m*; *3* — $1{,}3 \cdot 10^5$ *V/m*; *4* — $2{,}6 \cdot 10^5$ *V/m*

In progress, this approach [41] has demonstrated to be also useful to minimize the time of silicon substrate inspection. Silicon surface point defects, being self-organized in surface fractal cluster, could serve successfully as the nuclei of the new orientation type for LC layer put in tight contact with it.

We have demonstrated [42] that LC layer being in contact with plane conducting substrate undergo orientational self-organization due to the process of thermoionic emission from substrate which influences the charge distribution near the surface and changes the system's free energy.

Conclusions

Taking into account all presented above, we could make the following conclusions:

1. The bio-magnetic fields could be used successfully as the most informative external part of human brain activity dealing with information exchange in dialogue system artificial intellect vs. natural (human) intellect.

2. It is possible to identify position of current dipoles or their systems acting in strong correlation with the use of biomagnetic fields investigation.

3. Existing methods of weak biomagnetic fields registration including superconducting SQUIDS could be hardly applied in the case of multi-sensor system, which is needed for real investigation of human intellect.

4. The effect of resonance dielectric response of nematic LC stimulated by order parameter fluctuations could be used as the basis of new supersensitive electromagnetic fractal field sensor.

5. $1/f$ noise stimulated self-organization of LC thin layer in the vicinity of zero frequencies could be used as well for experimental investigation of biomagnetic field peculiarities caused by intellectual activity of human brain.

6. Application of LC thin layer over the surface of silicon wafer produces a fractal magnetic field sensor (FMFS) comparable as to its sensitivity to SQUID.

7. Additional effect of FMFS is that it could be realized using well developed planar technology and fiber-optical sensor techniques.

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