The Use of Cholesteric Liquid Crystals in Oncology, Music Color Device and for Indication of Sorption Process

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Abstract—In the paper is shown the use of the cholesteric liquid crystal films in the developed: device for diagnostics of breast cancer, which are usual and comfortable for the women under conducting of diagnostics that permits to obtain the qualitative, contrasting with the high accuracy colored image of benign or malignant tumor; the music color device, which permits to “revive” by the different colors image on the panel in accordance with the frequency spectrum of the signal, which is coming from the electronic-music device; the indicator of sorption processes, which ensures the indication of absorption on the surface of mineral, by simple, safe, express and cheap method.

Keywords—Breast cancer diagnostics; music color device; sorption processes; cholesteric liquid crystal films.

INTRODUCTION
The cholesteric liquid crystals actively used for measuring the temperature gradients [1-15]. For this purpose is used the property of cholesteric liquid crystals under the certain temperature to possess, corresponded to this temperature, color. The use of different mixtures of cholesteric liquid crystals permits to use them for measuring of the temperature in the sufficiently wide range: from -20 to +250°C. Substances are prepared in the form of the flexible films, which can be applied to the solid surface for the record of the temperature gradients in different directions. The hydrophobic derivatives of polyvinyl alcohol and cholesteric liquid crystals are used as the raw material for the production of such films. Heat indicating (thermocolor) films are formed on the neutral base layer by the standard watering machines, which are used for the production of cine- and the photo materials.

RESEARCH ELABORATIONS
The technical parameters of the heat indicating liquid crystal films, used by author, were the parameters of the production of the institute of theoretical and applied mechanics of RAN (Russian Academy of Science) that were as follows:

- the optimum thickness of film, mkm 20-30;
- working temperature range, °C from -5 to +150;
- threshold sensitivity, wt/cm 2 · 10^{-4};
- spatial resolution, lines/mm 5-7;
- constant time, sec0.04-0.3;
- the number of used is more than 5000;
- time resource, years - more than 5;
- the high temperature sensitivity ΔT/Δλ = of 0.01°C/nm.

The samples of the heat indicating liquid crystal films are illustrated in photos of Figure 1.

Device for Diagnostics of Breast Cancer
In the human organism as a result of the exothermic biochemical processes, which are accompanied by the heat release in the cells and the tissues, and also due to the energy release, connected with the synthesis of DNA and RNA, is produced the large number of heat (50-100 kcal/grams). This heat is distributed inside of the organism using the circulating blood and the lymph. The blood circulation equalizes temperature gradients. The blood, because of the high thermal conductivity, which is not changed from the nature of motion, is capable of achieving intensive heat exchange between the central and peripheral areas of organism. The mixed venous blood is warmest. The blood is a little cooled in the lungs and, being extended in the great circle of blood circulation, supports the optimum temperature of tissues, organs and systems.

Fig. 1: Samples of heat indicating (thermocolor) liquid crystal films.
The temperature of the blood, which passes on the skin vessels, is reduced on 2-3°. The system of blood circulation is disrupted with the pathology. The changes are appeared because of the increased metabolism in the center of inflammation, which increases blood supply and, therefore, the blood thermal conductivity, which leads to the appearance of a center of hyperthermia. The temperature of the skin has the well-defined topography. Under other equal conditions, the minimal changes of the temperature of the skin are observed in the areas of neck and forehead, the maximal changes: in the distal extremities, which is explained by the influence of the highest divisions of nervous system. Among women frequently the skin temperature is lower than in men. This temperature is reduced with the age and its changeability under the action of environmental temperature is decreased. With any change of the balance of the temperature of the interior areas of body the thermoregulatory processes, which establish the new level of the equilibrium of the temperature of body with the environment, begin to work. Among healthy person the temperature distribution is symmetrical relative to the center line of body. The disturbance of this symmetry is the criterion of diagnostics of diseases. The temperature differential value serves by the quantitative expression of thermoasymmetry. The inflammatory processes and the tumors, which cause the local strengthening of metabolic processes, are one of the basic reasons for the appearance of temperature asymmetry. The medical heat viewing (thermography) is the only diagnostic method, which permits to give estimation to thermal processes in the organism of the human [6].

The effectiveness of this estimation determines the authenticity of diagnostics of disease. Two basic forms of the thermography are telethermography and contact cholesteric thermography. Telethermography is based on the transformation of infrared emitting of the human body to the electrical signal, which is visualized on the screen of thermal imager. The thermal imagers, used now in the telethermograph diagnostics, are the scanning devices, which consist of the systems of mirrors, which focus infrared emitting from the body surface on the sensitive receiver (Figure 2). This receiver requires cooling, which provides high sensitivity. In the device the thermal emitting consequently is converted to the electrical signal, which is amplified and which is registered as half-tone image (Figures 3, 4, 5).

At present time are used the thermal imagers with the optical-mechanical scanning, in which due to the spatial image scanning, is achieved the sequential conversion of infrared emitting to visual signal on the thermal imager screen. A common disadvantage of the existing thermal imagers is the need for their cooling to the temperature of liquid nitrogen, which causes their limited application.

At present time there is a new type of infrared radiometer. The infrared radiometer is based on the thermoelement film, which works at room temperature and which possesses a constant sensitivity in a wide range of wavelengths. Low sensitivity and large inertness is a disadvantage of the thermoelement film.

![Fig. 2: Thermal imager.](image-url)

![Fig. 3: Image on the thermal imager of breast cancer.](image-url)

![Fig. 4: Image on the thermal imager of breast cancer.](image-url)
The method of telethermography is characteristically the masking of the observed temperature signal of the inconstant emissivity of the skin and of skin uncontrollable bends. The resulting temperature error of the method composes the order of $1\degree C$ that does not provide the observation of hidden structures in the thickness of body, and error of the estimation of the temperature that is observed using the thermal imager composes $2.4\degree C$.

This error deliberately makes telethermograph method unacceptable for the detection of the hidden pathologies, since here are masked the low gradients of temperature of the order $0.01,..., 0.0001\degree C$ that are necessary for the visualization of small tumors, which are located on the significant depth in the patient body.

The contact cholesteric thermography is based on the optical properties of the cholesteric liquid crystals to change of their painting in the iridescent colors under their putting on the thermo emitting surfaces. Under this method of diagnostics the special plate with the liquid crystals is applied to the specific parts of human body. The crystals are colored in the different colors depending on temperature, as a result on the plate is obtained the picture, similar to the colored thermogram of the thermal imager: to the coldest parts correspond the red color, to the hottest parts correspond the blue color (in the thermal imager: to the coldest parts correspond the blue color, to the hottest parts correspond the red color - Figures 3, 4, 5).

In order to more simply fix the obtained data, the plate is pressed to the skin and is photographed. The contact cholesteric thermography can be achieved by another method: by putting directly on the skin of the composition of cholesteric liquid crystals. The compositions of liquid crystals applied on the skin, possessing by thermosensitivity, react on the heat stream via reconstruction of molecular structure.

The thermosensitivity of the cholesteric liquid crystals in contrast to the telethermograph method is within the limits of $0.001\degree C$ that permits to visualize the hidden pathologies of small tumors, which are located on the significant depth of patient body. Furthermore, method does not require cooling of device to the temperature of liquid nitrogen. As it was already said earlier, the existing contact cholesteric thermography uses pressing of special plate with the liquid crystals to the specific parts of patient body or putting of the composition of liquid crystals directly on the skin of the patient body.

This leads to the fact that the local temperature can reflect not only caused by the internal structures temperature relief, but also the relief, connected with the regime of cooling of the body by ambient temperature, which requires the use not only of narrow strips of the cholesteric liquid crystal mixtures in the large numbers, but also the fixation of patient at ambient temperature, supported with the adequate accuracy. The developed device for diagnostics of breast cancer completely removes disadvantages listed above. The developed device is the seamless brassiere, in which completely there are no seams on the cups (Figure 6). Cups are made from the thin cholesteric liquid crystal film (Figure 6).

This construction of device is usual and comfortable for the women under conducting diagnostics, completely covers and fixes female breast and permits to obtain the color contrasted with the high accuracy qualitative image of benign or malignant tumor, if the tumor is diagnosed among woman.

The developed device does not require pressing by the plate with the mixture of cholesteric liquid crystal the female breast or coating female breast by mixture of cholesteric liquid crystal, does not require the high economic expenditures, the expensive equipment, time on the cooling and is absolutely harmless and simple.

On Figure 7 is demonstrated the image, obtained on the left breast, affected by breast cancer (Figure 3), using the cholesteric liquid crystal film. The zones with the high temperature, affected by malignant tumor, are painted in the blue color. Analogously can be designed the devices for the complete scanning of men and women for the purpose of the diagnosis of benign, malignant tumors or any inflammatory process by using cholesteric liquid crystal films.
These constructions are based on the men and women swimming suits, which use the combination of cholesteric liquid crystal film, nylon and elastan (Figures 8, 9). This construction of devices is usual and comfortable for the men and the women with conducting of diagnostics, completely covers and fixes all body parts and permits to obtain the qualitative, contrasting with the high accuracy colored image of benign or malignant tumor, if the benign or malignant tumor is diagnosed among patients. Device does not require pressing by the plate with the mixture of cholesteric liquid crystal or coating directly by the mixture of cholesteric liquid crystal the body of patient, high economic expenditures, expensive equipment, time on the cooling, is absolutely harmless and simple.

On Figure 10 is demonstrated the image of the body of woman, obtained under conducting of the diagnostics using the thermal imager (Figure 10 (a)) and the image of the body of woman, obtained under conducting the diagnostics using the suit, which uses combination of cholesteric liquid crystal film, nylon and elastan (Figure 10(b)).

Fig. 7: Image, obtained on the left breast, affected by breast cancer (Figure 3) using the cholesteric liquid crystal film.

Fig. 8: Man swimming suit for diagnostics of the diseases. (a) the man swimming suit, which uses the nylon and the elastan. (b) the man swimming suit for diagnostics of diseases, which uses the combination of cholesteric liquid crystal film, the nylon and the elastan.

Fig. 9: Woman swimming suit for diagnostics of the diseases. (a) the woman swimming suit, which uses the nylon and the elastan. (b) the woman swimming suit for diagnostics of diseases, which uses the combination of cholesteric liquid crystal film, the nylon and the elastan.

Fig. 10: (a) The image of the body of woman, obtained under conducting the diagnostics, which uses the thermal imager and (b) the image of the body of woman, obtained under conducting the diagnostics, which uses the swimming suit with the combination of cholesteric liquid crystal film, the nylon and the elastan.
The devices during the process of work realize the sharp passages from the light to the darkness and, on the contrary, which harmful effect on human vision. The developed music color device is the fundamentally new device, the mechanism of work and spectacular effect of which, in the root differs from existing music color devices. The obtaining spectacular effect, good aesthetical perception and high efficiency is achieved by the use as the screen-panel the cholesteric liquid crystal film or strips from cholesteric liquid crystal film on the black background of paper-panel. The use of the cholesteric liquid crystal film, which changes its color with a change of the temperature, permits to “revive” by different colored image on the panel in accordance with the frequency spectrum of the split signal, which is coming from the electronic-music device. Under the use of the developed music color device is not necessary to use the incandescent lamps, the complicated power control units of the output stages.

Figure 11 presents the block schema of the developed music color device. The developed music color device includes:

- The block of low-frequency amplification - I.
- The blocks of the band-pass filters - 2, ..., 7.
- The blocks of the detectors - 8, ..., 13.
- The blocks of power amplification - 14, ..., 19.
- The resistance strips from graphite, which correspond to the separate colored lines of the picture of the panel, applied on the reverse side of screen-panel from the cholesteric liquid crystal film or on the black paper of the panel - 20, ..., 25.
- Screen-panel from the cholesteric liquid crystal film or from the thin sheet of black paper (in the case of the strips from the cholesteric liquid crystal film, glued on the separate colored lines of picture on the black paper of panel) - 26.

The music color device works as follows. The arrived from electronic-music device signal, amplified by the low-frequency amplification (I), is divided and passes through a number of band-pass filters (2, ..., 7), which transmit the signal with the definite frequency (formation of six signals with the corresponding frequencies from the initial split signal) and an assigned amplitude of electric current. In the blocks of power amplification (14, ..., 19), the assigned amplitude of frequency split signal becomes by the amplitude of current, that corresponds to the average output level of six formed signals. From the blocks of power amplification, the six formed signals are transmitted on the corresponding to each frequency resistance layer-strip (20, ..., 25). The resistance strips from graphite, which correspond to the separate colored lines of the picture on the panel, marked on the reverse side of screen-panel from the cholesteric liquid crystal film or on the black paper of panel, possess by the calculated resistance. The passing through the resistance strip calculated current heats resistance strip and located above strip the separate section of cholesteric liquid crystal panel or the strip of liquid crystal film on the black sheet of panel.
The passing through the resistance strip calculated current heats resistance strip and located above strip the separate section of cholesteric liquid crystal panel or the strip of liquid crystal film on the black sheet of panel. The quantity of heat, generated by the resistance strip under the passing of current with the frequency, which corresponds to the split signal, and with the amplitude that corresponds to the average output level of six formed signals, will have the following functional dependence:

\[ Q = f(\omega, I) \]  

(1)

Where \( Q \) is the quantity of heat, generated by the resistance strip under the passing of current; \( \omega \) is the frequency of current, corresponding to the split signal; \( I \) is the amplitude of the current, corresponding to the split signal. The heated separated section of cholesteric liquid crystal panel or the strip of the cholesteric of liquid crystal film on the black sheet of panel will accept color, as a result of the mobility of the structure of cholesteric liquid crystal change the color under the action of temperature, which corresponds to the calculated temperature. The accepted color of strip section of the cholesteric liquid crystal film corresponds to the calculated frequency and averaged amplitude of the outgoing split signal on the cholesteric liquid crystal film. On Figures 12, 13 are illustrated the work of music color device. When the music color device is switched off (Figure 12 (a), Figure 13 (a)), the panel has black background. When the music color device is switched on (Figure 12 (b), Figure 13 (b)), on the panel appears the many-colored image, whose each colored line “plays” in accordance with the frequency and the average signal amplitude, coming from the electronic-music device. The general consumed electrical energy of device does not exceed 100Wt.

**Indicator of Sorption Processes**

In the field of the minerals processing, in particular in the flotation, it is appeared the necessity of the determination of the sorption of floatation agents on the surface of minerals. The existing methods of determining the sorption of floatation agents on the surface of minerals use radioactive isotopes or infrared spectroscopy. Radioactive isotopes possess large radio toxicity, which is harmful for human health. Infrared spectroscopy requires the complicated equipment formulation. The developed indicator of sorption processes realizes the determination of the sorption of floatation agents on the surface of minerals by the simple, safe and available method, which permits to clearly visualize the sorption processes. The essence of the work of the developed indicator of sorption processes is concluded in the application as the indicator of sorption processes of cholesteric liquid crystal film. The application of a cholesteric liquid crystal film is concluded in the use of a unique property of cholesteric liquid crystal to change this crystal color under the temperature change. The mineral, processed by sorbent in the specific zone of mineral surface (Figure 14 (a)), is covered by the film of cholesteric liquid crystal (Figure 14 (b)), the color of film is red (minimal temperature).

To the mineral through the electrodes from both sides is connected the direct electric current. Under passing through the mineral of direct electric current, mineral is heated and heats its surface, processed by sorbent and covered by the cholesteric liquid crystal film. As a result the heated surface of mineral forms the gradient of temperatures between the covered by the sorbent surface and the uncovered surface of mineral. In this case the layer of sorbent is a heat insulator, as a result of which, the zone of the surface of mineral, covered by the sorbent, will have minimal temperature, and the remained surface of mineral will have the maximal temperature of heating mineral. As a result of the mobility of the structure of cholesteric liquid crystal film under a change of the temperature, the film in the zone covered by the sorbent does not change color, remaining by red, but in the zone uncovered by sorbent its color will be changed from the red to the blue, and the contrasting boundary line will have a green painting (Figure 14 (c)). Thus, the use of a cholesteric liquid crystal film as the indicator of sorption processes provides the safety of works, simplification in the procedure of indication, universality, rapidity, visualization, simplicity and cheapness of equipment.

**Fig. 14:** Work of the indicator of the sorption processes.

(a) The mineral is covered by the layer of the sorbent (it is shown the line of differentiation), (b) The mineral before work is covered by the cholesteric film (without electric current), (c) The indication of sorbent on the surface of mineral by the cholesteric film under use of electric current on the electrodes.
RESULTS AND CONCLUSION

On the basis of the unique property of cholesteric liquid crystals under the change of the temperature to change their color were used the cholesteric liquid crystal films and were developed:

(a) The Device for Diagnostics of Breast Cancer.

The developed device is the seamless brassiere, in which completely there are no seams on the cups. Cups are made from the thin cholesteric liquid crystal film. The developed device is usual and comfortable for the women under the conducting of diagnostics, which completely covers and fixes female breast and permits to obtain the qualitative, contrasting with the high accuracy colored image of benign or malignant tumor, if it is diagnosed among woman. Device does not require pressing by special plate, contained the mixture of cholesteric liquid crystal, or directly coating by the mixture of cholesteric liquid crystal the female breast, the high economic expenditures, expensive equipment, time on the cooling, is absolutely harmless and simple.

(b) The Music Color Device.

The developed music color device is the fundamentally new device, the mechanism of work and spectacular effect of which, in the root differs from of existing music color devices. The obtaining spectacular effect, good aesthetical perception and high efficiency is achieved by the use as the screen-panel the cholesteric liquid crystal film or strips from cholesteric liquid crystal film on the black background of paper-panel. The use of the cholesteric liquid crystal film, which changes its color with a change of the temperature, permits to “revive” by different colors image on the panel in accordance with the frequency spectrum of the split signal, which is coming from the electronic-music device. Under the use of the developed music color device is not necessary to use the incandescent lamps, the complicated power control units of the output stages.

(c) The Indicator of Sorption Processes.

The essence of the work of the developed indicator of sorption processes consists in the application as the indicator of sorption processes of the cholesteric liquid crystal film. The application of a cholesteric liquid crystal film consists in the use of a unique property of cholesteric liquid crystal, as a result of the mobility of its structure under the change of the temperature to change its color. The use of a cholesteric liquid crystal film as the indicator of sorption processes ensures safety of works, simplification of the procedure of indication, universality, rapidity, visualization, simplicity and cheapness of equipment.

REFERENCES