LOCAL HYPERTERMIA IN CROSSED LASER FLUXES

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***Abstract*: Work deals with the important and actual problem of oncology. The research problem provides the development of the device for procedures of local hypertermia of deeply located tumors. The developed device allows a constant monitorization of the process of heating and operative change of procedure of treatment.**
***Keywords*: local hypertermia; diode laser; crossed rays; near infrared region.**

I. INTRODUCTION

Nowaday some non-invasive (or little invasive) laser hyperthermia methods for the heating of tumors that are situated deep inside the biological tissues, are being examined and developed.

The method of interstitial photocoagulation consists of the admission of the light flux through the introduced into the tumor optic fiber. The disadvantage of the method consists of the treatment possibility of small areas (diameter of 1-3cm). The cause of this is the modification of the optic properties at the heating of the tissues that are located in the immediate vicinity with the radiant edge of the optic fiber. The volume of the heated areas may be enlarged using bigger power of the radiant flux [1], but may have not previsible consequences, for example: the temperature reach or surpass the vaporizing temperature of the intracellular liquid, which might start unknown and potentially dangerous processes, such as the boiling and carbonization of the tissue [2].

The method of the photodynamic therapy, that is exploiting the property of cancerous tumors concentrate of the photosensitive materials in the affected cells, is accomplished in 2 ways. The most wide-spread method – photochemotherapy involves photosensibilizators, whose molecules excite during the absorbing the photons and produse same dangerous such as: mithohondria distruction; the substantial modification of the oxygen metabolism through the generation of a very cytotoxic singlet oxygen ($^{1}O_2$) and a very much quantity of free radicals [3 – 5]. The second way – phototermotherapy, involves photosensibilizators that emited a big quantity of heat under the absorbtion of the light ray. Usually they are nanodimentioned structures such as a metallic powder, nanotubes, nanorodes and nanoshells with dielectric core and metallic covering [6]. The formation of free radicals and chemical compounds, whose role is too little studied at present is one of the disadvantage of all those photosensibilizator methods.

The classic hyperthermia methods uses the fact that at temperatures between 42-45C the DNA of the affected cells suffers irreversible changes and thus the pathological cells die. At the same time, the healthy cells are not affected by that temperatures. Using this property, we develope the device specialized for controlled heating of located inside the tissue the malign tumors. The device consists of same sources ($\lambda = 808nm$). The radiation at this length gets inside the biologic tissue at about 70-120 mm deep for the irradiation of about 10 W/cm^2 [7]. But of this irradiation the wide photothermal destroy of the surface tissue exposed for the times longer than 50ms is involved. The main problem, that consists in the admission of the laser radiation flux energy in interior regions without affecting the healthy tissue that located between the surface and the tumor, is solved through the location of the tumor at the intersection of a few rays, the irradiation of which at the surface of the tissue is below the critical value.

II. THE DEVICE FOR LOCAL HYPERTHERMIA IN CROSSED RAYS

Test installation for experimental research temperature distribution inside samples in crossed fluxes has been designed by Center of Medical Technique IIETI ASM. Basic parts of the installation listed below (Fig. 1):

- Laser-diods (LD) with individual beaming optical systems, directed to point in common;
- Multichannel data analyzer. Thermometry in divers places of the sample occur simultaneously by means of multiple spaced in volume thermal sensors associated to probe system with the aid of computer. At present thermocouples are used as thermal sensors.
- Accurate setting sample with thermal sensors to predetermined position relative to point in common of crossed fluxes is carried out by means of displacement of two-axis table. Table control and sample the position data of thermal sensors are performed by computer.
- Computer performs control, data acquisition and processing, easy-to-use display of temperature field.

Interface supports data flow and instruction stream between PC, thermo sensors and executors and is based on microcontroller (MC) MSP430F169.

Thermometry in divers places of the sample occur simultaneously by means of multiple spaced in volume thermal sensors. Thermoelectromotive each thermocouple is amplified own operational amplifier (OA) CMOS rail-to-rail output. Voltage output range 0.5 … 2.5V (supply voltage 3V) complies with temperature range 0^{o} … 50^{o}C.

Analog signal of each thermocouple, amplified with OA, comes to appropriate input in analog-digital

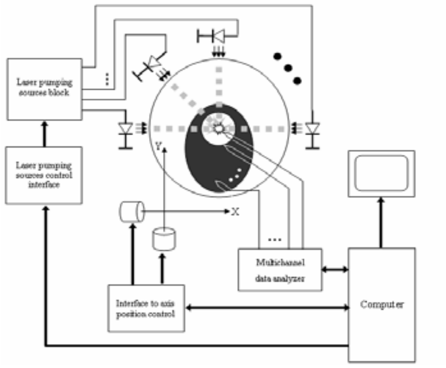

Fig. 1 Block diagram of installation to research temperature distribution inside samples in crossed fluxes

converter (ADC) AD7708 and, after converting, is transmitted to microcontroller MSP430. Microcontroller composes array current data temperature, compares it with specified from console PC volumes and issues instructions to executors, and sends data to PC to display of temperature field and decision making.

Otoh, according to instructions from PC and data on current temperature distribution inside sample microconroller yields digital or analog control signal and transmits it to LD-drivers inputs purposely to set correctly radiation mode (Fig. 2).

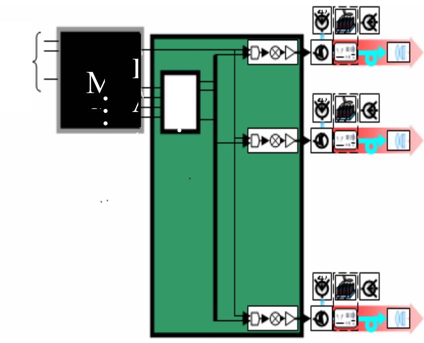
Fig. 2. Skeleton diagram of the laser diodes pumping control block;

If the temperature inside interesting area is below specified value, controller commands to activation LDs. When goal temperature at one or more points simultaneously has been reached, controller, in terms of compare current and predetermined data, commands switching off LDs. As soon as irradiated area has cooled per 0,2°…0,3°C, LDs are activated again etc. during local hyperthermia procedure. It is simple variant of pulse control method. Another method of local hyperthermia realization consists in smooth change LD emission power for the purpose to keep prescribed temperature accurate within ±0,1°C in set points of the sample.

Each LD is controlled by MC individually (Fig. 3).

Microcontroller opens input ports of each driver in turn whereby setting high level to "device select" (DS) pin and loads digital value as series cod (pin In_D) or voltage level (pin In_A), conformable to necessary.

Voltage level of the analog signal linearly depends on emission power and is settled to analog data bus

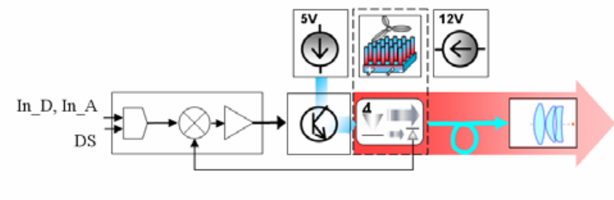

Fig. 3 Skeleton diagram of the individual laser diode control pumping

before regular driver is enabled load mode. If loaded data is digital, after DS-signal changing to low-level it comes to DAC and is converted to suitable voltage value, that is transmitted to analog adder input.

If control signal is analog, after DS-signal changing to low-level it is received to "sample and hold" circuit and further to second input of the analog adder.

Adder functions as modulator, if digital (input In_D) and analog (input In_A) controls use at the same time, ant it operates as buffer, when one of these controls is passive.

Resulting signal at adder output is transmitted as control signal to noninverting input of the operating amplifier that controls the current of the high-powered Darlington in laser-diode supply circuit.

Setting and keeping operating mode of the LD are realized by means of comparison the control signal and feedback signal that comes to inverting input of the above operational amplifier in Feedback signal is formed at circuit inclusive photodiode illuminated kickback flow through nontransmitting mirror LD.

Operational amplifier produces output voltage that initiates LD radiation mode capable parity voltage levels at OA inputs.

Thus LD driving occurs in terms of direct estimation of the beaming power.

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