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MULTI-FUNCTIONAL MICROPROBE LAB-ON-A-CHIP BASED ON THE ACTIVE-PIXEL SENSOR WITH THE POSITION-SENSITIVE CASSETTE MASKS ASSEMBLED FROM DISCRETE CONVERTERS OF DIFFERENT BIOPHYSICAL AND BIOCHEMICAL PARAMETERS INTO THE OPTICAL RESPONSE SIGNALS

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Abstract

The prototypes of automatic microfluidic devices for multiparametric mapping of biochemical and synthetic analytes using planar converters-visualizers have been designed. We propose to use a lab-on-a-chip with a number of replaceable cartridges-converters of various physical parameters/variables to optical signals, which can be detected using CMOS or CCD, as a single analytic & microelectronic platform for mapping and visualization of different physical and chemical parameters.

Keywords and phrases: lab-on-a-chip, multi-parametric mapping and imaging, planar converters, field visualizers, CMOS, ISFET, CCD, microfluidic devices, position-sensitive cassette masks.
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1. General Principles

The above system allows to perform a simultaneous mapping, detection, and visualization of a number of the sample characteristics, such as:

(a) Magnetic field (using magnetic film indicators and flux-detectors).

(b) Electrochemical parameters (potentiometric indicators).

(c) Laser beam transmission outside the visible spectral range (using the doped solid matrices).

(d) Distribution of the emitting regions in autoradiography (using the scintillation detectors with different quenching factors or "position-sensitive spinthariscopes").

(e) Polarization characteristics and the angular fluorescence polarization (using polaroid films with the rotation angles changed by the stepper motors).

(f) The local temperature of the sample at different points on a chip (according to the NIR-HDRI thermography principles).

It is also possible to perform the distribution analysis of any other sample characteristics derived from the above parameters (e.g., redox potential from the fluorescence measurements using specific dyes or the heat capacity from the thermographic data). Thus, we propose a novel analytical method using labs-on-a-chip capable of the complex analysis of various analyte parameters, provided by the design of the cassette of different converters moving relative to the sample.

The possibilities of the above analytical technique have been significantly expanded in recent years due to the development of the novel data processing software which allows to study the size distribution of the quantum dots, to perform the nucleic acid code decoding and to use the lab-on-a-chip as a spectrometric system with a complicated signal processing using a number of different methods in addition to the simple Fourier transform.

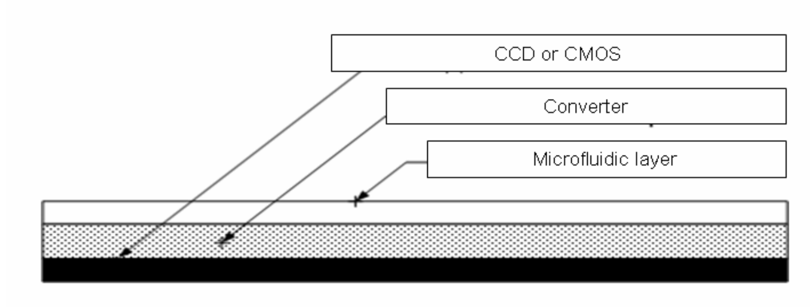

Figure 1. A physical scheme of the multi-parametric analysis.

2. Examples of Applications

(I) Monitoring of the biophysical parameters of cells and tissues during morphogenesis of the complex structures in a spectrozonal/ multispectral mode, as well as at various angles with the polarization analysis [1, 2] controlled by the five-axis automatic system.

(II) Synchronous *in situ* studies of the angular characteristics of the neuron development and their electrophysiological activity [3, 4].

(II) Cyclic code decoding of the nucleic acids including xenonucleic acids [5] and DNA-cryptography; genetic data qualimetry for synthetic biology, as well as paleogenetic and molecular phylogenetic data using a chip-sequencing technique [6].

(IV) The studies of colocalization of not only the biochemical agents, but also of their systems biological (SBGN), physico-chemical (QSPR), biophysical and pharmacological (QSAR) descriptors, derived from the automatic computer interpretation of the analytical data (COBAC) from the chip [7].

(V) Redox-mapping, including the study of the reactive oxygen species localization using lab-on-a-chip for ozonometric microscopy [8]. Any positional-sensitive measurements in a lab-on-a-chip can be calibrated by the spectrum using spectrophotometric/colorimetric temperature for tuple chemometric analyte systematization [9], as well as by the spatial coordinates for morphometric purposes and colocalization studies using different counting chambers' grids [10] with the chamber microgrooves serving as a useful analytical microfluidic instrument.

(VI) The studies on the reaction-diffusion processes coupled to the redox reactions which simulate primitive morphogenesis in biomimetic heterogeneous media, accompanied by the oscillatory and autowave behaviour of the active medium localized on the chip [11-13], particularly under optical pumping [14] with the appropriate filter in a mechanically controlled cartridge cassette of the chip.

(VII) Real-time monitoring in microbiological studies of the soil, greenhouse and wetland environments [15] with the telemetric radiofrequency signal transduction, which substitute the classical soil chambers and Rossi-Cholodny slides, providing a direct *in vivo* and *in situ* monitoring of the microbial community parameters in a telemetric mode instead of the subsequent analysis after the removal from the natural environment [16]. The above system with the RF broadcasting for the soil biophysical and microbiochemical monitoring is similar to the telemedicine of the future for agricultural industry.

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