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Application Analysis of Optical Detection Technology of Microfluidic Chip Based on Grating in Cell Research

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Abstract

Because of its integration and miniaturization, microfluidic chips can greatly shorten processing time, improve detection resolution and accuracy, and reduce consumption and cost. In biological and medical research, the separation of different types of cells has always been an important field of cell research, which can bring great convenience to the diagnosis and treatment of many diseases, but also will bring breakthroughs in life science research. Using single cell analysis technology to detect chemical components in a single cell is helpful to understand basic cell functions and to detect and identify a small number of abnormal cells in a large cell population. The research of cell biology is an important driving force for the research of modern life science. Accurate and effective cell biology research experiments enable human beings to further understand the generation and development process of life structure. In this paper, the behavior of fluid and cells in microfluidic chips is investigated. At the same time, the method of driving cells by high-focus laser microbeam is explored theoretically and experimentally.

Keywords

Microfluidic chips, Cells; Detection, Life structure.

1. INTRODUCTION

Because of its integration and miniaturization, microfluidic chips can greatly shorten processing time, improve detection resolution and accuracy, and greatly reduce consumption and cost [1]. As the basic unit of life structure and activity, cells are the basis of life science and biomedical research. Research based on cell level can greatly promote the development of medical diagnostic technology and promote the progress of medical field. Microfluidic analysis chip is a micro-total analysis system which integrates micropipes, micro-pumps, micro-valves, micro-reservoirs, micro-electrodes, micro-detection elements, windows and connectors in chip materials by micro-processing technology [2]. Using single cell analysis technology to detect chemical components in a single cell is helpful to understand basic cell functions and to detect and identify a small number of abnormal cells in a large cell population [3]. The detection technology of microfluidic chips has also played a very important role in the process of continuous application of microfluidic chips. Because microfluidic chips are most commonly used in the field of life science, there are special requirements for its detection [4]. With the research bottleneck brought by the deficiency of traditional cell separation methods, how to realize fast, high throughput and unlabeled cell screening has become a hot spot in the field of cell separation research.

The level of medical development is an important indicator to measure the level of social development, while medical diagnostic technology is an important indicator of medical development, and cell analysis is an important means to realize medical diagnosis [5]. With the

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continuous development and improvement of detection technology, detection methods and technologies for microfluidic chips have also been continuously improved. The research of cell biology is an important driving force for the research of modern life science. Accurate and effective cell biology research experiments enable human beings to further understand the generation and development process of life structure and promote the further development of human health level [6]. In the aspect of cell research and application, due to the good compatibility between micro-channel scale and cells, it is possible to realize high simulation of cell environment in vivo in vitro [7]. Therefore, it has many applications in cell culture, cell manipulation, sample processing and cell detection in life science. Through the study of single or trace cells, we can get information about cell clone correlation, intraclonal differences and continuing mutations [8]. The development of this detection method provides a theoretical and experimental basis for the development of microfluidic chip detection methods, and opens a new page for the application of microfluidic chip in cell analysis field.

2. MICROFLUIDIC CHIP DETECTION METHOD

Microfluidic chip is a micro-chemical system composed of microvalves, microchannels, microreactors, microsensors, microdetectors and other functional units fabricated on the chip by micro-processing technology. In this system, sample pretreatment, chemical reaction, separation, detection and other functions can be completed. Electroosmotic flow is generated by the induced charge generated by charged ions at the solid interface, which moves under the applied electric field and then drives the whole fluid to move. When fluids containing biological macromolecules flow in microchannels, different from macroscopic performance, fluid behavior will be affected by many factors such as micro-scale structure, materials, surface characteristics, fluid characteristics and so on [9]. Optical detection has the advantages of high sensitivity, simple equipment and easy combination with microfluidic chip. It has more potential for real-time detection of living cells. In the diffusion layer, the net charge density per unit volume of the solution is not zero. At this time, the existence of an applied electric field will produce a volume force to promote the ion movement in the diffusion layer. The movement of ions drives the fluid nearby, and then the fluid flow in the passage is driven forward together by the viscous force. Because all kinds of biological and chemical processes in microfluidic chip laboratory are usually completed in the geometric structure of micron scale, the detectors in microfluidic chip system must meet some special requirements compared with traditional laboratories.

Project quality control refers to the control over the progress of each stage and the deadline for the final completion of the project during the implementation of the project. The construction period of the working procedure follows lognormal distribution. The particle swarm optimization algorithm is applied to the regulation. Fig. 1 shows the planning results of critical chain method.

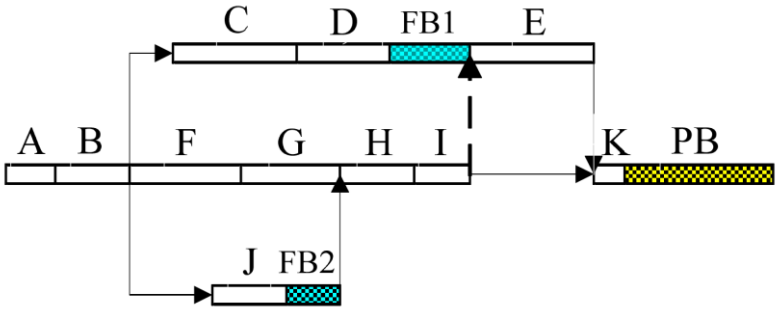

Fig 1. Key chain method planning results

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According to laminar flow theory, the velocity of fluid varies at different positions of microchannels, so the fluid produces different viscous resistance to cells. Cell dynamics relationships, including cell growth rate matrix removal rate relations, later became the basis of cell dynamics. The matrix removal rate formula is as follows:

$$o_j(t) = f\left(\left[\sum_{i=1}^{n} w_{ij} x_i\left(t-\tau_{ij}\right)\right] - T_{ij}\right) \tag{1}$$

The specific growth rate inhibition kinetic model is as follows:

$$Y_j(t) = \varphi\left(\sum_{i=1}^{n} w_{ji} x_i - \theta_j\right) \tag{2}$$

Revise it and propose the following inhibition model:

$$P_i = \frac{f_i}{\sum_{i=1}^{N} f_i} \tag{3}$$

The chemical luminescence detector detects the substance to be detected by detecting the intensity of luminescence in a special chemical reaction, does not need a light source, has simple instruments and equipment, and is easier to realize miniaturization and integration. The property of fluid that resists the relative sliding velocity between two layers of fluid is called viscosity. The viscosity depends on the nature of the fluid and varies significantly with temperature. Laser confocal technology can effectively reduce the irradiation volume of the sample, thus reducing the influence of scattered light on the sensitivity, thus the signal-to-noise ratio of confocal detection system is higher than that of non-confocal system. According to the advantage that the electrochemical detection method does not need the detector probe to contact with the microchip substrate, the detection is not affected by optical path and sample turbidity, and the electrochemical detection method has the advantages of high sensitivity, model selection, small volume, simple device, low cost, and compatibility with micromachining technology. During the processing of the chip, the structure of the mask determines the micro-channel structure of the chip, so the main content of designing the structure of the chip is to design the structure of the mask.

3. MICROFLUIDIC CHIP DETECTION METHOD

3.1. Fluid Behavior in Microfluidic Chips

The study of fluid flow in microfluidic chips can be divided into three aspects: theoretical analysis, numerical calculation and experimental simulation. For microfluidic chips, conductivity detection method is suitable for detecting small ion substances which are difficult to detect by other methods. It is a universal detection method, and the substances to be tested need not have chromogenic, fluorescent or electrochemical active groups. The pressure field of incompressible fluid is indirectly defined by the continuum equation. Because no external light source is needed in the detection, the interference is reduced and the requirement of the equipment for the light source is simplified. Only one photomultiplier tube and photodiode are needed as detectors. Because there is no direct solution to the pressure equation, the solution

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to the flow equation of incompressible fluid has its special difficulties. Complex media flow refers to the flow of multi-phase or multi-component media including liquid droplets, particles or cells. Due to the complexity of such media, the description of driving force and boundary conditions during fluid flow will be more complicated. Chemiluminescence and bioluminescence detection provide simple and relatively cheap equipment for microchip detection systems, which is in line with the development trend of miniaturization of chip laboratories.

The soft etching technology is simple in process, does not need particularly harsh micro-processing requirements and environmental conditions, and the formed template can be repeatedly used for many times, which greatly reduces the difficulty and cost of chip processing. Anaerobic digestion kinetics was established on the basis of a modified stage. The growth rate of cells is proportional to the utilization rate of matrix:

$$f_1(x)=\sum_{i=1}^{D-1}\left[100\left(x_{i+1}-x_i^2\right)^2+\left(x_i-1\right)^2\right] \tag{4}$$

The cell death rate can be expressed by the first-order reaction formula:

$$Cr_{(t+1)}=k\times Cr_{(t)}\times\left(1-Cr_{(t)}\right) \tag{5}$$

Using existing technology to build a multi-mode collaborative work environment. It has an integrated collaborative work support platform. Cooperative design and operation process as shown in Fig. 2.

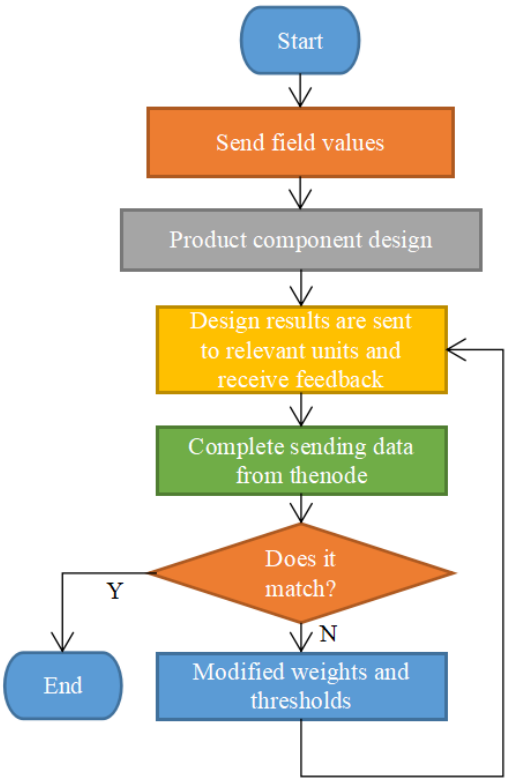

Fig 2. Microfluidic chip processing cooperation design and operation process

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The traditional fabrication materials of microfluidic chips are monocrystalline silicon, amorphous silicon, glass or quartz. Silicon has become the earliest material used to fabricate microfluidic chips because of its mature technological foundation in the field of microelectronics. Surface modification bonding is the modification of polymer surface by physical or chemical methods, such as improving the hydrophobicity, adsorbability and low surface charge of PDMS surface, which can achieve permanent bonding. The preparation of microfluidic chips by dry film method is a process of continuous optimization, and comparison and optimization are needed for the treatment of templates, film sticking techniques, exposure time, baking time, etc. The experimental research of microfluidic chip needs not only chip, but also feeding device for micro liquid, observation equipment for micro fluid inside the chip and consumables needed in the experimental process. By comparing the experimental results with the simulation results, the feasibility of forming single cell flow under sheath flow condition is confirmed. Through a series of experimental comparisons, the optimal conditions for forming single cell flow are determined.

3.2. Cell Flow Acquisition in Microfluidic Chip

There are two main forms of fluid flow, laminar flow and turbulent flow. Laminar flow means that there is no intermixing between the two layers in the flow process, i.e. the velocity of any given point in the fluid does not change with time.

Aiming at the medium access constraints of wireless communication networks, an agent node scheduling protocol is designed using binary sequences. The scheduling protocol is used to schedule the agent nodes that meet the conditions to access the network at the sampling time. Fig. 3 shows the structure of an agent node.

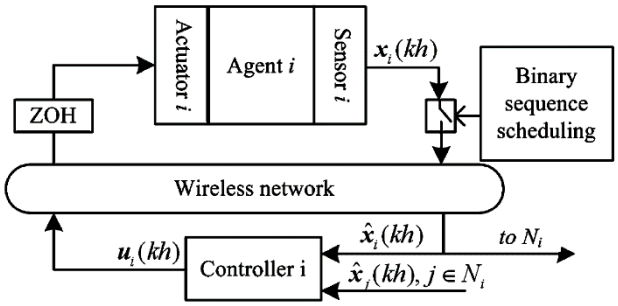

Fig 3. Structure of the agent node

The concentration of calcium ions can be calculated by using the ratio of fluorescence intensities emitted under excitation light of two different wavelengths. This method can dynamically monitor the change of calcium ion concentration in cells in real time and quantitatively. Refractive index detection is very sensitive to ambient temperature, pressure or flow rate, and can detect a variety of analytes after being combined with microfluidic devices and accurately controlling external conditions [10]. When the system works, reagents are placed in the reservoir near the center of the chip, and flow to the peripheral of the chip under the centrifugal force generated by the rotation of the chip. The process of reagent mixing, reaction and detection for enzyme analysis is completed in turn. For fluids, the flow characteristics of micro-scale fluids have changed greatly compared with macro-scale fluids. The flow characteristics of microfluids are complex, and there are many influencing factors. In fluid simulation, two physical fields, laminar flow module and particle tracking module, are selected. In the simulation process, specific initial values and boundary conditions are input to the model to realize the simulation of microfluidic chip injection in reality.

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4. CONCLUSIONS

Microfluidic chip technology is the frontier technology in the field of microanalysis, which is of great significance to future scientific research. Optical detection methods of microfluidic chips are various, and a chip can integrate a variety of detection aids. Using microfluidic chips to manipulate cells such as fluid shear stress, dropping treatment, combined with optical tweezers, nanotechnology, surface treatment and other means can often make detection more sensitive and simple. Microfluidic chip technology has brought modern laboratory research into an era of microminiaturization, bringing life science research and biomedical research to a new height. The driving effect of laser on the light pressure of particles makes people study the microscopic world further. The phenomenon of optical tweezers formed by light pressure gives people an effective tool to manipulate and capture particles. During the experimental operation, cell loading is a very important link, which is related to whether the cells can adhere to the wall smoothly in our detection area, facilitating our later staining and observation. In the field of cell separation, the combination of microfluidic chip technology and laser capture drive technology will realize the further development of non-contact and non-damage cell separation research. The system needs further design and optimization so as to finally realize the effectiveness and practicability of the cell separation system.

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