HIGH-GAS PRESSURE MICROFLUIDIC DEVICE

TECHNICAL FIELD

[0001] The present disclosure relates to the field of microfluidic technology, and more particularly, to a high-gas pressure microfluidic device.

BACKGROUND

[0002] A microfluidic technology refers to miniaturizing experimental functions such as biology and chemistry onto chips by means of manipulation of fluids at a micron level, to achieve complete experimental functions. The sample flows between the microfluidic chips and different functional modules in system through fluids. Therefore, drive control of the fluids at microscale is one of key factors for the microfluidic chips and system.

[0003] Continuous and simple medium flow control of sample flow in the microfluidic system, namely single-phase flow treatment in fluid mechanics, is the most common sample form in the microfluidic system. Differential pressure drive is the most widely used driving mode. The differential pressure drive refers to a method of driving a fluid to flow by resisting a viscous force generated by fluid flow in microchannels by means of pressure differential. In the industry, external gas sources, injection pumps, or peristaltic pumps are generally employed to generate the pressure differential, thereby achieving the fluid drive.

[0004] The injection pumps or peristaltic pumps generally rely on electric motors to drive, and system pressure control undergoes periodic changes, resulting in a decrease in stability and accuracy of microfluidic control. The implementation system in both of the two modes generally involve contact with the samples to be treated. However, in many biochemical experiments, the samples need to be treated in a non-contact manner, and contact part is implemented with consumable materials, making it difficult to treat the samples at low cost. Simple gas pressure control is relatively stable, but relying on the external gas sources may cause inconvenience to operating environment. Moreover, it is unable to control the

external gas sources to generate negative pressure, which is disadvantageous to automation of overall equipment.

SUMMARY

[0005] (I) Technical Problems to be Solved

[0006] An objective of the present disclosure is to provide, in response to the shortcomings of the existing technologies, a high-gas pressure microfluidic device which can generate high gas pressure and positive and negative pressures without an external gas source and can stably and accurately control a microfluidic flow rate.

[0007] (II) Technical Solutions

[0008] To solve the above problems, the present disclosure provides a high-gas pressure microfluidic device, which includes: a gas supply device, a gas pressure control device, a main control unit, and a microfluidic chip unit. The gas supply device includes an air compressor arranged inside a first case body, and the air compressor is connected to the first case body through an elastic component. The gas pressure control device includes a gas storage tank connected to the air compressor through a gas pipe, a gas pressure sensor arranged on the gas storage tank, and a gas pressure controller arranged between the gas storage tank and the microfluidic chip unit. An electromagnetic switch is arranged between the air compressor and the gas storage tank. The main control unit includes a main control board, which is electrically connected to the air compressor, the gas pressure sensor, the gas pressure controller, and the electromagnetic switch, respectively.

[0009] Alternatively, a sound absorbing layer is arranged on an inner wall of the first case body to absorb noise generated during operation of the air compressor.

[0010] Alternatively, a cooling device is arranged inside the first case body to cool the air compressor.

[0011] Alternatively, the air compressor is provided with a temperature sensor for detecting the temperature of the air compressor, and the temperature sensor is electrically connected to the main control board.

[0012] Alternatively, the main control unit also includes a human-machine interaction module for displaying data received by the main control unit and issue a control command.

[0013] Alternatively, the high-gas pressure microfluidic device also includes a power supply for supplying power to the gas supply device, the gas pressure control device, and the main control unit.

[0014] Alternatively, the gas supply device, the gas pressure control device, the main control unit, the microfluidic chip unit, and the power supply are arranged inside an outer housing. The outer housing is provided with an openable cover cap at a position corresponding to the microfluidic chip unit, for replacing the microfluidic chip unit. The outer housing is provided with an opening at a position corresponding to the human-machine interaction module, for exposing the human-machine interaction module.

[0015] (III) Beneficial Effects

[0016] The high-gas pressure microfluidic device provided by the present disclosure is provided with the air compressor and does not require an external gas source, making it flexible to use. The air compressor is fixed by the elastic component and is provided with the sound absorbing layer and the cooling device. With a structural design integrating shock absorption, noise reduction, sound insulation and heat dissipation, the air compressor greatly reduces system noise, such that noise generated by the air compressor is equivalent to environmental noise in a laboratory. Thus, the air compressor is suitable for use in laboratory environment. By storing gas with a certain pressure in the gas storage tank to supply gas to the microfluidic chip unit, working time and energy consumption of the air compressor can be reduced, and heat generation can be reduced as well. The microfluidic flow rate of a sample in the microfluidic chip unit can be stably and accurately controlled by means of the gas pressure control device. Sample treatment can be completed with low-cost disposable consumables by means of non-contact treatment of samples, which can accomplish low-cost and large-scale commercialization. The device is provided with the air compressor and the electromagnetic switch, making it suitable for more microfluidic applications requiring high

pressure. The device can generate positive and negative pressures, and the switchover between the positive and negative pressures can be achieved by means of the main control unit, to complete automatic sampling and loading. Thus, it has a high degree of automation, and lays a foundation for implementation of unmanned systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] To describe the technical solutions of the embodiments of the present disclosure or those of the prior art more clearly, the accompanying drawings required for describing the embodiments or the prior art will be briefly introduced below. Apparently, the accompanying drawings in the following description are merely some embodiments of the present disclosure. To those of ordinary skills in the art, other accompanying drawings may also be derived from these accompanying drawings without creative efforts.

[0018] FIG. 1 is a schematic diagram of an internal structure of a high-gas pressure microfluidic device according to an embodiment of the present disclosure;

[0019] FIG. 2A is a schematic diagram of an external structure of a gas supply device of the high-gas pressure microfluidic device according to an embodiment of the present disclosure;

[0020] FIG. 2B is a schematic diagram of the internal structure of the gas supply device of the high-gas pressure microfluidic device according to an embodiment of the present disclosure; and

[0021] FIG. 3 is a schematic diagram of the external structure of the high-gas pressure microfluidic device according to an embodiment of the present disclosure.

[0022] Reference signs in the accompanying drawings are in order as follows:

[0023] 1, gas supply device; 11, first case body; 12, air compressor; 13, elastic component; 14, elastic part bracket; 2, gas pressure control device; 21, gas storage tank; 22, gas pressure controller; 3, main control unit; 31, main control board; 32, human-machine interaction module; 4, microfluidic chip unit; 5, cooling device; 6, power supply; 7, outer housing; 71, cover cap; and 72, base.

DETAILED DESCRIPTION

[0024] Specific implementation manners of the present disclosure are further described in detail below with reference to the embodiments and the accompanying drawings. Here, the following embodiments of the present disclosure are intended to illustrate the present disclosure, but not to limit scope of the present disclosure.

[0025] As shown in FIG. 1, the embodiments of the present disclosure provide a high-gas pressure microfluidic device, which includes a gas supply device 1, a gas pressure control device 2, a main control unit 3, and a microfluidic chip unit 4. Wherein,

[0026] the gas supply device 1 includes an air compressor 12 arranged inside a first case body 11, and the air compressor 12 is connected to the first case body 11 through an elastic component 13, as shown in FIGS. 2A and 2B. The elastic component 13 includes a plurality of elastic parts, such as shock absorbing spring, connected between the air compressor 12 and a frame of the first case body 11. As shown in FIG. 3, the air compressor 12 is provided with a plurality of elastic part brackets 14. For example, the elastic part brackets 14 are arranged at four corners on a bottom of the air compressor 12 and in a middle of a top surface of the air compressor 12 to fix one end of each elastic part in the elastic component 13. A corresponding position on the frame of the first case body 11 is provided with a fixing point to fix other end of the elastic part. The two ends of each elastic part in the elastic component 13 are respectively fixed to one elastic part bracket 14 and the fixing point corresponding to the position of the elastic part bracket 14, such that the air compressor 12 is fixed to the frame of the first case body 11 through the plurality of elastic parts. The air compressor 12 is arranged in the first case body 11 in a suspended manner. This fixing mode of the air compressor 12 enables the plurality of elastic parts fixing the air compressor 12 to greatly reduce vibration noise when the air compressor 12 vibrates violently during operation. Tension of each elastic part may be adjusted as needed to balance the force applied to the air compressor 12, such that the air compressor 12 maintains a balanced state.

[0027] To reduce the noise generated by the air compressor 12 during operation, a

sound absorbing layer (not shown in the figure) may also be arranged on an inner wall of the first case body 11 to absorb the noise generated by the air compressor during operation. For example, sound absorbing materials such as sound absorbing cottons and sound absorbing boards are pasted to the inner wall of the first case body 11. In this way, the noise generated by the air compressor 12 during operation is further reduced.

[0028] The gas pressure control device 2 includes a gas storage tank 21 connected to the air compressor 12 through a gas pipe (not shown in the figure), a gas pressure sensor (not shown in the figure) arranged on the gas storage tank 21, and a gas pressure controller 22 arranged between the gas storage tank 21 and the microfluidic chip unit 4. An electromagnetic switch (not shown in the figure) is arranged between the air compressor 12 and the gas storage tank 21. The main control unit 3 includes a main control board 31, which is electrically connected to the air compressor 12, the gas pressure sensor (not shown in the figure), the gas pressure controller 22, and the electromagnetic switch, respectively.

[0029] The air compressor 12 inflates the gas storage tank 21 through the gas pipe, and the gas pressure sensor detects the gas pressure in the gas storage tank 21 in real time, and sends a detected gas pressure value to the main control unit 3. When the main control unit 3 detects that the gas pressure in the gas storage tank 21 reaches a set gas pressure value, the main control board 31 in the main control unit 3 sends a command to the air compressor 12, such that the air compressor 12 stop operating. Next, the main control board 3 sends the command to the gas pressure controller 22, such that the gas pressure controller 22 supplies gas to the microfluidic chip unit 4 at a set gas pressure (at a certain gas pressure lower than the gas pressure in the storage tank 21), thereby allowing a liquid sample to be detected in the microfluidic chip unit 4 to enter a microfluidic chip in the microfluidic chip unit 4. The main control board 31 controls the gas pressure value of the gas supplied to the microfluidic chip unit 4 through the gas pressure controller 22, thereby achieving control of a flow rate of the liquid in the microfluidic chip unit 4. The microfluidic chip unit 4 is detachably connected to the gas pressure controller 22 in the form of consumable pack. Through this control method,

supply of the gas to the gas storage tank 21 can be intelligently controlled, thereby reducing working time and energy consumption of a gas source. A microfluidic flow rate of the sample in the microfluidic chip unit 4 can also be stably and accurately controlled.

[0030] When it is required to extract the sample to be processed from the microfluidic chip unit 4, the main control board 3 sends the command to the air compressor 12 to control the air compressor 12 to operate and generate a negative pressure, and the corresponding electromagnetic switch is switched to automatically extract the sample into the microfluidic chip unit 4.

[0031] Since the first case body 11 is a closed structure, and its inner wall is provided with the sound absorbing layer. Thus, heat generated during operation of the air compressor 12 in the first case body 11 leads to a rise in temperature of the first case body 11. For this reason, as shown in FIGS. 1 to 3, a cooling device 5 is arranged inside the first case body 11. For example, a liquid cooling heat transfer sheet is arranged at the top of the air compressor 12, and the heat is transferred out of the first case body 11 through a liquid cooling system. Furthermore, a ventilator may also be arranged outside the first case body 11 to dissipate the heat from the first case body 11.

[0032] To timely dissipate the heat from the first case body 11, a temperature sensor (not shown in the figure) may be arranged on the air compressor 12 to detect the temperature of the air compressor 12 in real time. The temperature sensor is electrically connected to the main control unit 3, and sends detected temperature data of the air compressor 12 to the main control unit 3. When the temperature of the air compressor 12 exceeds a set temperature, the main control unit 3 sends a command to the cooling device 5, such that the cooling device 5 is started to cool and dissipate the heat from the air compressor 12. When the temperature of the air compressor 12 drops below the set temperature, the main control unit 3 sends a command to the cooling device 5, such that the cooling device 5 stops operating.

[0033] The main control unit 3 also includes a human-machine interaction module 32 for displaying the data received by the main control unit 3 and issuing a control command.

The human-machine interaction module 32 is electrically connected to the main control board 31. The human-machine interaction module is arranged for displaying various data received by the main control board 31, such as the gas pressure value detected in the gas storage tank 21 by the gas pressure sensor arranged on the gas storage tank 21, or the temperature value detected by the temperature sensor arranged on the air compressor 12. The main control board 31 may also be controlled to send various commands through the human-machine interaction module.

[0034] A power supply 6 is also provided to supply power to various parts in the gas supply device 1, the gas pressure control device 2, and the main control unit 3.

[0035] As shown in FIGS. 1 and 3, the gas supply device 1, the gas pressure control device 2, the main control unit 3, the microfluidic chip unit 4, and the power supply 6 are arranged inside an outer housing 7; wherein, the gas supply device 1, the gas pressure control device 2, and the main control unit 3 are all fixed to a base 72 of the outer housing 7. The outer housing 7 is provided with an openable cover cap 71 at a position corresponding to the microfluidic chip unit 4 for replacing the microfluidic chip unit 4. The outer housing 7 is provided with an opening at a position corresponding to the human-machine interaction module 32 to expose the human-machine interaction module 32.

[0036] The high-gas pressure microfluidic device provided by the present disclosure is provided with the air compressor and does not require an external gas source, making it flexible to use. The air compressor is fixed by the elastic component and is provided with the sound absorbing layer and the cooling device. With a structural design integrating shock absorption, noise reduction, sound insulation and heat dissipation, the air compressor greatly reduces system noise, such that noise generated by the air compressor is equivalent to environmental noise in a laboratory. Thus, the air compressor is suitable for use in laboratory environment. By storing gas with a certain pressure in the gas storage tank to supply gas to the microfluidic chip unit, working time and energy consumption of the air compressor can be reduced, and heat generation can be reduced. The microfluidic flow rate of a sample in the

microfluidic chip unit can be stably and accurately controlled by means of the gas pressure control device. Sample treatment can be completed with low-cost disposable consumables by means of non-contact treatment of samples, which can accomplish low-cost and large-scale commercialization. The device is provided with the air compressor and the electromagnetic switch, making it suitable for more microfluidic applications requiring for high pressure. The device can generate positive and negative pressures, with switchover between the positive pressure and the negative pressure achievable by means of the main control unit, completes automatic sampling and sample injection, has a higher degree of automation, and lays a foundation for implementation of unmanned systems.

[0037] In the present disclosure, orientations or positional relationships denoted by terms such as “upper”, “lower”, “left”, “right”, “front”, “back”, “vertical”, “horizontal”, “side”, and “bottom” are based on the orientations or positional relationships shown in the accompanying drawings. The terms are only relationship terms determined to facilitate the description of a structural relationship between components or elements in the present disclosure instead of referring to any components or elements in the present disclosure, and thus cannot be understood as limitations to the present disclosure.

[0038] In the description of the present disclosure, it is to be noted that unless specified or limited otherwise, terms “installation”, “connecting” or “connection” should be understood in a broad sense, which may be, for example, a fixed connection, a detachable connection or an integrated connection, a mechanical connection or an electrical connection, a direct connection or indirect connection by means of an intermediary, or internal communication between two components. For those of ordinary skills in the art, specific meanings of the terms in the present disclosure may be understood according to specific conditions, but cannot be understood as limitations to the present disclosure.

[0039] It is to be noted that the terms used herein are only for the purpose of describing the specific embodiments, and are not intended to limit the exemplary embodiments according to the present disclosure. As used herein, the singular forms are

intended to include the plural forms unless the context clearly dictates otherwise. In addition, it should be understood that when the terms “including” and/or “comprising” are used in this specification, they indicate the presence of features, steps, operations, devices, components, and/or combinations thereof.

[0040] The above embodiments are only intended to describe the present disclosure rather than limit the present disclosure. Although the present disclosure is described in detail with reference to the embodiments, those of ordinary skills in the art should understand that various combinations, modifications or equivalent substitutions to the technical solutions of the present disclosure will not depart from the spirit and scope of the technical solutions of the present disclosure, and should fall within the scope of the claims of the present disclosure.

WHAT IS CLAIMED IS:

1. A high-gas pressure microfluidic device comprising: a gas supply device (1), a gas pressure control device (2), a main control unit (3), and a microfluidic chip unit (4);

wherein the gas supply device (1) comprises an air compressor (12) arranged inside a first case body (11), and the air compressor (12) is connected to the first case body (11) through an elastic component (13);

the gas pressure control device (2) comprises a gas storage tank (21) connected to the air compressor (12) through a gas pipe, a gas pressure sensor arranged on the gas storage tank (21), and a gas pressure controller (22) arranged between the gas storage tank (21) and the microfluidic chip unit (4);

an electromagnetic switch is arranged between the air compressor (12) and the gas storage tank (21); and

the main control unit (3) comprises a main control board (31) which is electrically connected to the air compressor (12), the gas pressure sensor, the gas pressure controller (22), and the electromagnetic switch, respectively.

2. The high-gas pressure microfluidic device according to claim 1, characterized in that, a sound absorbing layer is arranged on an inner wall of the first case body (11) to absorb noise generated during operation of the air compressor (12).

3. The high-gas pressure microfluidic device according to claim 2, characterized in that, a cooling device (5) is arranged inside the first case body (11) to cool the air compressor (12).

4. The high-gas pressure microfluidic device according to claim 2, characterized in that, the air compressor (12) is provided with a temperature sensor for detecting the temperature of the air compressor (12), and the temperature sensor is electrically connected to the main control board (31).

5. The high-gas pressure microfluidic device according to claim 1, characterized in that,

the main control unit (3) further comprises a human-machine interaction module (32) for displaying data received by the main control unit (3) and issuing a control command.

6. The high-gas pressure microfluidic device according to any one of claims 1 to 5, characterized in that, it further comprises a power supply (6) for supplying power to the gas supply device (1), the gas pressure control device (2), and the main control unit (3).

7. The high-gas pressure microfluidic device according to claim 6, characterized in that,

the gas supply device (1), the gas pressure control device (2), the main control unit (3), the microfluidic chip unit (4), and the power supply (6) are arranged inside an outer housing (7);

the outer housing (7) is provided with an openable cover cap (71) at a position corresponding to the microfluidic chip unit (4) for replacing the microfluidic chip unit (4); and

the outer housing (7) is provided with an opening at a position corresponding to the human-machine interaction module (32) to expose the human-machine interaction module (32).