

Claims

1. A multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path, comprising: a chip body, provided with a sample loading chamber, a plurality of reaction chambers, and a microfluidic channel, wherein the sample loading chamber is communicated with an external air path and a sample output through hole of the sample loading chamber is communicated with the reaction chambers through the microfluidic channel, the microfluidic channel comprises a sample output main channel and a plurality of sample distribution channels disposed in one-to-one correspondence to the reaction chambers; and the sample distribution channels are separately disposed, and comprise sample distribution chamber sample output channels and reaction chamber sample input channels, wherein:

one end of the sample output main channel is communicated with the sample output through hole of the sample loading chamber, and the other end is communicated with the sample distribution chamber;

the reaction chambers are arranged in two rows that are symmetrically distributed on two sides of the sample distribution chamber with the axis of the sample output main channel as a line of symmetry;

the sample distribution chamber sample output channels of the sample distribution channels are evenly distributed on the periphery of the sample distribution chamber, and the reaction chamber sample input channels are symmetrically arranged on two sides of the sample distribution chamber with the axis of the sample output main channel as a line of symmetry; and

each sample distribution chamber sample output channel and its corresponding reaction chamber sample input channel are communicated through a sample distribution connection channel formed through heat sealing processing for a thin film on the chip body; each sample distribution connection channel extends across the corresponding sample distribution chamber sample output channel and reaction chamber sample input channel; and a thin film part of the sample distribution connection channel can form a sample distribution occlusion

portion through heat sealing processing, to intercept the flow in the sample distribution channels; wherein:

the chip body comprises an upper thin film, an upper-layer chip, a lower-layer chip, and a lower thin film, wherein

the upper-layer chip is partitioned into a sample loading zone and a reaction zone; a sample loading pool is provided on the sample loading zone of the upper-layer chip, a sample loading chamber is formed by putting a plug in a sample loading hole of the sample loading pool, and the sample output through hole of the sample loading chamber is disposed on the bottom of the sample loading pool; the reaction zone of the upper-layer chip is provided with a sample inlet hole of the sample distribution connection channel and a sample outlet hole of the sample distribution connection channel separately; and the sample output through hole of the sample loading chamber, the sample inlet hole of the sample distribution connection channel, and the sample outlet hole of the sample distribution connection channel are all through holes vertically running through the upper-layer chip;

the lower-layer chip is located below the upper-layer chip, and is connected to a lower surface of the upper-layer chip in a bonding manner; and the lower-layer chip is provided with a lower-layer chip reaction zone on a position corresponding to the reaction zone of the upper-layer chip;

the lower-layer chip reaction zone is provided with a sample distribution pool, a plurality of reaction pools wherein the lower thin film covers a lower surface of a reaction zone of the lower-layer chip, and the bottom of each reaction pool is formed by the lower thin film, a sample distribution chamber sample output channel, and a reaction chamber sample input channel; a sample distribution chamber is formed after the sample distribution pool is covered by the lower surface of the upper-layer chip, and the sample distribution pool is communicated with the sample output through hole disposed on the bottom of the sample loading pool through the sample output main channel disposed on the lower-layer chip; and

the reaction zone of the upper-layer chip further includes a plurality of reaction pool upper covers each disposed on the lower surface of the upper-layer chip at a position corresponding to position of a reaction pool of the lower-layer chip; and each reaction chamber is formed by sealing a reaction pool with a reaction pool upper cover through heat sealing of the lower thin film;

the sample inlet hole of the sample distribution connection channel is disposed directly above the sample outlet of the sample distribution chamber sample output channel, and the sample outlet hole of the sample distribution connection channel is disposed directly above the sample inlet of the reaction chamber sample input channel; and

the upper thin film covers an upper surface of the reaction zone of the upper-layer chip, and a sample distribution connection passage can be formed between the sample inlet hole of the sample distribution connection channel and the sample outlet hole of the sample distribution connection channel after the upper thin film undergoes heat sealing processing by a heat sealing device; and a thin film part of the sample distribution connection passage can also form a sample distribution occlusion portion after a heat sealing device performs heat sealing processing thereon, to intercept the flow in the sample distribution passage.

2. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to claim 1, wherein the chip body is further provided with a filter element passage and a test paper passage in communication with a liquid outlet of the filter element passage; wherein a breathable and liquid-impermeable filter element is provided in the filter element passage, and a color test paper is provided in the test paper passage; each reaction chamber is provided with an outlet, and the outlet of each reaction chamber can be communicated with an inlet of the filter element passage through an overflow passage formed through heat sealing processing for a thin film on the chip body, wherein a part of the upper thin film serves as the overflow passage, the overflow passage extending across the outlet of the reaction chamber and the inlet of the filter element passage; and a

thin film part of the overflow passage can form an overflow occlusion portion through heat sealing processing, to intercept the flow at the outlet of the reaction chamber.

3. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to claim 2, wherein there is a plurality of filter element passages arranged in one-to-one correspondence to the reaction chambers, and the liquid outlets of the filter element passages converge in communication with the test paper passage; and there are two test paper passages that are correspondingly arranged outside of the two rows of the reaction chambers.

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4. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to any one of claims 1 to 3, wherein for each reaction pool, the reaction zone of the upper-layer chip is provided with an overflow passage sample inlet hole and an overflow passage sample outlet hole; and the overflow passage sample inlet hole and the overflow passage sample outlet hole are both through holes vertically running through the upper-layer chip, and the overflow passage sample inlet hole is arranged to just run through the reaction pool upper cover;

after the heat sealing device performs heat sealing processing on the upper thin film, an overflow passage can be formed between the corresponding overflow passage sample inlet hole and overflow passage sample outlet hole; and a thin film part of the overflow passage can also form an overflow occlusion portion after the heat sealing device performs heat sealing processing thereon, to intercept the flow at the outlet of the reaction chamber;

the overflow passages are arranged in two rows that are correspondingly distributed outside of the corresponding reaction pool;

an upper surface of the lower-layer chip is provided with a through hole in communication with the filter element passage on a position corresponding to each overflow passage sample outlet hole;

the number of the filter element passages is the same as that of the overflow passage sample outlet holes, and the filter element passages are arranged below

the overflow passage sample outlet holes in rows; the filter element passages are arranged on the lower surface of the lower-layer chip, a breathable and liquid-impermeable filter element is provided in each filter element passage, and liquid outlets of the filter element passages in each row converge in communication with a test paper passage; and

the test paper passage is provided on the back side of the lower-layer chip, and positioned outside of the filter element passage.

5. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to claim 4, wherein the heat sealing device comprises a heat sealing cover provided with a channel block and a heat sealing block, wherein:

the channel block is provided with mold recesses a and mold recesses b; the mold recess a matches up with the sample distribution connection passage in size, and a distribution of the mold recesses a on the channel block is consistent with that of the sample distribution connection passages on the upper-layer chip; the mold recess b matches up with the overflow passage in size, and a distribution of the mold recesses b on the channel block is consistent with that of the overflow passages on the upper-layer chip; and

the heatsealing block is provided with a mold protrusion a and a mold protrusion b; the mold protrusion a comprises two protruding bars, and the two protruding bars can respectively press against thin film parts of the overflow passages in two rows; the mold protrusion b is an annular protrusion that can press against thin film parts of the sample distribution connection passages.

6. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to any one of claims 1 to 5, wherein the upper-layer chip and the lower-layer chip are integrally bonded by connecting a cylinder and a positioning hole in a fitted manner.

7. The multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to any one of claims 1 to 6, wherein a reaction dry powder reagent required for a polymerase chain reaction (PCR) is

pre-embedded in the reaction chamber, the reagent comprising an enzyme, primer, probe and buffer required for the PCR reaction.

8. A method of using a multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path, based on the multi-flux microfluidic chip for nucleic acid detection and capable of actively controlling a flow path according to claim 5, comprising the following steps:

1) assembling an upper-layer chip and a lower-layer chip into a whole in a bonding manner;

2) using a channel block of a heat sealing device to perform heat sealing processing on an upper thin film, such that overflow passages and sample distribution connection passages are formed between the upper thin film and the upper-layer chip, wherein in this case, a microfluidic channel between a sample loading pool and a reaction pool is in an opened state, and a microfluidic channel between the reaction pool and a filter element passage is also in an opened state;

3) pre-embedding a reaction dry powder reagent required for a polymerase chain reaction (PCR) in the reaction pool of the lower-layer chip, pre-disposing a breathable and liquid-impermeable filter element in the filter element passage, and pre-disposing a color test paper in a test paper passage;

4) covering a reaction zone of a lower surface of the lower-layer chip with a lower thin film, and performing heat sealing processing;

5) adding a sample into the sample loading pool;

6) mounting an external air path at a sample inlet of the sample loading pool; connecting to an air source, and under an air pressure provided by the air source, the sample in the sample loading pool passing through a sample output main channel and a sample distribution chamber successively, and flowing to a corresponding reaction pool through sample distribution chamber sample output channels, the sample distribution connection passages, and reaction chamber sample input channels; after the sample flowing out of the reaction pool enters the filter element passage through the overflow passages, an instrument stopping running of the external air path by detecting a pressure value;

7) using a heat sealing block of the heat sealing device to perform heat sealing processing on the upper thin film, such that an overflow occlusion portion is formed between a thin film part of each overflow passage and the upper-layer chip, and a sample distribution occlusion portion is formed between a thin film part of each sample distribution connection passage and the upper-layer chip, wherein in this case, the front end and the rear end of the reaction pool are both in a flow intercepted state and the reaction pools are closed;

8) putting a chip plug;

9) the sample and the reaction dry powder reagent in the reaction pool undergoing a PCR reaction; and

10) reading fluorescent data after completion of the reaction.