(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 974 814 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.10.2008 Bulletin 2008/40

(51) Int Cl.:
B01L 3/00 *(2006.01)* ***F04B 19/00*** *(2006.01)*

(21) Application number: **07104818.5**

(22) Date of filing: **23.03.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(71) Applicant: **Koninklijke Philips Electronics N.V.**
5621 BA Eindhoven (NL)

(72) Inventor: **The designation of the inventor has not yet been filed**

(74) Representative: **Van Velzen, Maaike Mathilde**
Philips
Intellectual Property & Standards
P.O. Box 220
5600 AE Eindhoven (NL)

(54) A micro-fluidic device based upon active matrix principles

(57) A micro-fluidic device (1) including a two-dimensional array of a plurality of components (2) for processing a fluid and/or for sensing properties of the fluid is suggested. The components comprise at least one heater element (13) for thermophoretic movement of fluid. The active matrix includes a two-dimensional array of electronic components (12) realized in thin film technology. The active matrix provides a high versatility of the device. The thin film technology ensures a very cost efficient manufacturing also of large devices.

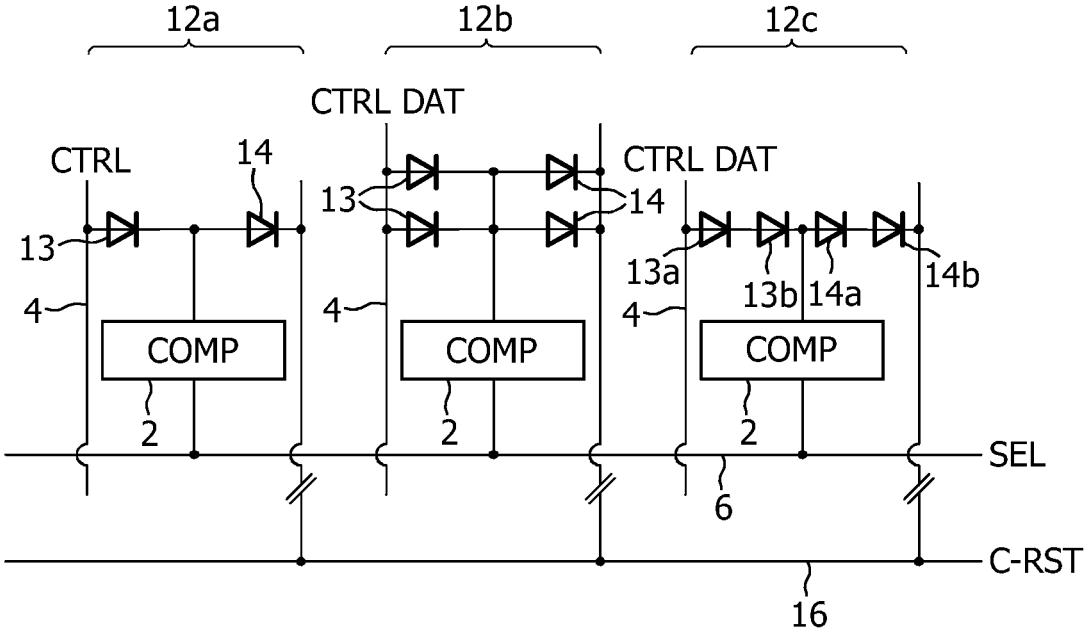

FIG. 3

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Description

FIELD OF THE INVENTION

[0001] The present invention is related to a micro-fluidic device including a two-dimensional array of a plurality of components for processing a fluid and/or for sensing properties of the fluid.

BACKGROUND OF THE INVENTION

[0002] Micro-fluidic devices are at the heart of most biochip technologies, being used for both the preparation of fluidic samples and their subsequent analysis. The samples may e.g. be blood based. As will be appreciated by those in the art, the sample solution may comprise any number of things, including, but not limited to, bodily fluids like blood, urine, serum, lymph, saliva, anal and vaginal secretions, perspiration and semen of virtually any organism: Mammalian samples are preferred and human samples are particularly preferred; environmental samples (e.g. air, agricultural, water and soil samples); biological warfare agent samples; research samples (i.e. in the case of nucleic acids, the sample may be the products of an amplification reaction, including both target an signal amplification); purified samples, such as purified genomic DNA, RNA, proteins etc.; unpurified samples and samples containing (parts of) cells, bacteria, virusses, parasites or funghi.

[0003] As it is well known in the art, virtually any experimental manipulation may have been done on the sample. In general, the terms "biochip" or "Lab-on-a-Chip" or alike, refer to systems, comprising at least one micro-fluidic component or biosensor, that regulate, transport, mix and store minute quantities of fluids rapidly and reliably to carry out desired physical, chemical and biochemical reactions in larger numbers. These devices offer the possibility of human health assessment, genetic screening and pathogen detection. In addition, these devices have many other applications for manipulation and/or analysis of non-biological samples. Biochip devices are already being used to carry out a sequence of tasks, e.g. cell lyses, material extraction, washing, sample amplification, analysis etc. They are progressively used to carry out several preparation and analysis tasks in parallel, e.g. detection of several bacterial diseases. As such, micro-fluidic devices and biochips already contain a multiplicity of components, the number of which will only increase as the devices become more effective and more versatile.

[0004] Many of the components are electrical components used to sense or modify a property of the sample or fluid, such as heating elements, pumping elements, valves etc., and are frequently realized by direct fabrication of thin film electronics on the substrate of the device. Suitable properties that can be sensed or modified include, but are not limited to, temperature; flow rate or velocity; pressure, fluid, sample or analyte presence or absence, concentration, amount, mobility, or distribution; an optical characteristic; a magnetic characteristic; an electrical characteristic; electric field strength, disposition, or polarity.

[0005] Co-pending application IB2006/053434 discloses a micro-fluidic device, e.g. a biochip, fabricated on a substrate based upon active matrix principles. The device is preferably fabricated from one of the well known large area electronics technologies, such as a-Si, LTPS or organic transistor technologies. The active matrix makes it possible to independently control a larger number of components on the device with a smaller number of control terminals. This device enables accurate and localized control of temperature in an active matrix set up, without the need for a large device periphery to locate the I/O pins.

[0006] One of the important control points in using microfluidic devices for biochemical assays in eg biosensors relates to the movement of biological samples in fluids or in microdroplets through microchannels in a device. It is an object of the invention to provide a method for movement of biological samples in a microfluidic device, which obviates the needs for external mechanical pumps. It is a further object to provide a device suitable for use in this method.

[0007] We have surprisingly found that this object is achieved by a micro-fluidic device, e.g. a biochip, fabricated on a substrate based upon active matrix principles and including at least one heating element. The device is preferably fabricated from one of the well known large area electronics technologies, such as a-Si, LTPS or organic transistor technologies. The active matrix makes it possible to independently control a larger number of components on the device with a smaller number of control terminals. The device may be fabricated with a rigid or a flexible substrate.It is a further object of the invention to provide an array of temperature control points in the device that can be processed in parallel and independently, in a cost-effective way on a biochip or alike system, without the need for a large device periphery to locate the I/O pins.

SUMMARY OF THE INVENTION

[0008] The invention relates to a micro-fluidic device comprising a two-dimensional array of a plurality of components (2) for processing a fluid and/or for sensing properties of the fluid, wherein the components comprise one or more heater elements for thermally induced manipulation of the fluid , and wherein each component (2) is coupled to at least one control terminal (9, 10) enabling an active matrix to change the state of each component individually, and wherein the active matrix includes a two-dimensional array of electronic components realized in thin film technology wherein the device does not contain mechanical actuation means.

[0009] The device according to the invention is constructed such that transport of fluidic microdroplets and

particles in a fluidic environment is not based on mechanical pumping or other physical actuation means but relies on thermocapillary fluid transport.

[0010] The device comprises at least one, preferably two, even more preferred a multiplicity of heater elements. Such a device is referred to as a thermal processing array. These heater elements are suitable for heating fluid that may be present in compartments of the microfluidic device. Thermocapillary transport relies on the local heating of one or more fluid microdroplets. Droplet movement results from the creation of a thermal gradient to change the interfacial tension at the front and the back surface of the droplet thus generating pressure differences across the droplet.

[0011] The thermal processing array can be used to create a defined time-dependent temperature profile if the reaction compartment is also configured in the form of an array. This profile or temperature regime that is generated can control the movement of the fluid or particles and microdroplets in a fluidic environment.

[0012] In a most preferred embodiment, the thermal processing array comprises a multiplicity of individually addressable and drivable heating elements, and may preferably comprise additional elements such as temperature sensors.

[0013] The inclusion of at least one temperature sensor is highly preferred. Even more preferred, the device comprises a multiplicity of temperature sensors to control a pre-defined temperature profile across an array of components. This embodiment is illustrated in figure 4.

[0014] Preferably, the components for heating, and the other optional components, are all present on a biochemical processing module, which is preferably located in a biochip, lab-on-a-chip, microfluidic device, or alike system. The micro-fluidic device is preferably a disposable unit, which may be a replaceable part of a larger disposable or non-disposable unit (e.g. lab-on-a-chip, genechips, microfluidic device, or alike system). In addition to the components, the device may optionally comprise compartments or cavities that can hold a fluid. Such compartments are also referred to as array elements.

[0015] In one advantageous embodiment of the invention the electronic components of the active matrix are formed by thin film transistors having gate, source and drain electrodes. In this case the active matrix includes a set of select lines and a set of control lines such that each individual component is controlled by one select line and one control line and the gate electrode of each thin film transistor is connected to a select line.

[0016] In another advantageous embodiment of the invention a memory device is provided for storing a control signal supplied to the control terminal.

[0017] In an alternative embodiment of the invention the electronic components are formed by thin film diodes, e.g. metal-insulator-metal (MIM) diodes. It is preferred that a MIM diode connects a first electrode of each component to a control line, and a second electrode of each component is connected to a select line.

[0018] In another advantageous embodiment of the invention the thin film diodes are PIN or Schottky diodes, wherein a first diode connects a first electrode of each component to a control line, wherein a second diode connects the first electrode of each component to a common rest line and wherein a second electrode of each component is connected to a select line.

[0019] In an advantageous development of the invention the first diode is replaced by a pair of diodes connected in parallel and the second diode as well is replaced by a pair of diodes connected in parallel.

[0020] In yet another advantageous development the first diode is replaced by a pair of diodes connected in series, and also the second diode is replaced by a pair of diodes connected in series.

[0021] In a further aspect the invention relates to a method for moving particles in a fluidic environment in a microfluidic device according to the invention, said device comprising a plurality of heater elements which are subjected to a temperature profile regime such that the movement of the particles is controlled on the basis of thermophoresis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention will be better understood and other particular features and advantages will become apparent on reading the following description appended with drawings. In the drawings:

Fig. 1 a schematic block diagram of a micro-fluidic device according to the invention illustrating the active matrix concept; At least one of the components (2) is a heater element.

Fig. 2 a first embodiment of the micro-fluidic device, the active matrix of which is based on thin film transistors; At least one of the components (2) is a heater element.

Fig. 3 shows a device wherein it is possible to sequentially activate heaters in different lines.

Fig. 4 shows a microfluidic device comprising a multiplicity of temperature sensors.

DETAILED DESCRIPTION

[0023] In the context of the invention, thermophoresis is the motion of particles, species or microdroplets in a fluid under the influence of a thermal gradient. This phenomenon is for example described in S. Weigand, J. Phys Condens. Matter 16 357-379 (2004). Particles may be any particles. The invention is especially suitable for the concentration of biological material that is suspended in a fluid such as blood. Preferred particles are nucleic acids and proteins. The device and method according to the invention are especially beneficial for the movement and concentration of DNA in a biological sample.

[0024] In the context of the invention, thermocapillary transport is the movement and mixing of micro-droplets

through micro-channels in micro-scale devices, comprising e.g. microdroplet transport channels, reaction regions, electrophoresis modules and radiation detectors. The discrete droplets are differentially heated and propelled through the channels. The droplet movement is performed using thermal gradients to change the interfacial tension at the front and the back surface of the droplet and thus generate pressure differences across the droplet.

[0025] The patents by Bums et al. (University of Michigan: US 6057149, US 6048734, US 6130098, US 6271021, US 2001/0046703, US 2002/0168671) describe the use of thermal control for thermocapillary fluid transport.

[0026] In the context of the invention, electro-thermal pumping is based upon the electrohydrodynamic pump, driven by a high frequency traveling electric wave. The pumping rate is dependent on the profile (i.e. the inhomogeneity) of the dielectric properties of the medium being pumped. Defined thermal gradients are used to control the dielectric profiles and hence control the pumping action.

[0027] The microfluidic device according to the present invention is suitable for use in the movement of fluids. These fluids may be single fluids or mixtures of fluids. Optionally the fluids comprise particles. For some of the embodiments that are explained in this specification, the presence of particles is preferred.

[0028] The microfluidic device comprises at least one heater for thermally induced manipulation. This manipulation comprises transport, interruption of transport, mixing, concentration or dilution or convection of fluid or a suspension of particles in a fluid.

[0029] In the device, the fluid may be incorporated in the form of isolated microdroplets or fluid plugs.

[0030] Fig. 1 illustrates the general concept of a microfluidic device based on an active matrix. The micro-fluidic device as a whole is designated with the reference number 1. The device comprises a two-dimensional array of components 2. Each component 2 is associated with a switching means 3 arranged to selectively activate the component 2. Each switching means is connected to a control line 4 and a select line 6. The control lines 4 are connected to a common control driver 7. The select lines 6 are connected to a common select driver 8. The control lines 4 in conjunction with the select lines 6 form a two-dimensional array of control terminals 9, 10.

[0031] In this way an active matrix is realized to ensure that all components can be driven independently. The component 2 may be any electronic device e.g. a heater element, a pumping element, a valve, a sensing component etc. being driven by either a voltage or a current signal. It is to be understood that the examples for the components 2 are not to be construed in a limiting sense. Activating a component 2 means changing its state e.g. by turning it from on to off, or vice versa or by changing its setting. It is also noted that the individual switching means 3 may comprise a plurality of sub components comprising both active and/or passive electronic components. However, there is no requirement that all sub components are activated together. In the device according to the invention, at least 2 of the components are heater elements. This enables the creation of temperature profile over microfluidic channels that are present in the device.

[0032] The operation of the micro-fluidic device 1 illustrated in Fig. 1 to independently control a single component 2 is as follows:

- In the non-addressing state, all select lines 6 are set to a voltage where the switching elements 3 are non-conducting. In this case, no component 2 is activated.
- In order to activate a preselected component 2 the select driver 8 applies a select signal to the select line 6 to which the preselected component 2 is coupled. As a consequence all switching means 3 connected to the same select line 6 are switched into a conducting state.
- A control signal generated by the control driver 7, e.g. a voltage or a current is applied to the control line where the preselected component 2 is situated. The control signal is set to its desired level and is passed through the switching means 3 to the component 2, causing the component to be activated.
- The control signals in all other control lines 4 are held at a level, which will not change the state of the remaining components connected to the same select line 6 as the preselected component 2. In this example, they will remain un-activated.
- All other select lines 6 will be held in the non-select state, so that the other components 2 connected to the same control line 4 as the preselected component will not be activated because their associated switching means 3 remain in a non-conducting state.
- After the preselected component is set into the desired state, the respective select line 6 is unselected, returning all switching means 3 into a non-conducting state, preventing any further change in the state of the preselected component.

[0033] The device will then remain in the non-addressed state until the following control signal requires to change the state of any one of the components 2, at which point the above sequence of operation is repeated.

[0034] The two-dimensional array formed by the control lines 4 and the select lines 6 can also be described in terms of rows and columns, where the select lines 6 define the rows and the control lines 4 the columns.

[0035] It is also possible to control more than one component 2 in a given row simultaneously by applying a control signal to more than one column in the array during the select period. It is possible to sequentially control components in different rows by activating another row by using the select driver and applying a control signal to one or more columns in the array.

[0036] It is also possible to address the micro-fluidic device 1 such that a component 2 is only activated while the control signal is present. However, in a preferred embodiment, it is advantageous to incorporate a memory device into the component whereby the control signal is remembered after the select period is completed. For the memory device a capacitor or a transistor based memory element is suitable. This makes it possible to have a multiplicity of components at any point across the array activated simultaneously. This option is not available in the passive system known in the prior art. Of course, if a memory device is available, a second control signal will explicitly be required to de-activate the component.

[0037] Preferably the device comprises compartments and channels, most preferred microfluidic channels, that connect one compartment to at least one, or more preferred a plurality of, other compartments. The movement of particles and microdroplets in the channels of the device relies at least partly on thermophoresis. In such an embodiment, fluids may be moved sequentially from one compartment to another or alternatively many compartments may be processed in parallel.

[0038] The invention further provides a method for moving particles in a fluidic environment in a microfluidic device according to the invention, said device comprising a plurality of heater elements which are subjected to a temperature profile regime such that the movement of the particles is controlled on the basis of thermophoresis.

[0039] In this method the temperature profile regime is preferably such that particles are concentrated in a specific compartment of the device. This enables the concentration of compounds such as DNA in a fluid. The concentration of DNA may reduce the need to do PCR to increase the amount of DNA to an amount higher than the detection limit. Another advantage of concentrating DNA is that it enables contact with probes that may be present at specific spots in the device.

[0040] Whilst one aspect of the invention relies on thermophoresis as a means for transporting compounds in fluids or microdroplets of fluid, other aspects of the invention rely upon other non-mechanical fluid movement mechanisms such as electrothermal pumping. Electrothermal movement is driven by a high frequency traveling electric wave. The resulting flow rate of fluid is dependent on the profile (i.e. the inhomogeniety) of the dielectric properties of the medium that is present in the device which may additionally be modified by the temperature profile as generated by the thermal processing array. Optionally at least one of the components of the device is capable of creating a high frequency traveling electric wave. In a further aspect the invention relates to a method wherein movement of particles or fluid microdroplets based on thermophoresis is combined with electrohydrodynamic pumping. As described above, still a further aspect of the invention relies upon thermocapillary transport, which is the movement and mixing of micro-droplets through micro-channels in micro-scale devices. The discrete droplets are differentially heated and propelled through the channels. The droplet movement is performed using thermal gradients to change the interfacial tension at the front and the back surface of the droplet and thus generate pressure differences across the droplet. Optionally several methods of non-mechanical fluid or sample manipulation, such as electrophoretic, electrothermal pumping and electrocapillary transport may be combined.

[0041] In particular, the invention enables accurate, reproducible, reliable and fast thermal cycling during DNA amplification on a biochip, for instance using (multiplexed) PCR or (multiplexed) real-time quantitative PCR (RQ-PCR), such that the temperature of the array elements may be individually and in parallel controlled, without significant additional costs or issues concerning the number of input and output pins. Moreover, with respect to the situation in which the heating elements are located in the bench-top machine, this invention offers a more optimal and more reliable thermal contact between temperature components and fluid. Optionally the DNA amplification in a temperature controlled environment is combined with thermophoresis for concentrating DNA at a specific location in the device.

[0042] In another aspect the invention relates to use of the device according to the invention in a process wherein the temperature is changed according to a predefined regime.

[0043] Last but not least, this invention allows an advantageous way of performing RQ-PCR on a biochip by combining a cost-effective high performance thermal processing array (e.g. high resolution, individual and parallel temperature control of compartments, high reproducibility, high reliability and high accuracy) on the disposable, with the high performance (e.g. high resolution, high signal-to-noise ratio) of an optical detection setup (e.g. light source, CCD camera, filters) generally used in a bench-top machine for detection of fluorescent signals in molecular diagnostics.

[0044] Hence in a further aspect the invention relates to a method of performing the PCR process, preferably RQ-PCR process wherein use is made of the micro-fluidic device as described above.

[0045] In another aspect the invention relates to the microfluidic device as described above, in combination with an optical detection set up.

[0046] In a further aspect the invention relates to a method of detecting a product using a diagnostic device comprising a micro-fluidic device according to the invention, wherein the detection is based on optical methods.

[0047] After having illustrated the general concept and the advantages of a micro-fluidic device 1 in the following description specific embodiments will be explained.

[0048] The first embodiment describes an active matrix micro-fluid device based on thin film transistors

[0049] Fig. 2 exhibits an active matrix micro-fluidic device 1 using thin film transistors (TFT) 12 as switching means 3 to ensure that all components, for example the heating elements, can independently be activated. Each

component 2 is connected to the matrix of control terminals via a TFT switch 12. At least one of the components is a heater element. TFTs are well known switching elements in thin film large area electronics, and have found extensive use e.g. in flat panel display applications. Industrially, the major manufacturing methods for TFTs are based upon either amorphous-silicon (a-Si) or low temperature polycrystalline silicon (LTPS) technologies. But other technologies such as organic semiconductors or other non-Si based semiconductor technologies, such as CdSe, can be used. The operation of the device illustrated in Fig. 2 to independently control a single component 2 is as follows:

- In the non-addressing state, all select lines 6 are set to a voltage where the TFTs are non-conducting. In the case of a-Si, we have typically an n-type TFT and hence a negative voltage has to be applied to the gate of the TFTs. In this case, no component 2 is activated.
- In order to activate a preselected component 2 the select driver 8 applies a positive select signal to the select line 6 to which the preselected component 2 is connected. Thus, all TFTs 12 connected to this select line are switched into their conducting state.
- A control signal generated by the control driver 7, a voltage or current signal is applied to the column where the preselected component is located. The TFT 12 passes the control signal to the preselected component, which is coupled to the drain of the TFT, for activating the component.
- The control signals in all other columns are held at a level that will not change the state of remaining components of the row. In this example, they will remain un-activated.
- The select signals of all other rows will be held in the non-select state by applying a negative voltage signal to the gate of the TFTs, so that the other components are connected to the same column via non-conducting TFTs and will not be activated.
- After the component is set into the desired state, the TFTs 12 in the row are again set to the non-conducting state, preventing any further change in the state of the component.

[0050] The device will then remain in the non-addressed state until the following control signal requires to change the state of any one of the components, at which point the above sequence of operation is repeated.

[0051] With a TFT based switch, it is again possible to control more than one component in a given row simultaneously by applying a control signal to more than one column in the array during the select period. It is possible to sequentially control components in different rows by activating another row by using the select driver and by applying a control signal to one or more columns in the array. Furthermore, it is still possible to address the system such that the component is only activated while the control signal is present, or alternatively to incorporate a memory device into the component (e.g. a capacitor element, or a transistor based memory element) whereby the control signal is remembered after the select period is completed.

[0052] In another embodiment, the heater elements are provided as a regular array of identical units, whereby the heaters are connected to the driver via the switches (e.g. transistors) of the active matrix. The gates of the transistors are connected to a select driver (for example a standard shift register gate driver as used for an AM-LCD), whilst the source is connected to the heater driver, for example a set of voltage or current drivers. Operation is as follows:

- To activate a given heater element, the transistors in the line incorporating the required heater are switched into the conducting state (by e.g. applying a positive voltage to the gates from the select driver).
- The signal (voltage or current) in the column where the heater is situated is set to its desired value. This signal is passed through the conducting TFT to the heater element, resulting in a local temperature increase.
- The driving signal in all other columns is held at a voltage or current, which will not cause heating (this will typically be 0V or 0A).
- After the temperature increase has been realized, the transistors in the line are again set to the non-conducting state, preventing further heater activation.

[0053] It is also possible to activate more than one heater in a given line simultaneously by applying a signal to more than one column in the array. It is possible to sequentially activate heaters in different lines by activating another line (using the gate driver) and applying a signal to one or more columns in the array. This embodiment is illustrated in figure 3. In a first embodiment the biochemical processing module comprises a discrete array of heating elements (13) based on active matrix principles, such that a reaction compartment (14) contains a plurality of heaters. In figure 3 the following is shown:

- heating element (13)
- reaction compartment (14)
- transistor switch (16)
- heater electrode (15)
- common electrode (17)

[0054] There are several options for configuring the biochemical processing module depending upon the required heat processing.

[0055] Whilst in this embodiment of figure 3 a driver is considered which is capable of providing (if required) signals to all columns of the array simultaneously, it is also feasible to consider a more simple driver with a function of a de-multiplexer. In this example (figure 5a) only a

single output driver is required to generate the heating signals (e.g. a voltage or a current). The function of the de-multiplex circuit is simply to route the heater signal to one of the columns, whereby only the heater is activated in the selected line in that column. It should be understood that a plurality of drivers with a function of a de-multiplexer may be used to drive the entire heater array.

[0056] In another embodiment according to the invention, an integrated heater driver is included per heating elements based on active matrix technology. This embodiment is advantageous for generating desired temperature profiles by adjusting the control signals brought to the integrated heater driver by the active matrix switching array. In particular, either the magnitude or the duration of the control signals may be adjusted to locally alter the temperature profile. The control signals may be in the form of current signals, but are more usually in the form of voltage signals. In the latter case, a voltage signal generated by the control driver (7) can be used to set the level of current generated by the integrated heater driver, for example by setting the voltage at the gate of a driving transistor in a transconductance circuit, where the gate-source voltage of the transistor defines the current flowing through the transistor. Alternatively, the duration of the current may be controlled by voltage signals provided on the select lines (6), which alternately turn the integrated heater driver on and off with a controlled time duration.

[0057] In yet another embodiment, the device comprises a local driver provided with a memory function. This allows the heating signal to be applied for a longer period of time, enabling better and more accurate control of a given temperature profile.

[0058] The inclusion of at least one temperature sensor is highly preferred. Even more preferred, the device comprises a multiplicity of temperature sensors to control a pre-defined temperature profile across an array of components or compartments. This embodiment is illustrated in figure 4.

[0059] In this embodiment (figure 4), the biochemical processing module comprises a compartment (14) or a plurality (e.g. array) of compartments (14) and a discrete array of heating elements (13) and the at least one temperature sensor (T). Each heating element is individually drivable, whereby a multiplicity of temperature profiles may be created. The temperature profile can advantageously be measured by a plurality of temperature sensors.

[0060] In embodiments, the temperature sensors may be used to prevent a temperature from extending beyond a given range, and may preferably be used to define and control the desired temperature profile.

[0061] To make the device especially suitable for a PCR process, it is advantageous to include a cooling element. In an embodiment, cooling is provided by a (bench-top) machine handling a PCR module, for instance by bringing the PCR module in thermal contact with a cooled mass, peltier element, etc., or by use of convection (e.g. fan). In another embodiment, a cooling element is incorporated in the PCR module, such as a thin-film peltier element, or an array of cooling elements is incorporated.

Claims

1. Micro-fluidic device (1) comprising a two-dimensional array of a plurality of components (2) for processing a fluid and/or for sensing properties of the fluid, wherein the components comprise one or more heater elements for thermally induced manipulation of the fluid , and wherein each component (2) is coupled to at least one control terminal (9, 10) enabling an active matrix to change the state of each component individually, and wherein the active matrix includes a two-dimensional array of electronic components realized in thin film technology wherein the device does not contain mechanical actuation means.

2. Micro-fluidic device (1) according to claim 1, comprising two or more heater elements.

3. Micro-fluidic device (1) according to claim 1, wherein the electronic components of the active matrix are formed by thin film transistors having gate, source and drain electrodes.

4. Micro-fluidic device (1) according to claim 2, wherein the active matrix includes a set of select lines (6) and a set of control lines (4) such that each individual component (2) is controlled by one select line (6) and one control line (4) and in that the gate electrode of each thin film transistor is connected to a select line (6).

5. Micro-fluidic device (1) according to claim 1, wherein a memory device is provided for storing a control signal supplied to the control terminal (9, 10).

6. Micro-fluidic device (1) according to claim 1, comprising a multiplicity of individually addressable and drivable heater elements (13).

7. Micro-fluidic device (1) according to claim 1, further comprising a temperature sensor.

8. Micro-fluidic device (1) according to claim 1 further comprising a cooling element.

9. Micro-fluidic device (1) according to claim 1, wherein at least one of the components is capable of generating a high frequency traveling electric wave.

10. Method for manipulating a fluid in a microfluidic device said device comprising one or more heater elements which are capable of generating a temperature profile regime such that the movement of the

fluid is controlled on the basis of thermocapillary transport.

11. Method for manipulating a fluid in a microfluidic device , said device comprising one or more heater elements which generate a temperature profile regime such that the movement of the fluid is controlled on the basis of electrohydrodynamic pumping, and whereby the temperature profile is used to locally modify the dielectric properties of the fluid.

12. Method according to claim 10 or 11 wherein the device is a micro-fluidic device according to claim 1.

13. Method for manipulating particles in a fluidic environment in a microfluidic device according to claim 1, said device comprising one or more heater elements which are capable of generating a temperature profile regime such that the movement of the particles is controlled on the basis of thermophoresis.

14. Method according to claim 13 wherein the device comprises a plurality of heater elements.

15. Method according to claim 13 wherein the temperature profile regime is such that particles are concentrated in a specific compartment of the device.

16. Method of detecting a product using a diagnostic device comprising a micro-fluidic device according to any of claims 1-9, wherein the detection is based on optical methods.

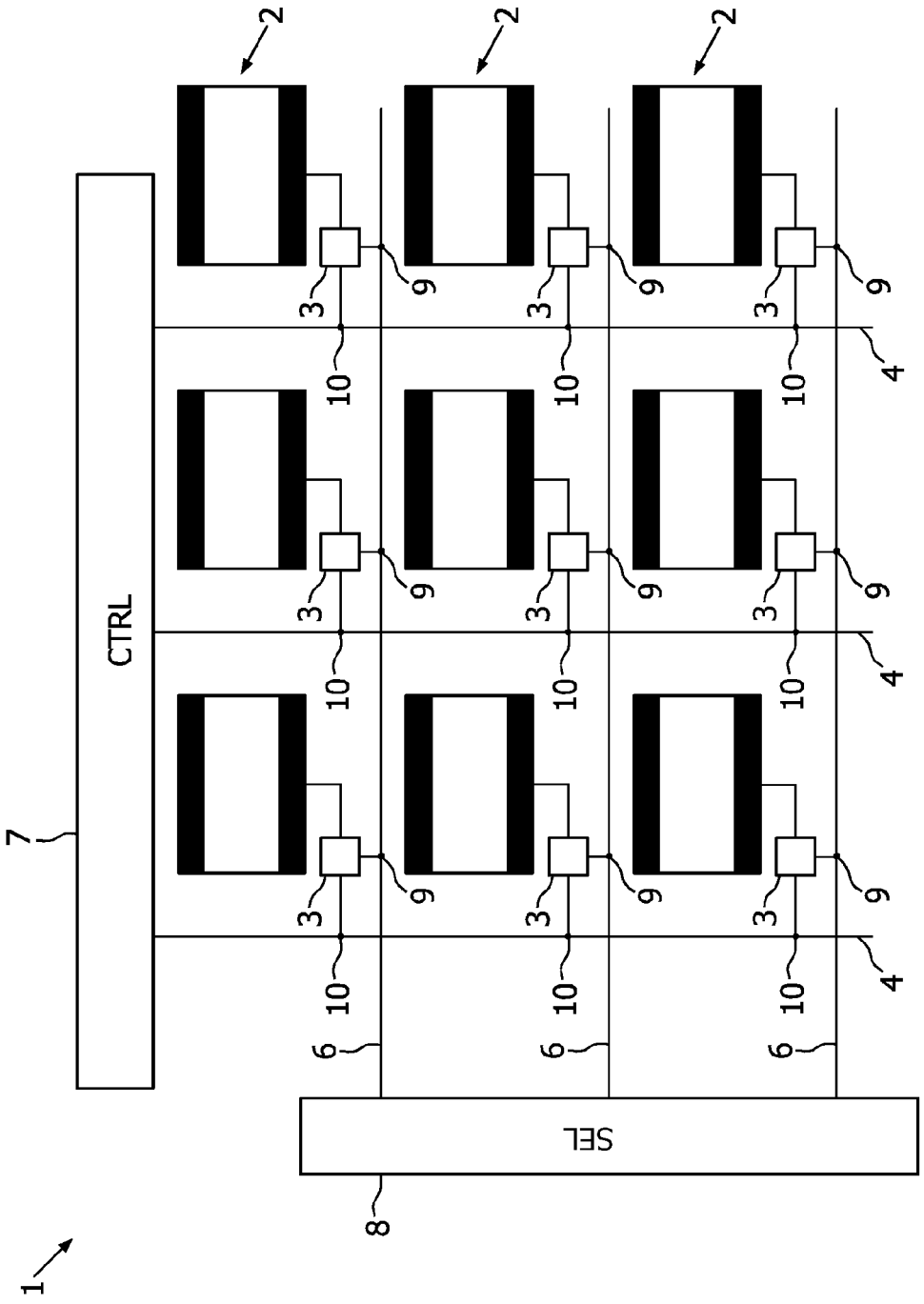


FIG. 1

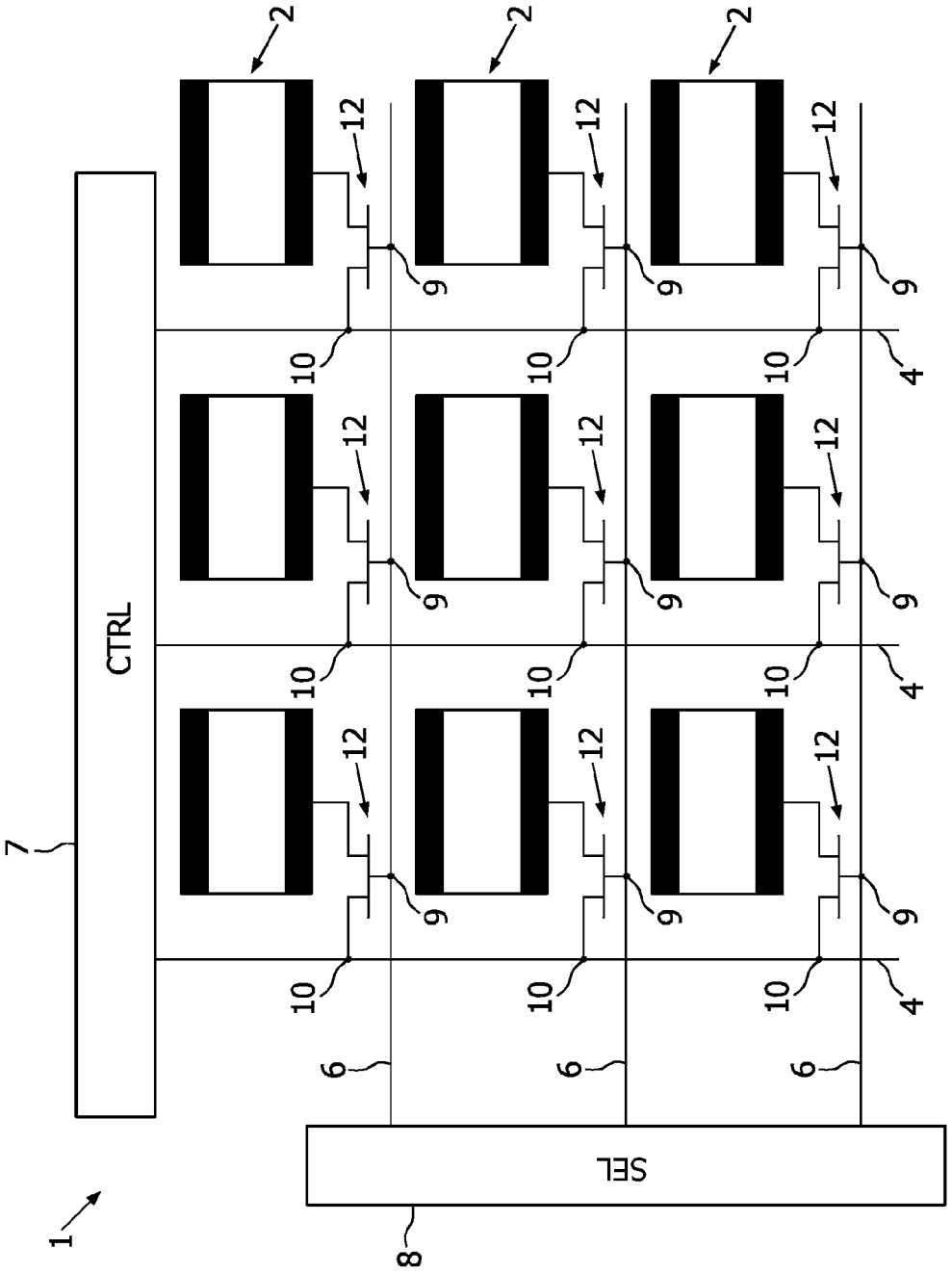
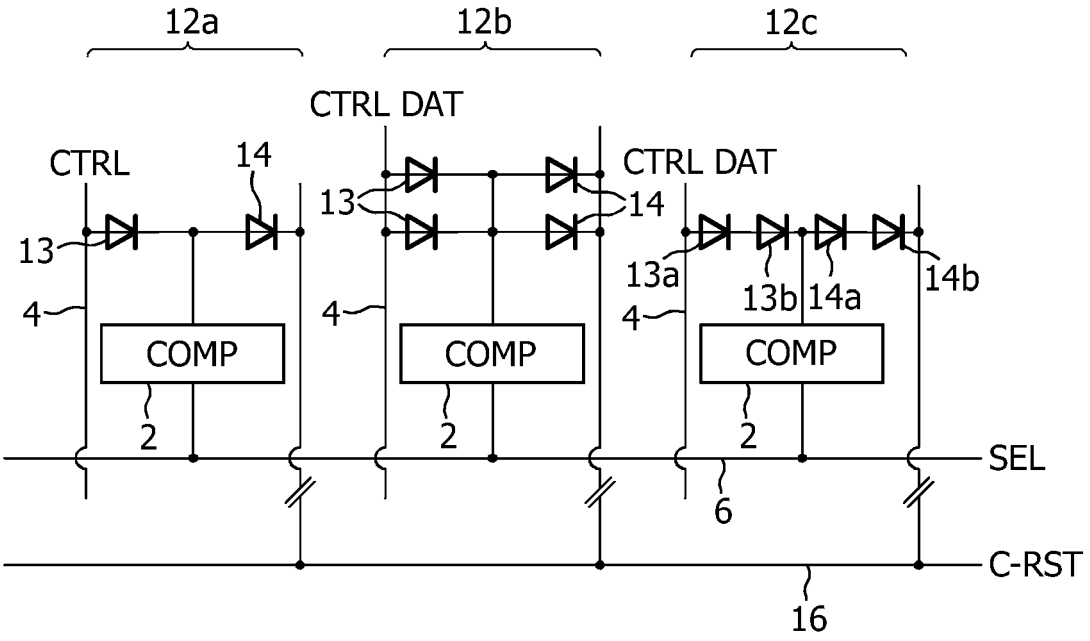


FIG. 2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12b
12c
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CTRL
14
CTRL DAT
13
14
13
13a
13b
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14b
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4
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COMP
COMP
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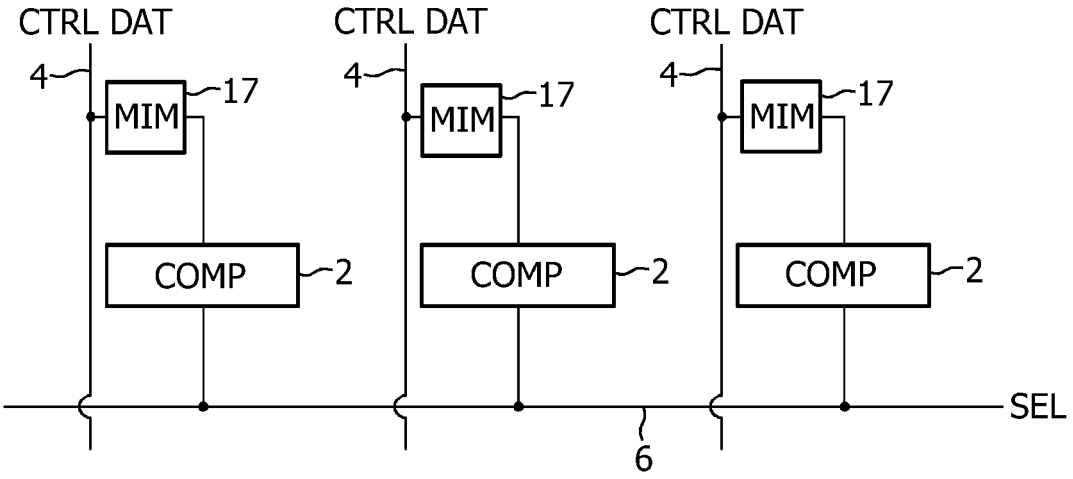
2
2
SEL
6
C-RST
16

FIG. 3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CTRL DAT
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4
4
MIM
MIM
MIM
17
17
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COMP
COMP
COMP
2
2
2
SEL
6

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
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