US 20140274814A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2014/0274814 A1

(43) Pub. Date: Sep. 18, 2014

Ludwig

(54) **REMOVABLE FLUIDICS STRUCTURES FOR MICROARRAY, MICROPLATES, SENSOR ARRAYS, AND OTHER REMOVABLE MEDIA**

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(21) Appl. No.: **13/815,757**

(22) Filed: **Mar. 15, 2013**

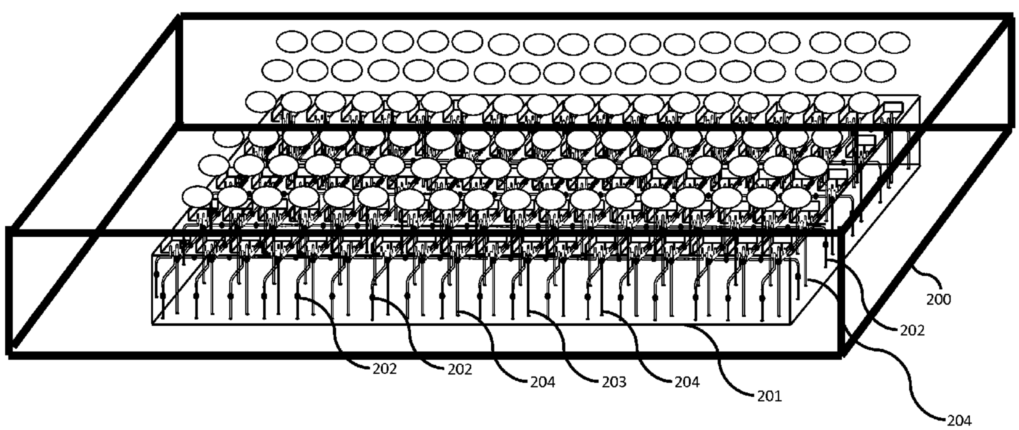
Publication Classification

(51) **Int. Cl.**
G01N 35/10 (2006.01)

(52) **U.S. Cl.**
CPC ***G01N 35/1074*** (2013.01)
USPC **506/43**

(57) **ABSTRACT**

A removable microfluidics structure comprising at least one actuated fluid delivery element, wherein the actuated fluid delivery element is a pump element of a valve element configured to control fluid delivery to or from a removable media detachably coupled with the removable microfluidics structure based on an actuation force. The actuation force is an external actuation force or an internal actuation force. The removable microfluidics structure may include an electromechnical actuator for providing the actuation force, such as a solenoid, a solenoid with an ferromagnetic core or a piezoelectric actuator. The removable microfluidics structure may further include a coupling mechanism for detachably coupling the removable microfluidics structure with the removable media, such as a cell array, such that when the microfluidics structure couples with the removable media, the microfluidics structure controls fluid delivery to or from a cell of the cell array.



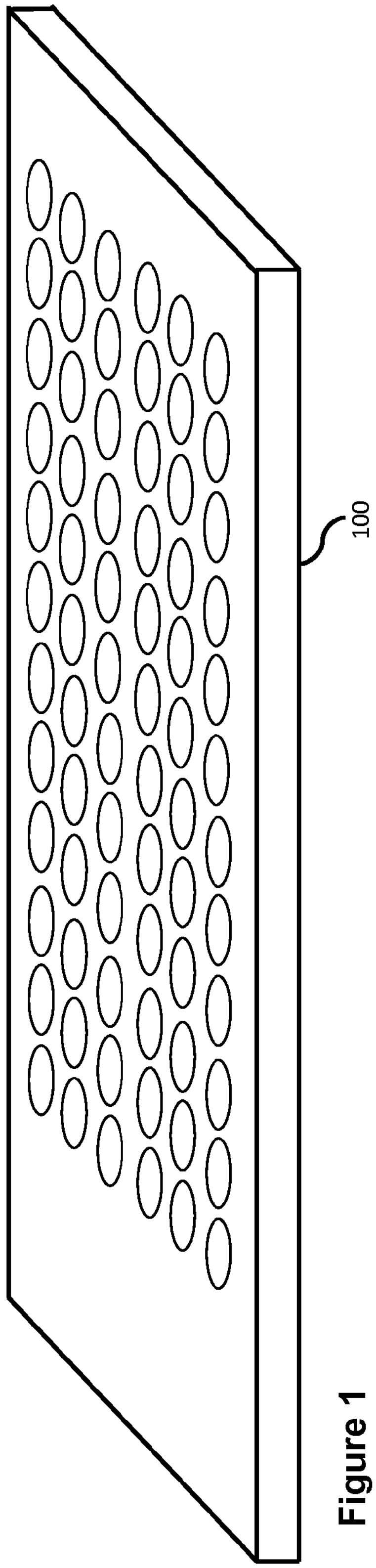


Figure 1

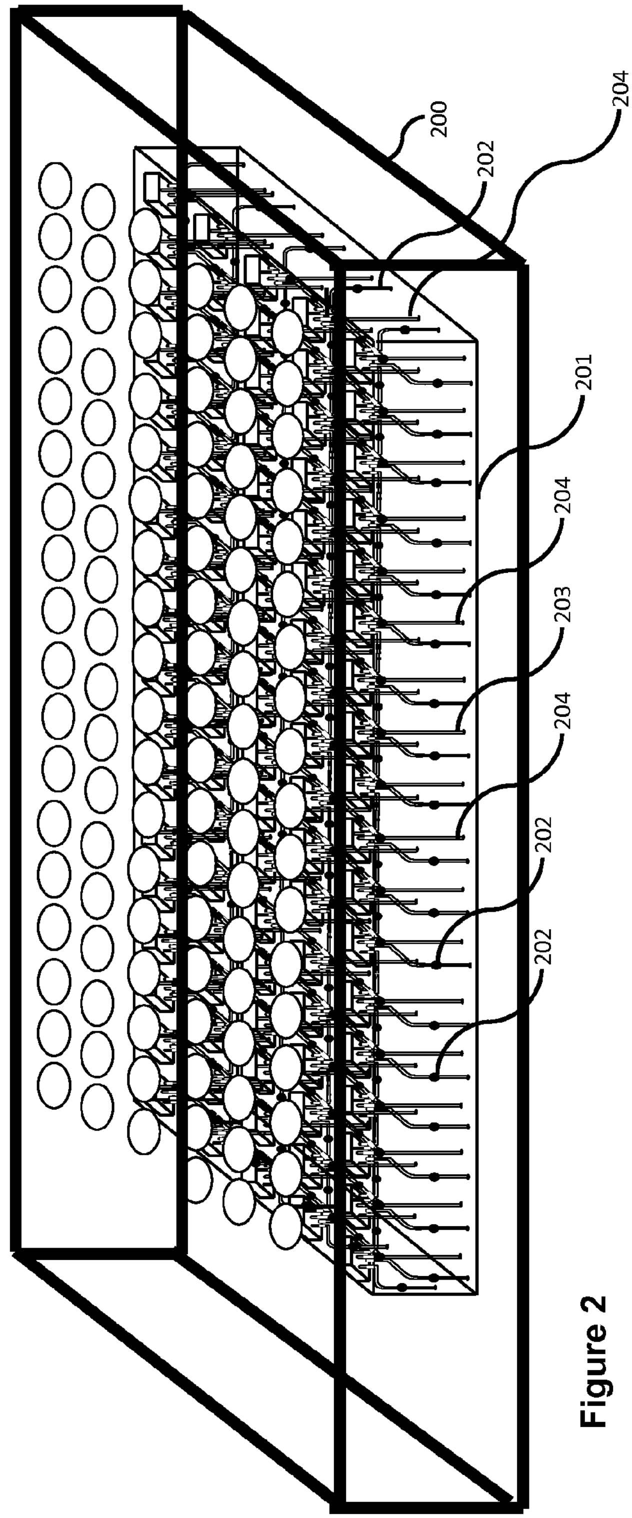
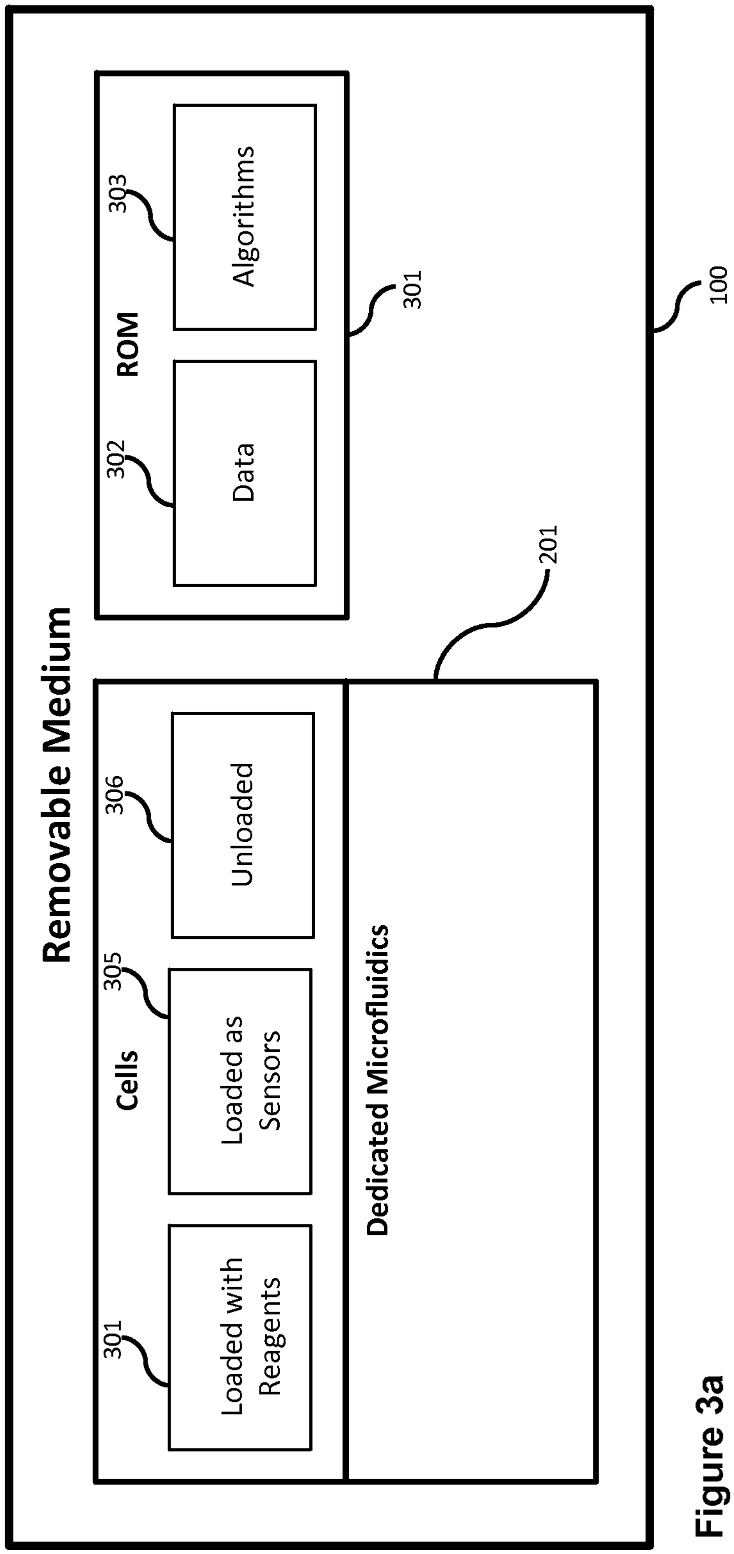


Figure 2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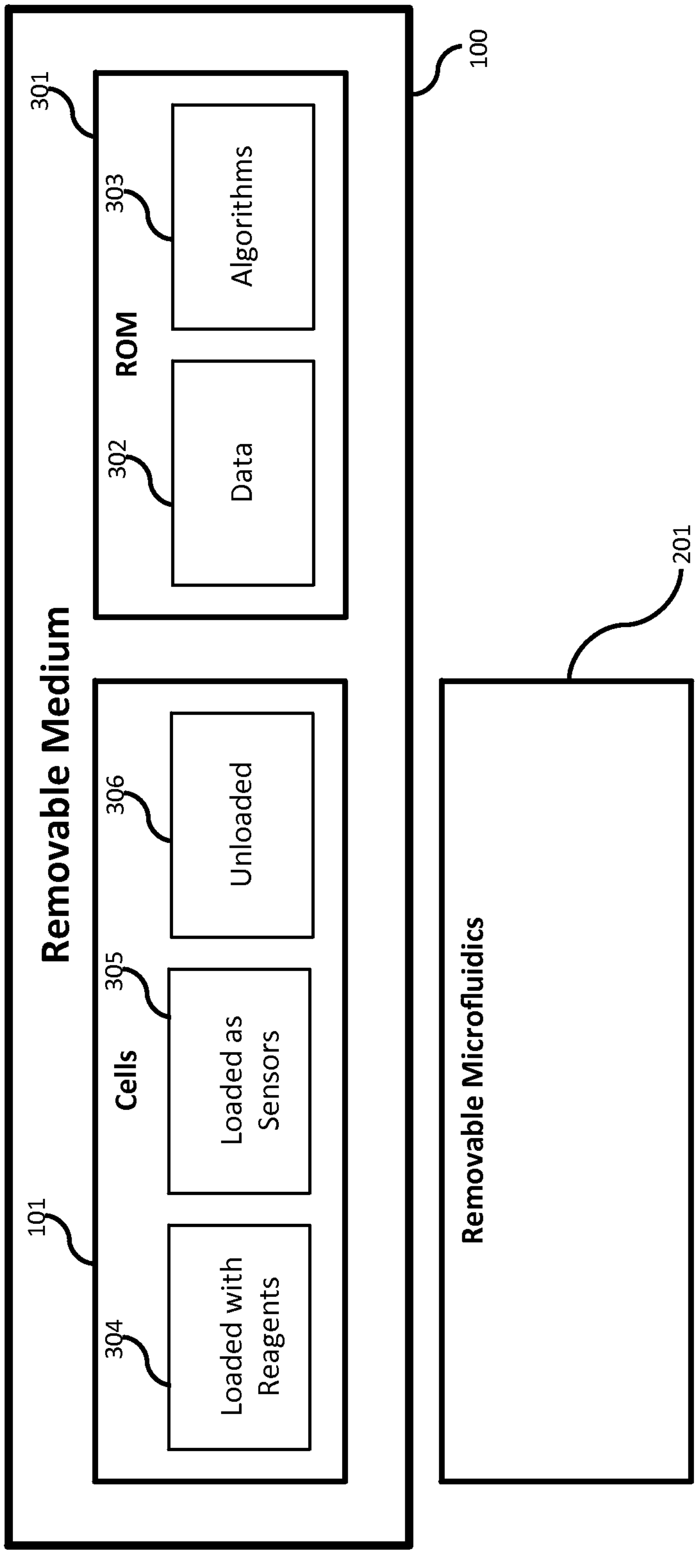
ROM
Data
Algorithms
302
303
301
100
201
Cells
Loaded with Reagents
Loaded as Sensors
Unloaded
301
305
306
Dedicated Microfluidics

Figure 3a


Removable Medium
ROM
Algorithms
Data
Cells
Loaded with Reagents
Loaded as Sensors
Unloaded
Removable Microfluidics
100
101
201
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302
303
304
305
306

Figure 3b

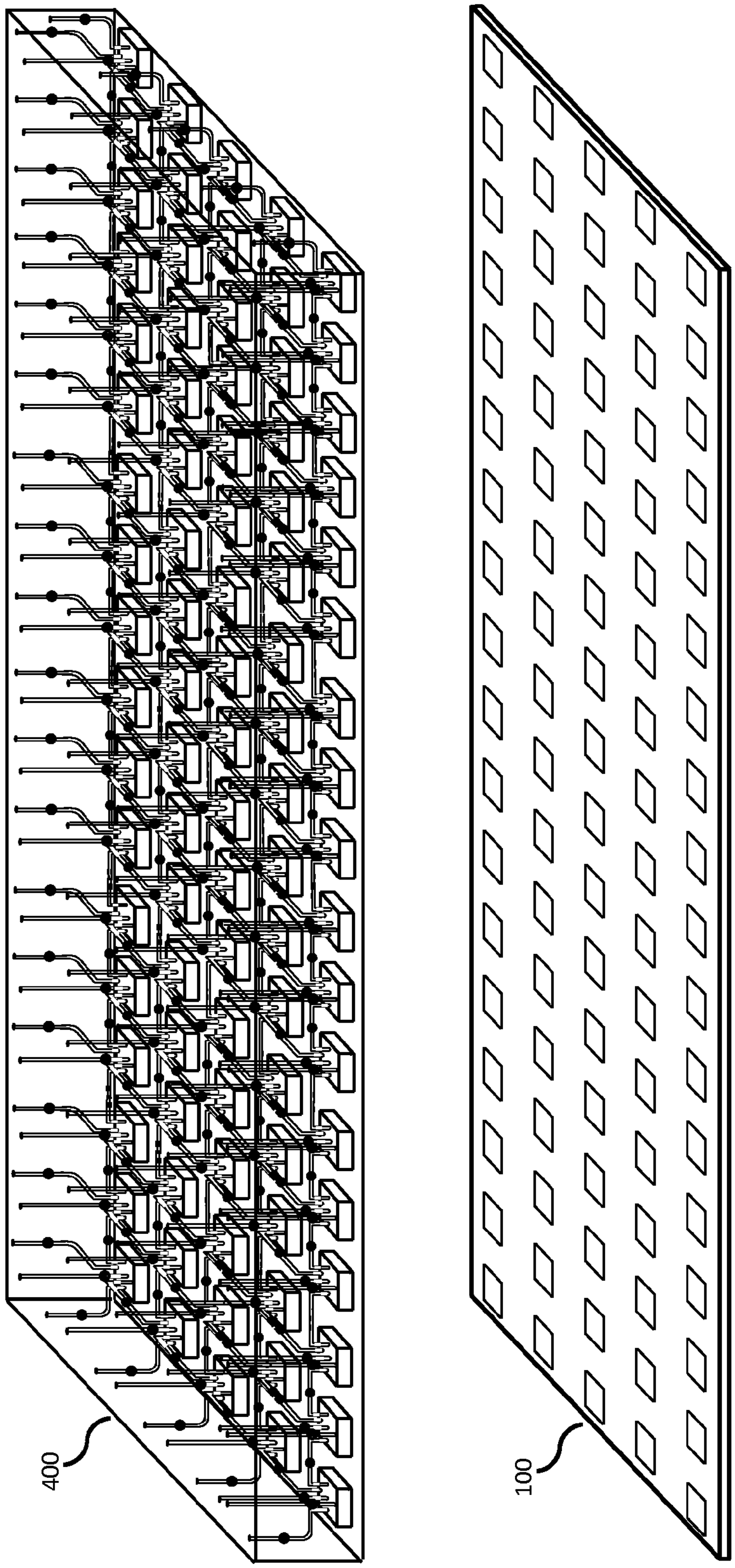


Figure 4

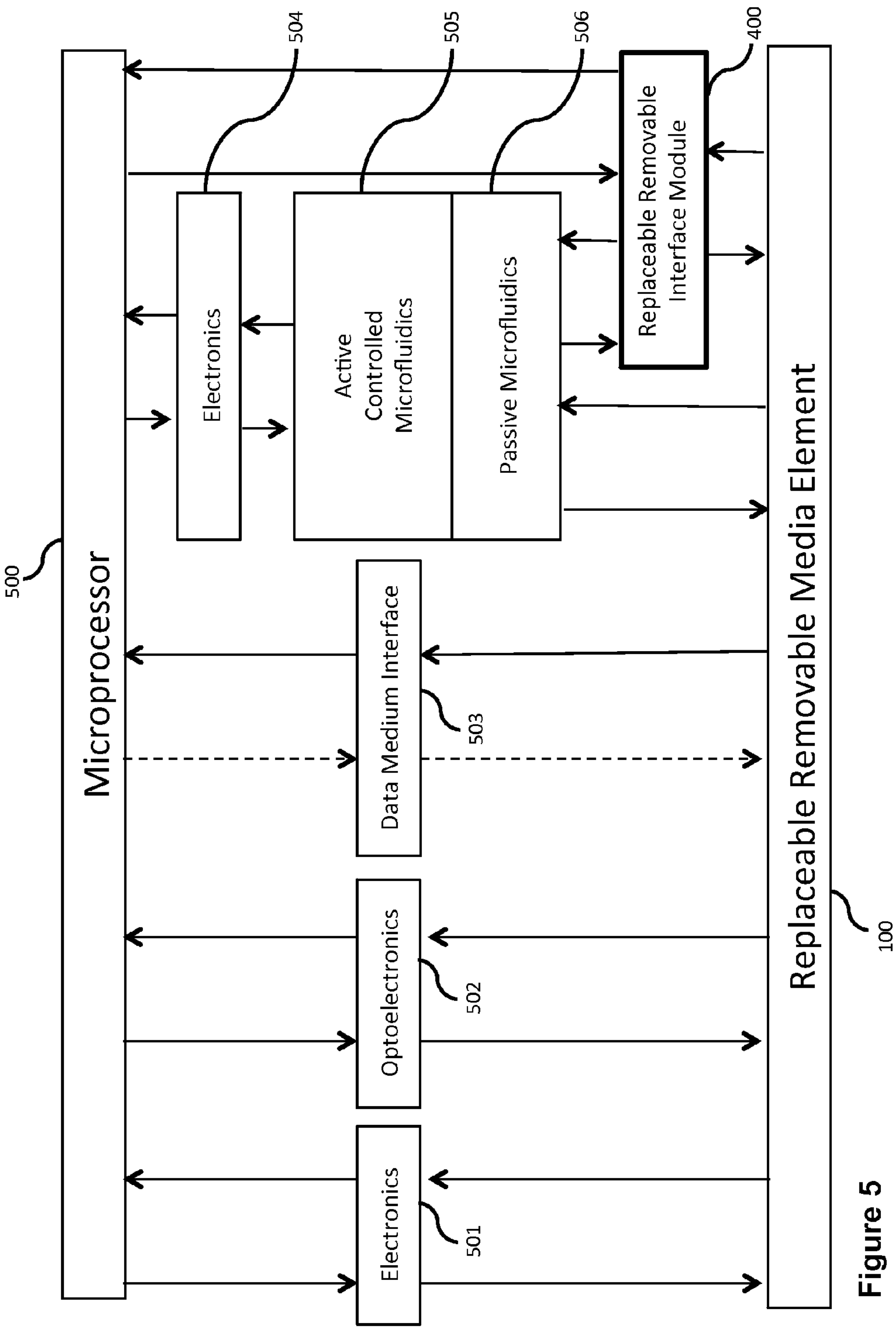

Microprocessor
500
Electronics
504
Active Controlled Microfluidics
505
Passive Microfluidics
506
Replaceable Removable Interface Module
400
Data Medium Interface
503
Optoelectronics
502
Electronics
501
Replaceable Removable Media Element
100

Figure 5

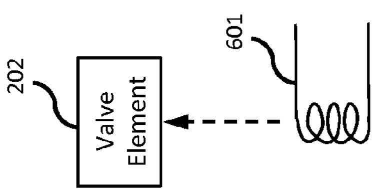


Figure 6a

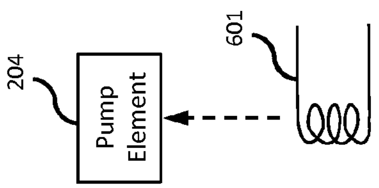


Figure 6b

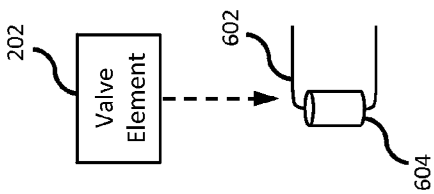


Figure 6c

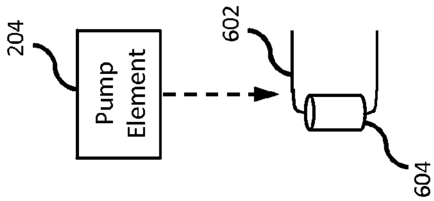


Figure 6d

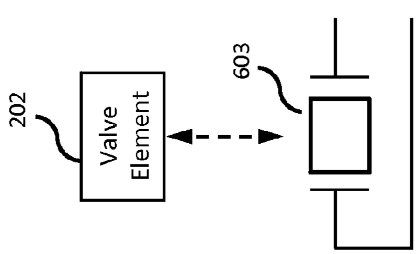


Figure 6e

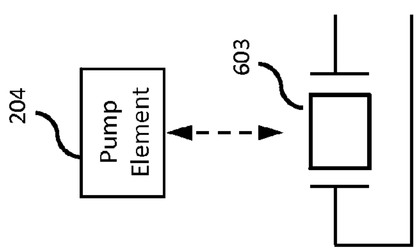


Figure 6f

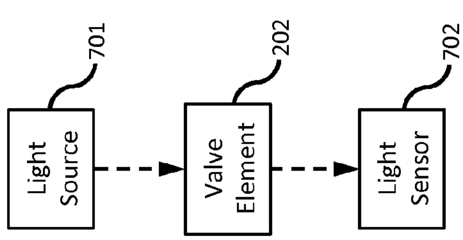


Figure 7a

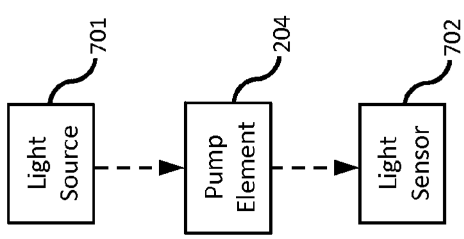


Figure 7b

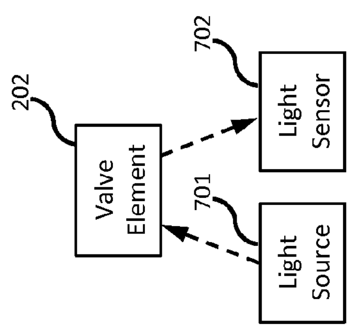


Figure 7c

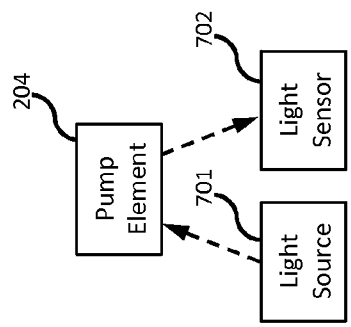


Figure 7d

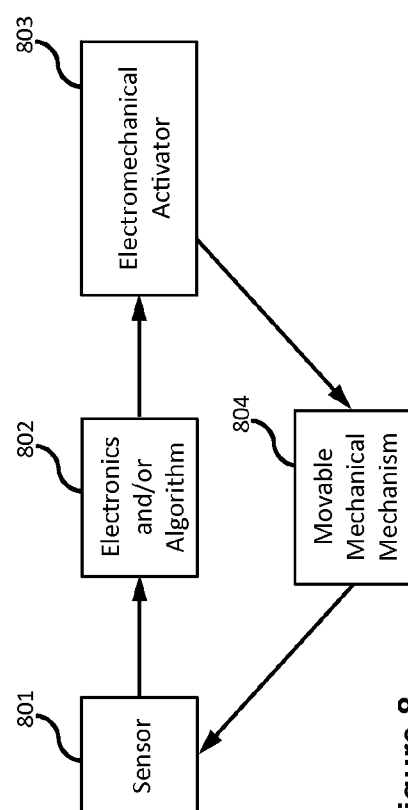
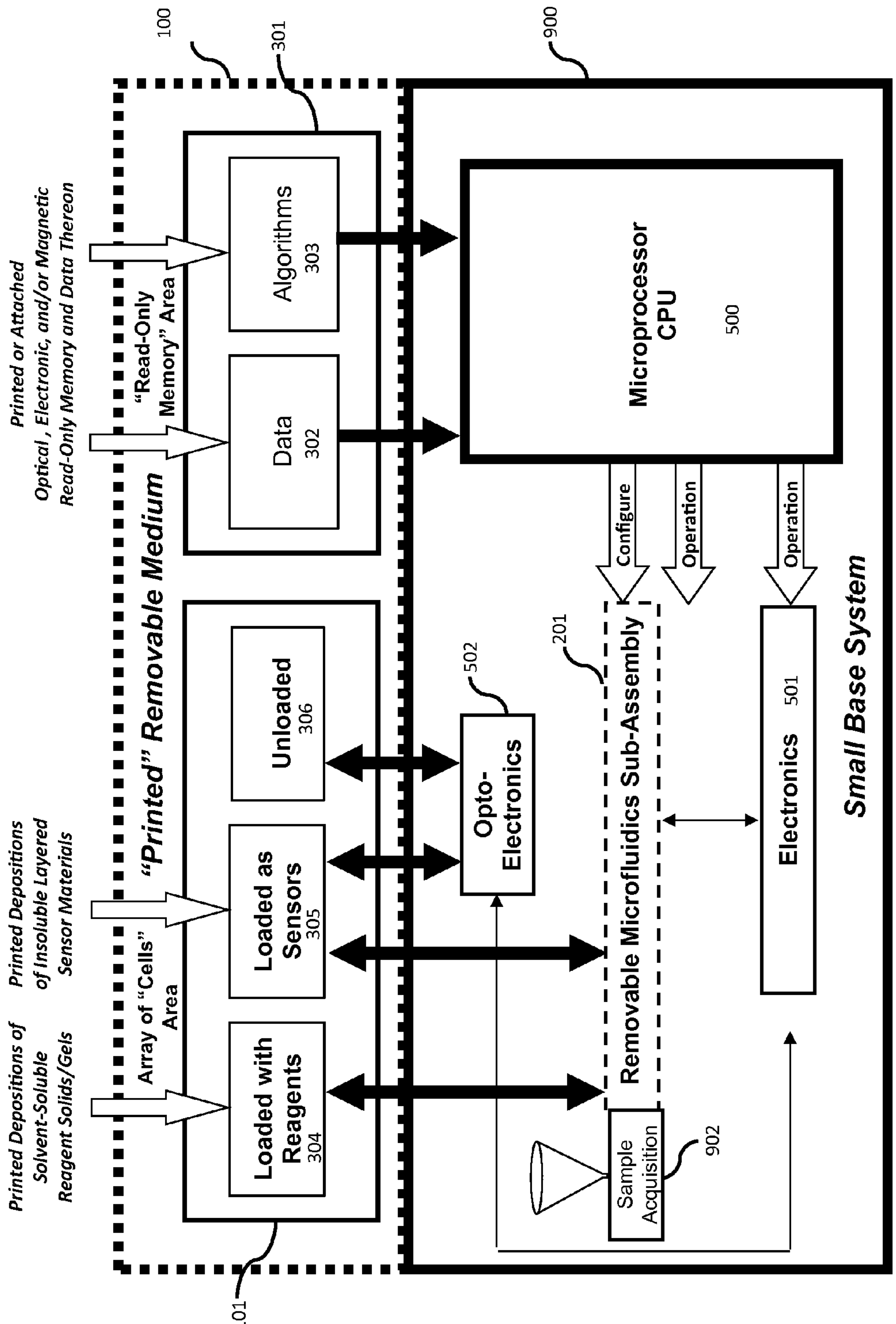


Figure 8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101
"Printed" Removable Medium
Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Array of "Cells" Area
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
Printed or Attached Optical , Electronic, and/or Magnetic Read-Only Memory and Data Thereon
"Read-Only Memory" Area
Data 302
Algorithms 303
301
900
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Electronics 501
Sample Acquisition
902
Small Base System

Figure 9a

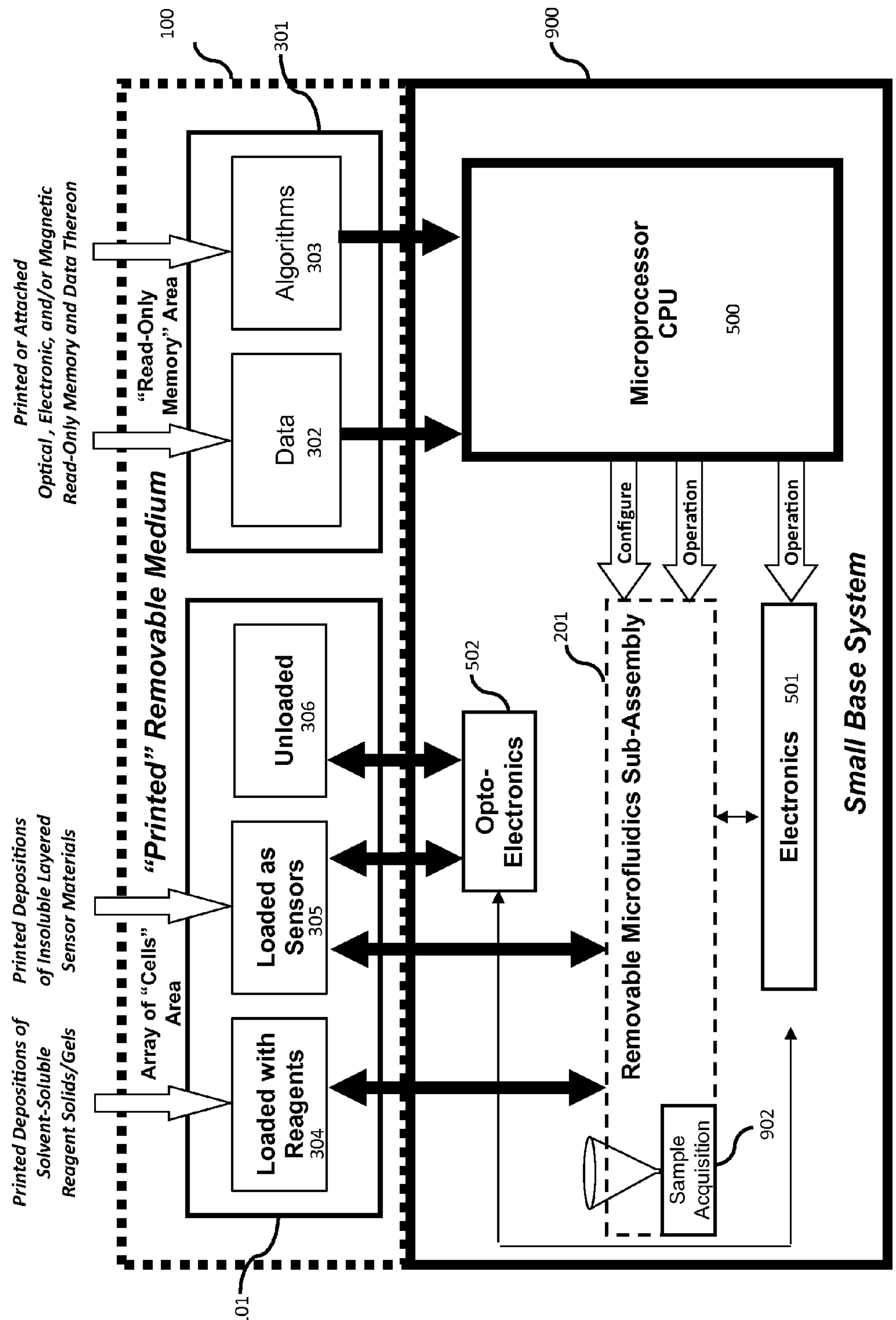

100
101
"Printed" Removable Medium
Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Printed or Attached Optical, Electronic, and/or Magnetic Read-Only Memory and Data Thereon
Array of "Cells" Area
"Read-Only Memory" Area
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
301
Data 302
Algorithms 303
900
Microprocessor CPU
500
Configure
Operation
Operation
Opto-Electronics
502
201
Removable Microfluidics Sub-Assembly
Electronics 501
Sample Acquisition
902
Small Base System

Figure 9b

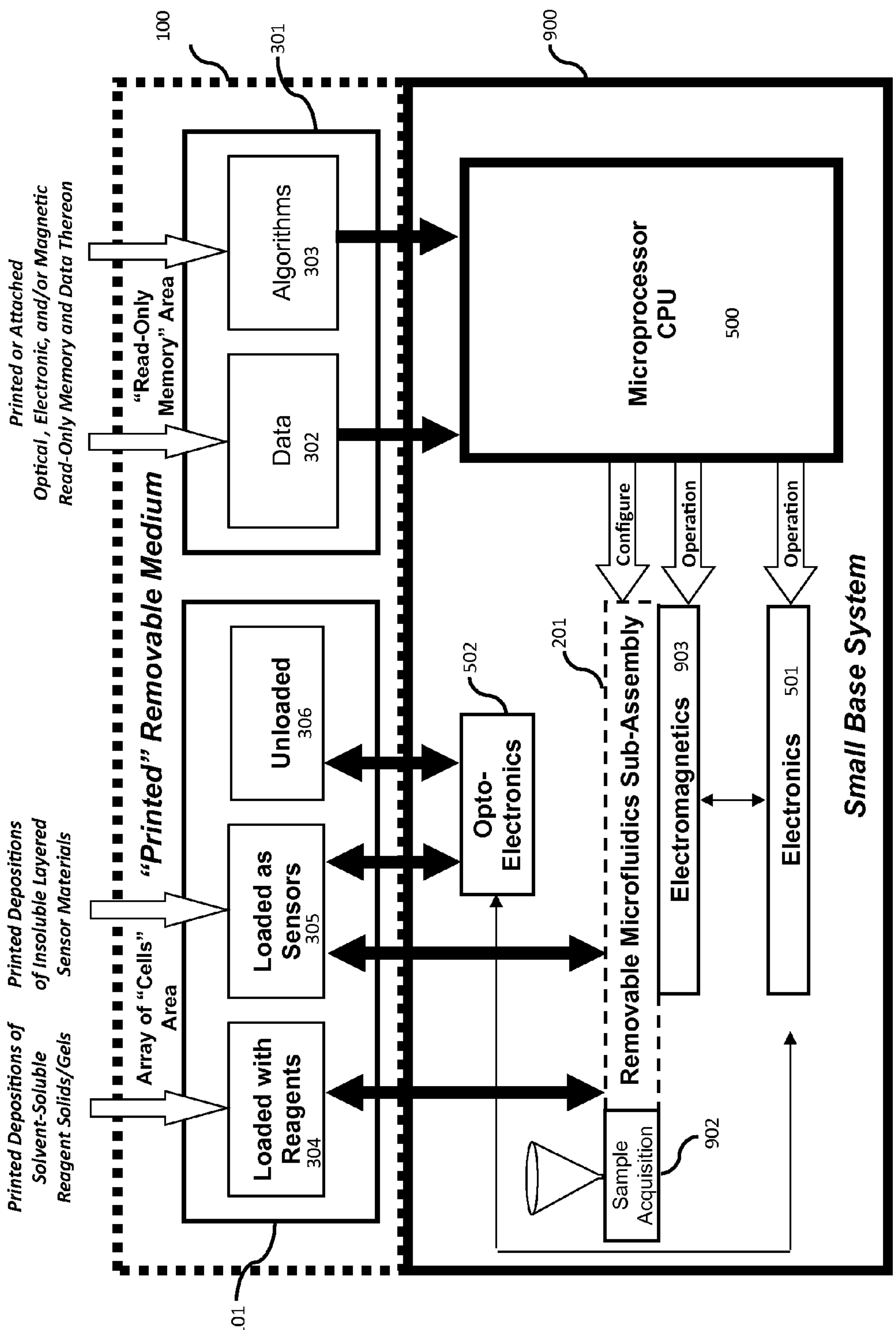
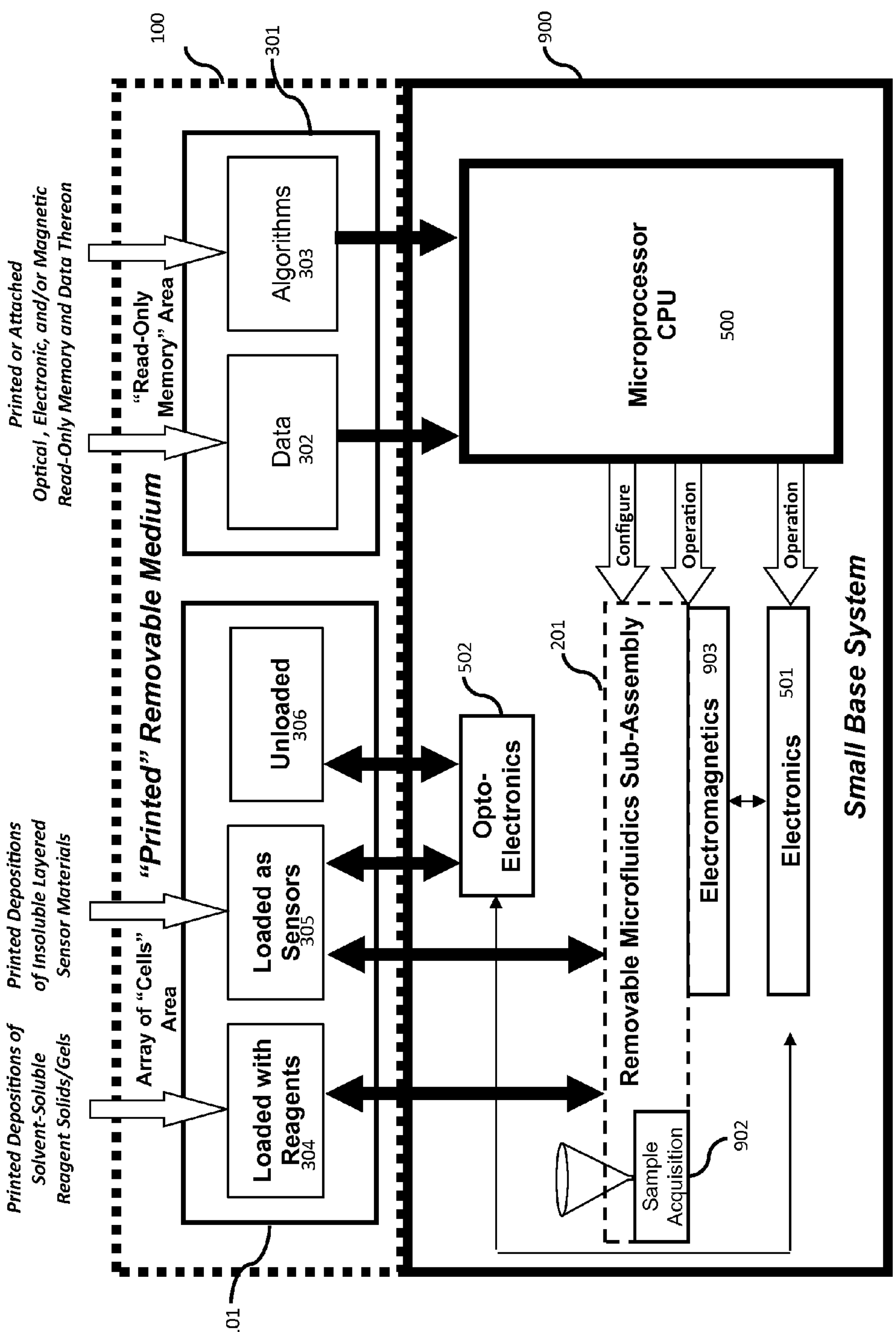

Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Printed or Attached Optical, Electronic, and/or Magnetic Read-Only Memory and Data Thereon
100
101
301
Array of "Cells" Area
"Read-Only Memory" Area
"Printed" Removable Medium
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
Data 302
Algorithms 303
900
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Electromagnetics 903
Electronics 501
Sample Acquisition
902
Small Base System

Figure 9c



Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Printed or Attached Optical, Electronic, and/or Magnetic Read-Only Memory and Data Thereon
100
301
900
101
"Printed" Removable Medium
Array of "Cells" Area
"Read-Only Memory" Area
Loaded with Reagents
304
Loaded as Sensors
305
Unloaded
306
Data
302
Algorithms
303
Microprocessor CPU
500
Configure
Operation
Operation
Opto-Electronics
502
201
Removable Microfluidics Sub-Assembly
Electromagnetics
903
Electronics
501
Sample Acquisition
902
Small Base System

Figure 9d

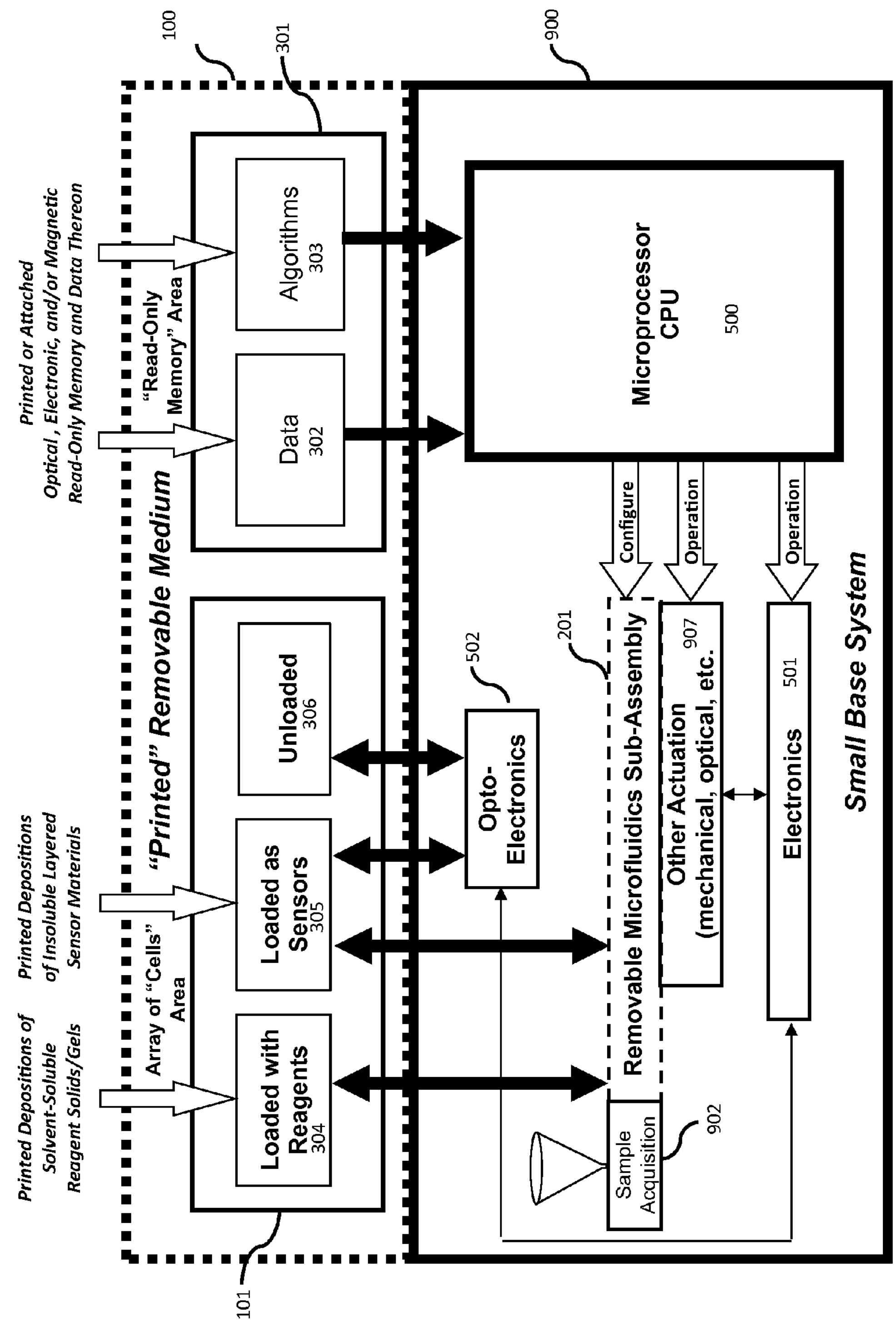
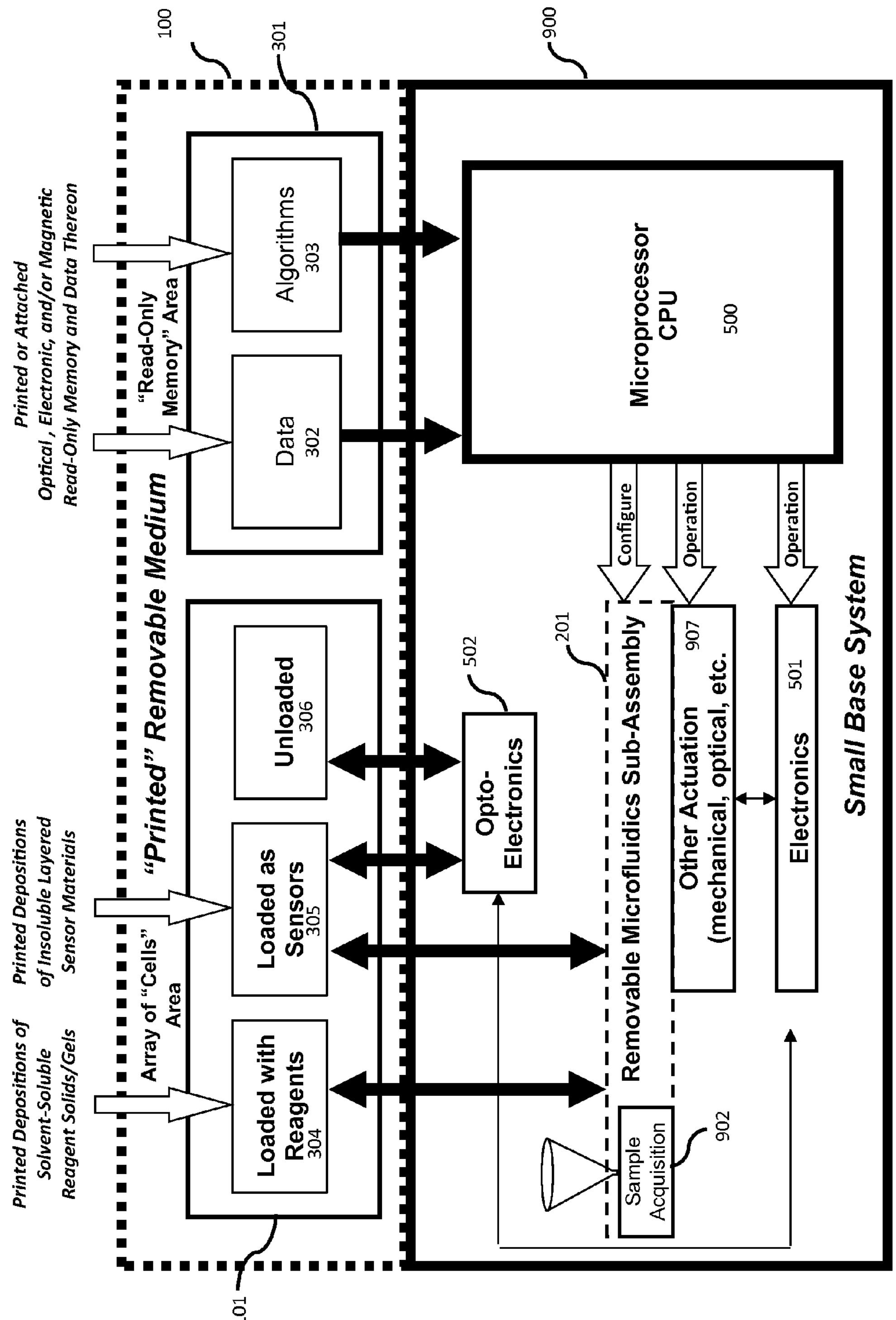

Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Printed or Attached Optical , Electronic, and/or Magnetic Read-Only Memory and Data Thereon
100
101
301
Array of "Cells" Area
"Printed" Removable Medium
"Read-Only Memory" Area
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
Data 302
Algorithms 303
900
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Other Actuation (mechanical, optical, etc.
907
Electronics
501
Sample Acquisition
902
Small Base System

Figure 9e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Read-Only Memory and Data Thereon
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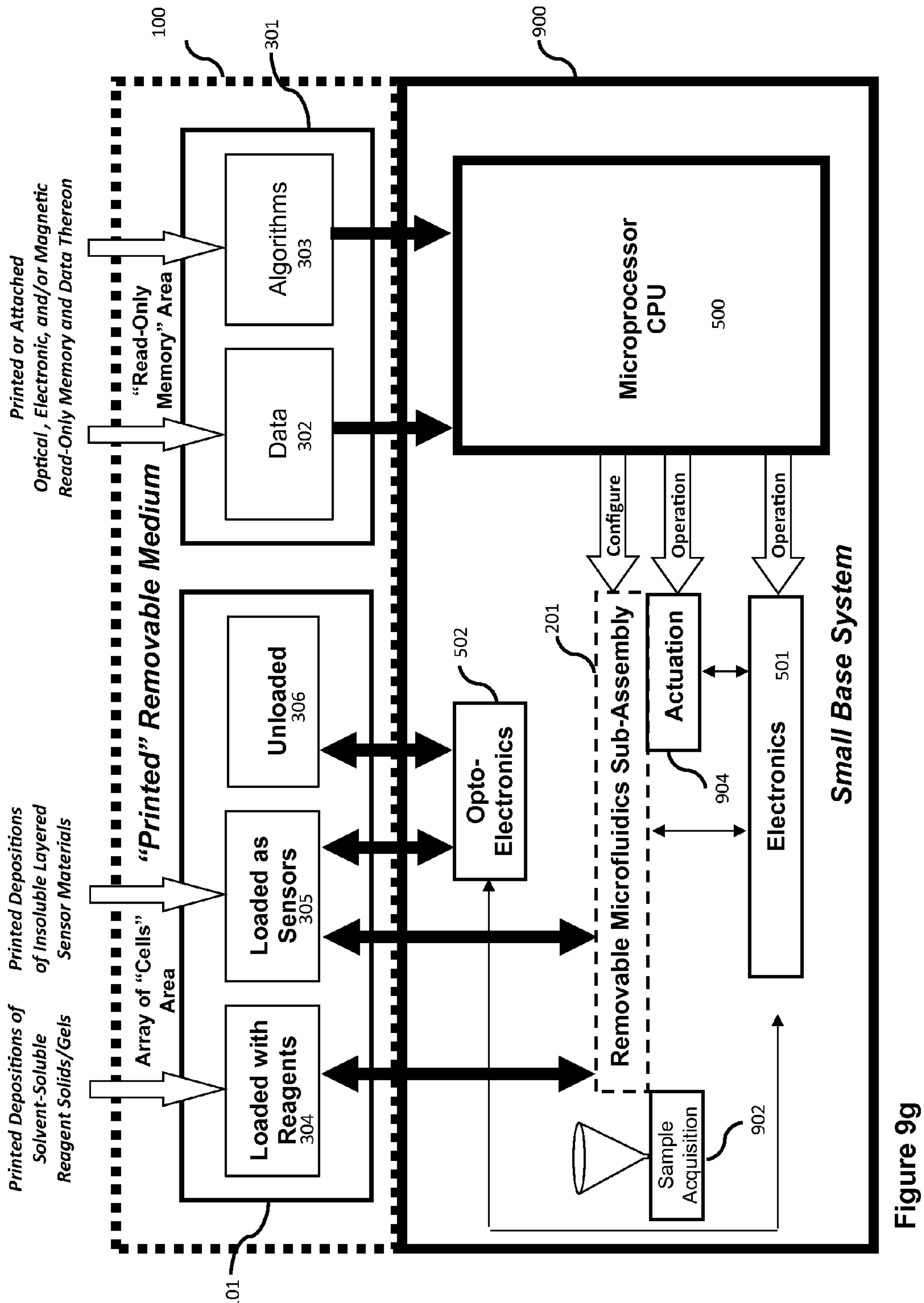
302
Algorithms
303
Printed Depositions of
Solvent-Soluble
Reagent Solids/Gels
Printed Depositions
of Insoluble Layered
Sensor Materials
Array of "Cells" Area
Loaded with Reagents
304
Loaded as Sensors
305
Unloaded
306
900
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Other Actuation
(mechanical, optical, etc.
907
Electronics
501
Sample Acquisition
902
Small Base System

Figure 9f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Array of "Cells" Area
"Read-Only Memory" Area
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
Data 302
Algorithms 303
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Actuation
904
Electronics
501
Sample Acquisition
902
Small Base System

Figure 9g

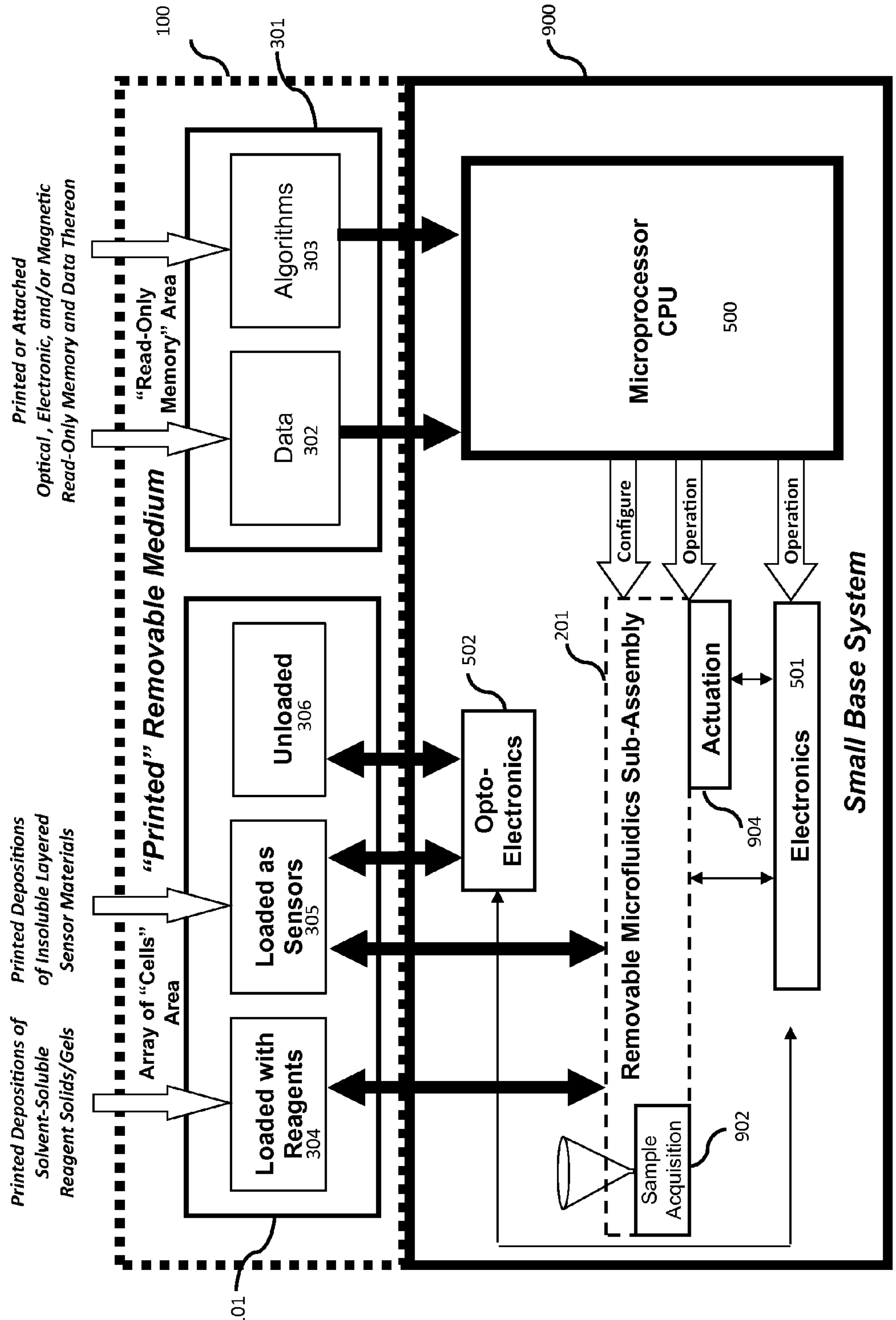
100
101
301
900
Printed Depositions of Solvent-Soluble Reagent Solids/Gels
Printed Depositions of Insoluble Layered Sensor Materials
Printed or Attached Optical , Electronic, and/or Magnetic Read-Only Memory and Data Thereon
"Printed" Removable Medium
Array of "Cells" Area
"Read-Only Memory" Area
Loaded with Reagents 304
Loaded as Sensors 305
Unloaded 306
Data 302
Algorithms 303
Microprocessor CPU
500
Configure
Operation
Operation
502
Opto-Electronics
201
Removable Microfluidics Sub-Assembly
Actuation
904
Electronics
501
Sample Acquisition
902
Small Base System

Figure 9h

REMOVABLE FLUIDICS STRUCTURES FOR MICROARRAY, MICROPLATES, SENSOR ARRAYS, AND OTHER REMOVABLE MEDIA

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field

[0002] The disclosed embodiments relate in general to the area of miniature bioechemical and chemical detectors for pathogens, biomarkers, toxins, and other materials and, more specifically, to removable fluidics structures for microarray, microplates, sensor arrays, and other removable media and the associated methods.

[0003] 2. Description of the Related Art

[0004] There is a strong need for a miniature, low cost platform(s) for addressing practical problems associated with the biochemical and chemical detectors for pathogens, biomarkers, toxins, and other materials.

SUMMARY OF THE INVENTION

[0005] The embodiments described herein are directed to methods and systems that substantially obviate one or more of the above and other problems associated with conventional technology.

[0006] In accordance with one aspect of the inventive concepts described herein, there is provided a removable microfluidics structure comprising at least one actuated fluid delivery element, wherein the actuated fluid delivery element is a pump element of a valve element configured to control fluid delivery to or from a removable media detachably coupled with the removable microfluidics structure based on an actuation force.

[0007] In one or more embodiments, the actuation force is an external actuation force.

[0008] In one or more embodiments, the actuation force is an internal actuation force.

[0009] In one or more embodiments, the removable microfluidics structure may further include an electromechanical actuator for providing the actuation force.

[0010] In one or more embodiments, the electromechanical actuator comprises a solenoid.

[0011] In one or more embodiments, the electromechanical actuator comprises a solenoid with an ferromagnetic core.

[0012] In one or more embodiments, the electromechanical actuator comprises a piezoelectric actuator.

[0013] In one or more embodiments, the removable microfluidics structure may further include coupling mechanism for detachably coupling the removable microfluidics structure with the removable media.

[0014] In one or more embodiments, the removable media is a cell array.

[0015] In one or more embodiments, when the microfluidics structure couples with the removable media, the microfluidics structure controls fluid delivery to or from a cell of the cell array.

[0016] In accordance with one aspect of the inventive concepts described herein, there is provided a base system comprising a removable microfluidics structure comprising at least one actuated fluid delivery element, wherein the actuated fluid delivery element is a pump element of a valve element configured to control fluid delivery to or from a removable media detachably coupled with the base system based on an actuation force, the base system further comprising a control logic for controlling the fluid delivery to or from a removable media.

[0017] In one or more embodiments, the actuation force is an external actuation force.

[0018] In one or more embodiments, the actuation force is an internal actuation force.

[0019] In one or more embodiments, the base system further comprises an electromechnical actuator for providing the actuation force.

[0020] In one or more embodiments, the electromechanical actuator comprises a solenoid.

[0021] In one or more embodiments, the electromechanical actuator comprises a solenoid with an ferromagnetic core.

[0022] In one or more embodiments, the electromechanical actuator comprises a piezoelectric actuator.

[0023] In one or more embodiments, the base system further comprises a coupling mechanism for detachably coupling the removable microfluidics structure with the removable media.

[0024] In one or more embodiments, the removable media comprises is a cell array.

[0025] In one or more embodiments, the when base system couples with the removable media, the microfluidics structure controls fluid delivery to or from a cell of the cell array.

[0026] Additional aspects related to the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. Aspects of the invention may be realized and attained by means of the elements and combinations of various elements and aspects particularly pointed out in the following detailed description and the appended claims.

[0027] It is to be understood that both the foregoing and the following descriptions are exemplary and explanatory only and are not intended to limit the claimed invention or application thereof in any manner whatsoever.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The accompanying drawings, which are incorporated in and constitute a part of this specification exemplify the embodiments of the present invention and, together with the description, serve to explain and illustrate principles of the inventive concepts. Specifically:

[0029] FIG. **1** illustrates an exemplary embodiment of a removable replaceable media element.

[0030] FIG. **2** illustrates an exemplary embodiment of a base unit with an integrated inventive microfluidics assembly.

[0031] FIG. **3***a* illustrates an abstract representation of an exemplary embodiment of a removable replaceable media element with a dedicated microfluidics assembly.

[0032] FIG. **3***b* illustrates an abstract representation of an exemplary embodiment of a removable replaceable media element with a removable microfluidics assembly.

[0033] FIG. **4** illustrates an exemplary embodiment, wherein the interfacing module can be configured to be inserted into either the base unit or attached to the removable replaceable media element in either a fixed or a replaceable arrangement.

[0034] FIG. **5** illustrates an exemplary high-level combined signal flow and fluidic flow representation of an exemplary embodiment of the invention.

[0035] FIG. **6***a* illustrates an exemplary embodiment, wherein a valve element is actuated using a solenoid.

[0036] FIG. **6***b* illustrates an exemplary embodiment, wherein a pump element is actuated using a solenoid.

[0037] FIG. **6***c* illustrates an exemplary embodiment, wherein a valve element is actuated using a solenoid having a movable ferromagnetic slug.

[0038] FIG. **6***d* illustrates an exemplary embodiment, wherein a pump element is actuated using a solenoid having a movable ferromagnetic slug.

[0039] FIG. **6***e* illustrates an exemplary embodiment, wherein a valve element is actuated using a piezo-electric actuator.

[0040] FIG. **6***f* illustrates an exemplary embodiment, wherein a pump element is actuated using a piezo-electric actuator.

[0041] FIG. **7***a* illustrates an exemplary embodiment of an illumination configuration involving a backside illumination of a valve element.

[0042] FIG. **7***b* illustrates an exemplary embodiment of an illumination configuration involving a backside illumination of a pump element.

[0043] FIG. **7***c* illustrates an exemplary, embodiment of an illumination configuration involving a frontside illumination of a valve element.

[0044] FIG. **7***d* illustrates an exemplary embodiment of an illumination configuration involving a frontside illumination of a pump element.

[0045] FIG. **8** illustrates an exemplary operational diagram of an embodiment of the invention.

[0046] FIG. **9***a* illustrates one exemplary embodiment of the invention having a removable microfluidics assembly electrically coupled with electronics of the base system and having a separate sample acquisition.

[0047] FIG. **9***b* illustrates one exemplary embodiment of the invention having a removable microfluidics assembly electrically coupled with electronics of the base system and having an integrated sample acquisition.

[0048] FIG. **9***c* illustrates one exemplary embodiment of the invention having an electromagnetically actuated removable microfluidics assembly and a separate sample acquisition.

[0049] FIG. **9***d* illustrates one exemplary embodiment of the invention having an electromagnetically actuated removable microfluidics assembly and an integrated sample acquisition.

[0050] FIG. **9***e* illustrates one exemplary embodiment of the invention having an otherwise actuated removable microfluidics assembly and a separate sample acquisition.

[0051] FIG. **9***f* illustrates one exemplary embodiment of the invention having an otherwise actuated removable microfluidics assembly and an integrated sample acquisition.

[0052] FIG. **9***g* illustrates one exemplary embodiment of the invention having an actuated removable microfluidics assembly electrically coupled with electronics of the base system and having a separate sample acquisition.

[0053] FIG. **9***h* illustrates one exemplary embodiment of the invention having an actuated removable microfluidics assembly electrically coupled with electronics of the base system and having an integrated sample acquisition.

DETAILED DESCRIPTION

[0054] In the following detailed description, reference will be made to the accompanying drawing(s), in which identical functional elements are designated with like numerals. The aforementioned accompanying drawings show by way of illustration, and not by way of limitation, specific embodiments and implementations consistent with principles of the present invention. These implementations are described in sufficient detail to enable those skilled in the art to practice the invention and it is to be understood that other implementations may be utilized and that structural changes and/or substitutions of various elements may be made without departing from the scope and spirit of present invention. The following detailed description is, therefore, not to be construed in a limited sense. Additionally, the various embodiments of the invention as described may be implemented in the form of a software running on a general purpose computer, in the form of a specialized hardware, or combination of software and hardware.

[0055] In accordance with one aspect of the inventive concepts described herein, there is provided a removable microfluidics structures for microarray, microplates, sensor arrays, and other removable media. In one or more embodiments, the removable microfluidics structure comprises at least one fluid delivery element. In one embodiment, the fluid delivery element is a pump element. In one embodiment, the fluid delivery element is a valve element. In one embodiment, the fluid delivery element is a tubing element. The fluid delivery element may be internally or externally actuated using solenoids, piezoelectric crystals or any other suitable means. In one embodiment, the microfluidics structure is integrated into a removable media, such as an array. In another embodiment, the microfluidics structures is detachably coupled with a removable media, such as an array media having an array of cells, such that each microfluidics structure couples with a cell of the array. In one embodiment, the microfluidics structures may be integrated into or detachably coupled with a base system. In one or more embodiments, the removable microfluidics structures may be microprocessor controlled using interface electronics.

[0056] FIG. **1** illustrates an exemplary embodiment of a removable replaceable media element **100**. In one or more embodiments, the removable replaceable media element **100** comprises a single piece of transparent plastic material, such as Poly (methyl methacrylate), acrylic or any other suitable transparent material. The removable replaceable media element **100** may incorporate a plurality of cells **101** arranged in an array-like pattern. In one or more embodiments, the removable replaceable media element **100** is 3D-printetd in accordance with techniques well known to persons of skill in the art.

[0057] FIG. **2** illustrates an exemplary embodiment of a base system **200** with an integrated or removable inventive microfluidics subassembly **201**. The shown embodiment of the microfluidics subassembly **201** incorporates multiple valves **202**, tubing **203**, pumps **204** configured to appropriately deliver fluid sample materials to or from the cells **101** of the removable replaceable media element **100** shown in FIG. **1**. The valves **202** and/or pumps **204** may be internally or externally actuated using one of the actuation mechanisms described in detail below.

[0058] FIG. **3***a* illustrates an abstract representation of an exemplary embodiment of a removable replaceable media element **100** with an integrated dedicated microfluidics subassembly **201**. The cells **101** of the replaceable media element **100** include cells **304** loaded with reagents such as printed depositions of solvent-soluble reagent solids or gels, cells **305** loaded as sensors with printed depositions of insoluble layered sensor materials as well as unloaded cells **306**. The dedicated microfluidics subassembly **201** is integrated within the removable replaceable media element **100** such that the valves **202**, tubing **203**, and/or pumps **204** of the microfluidics subassembly **201** are coupled with the appropriate cells **101** to enable fluid delivery.

[0059] In addition, in one or more embodiments, the removable replaceable media element **100** comprises a memory unit **301**, such a read-only memory unit (ROM) or other non-volatile data storage device, of optical, electronic and/or magnetic type for storing data **302** describing the content of the array of cells **101**. In addition, the memory unit **301** may store algorithms **303** for processing any information associated with the array of cells **101**.

[0060] FIG. **3***b* illustrates an abstract representation of an exemplary embodiment of a removable replaceable media element with a removable microfluidics assembly. The cells **101** of the replaceable media element **100** include cells **304** loaded with reagents, cells **305** loaded as sensors as well as unloaded cells **306**. The dedicated microfluidics subassembly **201** is detachably coupled with the removable replaceable media element **100** such that the valves **202**, tubing **203**, and/or pumps **204** of the microfluidics subassembly **201** are coupled with the appropriate cells **101** to enable fluid delivery.

[0061] In addition, in one or more embodiments, the removable replaceable media element **100** of FIG. **3***b* comprises a memory unit **301**, such a read-only memory unit (ROM) or other non-volatile data storage device, for storing data **302** describing the content of the array of cells **101**. In addition, the memory unit **301** may store algorithms **303** for processing any information associated with the array of cells **101**.

[0062] FIG. **4** illustrates an exemplary embodiment, wherein the interfacing module **400** can be configured to be inserted into either the base unit or attached to the removable replaceable media element **100** in either a fixed or a replaceable arrangement. The interfacing module **400** comprises the microfluidics elements including valves **202**, tubing **203**, and/or pumps **204**. When the interfacing module **400** is mated with the replaceable media element **100**, the aforesaid microfluidics elements (valves **202**, tubing **203**, and/or pumps **204**) of the interfacing module **400** couple with the appropriate cells **101** of the removable replaceable media element **100** to enable fluid delivery. The valves **202** and/or pumps **204** of the interfacing module **400** may be internally or externally actuated using one of the actuation mechanisms described in detail below.

[0063] FIG. **5** illustrates an exemplary high-level combined signal flow and fluidic flow representation of an exemplary embodiment of the invention. The overall operation of the exemplary embodiment of the invention is controlled by the microprocessor **500**. The electronics **501** is provided for interfacing the microprocessor **500** with the sensors disposed within the removable replaceable media element **100** and for receiving the data from the aforesaid sensors. On the other hand, the optoelectronics **502** is used for reading optical information related to the content of the cells **101** loaded with reagents. The data medium interface interfaces the microprocessor **500** with the memory unit **301** located on the removable replaceable media element **100** for facilitating read-out of the data and algorithms stored in that memory unit **301**.

[0064] Electronics **504** interfaces the microprocessor **500** with the active controlled microfluidics **505**, which are controlled by the microprocessor **500** to provide appropriate fluid delivery. Additionally provided is a passive microfluidics **506** and the replaceable removable interface module **400** described above.

[0065] FIG. **6***a* illustrates an exemplary embodiment, wherein a valve element **202** is actuated using a solenoid **601**. FIG. **6***b* illustrates an exemplary embodiment, wherein a pump element **204** is actuated using a solenoid **601**.

[0066] FIG. **6***c* illustrates an exemplary embodiment, wherein a valve element **202** is actuated using a solenoid **602** having a movable ferromagnetic slug **604**.

[0067] FIG. **6***d* illustrates an exemplary embodiment, wherein a pump element **204** is actuated using a solenoid **602** having a movable ferromagnetic slug **604**.

[0068] FIG. **6***e* illustrates an exemplary embodiment, wherein a valve element **202** is actuated using a piezo-electric actuator **603**.

[0069] FIG. **6***f* illustrates an exemplary embodiment, wherein a pump element **204** is actuated using a piezo-electric actuator **603**. It should be noted that the inventive concepts described herein are not limited to the shown actuation methods and any other mow know or later developed actuation techniques for the aforesaid microfluidics elements (valves **202**, tubing **203**, and/or pumps **204**) can similarly be used.

[0070] FIG. **7***a* illustrates an exemplary embodiment of an illumination configuration involving a backside illumination of a valve element **202** using a light from a light source **701**. In the shown embodiment, the light transmitted by the valve element **202** is collected by the light sensor **702**.

[0071] FIG. **7***b* illustrates an exemplary embodiment of an illumination configuration involving a backside illumination of a pump element **204** using a light from a light source **701**. In the shown embodiment, the light transmitted by the pump element **204** is collected by the light sensor **702**.

[0072] FIG. **7***c* illustrates an exemplary embodiment of an illumination configuration involving a frontside illumination of a valve element **202** using a light from a light source **701**. In the shown embodiment, the light reflected by the valve element **202** is collected by the light sensor **702**.

[0073] FIG. **7***d* illustrates an exemplary embodiment of an illumination configuration involving a frontside illumination of a pump element **204** using a light from a light source **701**. In the shown embodiment, the light reflected by the pump element **204** is collected by the light sensor **702**.

[0074] FIG. **8** illustrates an exemplary operational diagram of an embodiment of the invention. In the shown embodiment, the information from the sensor **801** is processed and analyzed by electronics **802**, which controls electromechanical actuator **803** based on the information received from the sensor **801**. The elctromechanical actuator, which may include structures shown in any of the FIGS. **6***a*-**6***f*, controls the aforesaid microfluidics elements (valves **202**, tubing **203**, and/or pumps **204**), which, in turn, control the fluid flow to the sensor **801**.

[0075] FIG. **9***a* illustrates one exemplary embodiment of the invention having a removable microfluidics sub-assembly **201** electrically coupled with electronics of the base system **900** and having a separate sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly. **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**.

[0076] FIG. **9***b* illustrates one exemplary embodiment of the invention having a removable microfluidics sub-assembly **201** electrically coupled with electronics of the base system **900** and having an integrated sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**.

[0077] FIG. **9***c* illustrates one exemplary embodiment of the invention having an electromagnetically actuated removable microfluidics assembly **201** and a separate sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** is actuated using the electromagnetic actuator **903** controlled by the microprocessor **500**.

[0078] FIG. **9***d* illustrates one exemplary embodiment of the invention having an electromagnetically actuated removable microfluidics assembly **201** and an integrated sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** with integrated sample acquisition module **902** is actuated using the electromagnetic actuator **903** controlled by the microprocessor **500**.

[0079] FIG. **9***e* illustrates one exemplary embodiment of the invention having an otherwise actuated removable microfluidics assembly and a separate sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** is actuated using the other actuator **907** controlled by the microprocessor **500**.

[0080] FIG. **9***f* illustrates one exemplary embodiment of the invention having an otherwise actuated removable microfluidics assembly and an integrated sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** with an integrated sample acquisition module **902** is actuated using the other actuator **907** controlled by the microprocessor **500**.

[0081] FIG. **9***g* illustrates one exemplary embodiment of the invention having an actuated removable microfluidics assembly **201** electrically coupled with electronics module **501** of the base system **900** and having a separate sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** is actuated using the actuator **904** controlled by the microprocessor **500**.

[0082] FIG. **9***h* illustrates one exemplary embodiment of the invention having an actuated removable microfluidics assembly **201** electrically coupled with electronics module **501** of the base system **900** and having an integrated sample acquisition module **902**. The shown embodiment incorporates a microprocessor **500** disposed in a small base system **900**, which performs overall control of the operation of the shown embodiment. The electronics **501** interfaces the microprocessor **500** with the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** may also be configured directly by the microprocessor **500**. Additionally provided is opto-electronics **502** for obtaining optical readout from at least some of the cells **101** in the cell matrix of the removable replaceable media element **100**. In the shown embodiment, the sample acquisition is separate from the removable microfluidics sub-assembly **201**. The removable microfluidics sub-assembly **201** with an integrated sample acquisition module **902** is actuated using the actuator **904** controlled by the microprocessor **500**.

[0083] Finally, it should be understood that processes and techniques described herein are not inherently related to any particular apparatus and may be implemented by any suitable combination of components. Further, various types of general purpose devices may be used in accordance with the teachings described herein. It may also prove advantageous to construct specialized apparatus to perform the method steps described herein. The present invention has been described in relation to particular examples, which are intended in all respects to be illustrative rather than restrictive. Those skilled in the art will appreciate that many different combinations of hardware, software, and firmware will be suitable for practicing the present invention. For example, the described software may be implemented in a wide variety of programming or scripting languages, such as Assembler, C/C++, Objective-C, perl, shell, PHP, Java, as well as any now known or later developed programming or scripting language.

[0084] Moreover, other implementations of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. Various aspects and/or components of the described embodiments may be used singly or in any combination in the removable microfluidics structures and the associated systems and methods. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A removable microfluidics structure comprising at least one actuated fluid delivery element, wherein the actuated fluid delivery element is a pump element of a valve element configured to control fluid delivery to or from a removable media detachably coupled with the removable microfluidics structure based on an actuation force.

2. The removable microfluidics structure of claim **1**, wherein the actuation force is an external actuation force.

3. The removable microfluidics structure of claim **1**, wherein the actuation force is an internal actuation force.

4. The removable microfluidics structure of claim **1**, further comprising an electromechanical actuator for providing the actuation force.

5. The removable microfluidics structure of claim **4**, wherein the electromechanical actuator comprises a solenoid.

6. The removable microfluidics structure of claim **4**, wherein the electromechanical actuator comprises a solenoid with an ferromagnetic core.

7. The removable microfluidics structure of claim **4**, wherein the electromechanical actuator comprises a piezoelectric actuator.

8. The removable microfluidics structure of claim **1**, further comprising a coupling mechanism for detachably coupling the removable microfluidics structure with the removable media.

9. The removable microfluidics structure of claim **1**, wherein the removable media is a cell array.

10. The removable microfluidics structure of claim **9**, wherein when the microfluidics structure couples with the removable media, the microfluidics structure controls fluid delivery to or from a cell of the cell array.

11. A base system comprising a removable microfluidics structure comprising at least one actuated fluid delivery element, wherein the actuated fluid delivery element is a pump element of a valve element configured to control fluid delivery to or from a removable media detachably coupled with the base system based on an actuation force, the base system further comprising a control logic for controlling the fluid delivery to or from a removable media.

12. The base system of claim **11**, wherein the actuation force is an external actuation force.

13. The base system of claim **11**, wherein the actuation force is an internal actuation force.

14. The base system of claim **11**, further comprising an electromechnical actuator for providing the actuation force.

15. The base system of claim **14**, wherein the electromechnical actuator comprises a solenoid.

16. The base system of claim **14**, wherein the electromechnical actuator comprises a solenoid with an ferromagnetic core.

17. The base system of claim **14**, wherein the electromechnical actuator comprises a piezoelectric actuator.

18. The base system of claim **11**, further comprising a coupling mechanism for detachably coupling the removable microfluidics structure with the removable media.

19. The base system of claim **11**, wherein the removable media comprises is a cell array.

20. The base system of claim **19**, wherein when the base system couples with the removable media, the microfluidics structure controls fluid delivery to or from a cell of the cell array.

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