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(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.** [US/US]; 11445 Compaq Center Drive W., Houston, Texas 77070 (US).

(72) Inventors: **GE, Ning**; 1501 Page Mill Rd., Palo Alto, California 94304-1100 (US). **CHIA, Leong Yap**; Depot 2 138 Depot Road, #01-01, #02-01, #04-01, #05-01, #06-01, & #07-01, Singapore 109683 (SG). **LEE, Pin Chin**; Depot 2 138 Depot Road, #01-01, #02-01, #04-01, #05-01, #06-01, & #07-01, Singapore 109683 (SG).

(74) Agents: **COLLINS, David, W.** et al.; Hewlett-Packard Company, Intellectual Property Administration, 3404 E. Harmony Road, Mail Stop 35, Fort Collins, Colorado 80528 (US).

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(54) Title: PRINTHEAD WITH A NUMBER OF SHARED ENCLOSED SELECTORS

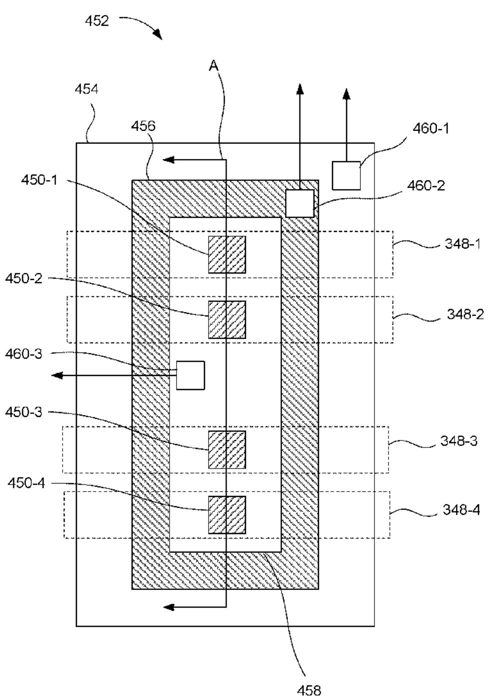

Fig. 4A

(57) Abstract: A printhead with a number of enclosed shared selectors is described. The printhead includes a number of nozzles to deposit an amount of fluid onto a print medium. Each nozzle includes a firing chamber to hold an amount of fluid, an opening to dispense the amount of fluid onto a print medium, and an ejector to eject the amount of fluid through the opening. The printhead also includes a memristor array. The memristor array includes a number of memristors to store information and a number of selectors. The number of selectors includes a number of column selectors to select columns of memristors and a number of row selectors to select rows of memristors. A portion of the number of selectors are enclosed selectors.

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PRINTHEAD WITH A NUMBER OF ENCLOSED SHARED SELECTORS

BACKGROUND

[0001] A memory system may be used to store information. In some examples, imaging devices, such as printheads may include memory to store information relating to printer cartridge identification, security information, and authentication information, among other types of information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The accompanying drawings illustrate various examples of the principles described herein and are a part of the specification. The illustrated examples do not limit the scope of the claims.

[0003] Fig. 1 is a diagram of a printing system with a printer cartridge and printhead for depositing fluid onto a surface according to one example of the principles described herein.

[0004] Fig. 2A is a diagram of a printer cartridge with a number of enclosed shared selectors according to one example of the principles described herein.

[0005] Fig. 2B is a cross sectional diagram of a printer cartridge with a number of enclosed shared selectors according to one example of the principles described herein.

[0006] Fig. 3 is a block diagram of a printer cartridge that uses a printhead with a number of enclosed shared selectors according to one example of the principles described herein.

[0007] Figs. 4A and 4B are views of a number of memristors disposed on top of a shared selector according to one example of the principles described herein.

[0008] Fig. 5 is a diagram of a memristor array according to one example of the principles described herein.

[0009] Fig. 6 is a circuit diagram of a memristor cell according to one example of the principles described herein.

[0010] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements.

DETAILED DESCRIPTION

[0011] Memory devices are used to store information for a printer cartridge. Printer cartridges include memory to store information related to the operation of the printhead. For example, a printhead may include memory to store information related 1) to the printhead; 2) to fluid, such as ink, used by the printhead; or 3) to the use and maintenance of the printhead. Other examples of information that may be stored on a printhead include information relating to 1) a fluid supply, 2) fluid identification information, 3) fluid characterization information, and 4) fluid usage data, among other types of fluid or imaging device related data. More examples of information that may be stored include identification information, serial numbers, security information, feature information, Anti-Counterfeiting (ACF) information, among other types of information. While memory usage on printheads is desirable, changing circumstances may reduce their efficacy in storing information.

[0012] For example, an increasing trend in counterfeiting may lead to current memory storage size being too small to contain sufficient anti-counterfeiting information and security and authentication information. Additionally, with loyalty customer reward programs, new business models and other customer relation management programs through cloud-printing and other printing architectures, additional market data, customer appreciation value information, encryption information, and other types of information on the rise, a manufacturer may desire to store more information on a memory device.

[0013] Moreover, as new technologies develop, circuit space is at a premium. Accordingly, it may be desirable for the greater amounts of data storage to occupy less space within a device. Memristors may be used due to their non-volatility, low operational power consumption characteristics, and their compact size. A memristor selectively stores data based on a resistance state of the memristor. For example, a memristor may be in a low resistance state indicated by a “1,” or a high resistance state indicated by a “0.” Memristors may form a string of ones and zeroes that will store the aforementioned data. If an analog memristor is used, there may be many different resistance states.

[0014] A memristor may switch between a low resistance state and a high resistance state during a switching event in which a voltage is passed to the memristor. Each memristor has a switching voltage that refers to a voltage used to switch the state of the memristors. When the supplied voltage is greater than the memristor switching voltage, the memristor switches state. While memristors may be beneficial as memory storage devices, their use presents a number of complications. For example, in some memristor array structures, selection of an individual memristor within the array may be complicated such that there are inefficiencies in the memristor array. Moreover, the circuitry involved in selecting an individual memristor may occupy valuable space on the printhead.

[0015] Accordingly, the printer cartridge and printhead described herein allow for additional memory storage that occupies a smaller area on a substrate. For example, the printer cartridge and printhead disclosed herein describe a number of memristor arrays that include memristor selection elements that are positioned on opposite sides of the memristor array. Similarly, the printer cartridge and printhead disclosed herein describe a memristor array that includes an enclosed shared selector that is disposed underneath the memristor array. The enclosed shared selector may include a number of enclosed gate selection transistors. The memristors associated with the enclosed shared selectors may be disposed on top of drains of the number of enclosed gate selection transistors. This may provide an increased storage density of the memristor array. In general, the use of memristor arrays may be beneficial as they provide a greater storage capacity than other non-volatile memory devices, for a given footprint. Still further, memristors can be manufactured and implemented relatively cheaply, thereby reducing the cost associated with printhead production. Memristors using shared selectors may allow formation of memristor arrays with higher densities. Memristors with shared selectors may also increase manufacturing efficiency by increasing the size of components of the memristor array and reducing the number of components used to make a given number of memristor cells. The use of shared selectors may also reduce the number of control lines used.

[0016] The present disclosure describes a printhead with a number of enclosed shared selectors. The printhead includes a number of nozzles to deposit an amount of fluid onto a print medium. Each nozzle includes a firing chamber to hold the amount of fluid, an opening to dispense the amount of fluid onto the print medium, and an ejector to eject the amount of fluid through the opening. The printhead also includes a memristor array. The memristor array includes a number of memristors to store information. The memristor array also includes a number of selectors. Each selector includes a number of column selectors to select columns of memristors and a number of row selectors to select rows of memristors. A portion of the number of selectors are enclosed selectors.

[0017] The present disclosure describes a printer cartridge with a number of enclosed shared selectors. The cartridge includes a fluid supply and a printhead to deposit fluid from the fluid supply onto a print medium. The printhead includes a memristor array. The memristor array includes a plurality of memristors to store information. The memristor array also includes a number of selectors. The number of selectors include a number of column selectors to select columns of memristors and a number of row selectors to select rows of transistors. At least one of the number of selectors is an enclosed selector that includes a plurality of selection transistors.

[0018] A printer cartridge and a printhead that utilize a shared selector between memristor cells may be beneficial by providing a simplified and cost-effective manufacturing process to produce a memristor that is relatively small while storing a large amount of information. The memristors using shared enclosed gate transistors may have further benefits including 1) having fewer components, 2) having larger components which increases manufacturing efficiency, 3) enhancing electrical connection efficiency, and 4) reducing the number of signals used in controlling the memristor array.

[0019] As used in the present specification and in the appended claims, the term “memory” is meant to be understood broadly as an element that stores information. Memory may be divided into sub-categories. For example, memory may include a number of memory arrays. “Memory arrays” may refer to a division of memory and may be further divided. For example, each memory array may include a number of memory banks of memristors and the associated controls.

[0020] As used in the present specification and in the appended claims, the term “memristor” may refer to a passive two-terminal circuit element that maintains a functional relationship between the time integral of current, and the time integral of voltage.

[0021] As used in the present specification and in the appended claims, the term “memristor cell” is meant to be understood broadly as a component of a memristor array that includes a memristor, a column selector, and a row selector. The column selector may be a column select transistor and the row selector may be a row select transistor. A memristor cell or memristor that is “active” may refer to a memristor cell in which the memristor may be accessed by a controller. An active memristor may be read or may have a state imposed on it. By comparison, a memristor cell or memristor that is “inactive” may refer to a memristor cell in which the memristor is unavailable to store data or be read. A memristor cell, or memristor, may be active when the column select transistor and row select transistor corresponding to the memristor cell are closed, in other words, when the column select transistor and row select transistor form a closed circuit with the controller.

[0022] As used in the present specification and in the appended claims, the term “column” refers to an element or collection of elements oriented in the up and down direction, while “row” refers to an orientation in the left and right direction. Since electronic components can be rotated during design or layout, rows may be converted to columns and vice versa. Accordingly, the use of either “column” or “row” refers to a local orientation with regards to the structure that contains the referenced component and does not refer to the overall chip structure. Accordingly, the terms row and column may be switched in the description and produce an equivalent device.

[0023] As used in the present specification and in the appended claims, the term “printer cartridge” may refer to a device used in the ejection of ink, or other fluid, onto a print medium. In general, a printer cartridge may be a fluidic ejection device that dispenses fluid such as ink, wax, polymers or other fluids. A printer cartridge may include a printhead. In some examples, a printhead may be used in printers, graphic plotters, copiers and facsimile machines. In these examples, a printhead may eject ink, or another fluid, onto a medium such as paper to form a desired image.

[0024] Accordingly, as used in the present specification and in the appended claims, the term “printer” is meant to be understood broadly as any device capable of selectively placing a fluid onto a print medium. In one example the printer is an inkjet printer. In another example, the printer is a three-dimensional printer. In yet another example, the printer is a digital titration device.

[0025] Still further, as used in the present specification and in the appended claims, the term “fluid” is meant to be understood broadly as any substance that continually deforms under an applied shear stress. In one example, a fluid may be a pharmaceutical. In another example, the fluid may be an ink. In another example, the fluid may be a liquid.

[0026] Still further, as used in the present specification and in the appended claims, the term “print medium” is meant to be understood broadly as any surface onto which a fluid ejected from a nozzle of a printer cartridge may be deposited. In one example, the print medium may be paper. In another example, the print medium may be an edible substrate. In yet one more example, the print medium may be a medicinal pill.

[0027] Still further, as used in the present specification and in the appended claims, the term “a number of” or similar language may include any positive number from 1 to infinity.

[0028] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present systems and methods. It will be apparent, however, to one skilled in the art that the present apparatus, systems, and methods may be practiced without these specific details. Reference in the specification to “an example” or similar language means that a particular feature, structure, or characteristic described is included in at least that one example, but not necessarily in other examples.

[0029] Turning now to the figures, Fig. 1 is a diagram of a printing system (100) with a printer cartridge (114) and printhead (116) according to one example of the principles described herein. In some examples, the printing system (100) may be included on a printer. The system (100) includes an interface with a computing device (102). The interface enables the system (100) and specifically the processor (108) to interface with various hardware elements, such as the computing device (102), external and internal to the system (100). Other examples of external devices include external storage devices, network devices such as servers, switches, routers, and client devices among other types of external devices.

[0030] In general, the computing device (102) may be any source from which the system (100) may receive data describing a job to be executed by the controller (106) in order to eject fluid onto the print medium (126). For example, via the interface, the controller (106) receives data from the computing device (102) and temporarily stores the data in the data storage device (110). Data may be sent to the controller (106) along an electronic, infrared, optical, or other information transfer path. The data may represent a document and/or file to be printed. As such, data forms a job for and includes job commands and/or command parameters.

[0031] A controller (106) includes a processor (108), a data storage device (110), and other electronics for communicating with and controlling the printhead (116). The controller (106) receives data from the computing device (102) and temporarily stores data in the data storage device (110).

[0032] The controller (106) controls the printhead (116) in ejecting fluid from the nozzles (124). For example, the controller (106) defines a pattern of ejected fluid drops that form characters, symbols, and/or other graphics or images on the print medium (126). The pattern of ejected fluid drops is determined by the print job commands and/or command parameters received from the computing device (102). The controller (106) may be an application specific integrated circuit (ASIC), on a printer or example, to determine the level of fluid in the printhead (116) based on resistance values of memristors integrated on the printhead (116). The ASIC may include a current source and an analog to digital converter (ADC). The ASIC converts a voltage present at the current source to determine a resistance of a memristor, and then determine a corresponding digital resistance value through the ADC. Computer readable program code, executed through executable instructions enables the resistance determination and the subsequent digital conversion through the ADC.

[0033] The processor (108) may include the hardware architecture to retrieve executable code from the data storage device (110) and execute the executable code. The executable code may, when executed by the processor (108), cause the processor (108) to implement at least the functionality of ejecting fluid onto the print medium (126). The executable code may, when executed by the processor (108), cause the processor (108) to implement the functionality of providing instructions to the power supply (130) such that the power supply (130) provides power to the components of the system (100).

[0034] The data storage device (110) may store data such as executable program code that is executed by the processor (108) or other processing device. The data storage device (110) may specifically store computer code representing a number of applications that the processor (108) executes to implement at least the functionality described herein.

[0035] The data storage device (110) may include various types of memory modules, including volatile and nonvolatile memory. For example, the data storage device (110) of the present example includes Random Access Memory (RAM), Read Only Memory (ROM), and Hard Disk Drive (HDD) memory. Many other types of memory may also be utilized, and the present specification contemplates the use of many varying type(s) of memory in the data storage device (110) as may suit a particular application of the principles described herein. In certain examples, different types of memory in the data storage device (110) may be used for different data storage needs. For example, in certain examples the processor (108) may boot from Read Only Memory (ROM), maintain nonvolatile storage in the Hard Disk Drive (HDD) memory, and execute program code stored in Random Access Memory (RAM).

[0036] Generally, the data storage device (110) may include a computer readable medium, a computer readable storage medium, or a non-transitory computer readable medium, among others. For example, the data storage device (110) may be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium may include, for example, the following: an electrical connection having a number of wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store computer usable program code for use by or in connection with an instruction execution system, apparatus, or device. In another example, a computer readable storage medium may be any non-transitory medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0037] The printing system (100) includes a printer cartridge (114) that includes a printhead (116) and a reservoir (112). The printer cartridge (114) may be removable from the system (100) for example, as a replaceable printer cartridge (114).

[0038] The printer cartridge (114) includes a printhead (116) that ejects drops of fluid through a plurality of nozzles (124) towards a print medium (126). The print medium (126) may be any type of suitable sheet or roll material, such as paper, card stock, transparencies, polyester, plywood, foam board, fabric, canvas, and the like. In another example, the print medium (126) may be an edible substrate. In yet one more example, the print medium (126) may be a medicinal pill.

[0039] Nozzles (124) may be arranged in columns or arrays such that properly sequenced ejection of fluid from the nozzles (124) causes characters, symbols, and/or other graphics or images to be printed on the print medium (126) as the printhead (116) and print medium (126) are moved relative to each other. In one example, the number of nozzles (124) fired may be a number less than the total number of nozzles (124) available and defined on the printhead (116).

[0040] The printer cartridge (114) also includes a fluid reservoir (112) to supply an amount of fluid to the printhead (116). In general, fluid flows between the reservoir (112) and the printhead (116). In some examples, a portion of the fluid supplied to printhead (116) is consumed during operation and fluid not consumed during printing is returned to the reservoir (112).

[0041] In some examples, a mounting assembly positions the printhead (116) relative to a media transport assembly, and media transport assembly positioning the print medium (126) relative to printhead (116). Thus, a print zone (128), indicated by the dashed box, is defined adjacent to the nozzles (124) in an area between the printhead (116) and the print medium (126). In one example, the printhead (116) is a scanning type printhead (116). As such, the mounting assembly includes a carriage for moving the printhead (116) relative to the media transport assembly to scan the print medium (126). In another example, the printhead (116) is a non-scanning type printhead (116). As such, the mounting assembly fixes the printhead (116) at a prescribed position relative to the media transport assembly. Thus, the media transport assembly positions the print medium (126) relative to the printhead (116).

[0042] Fig. 2A is a diagram of a printer cartridge (114) and printhead (116) with a number of enclosed shared selectors according to one example of the principles described herein. As discussed above, the printhead (116) may include a number of nozzles (124). In some examples, the printhead (116) may be broken up into a number of print dies with each die having a number of nozzles (124). The printhead (116) may be any type of printhead (116) including, for example, a printhead (116) as described in Figs. 2A and 2B. The examples shown in Figs. 2A and 2B are not meant to limit the present description. Instead, various types of printheads (116) may be used in conjunction with the principles described herein.

[0043] The printer cartridge (114) also includes a fluid reservoir (112), a flexible cable (236), conductive pads (238), and a memristor array (240). The flexible cable (236) is adhered to two sides of the printer cartridge (114) and contains traces that electrically connect the memristor array (240) and printhead (116) with the conductive pads (238).

[0044] The printer cartridge (114) may be installed into a cradle. When the printer cartridge (114) is correctly installed into a device such as a printer, the conductive pads (238) are pressed against corresponding electrical contacts in the cradle, allowing the device to communicate with, and control the electrical functions of, the printer cartridge (114). For example, the conductive pads (238) allow the device to access and write to the memristor array (240).

[0045] The memristor array (240) may contain a variety of information including the type of printer cartridge (114), the kind of fluid contained in the printer cartridge (114), an estimate of the amount of fluid remaining in the fluid reservoir (112), calibration data, error information, and other data. In one example, the memristor array (240) may include information regarding when the printer cartridge (114) should be maintained. The memristor array (240) may include other information as described below in connection with Fig. 3.

[0046] To eject fluid, the system (Fig. 1, 100) moves the carriage containing the printer cartridge (114) relative to a print medium (Fig. 1, 126). At appropriate times, the system (Fig. 1, 100) sends electrical signals to the printer cartridge (114) via the electrical contacts in the cradle. The electrical signals pass through the conductive pads (238) and are routed through the flexible cable (236) to the printhead (116). The printhead (116) then ejects a small droplet of fluid from the reservoir (112) onto the surface of the print medium (Fig. 1, 126).

[0047] The printhead (116) may include any number of nozzles (124). In an example where the fluid is an ink, a first subset of nozzles (124) may eject a first color of ink while a second subset of nozzles (124) may eject a second color of ink. Additional groups of nozzles (124) may be reserved for additional colors of ink.

[0048] Fig. 2B is a cross sectional diagram of a printer cartridge (114) and printhead (116) with a number of enclosed shared selectors according to one example of the principles described herein. The printer cartridge (114) may include a fluid supply (112) that supplies the fluid to the printhead (116) for deposition onto a print medium (Fig. 1, 126). In some examples, the fluid may be ink. For example, the printer cartridge (114) may be an inkjet printer cartridge, the printhead (116) may be an inkjet printhead, and the ink may be inkjet ink.

[0049] The printer cartridge (114) may include a printhead (116) to carry out at least a part of the functionality of depositing fluid onto a print medium (Fig. 1, 126). The printhead (116) may include a number of components for depositing a fluid onto a surface. For example, the printhead (116) may include a number of nozzles (124). For simplicity, Fig. 2B indicates a single nozzle (124), however a number of nozzles (124) are present on the printhead (116). A nozzle (124) may include an ejector (242), a firing chamber (244), and an opening (246). The opening (246) may allow fluid, such as ink, to be deposited onto a surface, such as a print medium (Fig. 1, 126). The firing chamber (244) may include a small amount of fluid. The ejector (242) may be a mechanism for ejecting fluid through the opening (246) from the firing chamber (206), where the ejector (242) may include a firing resistor or other thermal device, a piezoelectric element, or other mechanism for ejecting fluid from the firing chamber (244).

[0050] For example, the ejector (242) may be a firing resistor. The firing resistor heats up in response to an applied voltage. As the firing resistor heats up, a portion of the fluid in the firing chamber (244) vaporizes to form a bubble. This bubble pushes liquid fluid out the opening (246) and onto the print medium (Fig. 1, 126). As the vaporized fluid bubble pops, fluid is drawn into the firing chamber (244) from the fluid supply (112), and the process repeats. In this example, the printhead (116) may be a thermal inkjet (TIJ) printhead.

[0051] In another example, the ejector (242) may be a piezoelectric device. As a voltage is applied, the piezoelectric device changes shape which generates a pressure pulse in the firing chamber (244) that pushes a fluid out the opening (246) and onto the print medium (Fig. 1, 126). In this example, the printhead (116) may be a piezoelectric inkjet (PIJ) printhead.

[0052] The printhead (116) and printer cartridge (114) may also include other components to carry out various functions related to fluidic ejection. For simplicity, in Figs. 2A and 2B, a number of these components and circuitry included in the printhead (116) and printer cartridge (114) are not indicated; however such components may be present in the printhead (116) and printer cartridge (114).

[0053] Fig. 3 is a block diagram of a printer cartridge (114) that uses a printhead (116) with a number of enclosed shared selectors according to one example of the principles described herein. In some examples, the printer cartridge (114) includes a printhead (116) that carries out at least a part of the functionality of the printer cartridge (114). For example, the printhead (116) may include a number of nozzles (Fig. 1, 124). The printhead (116) ejects drops of fluid from the nozzles (Fig. 1, 124) onto a print medium (Fig. 1, 126) in accordance with a received print job. The printhead (116) may also include other circuitry to carry out various functions related to printing. In some examples, the printhead (116) is part of a larger system such as an integrated printhead (IPH). The printhead (116) may be of varying types. For example, the printhead (116) may be a thermal inkjet printhead or a piezoelectric inkjet printhead, among other types of printhead (116).

[0054] The printhead (116) includes a memristor array (240) to store information relating to the printer cartridge (114) and/or the printhead (116). In some examples, the memristor array (240) includes a number of memristor cells (348) formed in the printhead (116). Each memristor cell (348) may be used to store information and may include a memristor, a column selector, and a row selector. The column selector may be a column select transistor and the row selector may be a row select transistor. More specifically, each memristor cell (348) may store a bit of information. A memristor cell (348) is active when both the column selector and a row selector corresponding to the memristor cell (348) are closed. To store information, each memristor in a memristor cell (348) may be set to a particular logic state. As memristors are non-volatile, this logic state is retained even when power is removed from the printhead (116). A memristor has a metal-insulator-metal layered structure. More specifically, the memristor may include a bottom electrode (metal), a switching oxide (insulator or semiconductor), and a top electrode (metal). The electrodes may be made from any suitable conductive material.

[0055] The number of memristor cells (348) may be arranged in rows and columns, for example in a cross bar array. While Fig. 3 depicts two memristor cells (348-1, 348-2), a memristor array (240) may include any number of memristor cells (348) arranged in any number of rows and columns. For example, a memristor array (240) may be an 8x8 array or an 8x16 array of memristor devices (348). In some examples, the number rows and columns are equal. In other examples, the memristor array (240) may include different numbers of rows and columns.

[0056] The memristor array (240) may be used to store any type of data. Examples of data that may be stored in the memristor array (240) include fluid supply specific data and/or fluid identification data, fluid characterization data, fluid usage data, printhead (116) specific data, printhead (116) identification data, warranty data, printhead (116) characterization data, printhead (116) usage data, authentication data, security data, Anti-

Counterfeiting data (ACF), fluid drop weight, firing frequency, initial printing position, acceleration information, and gyro information, among other forms of data. In a number of examples, the memristor array (240) is written at the time of manufacturing and/or during the operation of the printer cartridge (114).

[0057] In some examples, the printer cartridge (114) may be coupled to a controller (106). The controller (106) receives a control signal from an external computing device (Fig. 1, 102). The controller (106) may be an application-specific integrated circuit (ASIC), for example, a printer ASIC. A computing device (Fig. 1, 102) may send a job to the printer cartridge (114), the job being made up of text, images, or combinations thereof to be deposited onto a print medium (Fig. 1, 126).

[0058] The controller (106) may facilitate storing information to the memristor arrays (240). Specifically, the controller (106) may pass at least one control signal to the memristor in a memristor cell (348). For example, the controller (106) may be coupled to the printhead (116), via a control line (372) such as an identification line. Via the identification line, the controller (106) may change the resistance state of a number of memristors in the memristor array (240) to effectively store information to a memristor array (240). For example, the controller (106) may send data such as authentication data, security data, and job data, in addition to other types of data to the printhead (116) to be stored on the memristor array (240). The identification line may also be used to read the resistance state of memristor cells (348) in the memristor array (240) to recover the stored information.

[0059] While specific reference is made to an identification line, the controller (106) may share a number of lines of communication with the printhead (116), such as data lines, clock lines, and fire lines. For simplicity, in Fig. 3 the different control lines (372) are indicated by a single arrow.

[0060] Figs. 4A and 4B are views of a number of memristors (450) disposed on top of a shared selector (452) according to one example of the principles described herein. Specifically, Fig. 4A is a top view of a number of memristors (450) disposed on top of a shared selector (452) and Fig. 4B is a cross-sectional view, taken along the line A, of a number of memristors (450) disposed on the shared selector (452). Memristor cells (348) are indicated by a dashed line.

[0061] As described above, a number of memristor cells (348) may include a memristor (450) and a number of selectors, specifically a column selector and a row selector. At least one of the selectors may be an enclosed shared selector (452). Figs. 4A and 4B depict the enclosed shared selector (452) and a number of memristors (450). Specifically, Figs. 4A and 4B depict four memristor cells (348-1, 348-2, 348-3, 348-4) and four corresponding memristors (450-1, 450-2, 450-3, 450-4), disposed on top of an enclosed selector (452). It should be noted that while Figs. 4A and 4B depict a specific number of memristor cells (348) and memristors (450), any number of memristors (450) and memristor cells (348) may share an enclosed selector (452).

[0062] The selector (452) may be a selection transistor that selectively activates a memristor (348). The selection transistor may function to selectively target a memristor (450). A transistor is a device that regulates current and acts as a switch for electronic signals. For example, a transistor may apply voltage a memristor (450), which changes the state of the memristor (450), i.e., from a low resistance state to a high resistance state or from a high resistance state to a low resistance state. As described above, this change of state allows a memristor (450) to store information. Similarly, providing a closed circuit through the memristor (450) allows reading of the memristor (450) resistance state to read the stored information.

[0063] A transistor may include a source (454), a gate (456), and a drain (458). The source (454) may be a continuous shape that surrounds the gate (456) of the transistor. In other words, the gate (456) may be an enclosed gate that is positioned within a central portion of the source (454). Similarly, the gate (456) may be a continuous shape that surrounds the drain (458) of the transistor. In other words, the drain (458) may be an enclosed drain that is positioned within a central portion of the enclosed gate (456).

[0064] As described above, a memristor (450) may be disposed on a drain (458) of the transistor. More specifically, the bottom electrode (474) of a memristor (450) may be disposed on the drain (458) of the transistor. A memristor (450) disposed on a drain (458) of an enclosed gate (450) transistor may be beneficial by reducing the footprint of the memristor array (Fig. 2, 240) on a printhead (Fig. 1, 116). Additionally, as the memristor (450) bottom electrode (474) is disposed directly on the drain (458), no additional routing elements are used to join the memristor (450) to the transistor.

[0065] As depicted in Fig. 4, the drain (458) may be rectangular. In some examples, the memristors (450) that share the drain (458) are in a single row or column. In other words, the memristors (450) in a single row or column share a drain (458). In other examples, memristors (450) in adjacent rows or adjacent columns share a drain (458). The inclusion of shared drains (458) may be beneficial by allowing the embedding of logic into the memristor array (Fig. 2, 240) without reducing its information storage capacity or increasing the array size.

[0066] Additionally, as the shared drains (458) are larger they may be less susceptible to manufacturing defects. Still further, shared drains (458) may be easier to electrically connect to other components. More specifically, shared drains (458) may be easier to connect because there is a single external connection instead of one for each individual memristor (450). The increased size also provides more locations where connections may be made.

[0067] Similarly the larger selector (452) includes a larger gate (456) to separate the drain (458) and the source (454). The larger gate (456) reduces the transistor “on” resistance between the drain (458) and the source (454). Increasing the length of the drain (458), for a given width of a rectangular drain (458), produces a linear increase in area of the drain (458). In contrast, the increase in perimeter is not linear because a portion of the perimeter in the direction of consolidation of the smaller enclosures goes away. Since the defect odds are roughly proportional to perimeter, in some examples the odds of a manufacturing defect in the gate (456) decrease with use of shared enclosed selectors (452).

[0068] As described above, a transistor allows for electrical signals to be passed between the controller (Fig. 1, 106) and the memristor array (Fig. 2,

240) of which the memristor (450) is a part. Accordingly, each component within the transistor may be coupled to routing elements (460) that couple the components to other devices. For example, the source (454) may be coupled to a first routing element (460-1) that is coupled to ground. Another routing element (460-3) couples the transistor, and corresponding memristor (450), to an identification line such that the memristor (450) may store information. The gate (456) may be coupled to another routing element (460-2) that is coupled to the controller (Fig. 1, 106) such that the memristor (348) may be accessed, and may subsequently store information.

[0069] Turning to Fig. 4B, in some examples, the enclosed gate (456) may be formed in a dielectric layer (476) of the structure. The dielectric layer (476) may electrically isolate the transistor from other components such as the memristor (450). In some examples, the dielectric layer (476) may be formed of undoped silicon glass (USG), borophosphosilicate glass (BPSG), phosphosilicate glass (PSG) layer, and combinations thereof among other dielectric materials.

[0070] As described above, a memristor (450) may have a metal-insulator-metal structure. More specifically, the memristor (450) may include a bottom electrode (474), a switching oxide (478), and a top electrode (480). For simplicity, in Fig. 4B, a single instance of a bottom electrode (474), a switching oxide (478), and a top electrode (480) are identified by reference numbers.

[0071] The switching oxide (478) and a portion of the bottom electrode (474) may be disposed in a memristor substrate layer (482). The memristor substrate layer (482) may insulate the memristor (450) and prevent undesirable current leak in the memristor array (Fig. 2, 240). In some examples, the memristor substrate layer (482) may be at least one of USG, BPSG, PSG or combinations thereof.

[0072] In some examples, a passivation layer (484) may be disposed on top of the top electrode (480). The passivation layer (484) protects the memristor (450) and other components from environmental factors such as air and water. Examples of passivation layer (484) materials include silicon carbide

(SiC), silicon nitride (SiN), and combinations thereof, among other passivation materials (484).

[0073] A printhead (Fig. 1, 116) with a number of shared enclosed selectors (452) may be beneficial as it consolidates the memory array (Fig. 2, 240) without increasing the defect rate of the memory array (Fig. 2, 240). For example, a column of eight memristor cells (Fig. 3, 348) with a single shared column selector (452) may have a lower defect rate than column of eight memristors cells (Fig. 3, 348) with eight column selectors (452) that occupy the same footprint.

[0074] In Figs. 4A and 4B, while a particular cross-hatching has been used to simplify distinction between a number of elements, such cross-hatching does not indicate particular material properties of those elements.

[0075] Fig. 5 is a diagram of a memristor array (240) according to one example of the principles described herein. While Fig. 5, depicts four rows and four columns of memristors (450), the memristor array (240) may include any number of memristors (450) arranged in any number of symmetric or asymmetric rows or columns. Fig. 5 depicts a number of shared enclosed selectors (452-1, 452-2, 452-3, 452-4). Specifically, Fig. 5, depicts the shared enclosed selectors (452) as column selectors. The shared enclosed selectors (452) depicted in Fig. 5, may have a similar structure as depicted in Figs. 4A and 4B, however, for simplicity, some of the details of the shared enclosed selectors (452) have been omitted in Fig. 5. Disposed on each shared column selector (452) are four memristors (450). For simplicity, one memristor (450) is indicated with a reference numeral. As described above, each memristor cell (Fig. 3, 348) includes a column selector (452) and a row selector (562). In some examples, on either side of the column selectors (452), are two row selectors (562-1, 562-2, 562-3, 562-4), each of which is coupled to a number of rows of memristors (450) as indicated by the line (564). For simplicity one connection line (564) between a row selector (562) and a row of memristors (450) includes a reference number. Again, while a specific number of memristors (450), column selectors (452), and row selectors (564) are depicted, the memristor array (240) may be made up of any number of any of these elements.

[0076] The memristors (450) may be indicated by a row and column position. Application of the appropriate control signals to the corresponding row selector (562) and column selector (452) target a corresponding memristor (450) such that it may be read from or written to.

[0077] A memristor array (240) having the row selectors (562) on opposite sides of the memristor array (240) may be beneficial by reducing the spacing between memristors (450) in the opposite direction. For example, rows of memristors (450) may be placed closer together as additional space to position row selectors (562) on one side of the memristor array (240) is alleviated as the row selectors (562) are staggered.

[0078] Further increases in memristor array (240) density may be achieved by staggering multiple columns of row selectors (562) on each side of the memristor array (240). In this way, the density of memristors (450) in the memristor array (240) may be dependent upon the size of the memristors (450) and associated signal wires and not upon the size of the selectors (452, 562).

[0079] While Fig. 5 depicts the row selectors (562) being in line with each other and that the lines (564) running from a number of the row selectors (562-2, 562-4) on the right of the drawing undergoing a small jog to reach the corresponding memristors (450), other geometries are possible. For example, the row selectors (562-2, 562-4) on the right side could be moved down so that the communication lines (564) are straight.

[0080] Positioning the row selectors (562) on the right and left of the memristor array (240) with column selectors (452) on the top of the memristor array (240) may allow a side of the memristor array (240), i.e., a bottom side, available for the control lines (Fig. 3, 372) between the controller (Fig. 1, 106) and the printhead (Fig. 1, 116) to facilitate data transfer. In one example the control lines (Fig. 3, 372) are associated with the communication lines (564), accordingly the control lines (Fig. 3, 372) may be parallel to the communication lines to the selectors (452, 562).

[0081] While Fig. 5 depicts the row and column spacing of the memristors (450) as being equal, the spacing between memristors (450) within a memristor array (240) may vary. The use of selectors (562) on opposite sides of the memristor array (240) allows a tighter packing of the memristor array (240) The use of multiple columns of selectors (452) on both opposite sides of the memristor array (240) allow even higher packing density in the other direction. In some examples, the higher packing density allows creation of rows or columns with more memristors (450). The higher packing density allows a memristor array (240) to have the same number of memristors (450) in a smaller footprint. The ability to generate tight densities in the memristor array (240) may allow for large data storage compared to other geometries using the same footprint.

[0082] The shared enclosed drain (Fig. 4, 458) of the column selector (452) coupled with the electrical isolation between columns allows an entire row to be read by selecting a row and selecting a number of columns. Doing so may be beneficial as it alleviates the need for a column selector signal at the memristor array (240). Another potential benefit of a memristor array (240) having enclosed shared transistors (452) is the reduced number of bits in the row selector signal, for instance a 16 bit word cuts the row signals by 4 bits while a 64 bit word cuts the row signal by 6 bits. These reductions are more significant when working with smaller memristor arrays (240) where the controls take up a proportionally greater percentage of the footprint. They are also more significant when working from a controller (Fig. 1, 106) that signals across a printer cartridge (Fig. 1, 114) and a printhead (Fig. 1, 116) to the memristor array (Fig. 2, 240). In one example, the row signal could be provided to multiple memristor arrays (240) simultaneously, allowing words of any desired length to be read or stored. Another potential benefit is the reduced number of operations and clock signals to transfer data into or out of the memristor array (240) since it can be transferred in parallel by word rather than serially by bit.

[0083] Fig. 6 is a circuit diagram of a memristor cell (348) according to one example of the principles described herein. As described above, each memristor cell (348) in a memory array (Fig. 2, 240) may include a memristor

(450), a column selector (Fig. 4, 452) and a row selector (Fig. 5, 562). In one example, the column selector (Fig. 4, 452) is a column select transistor (668). Similarly, the row selector (Fig. 5, 562) may be a row select transistor (666). A memristor (450) may store information by virtue of the memristor (450) resistance state. A memristor (450) may be accessed by an ID line (670), which is an example of the control line (Fig. 3, 372), when activated. An active memristor (450) may be one where the column select transistor (688) and the row select transistor (666) are both closed, as described above. The column select transistor (668) may be controlled by the column select signal (614) received from the controller (Fig. 1, 106). Likewise, the row select transistor (666) may be controlled by a row select signal (612) received from the controller (Fig. 1, 106).

[0084] In some examples, the row or column select transistors (666, 668) serve to buffer the memristor (450) from accidental state changes by increasing the switching voltage of the memristor (450) used to induce a state change in the memristor (450).

[0085] A printer cartridge (Fig. 1, 114) with a printhead (Fig. 1, 116) with a number of enclosed shared selectors (Fig. 4, 452) may have a number of advantages, including: (1) reducing space per stored bit; (2) forming an N x N or M x N storage matrix with nonstandard proportions to accommodate available space; (3) integrating logical functions on out signals; (4) reducing defect rates of the memristor array (Fig. 2, 240); (5) providing a compact transistor and memristor (Fig. 4, 450) structure; (6) improving printhead (Fig. 1, 116) memory performance; and (7) reducing cost of memory fabrication.

[0086] Aspects of the present system are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to examples of the principles described herein. Each block of the flowchart illustrations and block diagrams, and combinations of blocks in the flowchart illustrations and block diagrams, may be implemented by computer usable program code. The computer usable program code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the computer usable program code, when executed via, for example, the processor (Fig. 1, 108) of the system (Fig. 1, 100) or other programmable data processing apparatus, implement the functions or acts specified in the flowchart and/or block diagram block or blocks. In one example, the computer usable program code may be embodied within a computer readable storage medium; the computer readable storage medium being part of the computer program product. In one example, the computer readable storage medium is a non-transitory computer readable medium.

[0087] The preceding description has been presented to illustrate and describe examples of the principles described. This description is not intended to be exhaustive or to limit these principles to any precise form disclosed. Many modifications and variations are possible in light of the above teaching.

CLAIMS

WHAT IS CLAIMED IS:

1. A printhead with a number of enclosed shared selectors, the printhead comprising:

a number of nozzles to deposit an amount of fluid onto a print medium, each nozzle comprising:

a firing chamber to hold the amount of fluid;

an opening to dispense the amount of fluid onto a print medium; and

an ejector to eject the amount of fluid through the opening; and

a memristor array comprising:

a number of memristors to store information;

a number of selectors comprising:

a number of column selectors to select columns of memristors; and

a number of row selectors to select rows of memristors;

in which a portion of the number of selectors are enclosed selectors.

2. The printhead of claim 1, in which the fluid is inkjet ink.

3. The printhead of claim 1, in which the enclosed selectors are disposed underneath a number of corresponding memristors.

4. The printhead of claim 1, in which:

the enclosed selectors comprise a number of selection transistors corresponding to the number of corresponding memristors; and

bottom electrodes for the number of corresponding memristors are disposed on top of a number of drains of the number of selection transistors.

5. The printhead of claim 1, in which the enclosed selectors are longer than other selectors of the memristor array.

6. The printhead of claim 1, in which the enclosed selectors have a lower resistance than other selectors of the memristor array.

7. The printhead of claim 1, in which the enclosed selectors are shared by at least eight memristors.

8. The printhead of claim 1, in which a first portion of the row selectors are positioned on a first side of the memristor array and a second portion of the row selectors are positioned on a second side of the memristor array.

9. The printhead of claim 1, in which the first portion of the row selectors corresponds to non-sequential rows of memristors.

10. A printer cartridge with a number of enclosed shared selectors, the cartridge comprising:

a fluid supply; and

a printhead to deposit fluid from the fluid supply onto a print medium, the printhead comprising;

a memristor array comprising:

a plurality of memristors to store information;

a number of selectors comprising:

a number of column selectors to select columns of memristors; and

a number of row selectors to select rows of memristors;

in which at least one of the number of selectors is an enclosed selector that includes a plurality of selection transistors.

11. The cartridge of claim 10, in which:
the fluid is inkjet ink;
the printer cartridge is an inkjet printer cartridge; and
the printhead is an inkjet printhead.

12. The cartridge of claim 10, in which the length of the enclosed selector is larger than the length of other selectors in the memristor array.

13. The cartridge of claim 10, in which the number of column selectors are enclosed shared selectors and a first portion of the number of row selectors are positioned on a first side of the memristor array and a second portion of the number of row selectors are positioned on a second side of the memristor array.

14. The cartridge of claim 13, in which the number of row selectors are enclosed shared selectors and a first portion of the number of column selectors are positioned on a first side of the memristor array and a second portion of the number of column selectors are position on a second side of the memristor array.

15. The cartridge of claim 10, in which the distance between sequential row selectors is greater than the distance between sequential column selectors.

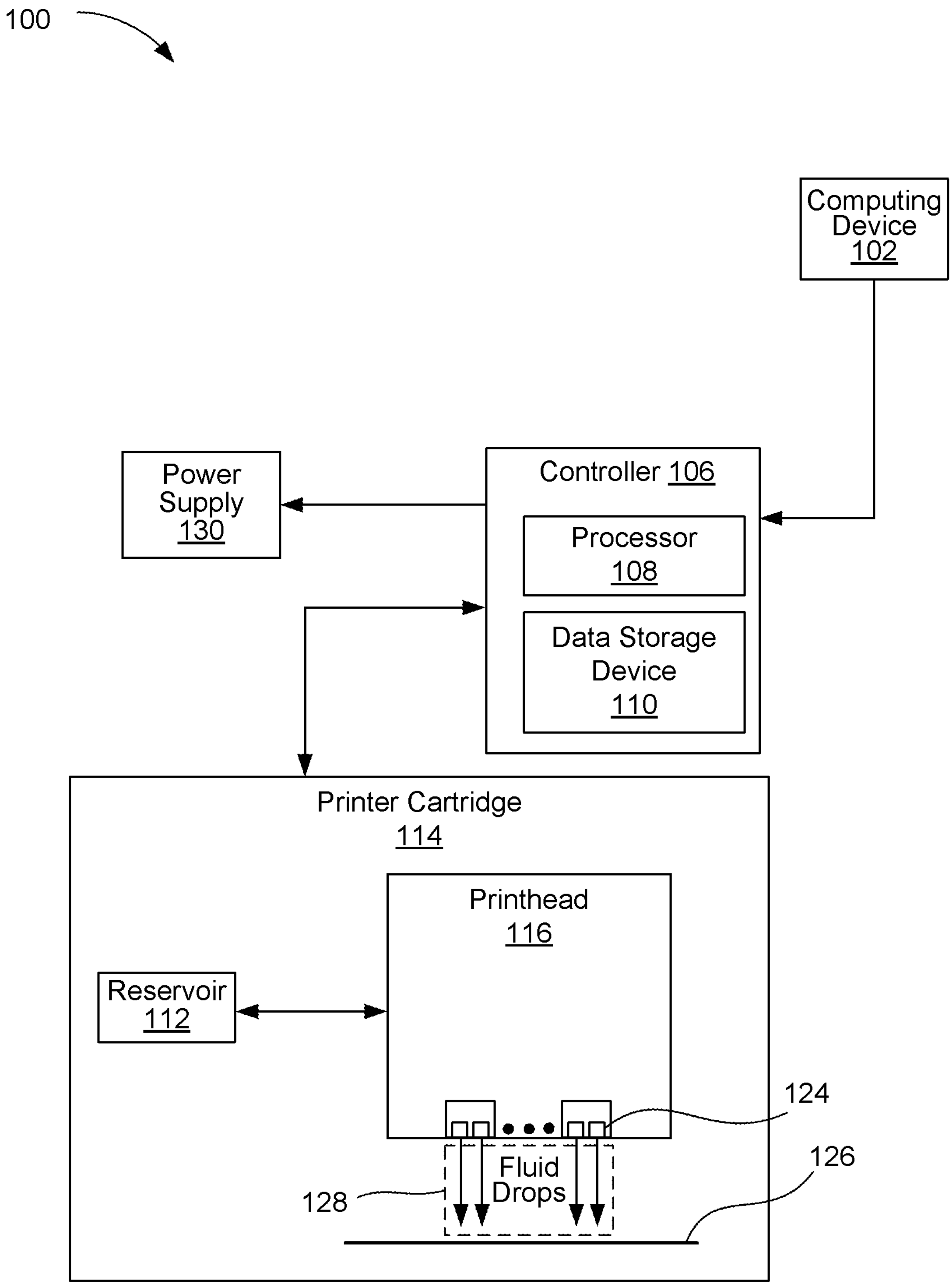
100
Computing Device 102
Power Supply 130
Controller 106
Processor 108
Data Storage Device 110
Printer Cartridge 114
Printhead 116
Reservoir 112
124
Fluid Drops
128
126

Fig. 1

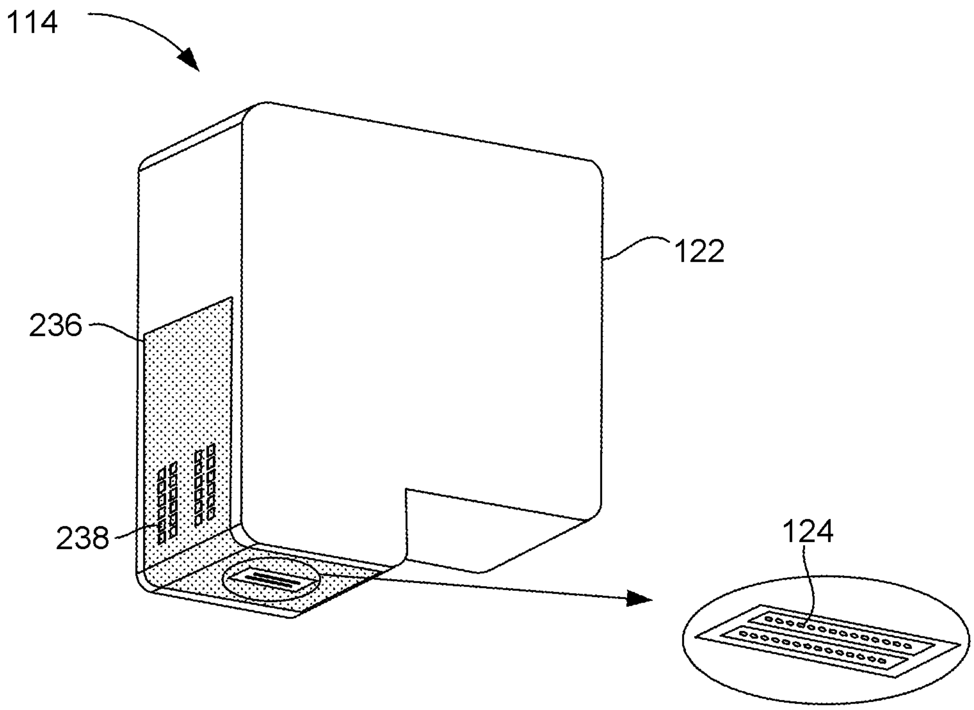

Fig. 2A

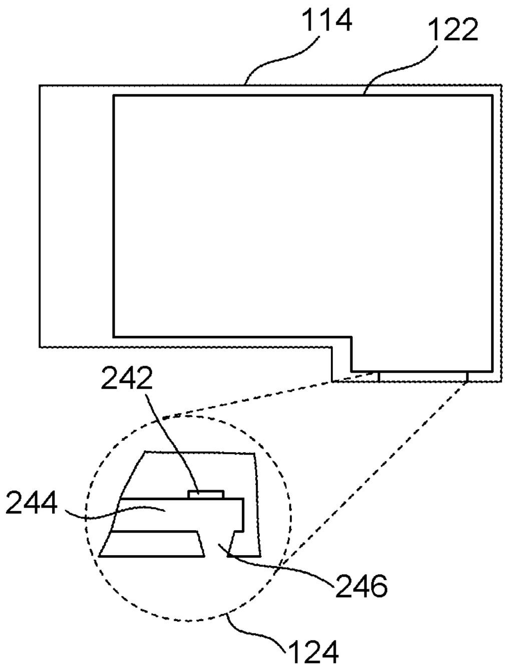

Fig. 2B

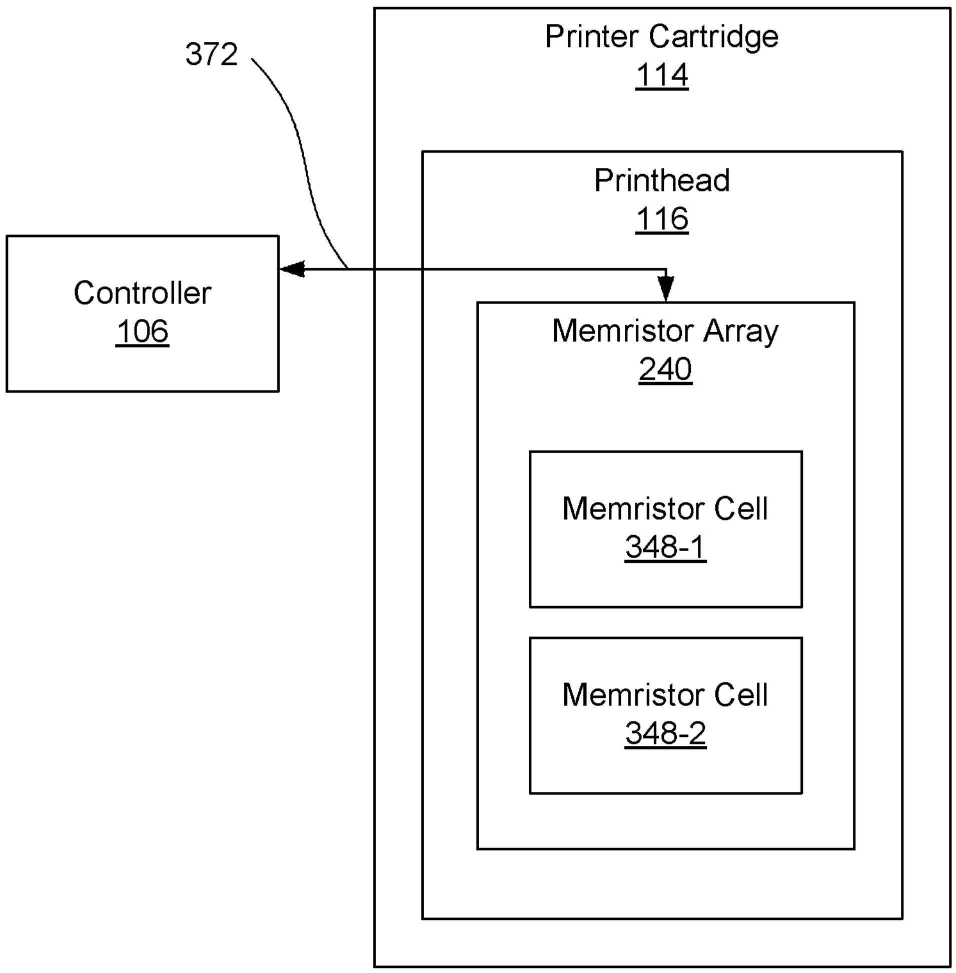
372
Printer Cartridge
114
Printhead
116
Controller
106
Memristor Array
240
Memristor Cell
348-1
Memristor Cell
348-2

Fig. 3

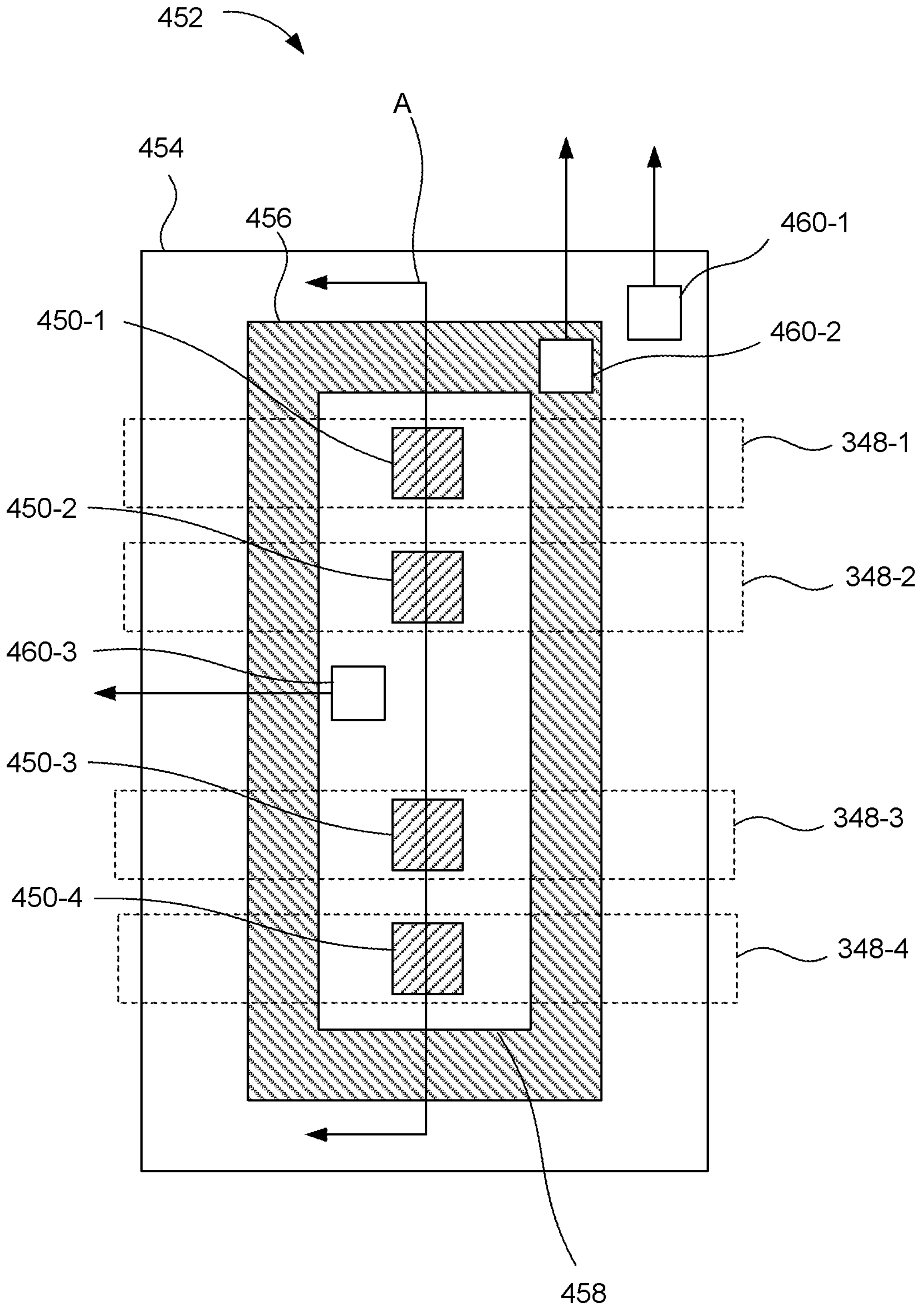
452
A
454
456
460-1
450-1
460-2
348-1
450-2
348-2
460-3
450-3
348-3
450-4
348-4
458

Fig. 4A

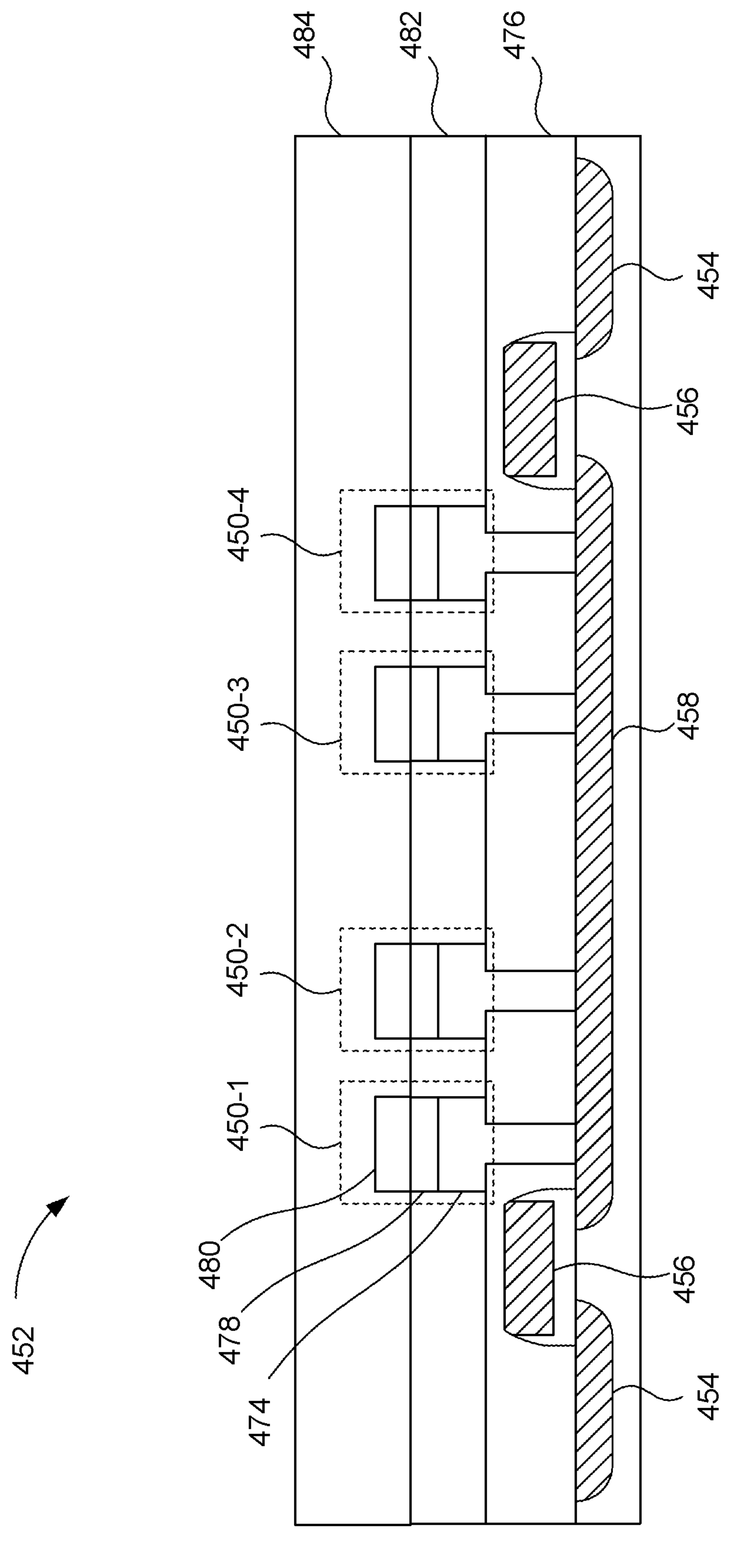
484
482
476
454
456
458
450-4
450-3
450-2
450-1
480
478
474
456
454
452

Fig. 4B

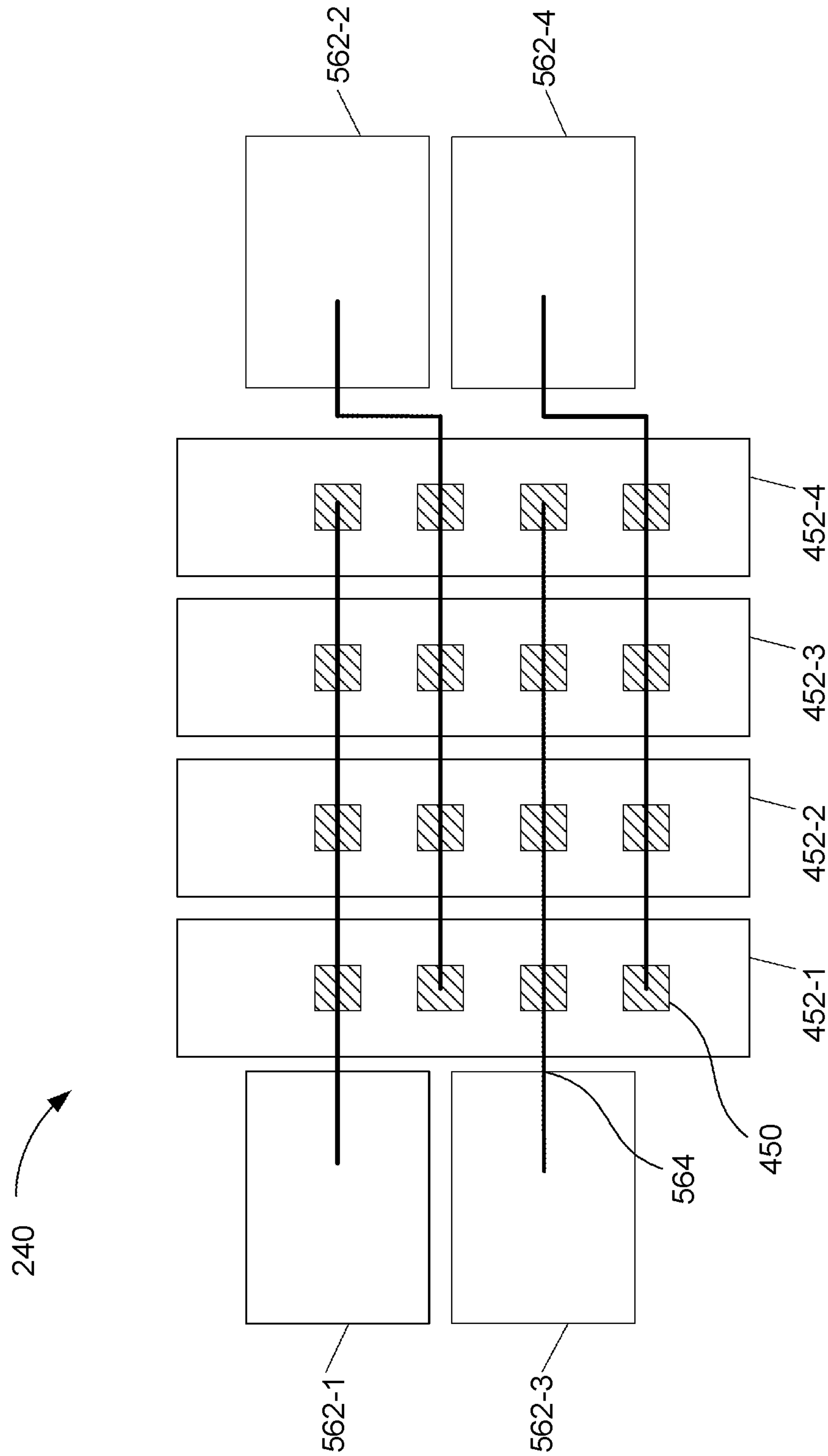

Fig. 5

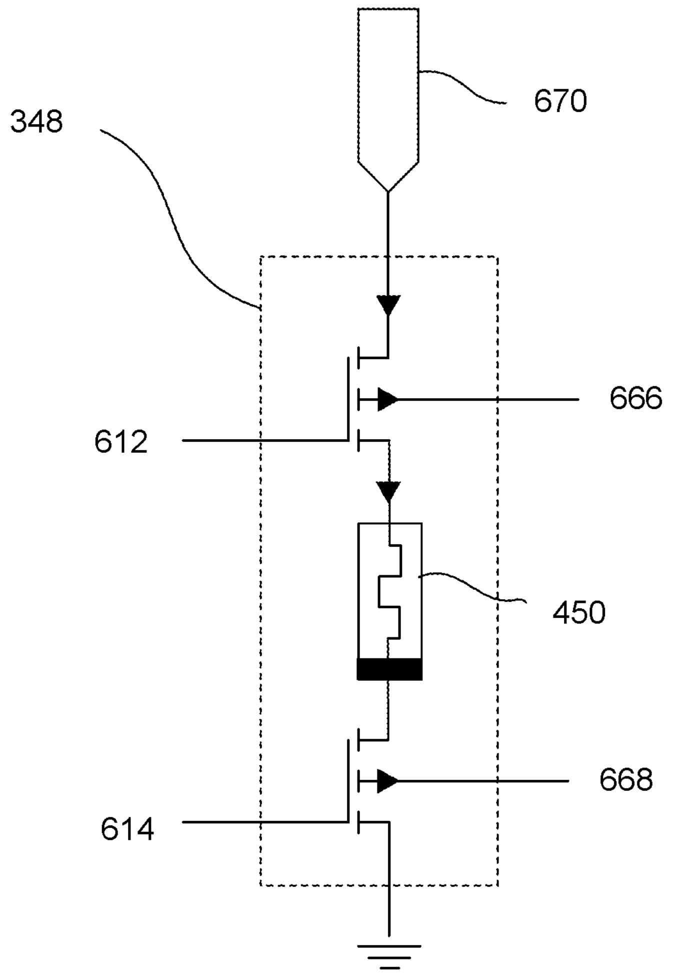

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/063093

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/175(2006.01)i, B41J 2/135(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J 2/175; G06F 12/02; G11C 7/10; G11C 7/00; B41J 2/07; B41J 29/38; G11C 11/00; B41J 2/135

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: printhead, cartridge, row, column, memristive, memristor, transistor, selector, nozzle

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2013-0106930 A1 (LEA et al.) 02 May 2013 See abstract, paragraphs [0015]-[0025], [0031], [0032], and figures 1-5C.	10-15 1-9
Y	US 2013-0278656 A1 (GOVYADINOV et al.) 24 October 2013 See paragraphs [0030]-[0032] and figure 2.	1-9
A	US 2014-0215121 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 31 July 2014 See paragraphs [0023], [0059]-[0066] and figures 7-9.	1-15
A	US 2013-0070534 A1 (CARTER et al.) 21 March 2013 See paragraphs [0043]-[0045] and figures 1, 2, 5A-5D.	1-15
A	US 2013-0100727 A1 (ORDENTILICH et al.) 25 April 2013 See abstract, claims 1, 4, 5, and figure 1.	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 July 2015 (31.07.2015)	**07 August 2015 (07.08.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
KIM, Jin Ho
Telephone No. +82-42-481-8699

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/063093

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013-0106930 A1	02/05/2013	US 8882217 B2	11/11/2014
US 2013-0278656 A1	24/10/2013	US 8899709 B2	02/12/2014
US 2014-0215121 A1	31/07/2014	US 9070436 B2	30/06/2015
US 2013-0070534 A1	21/03/2013	US 8681579 B2 WO 2012-091691 A2 WO 2012-091691 A3	25/03/2014 05/07/2012 27/12/2012
US 2013-0100727 A1	25/04/2013	US 8537596 B2	17/09/2013