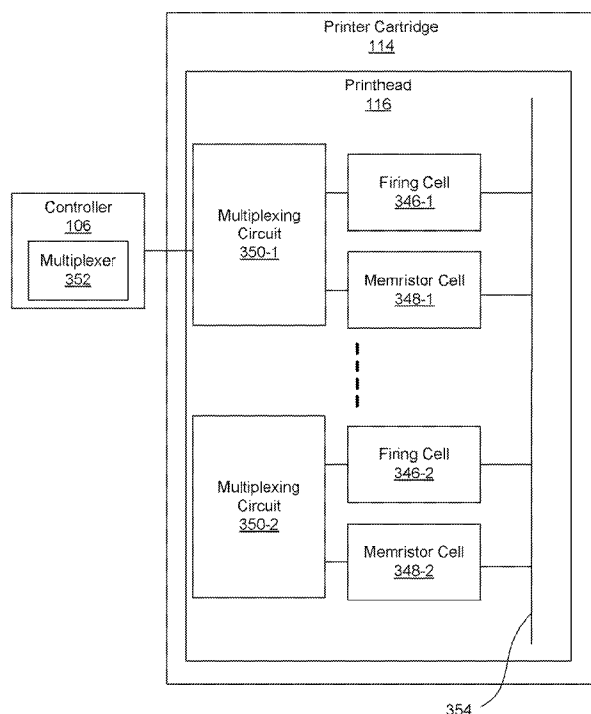




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(54) **Title:** PRINthead WITH A NUMBER OF MEMRISTOR CELLS AND A NUMBER OF FIRING CELLS COUPLED TO A SHARED FIRE LINE

**Fig. 3**

(57) **Abstract:** A printhead with a number of memristor cells and a number of firing cells coupled to a shared fire line is described. The printhead includes a number of firing cells to deposit an amount of fluid onto a print medium. Each firing cell 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 number of memristor cells to store information, a multiplexing circuit to select at least one memristor cell and at least one firing cell based on at least one control signal, and a shared fire line to activate the selected memristor cell and the selected firing cell.



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PRINthead WITH A NUMBER OF MEMRISTOR CELLS AND A NUMBER OF FIRING CELLS COUPLED TO A SHARED FIRE LINE

BACKGROUND

[0001] A memory system may be used to store data. 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 according to one example of the principles described herein.

[0004] Fig. 2A is a diagram of a printer cartridge with a number of memristor cells and a number of firing cells coupled to a shared fire line 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 memristor cells and a number of firing cells coupled to a shared fire line 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 memristor cells and a number of firing cells coupled to a shared fire line according to another example of the principles described herein.

[0007] Fig. 4 is a circuit diagram of a firing cell and a memristor cell coupled to a shared fire line according to one example of the principles described herein.

[0008] Fig. 5 is a diagram of a printhead with multiple memristor cells and multiple firing cells coupled to multiple shared fire lines according to one example of the principles described herein.

[0009] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements.

DETAILED DESCRIPTION

[0010] 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.

[0011] For example, an increasing trend in counterfeiting may lead to current memory devices 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.

[0012] 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.

[0013] 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.

[0014] For example, a printhead may include a number of large memory banks, all memory banks being controlled by a single control line such as an identification (ID) line. Given the size of the large memory banks and the number of memory banks on a printhead, the memory banks and associated routing lines (i.e., ID line) may take up valuable space on the printhead. Moreover, addressing a large memory bank with a single control line may be slow and cumbersome.

[0015] According, the present specification describes a printhead that alleviates these, and other, complications. More specifically, the printhead includes a number of memristor cells that, along with a number of firing cells, are coupled to and activated by a shared fire line. More specifically, a firing cell and memristor cell may be selected via a multiplexing circuit, and may be activated by the shared fire line.

[0016] Specifically, the present disclosure describes a printhead with a number of memristor cells and a number of firing cells coupled to a shared fire line. The printhead includes a number of firing cells to deposit an amount of

fluid onto a print medium. Each firing cell includes 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. The printhead also includes a number of memristor cells to store information. A multiplexing circuit selects at least one memristor cell and at least one firing cell based on at least one control signal and a shared fire line activates the selected memristor cell and the selected firing cell.

[0017] The present disclosure describes a printer cartridge with a number of memristor cells and a number of firing cells coupled to a shared fire line. The cartridge includes a fluid supply and a printhead to deposit fluid from the fluid supply onto a print medium. The printhead includes a number of firing cells to eject the amount of fluid from the fluid supply onto a print medium, a number of memristor cells to store information, a multiplexing circuit to select at least one memristor cell and at least one firing cell and a shared fire line to activate the selected memristor cell and the selected firing cell.

[0018] A printer cartridge and a printhead that utilize a memristor cell and a firing cell that are both coupled, and activated by, a shared fire line may be beneficial by providing a faster reading operation as the printhead contains more fire lines than identification lines and a more efficient memory storage by utilizing components presently situated on a printhead. For example, the shared fire line may execute a fire line operation such as providing power to an ejector such as a firing resistor. The shared fire line may also execute an identification line operation such as reading and writing information to memory. More specifically, the printhead may utilize fire lines to read from and write to the memristor cell. Doing so may reduce the footprint of a memristor cell by reducing the routing traces on the printhead. More specifically, the printhead of the present specification, instead of having separate routing mechanisms for the activation of the memristor cells and firing cells, may utilize a single routing mechanism (i.e., the shared fire lines) to activate both the memristor cells and the firing cells.

[0019] Moreover, utilizing the fire lines, which may be more numerous than an ID line, may improve the reading and writing time of the printhead. For

example, while a printhead may have one ID line, the printhead may have multiple fire lines. Accordingly, the printhead may contain the same amount of storage but may reduce the time to read and write based on the number of additional lines (i.e., fire lines) used to activate the memristor cells.

[0020] 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 or a desired three-dimensional geometry.

[0021] 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.

[0022] 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.

[0023] 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.

[0024] Further, 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. A memristor cell may refer to a memristor element that includes any number of memristors. For example, a memristor cell may include an array of memristors. In another example, a memristor cell may include a single memristor.

[0025] Still further, as used in the present specification and in the appended claims, the term "activated," "activate," or similar terminology refers to a memristor cell or a firing cell that is performing a function relative to the cell. For example, an active firing cell is one that is performing the ejection of fluid from the printhead. Similarly, an active memristor cell is one that is being read from, or written to.

[0026] Yet 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 including 1 to infinity; zero not being a number, but the absence of a number.

[0027] 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.

[0028] Turning now to the figures, Fig. 1 is a diagram of a printing system (100) according to one example of the principles described herein. The printing system (100) includes a printer (104). The printer (104) includes an interface with a computing device (102). The interface enables the printer (104) and specifically the processor (108) to interface with various hardware elements, such as the computing device (102), external and internal to the printer (104). 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.

[0029] In general, the computing device (102) may be any source from which the printer (104) may receive data describing a print job to be executed by the controller (106) of the printer (104) in order to print an image 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 printer (104) 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 print job for the printer (104) and includes print job commands and/or command parameters.

[0030] A controller (106) of the printer (104) includes a processor (108), a data storage device (110), and other electronics for communicating with and controlling the printhead (116), mounting assembly (118), and media transport assembly (120). The controller (106) receives data from the computing device (102) and temporarily stores data in the data storage device (110).

[0031] The controller (106) controls the printhead (116) in ejecting fluid from the firing cells (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 a printer (104) application specific integrated circuit (ASIC) to determine the level of fluid in the printhead (116) based on resistance values of memristors integrated on the printhead (116). The printer 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.

[0032] 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 printing on the print medium (126), and actuating the mounting assembly (118) and the media transport assembly (120) according to the present specification. 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 printer (104).

[0033] 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.

[0034] 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).

[0035] 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, but not limited to, 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.

[0036] The printing system (100) includes a printer cartridge (114) that includes a printhead (116), a reservoir (112), and a conditioning assembly (132). The printer cartridge (114) may be removable from the printer (104) for example, as a replaceable printer cartridge (114).

[0037] The printer cartridge (114) includes a printhead (116) that ejects drops of fluid through a plurality of firing cells (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.

[0038] Firing cells (124) may be arranged in columns or arrays such that properly sequenced ejection of fluid from the firing cells (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 firing cells (124) fired may be a number less than the total number of firing cells (124) available and defined on the printhead (116).

[0039] The printer cartridge (114) also includes a fluid reservoir (112) to supply an amount of fluid to the printhead (116). In general, fluid flows from the reservoir (112) to the printhead (116), and the reservoir (112) and the

printhead (116) form a one-way fluid delivery system or a recirculating fluid delivery system. In a one-way fluid delivery system, fluid supplied to the printhead (116) is consumed during printing. In a recirculating fluid delivery system, however, a portion of the fluid supplied to printhead (116) is consumed during printing. Fluid not consumed during printing is returned to the reservoir (112).

[0040] The reservoir (112) may supply fluid under positive pressure through a conditioning assembly (132) to the printhead (116) via an interface connection, such as a supply tube. The reservoir (112) may include pumps and pressure regulators. Conditioning in the conditioning assembly (132) may include filtering, pre-heating, pressure surge absorption, and degassing. Fluid is drawn under negative pressure from the printhead (116) to the reservoir (112). The pressure difference between the inlet and outlet to the printhead (116) is selected to achieve the correct backpressure at the firing cells (124).

[0041] A mounting assembly (118) positions the printhead (116) relative to media transport assembly (120), and media transport assembly (120) positioning the print medium (126) relative to printhead (116). Thus, a print zone (128), indicated by the dashed box, is defined adjacent to the firing cells (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 (118) includes a carriage for moving the printhead (116) relative to the media transport assembly (120) to scan the print medium (126). In another example, the printhead (116) is a non-scanning type printhead (116). As such, the mounting assembly (118) fixes the printhead (116) at a prescribed position relative to the media transport assembly (120). Thus, the media transport assembly (120) 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 memristors having parallel current distributors according to one example of the principles described herein. As discussed above, the printhead (116) may comprise a number of firing cells (124). In some examples, the printhead (116) may be broken up into a number of print dies with each die

having a number of firing cells (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 that is integral to the carriage of a printer (Fig. 1, 104). When the printer cartridge (114) is correctly installed, the conductive pads (238) are pressed against corresponding electrical contacts in the cradle, allowing the printer (Fig. 1, 104) to communicate with, and control the electrical functions of, the printer cartridge (114). For example, the conductive pads (238) allow the printer (Fig. 1, 104) 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 create an image, the printer (Fig. 1, 104) moves the carriage containing the printer cartridge (114) over a print medium (Fig. 1, 126). At appropriate times, the printer (Fig. 1, 104) 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). These droplets combine to form an image on the surface of the print medium (Fig. 1, 126).

[0047] The printhead (116) may include any number of firing cells (124). In an example where the fluid is an ink, a first subset of firing cells (124) may eject a first color of ink while a second subset of firing cells (124) may eject a second color of ink. Additional groups of firing cells (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 memristors disposed on enclosed gate transistors 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. 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 surface. 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 firing cells (124). For simplicity, Fig. 2B indicates a single firing cell (124), however a number of firing cells (124) are present on the printhead (116). A firing cell (124) may include an ejector (242), a firing chamber (244), and an opening (222). The opening (222) 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 an opening (222) from a firing chamber (244), 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 (222) and onto the print medium (Fig. 1, 126). As the vaporized fluid bubble pops, a vacuum pressure within the firing chamber (244) draws fluid 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 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 (222) and onto the print medium (Fig. 1, 126). In this example, the printhead (116) may be a piezoelectric inkjet printhead.

[0052] The printhead (116) and printer cartridge (114) may also include other components to carry out various functions related to printing. 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). In some examples, the printer cartridge (114) is removable from a printing system for example, as a disposable printer cartridge.

[0053] Fig. 3 is a block diagram of a printer cartridge (114) that uses a printhead (116) with a number of memristor cells (348-1, 348-2) and a number of firing cells (346-1, 346-2) coupled to a shared fire line (354) 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 firing cells (346). The printhead (116) ejects drops of fluid from the openings (Fig. 2, 222) of the firing cells (346) 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 (TIJ) printhead or a piezoelectric inkjet (PIJ) printhead, among other types of printhead (116).

[0054] In a printhead (116), the firing cell (346) is a component that performs the ejection of fluid, such as ink from the printhead (116). The firing cell (346) may include a number of components to carry out this functionality. For example, the firing cell (346) may include a number of ejectors (Fig. 2, 242) such as resistors and piezoelectric components that vaporize liquid ink in the firing chamber (Fig. 2, 244) or via pressure, push liquid ink out of the opening (Fig. 2, 222). The firing cell (346) may also include a number of firing transistors that provide an energy pulse to the number of ejectors (Fig. 2, 242). For example, the firing transistor may be a high current transistor such as a power field effect transistor (powerFET). In this powerFET, a large current such as 1.0 to 1.5 Amperes (A) may pass through the transistor and heat up the ejector (Fig. 2, 242) in the case of a thermal inkjet, or that cause the ejector (Fig. 2, 242) to change shape in the case of a piezoelectric ejector and by so doing, causes the ink to be dispensed through the opening (Fig. 2, 222). The firing cell (346) may include any number of firing transistors and ejectors (Fig. 2, 242). Moreover, while Fig. 3 depicts two firing cells (346), any number of firing cells (346) may be present on the printhead (116) as described below in connection with Fig. 5

[0055] The printhead (116) also includes a number of memristor cells (348) to store information. As used in the present specification a memristor cell (348) may refer to any combination of memristor storage devices. For example, a memristor cell (348) may refer to a memristor array that includes a number of memristors arranged in an array such as a cross bar array. In another example, the memristor cell (348) may refer to a single memristor as depicted below in Fig. 4.

[0056] As described above, a memristor is a circuit element that may be used to store information by placing the memristor in different resistance states. In other words, to store information, each memristor 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).

[0057] A memristor has a metal-insulator-metal layered structure. More specifically, the memristor may include a bottom electrode (metallic), an insulating or semiconducting layer, and a top electrode (metallic). A memristor

may be classified as an anion or a cation device. In an anion based device, the insulating layer is typically an oxide material. Examples of such oxide insulators include transition metal oxides, complex oxides, and large band gap dielectrics in addition to other non-oxide materials. An aluminum copper silicon oxide or tantalum oxide may be examples of a switching oxide in an anion device. In these devices, the switching mechanism is the oxygen vacancies in the oxide that are positively charged. By comparison, in a cation based device the electrodes (i.e., the bottom electrode, the top electrode, or combinations thereof) are formed from an electrochemically active metal such as copper or silver. In these devices, the insulating layer is usually an electrolyte material, such as arsenic trisulfide, but it can be oxide, such as silicon dioxide.

[0058] The memristor cell (348) may be used to store any type of data. Examples of data that may be stored in the memristor cell (348) 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), ink drop weight, firing frequency, initial printing position, acceleration information, and gyro information, among other forms of data. In a number of examples, the memristor cell is written at the time of manufacturing and/or during the operation of the printer cartridge (114).

[0059] As described, the memristor cell (348) may include any number of memristors ranging from a single memristor to a number of memristors organized in an array. Accordingly, the number of firing transistors in a firing cell (346) may be different from the number of memristors in a memristor cell (348). For example, a single firing transistor may be coupled to multiple memristors. Similarly, a single memristor may be coupled to a number of firing transistors.

[0060] In some examples, the printer cartridge (114) includes a number of multiplexing circuits (350-1, 350-2) that receive control signals from an external computing device (Fig. 1, 102). The multiplexing circuits (350) select at least one memristor cell (348) and at least one firing cell (346) based

on at least one control signal. More specifically, the multiplexing circuit (350) may receive a control signal from the controller (106). An address generator in the multiplexing circuit may generate an address based on the control signal, which address is used by a decoder within the multiplexing circuit (350) to select at least one memristor cell (348) and at least one firing cell (346). For example, as will be described below, the multiplexing circuits (350) may receive a first control signal from a controller (106) that indicates that a particular memristor cell (348) should be activated. That is, the control signal may identify a particular memristor cell (348) such that the memristor cell (348) may either have data written to the memristor cell (348) or data read from the memristor cell (348). In this example, the multiplexing circuit (350) selects the particular memristor cell (348) to be activated. At another point in time, the multiplexing circuit (350) may receive a second control signal from the controller (106) that indicates that a particular firing cell (346) should be activated. That is, the control signal may identify a particular firing cell (346) wherein an ejector (Fig. 2, 242) in that firing cell (346) is to be heated or changed in shape to dispense ink through the opening (Fig. 2, 222).

[0061] The multiplexing circuit (350) may select the firing cell (346) and memristor cell (348) simultaneously or at different periods in time. For example, the multiplexing circuit (350) may receive a first control signal at a first point in time. In this example, corresponding to this first point in time, the multiplexing circuit (350) may select the memristor cell (348) and the shared fire line (354) may activate the memristor cell (348). At a second and distinct point in time, the multiplexing circuit (350) may receive a second control signal. Corresponding to this second point in time, the multiplexing circuit (350) may select the firing cell (346) and the shared fire line (354) may activate the firing cell (346).

[0062] As described above, the multiplexing circuit (350) may receive a signal from a controller (106). The controller (106) may be an Application-Specific Integrated Circuit (ASIC) found on a computing device (Fig. 1, 102) external to the printer cartridge (114). For example, the controller (106) may be found on the printer (Fig. 1, 104). The controller (106) may facilitate storing

information to the memristor cells (348). Specifically, the controller (106) may pass at least one control signal to the multiplexing circuit (350), which control signal is to be passed to the number of memristor cells (348) and the number of firing cells (346).

[0063] A specific example of a controller (106) passing a control signal to select a memristor cell (348) and a firing cell (346) is given as follows. In one example, the controller (106) sends a first control signal to the multiplexing circuit (350). The first control signal may select a memristor cell (348) that is to be activated, or that is to be read from or written to. More specifically, if an operation is carried out in which a particular memristor cell (348) is to be switched from a high resistance state to a low resistance state, the controller (106) may pass a signal to the multiplexing circuit (350) so indicating. The multiplexing circuit (350) may then carry out a number of functions, such as address generation and decoding, to select the memristor cell (348) such that it may be read from or written to, by the shared fire line (354).

[0064] The controller (106) may also send a second control signal to the multiplexing circuit (350). The second control signal may select a firing cell (346) that is to be activated, or that is to be used in the ejection of fluid from the printer cartridge (300). More specifically, if a particular ejector (Fig. 2, 242) is to be used to eject ink, the controller (106) may pass a signal to the multiplexing circuit (350) so indicating. The multiplexing circuit (350) may then carry out a number of functions, such as address generation and decoding, to select a firing transistor within the firing cell (346) such that the firing transistor receives energy from the shared fire line (354) and the ejector (Fig. 2, 242) ejects fluid from the fluid supply (Fig. 1, 112) onto the print medium (Fig. 1, 126).

[0065] As described above, a printhead (116) may include a number of multiplexing circuits (350), firing cells (346), memristor cells (348), and shared fire lines (354). To this end, the controller (106) may include a multiplexer (352) that selects a firing cell (346) from among multiple firing cells (346) to activate. For example, a single second control signal may be generated. The multiplexer (352) may include circuitry that processes the second control signal, and passes

it to the multiple multiplexing circuit (350), the multiplexing circuit (350) then process the signal to select a corresponding firing cell (346).

[0066] The printhead (116) also includes a shared fire line (354) that selectively activates the memristor cell (348) and the firing cell (346) that are selected by the multiplexing circuit (350). More specifically, if a particular firing cell (346) is selected, the shared fire line (354) may supply energy to a firing resistor such that the ejector (Fig. 2, 242) may be heated up, changed in shape, or otherwise manipulated to eject ink from the opening (Fig. 2, 246). Similarly, if a particular memristor cell (348) is selected, the shared fire line (354) may write data to or read data from the memristor cell (348). More specifically, the shared fire line (354) may supply a voltage that would switch a resistance state of a memristor within the memristor cell (348).

[0067] While Fig. 3 depicts two multiplexing circuits (350-1, 350-2), two firing cells (346-1, 346-2), and two memristor cells (348-1, 348-2), the printhead (116) may include any number of these elements. In this example, the multiple multiplexing circuits (350) may each receive a control signal from a controller (106) and may process the control signal to determine whether the corresponding firing cell (346) or memristor cell (348) are to be activated.

[0068] Coupling both the firing cell (346) and the memristor cell (348) to the shared fire line (354) has a number of advantages. For example, the printhead (116) of the current specification is more efficient in that it removes additional routing elements. More specifically, a separate control line for the memristor cell (348) is not used as the memristor cell (348) is controlled by the shared fire line (354). This reduced routing structure reduces the space on a printhead (116) that is occupied by a memory element and frees that space up to be used by other components. Moreover, the reduced routing also likely results in a lower cost of fabrication as well.

[0069] Moreover, as described above, a printhead (116) may have more fire lines (354) than identification (ID) lines, accordingly, using the fire lines (354) as opposed to the ID lines, to activate the memristor cells (348) may speed up read and write times. More specifically, relying on a single ID line to address a large memory block may consume valuable processing time. By

comparison, using multiple shared fire lines (354) to address smaller memory arrays that total the same amount of storage as the memory block, allows for faster read and write times.

[0070] Still further, the printhead (116) as depicted in Fig. 3 and other figures may be beneficial in that it may be backwards compatible with circuitry in a printhead (116). For example, a fire line (354) and a multiplexer (352) may be present in a number of printheads (116). In this example, the printhead (116) with the multiplexing circuit (350) and firing cell (346) and memristor cell (348) may be backward compatible with the existing fire line (354), controller (106), and multiplexer (352).

[0071] Fig. 4 is a circuit diagram of a firing cell (346) and a memristor cell (348) coupled to a shared fire line (354) according to one example of the principles described herein. As depicted in Fig. 4, the firing cell (346) is indicated by a dashed box. As described above, the firing cell (346) may include a number of ejectors (Fig. 2, 242). Specific examples have been given of thermal inkjet printheads (Fig. 1, 116) which use a firing resistor (462) such as the one depicted in Fig. 4 to vaporize ink within a fluid reservoir (Fig. 1, 112) to expel a portion of ink from the fluid supply (Fig. 1, 112) through the opening (Fig. 2, 222). Accordingly, a firing cell (346) may include a firing resistor (462) to heat up and vaporize the fluid in the fluid supply (Fig. 1, 112). While Fig. 4 depicts a firing resistor (462), the ejector (Fig. 2, 242) may be a number of other components such as a piezoelectric component that changes shape in response to an applied voltage. Similarly, the ejector (Fig. 2, 242) may be any other component that physically ejects a fluid, such as ink, onto a surface and the present specification may be implemented with any number and type of ejector (Fig. 2, 242).

[0072] The firing cell (346) may also include a number of firing transistors (460) that supply energy to the ejector (Fig. 2, 242). For example, in the thermal inkjet device of Fig. 4, the firing transistor (460) may allow a voltage to be applied to the firing resistor (462) such that the firing resistor (462) heats up. In the case of a piezoelectric device, the firing transistor (460) may allow a voltage to be applied to a piezoelectric material such that the piezoelectric

material changes shape in response to the voltage thereby creating a pressure pulse that ejects ink from the opening (Fig. 2, 222).

[0073] A transistor is a device that regulates current and acts as a switch for electronic signals. For example, a transistor may allow current to flow to the firing resistor (462), which allows the firing resistor (462) to eject fluid from the printhead (Fig. 1, 116) as described above. A transistor may include a source, a gate, and a drain. Electrical current flows between the source to the drain based on an applied voltage at the gate. For example, when no voltage is applied at the gate, no current flows between the source and the drain. By comparison, when there is an applied voltage at the gate, current readily flows between the source and the drain. In this example, the gate may be coupled to the multiplexing circuit (350). In other words, the multiplexing circuit (350) selects a firing cell (346) by allowing current to flow between the shared fire line (354) and ground.

[0074] The firing transistor (460) may be a transistor that handles a large amount of power. For example, the firing transistor (460) may be a power metal oxide semiconductor field effect transistor (powerFET). Using a transistor that handles a large amount of power may be beneficial in that an ejector (Fig. 2, 242) such as a firing resistor (462) may use a lot of energy to eject fluid, such as ink, from the printhead (Fig. 1, 116).

[0075] As depicted in Fig. 4, the memristor cell (348) is indicated by a dashed box. As described above, the memristor cell (348) may include a number of memristors (458). A memristor (458) may be a circuit component that stores information based on a resistance state of the memristor (458). For example, a memristor (458) may be in a low resistance state which low resistance state is associated with a logical value of "0." The memristor (458) may also be in a high resistance state which high resistance state is associated with a logical value of "1." A number of memristors (458) in different states may form a string of 1s and 0s which represent stored information. While Fig. 4 depicts a single memristor (458), the memristor cell (348) may include a number of memristors (458), such as memristors (458) in a cross bar array.

[0076] The memristor cell (348) may also include a number of selection transistors (456) that allow a memristor (458) to be accessed by the shared fire line (354). In other words, the selection transistor (456) identifies a memristor (458) and the fire line (354) may then read data from, or write data to, the identified memristor (458).

[0077] As described above, a transistor is a device that regulates current and acts as a switch for electronic signals. For example, a transistor may allow current to flow to the memristor cell (348), which allows the shared fire line (354) to read information from, or write information to the memristor (458). A transistor may include a source, a gate, and a drain. Electrical current flows between the source to the drain based on an applied voltage at the gate. For example, when no voltage is applied at the gate, no current flows between the source and the drain. By comparison, when there is an applied voltage at the gate, current readily flows between the source and the drain. In this example, the gate may be coupled to the decoder (350). In other words, the multiplexing circuit (350) selects a memristor cell (348) by closing the gate. The memristor (458) may then be activated by allowing current to flow through the memristor (458).

[0078] Fig. 5 is a diagram of a printhead (116) with multiple memristor cells (348) and multiple firing cells (346) coupled to multiple shared fire lines (354) according to one example of the principles described herein. As described above, in some examples, the printhead (116) includes multiple memristor cells (348-1, 348-2, 348-3, 348-4) and multiple firing cells (346-1, 346-2, 346-3, 346-4). The printhead (116) may include multiple shared fire lines (354-1, 354-2) that are coupled to the multiple memristor cells (348) and multiple firing cells (346). More specifically, each shared fire line (354) may be coupled to at least one memristor cell (348) and at least one firing cell (346). In this example, the controller (106), via the multiplexer (352), sends a first control signal to select a memristor cell (348) and sends a second control signal to select a firing cell (346) to both decoders (350-1, 350-2). The multiplexing circuits (Fig. 3, 350) may then process the control signals and may select a memristor cell (348), firing cell (346), or combinations thereof based on the first

control signal, the second control signal, or combinations thereof. Specifically, an address generator (564) may receive the control signals from the controller (106) and pass them to a number of decoders (566). The decoders (566-1, 566-2) then decode the addresses from the address generator (564) and select at least one memristor cell (348) and at least one firing cell (346).

[0079] In this example, a large memory block may be divided into the smaller memristor cells (348). The smaller memristor cells (348) allow the memory to be read faster than if all memory were concentrated in a single location. Additionally, the multiple shared fire lines (354) may be beneficial by allowing memory to be accessed in parallel, i.e., multiple memristor cells (348) may be accessed at the same time as opposed to a single memory block being accessed individually. Moreover, while Fig. 5 depicts a specific number of address generators (564), decoders (566) shared fire lines (354), firing cells (346), and memristor cells (348), any number of any component may be used in the printhead (116).

[0080] A printer cartridge (Fig. 1, 114) and printhead (Fig. 1, 116) with a number of memristor cells (Fig. 3, 348) and a number of firing cells (Fig. 3, 346) coupled to a shared fire line (Fig. 3, 354) may have a number of advantages, including: (1) being backward compatible with components on a printhead (Fig. 1, 116); (2) reducing the overall routing structure of the printhead (Fig. 1, 116); (3) reducing the footprint of memory storage on a printhead (Fig. 1, 116); (4) improving read and write times from and to the printhead (Fig. 1, 116); (5) enlarging memory storage capability on the printhead (Fig. 1, 116); and (5) reducing the cost of fabrication of the printhead (Fig. 1, 116).

[0081] 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 printer (Fig. 1, 104) 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.

[0082] 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

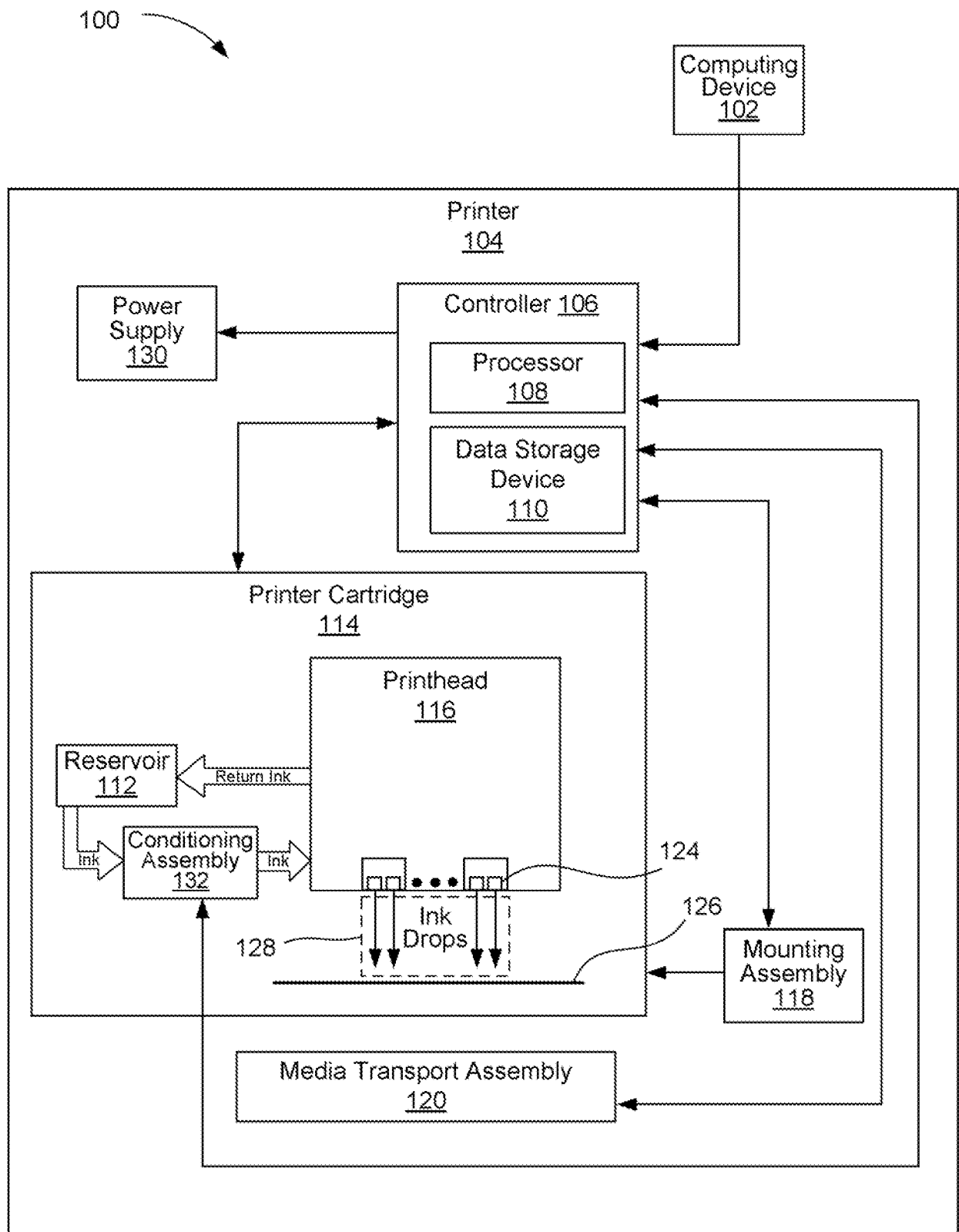
WHAT IS CLAIMED IS:

1. A printhead with a number of memristor cells and a number of firing cells coupled to a shared fire line, the printhead comprising:
 - a number of firing cells to deposit an amount of fluid onto a print medium, each firing cell comprising:
 - 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;
 - a number of memristor cells to store information;
 - a multiplexing circuit to select at least one memristor cell and at least one firing cell based on at least one control signal; and
 - a shared fire line to activate the selected memristor cell and the selected firing cell.
2. The printhead of claim 1, in which the fluid is inkjet ink.
3. The printhead of claim 1, in which the ejector is a power field effect transistor to provide an energy pulse to the ejector.
4. The printhead of claim 1, in which the printhead is coupled to a multiplexer to select the firing cell from among a number of firing cells on a printhead.
5. The printhead of claim 1, in which the memristor cell comprises a memristor array comprising multiple memristors.
6. The printhead of claim 1, in which the memristor cell comprises a memristor.

7. The printhead of claim 1, in which the shared fire line switches a resistance state of a memristor in the memristor cell.
8. A printer cartridge with a number of memristor cells and number of firing cells coupled to a shared fire line, the printer cartridge comprising:
 - a fluid supply; and
 - a printhead to deposit fluid from the fluid supply onto a print medium, the printhead comprising:
 - a number of firing cells to eject the fluid from the fluid supply onto a print medium;
 - a number of memristor cells to store information;
 - a multiplexing circuit to select at least one memristor cell and at least one firing cell based on at least one control signal; and
 - a shared fire line to activate the selected memristor cell and the selected firing cell.
9. The cartridge of claim 8, in which:
 - the fluid is inkjet ink;
 - the printer cartridge is an inkjet printer cartridge; and
 - the printhead is an inkjet printhead.
10. The cartridge of claim 8, in which the inkjet printhead is a thermal inkjet printhead.
11. The cartridge of claim 8, in which the multiplexing circuit receives at least one control signal from a controller.
12. The cartridge of claim 11, in which the multiplexing circuit receives:
 - a first control signal to select a memristor cell to activate; and
 - a second control signal to select a firing cell to activate.

13. The cartridge of claim 8, in which a number of firing transistors in a firing cell is different from a number of memristors in a memristor cell.
14. The cartridge of claim 8, in which the printhead includes multiple memristor cells and multiple firing cells.
15. The cartridge of claim 14, further comprising multiple shared fire lines, each shared fire line being coupled to at least one memristor cell and at least one firing cell.

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**Fig. 1**

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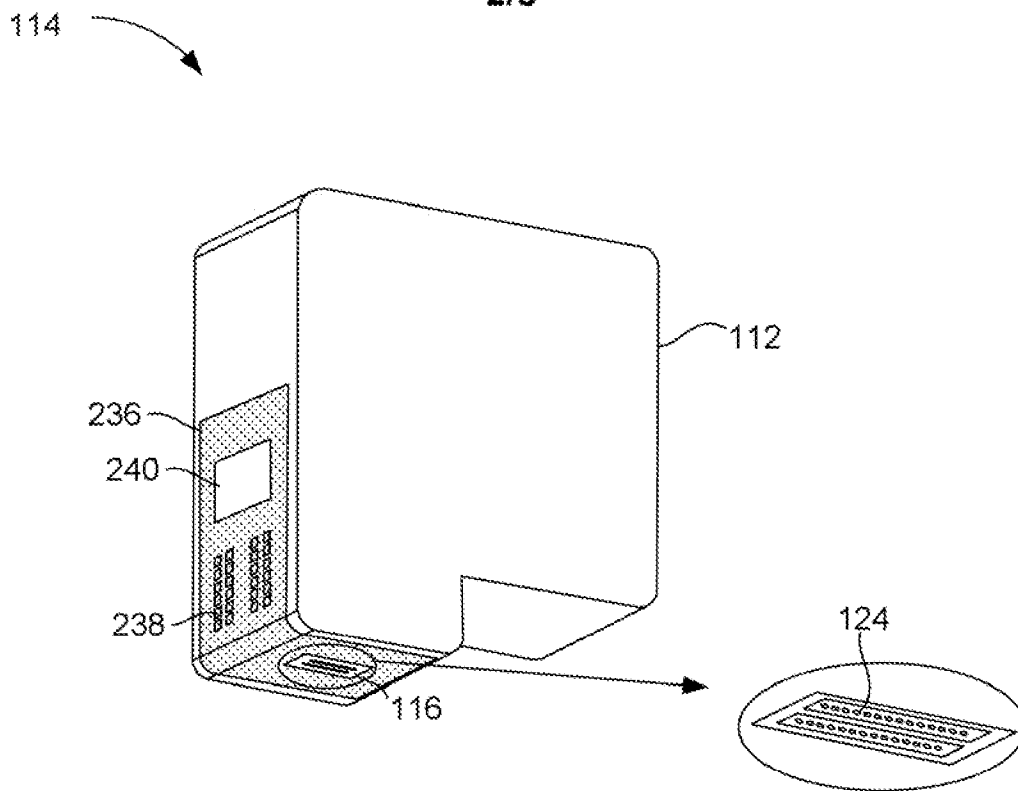


Fig. 2A

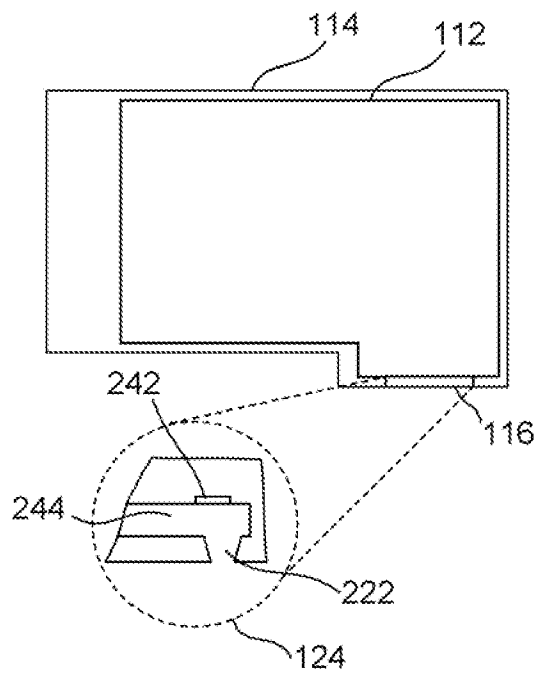
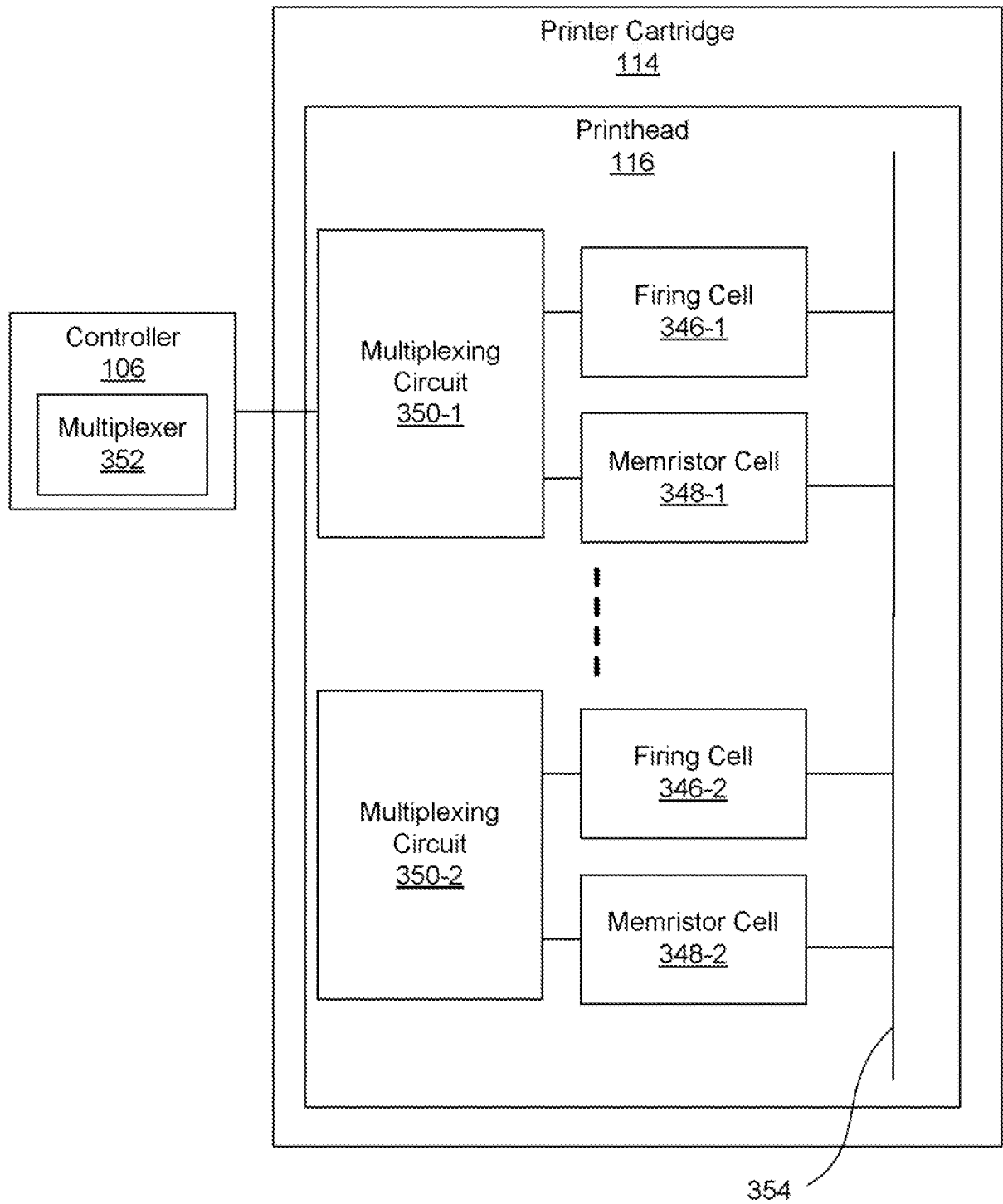
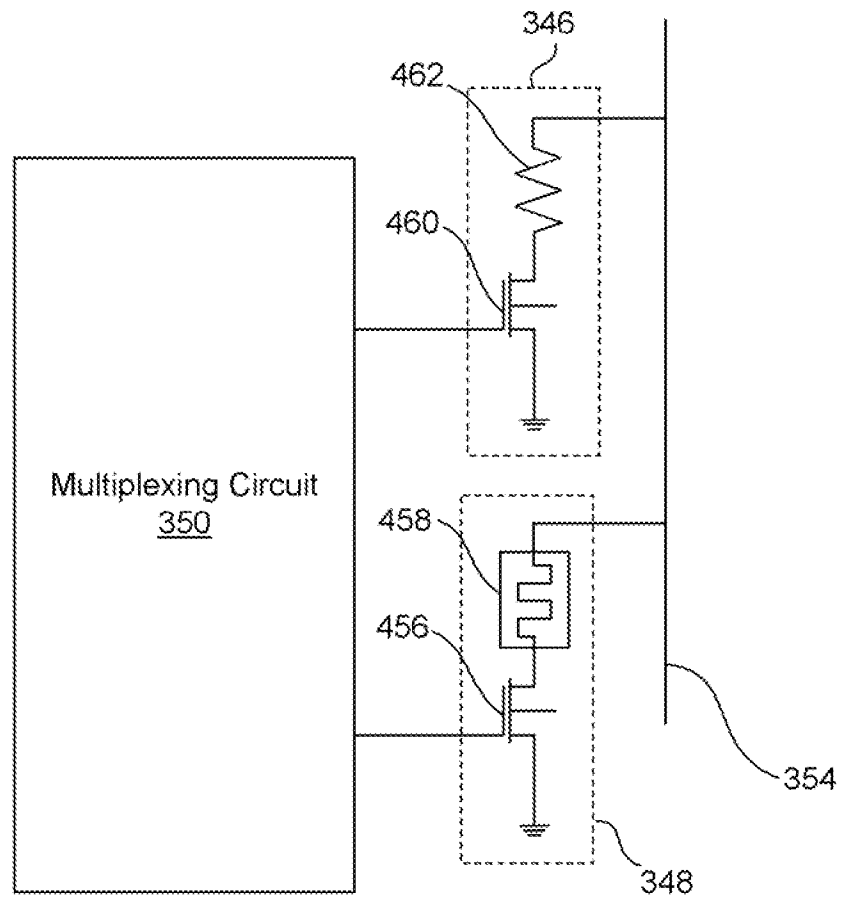


Fig. 2B

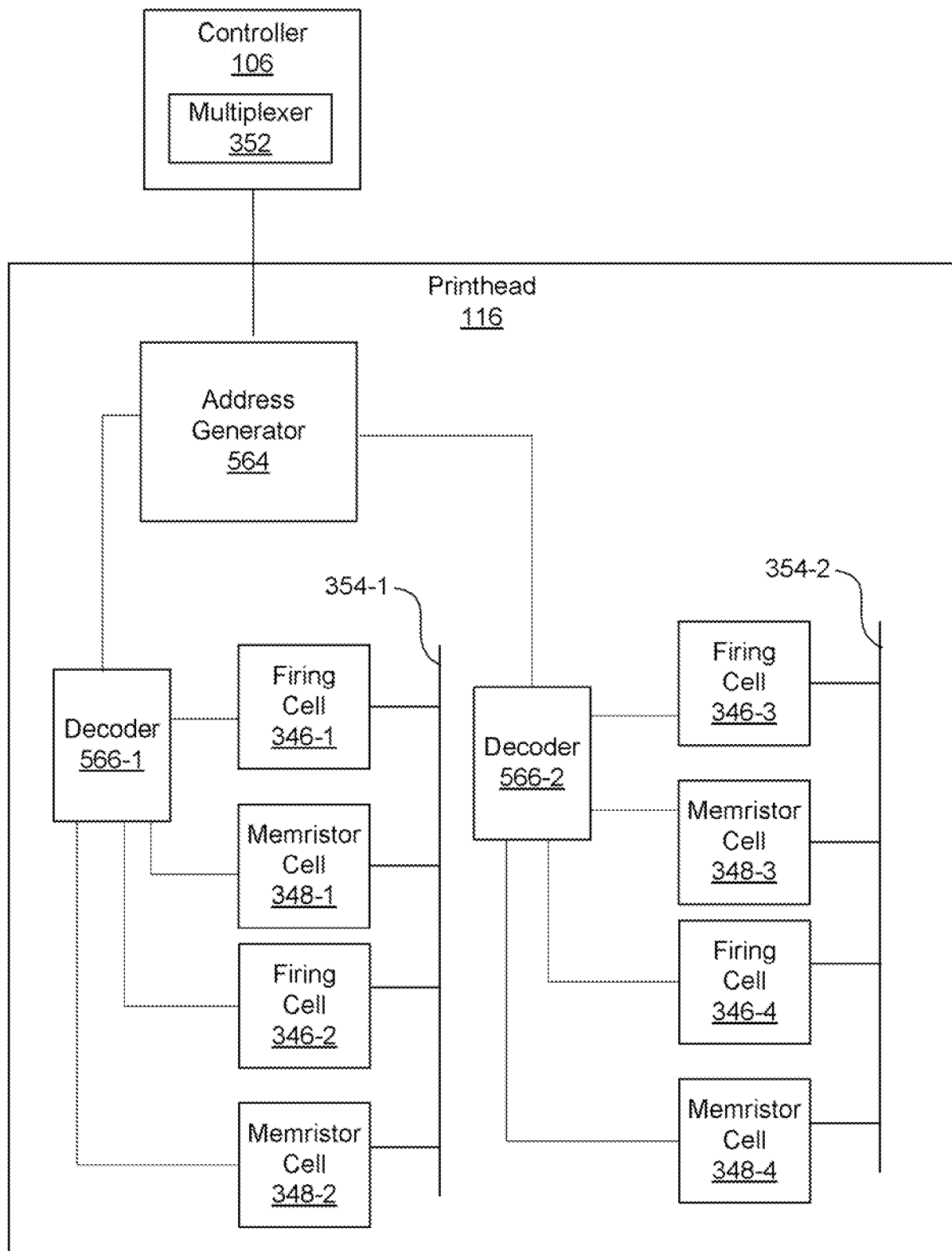
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**Fig. 3**

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**Fig. 4**

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**Fig. 5**

A. CLASSIFICATION OF SUBJECT MATTER**B41J 2/175(2006.01)i, B41J 2/14(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
B41J 2/175; B41J 214; B41J 2/04; B21D 53/76; B41J 205; B41J 2/07; B41J 29/38; B41J 2/14Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: memristor, firing cell, firing chamber, ejector, firing line, non-volatile memory, and printhead**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0284558 A1 (CERUTTI, WALTER) 19 November 2009 See abstract, paragraphs [0004], [0024], [0046]–[0057], and figures 1–1b.	1–15
Y	US 2011-0310181 A1 (CURCIO et al.) 22 December 2011 See abstract, paragraphs [0023]–[0024], and figure 1.	1–7
Y	US 2013-0106930 A1 (LEA et al.) 02 May 2013 See abstract, paragraphs [0014], [0022], and figures 1–2.	1–15
A	US 2009-0244132 A1 (BRUCE et al.) 01 October 2009 See abstract, paragraph [0068], and figure 9.	1–15
A	US 6808241 B2 (MACKENZIE et al.) 26 October 2004 See abstract, column 4, lines 24–56, and figure 3.	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

09 April 2015 (09.04.2015)

Date of mailing of the international search report

09 April 2015 (09.04.2015)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
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Republic of Korea

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/048263

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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