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### CONTACT-TYPE PATTERNING APPARATUS

#### Abstract

A contact-type patterning apparatus includes: a nozzle comprising an electrode configured to receive a voltage to generate an electric field toward a substrate, and configured to eject a fluid so that the fluid is connected to the substrate; a voltage supply configured to apply the voltage to the electrode; a screw-type pump configured to supply the fluid into the nozzle through a screw configured to receive power from a motor to rotate; a transfer part configured to transfer the nozzle or the substrate so that the fluid is patterned in a line shape; and a controller configured to control a level of the voltage applied through the voltage supply, an operation of the transfer part, and an operation of the pump.

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## **Background/Summary**

### **CROSS-REFERENCE TO RELATED APPLICATION**

[0001] The present application claims priority to and the benefit of Korean Patent Application No. 10-2024-0019772, filed on Feb. 8, 2024, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

### **BACKGROUND**

#### **1. Field**

[0002] Aspects of some embodiments of the present disclosure relate to a contact-type patterning apparatus.

#### **2. Description of the Related Art**

[0003] Processes of manufacturing LCDs, touch screen panels and the like involve various operations for forming fine patterns on substrates.

[0004] Etching techniques such as light exposure may be used as techniques for forming such fine patterns. However, in the etching techniques, spaces in which etching is performed need to be maintained in a vacuum state, and thus manufacturing time and manufacturing costs may increase.

[0005] Accordingly, inkjet printing techniques of spraying inks onto substrates to form patterns may be utilized. In inkjet printing techniques, as inks including electrode materials are sprayed onto objects to form patterns, the manufacturing costs may be relatively reduced. However, there may be a limitation that it may be difficult to utilize inks having a high viscosity to form patterns having a fine line width.

[0006] Meanwhile, contact-type printing apparatuses, in which inks dispensed from nozzles are in direct contact with objects to perform continuous line patterning in order to achieve the fine line width through the inkjet printing techniques may be utilized.

[0007] However, in a contact-type patterning method, as a patterning speed is increased, the inks may be disconnected without maintaining a contact state with objects to cause discontinuous sections. Accordingly, the continuous line patterning may be difficult to perform. For example, there may be a limitation that when the continuous patterning is formed, a line width or a thickness may not be constant in acceleration and deceleration sections around a start point and an end point of a pattern compared to an intermediate point.

[0008] The above information disclosed in this Background section is only for enhancement of understanding of the background and therefore the information discussed in this Background section does not necessarily constitute prior art.

### **SUMMARY**

[0009] Aspects of some embodiments of the present disclosure relate to a contact-type patterning apparatus, and for example, to a contact-type patterning apparatus that allows an ink ejected from a nozzle to be in direct contact with a substrate to perform continuous line patterning.

[0010] Aspects of some embodiments of the present disclosure may include a contact-type

patterning apparatus which uses a screw-type pump, and synchronizes and controls a voltage applied to a nozzle, a patterning rate, and an operation of the pump to be capable of performing a patterning process in a constant line width even with an ink having a high viscosity in a contact manner without a discontinuous section.

[0011] The characteristics of embodiments according to the present disclosure are not limited to the aforesaid, but other characteristics not described herein will be more clearly understood by those skilled in the art from descriptions below.

[0012] Aspects of some embodiments according to the present disclosure include a contact-type patterning apparatus including a nozzle which includes an electrode that receives a voltage to generate an electric field toward a substrate, and ejects a fluid so that the fluid is connected to the substrate, a voltage supply part which applies the voltage to the electrode, a screw-type pump which supplies the fluid into the nozzle through a screw that receives power from a motor to rotate, a transfer part which transfers the nozzle or the substrate so that the fluid is patterned in a line shape, and a controller which controls a level of the voltage applied through the voltage supply part, an operation of the transfer part, and an operation of the pump.

[0013] According to some embodiments, the controller may synchronize and control a transfer speed of the substrate or the nozzle by the transfer part and a rotation speed of the motor of the pump, and control the level of the voltage applied to the electrode from the voltage supply part according to the synchronized speed control.

[0014] According to some embodiments, in an acceleration section of the transfer part, in which the patterning starts, and a deceleration section of the transfer part, in which the patterning ends, the controller may synchronize and control the transfer speed of the substrate or the nozzle by the transfer part and the rotation speed of the motor of the pump, and control the level of the voltage applied to the electrode from the voltage supply part according to the synchronized speed control.

[0015] According to some embodiments, the substrate may be transferred in a stage moving manner, and the controller may control a movement speed of a stage, which supports the substrate, to control the transfer speed of the substrate.

[0016] According to some embodiments, the substrate may be transferred in a roll-to-roll manner, and the controller may control a rotation speed of a roll, which supports the substrate, to control the transfer speed of the substrate.

[0017] According to some embodiments, the substrate may be transferred in a conveyor manner, and the controller may control a movement speed of a conveyor, on which the substrate is seated, to control the transfer speed of the substrate.

[0018] According to some embodiments, a connecting portion between the motor of the pump and the screw may include an insulation material so that when the voltage supplied from the voltage supply part is blocked from being applied to the motor.

[0019] According to some embodiments, the fluid may have a viscosity of about 200,000 cP or less.

[0020] According to some embodiments, the contact-type patterning apparatus may further include a shape information providing part that provides three-dimensional surface shape information of the substrate. In consideration of a change in distribution of the electric field according to the three-dimensional surface shape information provided from the shape information providing part, the controller may control the level of the voltage applied to the electrode through the voltage supply part.

[0021] According to some embodiments, the contact-type patterning apparatus may further include a flow rate monitoring part that monitors a flow rate of the fluid ejected from the nozzle, and the flow rate monitoring part may include a camera that photographs the fluid ejected from the nozzle.

[0022] According to some embodiments, the pump may be a uniaxial eccentric screw pump.

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## Description

## BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The accompanying drawings are included to provide a further understanding of embodiments according to the present disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate aspects of some embodiments of the present disclosure and, together with the description, serve to explain aspects of some embodiments of the present disclosure. In the drawings:

[0024] FIG. 1 is a schematic view illustrating a configuration of a contact-type patterning apparatus according to some embodiments of the present disclosure;

[0025] FIG. 2 is a view illustrating a contact-type patterning apparatus in a conveyor manner according to some embodiments of the present disclosure;

[0026] FIG. 3 is a view illustrating a contact-type patterning apparatus in a roll-to-roll manner according to some embodiments of the present disclosure;

[0027] FIG. 4 is a view for comparing ejected shapes of inks according to control of a controller;

[0028] FIG. 5 is a view illustrating one example of a synchronization profile of a stage driving motor and a motor of a pump according to a patterning section;

[0029] FIG. 6 is a view illustrating a result of synchronizing a stage driving motor and a motor of a pump to perform a patterning process;

[0030] FIG. 7 is a view illustrating a result of synchronizing a stage driving motor and a motor of a pump and also controlling a level of a voltage applied to an electrode from a controller to perform patterning;

[0031] FIG. 8 illustrates a contact-type patterning apparatus for a substrate S having a three-dimensional surface according to some embodiments of the present disclosure; and

[0032] FIGS. 9 and 10 are views for describing a patterning operation of a contact-type patterning apparatus according to some embodiments of the present disclosure.

## DETAILED DESCRIPTION

[0033] In this specification, it will be understood that when an element (or region, layer, section, etc.) is referred to as being “on”, “connected to” or “coupled to” another element, it can be located directly on, connected or coupled to the other element or a third element may be located between the elements.

[0034] Like reference numbers or symbols refer to like elements throughout. In addition, in the drawings, the thickness, the ratio, and the dimension of elements are exaggerated for effective description of the technical contents.

[0035] The term “and/or” includes one or more combinations which may be defined by relevant elements.

[0036] It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element.

[0037] For example, a first element could be termed a second element without departing from the teachings of the present invention, and similarly, a second element could be termed a first element. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0038] In addition, the terms, such as “below”, “beneath”, “on” and “above”, are used for explaining the relation of elements shown in the drawings. The terms are relative concepts and are explained based on the direction shown in the drawing.

[0039] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless

expressly so defined herein.

[0040] It will be further understood that the terms such as “includes” or “has”, when used herein, specify the presence of stated features, numerals, steps, operations, elements, parts, or the combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, elements, parts, or the combination thereof.

[0041] Hereinafter, aspects of some embodiments of the present disclosure will be described in more detail with reference to the accompanying drawings.

[0042] FIG. 1 is a schematic view illustrating a configuration of a contact-type patterning apparatus according to some embodiments of the present disclosure. FIG. 2 is a view illustrating a contact-type patterning apparatus in a conveyor manner according to some embodiments of the present disclosure. FIG. 3 is a view illustrating a contact-type patterning apparatus in a roll-to-roll manner according to some embodiments of the present disclosure.

[0043] Referring to FIG. 1, the contact-type patterning apparatus DPA according to some embodiments of the present disclosure may include a nozzle **100**, a voltage supply part (or a voltage supply, or a power supply) **330**, a pump **200**, transfer parts **310** and **320**, and a controller **400**.

[0044] The contact-type patterning apparatus DPA according to some embodiments of the present disclosure may maintain a fluid LQ ejected from the nozzle **100** to be in contact with a substrate S so as to perform a patterning process in a continuous line shape.

[0045] The nozzle **100** may be located below the pump **200**. A stage **1000** may be located below the nozzle **100**. The substrate S that is a workpiece may be located on the stage **1000**. The substrate S may be located below the nozzle **100**.

[0046] The nozzle **100** may eject the fluid LQ dispensed from the pump **200** toward the substrate S. A meniscus M of the fluid LQ may be formed in an outlet in an end of the nozzle **100**.

[0047] According to the meniscus M formed in the end of the nozzle **100**, the fluid LQ may be substantially in contact with the end of the nozzle **100** and the substrate S together. When the nozzle **100** or the substrate S is transferred, the patterning process in a continuous line shape may be performed while the fluid LQ is maintained to be in contact with the substrate S.

[0048] An electrode may be provided inside the nozzle **100** according to some embodiments of the present disclosure. The electrode may be provided inside the nozzle **100** separately from the nozzle **100**. However, embodiments according to the present disclosure are not limited thereto, and the nozzle **100** itself may be made of a metallic material to provide the electrode.

[0049] When a high voltage is applied to the electrode from the voltage supply part **330**, an electric field may be generated toward the substrate S. For example, the stage **1000** may be grounded, and a high voltage may be applied from the voltage supply part to the electrode in the nozzle **100** or the high voltage may be applied to the metallic nozzle **100**, so that the electric field is generated toward the substrate S. As the voltage increases, strength of the electrical field may become greater.

[0050] Due to force of the electric field generated through the voltage applied to the electrode from the voltage supply part **330**, the fluid LQ supplied into the nozzle **100** from the pump **200** may be in contact with the substrate S in a state in which the meniscus M is formed in the end of the nozzle **100**.

[0051] Here, the contact between the meniscus M of the fluid LQ and the substrate S may be defined as a state in which, after the meniscus M is formed in the end of the nozzle **100**, the meniscus M of the fluid LQ is in contact with the substrate S by transferring the nozzle **100** in a direction that is close to the substrate S. However, embodiments according to the present disclosure are not limited thereto, and the contact between the meniscus M of the fluid LQ and the substrate S may be defined as a state in which, after the nozzle **100** and the substrate S are transferred to be close to each other, the meniscus M of the fluid LQ is formed in the end of the nozzle **100** and simultaneously the meniscus M of the fluid LQ is in contact with the substrate S.

[0052] A spaced distance between the nozzle **100** and the substrate S may be at least 50  $\mu\text{m}$  (or

about 50  $\mu\text{m}$ ) or less, but may be changed according to a diameter of the nozzle **100**, viscosity and surface tension of the fluid LQ, and the like. The fluid LQ may be in contact with the substrate S by bringing the nozzle **100** close to the substrate S to be at least 50  $\mu\text{m}$  (or about 50  $\mu\text{m}$ ) or less. However, the spaced distance between the nozzle **100** and the substrate S is not necessarily limited thereto.

[0053] When the nozzle **100** or the substrate S is transferred due to an operation of a first transfer part **310** or a second transfer part **320** to be described later, the meniscus M may be changed into an elongated shape (illustrated in FIG. **10**) due to frictional force caused by a viscosity between the substrate S and the fluid LQ so that the meniscus M is maintained in the state of being in contact with the substrate S.

[0054] As illustrated in FIGS. **2** and **3**, the contact-type patterning apparatus according to some embodiments of the present disclosure may arrange a plurality of nozzles **100** to be spaced apart from each other in a line so as to pattern a plurality of line patterns at the same time.

[0055] The voltage supply part **330** applies a high voltage to the electrode of the nozzle **100**. And then, according to the electric field generated due to the voltage applied to the nozzle **100** to face the substrate S, the meniscus M may be formed in the end of the nozzle **100**, and also the voltage applied to the nozzle **100** may be transmitted to a surface of the fluid LQ. Even though the substrate S or the nozzle **100** moves to change the shape of the meniscus M, when the voltage is transmitted to the surface of the fluid LQ, electric stress that allows the fluid LQ to connect the substrate S and the nozzle **100** to each other may be generated. A state in which the fluid LQ connects the substrate S and the nozzle **100** to each other may be defined as a state in which the fluid LQ is in contact with the substrate S and the nozzle **100** together.

[0056] The state in which the fluid LQ is connected between the substrate S and the nozzle **100** may be provided by the surface tension generated on the surface of the fluid LQ and the frictional force between the substrate S and the fluid LQ due to the viscosity. In addition, the electric stress due to the voltage applied from the voltage supply part **330** may allow the state, in which the fluid LQ is connected between the substrate S and the nozzle **100**, to be maintained during the patterning process.

[0057] The pump **200** may supply, into the nozzle **100**, the fluid LQ for use in the patterning process. Here, some embodiments according to the present disclosure may use a screw-type pump that supplies the fluid LQ into the nozzle **100** through a screw rotating in response to power of the motor **210**. When the screw-type pump **200** is used, the fluid LQ having a high viscosity may also be quantitatively easily supplied to the nozzle **100**. According to some embodiments of the present disclosure, the fluid LQ having a viscosity of 200,000 cP (or about 200,000 cP) or less may be used to perform the patterning process.

[0058] Hereinafter, a uniaxial eccentric screw pump **200** that is one example of the screw-type pump **200** illustrated in FIG. **1** will be described.

[0059] The pump **200** may include a motor **210**, a pump casing **220**, a power transmitting coupling **230**, a coupling rod **240**, a coupling cover **250**, a stator **260**, and a rotor **270**.

[0060] The motor **210** that operates the pump **200** may be located on the pump casing **220**. An upper portion of the power transmitting coupling **230** may be connected to a shaft **212** of the motor **210**, and a lower portion of the power transmitting coupling **230** may be connected to an upper end of the coupling rod **240**. According to the connecting structure, the power transmitting coupling **230** may transmit the power (or torque) of the motor **210** to the coupling rod **240**.

[0061] The coupling cover **250** may be connected to an upper portion of the pump casing **220**. The power transmitting coupling **230** may be located inside the coupling cover **250**. Here, a coupling portion between the coupling cover **250** and the motor **210** and a coupling portion between the coupling cover **250** and the pump casing **220** may be sealed. The sealing structure may block the fluid LQ supplied into the pump casing **220** from being introduced into the motor **210** located thereabove.

[0062] The coupling rod **240** may be located inside the pump casing **220**. The stator **260** may be located below the pump casing **220**. The rotor **270** that is coupled to a lower end of the coupling rod **240** to rotate together with the coupling rod **240** may be inserted into a cavity CVT defined inside the stator **260**. The cavity CVT defined in the stator **260** may be provided to pass through the stator **260** vertically. An inner circumferential surface of the stator **260** that defines the cavity CVT may have a single-stage or multistage female screw shape.

[0063] The rotor **270** may have a single-stage or multistage male screw shape corresponding to the shape of the inner circumferential surface of the stator **260**. An outer circumferential surface of the rotor **270** may have a single-stage or multistage male screw shape. When the rotor **270** is located in the cavity CVT of the stator **260**, a transfer space **265** which is defined in a longitudinal direction (e.g., a vertical direction or an extension direction of the contact-type patterning apparatus DPA) may be defined. The transfer space **265** may be defined between the inner circumferential surface of the stator **260** and the outer circumferential surface of the rotor **270**.

[0064] The power of the motor **210** may be transmitted to the rotor **270** through the coupling rod **240**. The rotor **270** may rotate due to the power of the motor **210**. Here, when the rotor **270** receives the power of the motor **210** to rotate, the rotor **270** may eccentrically rotate in the cavity CVT of the stator **260**.

[0065] An inflow pipe **222** may be connected to a lower portion of the pump casing **220**. The inflow pipe **222** may be connected to a tank, which stores the fluid LQ, to receive the fluid LQ.

[0066] The rotating rotor **270** may transfer the fluid LQ, which is supplied into the pump casing **220** through the inflow pipe **222** to be located in the transfer space **265**, downward, i.e., in the longitudinal direction, so that the fluid LQ is quantitatively supplied into the nozzle **100**.

[0067] According to some embodiments of the present disclosure, a connecting portion between the motor **210** and the rotor **270** may be made of an insulation material so that when the voltage supply part **330** supplies a high voltage to the electrode (or metallic nozzle) in the nozzle **100**, the voltage is blocked from being applied to the motor **210** through the fluid LQ. Thus, the high voltage applied to the electrode in the nozzle **100** may not be delivered to the motor **210**, and thus the motor **210** may not be damaged or abnormally operated.

[0068] According to some embodiments of the present disclosure, each of the coupling cover **250** and the coupling rod **240** may be made of an insulation material. The coupling cover **250** and the coupling rod **240**, each of which is made of an insulation material, may block the voltage supplied to the electrode of the nozzle **100** from being transmitted to the motor **210**.

[0069] The transfer parts **310** and **320** may transfer the nozzle **100** or the substrate S so that the fluid LQ is patterned in a line shape. In addition, the transfer parts **310** and **320** may transfer the nozzle **100** so as to adjust a spaced distance between the nozzle **100** and the substrate S.

[0070] The transfer parts **310** and **320** may include a first transfer part **310** and a second transfer part **320**. The first transfer part **310** may transfer the nozzle **100**. The first transfer part **310** illustrated in FIG. 1 may transfer the nozzle **100** in a direction (Z-axis direction) that is away from, or close to, the substrate S. However, embodiments according to the present disclosure are not limited thereto. For example, as illustrated in FIG. 2, the first transfer part **310** may transfer the nozzle **100** in a virtual plane direction (e.g., Z-axis or Y-axis direction) parallel to the substrate S. Components of the first transfer part **310** will not be described in detail as being known techniques in the printing apparatus.

[0071] The second transfer part **320** may be located below the substrate S to move the substrate S along a virtual plane parallel to the substrate S. When movement on the virtual plane parallel to the substrate S is defined as an X-axis or Y-axis movement, the second transfer part **320** may move the substrate S in a direction of at least one of the X axis or the Y axis. As illustrated in FIG. 1, when the contact-type patterning apparatus DPA according to some embodiments of the present disclosure is a stage **1000** moving-type apparatus that seats the substrate S on the stage **1000** and performs the patterning while moving the stage **1000**, the second transfer part **320** may be

embodied in a shape that moves the stage **1000** in the X-axis or Y-axis direction.

[0072] As illustrated in FIG. 2, when the contact-type patterning apparatus DPA according to some embodiments of the present disclosure performs the patterning while transferring the substrate S in a conveyor manner, the second transfer part **320** may be embodied in a shape that moves a conveyor (with no reference numeral), which supports the substrate S, in one direction.

[0073] Alternatively, as illustrated in FIG. 3, when the contact-type patterning apparatus DPA according to some embodiments of the present disclosure performs the patterning while transferring the substrate S in a roll-to-roll manner, the second transfer part **320** may be embodied in a manner that rotates a roller (with no reference numeral), which winds and supports the substrate S, in one direction.

[0074] The controller **400** may control an operation of each of the voltage supply part **330**, the first and second transfer parts **310** and **320**, and the pump **200**.

[0075] The controller **400** may control a level of a voltage applied to the electrode of the nozzle **100** from the voltage supply part **330** so that the fluid LQ ejected from the end of the nozzle **100** is patterned on the substrate S in a continuous line shape. In order to maintain the state in which the fluid LQ dispensed from the end of the nozzle **100** is in contact with the substrate S, the level of the voltage applied to the nozzle **100** from the voltage supply part **330** has a great impact, and thus it is important that the level of the voltage is controlled as appropriate through the controller **400**.

[0076] The controller **400** may adjust the level of the voltage applied to the electrode of the nozzle **100** from the voltage supply part **330** to perform control so that the meniscus M is formed at a side of the outlet in the end of the nozzle **100**. In addition, when the nozzle **100** and the substrate S are moved relative to each other by the first and second transfer parts **310** and **320**, the controller **400** may perform control so that the meniscus M is not disconnected between the substrate S and the nozzle **100**.

[0077] A force applied to the fluid LQ when the substrate S or the nozzle **100** move may be frictional force caused by viscosity, surface tension, and electric stress caused by a voltage applied to a surface of the fluid LQ. Due to an interaction among the frictional force, the surface tension, and the electric stress, the state in which the fluid LQ is connected between the substrate S and the nozzle **100** may be maintained so that the process for patterning a continuous line is performed.

[0078] For example, when the fluid LQ having a high viscosity is used for the patterning process like embodiments of the present disclosure, it is very difficult to form the meniscus M in the end of the nozzle **100** due to the viscosity and the surface tension. Thus, it is important to apply an appropriate voltage to the nozzle **100** from the voltage supply part **330** to form the meniscus M.

[0079] In addition, the controller **400** may control movement of a motor of a driving part constituting the first transfer part **310** or the second transfer part **320**. For example, when the first transfer part **310** is embodied to move the nozzle **100** in a direction of at least one of the X, Y, or Z axis, the controller **400** may control an operation (particularly, speed) of the motor that drives the nozzle **100** in a direction of a specific axis.

[0080] In addition, when the second transfer part **320** is embodied to move the stage **1000** as illustrated in FIG. 1, the controller **400** may control an operation (particularly, speed) of the motor that moves the stage **1000**.

[0081] When the second transfer part **320** is embodied to drive the conveyor as illustrated in FIG. 2, the controller **400** may control an operation (particularly, speed) of the motor that operates the conveyor.

[0082] When the second transfer part **320** is embodied to drive a roller that winds and supports the substrate S as illustrated in FIG. 3, the controller **400** may control an operation (particularly, speed) of the motor that rotates the roller.

[0083] Thus, the controller **400** may control an operation of the first transfer part **310** or the second transfer part **320** to control a transfer speed of the nozzle **100** or the substrate S so that a patterning rate is controlled.



[0084] As described above, the patterning rate, the viscosity of the fluid LQ, and the level of the voltage applied to the surface of the fluid LQ need to be adjusted in order to define a continuous line pattern. An operation of the first transfer part **310** or the second transfer part **320** may be controlled by the controller **400** to control the transfer speed of the nozzle **100** or the substrate S so that the patterning rate is controlled.

[0085] The level of the voltage applied from the voltage supply part **330** may be changed depending on a relative velocity between the substrate S and the nozzle **100**.

[0086] According to some embodiments, the contact-type patterning apparatus DPA may further include a flow rate monitoring part that monitors a flow rate of the fluid LQ ejected from the nozzle **100**. The flow rate monitoring part may include a camera that photographs the fluid LQ ejected from the nozzle **100**, but is not necessarily limited thereto.

[0087] A state of the patterning may be monitored in real time by the flow rate monitoring part. For example, when occurrence of disconnection of the pattern or a change in size of the pattern is confirmed through the flow rate monitoring part, the controller **400** may control the patterning rate or control the level of the voltage applied from the voltage supply part **330** so that a uniform and continuous patterning process is performed.

[0088] Hereinafter, a control operation of the controller **400** according to some embodiments of the present disclosure will be described below in more detail.

[0089] FIG. **4** is a view for comparing ejected shapes of inks according to control of a controller. FIG. **5** is a view illustrating one example of a synchronization profile of a stage driving motor and a motor of a pump according to a patterning section. FIG. **6** is a view illustrating a result of synchronizing a stage driving motor and a motor of a pump to perform a patterning process. FIG. **7** is a view illustrating a result of synchronizing a stage driving motor and a motor of a pump and also controlling a level of a voltage applied to an electrode from a controller to perform patterning.

[0090] Referring to FIG. **1**, the controller **400** may synchronize a rotation speed of the motor **210** of the pump and a movement speed between the substrate S and the nozzle **100** by the first transfer part **210** or the second transfer part **310**. Hereinafter, a case in which when the substrate S and the nozzle **320** are moved relative to each other for the continuous patterning process, a position of the nozzle **100** is fixed, and the stage **1000** is driven by the second transfer part **320** to move the substrate S, will be described as an example.

[0091] The second transfer part **320** may include a stage driving motor (with no reference numeral) for driving the stage **1000**. According to some embodiments of the present disclosure, the controller **400** may control a rotation speed of the motor **210** and a stage driving motor of the second transfer part **320** that drives the stage **1000**, and may synchronize and control the rotation speed of the motor **210** and the stage driving motor.

[0092] Referring to FIG. **5**, in an acceleration section when the patterning starts, the controller **400** may perform control so that when the rotation speed of the stage driving motor is increased to an acceleration (e.g., a set or predetermined acceleration), the rotation speed of the motor **210** is also increased to the acceleration (e.g., a set or predetermined acceleration). When the patterning is performed at a constant velocity in a patterning midsection, the controller **400** may perform control so that the rotation speed of the stage driving motor and the rotation speed of the motor **210** are constant. In addition, in a deceleration section adjacent to a point at which the patterning ends, the controller **400** may perform control so that when the rotation speed of the stage driving motor is decreased to an acceleration (e.g., a set or predetermined acceleration), the rotation speed of the motor **210** is also decreased to the acceleration (e.g., a set or predetermined acceleration).

[0093] Accordingly, when the patterning rate is increased, the controller **400** may increase the flow rate of the fluid LQ introduced into the nozzle **100** from the pump **200** in proportion to the patterning rate, and when the patterning rate is decreased, the controller **400** may decrease the flow rate of the fluid LQ introduced into the nozzle **100** from the pump **200** in proportion to the patterning rate.

[0094] Here, according to some embodiments of the present disclosure, the controller **400** may control the level of the voltage applied from the voltage supply part **330** differently according to the synchronized patterning rate so as to perform control so that a line width or thickness to be patterned is constant.

[0095] For example, as illustrated in FIG. 5, in the acceleration section in which the continuous patterning starts, and the deceleration section in which the continuous patterning ends, the controller **400** may supply a voltage having an appropriate level to the electrode of the nozzle **100** according to synchronized velocity distribution so that patterning having a constant line width or thickness is defined also around a start point and an end point.

[0096] Referring to (a) of FIG. 4, when only synchronization is performed on the motor of the stage driving motor and the motor **210**, a lump phenomenon of a chemical liquid (fluid LQ described above) ejected from the nozzle **100** may occur according to the meniscus M of the chemical liquid. For example, a section in which the patterning rate is low is prone to the lump phenomenon.

[0097] Referring to (b) of FIG. 4, when operations of the motor of the stage driving motor and the motor **210** are synchronized and also the level of the voltage applied to the electrode from the voltage supply part **330** is controlled, the lump phenomenon may be controlled.

[0098] Referring to FIG. 6, FIG. 6 illustrates a result when only the synchronization of the stage driving motor and the motor **210** is performed to perform the patterning process. It may be confirmed that the lump phenomenon occurs in the acceleration and deceleration sections for the start point and the end point so that the patterning is formed in line widths/thicknesses different from those of an intermediate point.

[0099] Referring to FIG. 7, it may be confirmed that when the patterning is performed by controlling the level of the voltage applied to the electrode of the nozzle **100** from the voltage supply part **330** together with the synchronization of the stage driving motor and the motor **210**, the patterning is formed in a constant line width/thickness over the entirety section including the start point and the end point.

[0100] Hereinafter, a contact-type patterning apparatus according to some embodiments of the present disclosure will be described in more detail.

[0101] FIG. 8 illustrates a contact-type patterning apparatus for a substrate S having a three-dimensional surface according to some embodiments of the present disclosure.

[0102] FIG. 8 relates to a contact-type patterning apparatus DPA-1 capable of patterning a continuous line shape on a substrate S having a three-dimensional shape, of which a surface is not planar, while maintaining a state in which a fluid LQ dispensed through a nozzle **100** is in contact with the substrate S. Hereinafter, the contact-type patterning apparatus DPA-1 illustrated in FIG. 8 will be described by focusing on differences with the contact-type patterning apparatus DPA described with reference to FIGS. 1 to 7.

[0103] Referring to FIG. 8, the contact-type patterning apparatus DPA-1 may further include a shape information providing part **340** together with the nozzle **100**, the voltage supply part **330**, the pump **200**, the first and second transfer parts **310** and **320**, and the controller **400** that are described above. The shape information providing part **340** may obtain and store shape information of a surface of the substrate S, and provide the controller **400** with the shape information of the surface of the substrate S.

[0104] According to some embodiments of the present disclosure, the shape information providing part **340** may provide the controller **400** with the shape information of the substrate S in such a manner that the information of the surface of the substrate S is measured and stored in real time simultaneously (or concurrently) with the patterning process. However, embodiments according to the present disclosure are not limited thereto, and the shape information of the surface of the substrate S may be obtained and stored before the patterning process so that the shape information is provided to the controller **400**.

[0105] Vision sensors such as displacement sensor, touch sensor, capacitance sensor, infrared ray sensor, and interferometer, may be utilized for sensing the information on the surface of the substrate (S), but embodiments according to the present disclosure are not limited thereto. For example, all of existing sensors capable of measuring a three-dimensional surface may be utilized. [0106] The controller **400** may control a level of a voltage applied to an electrode in the nozzle **100** from the voltage supply part **330** so that the fluid LQ ejected from an end of the nozzle **100** is patterned on the substrate S in a continuous line shape.

[0107] The controller **400** may receive shape information of a surface of the substrate S from the shape information providing part **340** to control the level of the voltage applied to the electrode in the nozzle **100** from the voltage supply part **330**. In addition, the controller **400** may receive information of the surface of the substrate S from the shape information providing part **340** to control the first and second transfer parts **310** and **320**, thereby controlling a patterning rate according to the shape information. In addition, the controller **400** may receive height information of the shape information of the surface of the substrate S to adjust a spaced distance between the nozzle **100** and the substrate S, thereby maintaining a state in which the meniscus M and the substrate S are in contact with each other.

[0108] Distribution of an electric field may be changed because of the influence of a shape of a structure around an area to be patterned from the nozzle **100** or a previously patterned pattern. For example, when the nozzle **100** is moved with respect to the three-dimensional surface, the distribution of the electric field may be changed in real time according to a change in shape of the three-dimensional surface. According to some embodiments of the present disclosure, a change in three-dimensional electric field distribution due to the shape of the structure around the area to be patterned or the previously patterned pattern may be obtained through a simulation using a computer. Based on this change, the controller **400** may control the level of the voltage applied to the electrode of the nozzle **100** through the voltage supply part **330**.

[0109] Hereinafter, an operation of a contact-type patterning apparatus according to some embodiments of the present disclosure will be described below in more detail.

[0110] FIGS. **9** and **10** are views for describing a patterning operation of a contact-type patterning apparatus according to some embodiments of the present disclosure.

[0111] Referring to FIG. **9**, when a voltage is applied to an electrode of a nozzle **100** through a voltage supply part **330**, an electric field may be generated toward a substrate S, and the voltage may be applied to a surface of a fluid LQ so that a meniscus M having a convex shape is formed in an end of the nozzle **100**.

[0112] Here, in consideration of a viscosity of the fluid LQ, the controller **400** may adopt an appropriate level of the voltage applied from the voltage supply part **330** to perform control so that the meniscus M having a convex shape is formed in the end of the nozzle **100**.

[0113] When a size of the meniscus M formed in the end of the nozzle **100** is considered, a spaced distance between the substrate S and the nozzle **100** may be set to at least  $\frac{1}{2}$  or less of the size of the meniscus M formed at a side of the nozzle **100**. When the spaced distance between the substrate S and the nozzle **100** is set to be greater than the aforesaid, the fluid LQ may be disconnected. When the nozzle **100** having a size of 100  $\mu\text{m}$  (or about 100  $\mu\text{m}$ ) or less used generally for micro-patterning is adopted, the spaced distance between the substrate S and the nozzle **100** may be set to 50  $\mu\text{m}$  (or about 50  $\mu\text{m}$ ) or less.

[0114] When the meniscus M is formed, in a state in which the substrate S and the nozzle **100** are arranged to be close to each other by a first transfer part **310**, the meniscus M may be formed, and the meniscus M of the fluid LQ may be in contact with the substrate S at the same time. However, embodiments according to the present disclosure are not limited thereto. For example, the meniscus M may be formed in the end of the nozzle **100**, and then the nozzle **100** may be moved to a side of the substrate S by the first transfer part **310** so that the meniscus M of the fluid LQ is in contact with the substrate S.

[0115] Referring FIG. 10, in a state in which the meniscus M is in contact with the substrate S, the controller 400 may operate the first transfer part 310 or the second transfer part 320, and the nozzle 100 or the substrate S may be transferred by the first and second transfer parts 310 and 320 to perform a line patterning process.

[0116] Here, in a situation in which the fluid LQ used for the patterning is preset, a viscosity of the fluid LQ corresponds to a constant number, and thus variables that maintain continuity of a line during the line patterning process may be a patterning rate and a level of the voltage applied from the voltage supply part 330. As described above, the patterning rate may be adjusted by controlling the first transfer part 310 or the second transfer part 320 by the controller 400 to control a movement speed of the nozzle 100 or the substrate S.

[0117] Here, the controller 400 may synchronize a rotation speed of a motor 210 and the movement speed between the substrate S and the nozzle 100 by the first transfer part 210 or the second transfer part 310. Accordingly, when the patterning rate is increased, a flow rate of the fluid LQ introduced into the nozzle 100 from a pump 200 may be increased in proportion to the patterning rate, and when the patterning rate is decreased, the flow rate of the fluid LQ introduced into the nozzle 100 from the pump 200 may be decreased in proportion to the patterning rate.

[0118] The controller 400 may control the level of the voltage applied to the electrode of the nozzle 100 from the voltage supply part 330 according to the synchronized speed of the motor 210 so that the fluid LQ is maintained to be in contact with the substrate S, and also disconnection of the fluid LQ between the substrate S and the nozzle 100 may be prevented or reduced. Thus, patterning in a continuous line shape may be formed. In addition, through the adjustment of the level of the voltage, a lump phenomenon may not occur, and a line width or thickness to be patterned may be controlled to be constant.

[0119] Here, a principle that instances of disconnection of the fluid LQ between the substrate S and the nozzle 100 is prevented or reduced may be explained through equilibrium of three forces that are a frictional force between the substrate S and the fluid LQ due to the viscosity, surface tension of the fluid LQ, and electric stress caused by the voltage applied to the fluid LQ.

[0120] Referring to FIG. 10, in a case in which the voltage is not applied to the nozzle 100, surface tension ( $F_\sigma$ ) and frictional force ( $F_u$ ) due to the viscosity are applied to the meniscus M, and these are each represented by the following Equation 1.

$$[00001] F_\sigma = \frac{4\gamma}{dn} \quad \text{Equation1} \quad f_v = \mu \frac{U^2}{D}$$

[0121] Here,  $\gamma$  indicates a surface tension coefficient of the fluid LQ,  $dn$  indicates a diameter of the nozzle 100,  $\mu$  indicates a viscosity of the fluid LQ,  $U$  indicates a movement speed of the nozzle 100, and  $D$  indicates a spaced distance between the nozzle 100 and the substrate S.

[0122] The aforementioned surface tension ( $F_\sigma$ ) and friction force ( $F_u$ ) due to the viscosity constitute an equilibrium equation together with a hydrostatic pressure ( $\Delta P$ ) of the fluid LQ, and this is as in the following Equation 2.

$$[00002] \Delta P - \frac{4\gamma}{dn} + \mu \frac{U^2}{D} = 0 \quad \text{Equation2}$$

[0123] Here, a balance equation for a flow rate ( $Q$ ) of the fluid LQ dispensed from the nozzle 100 is as in the following Equation 3.

$$[00003] Q = \frac{\pi dn^4}{128\mu L} (\Delta P - \frac{4\gamma}{dn} + \mu \frac{U^2}{D}) \quad \text{Equation3}$$

[0124] Here,  $L$  indicates a length of the nozzle 100.

[0125] That is, in a case in which a voltage is not applied to the nozzle 100, the balance equation for the flow rate ( $Q$ ) may be satisfied to perform the patterning process.

[0126] Here, when a voltage is applied to the nozzle 100, electric force ( $F_e$ ) is applied in addition to the surface tension ( $F_\sigma$ ) and the frictional force ( $F_u$ ) due to the viscosity, and this is as in the following Equation 4.

$$[00004] F_e = \frac{1}{2} E^2 \nabla \epsilon = \frac{1}{2L} E^2 \epsilon \quad \text{Equation4}$$

[0127] Here, E indicates a level of the applied voltage, and  $\epsilon$  indicates a dielectric constant of the fluid LQ.

[0128] Due to the aforementioned electric force (Fe), the equilibrium equation and the balance equation are as in the following Equation 5.

[00005]  $\Delta P - \frac{4\gamma}{dn} + \mu \frac{U^2}{D} + \frac{E^2 \epsilon}{2} = 0$  Equation5  $Q = \frac{\pi dn^4}{128 \mu L} (\Delta P - \frac{4\gamma}{dn} + \mu \frac{U^2}{D} + \frac{E^2 \epsilon}{2})$

[0129] That is, when a contact-type patterning process is performed, an important factor involving the patterning rate is a flow rate (Q) ejected from the nozzle **100**. When a voltage is not applied, the flow rate may be determined simply by the hydrostatic pressure, but when a voltage is applied, the voltage may serve to increase the flow rate (Q). Thus, even when the patterning rate is increased, as a liquid surface of the meniscus M is stretched, the patterning process may be performed so that patterning in a continuous line shape is formed.

[0130] The contact-type patterning apparatus according to some embodiments of the present disclosure may perform the patterning process for forming the line pattern even with the ink having the high viscosity in the contact manner without the discontinuous section.

[0131] In addition, the contact-type patterning apparatus according to some embodiments of the present disclosure may perform the patterning process for forming the line pattern having the constant line width even in the acceleration and deceleration sections around the start point and the end point of the pattern when compared to the intermediate point.

[0132] In addition, the contact-type patterning apparatus according to some embodiments of the present disclosure may block the voltage applied to the nozzle from being introduced into the driving part (e.g., motor) of the pump to prevent or reduce damage to the equipment or avoid or reduce the pattern precision being reduced.

[0133] Although aspects of some embodiments of the present disclosure have been described, it is understood that embodiments according to the present disclosure should not be limited to these embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of embodiments according to the present disclosure as hereinafter claimed. In addition, the embodiments set forth herein are to describe the technical spirit of the present invention and not to limit, and these embodiments set forth herein are provided so that this disclosure will be thorough and complete, and will more fully convey the scope of embodiments according to the present disclosure to those skilled in the art.

## Claims

1. A contact-type patterning apparatus comprising: a nozzle comprising an electrode configured to receive a voltage to generate an electric field toward a substrate, and configured to eject a fluid so that the fluid is connected to the substrate; a voltage supply configured to apply the voltage to the electrode; a screw-type pump configured to supply the fluid into the nozzle through a screw configured to receive power from a motor to rotate; a transfer part configured to transfer the nozzle or the substrate so that the fluid is patterned in a line shape; and a controller configured to control a level of the voltage applied through the voltage supply, an operation of the transfer part, and an operation of the pump.
2. The contact-type patterning apparatus of claim 1, wherein the controller is configured to synchronize and to control a transfer speed of the substrate or the nozzle by the transfer part and a rotation speed of the motor of the pump, and to control the level of the voltage applied to the electrode from the voltage supply according to the synchronized speed control.
3. The contact-type patterning apparatus of claim 2, wherein, in an acceleration section of the transfer part in which the patterning starts, and a deceleration section of the transfer part in which the patterning ends, the controller is configured to synchronize and control the transfer speed of the substrate or the nozzle by the transfer part and the rotation speed of the motor of the pump, and to

control the level of the voltage applied to the electrode from the voltage supply according to the synchronized speed control.

**4.** The contact-type patterning apparatus of claim 3, wherein the contact-type patterning apparatus is configured to transfer the substrate in a stage moving manner, and the controller is configured to control a movement speed of a stage, which supports the substrate, to control the transfer speed of the substrate.

**5.** The contact-type patterning apparatus of claim 3, wherein the contact-type patterning apparatus is configured to transfer the substrate in a roll-to-roll manner, and the controller is configured to control a rotation speed of a roll, which supports the substrate, to control the transfer speed of the substrate.

**6.** The contact-type patterning apparatus of claim 3, wherein the contact-type patterning apparatus is configured to transfer the substrate in a conveyor manner, and the controller is configured to control a movement speed of a conveyor, on which the substrate is seated, to control the transfer speed of the substrate.

**7.** The contact-type patterning apparatus of claim 1, wherein a connecting portion between the motor of the pump and the screw includes an insulation material such that a voltage supplied from the voltage supply is blocked from being applied to the motor.

**8.** The contact-type patterning apparatus of claim 1, wherein the fluid has a viscosity of 200,000 cP or less.

**9.** The contact-type patterning apparatus of claim 1, further comprising a shape information providing part configured to provide three-dimensional surface shape information of the substrate, wherein, in consideration of a change in distribution of the electric field according to the three-dimensional surface shape information provided from the shape information providing part, the controller is configured to control the level of the voltage applied to the electrode through the voltage supply.

**10.** The contact-type patterning apparatus of claim 1, further comprising a flow rate monitoring part configured to monitor a flow rate of the fluid ejected from the nozzle.

**11.** The contact-type patterning apparatus of claim 10, wherein the flow rate monitoring part comprises a camera configured to photograph the fluid ejected from the nozzle.

**12.** The contact-type patterning apparatus of claim 1, wherein the pump is a uniaxial eccentric screw pump.

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