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(54) INKJET PRINT HEAD AND METHOD OF MANUFACTURING SUCH PRINT HEAD

(57) An inkjet print head comprises a silicon part having at least a part of a fluidic path arranged therein. A method of manufacturing such inkjet print head comprises the steps of electrically connecting the silicon part to an electrical source; providing an alkaline fluid in the fluidic path; electrically connecting the alkaline fluid to the electrical source; and applying a voltage over the alkaline fluid and the silicon part, wherein the voltage is higher than a passivation voltage to form an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid. The oxide layer prevents against undesired etching of silicon by the alkaline fluid that is being ejected by the inkjet print head.

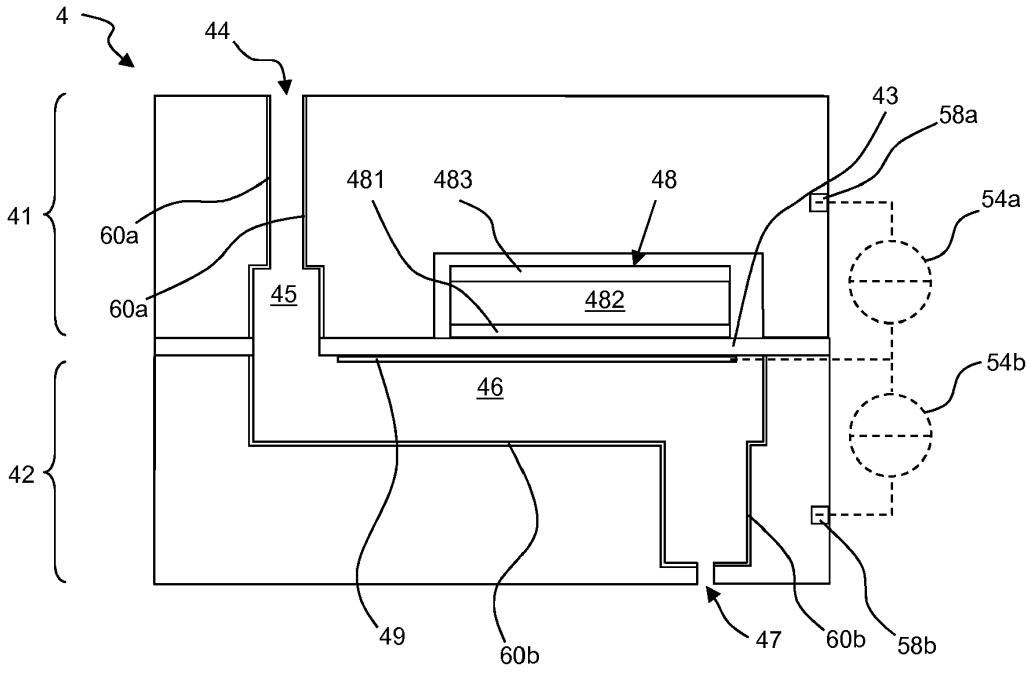


Fig. 4

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Description

FIELD OF THE INVENTION

[0001] The present invention generally pertains to inkjet print heads comprising a silicon part, wherein the silicon part may come into contact with an alkaline fluid. Further, the present invention pertains to a method of manufacturing such print heads.

BACKGROUND ART

[0002] It is known to design and manufacture inkjet print heads from silicon wafers using lithographic techniques and etching a fluidic path and other functional structures in the silicon wafers. Other functional structures may be an electromechanical transducer, such as a piezoelectric actuator, for generating a pressure change in a fluid, which fluid is arranged in the fluidic part.

[0003] Such inkjet print heads may be used to eject droplets of numerous different kinds of fluid. Moreover, there is a desire to eject droplets of an alkaline fluid, which alkaline fluid has an etching effect on the silicon part of the print head. In other words, over time, such alkaline fluid will etch away parts of the silicon. Thus, an interface with other parts like an adhesive may be affected, possibly resulting in delamination of adhered layers, or dimensions of the fluidic path may change over time. Changes in the dimensions of the fluidic part affect acoustic properties, which acoustic properties determine droplet formation. For example, due to the changed dimensions, generated droplets may decrease or increase in size or the generated droplets may be ejected with a different speed or ejection angle. Eventually, no droplets may be ejected at all. Still, when used in an inkjet printing assembly for generating images by ejection of droplets of ink, image quality will deteriorate due to the changed droplet properties.

[0004] It is known to protect the silicon parts against etching by an alkaline fluid by providing a siliconoxide layer on a surface of the silicon part that comes into contact with the fluid. For example, a thermal oxide layer may be generated by heating the silicon in an oxygen containing environment. To prevent damage to other parts of the print head, such heating may not be feasible.

[0005] In another known example, a dense oxide, not necessarily siliconoxide, may be applied as a coating by suitable processing like atomic layer deposition (ALD). In view of the small structures, this may be insufficiently effective or may affect the acoustic properties in the structures too much.

[0006] In EP2855607 it is proposed to add a silicon doping agent in the fluid to prevent silicon etching. Such method may reduce an etching speed, but is expected to be insufficient over a longer period of time.

[0007] US 2010/259582 A1 discloses an inkjet print head comprising a silicon substrate with an ink flow channel arranged therein. Ink circulation tubes of made of glass tubes are bonded to the silicon substrate.

[0008] It is an object to provide for an alternative method for applying a protective layer and to provide for an inkjet print head having a reliable protective layer.

SUMMARY OF THE INVENTION

[0009] In an aspect, the present invention provides for a method of manufacturing an inkjet print head, wherein the inkjet print head comprises a silicon part having at least a part of a fluidic path arranged therein. The method comprises the steps of electrically connecting the silicon part to an electrical source; providing an alkaline fluid in the fluidic path; electrically connecting the alkaline fluid to the electrical source; and applying a voltage over the alkaline fluid and the silicon part, wherein the voltage is higher than a passivation voltage to form an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid.

[0010] The etching properties of an alkaline fluid change into an oxidizing property when a sufficiently high voltage is applied, i.e. a voltage higher than the passivation voltage. It has been found that the voltage may be sufficiently high at about 0.6 Volts or more, depending on materials used. For example, the electrode may be formed of platinum, but may also be formed of any other suitable electrically conductive material, which material should not dissolve in the alkaline solution. Further, the silicon is to be connected as the anode, while the electrode is to be connected as the cathode. It is noted that below the passivation voltage, etching of the silicon surface occurs.

[0011] With the method according to the present invention, a reliable silicon-oxide may be grown at the locations where a surface of the silicon is in contact with the alkaline fluid. Moreover, it is noted that the oxide layer may only grow to a certain layer thickness, wherein the thickness depends on the voltage applied. With a higher voltage, a thicker oxide layer is obtained. When a maximum layer thickness is obtained, the oxidizing process stops despite the presence of the voltage. Thus, having selected a suitable voltage corresponding to a desired layer thickness, process parameters do not require highly accurate control. Further, presuming that wear of the oxide layer may occur, reapplying the voltage may cure any defects in the oxide layer without affecting any undamaged parts of the oxide layer.

[0012] The silicon used should be common n-type silicon. Doped p-type silicon may not provide for the desired oxide layer, depending on an amount of dopant present in the silicon.

[0013] The voltage may as well be applied when the inkjet print head is mounted and used in an inkjet printing assembly to maintain and/or repair the oxide layer. Therefore, in an aspect of the present invention, an inkjet print head is provided, wherein the inkjet print head comprises a silicon part having at least a part of a fluidic path arranged therein; an electrical connection pad in electri-

cal communication with the silicon part; and an electrode arranged in the fluidic path. Thus, the inkjet print head is configured to be operated with a voltage, while the electrical connection and electrode may as well be used during manufacturing of the inkjet print head to obtain the initial oxide layer.

[0014] In an embodiment, the inkjet print head comprises at least two layers, each layer composed of silicon and each having etched therein a part of the fluidic path. Many common MEMS-based inkjet print head are formed by stacked silicon layers. Such inkjet print heads are very suitable for use in the present invention. Moreover, in view of the common use of an adhesive between the silicon layers, such print heads are usually not suitable for applying a thermal oxide layer, since the adhesive is usually not resistant to the required temperature for thermal oxidation.

[0015] In an embodiment, the fluidic path comprises a fluid inlet port, a pressure chamber and a nozzle orifice and the inkjet print head further comprises an electromechanical transducer in operative mechanical coupling with the pressure chamber for changing a pressure in a fluid arranged in the pressure chamber.

[0016] In an aspect, the present invention provides an inkjet printing assembly comprising the above-described inkjet print head according to the present invention. Further, the inkjet printing assembly comprises an electrical source, wherein the electrical source is electrically connected to the electrical connection pad of the print head and to the electrode of the print head. In this inkjet printing assembly, the electrical source is configured to apply a voltage over the electrical connection pad and the electrode such to apply a voltage higher than about 0.6 Volts over the silicon part and an alkaline fluid arranged in the fluidic path to form, maintain or repair an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid. Thus, the lifetime of the print head may be extended as the protective oxide layer is maintainable in a perfect condition, preventing undesired etching by the alkaline fluid.

[0017] In an embodiment, the inkjet printing assembly has a first operating mode and a second operating mode, wherein in the first operating mode the electrical source does not apply a voltage over the electrical connection pad and the electrode and wherein in the second operating mode the electrical source applies the voltage higher than about 0.6 Volts. Having at least two operating modes available, the oxidation voltage does not need to be applied constantly. For example, the second operating mode may be selected by an operator once in a while or a control unit of the printing assembly may automatically select the second operating mode after a predetermined time of operating in the first operating mode. Other selection criteria are contemplated and may be used as well within the scope of the present invention.

[0018] In an embodiment, the inkjet printing assembly has a maintenance mode, wherein the maintenance mode comprises the step of applying the voltage higher than about 0.6 Volts over the electrical connection pad and the electrode. The oxidation voltage may also only be applied during a maintenance operation of the inkjet printing assembly, in which maintenance mode the inkjet print head is not used for expelling droplets. This maintenance mode may be very suitable in case the droplet forming is negatively affected by the presence of the oxidation voltage.

[0019] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying schematical drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1A	is a perspective view of an embodiment of an inkjet printer;
Fig. 1B	is a schematic drawing for illustrating an inkjet process;
Fig. 2	is a schematic cross-section of an embodiment of an inkjet print head;
Figs. 3A - 3C	is a schematic drawing for illustrating a process of electrochemical oxidation; and
Fig. 4	is a schematic cross-section of an embodiment of an inkjet print head according to the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0021] The present invention will now be described with reference to the accompanying drawings, wherein the same reference numerals have been used to identify the same or similar elements throughout the several views.

[0022] Fig. 1A shows an image forming apparatus 36, wherein printing is achieved using an inkjet printing process. The wide-format image forming apparatus 36 comprises a housing 26, wherein the printing assembly, for example the ink jet printing assembly shown in Fig. 1B is placed. The image forming apparatus 36 also comprises a storage means for storing image receiving member 28, 30, a delivery station to collect the image receiving member 28, 30 after printing and storage means for marking material 20. In

[0023] Fig. 1A, the delivery station is embodied as a delivery tray 32. Optionally, the delivery station may com-

prise processing means for processing the image receiving member 28, 30 after printing, e.g. a folder or a puncher. The wide-format image forming apparatus 36 furthermore comprises means for receiving print jobs and optionally means for manipulating print jobs. These means may include a user interface unit 24 and/or a control unit 34, for example a computer.

[0024] Images are printed on an image receiving member, for example paper, supplied by a roll 28, 30. The roll 28 is supported on the roll support R1, while the roll 30 is supported on the roll support R2. Alternatively, cut sheet image receiving members may be used instead of rolls 28, 30 of image receiving member. Printed sheets of the image receiving member, cut off from the roll 28, 30, are deposited in the delivery tray 32.

[0025] Each one of the marking materials for use in the printing assembly are stored in four containers 20 arranged in fluid connection with the respective print heads for supplying marking material to said print heads.

[0026] The local user interface unit 24 is integrated to the print engine and may comprise a display unit and a control panel. Alternatively, the control panel may be integrated in the display unit, for example in the form of a touch-screen control panel. The local user interface unit 24 is connected to a control unit 34 placed inside the printing apparatus 36. The control unit 34, for example a computer, comprises a processor adapted to issue commands to the print engine, for example for controlling the print process. The image forming apparatus 36 may optionally be connected to a network N. The connection to the network N is diagrammatically shown in the form of a cable 22, but nevertheless, the connection could be wireless. The image forming apparatus 36 may receive printing jobs via the network. Further, optionally, the controller of the printer may be provided with a USB port, so printing jobs may be sent to the printer via this USB port.

[0027] Fig. 1B shows an ink jet printing assembly 3 for illustrating a scanning inkjet printing process. The inkjet printing assembly 3 comprises supporting means for supporting an image receiving member 2. The supporting means are shown in Fig. 1B as a platen 1, but alternatively, the supporting means may be a flat surface. The platen 1, as depicted in Fig. 1B, is a rotatable drum, which is rotatable about its axis as indicated by arrow A. The supporting means may be optionally provided with suction holes for holding the image receiving member in a fixed position with respect to the supporting means. The inkjet printing assembly 3 comprises print heads 4a - 4d, mounted on a scanning print carriage 5. The scanning print carriage 5 is guided by suitable guiding means 6, 7 to move in reciprocation in the main scanning direction B. Each print head 4a - 4d comprises an orifice surface 9, which orifice surface 9 is provided with at least one orifice 8. The print heads 4a - 4d are configured to eject droplets of marking material onto the image receiving member 2. The platen 1, the carriage 5 and the print heads 4a - 4d are controlled by suitable controlling means 10a, 10b and 10c, respectively.

[0028] The image receiving member 2 may be a medium in web or in sheet form and may be composed of e.g. paper, cardboard, label stock, coated paper, plastic or textile. Alternatively, the image receiving member 2 may also be an intermediate member, endless or not. Examples of endless members, which may be moved cyclically, are a belt or a drum. The image receiving member 2 is moved in the sub-scanning direction A by the platen 1 along four print heads 4a - 4d provided with a fluid marking material.

[0029] A scanning print carriage 5 carries the four print heads 4a - 4d and may be moved in reciprocation in the main scanning direction B parallel to the platen 1, such as to enable scanning of the image receiving member 2 in the main scanning direction B. Only four print heads 4a - 4d are depicted for demonstrating the invention. In practice an arbitrary number of print heads may be employed. In any case, at least one print head 4a - 4d per color of marking material is placed on the scanning print carriage 5. For example, for a black-and-white printer, at least one print head 4a - 4d, usually containing black marking material is present. Alternatively, a black-and-white printer may comprise a white marking material, which is to be applied on a black image-receiving member 2. For a full-color printer, containing multiple colors, at least one print head 4a - 4d for each of the colors, usually black, cyan, magenta and yellow is present. Often, in a full-color printer, black marking material is used more frequently in comparison to differently colored marking material. Therefore, more print heads 4a - 4d containing black marking material may be provided on the scanning print carriage 5 compared to print heads 4a - 4d containing marking material in any of the other colors. Alternatively, the print head 4a - 4d containing black marking material may be larger than any of the print heads 4a - 4d, containing a differently colored marking material.

[0030] The carriage 5 is guided by guiding means 6, 7. These guiding means 6, 7 may be rods as depicted in Fig. 1B. The rods may be driven by suitable driving means (not shown). Alternatively, the carriage 5 may be guided by other guiding means, such as an arm being able to move the carriage 5. Another alternative is to move the image receiving material 2 in the main scanning direction B.

[0031] Each print head 4a - 4d comprises an orifice surface 9 having at least one orifice 8, in fluid communication with a pressure chamber containing fluid marking material provided in the print head 4a - 4d. On the orifice surface 9, a number of orifices 8 is arranged in a single linear array parallel to the sub-scanning direction A. Eight orifices 8 per print head 4a - 4d are depicted in Fig. 1B, however obviously in a practical embodiment several hundreds of orifices 8 may be provided per print head 4a - 4d, optionally arranged in multiple arrays. As depicted in Fig. 1B, the respective print heads 4a - 4d are placed parallel to each other such that corresponding orifices 8 of the respective print heads 4a - 4d are positioned in-line in the main scanning direction B. This means that a

line of image dots in the main scanning direction B may be formed by selectively activating up to four orifices 8, each of them being part of a different print head 4a - 4d. This parallel positioning of the print heads 4a - 4d with corresponding in-line placement of the orifices 8 is advantageous to increase productivity and/or improve print quality. Alternatively multiple print heads 4a - 4d may be placed on the print carriage adjacent to each other such that the orifices 8 of the respective print heads 4a - 4d are positioned in a staggered configuration instead of in-line. For instance, this may be done to increase the print resolution or to enlarge the effective print area, which may be addressed in a single scan in the main scanning direction. The image dots are formed by ejecting droplets of marking material from the orifices 8.

[0032] Upon ejection of the marking material, some marking material may be spilled and stay on the orifice surface 9 of the print head 4a - 4d. The ink present on the orifice surface 9, may negatively influence the ejection of droplets and the placement of these droplets on the image receiving member 2. Therefore, it may be advantageous to remove excess of ink from the orifice surface 9. The excess of ink may be removed for example by wiping with a wiper and/or by application of a suitable anti-wetting property of the surface, e.g. provided by a coating.

[0033] A print head according to the present invention may be employed in a printer as shown in Fig. 1A - 1B, but may as well be used in a printer having statically arranged print heads. In such a printer the recording substrate moves continuously relative to the print heads, while the print heads expel droplets at predetermined times to form an image on the image receiving member.

[0034] Fig. 2 shows a cross-section of a MEMS (Micro-Electro-Mechanical System) print head 4, wherein a fluidic path is arranged in a mainly silicon body. In particular, the print head 4 is formed from a first silicon layer 41 and a second silicon layer 42, having a membrane 43 inter posed therebetween. The membrane 43 may be formed from silicon-dioxide or any other suitable material. The fluidic path comprises a liquid inlet port 44, a liquid supply channel 45, a pressure chamber 46 and a nozzle orifice 47.

[0035] Further, the print head 4 comprises an actuator 48 comprising a bottom electrode 481, a piezoelectric layer 482 and a top electrode 483. The fluidic path 44-47 extends between the liquid inlet port 44 and the nozzle orifice 47. The fluidic path 44-7 extends preferably entirely inside the silicon part. The walls defining the fluid path 44-47 are thus substantially silicon walls. The liquid inlet port 44 is formed by an opening in the first silicon layer 42. The liquid inlet port 44 is positioned on an opposite side of the silicon part with respect to the nozzle orifice 47, which is formed by an opening in the second silicon part 42.

[0036] In operation, the fluidic path 44-47 is filled with a liquid, usually an ink, and an electric signal may be supplied to the bottom electrode 481 and the top electrode 483. Due to the electric signal, an electric field is generated in the piezoelectric layer 482, due to which the piezoelectric layer 482 expands. As a consequence of a rigid attachment to the membrane 43, the expansion of the piezoelectric layer 482 results in a bending of the actuator 48 and the membrane 43. The bending of the membrane 43 results in a change of a volume of the pressure chamber 46, which in effect results in a pressure change in the liquid in the pressure chamber 46. If the fluidic path is designed well, acoustic properties of the fluidic path in combination with a suitable movement and timing of the movement of the membrane 43 result in a droplet of the liquid being expelled through the nozzle orifice 47. This structure of the print head 4 and the corresponding actuation process are well-known in the art and are not further elucidated herein.

[0037] If the liquid used has alkaline properties, the silicon layers 41, 42, at walls of the ink supply channel 45, the pressure chamber 46 and the nozzle orifice 47, may be dissolved in the liquid. As a result, acoustic properties of the fluidic path change. As above-mentioned, the acoustic properties need to match an original acoustic design to assure that droplets are expelled, which droplets have a desired droplet volume, droplet speed, direction and other droplet properties. Hence, a change in the acoustic properties due to dissolving of silicon into the liquid is highly undesired, because even with the slightest change in dimensions, the acoustic properties may be deteriorated. It is known to protect against dissolving of silicon by applying an oxide layer, e.g. a silicon-oxide layer on surfaces in contact with the alkaline fluid.

[0038] In accordance with the present invention, a silicon-oxide may be generated by using an electrochemical oxidation process, which is illustrated in Figs. 3A - 3C. Fig. 3A illustrates the basic principle. A silicon element 50 is connected to an electrical source 54, which is also connected to an electrode 52. Both the silicon element 50 and the electrode 52 are arranged in an alkaline liquid 56. With a sufficiently high voltage applied by the electrical source 54, wherein the silicon element is connected as an anode and the electrode 52 is connected as a cathode, a surface of the silicon element 50 oxidizes, thereby generating a silicon-oxide film on a surface of the silicon element 50.

[0039] Fig. 3B shows a diagram of an applied voltage (in Volts; horizontal axis) and a resulting current per unit area (in mA per square centimeter; vertical axis). In the illustrated diagram, if the applied potential is above zero, the silicon is the anode. As apparent from Fig. 3B, initially with a potential increasing from zero, the current increases as well. At about 0.6 Volts, the current however decreases suddenly. At a potential above said about 0.6 Volts, the current remains relatively low, even with increasing potential. Said about 0.6 Volts is referred to as a passivation potential (also referred to herein as passivation voltage). Below the passivation potential, the silicon is being etched, i.e. dissolved in the alkaline fluid. Above the passivation potential, the etching does not oc-

cur. Instead, a stable surface oxide is formed, which surface oxide protects against etching.

[0040] Fig. 3C shows a development of a silicon-oxide layer by electrochemical oxidation and in relation to a time of application of the potential. It is noted that Fig. 3C corresponds to and is cited from Fig. 5 of US5877069. A potential (in Volts, horizontal axis) and a resulting layer thickness (in A (i.e. Angstrom: 10^{-10} m), vertical axis) are shown for a range of durations. For example, with a potential of 5 Volts, a silicon-oxide layer is formed. After two seconds (lowest line), the layer thickness is about 23 A; after 10 seconds the layer thickness has increased to about 31 A; after 60 seconds the layer thickness has increased to about 41 A; after 300 seconds the layer thickness has increased to about 50 A; and after 1800 seconds the layer thickness has increased to about 64 A.

[0041] At lower potentials, it is noted that the lines for 300 s and 1800 s appear to coincide. For example, at about 3 Volts, after 2 seconds, a layer thickness of about 18 A is obtained. After 60 seconds the thickness has increased to about 25 A. After 300 seconds and after 1800 seconds, the layer thickness has become about 28 A. So, at least for these lower potentials, a maximum layer thickness appears to be obtainable, allowing applying a voltage continuously to maintain the silicon-oxide layer. Further, a predetermined initial layer thickness may be easily obtained by sufficiently long applying a predetermined corresponding potential.

[0042] While an initial silicon-oxide surface layer may be obtained during manufacturing using electrochemical oxidation, the silicon-oxide surface layer may as well be obtained after manufacturing and even with the print head arranged in an inkjet printing assembly. Fig. 4 illustrates an embodiment of an inkjet print head 4 suitable for such operation. The inkjet print head 4 of Fig. 4 corresponds to the print head 4 of Fig. 2 except for the presence of an additional electrode 49, which in Fig. 4 extends into the pressure chamber 46. The additional electrode 49 is preferably made of a material resistant to an alkaline fluid. For example, platinum may be used in view its inert property.

[0043] With an alkaline liquid arranged in the fluid path, a first electrical source 54a may be connected between the additional electrode 49 and the first silicon layer 41 through a first electrical connection pad 58a. Due to the generated electrical field a first silicon-oxide surface layer 60a may be formed in the liquid supply channel 45. Similarly, with an alkaline liquid arranged in the fluid path, a second electrical source 54b may be connected between the additional electrode 49 and the second silicon layer 42 through a second electrical connection pad 58b. Due to the generated electrical field a second silicon-oxide surface layer 60b may be formed in the pressure chamber 46.

[0044] It is noted that the first electrical source 54a and the second electrical source 54b may of course be embodied as a single electrical source. Further, depending on the requirements and any initial processing during manufacturing, only one of the two silicon layers 41, 42 may be connected to an electrical source. Further, in view of the position of the additional electrode 49 relative to the silicon surfaces, the electric fields may differ locally, which may result in locally different silicon-oxide layer thicknesses. Within a predetermined range, such differences may be acceptable.

[0045] In other embodiments, the additional electrode may be arranged at any suitable position, wherein such position is electrically isolated from the silicon parts and a suitable electric field is generated at the location(s) where an oxide surface layer is desired.

[0046] Considering that protection against the alkaline liquid is important, a print head configured for maintaining or curing the oxide layer on the silicon surfaces in the fluidic path may be beneficial for increasing a lifetime of the print head. For example, the potential over the additional electrode 49 and a silicon layer 41, 42 may be applied continuously or periodically, e.g. after a predetermined duration of printing, or during a maintenance operation. Further, referring to Fig. 3B, sensing a current induced by the application of the potential might be used to determine whether the oxide surface layer is still intact and/or has been cured from defects.

[0047] Detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. In particular, features presented and described in separate dependent claims may be applied in combination and any advantageous combination of such claims is herewith disclosed.

[0048] Further, it is contemplated that structural elements may be generated by application of three-dimensional (3D) printing techniques. Therefore, any reference to a structural element is intended to encompass any computer executable instructions that instruct a computer to generate such a structural element by three-dimensional printing techniques or similar computer controlled manufacturing techniques. Furthermore, such a reference to a structural element encompasses a computer readable medium carrying such computer executable instructions.

[0049] Further, the terms and phrases used herein are not intended to be limiting; but rather, to provide an understandable description of the invention. The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected, although not necessarily direct-

ly.

[0050] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A method of manufacturing an inkjet print head (4), the inkjet print head (4) comprising a silicon part having at least a part of a fluidic path (44-47) arranged therein, the method comprising the steps of:

    • electrically connecting the silicon part to an electrical source (54);
    • providing an alkaline fluid in the fluidic path (44-47);
    • electrically connecting the alkaline fluid to the electrical source (54);

    characterized by the step of:

    • applying a voltage over the alkaline fluid and the silicon part, wherein the voltage is higher than a passivation voltage to form an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid.

2. An inkjet printing assembly comprising an inkjet print head (4) comprising:

    • a silicon part having at least a part of a fluidic path (44-47) arranged therein;
    • an electrical connection pad (58a-b) in electrical communication with the silicon part; and
    • an electrode (49) arranged in the fluidic path (44-47),

    wherein the inkjet print head (4) comprises at least two layers (41-42), each layer (41-42) composed of silicon and each having etched therein a part of the fluidic path (44-47), **characterized in that** the inkjet printhead assembly further comprises an electrical source (54), the electrical source (54) being electrically connected to the electrical connection pad (48a-b) and to the electrode (49), the electrical source (54) being configured to apply a voltage over the electrical connection pad (58a-b) and the electrode (49) such to apply a voltage higher than a passivation voltage over the silicon part and an alkaline fluid arranged in the fluidic path (44-47) to form an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid.

3. The inkjet print head assembly according to claim 2, wherein the fluidic path (44-47) comprises a fluid inlet port (44), a pressure chamber (46) and a nozzle orifice (47) and the inkjet print head (4) further comprises an electromechanical transducer (48) in operative mechanical coupling with the pressure chamber (46) for changing a pressure in a fluid arranged in the pressure chamber (46).

4. The inkjet printing assembly according to claim 3, wherein the inkjet printing assembly has a first operating mode and a second operating mode, wherein in the first operating mode the electrical source (54) does not apply a voltage over the electrical connection pad (58a-b) and the electrode (49) and wherein in the second operating mode the electrical source (54) applies the voltage higher than the passivation voltage.

5. The inkjet printing assembly according to claim 4, wherein the inkjet printing assembly has a maintenance mode, wherein the maintenance mode comprises the step of applying the voltage higher than the passivation voltage over the electrical connection pad and the electrode.

6. An inkjet print head (4) comprising:

    • a silicon part having at least a part of a fluidic path (44-47) arranged therein, the fluidic path (44-47) extending between a liquid inlet port (44) formed by an opening in the silicon part and a nozzle orifice (47), a liquid supply channel (45) for providing liquid from the liquid inklet port (44) to a pressure chamber (46) having a side wall at least partially formed by flexible membrane (43), and a nozzle orifice (47) connected to the pressure chamber (46) such that movement of the membrane 43 by means of an actuator (48) results in a droplet of the liquid being expelled through the nozzle orifice (47);
    • an electrical connection pad (58a, 58b) in electrical communication with the silicon part,

    characterized by:

    • an electrode (49) arranged in the fluidic path (44-47).

7. The inkjet print head (4) according to claim 6, wherein the electrode (49) extends inside the pressure chamber (46).

8. The inkjet print head (4) 4 according to claim 6 or 7, wherein the electrode (49) is arranged in the fluidic path (44-47), such that when electrical source (54) is electrically connected to the electrical connection pad (58a-b) and to the electrode (49), the electrical

source (54) is configured to apply a voltage over the electrical connection pad (58a-b) and the electrode (49) such to apply a voltage higher than a passivation voltage over the silicon part and an alkaline fluid arranged in the fluidic path (44-47) to form an oxide layer on a surface part of the silicon part, which surface part is in contact with the alkaline fluid.

9. The inkjet print head (4) 4 according to claim 6, 7, or 8, further comprising an silicon-oxide layer formed on walls of the fluidic path (44-47).

10. The inkjet print head (4) according to any of the claims 6 to 9, wherein the inkjet print head (4) was formed by the method according to claim 1.

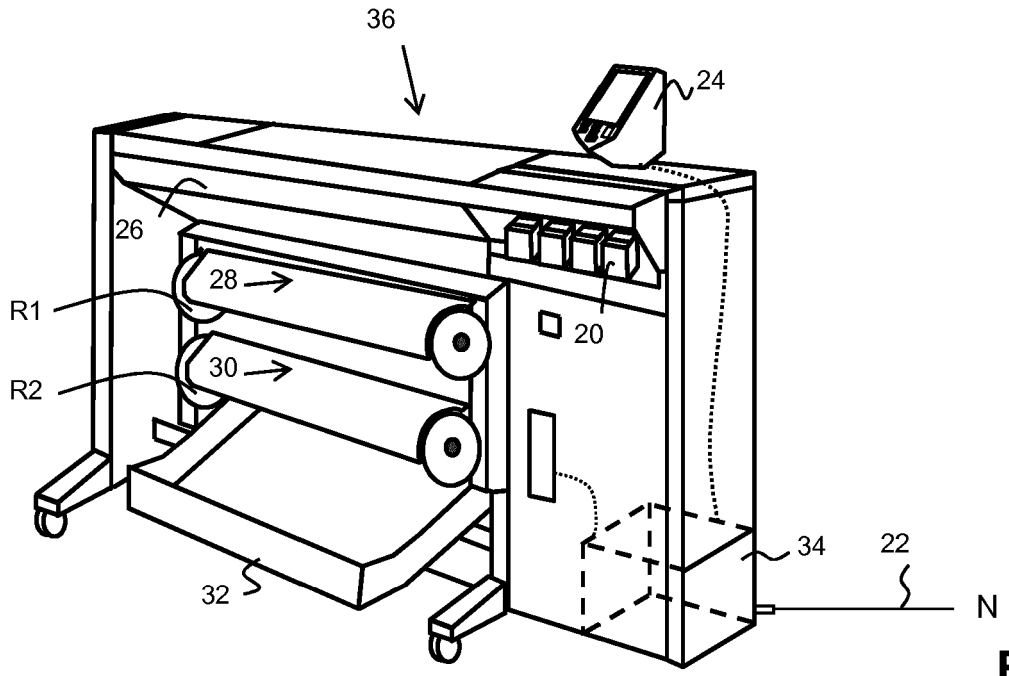

36
24
26
28
R1
30
R2
20
34
22
N
32

Fig. 1A

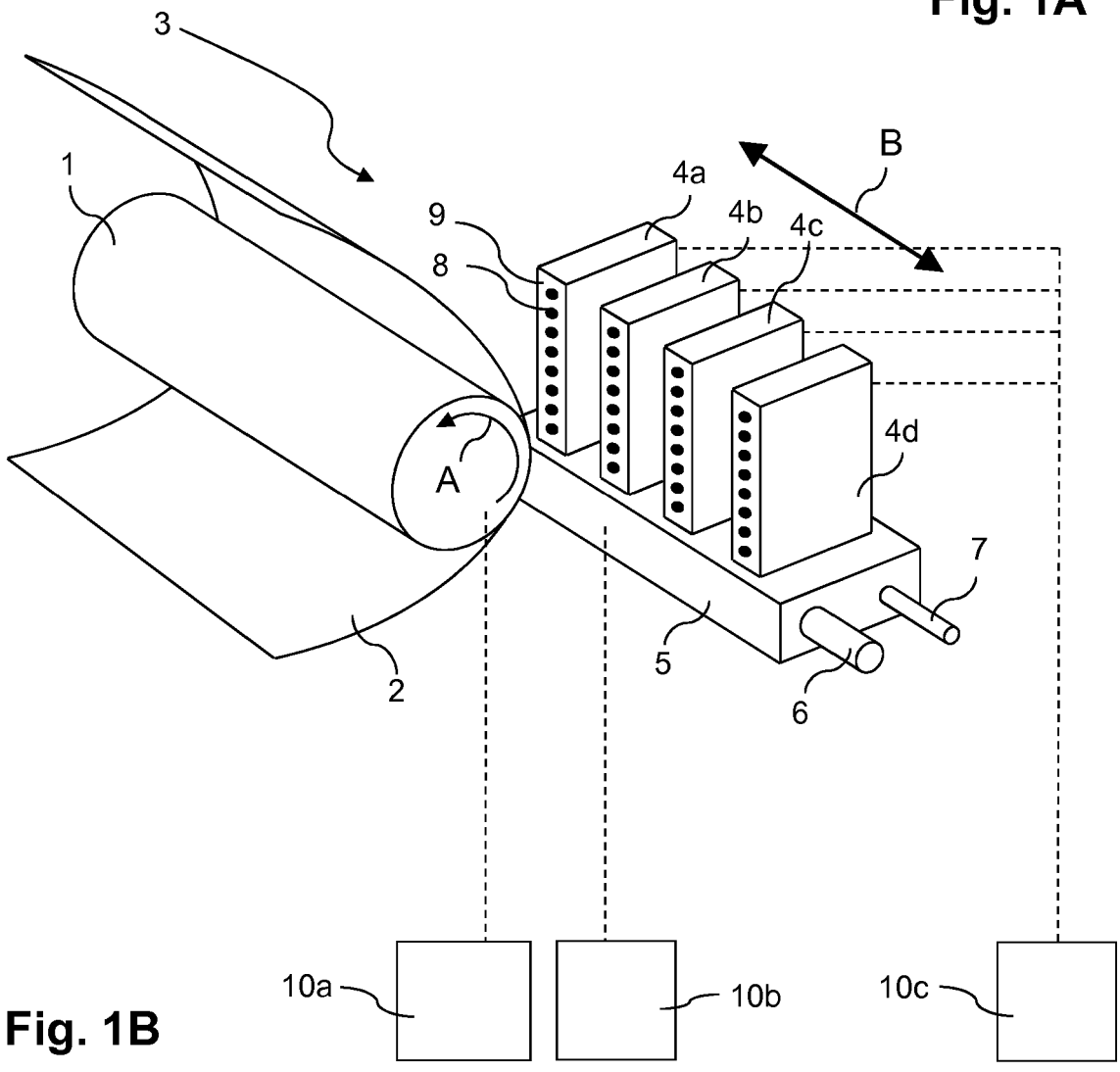

3
1
9
8
4a
4b
4c
B
4d
A
7
5
6
2
10a
10b
10c

Fig. 1B

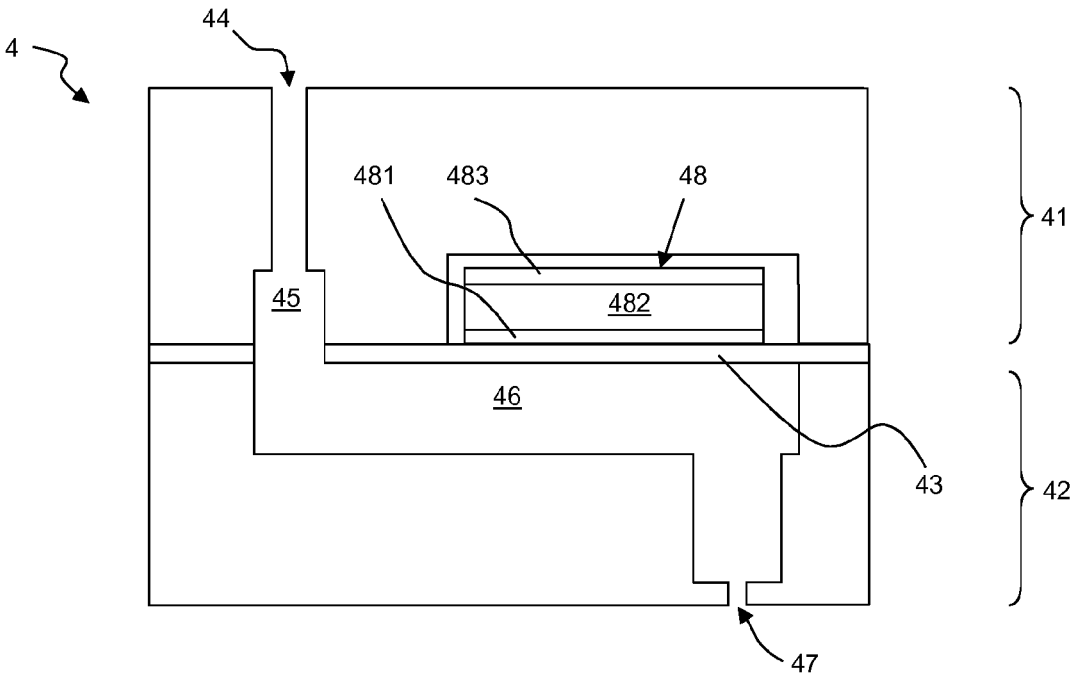


Fig. 2

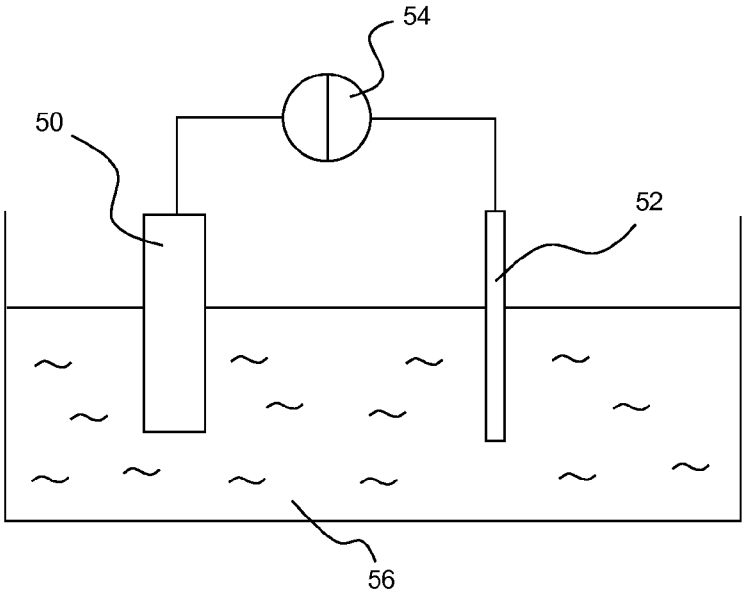


Fig. 3A

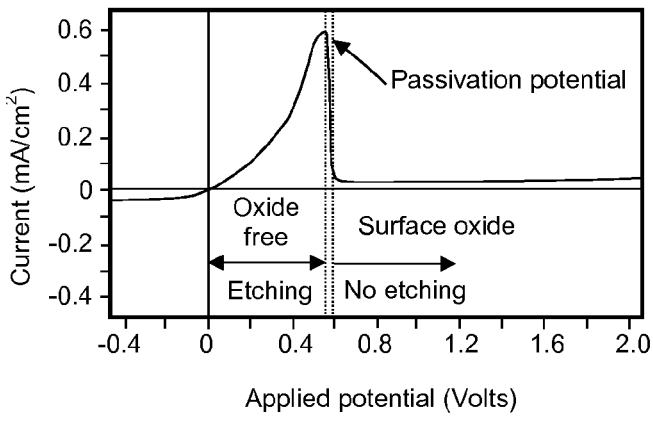


Fig. 3B

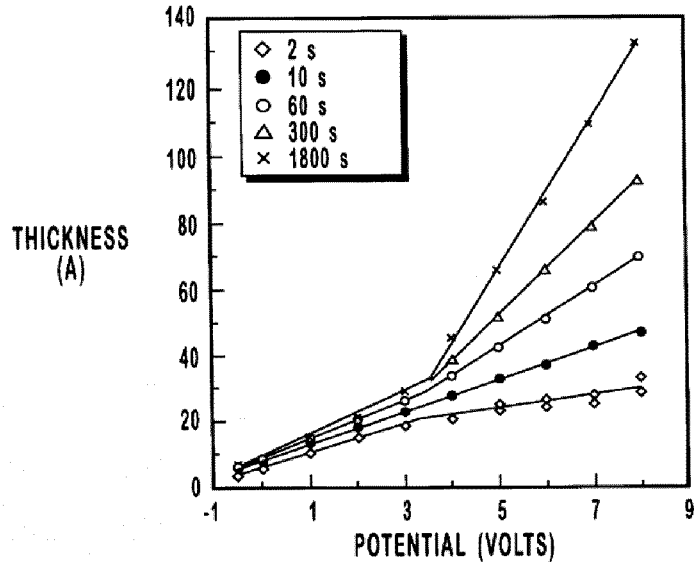

THICKNESS (A)
140
120
100
80
60
40
20
0
-1
1
3
5
7
9
POTENTIAL (VOLTS)
2 s
10 s
60 s
300 s
1800 s

Fig. 3C

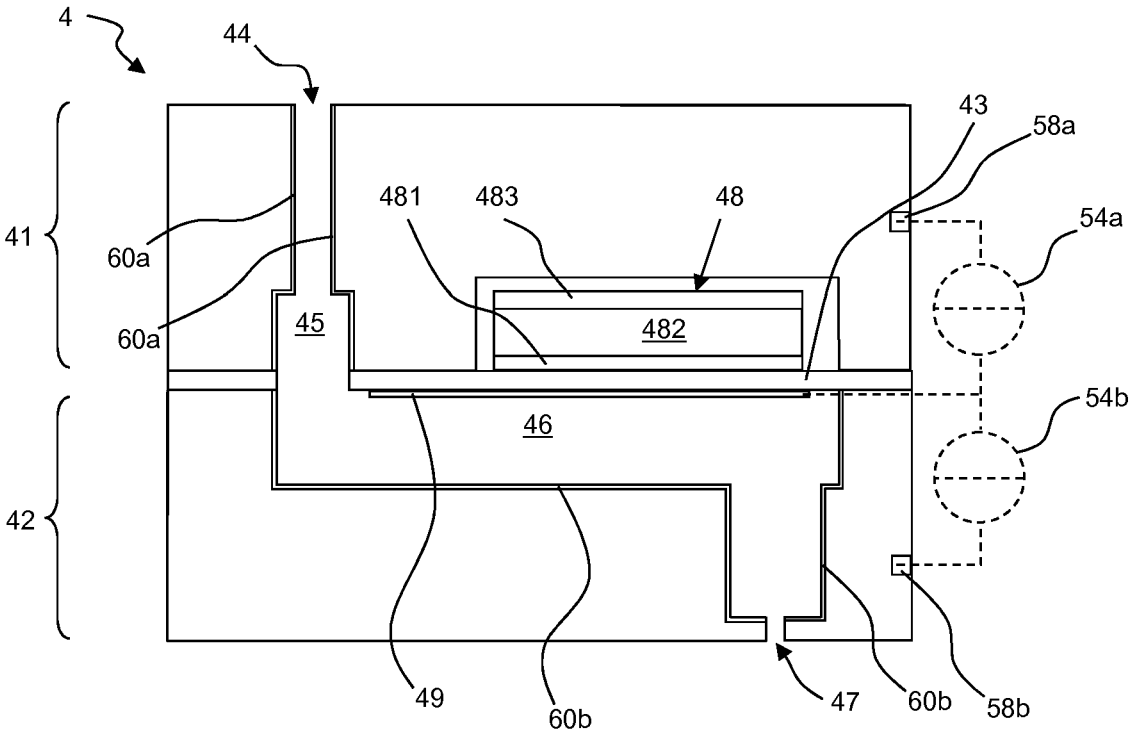

4
44
43
58a
481
483
48
54a
41
60a
60a
45
482
46
54b
42
49
60b
47
60b
58b

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 9243

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Place of search	Date of completion of the search	Examiner
The Hague	16 October 2018	Didenot, Benjamin

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