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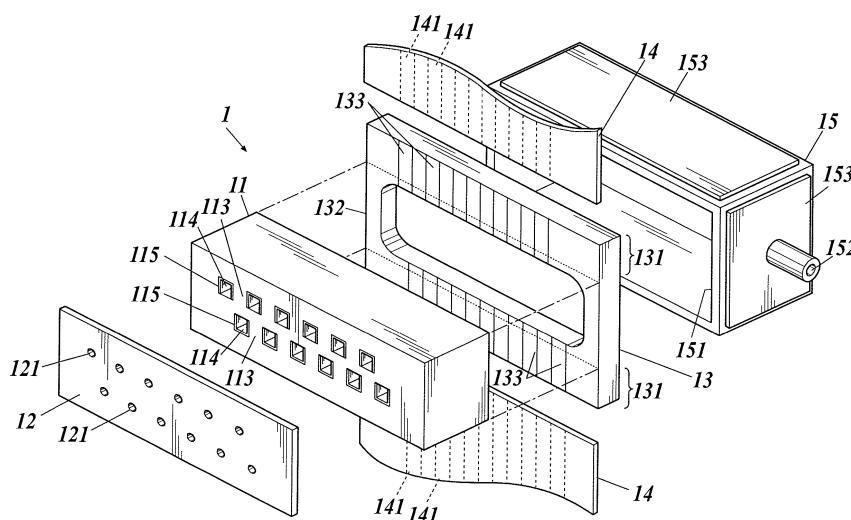
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(54) **INK JET HEAD AND INK JET RECORDING DEVICE**

(57) The problem of the present invention is to provide an ink jet head with which it is possible to suppress the occurrence of separation in a fastened part between a first member and a second member fastened to the first member when an ink heated to a prescribed temperature is discharged. The ink jet head is an ink jet head

of an ink jet recording device for discharging an ink heated to a prescribed temperature, and is characterized in being provided with a first member and a second member fastened to the first member, with a silane coupling agent interposed the interface between the first and the second members.

FIG.2



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to inkjet heads and inkjet recording apparatuses.

BACKGROUND ART

10 **[0002]** A typical inkjet recording apparatus includes an inkjet head ejecting ink from nozzles onto a recording medium to form an image on the recording medium. The inkjet head includes a head chip provided with an ejection energy applying means, such as a piezoelectric element, to energize the ink to be ejected. The component such as the head chip is fixed to other component with an adhesive, such as a curable resin. A protective film may be fixed to the surfaces of the head chip to protect the surfaces of the head chip.

15 **[0003]** Some of such inkjet recording apparatuses use an ink (phase transition ink) having a viscosity which reversibly changes by being heated, such as a UV ink curable through irradiation with ultraviolet rays. In use of the phase transition ink, which often has high viscosity at low temperatures, the inkjet head or the inkjet recording apparatus is configured to heat the ink in order to efficiently eject the ink from the inkjet head (for example, see Patent Literature 1).

CITATION LIST

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Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Laid-Open No. 2003-165217

25 SUMMARY OF INVENTION

PROBLEMS TO BE SOLVED BY INVENTION

30 **[0005]** Such an inkjet head may cause deterioration and thus separation of some fixed portions between the components forming the inkjet head.

[0006] In particular, an inkjet recording apparatus configured to heat the ink generates a difference in temperature between ink passages and their outer portions, causing physical distortion in the inkjet head. Thus deterioration of the fixed portions becomes more significant.

35 **[0007]** An object of the present invention is to provide an inkjet head which is provided with a first member and a second member fixed to the first member and does not cause separation of fixed portions between the first and second members during ejection of ink heated to a predetermined temperature, and an inkjet recording apparatus including the inkjet head.

MEANS FOR SOLVING PROBLEMS

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[0008] The problems described above are accordingly solved by the present invention which is characterized as follows:

1. An inkjet head which is disposed in an inkjet recording apparatus and ejects ink heated to a predetermined temperature, the inkjet head including:

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- a first member;
- a second member fixed to the first member; and
- a silane coupling agent disposed at an interface between the first member and the second member.

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2. The inkjet head of item 1., wherein the ink is a phase transition ink causing reversible phase transition between a solid state and a liquid state at a phase transition temperature.

3. The inkjet head of item 1., wherein the ink is a phase transition ink causing reversible phase transition between a gel state and a sol state at a phase transition temperature.

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4. The inkjet head of any one of items 1. to 3., wherein a fixed portion between the first member and the second member is in contact with the ink.

5. The inkjet head of any one of items 1. to 4., further including:

a common ink chamber disposed on an upstream side of the first member in an ink feeding direction to feed

the ink to a plurality of nozzles, and
a heater disposed on the common ink chamber to heat the ink.

6. The inkjet head of item 5., wherein the heater is disposed on an outer surface of the common ink chamber.
7. The inkjet head of any one of items 1. to 6., wherein the first member is a head chip ejecting the ink from a nozzle.
8. The inkjet head of any one of items 1. to 7., wherein the silane coupling agent is contained in a thermosetting adhesive.
9. The inkjet head of item 7, wherein the adhesive contains a conductive particle.
10. The inkjet head of any one of items 1. to 7., wherein the second member is a protective film disposed on a surface of the first member.
11. The inkjet head of any one of items 1. to 10., wherein the silane coupling agent contains sulfur.
12. The inkjet head of any one of items 1. to 11., wherein the inkjet head is driven at an ejection frequency of 20 kHz or more.
13. An inkjet recording apparatus including the inkjet head of any one of items 1. to 12.
14. The inkjet recording apparatus of item 13, further including a control unit not heating ink during an idling time of the inkjet recording apparatus and heating the ink during an operation time of the inkjet recording apparatus.

EFFECTS OF INVENTION

[0009] The present invention can provide an inkjet head which is provided with a first member and a second member fixed to the first member and does not cause separation of fixed portions between the first and second members during ejection of ink heated to a predetermined temperature, and an inkjet recording apparatus including the inkjet head.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

[Fig. 1] Fig. 1 is a diagram illustrating a schematic configuration of an exemplary inkjet recording apparatus of the present invention.

[Fig. 2] Fig. 2 is an exploded perspective view illustrating an exemplary inkjet head of the present invention.

[Fig. 3] Fig. 3 is a schematic cross-sectional view illustrating the exemplary inkjet head of the present invention.

[Fig. 4A] Fig. 4A is an enlarged cross-sectional view illustrating part of the inkjet head illustrated in Fig. 3.

[Fig. 4B] Fig. 4B is an enlarged cross-sectional view illustrating part of the inkjet head illustrated in Fig. 3.

MODES FOR CARRYING OUT THE INVENTION

[0011] An inkjet recording apparatus according to an embodiment of the present invention will now be described in detail by way of the drawings. The scope of the invention should not be limited to the examples illustrated. Components having the same functions and configurations are denoted by the same reference numerals, and the description thereof will be omitted.

[0012] The schematic configuration of an inkjet recording apparatus 100 of the present invention will be described with reference to Fig. 1. Fig. 1 illustrates the schematic configuration of an exemplary line-type inkjet recording apparatus 100.

[0013] The inkjet recording apparatus 100 of the present invention includes a conveying unit 20, an image forming unit 30, an ink feeding unit 40, and a control unit 50. Based on control by the control unit 50, the inkjet recording apparatus 100 forms an image by the image forming unit 30 with the ink fed from the ink feeding unit 40 onto a recording medium P conveyed by the conveying unit 20.

[0014] The conveying unit 20 holds the recording medium P on which an image is to be formed, and feeds the recording medium P to the image forming unit 30. The conveying unit 20 includes a feed roll 21, rollers 22 and 23, and a take-up roll 24. An elongated recording medium P in the form of a roll is fed from the feed roll 21, is conveyed while being supported by the rollers 22 and 23, and is wound around the take-up roll 24.

[0015] The image forming unit 30 ejects the ink onto the recording medium P to form an image. The image forming unit 30 includes a plurality of line heads 31, an irradiating unit 32, and a carriage 33 holding the plurality of line heads 31.

[0016] Each of the line heads 31 ejects the ink onto the recording medium P conveyed by the conveying unit 20 to form an image. The line heads 31 are separately disposed for yellow (Y), magenta (M), cyan (C), and black (K) colors. In Fig. 1, the line heads 31 corresponding to colors of Y, M, C, and K are sequentially disposed from upstream of the moving direction of the recording medium P by the conveying unit 20.

[0017] The line heads 31 of the present embodiment are disposed in the carriage 33, and each have a length (width)

extending across the recording medium P in the direction (cross direction) approximately perpendicular to the moving direction of the recording medium P. In other words, the inkjet recording apparatus 100 is a line head type inkjet recording apparatus of a one-pass system. Each line head 31 is composed of a plurality of inkjet heads 1 (see Figs. 2 and 3) aligned in rows. The carriage 33 also includes a carriage heater 33a, which is an external heater heating the ink from the outside of the inkjet head 1.

[0018] The irradiating unit 32 emits energy rays onto the ink, which is used in the inkjet recording apparatus 100 of the present embodiment, after the ink is ejected onto the recording medium P, to cure the ink. The irradiating unit 32 includes a fluorescent tube, such as a low pressure mercury lamp, and emits energy rays, such as ultraviolet rays, generated in the fluorescent tube. The irradiating unit 32 is disposed on a downstream side of the line heads 31 in the moving direction of the recording medium P. The irradiating unit 32 emits energy rays onto the recording medium P having an image formed thereon to cure the ink ejected onto the recording medium P.

[0019] Examples of the fluorescent tube emitting ultraviolet rays include low pressure mercury lamps, mercury lamps operated under a pressure of about several hundred pascals to 1 MPa, light sources usable as germicidal lamps, cold cathode ray tubes, ultraviolet ray laser light sources, metal halide lamps, and light emitting diodes. Among these light sources, more preferred are light sources that can emit a higher intensity of ultraviolet rays with low power consumption (such as light emitting diodes). The energy rays are not limited to ultraviolet rays. Any energy rays that can cure the ink according to the characteristics of the ink may be used. The light source is also varied according to the wavelength of the energy rays.

[0020] The ink feeding unit 40 includes ink tanks 41, pumps 42, ink tubes 43, sub tanks 44, ink tubes 45, and a heater 46. The ink feeding unit 40 stores the ink, and feeds the ink to the line heads 31 of the image forming unit 30, thereby enabling ejection of the ink of the respective color from nozzles of the line heads 31.

[0021] The ink in the ink tanks 41 is sent by the pumps 42 through the ink tubes 43 to the sub tanks 44, which adjusts the back pressure of the ink in the inkjet heads 1. Each of the sub tanks 44 is provided with a float sensor 44a. The control unit 50 operates each of the pumps 42 based on the data on the position of the ink level detected by the float sensor 44a to store a predetermined amount of ink. The ink in the sub tanks 44 is fed to the inkjet heads 1 through the ink tubes 45.

[0022] The ink feeding unit 40 is also provided with the heater 46, which serves as an external heater for heating the ink from the outside of the inkjet head 1. In the example illustrated in Fig. 1, the heater 46 is disposed so as to cover the whole ink feeding unit 40. The heater 46 may be separately disposed on any one of the components forming the ink feeding unit 40. Such a configuration allows the ink in the ink feeding unit 40 to be heated and kept warm, keeping the ink temperature at or above a predetermined temperature. The heater 46 is composed of a heating wire or a heat conducting member, for example. The heater 46 may be disposed so as to cover each of the components forming the ink feeding unit 40, or is attached to the outer surfaces of the components forming the ink feeding unit 40.

[0023] The ink used in the inkjet recording apparatus 100 of the present embodiment is not especially limited. For example, an ultraviolet ray (UV) curable ink may be used. The UV curable ink causes phase transition between a gel state and a liquid (sol) state, in response to the temperature, while not being irradiated with UV. For example, the ink has a predetermined phase transition temperature, for example, about 40 to 100°C, and is homogeneously liquefied (solates) through heating to the phase transition temperature or higher. The ink gels at the predetermined phase transition temperature including about normal room temperature (0 to 30°C) or lower.

[0024] Besides the ultraviolet ray curable ink, a phase transition ink causing reversible phase transition between a gel state and a sol state at the phase transition temperature or a phase transition ink causing reversible phase transition between a solid state and a liquid state at the phase transition temperature may also be used in the inkjet recording apparatus 100, for example. Any ink other than these phase transition inks may also be used.

[0025] The control unit 50 controls the operations of the units in the inkjet recording apparatus 100, and thus the overall operation of the inkjet recording apparatus 100. The control unit 50 includes a central processing unit (CPU), a read only memory (ROM), and a random access memory (RAM). In the control unit 50, a variety of processing programs stored in the ROM, such as a system program, are loaded into the RAM. The programs loaded in the RAM are executed by the CPU to execute a variety of control processes, such as an image forming process and the ink feeding process described above.

[0026] The schematic configuration of the inkjet head 1 of the present invention will be described with reference to Figs. 2, 3, 4A, and 4B. Fig. 2 is an exploded perspective view illustrating an exemplary inkjet head 1. Fig. 3 is a sectional view illustrating the exemplary inkjet head 1. Fig. 4A is an enlarged sectional view of the region A in Fig. 3. Fig. 4B is an enlarged sectional view of the region B in Fig. 3.

[0027] The inkjet head 1 includes a head chip (first member) 11, a nozzle plate 12 joined to the front surface of the head chip 11, a wiring substrate (second member) 13 joined to the rear surface of the head chip 11, flexible printed circuits (FPCs) 14 joined to the wiring substrate 13, and an ink manifold (common ink chamber) 15 joined to the rear surface of the wiring substrate 13.

[0028] Throughout the specification, the surface of the head chip 11 from which the ink is ejected refers to "front

surface", and its opposite surface refers to "rear surface". Seen from the front surface or the rear surface of the head chip 11, outer surfaces located above and below channels aligned in the head chip 11 refer to "top surface" and "bottom surface", respectively.

[0029] The head chip 11 includes driving walls 113 composed of piezoelectric elements and channels 114 alternately disposed. Each channel 114 has two side walls parallel to each other and substantially vertical to the top surface and the bottom surface of the channel. As illustrated in Fig. 3, each channel 114 has an inlet 114a and an outlet 114b disposed on the front surface and the rear surface of the head chip 11, respectively. Each channel 114 has a straight shape having a substantially identical dimension and shape from the inlet 114a to the outlet 114b in the length direction.

[0030] The head chip 11 has two rows, i.e., upper and lower rows of channels 114 as illustrated in the drawing. Although each row is composed of six channels 114 in the drawing, the row in the head chip 11 may be composed of any number of channels 114.

[0031] The head chip 11 is composed of a piezoelectric substrate composed of lead zirconate titanate (PZT), for example, and perforated to form pores corresponding to the channels 114.

[0032] Each channel 114 of the head chip 11 has a driving electrode 115 disposed on an inner wall of the channel. Examples of metal materials for the driving electrode 115 include Ni, Co, Cu, and Al. In particular, preferred is use of Al and Cu in view of electric resistance, and preferred is use of Ni in view of anti-corrosiveness, strength, and cost. The driving electrode 115 may have a laminate structure composed of an Al layer and an Au layer disposed on the Al layer.

[0033] Examples of the method of forming the driving electrode 115 include deposition, sputtering, plating, and chemical vapor deposition (CVD). Among these methods, preferred are plating, and particularly preferred is non-electrolytic plating. Non-electrolytic plating can produce a homogeneous metal coating film without pinholes. The plated film preferably has a thickness in the range of 0.5 to 5 μm .

[0034] The driving electrodes 115 are not formed on the front end surfaces of the driving walls 113 because the channels 114 should be independent of each other. To satisfy this requirement, the driving electrodes 115 can be selectively formed only on the inner surfaces of the channels 114, for example, as follows: A dry film or a resist is preliminarily disposed on the front end surfaces of the driving walls 113 during formation of the driving electrodes 115, and the dry film or the resist is removed after formation of the metal coating film.

[0035] Connection electrodes 116 which are electrically connected to the driving electrodes 115, respectively, are drawn out and disposed on the rear surface of the head chip 11.

[0036] As illustrated in Fig. 3, the connection electrodes 116 are disposed on the rear surface of the head chip 11 so that each of the connection electrodes extends from the rear end of the driving electrode 115 toward the top surface or the bottom surface of the head chip 11. Examples of metal materials for the connection electrode 116 include metals for forming electrodes, such as Al.

[0037] Similarly to the driving electrode 115, the connection electrode 116 may also have a laminate structure composed of an Al layer and an Au layer disposed on the Al layer. Similarly to the driving electrode 115, examples of the method of forming the connection electrodes 116 include deposition, sputtering, plating, and chemical vapor deposition (CVD).

[0038] Although the head chip 11 operates in a shear mode utilizing shear deformation of the driving walls 113, any operational mode may be used, such as a bend mode utilizing deflection of a piezoelectric element formed through bonding or CVD on a vibration plate disposed on one surface of the channel 114, or a push mode utilizing deformation of a vibration plate caused by expansion and shrinkage of a piezoelectric element bonded to the vibration plate.

[0039] The nozzle plate 12 includes nozzles 121 which are opened at positions corresponding to the channels 114 of the head chip 11. The nozzle plate 12 is bonded to the front surface of the head chip 11 with an epoxy adhesive.

[0040] The wiring substrate 13 in the form of a plate is disposed to connect wirings that apply drive voltage from a drive circuit (not illustrated) to the driving electrodes 115 of the head chip 11. The substrate used in the wiring substrate 13 can be a substrate composed of a non-polarized PZT material or a ceramic material, such as AlN-BN or AlN; a substrate composed of a plastic or glass material having low thermal expansion; or a substrate composed of a depolarized substrate material identical to that of the substrate for the piezoelectric element used in the head chip 11. To prevent distortion of the head chip 11 caused by a difference in coefficient of thermal expansion between the wiring substrate 13 and the head chip 11, the material for the wiring substrate 13 is preferably selected such that the difference is ± 1 ppm or less.

[0041] The wiring substrate 13 may be composed of not only a single plate but also a laminate with a desired thickness of several layers of thin plates.

[0042] The wiring substrate 13 has a length equal to that of the head chip 11 in the width direction. The wiring substrate 13 extends in the direction (the vertical direction in Figs. 2 and 3) perpendicular to the arranged direction (the channel row direction) of the channels 114 of the head chip 11, and projects from the top surface and the bottom surface of the head chip 11. End portions of the vertical projections of the wiring substrate 13 serve as wiring connection parts 131 for connecting the FPCs 14.

[0043] The wiring substrate 13 has an opening 132 penetrating through substantially the center of the wiring substrate 13. The opening 132 has a size that enables the inlets 114a of all of the channels 114 of the head chip 11 to be exposed

from the opening 132. Accordingly, all of the driving walls 113, all of the channels 114, and all of the driving electrodes 115 of the head chip 11 can be seen from the opening 132 after the wiring substrate 13 is joined to the rear surface of the head chip 11.

[0044] The method of forming the opening 132 may be selected according to the material for the wiring substrate from a method of processing a substrate with a dicing saw, a method of processing a substrate with an ultrasonic processing machine, or a method of molding a green ceramic material in a mold and then firing the molded product, for example.

[0045] The wiring substrate 13 includes wiring electrodes 133 disposed on the surface to be joined to the head chip 11. The wiring electrodes 133 are identical to the connection electrodes 116 disposed on the rear surface of the head chip 11 in number and pitch. The wiring electrodes 133 extend to the wiring connection parts 131, 131. The wiring electrodes 133 are electrically connected to wirings 141 disposed on the FPCs 14 during joining of the FPCs 14, and function as electrodes for applying drive voltage, which is fed from the drive circuit through the wirings 141 of the FPCs 14, through the connection electrodes 116 to the driving electrodes 115 in the channels 114.

[0046] The wiring electrodes 133 can be formed as follows: A positive resist is applied onto a surface of the wiring substrate 13 by spin coating. The positive resist is exposed to light through a mask with a stripe pattern, and is developed to expose the surface of the wiring substrate 13 from between the stripe pattern of the positive resist so that the pattern of the wiring substrate 13 becomes identical to that of the connection electrodes 116 in number and pitch. A metal for forming an electrode is applied onto the exposed surface of the wiring substrate 13 by a method, such as deposition or sputtering, to form a metal coating film. The metal for forming an electrode can be the same metal used in formation of the connection electrode 116.

[0047] The wiring substrate 13 is positioned such that the wiring electrodes 133 are electrically connected to the connection electrodes 116 of the head chip 11 and the inlets 114a of all of the channels 114 of the head chip 11 are exposed from the opening 132, and in this state, the wiring substrate 13 is bonded to the rear surface of the head chip 11. As illustrated in Fig. 4A, the wiring substrate 13 is bonded to the head chip 11 through heating of a thermosetting resin adhesive 61. The wiring substrate 13 is thereby fixed to the rear surface of the head chip 11 with the adhesive 61.

Any adhesive 61, such as an epoxy adhesive, may be used.

[0048] The adhesive 61 in the present embodiment contains a silane coupling agent. As a result, the silane coupling agent is disposed at the interface between the head chip 11 and the wiring substrate 13. Throughout the specification, the term "disposed at the interface" refers to the state of the silane coupling agent present between two components. The silane coupling agent may be present in the form of a layer between two components, or may be present between two components in the state where the silane coupling agent is contained in a different component (such as the adhesive 61).

[0049] Any silane coupling agent enabling chemical bond to the head chip 11 or the wiring substrate 13 may be used. More preferred are those that can be chemically bonded to the adhesive 61. Examples of such a silane coupling agent include halogenated silane coupling agents (such as 2-chloroethyltrimethoxysilane, 2-chloroethyltriethoxysilane, 3-chloropropyltrimethoxysilane, and 3-chloropropyltriethoxysilane); epoxy group-containing silane coupling agents (such as 3-glycidyloxypropyltriethoxysilane, 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, 2-(3,4-epoxycyclohexyl)ethyltriethoxysilane, 3-(3,4-epoxycyclohexyl)propyltrimethoxysilane, 2-glycidyloxyethyltrimethoxysilane, 2-glycidyloxyethyltriethoxysilane, and 3-glycidyloxypropyltrimethoxysilane); amino group-containing silane coupling agents (such as 2-aminoethyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 2-[N-(2-aminoethyl)amino]ethyltrimethoxysilane, 3-[N-(2-aminoethyl)amino]propyltrimethoxysilane, 3-(2-aminoethyl)amino]propyltriethoxysilane, and 3-[N-(2-aminoethyl)amino]propylmethyldimethoxysilane); mercapto group-containing silane coupling agents (such as 2-mercaptoethyltrimethoxysilane, 3-mercaptopropyltrimethoxysilane, and 3-mercaptopropyltriethoxysilane); thiocarboxylate group-containing silane coupling agents (such as 3-octanoylthio-1-propyltriethoxysilane); vinyl group-containing silane coupling agents (such as vinyltrimethoxysilane and vinyltriethoxysilane); and (meth)acryloyl group-containing silane coupling agents (such as 2-methacryloyloxyethyltrimethoxysilane, 2-methacryloyloxyethyltriethoxysilane, 2-acryloyloxyethyltrimethoxysilane, 3-methacryloyloxypropyltrimethoxysilane, 3-methacryloyloxypropyltriethoxysilane, and 3-acryloyloxypropyltrimethoxysilane). These silane coupling agents may be used alone or in combination. Among these silane coupling agents, preferred are silane coupling agents containing sulfur atoms (mercapto group-containing silane coupling agents and thiocarboxylate group-containing silane coupling agents), which can be used in a broader range irrespective of the materials for the head chip 11, the wiring substrate 13, and the adhesive 61.

[0050] Since the adhesive 61 contains the silane coupling agent, the silane coupling agent can form bonds with the head chip 11, the wiring substrate 13, and the adhesive 61 through heating of the adhesive 61 during bonding of the head chip 11 to the wiring substrate 13. These bonds enhance the fixing strength between the head chip 11 and the wiring substrate 13.

[0051] The ink heated to a predetermined temperature is circulated in the head chip 11 during operation of the inkjet recording apparatus 100 to heat the fixing portion between the head chip 11 and the wiring substrate 13. As a result, non-bonded portions (non-reacted portions during production of the inkjet head 1 and unbonded portions by hydrolysis after long-term use) of the silane coupling agent disposed at the interface between the head chip 11 and the wiring

substrate 13 can form chemical bonds, further enhancing the fixing strength between the head chip 11 and the wiring substrate 13. As illustrated in Fig. 3, the fixed portion between the head chip 11 and the wiring substrate 13 is in direct contact with the ink. Such a configuration facilitates heating of the fixed portion, and thus enhances the fixing strength between the head chip 11 and the wiring substrate 13.

[0052] The fixing strength between the head chip 11 and the wiring substrate 13 can be enhanced by the ink heated to a predetermined temperature and circulating through the fixed portion between the head chip 11 and the wiring substrate 13, thus reducing the separation of the fixed portion between the head chip 11 and the wiring substrate 13 caused by repeated deformation of the piezoelectric elements.

[0053] The adhesive 61 contains conductive particles. The conductive particles contained in the adhesive 61 ensure electrical connection between the head chip 11 and the wiring substrate 13. The conductive particles used are composed of, for example, Ni or Au. Alternatively, the conductive particles may be composed of any material that can impart conductivity to the adhesive 61. Preferred is use of a material that can be chemically bonded to the silane coupling agent contained in the adhesive 61 in the present embodiment.

[0054] The wiring substrate 13 may also be bonded to the head chip 11 with an anisotropic conductive film instead of the thermosetting adhesive 61, or with a heated and melted solder applied to at least one of the wiring electrode 133 and the connection electrode 116. Methods usually used in packaging techniques can also be appropriately used.

[0055] An adhesive 61 not containing conductive particles may be used.

[0056] As a result of bonding of the wiring substrate 13 to the rear surface of the head chip 11, electrodes (the connection electrodes 116 and the wiring electrodes 133) applying drive voltage fed from the drive circuit to the driving electrodes 115 in the channels 114 of the head chip 11 are drawn perpendicular to the rows of channels. Among these electrodes, the wiring electrodes 133 are drawn to the wiring connection parts 131, 131 largely projected from the head chip 11, facilitating electrical connection to the FPCs 14, 14. The FPCs 14, 14 joined to the wiring substrate 13 are not located on the rear side of the head chip 11. Such an arrangement can provide a large open space on the rear side of the head chip 11.

[0057] As illustrated in Fig. 4B, the head chip 11 includes a protective film (second member) 62 for the driving electrodes 115 to prevent corrosion of the driving electrodes 115. The protective film 62 is fixed to the surface of the head chip 11. The protective film 62 may be composed of a polyparaxylylene film, for example.

[0058] It is not preferred that the nozzle plate 12 be bonded to the head chip 11 before formation of the protective film 62 because the polyparaxylylene film as the protective film 62 is formed by CVD to adhere to the entire surfaces of the head chip 11. Thus, in a preferred embodiment, the protective film 62 is preliminarily formed, and then the nozzle plate 12 is bonded to the head chip 11. Since the protective film 62 is formed after bonding of the head chip 11 and the wiring substrate 13, the protective film 62 adheres to not only the head chip 11 but also the wiring substrate 13 to prevent corrosion of the electrodes of the wiring substrate 13.

[0059] The protective film 62 may be composed of any material other than polyparaxylylene that can prevent corrosion of the driving electrodes 115 and other electrodes.

[0060] A silane coupling agent layer 71 is disposed at the interface between the head chip 11 and the protective film 62 in the present embodiment. The silane coupling agent layer 71 can be formed with one of the silane coupling agents listed above as the silane coupling agents to be contained in the adhesive 61.

[0061] The silane coupling agent layer 71 can be disposed at the interface between the head chip 11 and the protective film 62, for example, by a method of applying a silane coupling agent solution onto surfaces of the head chip 11 before formation of the protective film 62, and drying the solution.

[0062] The silane coupling agent layer 71 disposed between the head chip 11 and the protective film 62 can enhance the fixing strength between the head chip 11 and the protective film 62 as in the case of the silane coupling agent disposed at the interface between the head chip 11 and the wiring substrate 13. The enhanced fixing strength can prevent the separation of fixed portion between the head chip 11 and the protective film 62.

[0063] The silane coupling agent disposed at the interface between the head chip 11 and the wiring substrate 13 and the silane coupling agent layer 71 disposed at the interface between the head chip 11 and the protective film 62 can effectively prevent the separation of the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62 during driving of the inkjet head 1 at a high frequency of 20 kHz or more.

[0064] An ink manifold 15 is disposed on an upstream side of the head chip 11 in the ink feeding direction to feed the ink through the opening 132 of the wiring substrate 13 to the channels 114 of the head chip 11. The ink manifold 15 has a box shape with an opening 151. The ink manifold 15 is joined to the wiring substrate 13 such that the opening 151 covers the opening 132 of the wiring substrate 13.

[0065] The opening 151 of the ink manifold 15 has a size that contains the opening 132 of the wiring substrate 13 and reaches the projections 131, 131. Thus, the opening 151 has an area larger than that of the rear surface of the head chip 11. By utilizing the projections 131, 131 of the wiring substrate 13 in joining of the ink manifold 15 and the wiring substrate 13, a large volume of ink relative to the dimensions of the head chip 11 can be stored. The ink is fed into the ink manifold 15 through an ink feeding port 152.

[0066] The ink manifold 15 includes internal heaters 153 disposed on outer surfaces thereof, respectively. Each of the internal heaters 153 may have any heating mechanism, such as a heating wire or a rubber heater, to heat the inside of the ink manifold 15. The internal heaters 153 can heat the ink to a predetermined temperature, and also heat the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62, enhancing the fixing strength between the head chip 11 and the wiring substrate 13 and that between the head chip 11 and the protective film 62 as described above. The internal heaters 153 are disposed near the wiring substrate 13 to efficiently heat the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62. As a result, the fixing strength between the head chip 11 and the wiring substrate 13 and that between the head chip 11 and the protective film 62 can be further enhanced. The internal heaters 153 are not necessarily disposed in the ink manifold 15 if the inkjet recording apparatus can heat the ink to a predetermined temperature.

[0067] In the present embodiment, the control unit 50 controls the external heaters, i.e., the carriage heater 33a and the heater 46, and the internal heaters 153 so as not to heat the ink during the idling time of the inkjet recording apparatus 100 and to heat the ink during the operation time of the inkjet recording apparatus 100. As a result, the ink can be heated only during the operation time of the inkjet recording apparatus 100 to promote the chemical reaction of the silane coupling agent, further ensuring a reduction in separation of the fixed portion between the head chip 11 and the wiring substrate 13 or the protective film 62.

[0068] In a wiring substrate 13 having a sufficient thickness, the ink manifold 15 may be replaced with a partially covered opening 132 of the wiring substrate 13 so as to form an ink feeding port. The opening 132 can thereby function as a common ink chamber from which the ink is fed to all the channels 114.

[0069] According to the embodiment, the inkjet recording apparatus 100 includes the inkjet head 1 ejecting ink heated to a predetermined temperature. The inkjet head 1 includes the head chip 11, and the wiring substrate 13 and protective film 62 which are fixed to the head chip 11. The silane coupling agent is disposed at the interface between the head chip 11 and the wiring substrate 13 and the interface between the head chip 11 and the protective film 62. Circulation of the heated ink heats the silane coupling agent to promote the chemical reaction thereof, forming chemical bonds in the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62. As a result, the separation of these fixed portions can be effectively reduced.

[0070] Since the fixed portion between the head chip 11 and the wiring substrate 13 fixed to the head chip 11 is in contact with the ink, this arrangement facilitates heating of the fixed portion, and thus promotes the chemical reaction of the silane coupling agent. As a result, the fixing strength between the head chip 11 and the wiring substrate 13 can be enhanced, more effectively reducing the separation generated in the fixed portion between the head chip 11 and the wiring substrate 13.

[0071] The inkjet head 1 further includes the ink manifold 15 disposed on an upstream side of the head chip 11 in the ink feeding direction to feed the ink to the head chip 11, and the internal heaters 153 disposed on the ink manifold 15 to heat the ink. Such a configuration can heat the ink near the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62, further enhancing the fixing strength between the head chip 11 and the wiring substrate 13 and that between the head chip 11 and the protective film 62.

[0072] The internal heaters 153 are disposed on the outer surfaces of the ink manifold 15, respectively. Such a configuration can further ensure the heating of the ink near the fixed portions between the head chip 11 and the wiring substrate 13 and between the head chip 11 and the protective film 62.

[0073] A silane coupling agent containing sulfur can be broadly used irrespective of the materials for the head chip 11 and the wiring substrate 13 and protective film 62 which are fixed to the head chip 11.

[0074] Although the inkjet recording apparatus 100 is designed to form an image on an elongate recording medium P in the embodiment, it can also form an image on short recording media. In this case, the inkjet recording apparatus 100 may include a recording medium accommodating unit (not illustrated).

[0075] Although the silane coupling agent contained in the adhesive 61 is disposed at the interface between the head chip 11 and the wiring substrate 13 and the silane coupling agent layer 71 is disposed between the head chip 11 and the protective film 62 in the embodiment, the silane coupling agent may be disposed in any other configuration. The silane coupling agent may be disposed at any one of the interfaces between the first member forming the inkjet head and the second members fixed to the first member.

[0076] The carriage 33 includes the carriage heater 33a, the ink feeding unit 40 includes the heater 46, and the ink manifold 15 includes the internal heaters 153 in the embodiment. All or part of these heaters may be omitted as long as the ink heated to a predetermined temperature can be ejected.

Examples

[0077] The present invention will now be described in more detail by way of Examples that should not be construed to limit the present invention. Units "parts" and "%" used in Examples represent "parts by mass" and "mass%", respectively,

unless otherwise specified.

[Example 1]

<<Preparation of Sample 1-1>>

[0078] A head chip of a shear mode to be used in production of the inkjet head illustrated in Figs. 2 and 3 was bonded to a wiring substrate with a thermosetting epoxy adhesive to produce an inkjet head. Although Fig. 2 illustrates a head chip having twelve channels, the head chip used in Examples had 512 channels. The thermosetting epoxy adhesive was composed of a mixture of EPIKOTE 807 (made by Japan Epoxy Resin Co., Ltd.) (30 mass%) and EPIKOTE 152 (made by Japan Epoxy Resin Co., Ltd.) (70 mass%) to which an imidazole curing agent 2-ethyl-4-methylimidazole (10 mass%) was further added. The thermosetting epoxy resin was heated at 100°C for one hour for curing.

[0079] The inkjet head was used to produce an inkjet recording apparatus having a configuration substantially identical to that illustrated in Fig. 1. The inkjet recording apparatus included no external heater in the carriage and the ink feeding unit and no internal heater.

[0080] A UV ink (8 cP at normal temperature) composed of a UV curable acrylic monomer was preliminarily ejected from the produced inkjet recording apparatus under an environment at room temperature (25°C). The ink was preliminarily ejected at a drive voltage of 20 V, number of pulses of 10^{10} times, and frequency of 4 kHz. The temperature of the ejected ink was controlled at 25°C.

[0081] Sample 1-1 was thereby prepared.

<<Preparation of Sample 1-2>>

[0082] An inkjet recording apparatus (Sample 1-2) was produced as in Sample 1-1 except that the thermosetting epoxy adhesive further contained an epoxy silane coupling agent 3-glycidyloxypropyltriethoxysilane (1 mass%).

[0083] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-1.

[0084] Sample 1-2 was thereby prepared.

<<Preparation of Sample 1-3>>

[0085] An inkjet recording apparatus (Sample 1-3) was produced as in Sample 1-1 except that an external carriage heater heating the ink from the outside of the inkjet head was disposed on a carriage.

[0086] AUVink (8 cP at 65°C) composed of a UV curable acrylic monomer was preliminarily ejected from the produced inkjet recording apparatus under an environment at room temperature (25°C). The ink was preliminarily ejected at a drive voltage of 20 V, number of pulses of 10^{10} times, and frequency of 4 kHz. The temperature of the ejected ink was controlled at 65°C.

[0087] Sample 1-3 was thereby prepared.

<<Preparation of Sample 1-4>>

[0088] An inkjet recording apparatus (Sample 1-4) was produced as in Sample 1-3 except that the thermosetting epoxy adhesive further contained an epoxy silane coupling agent 3-glycidyloxypropyltriethoxysilane (1 mass%).

[0089] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-3.

[0090] Sample 1-4 was thereby prepared.

<<Preparation of Sample 1-5>>

[0091] An inkjet recording apparatus (Sample 1-5) was produced as in Sample 1-4.

[0092] An UV ink (8 cP at 65°C) composed of a UV curable acrylic monomer was preliminarily ejected from the produced inkjet recording apparatus under an environment at room temperature (25°C). The ink was preliminarily ejected at a drive voltage of 20 V, number of pulses of 10^{10} times, and frequency of 25 kHz. The temperature of the ejected ink was controlled at 65°C.

[0093] Sample 1-5 was thereby prepared.

<<Preparation of Sample 1-6>>

[0094] An inkjet recording apparatus (Sample 1-6) was produced as in Sample 1-5 except that the thermosetting epoxy adhesive further contained conductive Ni particles (0.5 mass%).

[0095] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-5.

[0096] Sample 1-6 was thereby prepared.

<<Preparation of Sample 1-7>>

[0097] An inkjet recording apparatus (Sample 1-7) was produced as in Sample 1-5 except that the epoxy silane coupling agent was replaced with a mercapto silane coupling agent 3-mercaptopropyltrimethoxysilane (1 mass%).

[0098] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-5.

[0099] Sample 1-7 was thereby prepared.

<<Preparation of Sample 1-8>>

[0100] An inkjet recording apparatus (Sample 1-8) was produced as in Sample 1-7 except that the external heater was replaced with internal heaters disposed on outer surfaces of the ink manifold, respectively.

[0101] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-7.

[0102] Sample 1-8 was thereby prepared.

<<Preparation of Sample 1-9>>

[0103] An inkjet recording apparatus (Sample 1-9) was produced as in Sample 1-8.

[0104] A phase transition ink was preliminarily ejected from the produced inkjet recording apparatus under an environment at room temperature (25°C). Throughout the specification, the phase transition ink used in Examples refers to an ink that is solid at normal temperature and is liquid (8 cP at 65°C) under heat and is prepared by adding a predetermined amount of wax to the UV ink used in preliminary ejection in each sample. The ink was preliminarily ejected at a drive voltage of 20 V, number of pulses of 10^{10} times, and frequency of 25 kHz. The temperature of the ejected ink was controlled at 65°C.

[0105] Sample 1-9 was thereby prepared.

<<Preparation of Sample 1-10>>

[0106] An inkjet recording apparatus (Sample 1-10) was produced as in Sample 1-2 except that the head chip of a shear mode was replaced with a head chip of a bend mode.

[0107] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-2.

[0108] Sample 1-10 was thereby prepared.

<<Preparation of Sample 1-11>>

[0109] An inkjet recording apparatus (Sample 1-11) was produced as in Sample 1-10 except that the silane coupling agent was not added to the thermosetting epoxy adhesive and an external carriage heater heating the ink from the outside of the inkjet head was disposed on a carriage.

[0110] An UV ink (8 cP at 65°C) composed of a UV curable acrylic monomer was preliminarily ejected from the produced inkjet recording apparatus under an environment at room temperature (25°C). The ink was preliminarily ejected at a drive voltage of 20 V, number of pulses of 10^{10} times, and frequency of 4 kHz. The temperature of the ejected ink was controlled at 65°C.

[0111] Sample 1-11 was thereby prepared.

«Preparation of Sample 1-12»

[0112] An inkjet recording apparatus (Sample 1-12) was produced as in Sample 1-11 except that the thermosetting epoxy adhesive further contained an epoxy silane coupling agent 3-glycidyloxypropyltriethoxysilane (1 mass%).

[0113] The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-11.

[0114] Sample 1-12 was thereby prepared.

5 «Preparation of Sample 1-13»

[0115] An inkjet recording apparatus (Sample 1-13) was produced as in Sample 1-12 except that the external heater was replaced with internal heaters disposed on outer surfaces of the ink manifold, respectively.

10 **[0116]** The ink was preliminarily ejected from the produced inkjet recording apparatus under the same conditions as those in Sample 1-12.

[0117] Sample 1-13 was thereby prepared.

<<Evaluation of Samples 1-1 to 1-13>>

15 **[0118]** The inkjet recording apparatuses (Samples 1-1 to 1-13) were evaluated for the following items. The results of evaluation are shown in Table 1.

(1) Electric conduction test

20 **[0119]** In each of the samples, pulse signals were fed to the inkjet head from a drive circuit to measure the capacity values of the channels before and after the preliminary ejection of the ink. A channel having a capacity value reduced to 50% or less after the preliminary ejection of the ink was determined as disconnected. The samples were ranked according to the following criteria:

25 A: No disconnection.

B: 1 to 10 channels disconnected.

C: 11 or more channels disconnected.

(2) Measurement of ink ejection rate

30 **[0120]** The ink ejection rate was measured with the ink used in the preliminary ejection from the samples. Pulse signals were fed from the drive circuit to the inkjet head to eject the ink. Ink droplets ejected from nozzles were photographed, and their ejection rates were calculated. In each sample, the ink ejection rates were determined before and after the preliminary ejection, and the reduction in the ejection rate was calculated. The samples were ranked according to the following criteria. The ink was ejected such that the temperature of the ink ejected from the samples was equal to the temperature of the ink preliminarily ejected.

A: The reduction in the ink ejection rate is 1% or less.

40 B: The reduction in the ink ejection rate is more than 1% and 5% or less.

C: The reduction in the ink ejection rate is more than 5% and 10% or less.

D: The reduction in the ink ejection rate is more than 10% and 20% or less.

45 E: The reduction in the ink ejection rate is more than 20%.

(3) Measurement of distribution of ink ejection rate

50 **[0121]** The ink used in the preliminary ejection from the samples was used to determine the distribution of the ink ejection rate. Pulse signals were fed from the drive circuit to the inkjet head to eject the ink. Ink droplets ejected from nozzles were photographed, and the ejection rates were determined through calculation. The distribution of the ejection rates of observed ink droplets ejected from the nozzles was calculated, and the samples were ranked according to the following criteria. The ink was ejected such that the temperature of the ink ejected from the samples was equal to the temperature of the ink preliminarily ejected.

A: The ink ejection rate has a distribution of $\pm 10\%$ or less.

B: The ink ejection rate has a distribution of more than $\pm 10\%$ and 20% or less.

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C: The ink ejection rate has a distribution of more than $\pm 20\%$.

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[Table 1]

Sample No.	Head structure	Heater	Adhesive		Conditions on preliminary ejection			Results of evaluation				Notes
			Conductive particles	Silane coupling agent	Ink used	Ink temperature [°C]	Frequency [kHz]	Electric conduction test	Ink ejection rate	Distribution of ink ejection rate		
1-1	Shear mode	None	None	None	UV ink	25	4	B	D	C	Comparative example	
1-2	Shear mode	None	None	Epoxy	UV ink	25	4	B	C	C	Comparative example	
1-3	Shear mode	External heater	None	None	UV ink	65	4	C	E	C	Comparative example	
1-4	Shear mode	External heater	None	Epoxy	UVink	65	4	A	B	B	Present invention	
1-5	Shear mode	External heater	None	Epoxy	UV ink	65	25	A	C	B	Present invention	
1-6	Shear mode	External heater	Ni	Epoxy	UV ink	65	25	A	B	B	Present invention	
1-7	Shear mode	External heater	None	Mercapto	UV ink	65	25	A	B	B	Present invention	
1-8	Shear mode	Internal heater	Ni	Mercapto	UV ink	65	25	A	B	A	Present invention	
1-9	Shear mode	Internal heater	Ni	Mercapto	Phase transition ink	65	25	A	A	A	Present invention	
1-10	Bend mode	None	None	Epoxy	UVink	25	4	B	C	C	Comparative example	
1-11	Bend mode	External heater	None	None	UV ink	65	4	B	D	C	Comparative example	
1-12	Bend mode	External heater	None	Epoxy	UV ink	65	4	A	B	B	Present invention	
1-13	Bend mode	Internal heater	None	Epoxy	UV ink	65	4	A	B	A	Present invention	

(4) Summary

[0122] Table 1 shows that the results of Samples 1-4 to 1-9, 1-12, and 1-13 according to the present invention were better than those of Samples 1-1 to 1-3, 1-10, and 1-11 of Comparative Examples in the electric conduction test and the measurement of the ink ejection rate and the distribution of the ink ejection rate. It is believed that the silane coupling agent disposed at the interface between the head chip and the epoxy adhesive effectively reduced the separation of the fixed portions, preventing disconnection of the fixed portions and thus decreases a reduction in the ejection rate of the ink and a fluctuation in the distribution of the ink ejection rates of the nozzles.

[0123] The present inventors also confirmed that the effect of reducing the separation of the fixed portions was not achieved through mere addition of the silane coupling agent in the epoxy adhesive, but was achieved through heating of the silane coupling agent contained in the epoxy adhesive by circulation of the heated ink.

[Example 2]

<<Production of Sample 2-1>>

[0124] Aluminum was deposited into a thickness of 2 μm on a PZT substrate. A solution of 1% 3-acryloxypropyltrimethoxysilane (acrylic silane coupling agent) in isopropyl alcohol was applied on the aluminum layer into a dry coating thickness of 0.01 μm , and was dried at room temperature (25°C) for three hours. A protective film for the head chip composed of polyparaxylylene was formed into a thickness of 3 μm on the silane coupling agent layer. The substrate was immersed in a UV ink kept at 95°C for one month.

<<Production of Sample 2-2>>

[0125] Sample 2-2 was produced as in Production of Sample 2-1 except that the silane coupling agent layer was not disposed, and the substrate after film formation was immersed in a UV ink kept at 25°C for one month.

<<Production of Sample 2-3>>

[0126] Sample 2-2 was produced as in Production of Sample 2-1 except that the substrate after film formation was immersed in a UV ink kept at 25°C for one month.

<<Production of Sample 2-4>>

[0127] Sample 2-4 was produced as in Production of Sample 2-1 except that the silane coupling agent layer was not disposed.

<<Evaluation of Samples 2-1 to 2-4>>

(1) Separation test

[0128] A polyimide film with an epoxy adhesive was applied onto the protective film of each of the samples immersed in the UV ink, and was peeled. After the polyimide film was peeled, the states of the samples were visually observed, and were ranked according to the following criteria:

A: No separation of the protective film found.

B: Separation found between the aluminum layer and the protective film.

[Table 2]

Sample No.	Silane coupling agent	Ink temperature during immersion and storage [°C]	Results of evaluation	Notes
2-1	Acrylic	95	A	Present invention
2-2	None	25	B	Comparative example

(continued)

Sample No.	Silane coupling agent	Ink temperature during immersion and storage [°C]	Results of evaluation	Notes
2-3	Acrylic	25	B	Comparative example
2-4	None	95	B	Comparative example

(2) Summary

[0129] Table 2 shows that the separation of the protective film was reduced in Sample 2-1 according to the present invention compared to Samples 2-2 to 2-4 of Comparative Examples. This test confirmed that the silane coupling agent disposed at the interface between the head chip and the protective film can also effectively reduce the separation of the fixed portion between the head chip and the protective film.

INDUSTRIAL APPLICABILITY

[0130] Accordingly, the present invention can provide an inkjet head or ejecting ink heated to a predetermined temperature that can reduce the separation of the fixed portion between the first member and a second member fixed to the first member, and an inkjet recording apparatuses including the inkjet head.

REFERENCE SIGNS LIST

[0131]

- 1 inkjet head
- 11 head chip (first member)
- 12 nozzle plate
- 13 wiring substrate (second member)
- 14 FPC
- 15 ink manifold (common ink chamber)
- 20 conveying unit
- 30 image forming unit
- 31 line head
- 40 ink feeding unit
- 46 heater
- 61 adhesive
- 62 protective film (second member)
- 71 silane coupling agent layer
- 100 inkjet recording apparatus
- 113 driving wall
- 114 channel
- 115 driving electrode
- 116 connection electrode
- 121 nozzle
- 131 wiring connection part
- 133 wiring electrode
- 153 internal heater
- P recording medium

Claims

1. An inkjet head which is disposed in an inkjet recording apparatus and ejects ink heated to a predetermined temperature, the inkjet head comprising:

a first member;
a second member fixed to the first member; and
a silane coupling agent disposed at an interface between the first member and the second member.

- 5 **2.** The inkjet head of claim 1, wherein the ink is a phase transition ink causing reversible phase transition between a solid state and a liquid state at a phase transition temperature.
- 10 **3.** The inkjet head of claim 1, wherein the ink is a phase transition ink causing reversible phase transition between a gel state and a sol state at a phase transition temperature.
- 15 **4.** The inkjet head of any one of claims 1 to 3, wherein a fixed portion between the first member and the second member is in contact with the ink.
- 20 **5.** The inkjet head of any one of claims 1 to 4, further comprising:
a common ink chamber disposed on an upstream side of the first member in an ink feeding direction to feed the ink to a plurality of nozzles, and
a heater disposed on the common ink chamber to heat the ink.
- 25 **6.** The inkjet head of claim 5, wherein the heater is disposed on an outer surface of the common ink chamber.
- 30 **7.** The inkjet head of any one of claims 1 to 6, wherein the first member is a head chip ejecting the ink from a nozzle.
- 35 **8.** The inkjet head of any one of claims 1 to 7, wherein the silane coupling agent is contained in a thermosetting adhesive.
- 40 **9.** The inkjet head of claim 8, wherein the adhesive contains a conductive particle.
- 45 **10.** The inkjet head of any one of claims 1 to 7, wherein the second member is a protective film disposed on a surface of the first member.
- 50 **11.** The inkjet head of any one of claims 1 to 10, wherein the silane coupling agent contains sulfur.
- 55 **12.** The inkjet head of any one of claims 1 to 11, wherein the inkjet head is driven at an ejection frequency of 20 kHz or more.
- 60 **13.** An inkjet recording apparatus comprising the inkjet head of any one of claims 1 to 12.
- 65 **14.** The inkjet recording apparatus of claim 13, further comprising a control unit not heating ink during an idling time of the inkjet recording apparatus and heating the ink during an operation time of the inkjet recording apparatus.

FIG.1

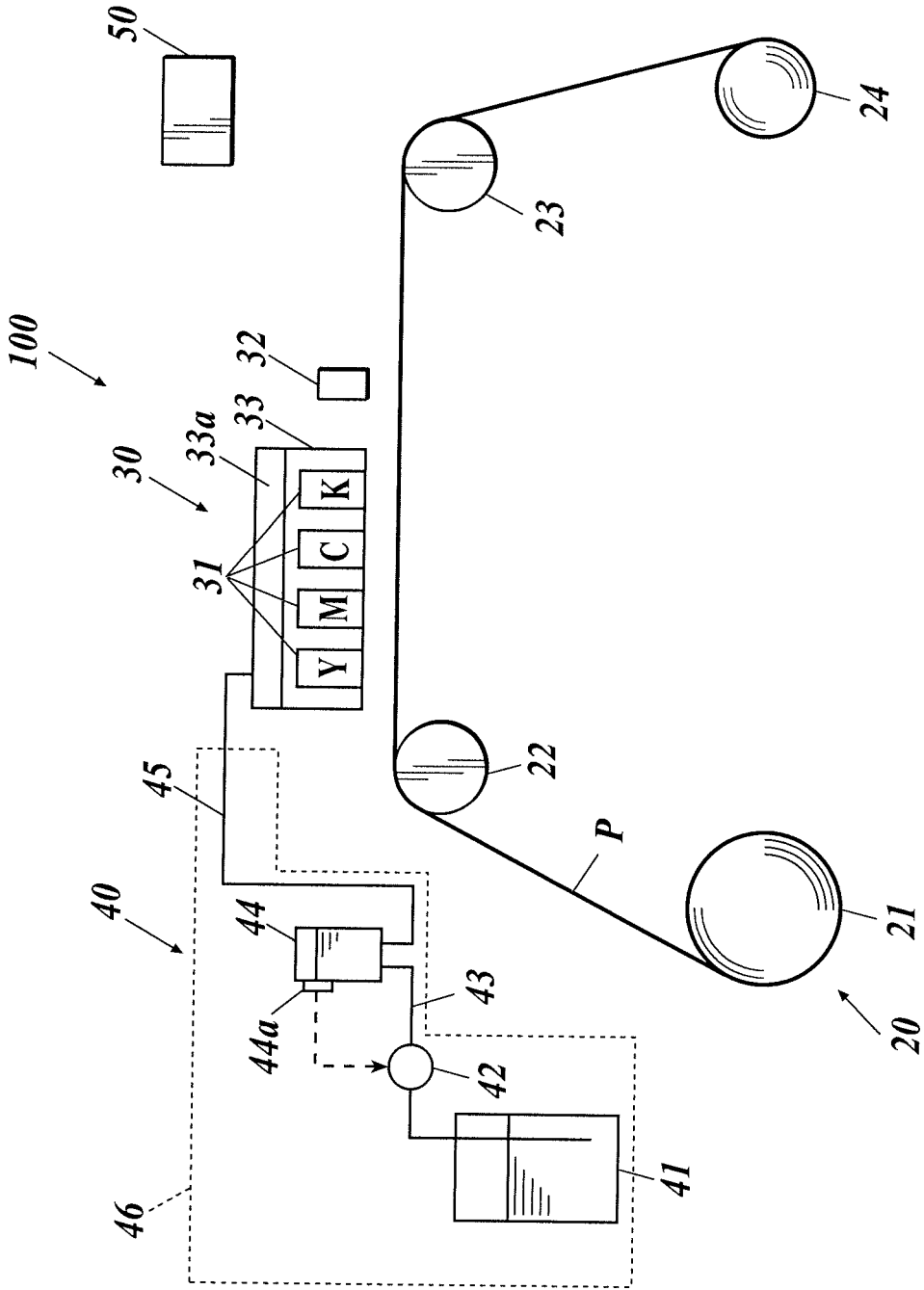


FIG.2

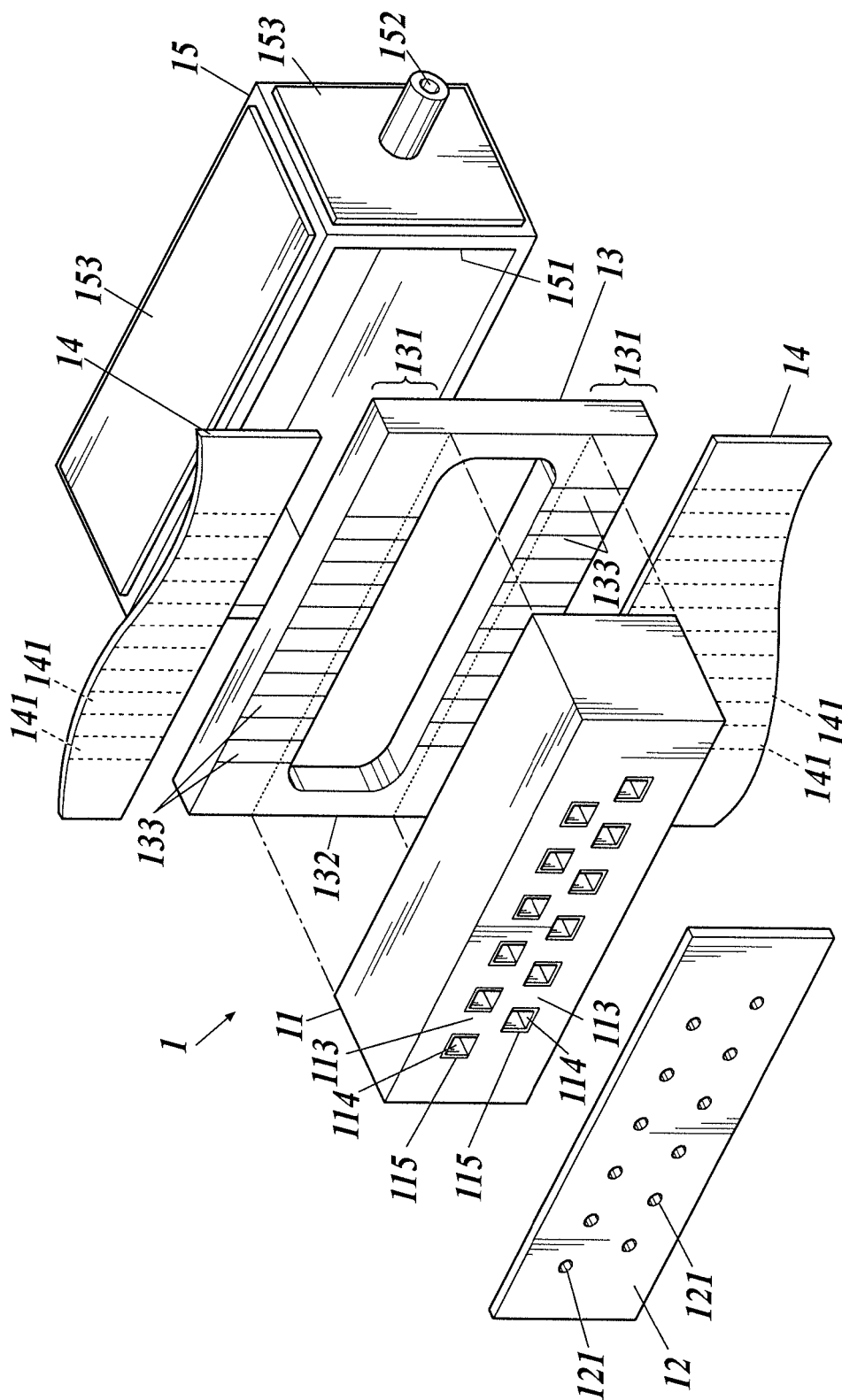


FIG.3

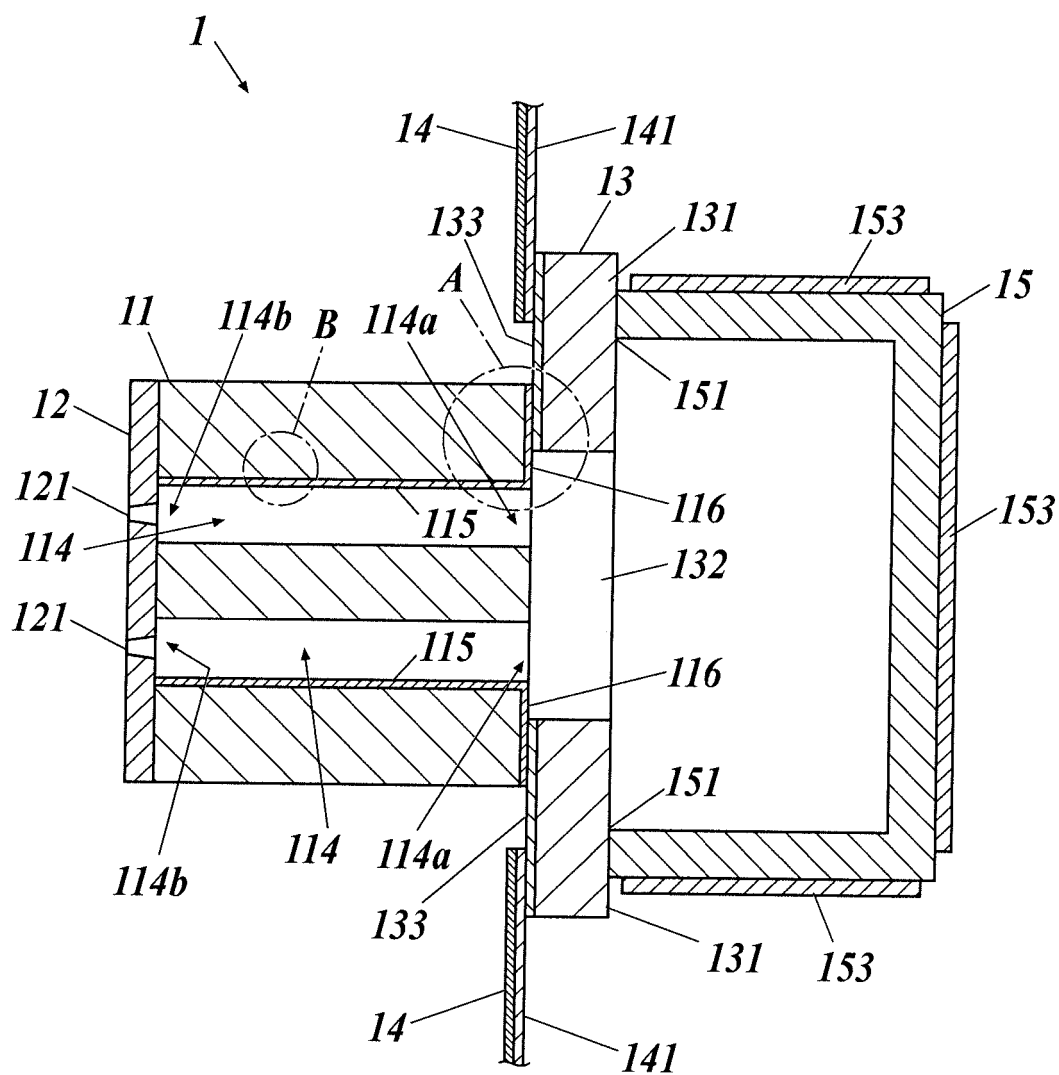


FIG.4A

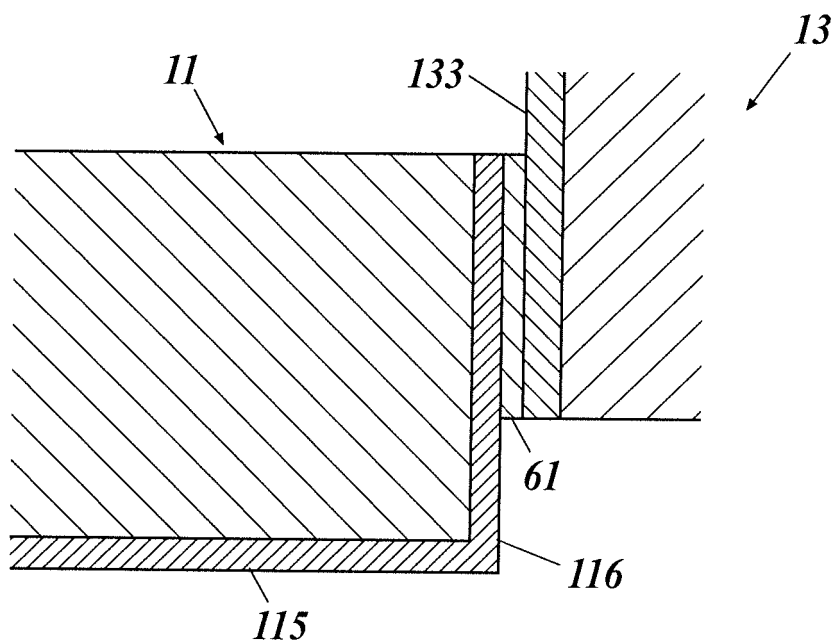
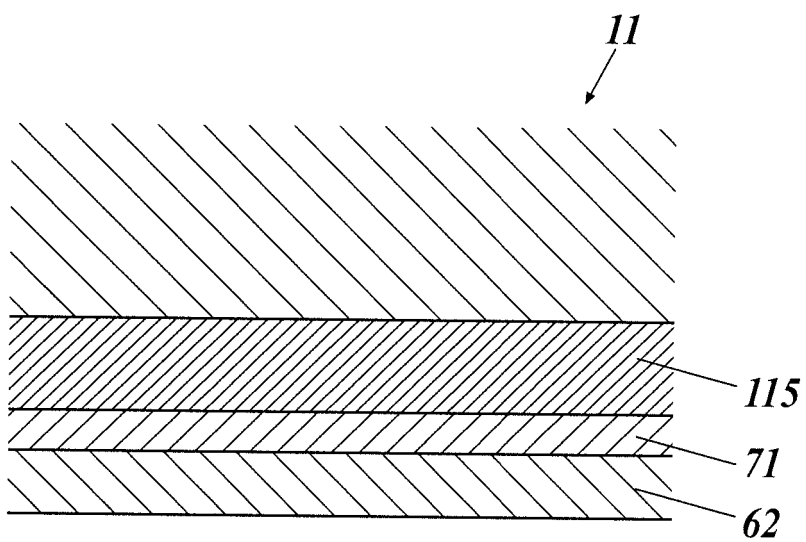


FIG.4B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/066326

A. CLASSIFICATION OF SUBJECT MATTER

B41J2/14(2006.01)i, B41J2/01(2006.01)i, B41J2/16(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J2/14, B41J2/01, B41J2/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
 Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-166309 A (Konica Minolta Holdings, Inc.), 30 July 2009 (30.07.2009), paragraphs [0028], [0033], [0044], [0051], [0079] to [0088], [0100]; fig. 1, 2, 5, 6 (Family: none)	1-14
Y	JP 2005-96150 A (Konica Minolta Holdings, Inc.), 14 April 2005 (14.04.2005), paragraphs [0040], [0050]; fig. 1 & US 2005/0052485 A1	1-14

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

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Date of the actual completion of the international search

19 June 2015 (19.06.15)

Date of mailing of the international search report

30 June 2015 (30.06.15)

Name and mailing address of the ISA/
 Japan Patent Office
 3-4-3, Kasumigaseki, Chiyoda-ku,
 Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/066326

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-49399 A (Canon Inc.), 22 February 1994 (22.02.1994), paragraphs [0004], [0005] & US 5439515 A1 & EP 0584509 A1 & JP 6-192605	2-3
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 9113/1992 (Laid-open No. 60844/1993) (Citizen Watch Co., Ltd.), 10 August 1993 (10.08.1993), paragraph [0005] (Family: none)	10
Y	JP 2013-59966 A (Ricoh Co., Ltd.), 04 April 2013 (04.04.2013), paragraphs [0023] to [0024] (Family: none)	11

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003165217 A [0004]