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(71) Applicant: **CANON KABUSHIKI KAISHA**
Tokyo (JP)

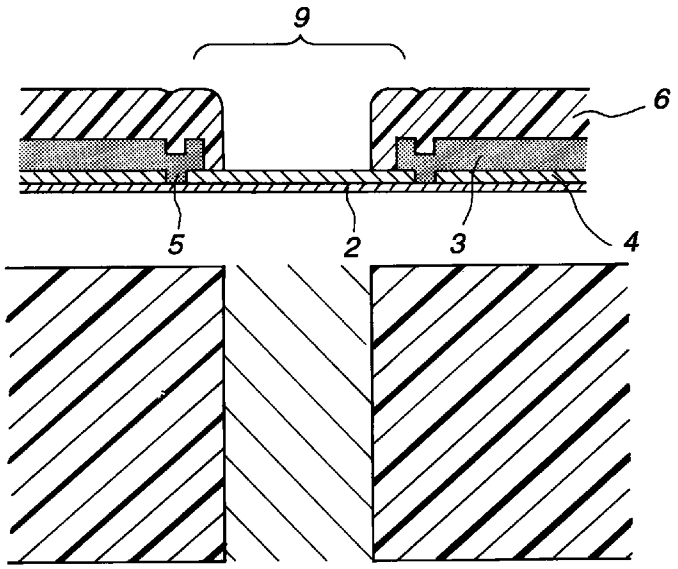
(72) Inventor: **Suzuki, Takumi**
Tokyo (JP)

(74) Representative: **Tiedtke, Harro, Dipl.-Ing.**
Patentanwaltsbüro
Tiedtke-Bühling-Kinne & Partner
Bavariaring 4
80336 München (DE)

(54) An ink-jet head, a substrate for an ink-jet head, and an ink-jet apparatus

(57) A substrate for an ink-jet head provides a protective layer which can assuredly cover electrothermal transducers even if the thickness of the layer is small. A thin intermediate layer is provided between a heating resistive layer and electrodes. The thin intermediate layer is an insulator on heating portions of the heating resistive layer. According to such a configuration, the life of the heating resistive layer becomes long, and occurrence of burnt deposits is suppressed. Since steps at portions where the thin intermediate layer is provided are small, an excellent film quality can be obtained even if the thickness of the protective layer is relatively small, and an excellent protective property is obtained.

FIG.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an ink-jet head for performing printing by forming a very small droplet by discharging a printing liquid, such as ink or the like, utilizing thermal energy, and causing the droplet to adhere to a printing material, such as paper or the like. The invention also relates to a substrate for such an ink-jet head, and to an ink-jet apparatus.

Description of the Related Art

An ink-jet head used in an ink-jet printing method of utilizing thermal energy for forming a very small droplet to be discharged generally includes a heating resistive layer provided on a substrate, respective pairs of electrodes provided on the heating resistive layer and electrically connected thereto, and respective heating portions of the heating resistive layer provided between the pairs of electrodes. Thermal energy is generated from selected ones of the heating portions by passing current through the heating resistive layer from the corresponding pairs of electrodes. The state of ink in an ink channel is changed by the thermal energy, and printing is performed by discharging the ink onto a printing material by the pressure caused by volume expansion of bubbles in this changed state.

The configurations of such ink-jet heads are disclosed, for example, in Japanese Patent Laid-Open Application (Kokai) Nos. 55-128467 (1980) and 59-194866 (1984).

FIGS. 7(A) and 7(B) are schematic diagrams illustrating the general configuration of such an ink-jet head.

In FIGS. 7(A) and 7(B), reference numeral 1 represents a substrate for an ink-jet head on which a heating resistive layer 2 and pairs of electrodes 3 are provided. The heating resistive layer 2 for converting electric energy into thermal energy is provided on the surface of the insulating ink-jet-head substrate 1, and the pairs of electrodes 3 for passing current through the heating resistive layer 2 are provided on the heating resistive layer 2. The pairs of electrodes 3 comprise individual electrode portions for selectively driving segments of the heating resistive layer 2, and a common electrode portion for distributing current. The thermal energy is generated from a heating portion 9 provided between the corresponding pair of electrodes. A protective layer 6, for preventing the heating resistive layer 2 and the electrodes 3 from galvanic corrosion, and destruction due to cavitation, is provided on the heating resistive layer 2 including the heating portion 9 and the electrodes 3.

Reference numeral 8 represents discharging ports for discharging ink. The heating portions 9 are provided in an ink channel 7 communicating with the discharging ports 8. Reference numeral 10 represents an ink chamber, communicating with the ink channel 7, for supplying the ink channel 7 with ink. The ink channel 7 and the ink chamber 10 are configured by recesses provided in a top plate 11, and the ink-jet-head substrate 1. An ink supply port 12 for supplying the ink chamber 10 with ink is formed in the top plate 11.

In such a conventional ink-jet head, the thickness of the protective layer is about 1 - 3 μm in order to maintain its covering property in steps produced by the electrodes in the vicinity of the heating portions. However, when such a thick protective layer is present on the heating portions, loss of thermal energy due to the protective layer is unnegligible. Hence, in order to obtain a temperature necessary for bubbling ink on the surface of the protective layer, the temperature at the heating portion must be higher than the temperature on the surface of the protective layer. This is one of the reasons for accelerating degradation of the heating resistive layer. Furthermore, when the temperature at the heating portion is increased, bubbling of ink occurs in the midst of application of thermal energy. Hence, energy supplied after the bubbling causes a rapid increase in the surface temperature of the protective layer, to decompose organic components of the ink, thereby producing burnt deposits on the protective layer.

In order to solve such problems, ink-jet heads in which a thinner protective layer is provided on heating portions have been devised. For example, in Japanese Patent Laid-Open Application (Kokai) No. 62-103148 (1987), a configuration is disclosed in which only portions of a protective layer, provided on electrothermal transducers, present on heating portions are thinned by performing half etching in dry etching. In Japanese Patent Laid-Open Application (Kokai) No. 63-191646 (1988), a configuration is disclosed in which an oxide film is formed by performing anodic oxidation of heating portions of a heating resistive layer, and an organic insulating film is formed on electrodes so that at least a part of the oxide film is exposed.

However, in the first configuration, since the thickness of the protective layer on the heating portions is determined by the state of the etching, it is difficult to strictly control the thickness of the protective layer on the heating portions. As a result, discharging characteristics of respective ink-jet heads may slightly differ from one another. In the second configuration, in addition to the fact that it is difficult to control the thickness of the oxide film on the heating portions as in the first configuration, only materials having an excellent protective property obtained by performing anodic oxidation of the heating resistive layer can be used.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above-described problems.

It is an object of the present invention to provide a substrate for an ink-jet head in which the thickness of a protective layer on heating portions can be strictly controlled to a desired value, and a desired material can be used as a heating resistive layer.

It is another object of the present invention to provide a substrate for an ink-jet head which has an excellent protective property even if the thickness of a protective layer on heating portions is small.

It is still another object of the present invention to provide a substrate for an ink-jet head in which the life of a heating resistive layer is long, and few burnt deposits are produced on a protective layer.

In order to achieve these objectives, the inventors of the present invention propose a configuration in which a thin intermediate layer is provided between a heating resistive layer and electrodes, and the thin intermediate layer on heating portions comprises an insulator. According to this configuration, since-steps at portions where the thin intermediate layer is provided are small, an excellent film quality can be obtained even when the thickness of the layer is relatively small. Hence, an excellent protective property is obtained.

Also proposed is a configuration in which a protective layer is provided so as to expose the insulator.

Also proposed is a configuration in which the thin intermediate layer comprises an insulator, and the electrodes are electrically connected to the heating resistive layer through throughholes provided in the thin intermediate layer.

Also proposed is a configuration in which the thin intermediate layer comprises a metal, and the thin intermediate layer on the heating portions is insulated.

The present invention also includes an ink-jet head using the substrate for an ink-jet head according to the present invention.

The present invention also includes an ink-jet apparatus which mounts an ink-jet head using the substrate for an ink-jet head according to the present invention.

According to one aspect, the present invention which achieves these objectives relates to a substrate for an ink-jet head, the substrate comprising a heating resistive layer for generating thermal energy utilized for discharging a liquid, respective pairs of electrodes electrically connected to the heating resistive layer thereon, and heating portions of the heating resistive layer provided between corresponding pairs of electrodes. Thermal energy is generated from the heating portions by passing current through the heating resistive layer from the electrodes. The substrate also comprises a thin intermediate layer between the heating resistive layer and the electrodes. The thin intermediate layer comprises an insulator at least on the heating portions.

According to another aspect, the present invention which achieves these objectives relates to an ink-jet head comprising a substrate for the ink-jet head, comprising a heating resistive layer for generating thermal energy utilized for discharging a liquid, respective pairs of electrodes electrically connected to the heating resistive layer thereon, and heating portions of the heating resistive layer provided between corresponding pairs of electrodes, for generating thermal energy from the heating portions by passing current through the heating resistive layer from the electrodes, discharging ports for discharging the liquid, an ink channel communicating with the discharging ports, an ink chamber for supplying the ink channel with ink, and a thin intermediate layer provided between the heating resistive layer and the electrodes. The thin intermediate layer comprises an insulator at least on the heating portions.

According to still another aspect, the present invention which achieves these objectives relates to an ink-jet apparatus comprising an ink-jet head, comprising a substrate for the ink-jet head, comprising a heating resistive layer for generating thermal energy utilized for discharging a liquid, respective pairs of electrodes electrically connected to the heating resistive layer thereon, and heating portions of the heating resistive layer provided between corresponding pairs of electrodes, for generating thermal energy from the heating portions by passing current through the heating resistive layer from the electrodes, discharging ports for discharging the liquid, an ink channel communicating with the discharging ports, an ink chamber for supplying the ink channel with ink, and conveying means for conveying a printing material onto which the liquid is discharged. The ink-jet apparatus also comprises a thin intermediate layer provided between the heating resistive layer and the electrodes. The thin intermediate layer comprises an insulator at least on the heating portions.

The foregoing and other objects, advantages and features of the present invention will become more apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating the surrounding structure of a heating portion of an ink-jet head according to a first embodiment of the present invention;

FIGS. 2(A) and 2(B) are schematic diagrams illustrating a substrate for an ink-jet head according to a second embodiment of the present invention;

FIG. 3 is a schematic diagram illustrating a substrate for an ink-jet head according to a third embodiment of the present invention;

FIG. 4 is a schematic diagram illustrating a substrate for an ink-jet head according to a fourth embodiment of the present invention;

FIGS. 5(A) through 5(C) are schematic diagrams illustrating production processes of the substrate for an ink-jet head according to the fourth embodiment;

FIG. 6 is an external perspective view illustrating an ink-jet apparatus (IJA) which mounts an ink-jet head obtained according to the present invention as an ink-jet-head cartridge (IJC); and

FIGS. 7(A) and 7(B) are schematic diagrams illustrating the configuration of a general ink-jet head.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the drawings.

First Embodiment

FIG. 1 is a schematic diagram illustrating the surrounding structure of an ink-jet head according to a first embodiment of the present invention.

The present invention provides the configuration of a protective layer which can assuredly cover electrothermal transducers even if the thickness of the layer is small. That is, a thin intermediate layer is provided between a heating resistive layer and electrodes, and the thin intermediate layer on heating portions comprises an insulator. According to this configuration, the life of the heating resistive layer is increased, and occurrence of burnt deposits is suppressed. Since steps at portions where the thin intermediate layer is provided are small, an excellent film quality is obtained even if the thickness of the layer is small, and therefore an excellent protective property is obtained.

In FIG. 1, reference numeral 2 represents a heating resistive layer for generating thermal energy utilized for discharging ink. Reference numeral 3 represents interconnection conductors, serving as electrodes, provided on the heating resistive layer 2 and electrically connected thereto, for passing current through the heating resistive layer 2. Reference numeral 9 represents a heating portion where the interconnection conductor 3 is not provided on the heating resistive layer 2. Thermal energy is generated from the heating portion 9.

An thin intermediate layer 4 is provided between the heating resistive layer 2 and the interconnection conductor 3. In the present embodiment, Si_3N_4 is used for the thin intermediate layer 4.

The important point in the present embodiment is that the portion of the thin intermediate layer 4 present on the heating portion 9 is an insulator. The thin intermediate layer 4 covers the heating portion 9 and contacts both of the heating resistive layer 2 and the interconnection conductors 3. Hence, if the portion of the thin intermediate layer 4 present on the heating portion 9 is a conductor, current flows through the thin intermediate layer 4, and therefore the heating portion 9 does not operate. The thin intermediate layer 4 may comprise an insulator, or a metal or the like whose portion on the heating portion 9 is processed to be an insulator. When using an insulator for the thin intermediate layer 4, it is necessary to provide throughholes 5 for electrically connecting the heating resistive layer 2 to the interconnection conductors 3.

Any insulating or metallic materials having cavitation-resistive property may be used for the thin intermediate layer 4. For example, insulators, such as Si_3N_4 and SiC, and metals, such as Ta and Fe, may be used.

Since the thin intermediate layer 4 is proived on the heating resistive layer 2, it can be formed in a state in which substantially no steps are produced. Accordingly, a layer having an excellent film property can be formed even if the thickness of the layer is small. In consideration of the covering property and the effect of provision of a thin film, the thickness of the thin intermediate layer 4 is preferably 200 - 700 nm.

When using a metal for the thin intermediate layer 4, it is preferable to perform heat treatment in an oxygen or nitrogen atmosphere for making a portion on the heating portion 9 an insulator. That is, particularly when using Al for the electrodes 3, the growth of an oxide or nitride layer is prevented by Al_2O_3 or AlN formed on Al by the heat treatment, and nitriding or oxidation stops at a thickness of about 100 nm. On the other hand, the portion of the thin intermediate layer 4 on the heating portion 9 is completely subjected to nitriding or oxidized. Accordingly, by performing insulating processing by heat treatment in an oxygen or nitrogen atmosphere, a conductive portion having a substantially constant thickness can be obtained in an electrode portion even if the time period of the heat treatment is not controlled. It is, of course, possible to perform insulating processing according to anodic oxidation or the like by controlling the time period of the insulating processing.

When using an insulator for the thin intermediate layer 4, a protective layer 6 is provided on the interconnection conductors 3. The protective layer 6 is formed, for example, by coating an organic resin. At that time, the protective layer 6 is provided except on the heating portion 9. However, since no problem arises even if the resin is coated on a boundary portion between the interconnection conductors 3 and the heating portion 9 because the temperature of the boundary portion is lower than the temperature at a central portion, it is preferable, from the viewpoint of reliability, to coat the resin on portions of the heating portion 9 in the proximity of the interconnection conductors 3 (boundary portions) in order to assuredly protect the interconnection conductor 3. It is also possible to perform insulating processing only for the interconnection conductor 3 as when using a metal for the thin intermediate layer 4.

Next, a description will be provided of a method of manufacturing an ink-jet head according to the first embodiment.

A Ta/Ir layer having a thickness of 100 nm was formed on a Si substrate 1 having a thermally oxidized film, serving as a heat storage layer, by sputtering. The formed layer was etched to a desired pattern, as shown in FIG. 1, to form the heating resistive layer 2.

Thereafter, a Si_3N_4 film, serving as the thin intermediate layer 4, having a thickness of 300 nm was formed on the heating resistive layer 2 by sputtering, and throughholes 5 for electrically connecting the interconnection conductors 3, serving as the electrodes, to the heating resistive layer 2 were formed by etching.

Then, an Al film having a thickness of 500 nm was formed on the thin intermediate layer 4 by sputtering.

The formed layer was etched to a desired pattern, as shown in FIG. 1, to form the interconnection conductors 3.

Then, the protective layer 6 was formed by coating Photoneece (trade name: made by Toray Industries, Inc.), serving as an organic resin, on the interconnection conductor 3 to a thickness of 1 µm followed by provisional curing at 80 - 90 °C, patterning the cured film to a desired shape, and performing complete curing of the film at 350 - 450 °C.

A top plate having recesses for an ink channel and an ink chamber was connected onto the ink-jet-head substrate obtained in the above-described manner, and thus the ink-jet head of the present embodiment was obtained.

Printing was performed using the ink-jet head of the present embodiment. No disconnection due to galvanic corrosion or the like of the heating resistive layer was observed. The same degree of reliability as in conventinal heads was obtained, and occurrence of burnt deposits on the heating portions could be reduced.

Second Embodiment

In the first embodiment, the heating resistive layer 2 is provided also under the interconnection conductor 3, serving as the electrodes. In a second embodiment of the present invention, however, a heating resistive layer is provided only at portions which serve as heating portions.

FIGS. 2(A) and 2(B) are schematic diagrams illustrating a substrate for an ink-jet head according to the second embodiment. The ink-jet head is formed as in the first embodiment except that the pattern of the heating resistive layer is changed as shown in FIGS. 2(A) and 2(B). A thin intermediate layer may be provided only on a heating portion, as shown in FIG. 2(B). In this case, it is unnecessary to provide throughholes.

Printing was performed using the ink-jet head of the present embodiment. No disconnection due to galvanic corrosion or the like of the heating resistive layer was observed. The same degree of reliability as in conventinal heads was obtained, and occurrence of burnt deposits on the heating portions could be reduced.

Third Embodiment

A description will now be provided of a method for manufacturing an ink-jet head, in which a thin intermediate layer 4 comprises two layers made of an insulator and a metal, according to a third embodiment of the present invention.

FIG. 3 is a schematic diagram illustrating the ink-jet head according to the third embodiment.

A HfB_2 film having a thickness of 100 nm was formed on an Si substrate 1 having a thermally oxided film, serving as a heat storage layer, by sputtering. The formed film was etched to a desired pattern, as shown in FIG. 3, to form a heating resistive layer 2.

Thereafter, a Si_3N_4 film having a thickness of 300 nm was formed on the heating resistive layer 2 by sputtering as a first thin intermediate layer 4a. Then, throughholes 5 for electrically connecting the interconnection conductors 3, serving as electrodes, to the heating resistive layer 2 were formed by etching.

Then, a Ta film having a thickness of 200 nm was formed on the Si_3N_4 layer 4a by sputtering, and portions in the vicinity of boundaries between the formed film and the interconnection conductors 3, and portions between the patterns of the heating resistive layer 2 were etched, to form a second thin intermediate layer 4b.

Then, an Al film having a thickness of 500 nm was formed on the second thin intermediate layer 4b by sputtering. The formed film was etched to a desired pattern, as shown in FIG. 3, to form the interconnection conductors 3.

Then, a protective layer 6 made of an organic resin was coated on the interconnection conductors 3 to a thickness of 1 µm, and the organic resin present on the heating portions was removed.

A top plate having recesses for an ink channel and an ink chamber was connected onto the ink-jet-head substrate obtained in the above-described manner, and thus the ink-jet head of the present embodiment was obtained.

Printing was performed using the ink-jet head of the present embodiment. No disconnection due to galvanic corrosion or the like of the heating resistive layer was observed. The same degree of reliability as in conventinal heads was obtained, and occurrence of burnt deposits on the heating portions could be reduced.

Fourth Embodiment

Next, a description will be provided of a method for forming an ink-jet head, in which a metal is used for a thin intermediate layer, according to a fourth embodiment of the present invention.

FIG. 4 is a schematic diagram illustrating a substrate for an ink-jet head according to the fourth embodiment.

FIGS. 5(A) through 5(C) are diagrams illustrating production processes of the substrate for an ink-jet head according to the fourth embodiment.

A Ta/Ir film having a thickness of 100 nm was formed on a Si substrate 1 having a thermally oxided film, serving as a heat storage layer, by sputtering. The formed film was etched to a desired pattern to form a heating resistive layer 2 (FIG. 5(A)). Then, a Ta film having a thickness of 200 nm was formed on the heating resistive layer 2 by sputtering, to form a thin intermediate layer 4.

Thereafter, an Al film having a thickness of 500 nm was formed by sputtering on the thin intermediate layer 4. The formed film was etched to a desired pattern to form interconnection conductors 3 (FIG. 5(B)).

Then, the substrate was left in the atmosphere at 500 °C for 10 - 30 hours. The surface of the Ta film between the patterns of the interconnection conductors 3 on the heating portions 9 and the surface of the Al film were oxidized to form oxide films (FIG. 5(C)).

The Ta film, serving as the thin intermediate layer 4, is completely converted into a Ta_2O_5 film. However, since the growth of an oxide layer is prevented by an Al_2O_3 film formed on the Al film, serving as the interconnection conductors 3, the oxidation stops when the thickness of the Al film becomes about 100 nm.

Thus, the Ta film between the patterns of the interconnection conductors 3 on the heating portions 9 is oxidized. Hence, the Ta/Ir film of the heating resistive layer 2 is not dissolved even if it is immersed in ink.

A top plate having recesses for an ink channel and an ink chamber was connected onto the ink-jet-head substrate obtained in the above-described manner, and thus the ink-jet head of the present embodiment was obtained.

Printing was performed using the ink-jet head of the present embodiment. No disconnection due to galvanic corrosion or the like of the heating resistive layer was observed. The same degree of reliability as in conventinal heads was obtained, and occurrence of burnt deposits on the heating portions could be reduced.

Fifth Embodiment

An ink-jet head was manufactured in the same manner as in the fourth embodiment except that the heating resistive layer and the thin intermediate layer were changed from the Ta/Ir film and the Ta film to a HfB_2 film and a Fe film, respectively, and insulating processing was performed in a nitrogen atomsphere.

Printing was performed using the ink-jet head of the present embodiment. No disconnection due to galvanic corrosion or the like of the heating resistive layer was observed. The same degree of reliability as in conventinal heads was obtained, and occurrence of burnt deposits on the heating portions could be reduced.

A description will now be provided of an example of an ink-jet apparatus which can mount an ink-jet head according to the present invention.

FIG. 6 is an external perspective view illustrating an example of an ink-jet apparatus (IJA) which mounts an ink-jet head obtained according to the present invention as an ink-jet-head cartridge (IJC).

In FIG. 6, reference number 20 represents an ink-jet-head cartridge including nozzles for discharging ink while facing a printing surface of printing paper, serving as a printing medium, fed onto a platen 24. Reference numeral 16 represents a carriage 16 for holding the IJC 20. The carriage 16 is connected to a part of a driving belt 18 for transmitting the driving force of a driving motor 17, and is slidable along two guide shafts 19A and 19B disposed in parallel with each other. Hence, the IJC 20 can reciprocate over the entire width of the printing paper.

A head recovery device 26 is disposed at one end of a moving path of the IJC 20, for example, at a position facing a home position. Capping of the IJC 20 is performed by the driving force of a motor 22 via a transmission mechanism 23. By performing capping when, for example, terminating printing, the IJC 20 is protected.

A blade 30 made of a silicone rubber, serving as a wiping member, is disposed at a side of the head recovery device 26. The blade 30 is held by a blade holding member 30A in the form of a cantilever, and operates by the motor 22 and the transmission mechanism 23, as the head recovery device 26, so as to be engageable with a discharging surface of the IJC 20. At an appropriate timing during a printing operation of the IJC 20, or after discharge recovery processing using the head recovery device 26, the blade 30 is protruded in the moving path of the IJC 20. Dew condensation, wetting, dust or the like on the discharging surface of the IJC 20 is wiped in accordance with the moving operation of the IJC 20.

The individual components shown in outline in the drawings are all well known in the ink-jet head, ink-jet-head substrate and ink-jet apparatus arts and their specific construction and operation are not critical to the operation or the best mode for carrying out the invention.

While the present invention has been described with respect to what is presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, the present invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

A substrate for an ink-jet head provides a protective layer which can assuredly cover electrothermal transducers even if the thickness of the layer is small. A thin intermediate layer is provided between a heating resistive layer and electrodes. The thin intermediate layer is an insulator on heating portions of the heating resistive layer. According to such a configuration, the life of the heating resistive layer becomes long, and occurrence of burnt deposits is suppressed. Since steps at portions where the thin intermediate layer is provided are small, an excellent film quality can be obtained even if the thickness of the protective layer is relatively small, and an excellent protective property is obtained.

Claims

1. A substrate for an ink-jet head, said substrate comprising:

   a heating resistive layer for generating thermal energy utilized for discharging a liquid;

   respective pairs of electrodes electrically connected to said heating resistive layer thereon;

and

heating portions of said heating resistive layer provided between corresponding pairs of electrodes, thermal energy being generated from said heating portions by passing current through said heating resistive layer from the electrodes; and

a thin intermediate layer provided between said heating resistive layer and the electrodes, said thin intermediate layer at least on said heating portions comprising an insulator.

2. A substrate according to Claim 1, wherein said thin intermediate layer comprises an insulator, and wherein the electrodes are electrically connected to said heating resistive layer through throughholes provided in said thin intermediate layer.

3. A substrate according to Claim 2, wherein said thin intermediate layer comprises Si_3N_4.

4. A substrate according to Claim 1, wherein the surfaces of the electrodes are insulated.

5. A substrate according to Claim 1, wherein a protective layer is provided on the electrodes except said heating portions.

6. A substrate according to Claim 1, wherein said thin intermediate layer comprises a metal, and wherein said thin intermediate layer on said heating portions is insulated.

7. A substrate according to Claim 6, wherein the insulator comprises an oxide or a nitride of the metal.

8. A substrate according to Claim 6, wherein the metal comprises Ta or Fe.

9. A substrate according to Claim 6, wherein the surfaces of the electrodes are insulated.

10. An ink-jet head comprising:

a substrate for said ink-jet head, comprising a heating resistive layer for generating thermal energy utilized for discharging a liquid, respective pairs of electrodes electrically connected to said heating resistive layer thereon, and heating portions of said heating resistive layer provided between corresponding pairs of electrodes, for generating thermal energy from said heating portions by passing current through said heating resistive layer from the electrodes;

discharging ports for discharging the liquid;

an ink channel communicating with said discharging ports;

an ink chamber for supplying said ink channel with ink; and

a thin intermediate layer provided between said heating resistive layer and said electrodes, said thin intermediate layer comprising an insulator at least on said heating portions.

11. An ink-jet head according to Claim 10, wherein said thin intermediate layer comprises an insulator, and wherein the electrodes are electrically connected to said heating resistive layer through throughholes provided in said thin intermediate layer.

12. An ink-jet head according to Claim 11, wherein said thin intermediate layer comprises Si_3N_4.

13. An ink-jet head according to Claim 10, wherein the surfaces of the electrodes are insulated.

14. An ink-jet head according to Claim 10, wherein a protective layer is provided on the electrodes except said heating portions.

15. An ink-jet head according to Claim 10, wherein said thin intermediate layer comprises a metal, and wherein said thin intermediate layer on said heating portions is insulated.

16. An ink-jet head according to Claim 15, wherein the insulator comprises an oxide or a nitride of the metal.

17. An ink-jet head according to Claim 15, wherein the metal comprises Ta or Fe.

18. An ink-jet head according to Claim 15, wherein the surfaces of the electrodes are insulated.

19. An ink-jet apparatus comprising: an ink-jet head comprising:

a substrate for the ink-jet head, comprising a heating resistive layer for generating thermal energy utilized for discharging a liquid, respective pairs of electrodes electrically connected to said heating resistive layer thereon, and heating portions of said heating resistive layer provided between corresponding pairs of electrodes, for generating thermal energy from said heating portions by passing current through said heating resistive layer from the electrodes;

discharging ports for discharging the liquid;

an ink channel communicating with said discharging ports; and

an ink chamber for supplying said ink channel with ink;

conveying means for conveying a printing material onto which the liquid is discharged; and

a thin intermediate layer provided between said heating resistive layer and the electrodes, said thin intermediate layer at least on said heating portions comprising an insulator.

FIG.1

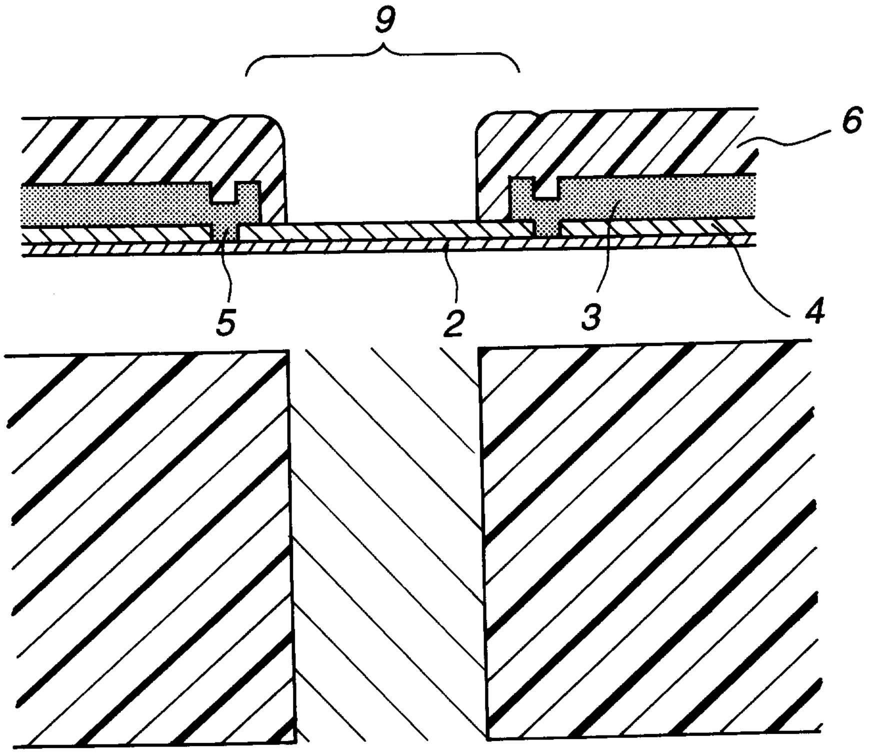

FIG.2(A)

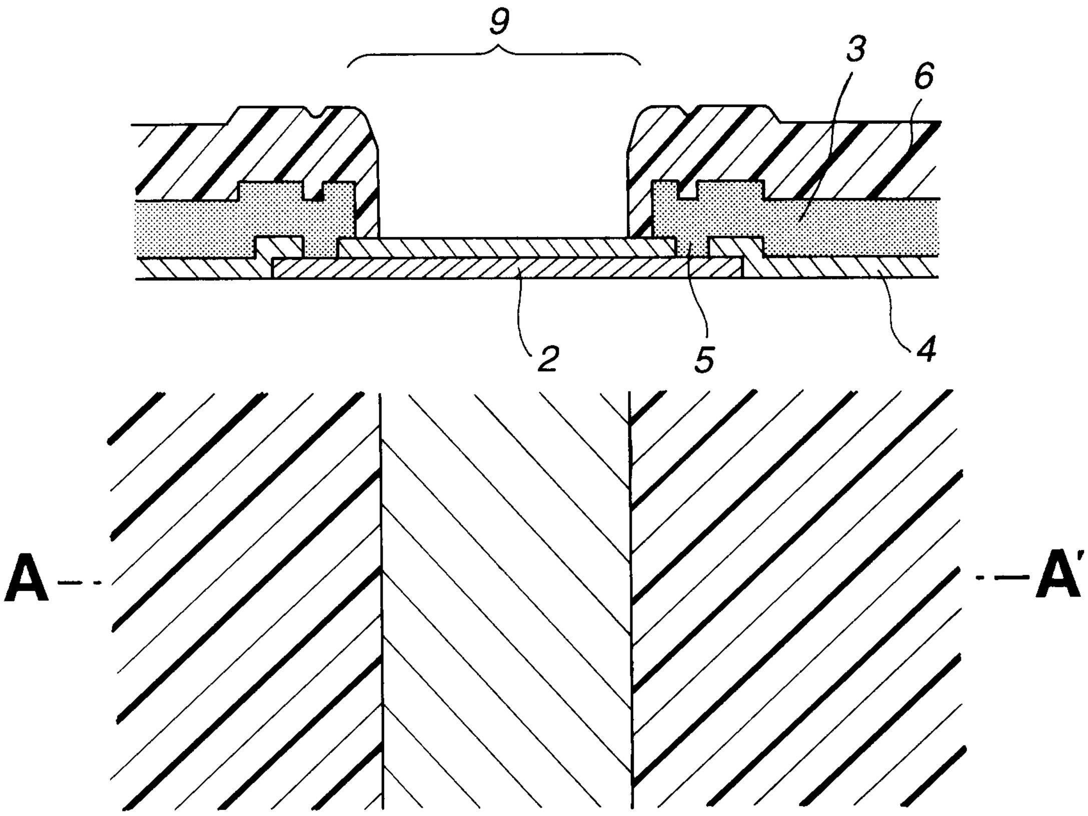

FIG.2(B)

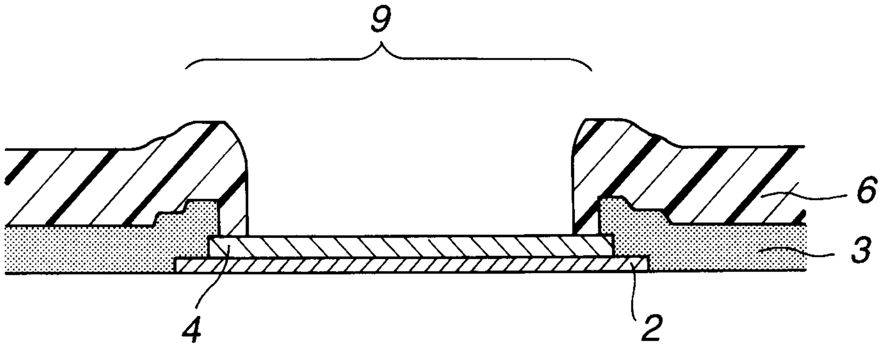

FIG.3

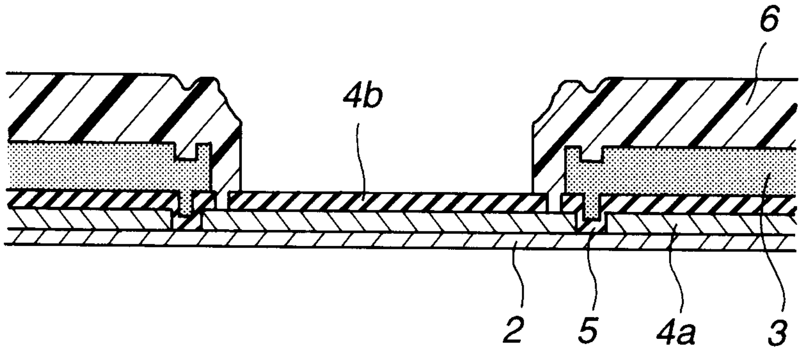

FIG.4

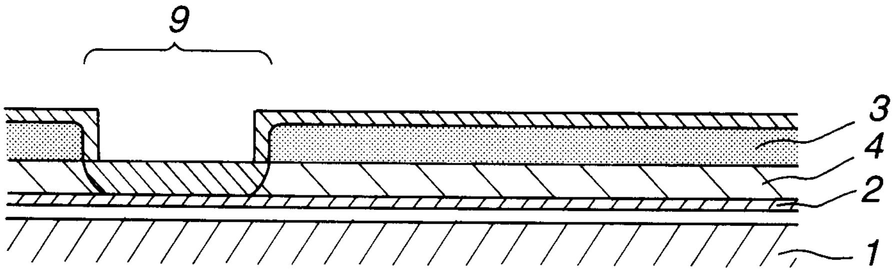

FIG.5(A)

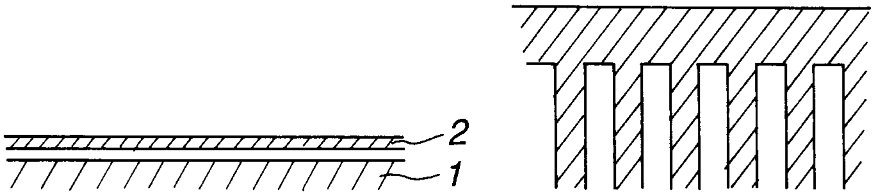

FIG.5(B)

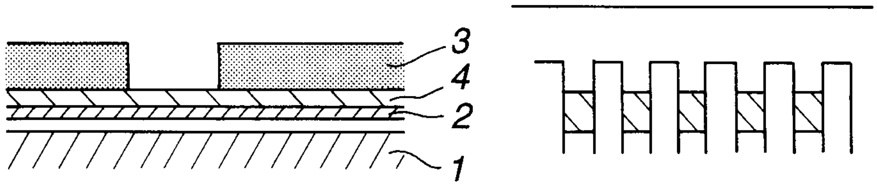

FIG.5(C)

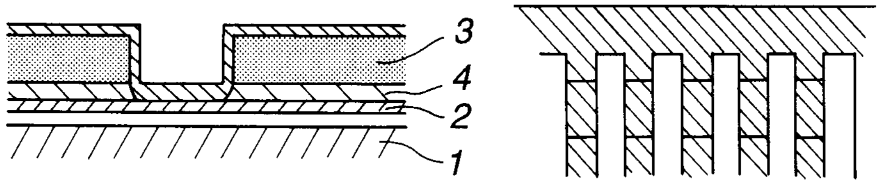

FIG.6

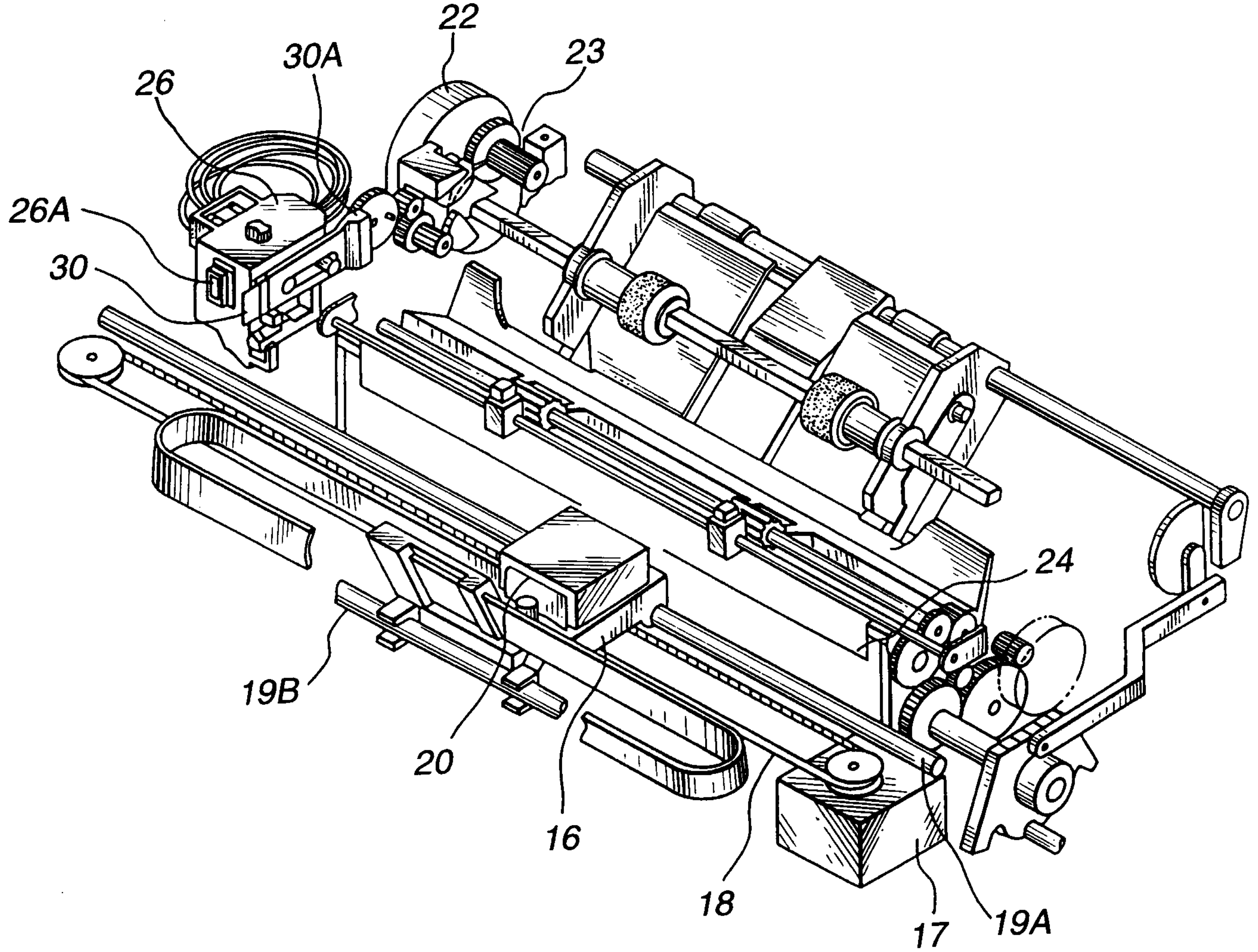

FIG.7(A)

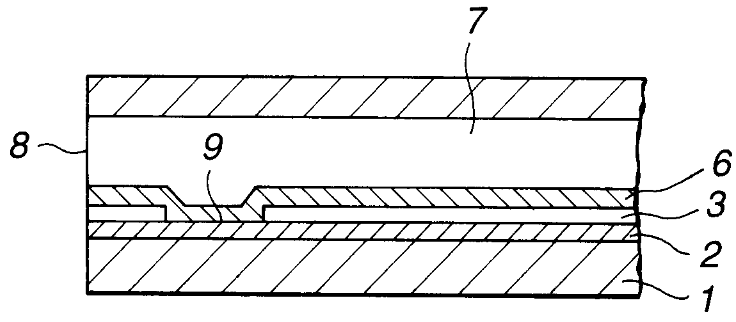

FIG.7(B)