

1

Process for Manufacturing an Electrothermal
Transducer for a Liquid Jet Recording Head

5 BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a process for manufacturing an electrothermal transducer for a liquid jet recording head capable of ejecting liquid and forming
10 flying liquid droplets to effect recording.

Description of the Prior Art

Liquid ejecting recording methods (ink jet recording methods) have recently attracted attention since the noise during the recording is negligibly small and the
15 recording can be made on plain paper.

Among such recording methods, a method disclosed in Japanese Patent Application Laid-open No. 51837/1979 is different from other methods in a feature that the motive force for ejecting liquid droplets is produced by applying
20 thermal energy to liquid. That is, according to the method, a liquid subjected to thermal energy abruptly changes the volume due to the change in state and the force thus produced ejects the liquid from an orifice at the tip of the recording head portion to form flying liquid droplets
25 and attach the droplets to a receiving member to effect recording.

The recording head portion of a recording apparatus

1 used for the above-mentioned recording method is consti-
tuted of an orifice for ejecting liquid, a liquid ejecting
portion having a liquid flow path containing, as a part of
the constitution, a heat actuating portion which is
5 communicated with the orifice and where thermal energy is
applied to the liquid, and an electrothermal transducer as
a means for generating thermal energy.

The above-mentioned electrothermal transducer is
constituted of a resistive heater layer formed on a support,
10 and a pair of electrodes disposed opposite to each other
and connected with the resistive heater layer. The
resistive heater layer has a heat generating region (heat
generating portion) between the electrodes. The above-
mentioned electrothermal transducer is generally provided on
15 a support and a single or plural protective layers are
provided on the surface of at least the portion contacting
the liquid of the electrothermal transducer, for example, so
as to protect chemically or physically the electrothermal
transducer from the liquid, prevent short circuit between
20 the electrodes through the liquid, and inhibit electrolytic
corrosion caused by current flowing from the electrodes to
the liquid. The protective layers may be generally
produced by a thin film forming method such as sputtering,
CVD, vapor deposition and the like.

25 However, the above-mentioned protective layers
sometimes suffer from a problem that, upon forming the
protective layers, a so-called micro-crack is formed at

1 edge portion of the electrode portion and a defect such as
so-called pinhole and the like is liable to form due to an
incomplete washing or dusts generated upon forming the layer.
It is very difficult to form protective layers completely
5 free from such defects, and when such defects are present
in the protective layers, the electrodes are shortcircuited
through the liquid to cause corrosion and dissolution of
the electrodes and resistive heater layer resulting in
disconnection of electrothermal transducer during a long
10 time use.

The above-mentioned techniques and problems in the
techniques will be described below referring to the
drawings.

FIG. 1A is a partial plan view in the vicinity of a
15 heat generating portion of a substrate in a typical
embodiment of a prior art liquid jet recording head. In
FIG. 1A, a protecting layer for covering the surface is
omitted for simplification of the explanation. FIG. 1B is
a partial cross-sectional view taken along the dot and dash
20 line XY in FIG. 1A. FIG. 2 is given for explaining the
detailed structure of the substrate in FIG. 1 and is an
enlarged cross sectional view of the portion encircled with
a dotted line A in FIG. 1B.

In FIG. 1A and FIG. 1B, the electrothermal transducer
25 is constituted of a support 1, a resistive heater layer 2
formed on support 1, and electrodes 3 and 3' formed on the
resistive heater layer, and a protective layer 4 is provided

1 on the resulting assembly to protect the electrothermal
transducer from an ink. Resistive heater layer 2, electrodes
3 and 3', and protective layer 4 are provided on support 1
in the order as mentioned above.

5 Resistive heater layer 2 and electrodes 3 and 3'
constituting the above-mentioned electrothermal transducer
are patterned to form a predetermined shape by means of
etching or the like, and the portions other than heat
generating portion 11 are patterned in the same shape. At
10 heat generating portion 11, an electrode is not formed on
resistive heater layer 2 and the resistive heater layer 2
at that portion constitutes the heat generating portion 11.

Protective layer 4 is formed on desired portions
including the portions contacting the liquid above the
15 support by means of sputtering, CVD method, vapor deposition
or the like, and the resulting protective layer usually has
some defects such as micro-crack 6, pinhole 7 and the like
as shown in FIG. 2. When such defects are present in
protective layer 4, the liquid filling the portions above
20 the protective layer penetrates the defects to corrode and
dissolve resistive heater layer 2 and electrodes 3 and 3'
finally resulting in disconnection. Therefore, another
protective layer such as an organic resin layer and the like
has been heretofore usually provided on the protective layer
25 4. An example of a substrate of a liquid jet recording head
provided with such an organic resin layer is shown in FIG. 3.

In FIG. 3, an organic resin layer is provided on the

1 substrate having the constitution of FIG. 1, and FIG. 3
corresponds to the partial cross section of FIG. 1B. In
FIG. 3, 8 is an organic resin layer which is formed on the
whole surface of protective layer 4 except the portion
5 corresponding to heat actuating portion 5 by means of spin
coating, vapor deposition, plasma polymerization or the
like.

However, such prior art constitution suffers from
the following problems. Firstly, organic resin layer 8
10 contacts the liquid present thereon and therefore, during
the long time use, sometimes the resin is swelled or the
adhesion is lowered. In addition, if the protective layer
4 is thick, the transfer of the heat energy generated at
heat generating portion 11 to the liquid in the vicinity of
15 said portion 11 is hindered so that the quantity of heat to
be generated at the heat generating portion 11 should be
increased. As a result, the deterioration of resistive
heater layer 2 is accelerated. In such a case as above, the
time required for heating and cooling at the heat generating
20 portion 11 becomes long, and this is against the demand for
high speed recording. Further, the temperature at heat
generating portion 11 usually reaches about 200°C so that
the resin of organic resin layer 8 is sometimes subjected to
deterioration. Therefore, heretofore an organic resin layer
25 8 has not been provided at the portion of protective layer 4
in the vicinity of heat generating portion 11 and a single
layer structure, that is, only the protective layer 4, is

present there as shown in FIG.3. As a result, the organic resin layer is not effective against micro-crack 6 as illustrated in FIG.2.

5 SUMMARY OF THE INVENTION

10 An object of the present invention is to provide a process for manufacturing an electrothermal transducer for a liquid jet recording head free from the above-mentioned drawbacks.

15 Another object of the present invention is to provide a process for manufacturing an electrothermal transducer for a liquid jet recording head which is excellent in an overall durability upon a frequent repeated use or a continuous use for a long time and can stably maintain the initial good liquid droplet forming characteristics for a long time.

20 A further object of the present invention is to provide a process for manufacturing an electrothermal transducer for a liquid jet recording head having a high reliability upon the fabrication processing.

According to the invention there is provided an electrothermal transducer unit for a liquid jet recording head comprising a support, a resistive heater layer overlying the support, at least a pair of electrodes electrically connected with the resistive heater layer and a protective layer of insulating material overlying the heater layer and adjacent electrode portions wherein at least portions of the heater layer and/or electrodes exposed by defects in the protective layer are protected by anodic oxide generated in situ from the heater layer and/or the electrodes.

The invention also provides a process for the manufacture of an electrothermal transducer unit for liquid jet recording heads in which the unit comprises a support, a resistive heater layer and an electrode layer overlying the support, and a protective layer of insulating material overlying the heater and electrode layers and subject to defects, wherein the unit is exposed to anodic oxidation utilising the electrodes as anodes whereby anodic oxidation takes place at portions of the heater and electrode layers exposed by any said defect.

1

5 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a partial plan view of a heat generating portion and its vicinity of a substrate in a typical embodiment of a conventional liquid jet recording head, and FIG. 1B is a partial cross-sectional view taken along a dot and dash line XY in FIG. 1A; FIG. 2 is an enlarged view of a portion surrounded with a dotted line A shown in FIG. 1B; FIG. 3 is a partial cross-sectional view of a portion corresponding FIG. 1B in other conventional liquid jet recording head; FIG. 4A is a partial plan view of a heat generating portion and its vicinity of a substrate in an embodiment of a liquid jet recording head fabricated according to the present invention, and FIG. 4B is a partial cross-sectional view taken along a dot and dash line XY in FIG. 4A; FIG. 5 is an enlarged view of a portion corresponding to a portion surrounded with a dotted line A shown in FIG. 4B in another embodiment of the present invention; FIG. 6 is an enlarged view of a portion corresponding to a portion surrounded with a dotted line A shown in FIG. 4B in still another embodiment of the present invention; FIG. 7 is a schematically exploded view for explaining an inner construction in an embodiment of a liquid jet recording head fabricated according to the present invention; and FIG. 8 is

1 a schematic view for explaining an inner construction in
another embodiment of a liquid jet recording head fabricated
according to the present invention.

5 DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in detail
referring to the drawings.

FIG. 4A is a partial plan view of a heat generating
portion and its vicinity of a substrate in an embodiment of
10 a liquid jet recording head manufactured by a process of the
present invention. In FIG. 4A, a protective layer for
covering the surface is omitted for simplifying the
illustration. FIG. 4B is a partial cross-sectional view
taken along a dot and dash line XY in FIG. 4A. In FIG. 4,
15 the liquid flow path and the orifice member are omitted in
the same way as in FIG. 1. The substrate in FIG. 4 is
constructed in the same manner as the substrate of FIG. 1
except that an anodic oxidation method is used.

In FIG. 4A and FIG. 4B, 1 is a support, 2 is a
20 resistive heater layer, 3 and 3' are electrodes, 4 a
protective layer, 5 a heat actuating portion, and 11 a heat
generating portion. As materials constituting the said
support 1, resistive heater hayer 2, electrodes 3 and 3',
and protective layer 4, those used and proposed in the art
25 may be used widely. However, as the material constituting
protective layer 4, there may be used materials having
insulating property, preferably, inorganic materials.

1 The process according to the present invention is
illustrated below referring to the fabrication of the above-
mentioned substrate. First, resistive heater layer 2 is
formed on support 1 by a vapor deposition method, a
5 sputtering method or the like and, on the upper surface
thereof, electrodes 3 and 3' are further formed by the same
methods. Next, by the so-called photo-etching method or
the like, a part of the layer to be electrodes 3 and 3' and
a part of the layer to be resistive heater layer 2 are
10 removed successively from the top. Thereby, there are
formed resistive heater layer 2, electrodes 3 and 3', and
heat generating portion 11 having the desired shape on the
desired position and an electrothermal transducer comprising
them is constructed. Second, by the vapor deposition method,
15 the sputtering method or the like as shown above, protective
layer 4 is provided at least on the electrothermal trans-
ducer, preferably on a part of the substrate containing the
electrothermal transducer. The substrate in this step has,
for example, a defect as shown in FIG. 2. Finally, elec-
20 trodes 3 and 3' having such a defect as an anode are
subjected to an anodic oxidation treatment. By using the
anodic oxidation method, an anodic oxidation film is formed
on the said defective portions, that is, the portions in
which insulating property for a heat generation are not
25 maintained. By the above-mentioned film, these defective
portions in the electrothermal transducer may be protected
from liquid.

1 A detailed construction of the substrate fabricated
by the above-mentioned method according to the present
invention is illustrated below referring to the substrate
constructed as shown in FIG. 4. However, the following
5 embodiments are explained with a portion corresponding to
a portion surrounded with a dotted line A shown in FIG. 4B.

FIG. 5 shown an example of a detailed construction
of a substrate subjected to an anodic oxidation treatment
consisting of two steps using different electrolytes,
10 respectively. In FIG. 5, 9 is the anodic oxidation film
formed by the anodic oxidation treatment at the first step,
and 10 is the anodic oxidation film formed by the anodic
oxidation treatment at the second step.

These films may be formed on electrode 3' and
15 resistive heater layer 2 at the defective portions of
protective layer 4, for example, micro-crack 6 and pinhole
7 and if desired, around said portions. Further, its shape
is formed such that electrode 3' and resistive heater layer
2 do not directly contact liquid. The shape of the defects
20 in protective layer 4 such as micro-crack 6, pinhole 7 and
the like remains as it is, even after having applied the
anodic oxidation treatment. But, by forming the above-
mentioned film on the electrode or the resistive heater
layer fronting these defective portions, the electrode and
25 the resistive heater layer are protected from electrolytic
corrosion caused by direct contact between the liquid and
these portions. Thereby, there is provided a stable liquid

1 jet recording head free from disconnection or the like.

FIG. 6 shows an example of a substrate subjected only to the anodic oxidation treatment at the second step as shown in FIG. 5. In FIG. 6, 10 is an anodic oxidation
5 film. Property of these films formed in the defective portions varies depending upon the kind of an electrolyte, electrolytic conditions, materials of the electrode and resistive heater layer or the like. However, these conditions are not to be construed as being particularly
10 limitative so far as the objects of the present invention are accomplished. Further, the anodic oxidation method according to the present invention is not particularly limitative and there may be widely used generally known methods for applying the oxidation treatment to a metal
15 such as Al, Mg, Ti, Ta and the like.

The liquid jet recording head fabricated by the process according to the present invention is accomplished by forming a liquid flow path and an orifice corresponding to the heat generating portion on the substrate formed as
20 above.

FIG. 7 shows schematically an exploded view for explaining an inner construction of an embodiment of the accomplished liquid jet recording head. In this embodiment, orifice 205 is provided above a heat generating portion 203
25 (Only one is shown in the figure.). In this figure, 204 is a liquid flow path, 206 an ink flow path wall, 207 a common liquid chamber, 208 a second common liquid chamber, 209 a

1 throughhole interconnecting common liquid chamber 207 and
second common liquid chamber 208, and 210 a ceiling plate.
A wiring portion of the electrothermal transducer in the
figure is omitted.

5 FIG. 8 shows schematically another embodiment of
the accomplished liquid jet recording head. In this
embodiment, orifice 205 is formed at the tip of the liquid
flow path. 203 is a heat generating portion, 204 a liquid
flow path, 206 an ink flow path wall, 207 a common liquid
10 chamber, and 210 a ceiling plate. 211 shows an ink-supplying
port.

In the case of a substrate having electrodes and a
resistive heater layer insulated by the anodic oxidation as
shown above, although defects exist in the protective layer,
15 the density of defective portions in the protective layer is
zero in measurement by a copper decoration method using a
methanol solution. Therefore, electrolytic corrosion of
the electrodes and the resistive heater layer by the liquid
does not occur, and although the defects still remain in
20 the protective layer, there can be obtained a substrate
having no problem for a practical use by forming the above-
mentioned oxidation films on the electrode and the resistive
heater layer. In case that a protective layer is formed as
a multiple layer construction by laminating a metal layer
25 or the like on an insulating protective layer, its effect is
very great because a short circuit does not occur between
the electrothermal transducer and the metal protective layer.

1 The characteristic of the present invention is to
convert the liquid contacting surface of the electrothermal
transducer to an insulating material by the above-mentioned
anodic oxidation method, and its effect is the same even
5 though the electrolyte and the electrolytic condition change.

Using the substrate formed as described above, the
liquid jet recording head is fabricated and used, and a
stable recording can be performed over a long time without
the breaking or the like.

10 The method of the present invention is described in
more detail referring to the following examples.

Example 1

An SiO_2 film of 5 μm thick was formed as a substrate
by thermally oxidizing an Si wafer. On the resulting
15 substrate, a Ta layer is formed as a resistive heater layer
of 3000 $\text{\AA}$ thick by sputtering, and then an Al layer of 5000 $\text{\AA}$
thick is laminated by an electron beam deposition using Al
as an electrode material. Next, the electrodes and the
resistive heater layer are patterned to have a predetermined
20 shape as shown in FIG. 4A by photolithographic steps and
the electrothermal transducers of a predetermined number
are formed at the predetermined positions (a heat generating
portion, 50 μm in width, 150 μm in length). Then, on the
substrate provided with the above-mentioned electrothermal
25 transducer, an SiO_2 layer of 2.2 μm thick is deposited as a
protective layer by a high rate sputtering.

By the same process as described above, one hundred

1 substrates were fabricated. Among them, 50 substrates
(sample A), half the number, are subjected to the anodic
oxidation treatment as described below and other 50
substrates (sample B) are used as the samples of the
5 defective portions.

In each of sample B, a pinhole density is measured
by a copper decoration method in methanol solution known
generally as method for detecting the pinhole density of a
passivation film. The average of the pinhole density was
10 6 defects/cm². The defect as shown in FIG. 2 was observed
in all sample B.

Next, each of the sample A was subjected to the
anodic oxidation treatment of two steps as described below.
First, the substrate of sample A was immersed in a 10%
15 solution of phosphoric acid and voltage of 100V was applied
only to electrode 3' as an anode for 20 minutes. Second, as
the treatment at the second step, the substrate subjected to
the treatment at the first step as described above was
immersed in a mixture of aqueous 0.5 mol/l boric acid and
20 0.05 mol/l sodium tetraborate and voltage of 200V was applied
to electrodes 3' and 3 as the anode.

By the anodic oxidation treatment, the oxidation
film as shown in FIG. 5 was formed on these defective
portions in the substrate subjected to the anodic oxidation
25 treatment. By the oxidation treatment at the first step,
Al₂O₃ film was formed on portion 9 of electrode 3' in FIG. 5
and thickness of the oxidation film on resistive heater

1 layer 2 composed of Ta was about 1000Å. By the oxidation
treatment at the second step, the oxidation film containing
Al as a main component and having an excellent dielectric
strength was formed on the circumference of the oxidation
5 film on portion 9 of electrode 3' formed at the first step.
In this step, thickness of the oxidation film on resistive
heater layer 2 composed of Ta was about 1100Å.

For all of the substrates of sample A subjected to
the anodic oxidation treatment of the two steps, the pinhole
10 density was measured by the copper decoration method and any
pinhole was not detected.

In case that the above-mentioned treatment was not
effected, the pinhole density was 6 defects/cm². Therefore,
very good effect was obtained by this anodic oxidation
15 treatment.

Example 2

According to the same process as in Example 1, 50
substrates of sample A were fabricated. Next, each of these
was subjected only to the anodic oxidation treatment at the
20 second step in Example 1. That is, each of the substrates
was immersed in a mixture of aqueous 0.5 mol/l boric acid
and 0.05 mol/l sodium tetraborate and voltage of 200V was
applied to electrodes 3 and 3' as an anode as shown in
FIG. 4 for 20 minutes. Thereby, the anodic oxidation
25 treatment was performed. The oxidation film having the
same shape as in Example 1 was formed at these defective
portions (portion 10 in FIG. 6) in the substrate.

1 Pinhole density was measured by a copper decoration method
and any pinhole was not detected.

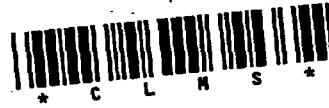
5

10

15

20

25



CLAIMS:

1. An electrothermal transducer unit for a liquid jet recording head comprising a support, a resistive heater layer overlying the support, at least a pair of electrodes electrically connected with the resistive heater layer and a protective layer of insulating material overlying the heater layer and adjacent electrode portions wherein at least portions of the heater layer and/or electrodes exposed by defects in the protective layer are protected by anodic oxide generated in situ from the heater layer and/or the electrodes.
2. A transducer unit according to claim 1 in which the protective layer is composed of a plurality of protective layers.
3. A transducer unit according to claim 2 in which at least one of the protective layer is an organic resin layer.
4. A transducer unit according to claim 2 in which the protective layer is constituted of an insulating protective layer and a metal layer.



5. A transducer unit according to claim 1 in which the protective layer is composed of an inorganic insulating material.
- 5 6. A transducer unit according to claim 2 in which at least one protective layer is an inorganic insulating material.
7. A transducer unit for a liquid jet recording head substantially as described with references to Figures 4 to 6 of the drawings.
- 10 8. A liquid jet recording head comprising a transducer unit according to any preceding claim.
- 15 9. A process for the manufacture of an electrothermal transducer unit for liquid jet recording heads in which the unit comprises a support, a resistive heater layer and an electrode layer overlying the support, and a protective layer of insulating material overlying the heater and electrode layers and subject to defects, wherein the unit is exposed to anodic oxidation utilising the electrodes as anodes whereby anodic oxidation takes place at portions of the heater and electrode layers exposed by any said defect.
- 20



-19-

10. A process according to claim 9 wherein the unit is subjected to a plurality of anodic oxidation treatments.

11. A process according to claim 10 wherein at
5 least two treatments are carried out with different electrolytes.

12. A process according to claim 9 substantially as described herein with reference to Example 1 or Example 2.
