

LIQUID JET RECORDING HEAD

5 This invention relates to a liquid jet recording head which ejects liquid to produce flying liquid droplets to record.

10 Ink jet recording methods (liquid jet recording methods) have recently attracted attention since they generate little noise, high recording speeds are possible, and the recordings can be made on plain paper without any special treatment such as fixation.

15 The liquid jet recording method disclosed in Japanese Patent Laid-open No. 51837/1979 and German Patent Laid-open (DOLS) No. 2843064 is different from other liquid jet recording methods in that heat energy is applied to liquid to produce a driving force for ejecting liquid droplets. That is, heat energy is applied to a liquid to cause an abrupt increase in its volume, ejecting the liquid from the orifice at the front of the recording head to form flying liquid droplets. The droplets attach to a record receiving member to effect recording.

25 In particular, the liquid jet recording method disclosed in DOLS 2843064 can not only be effective for so-called "drop-on-demand" recording methods, but also enables a high density multi-orifice recording head of a full-line type to be readily produced, and therefore, images of high resolution and high quality can be produced at a high speed.

35 The recording head portion of an apparatus used for the above-mentioned recording method comprises a liquid ejecting portion consisting of an orifice for ejecting liquid and a liquid flow path containing, as a part of the construction, a heat actuating portion communicating with the orifice and applying heat

energy for ejecting liquid droplets to the liquid, and an electrothermal transducer for generating heat energy.

5 The electrothermal transducer is provided with a pair of electrodes and a resistive heater layer connected to the electrodes and having a region generating heat (heat generating portion) between the electrodes.

10 A typical embodiment of the structure of such a liquid jet recording head is shown in Figs. 1A, 1B, 1C and 1D.

15 Fig. 1A is a partial front view of the liquid jet recording head viewed from the orifice side, and Figs. 1B, 1C and 1D are partial cross sectional views taken along the dot and dash line XY of Fig. 1A.

Recording head 100 consists of orifice 104

1 and liquid ejecting portion 105 formed by bonding the
surface of substrate 102 provided with electrothermal
transducer 101 to a grooved plate 103 having a predeter-
mined number of grooves of predetermined width and
5 depth at a predetermined line density such that the
grooved plate covers the substrate. In FIG. 1, the
recording head has a plurality of orifices 104, but the
present invention is not limited to such an embodiment
and a recording head having a single orifice is also
10 within the scope of the present invention.

Liquid ejecting portion 105 has orifice 104
ejecting liquid at the end and heat actuating portion
106 where thermal energy generated by electrothermal
transducer 101 is applied to liquid to form a bubble
15 and an abrupt state change due to expansion and
shrinkage of the volume occurs.

Heat actuating portion 106 is located above
heat generating portion 107 of electrothermal transducer
101, and a heat actuating surface 108 where heat gener-
20 ating portion 107 contacts the liquid is the bottom
surface of the heat actuating portion 106.

Heat generating portion 107 is constituted of
lower layer 109 provided on support 115, resistive
heater layer 110 provided on lower layer 109, and
25 first protective layer 111 provided on resistive heater
layer 110. Resistive heater layer 110 is provided with
electrodes 113 and 114 for flowing electric current

1 to the layer 110 to generate heat. Electrodes 113 is
an electrode common to heat generating portions of
liquid ejecting portions, and electrode 114 is a
selection electrode for selecting the heat generating
5 portion of each liquid ejecting portion to generate heat
and is provided along the liquid flow path of each
liquid ejecting portion.

First protective layer 111 serves to protect
chemically and physically resistive heater layer 110
10 from the liquid at the heat generating portion 107 by
isolating resistive heater layer 110 from the liquid
in the liquid flow path at liquid ejecting portion 105,
and also prevents short-circuit between electrodes 113
and 114 through the liquid. Thus, first protective
15 layer 111 serves to protect resistive heater layer 110.
First protective layer 111 also serves to prevent
electric leakage between adjacent electrodes. In
particular, it is important to prevent electric leakage
between selection electrodes and electrolytic corrosion
20 of electrodes caused by electric current flowing in an
electrode resulting from contact of an electrode under
the liquid flow path with the liquid which happens by
some cause. Therefore, such a first protective layer
111 having a protective function is provided on at
25 least an electrode which is disposed under a liquid
flow path.

1 The upper layer including the first protective
layer is required to have various properties depending
on the position to be disposed. That is, for example
the following characteristics are required at heat
5 generating portion 107:

- 1) heat resistance,
- 2) liquid resistance,
- 3) liquid penetration preventing property,
- 4) thermal conductivity,
- 10 5) oxidation preventing property,
- 6) insulating property, and
- 7) breakage preventing property.

At portions other than heat generating portion
107, sufficiently high liquid penetration preventing
15 property, liquid resistance and breakage preventing
property are required through the resisting property
to thermal conditions is not required to be so good.

However, at present there is not any material
for constituting the upper layer capable of sufficiently
20 satisfying all the characteristics 1) - 7) as mentioned
above. It is the present status that some of the
conditions 1) - 7) are not severely requested. For
example, at heat generating portion 107, materials
are selected by giving priority to conditions 1), 4)
25 and 5) while, at portions other than heat generating
portion 107, for example, at electrode portions,
materials are selected by giving priority to conditions

1 2), 3) and 7), and the materials thus selected are disposed on the corresponding region surfaces to form the upper layer.

Apart from the above, in the case of a liquid
5 jet recording head of a multi-orifice type, since a number of fine electrothermal transducers are formed on the substrate simultaneously, formation of each layer of the substrate and removal of a part of the formed layer are repeated, and as a result, the surface on
10 which each layer in the upper layer is to be formed becomes a fine uneven surface having step edge portions, and therefore, the step coverage property of the layers in the upper layer at the step edge portions becomes important. In other words, when the step coverage
15 property at the step edge portions is poor, penetration of the liquid occurs at the portions and causes electrolytic corrosion or dielectric breakdown. Further, when the formed upper layer suffers the formation of defects upon fabrication with a considerable probability,
20 penetration of liquid through the defect portion resulting in shortening the life of the electrothermal transducer to a great extent.

In view of the foregoing, it is required that the upper layer has a good step coverage property at
25 the step edge, defects such as pinholes and the like occur in the formed layer with only a low probability and even if the detects are formed, the number of

1 defects is negligibly small or less.

In order to satisfy those requisites, heretofore the upper layer has been produced by laminating the first protective layer composed of an inorganic
5 insulating material and the third protective layer composed of an organic material, or the first protective layer is constituted of two layers, that is, an under layer composed of an inorganic insulting material and an above layer composed of an inorganic material of
10 high toughness, relatively excellent mechanical strength and having adhesion and cohesion to the first protective layer and the third protective layer, such as metals and the like, or the second protective layer composed of an inorganic material such as metals and
15 the like overlies the third protective layer.

Though the third protective layer composed of an organic material is excellent in coating property, the heat resistance is poor so that the third
protective layer can not be provided on the resistive
20 heater layer at the heat generating portion. On the contrary, the second protective layer composed of an inorganic material such as metals is provided over the whole surface as an outermost surface layer of the substrate, or only on the resistive heater layer
25 of the heat generating portion. When the second protective layer is provided in such a manner as the latter, but the third protective layer 112 does

1 not overlap the second protective layer 116 as shown
in Fig. 1B, there is only the first protective layer
at portion b and therefore, a sufficient protection
can not be effected. Further, potential is locally
5 concentrated to that portion and at last, the electrode
layer begins to dissolve, that is, the corrosion
resistance is deteriorated. Even if the third
protective layer overlaps the second protective layer,
as far as the overlapping width is small as illustrated
10 in Figs. 1C and 1D, the liquid penetrates and potential
is concentrated when the liquid soaking time is long,
and therefore, dissolution of the electrode portion
occurs. On the contrary, when the overlapping width
is too large, there occur the following problems.
15 As shown in Fig. 1E, when, in the vicinity of the
heat generating portion, second protective layer 116
composed of an inorganic material such as metals and
the like is provided below third protective layer 112
composed of an organic material and on the first
20 protective layer 111, the probability of occurrence
of short between second protective layer 116 and
electrode 113 or 114 disadvantageously increases and
the yield of the products is extremely decreased.
As shown in Fig. 1F, when opposite to Fig. 1E, the
25 upper layer in the vicinity of the heat generating
portion are laminated such that third protective
layer 112 overlies first protective layer

1 111 and second protective layer 116 overlies the
third protective layer, the liquid penetrates from
the liquid flow path and exfoliation of the organic
material layer (the protective layer) proceeds due
5 to the stress of the inorganic material layer (the
second protective layer).

On the other hand, the liquid is vaporized
by heating at heat actuating portion 106, but the
vapor is immediately cooled to condense since it is
10 a subcooled boiling and the heating time is short.
Therefore, bubble formation and condensation are
repeated at a high frequency of several thousand
times per sec. in the vicinity of the heat actuating
surface, and the pressure change caused here breaks
15 often the substrate (cavitation corrosion).

Printed letter or signs of high image quality
and high density have been recently demanded, and there
are required more precise processing of minute portions
such as electrodes, resistive heater layers, accompany-
20 ing protective layers and the like.

An object of the present invention is to
provide a liquid jet recording head free from the
25 above-mentioned drawbacks.

Another object of the present invention is to
provide a liquid jet recording head which is

5 durable both in frequent repeated use and in continuous long term use, and which can maintain excellent liquid droplet forming characteristics.

5 A further object of the present invention is to provide a liquid jet recording head which can be fabricated with high reliability.

10 Still another object of the present invention is to provide a liquid jet recording head which can be fabricated in a high yield even when it is of a multi-orifice type.

15 According to one aspect of the present invention, there is provided a liquid jet recording head having a substrate and an upper layer; the substrate having a support, a resistive heater layer and electrodes electrically connected with the resistive heater layer such that portions of the resistive heater layer
20 located between the electrodes provide a plurality of electrothermal transducers for heating recording liquid; the upper layer comprising a first protective layer comprising an inorganic insulating material, and a second protective layer comprising an inorganic
25 material; the first and second protective layers being successively formed at least on the electrothermal

transducers and the second protective layer being in the form of a continuous strip which covers adjacent electrothermal transducers.

5 According to another aspect of the present invention, there is provided a liquid jet recording head having a plurality of outlet orifices and a corresponding plurality of heating means for the application of heat pulses to liquid in respective heating chambers
10 defined in the head for causing liquid droplets to eject from said orifices, wherein each of said heating means comprises an electrothermal transducer and each said transducers is covered by a laminated protective means, and wherein a continuous strip extending
15 across a plurality of adjacent said transducers provides one of the layers of said protective means for those transducers.

1 Reference is made to the drawings, in which:

Fig. 1A, B, C, D, E and F refer to the constitution of a conventional liquid jet recording head and Fig. 1G and H refer to the constitution of a liquid jet recording head according to the invention claimed in parent application no. 2153304A; Fig. 1A shows schematically a partial front view and each Fig. 1B, C, D, E, F, G and H is a partial cross-sectional view taken along a dot and dash line XY in Fig. 1A; Fig. 1B shows an embodiment where a second protective layer does not overlap a third protective layer; Fig. 1C, E and G show an embodiment where a third protective layer overlaps a second protective layer; Fig. 1D, F and H show an embodiment where a second protective layer overlaps a third protective layer;

15 Fig. 2 is a graph showing the relationship between the overlapping width b of a second protective layer and a third protective layer and a rate of disconnection;

Fig. 3A is a graph which shows the relationship between the overlapping width b and the rate of short, in the liquid jet recording head where a third protective layer overlaps a second; Fig. 3B is a graph which shows the relationship between the overlapping width b and the rate of film exfoliation, in the liquid jet recording head where a second protective layer overlaps a third protective layer;

25 Fig. 4A, B and C refer to the constitution of a conventional liquid jet recording head; Fig. 4A shows

1 schematically the partial front view; Fig. 4B is the
partial cross-sectional view taken along a dot and dash
line XY in Fig. 4A; Fig. 4C shows schematically a plan
view of the substrate; and Fig 5 refers to the constitution
5 of an embodiment of the liquid jet recording head according
to the present invention and shows schematically the plan
view of the substrate equivalent to Fig. 4C.

10 Referring to Fig. 1G and H, a first protective
layer 111 is composed of the inorganic insulating material,
for example, inorganic oxides such as SiO_2 and the like
and inorganic nitrides such as Si_3N_4 and the like. The
second protective layer 116 has toughness and a relatively
15 excellent mechanical strength. Further, the second layer
is preferably composed of a material having adhesion and
cohesion to the first protective layer, for example, a
metal material such as Ta and the like where the first
protective layer is composed of SiO_2 . As described above,
20 when the second protective layer is composed of an inorganic
material such as metals and the like which is relatively
tough and has a mechanical strength, the shock due to
cavitation caused upon jetting liquid can be sufficiently
absorbed especially at the heat actuating surface 108, and
25 the life of the electrothermal transducer 101 can be
extended to a great extent.

As materials constituting the first protective

1 layer 111, there are preferably used inorganic insulating materials relatively excellent in thermal conductivity and heat resistance, for example, inorganic oxides such as SiO_2 and the like, transition metal oxides such as titanium
5 oxide, vanadium oxide, niobium oxide, molybdenum oxide, tantalum oxide, tungsten oxide, chromium oxide, zirconium oxide, hafnium oxide, lanthanum oxide, yttrium oxide, manganese oxide and the like, metal oxides such as aluminum oxide, calcium oxide, strontium oxide, barium oxide,
10 silicon oxide and the like and composites thereof, high resistance nitrides such as silicon nitride, aluminum nitride, boron nitride, tantalum nitride and the like and composites of these oxides and nitrides, and thin film materials, for example, semiconductors comprising amorphous
15 silicon, amorphous selenium and the like which have low resistance as bulk, but may be made to have high resistance by a sputtering method, a CVD method, a vapor deposition method, a gas phase reaction method, a liquid coating method or the like.

20 As materials used for forming the second protective layer 116, in addition to Ta as mentioned above, there may be mentioned the elements of Group IIIa of the Periodic Table such as Sc, Y and the like, the elements of Group IVa such as Ti, Zr, Hf and the like, the elements of Group Va
25 such as V, Nb and the like, the elements of the Group VIa such as Cr, Mo, W and the like, the elements of Group VIII such as Fe, Co, Ni and the like, alloys of the above-

1 mentioned metals such as Ti-Ni, Ta-W, Ta-Mo-Ni, Ni-Cr, Fe-
Co, Ti-W, Fe-Ti, Fe-Ni, Fe-Cr, Fe-Ni-Cr and the like,
borides of the above-mentioned metals such as Ti-B, Ta-B,
Hf-B, W-B and the like, carbides of the above-mentioned
5 metals such as Ti-C, Zr-C, V-C, Ta-C, Mo-C, Ni-C, Cr-C and
the like, silicides of the above-mentioned metals such as
Mo-Si, W-Si, Ta-Si and the like, nitrides of the above-
mentioned metals such as Ti-N, Nb-N, Ta-N and the like.
Using these materials, the second protective layer may be
10 formed by the procedure such as a vapor deposition method,
a sputtering method, a CVD method and the like. The
second protective layer may be composed of the above
materials, alone or in combination.

The third protective layer is composed of an organic
15 insulating material which is excellent in prevention of
liquid penetration and liquid resistance, and further has
preferably the following characteristics:

- (1) Good film shapeability,
 - (2) Dense structure and free from pinholes,
 - 20 (3) Not swelled with and not dissolved in the ink,
 - (4) High insulating property when film-shaped,
 - (5) High heat resistance,
- and the like.

As the organic materials, there may also be used,
25 for example, silicone resin, fluorine resin, aromatic
polyamide, addition polymerization type polyimide, poly-
benzimidazole, metal chelate polymer, titanate acid ester,

1 epoxy resin, phthalic resin, thermosetting phenolic resin,
P-vinylphenolic resin, Zirox resin, triazine resin, BT
resin (addition polymerized resin of triazine resin and
bismaleimide) or the like. Alternatively, it is also
5 possible to form the third protective layer by vapor
deposition of polyxylylene resin and derivatives thereof.

Further, the third protective layer may also be
formed by film shaping according to a plasma polymerization
using various organic monomers such as thiourea, thio-
10 acetamide, vinyl ferrocene, 1,3,5-trichlorobenzene, chloro-
benzene, styrene, ferrocene, pyrrole, naphthalene, penta-
methylbenzene, nitrotoluene, acrylonitrile, diphenyl
selenide, p-toluidine, p-xylene, N,N-dimethyl-p-toluidine,
toluene, aniline, diphenyl mercury, hexamethylbenzene,
15 malononitrile, tetracyanoethylene, thiophene, benzene-
selenol, tetrafluoroethylene, ethylene, N-nitrosodiphenyl-
amine, acetylene, 1,2,4-trichlorobenzene, propane and the
like.

However, when a recording head of a high density
20 multi-orifice type is manufactured, apart from the above-
mentioned organic materials, it is desirable to use
organic materials capable of being very easily processed
by a fine photolithography as materials for forming the
third protective layer.

25 As examples of the organic materials, there may be
preferably used, for example, polyimidoisoindoloquinazo-
linedione (trade name; PIQ, produced by Hitachi Kasei Co.,

- 1 Japan), polyimide resin (trade name: PYRALIN, produced by
Du Pont, U.S.A.), cyclized polybutadiene (trade name: JSR-
CBR, CBR-M901, Japan Synthetic Rubber Co., Japan),
Photonith (trade name: produced by Toray Co., Japan),
5 other photosensitive polyimide and the like.

The support 115 is composed of silicon, glass,
ceramics or the like.

- Lower layer 109 is provided so as to control
mainly the transfer of heat generated at heat generating
10 portion 107 to support 115. The construction material is
selected and the layer thickness is designed in such a
way that the heat generated at heat generating portion
107 flows more to the heat actuating portion 106 side than
to other portions when heat energy is applied to the liquid
15 at heat actuating portion 106 while the heat remaining at
heat generating portion 107 flows rapidly to the support
115 side when the electric current to electrothermal trans-
ducer 101 is switched off.

- As the material for constituting lower layer 109,
20 there may be used inorganic materials represented by metal
oxides such as SiO_2 , zirconium oxide, tantalum oxide,
magnesium oxide and the like.

- As the material constituting resistive heater
layer 110, there may be used most materials capable of
25 generating heat as desired by flowing electric current.

As examples of the materials, there may be
preferably used, for example, tantalum nitride, nichrome,

1 silver-palladium alloy, silicon semiconductor, or a
metal such as hafnium, lanthanum, zirconium, titanium,
tantalum, tungsten, molybdenum, niobium, chromium, vanadium
and the like, alloys thereof, borides thereof or the like.

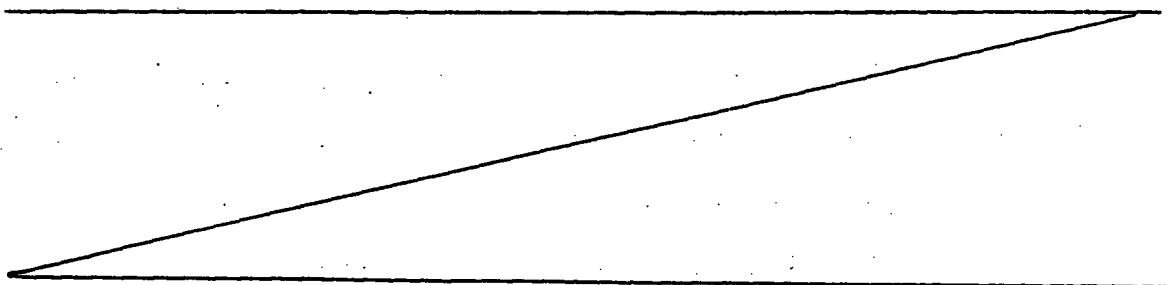
5 Among the materials constituting the resistive
heater layer 110, metal borides are especially excellent.
Of these, hafnium boride is the best, and next to this
compound there are zirconium boride, lanthanum boride,
tantalum boride, vanadium boride and niobium boride with
10 better characteristic in the order as mentioned.

Using the above-mentioned material, the resistive
heater layer 110 may be formed by the procedure such as an
electron beam method, a sputtering method and the like.

As the materials for constituting electrodes 113
15 and 114, there may be effectively used most of conventional
electrode materials, and there are mentioned, for example,
Al, Ag, Au, Pt, Cu and the like. The electrodes may be
formed at a predetermined position with a predetermined size,
shape and thickness by means of vapor deposition or the like.

20 The electrodes may be provided on or under the
resistive heater layer though the electrodes are formed on
the resistive heater layer in the Figures.

25



1 As the materials for constituting the grooved
plate 103 and the common liquid chamber provided at the
upstream portion of heat actuating portion 106, there
may be used most of the materials satisfying the following
5 conditions: i) the shape is hardly or not thermally
affected during fabricating the recording head or under
the circumstance of using the recording head; ii) a fine
precise processing can be applied thereto and the surface
accuracy can be easily obtained as desired; and iii) the
10 resulting liquid paths can be processed to permit the
liquid to flow smoothly in the paths.

Representative materials for the above-mentioned
purpose are preferably ceramics, glass, metals, plastics,
silicon wafer and the like, and in particular, glass and
15 silicon wafer are more preferable since they are easily
processed, and have an appropriate degree of heat
resistance, coefficient of thermal expansion and thermal
conductivity. It is desired to apply to the outer surface
of the circumference of orifice 104 a water repellent
20 treatment where the liquid is aqueous and an oil repellent
treatment where the liquid is non-aqueous, so as to
prevent the liquid from leaking and flowing to the outside
portion of orifice 104.

The order of overlapping of a third protective layer
25 and a second protective layer is not critical, and any one
of the layers may overlap the other as far as the over-
lapping width is within the above-mentioned range. It is

1 not necessary that the overlapping width is the same at all
portions in the vicinity of the electrothermal transducers,
but the overlapping width may be different from portion to
portion as far as it is within the above-mentioned range.

5 Fig. 5 shows an embodiment of the
liquid jet recording head according to the present invention.

In Fig. 5, according to the present invention, the
second protective layer is not provided individually on each
10 heat generating portion, but continuously covers adjacent
heat generating portions, that is, the second protective
layer is in a form of a bar.

Protective layers in the upper layer have mainly a
function isolating a resistive heater layer from liquid in
15 a liquid flow path and a function of cavitation resistance,
as mentioned above. In the embodiment of Fig. 5, the first
protective layer has mainly the former function while the
second protective layer has mainly the latter function.
Where the second protective layer is formed in the shape
20 as shown in Fig. 5, the patterning is easy. Therefore,
nozzles arranged at a high density can be fabricated
without any complicated and highly precise processing.
When this shape is employed, the probability of short at
electrodes, resistive heaters and the first protective
25 layers becomes about twice that in the case of the prior
art as shown in Fig. 1, but since the density of pinhole
which caused short is about $1 - 5 \times 10^{-3}$ pinholes per cm^2 ,

1 the probability of short is 0.02 - 0.1% even for a liquid
jet recording head with a density as high as 1000 nozzles,
and thereby a sufficiently high manufacturing yield can be
ensured. Judging collectively this type of arrangement
5 of the second protective layer taking into consideration
the easy fabrication, high yield and the like, the above-
mentioned liquid jet recording head is finally better in
points of density and image quality than that of prior art.

In the embodiment shown in Fig. 5, electrodes 113
10 and 114 below the liquid flow path are covered almost only
by a first protective layer 111. A third protective layer
composed of an organic material having an excellent
coating property may be formed above the first protective
layer except the portion corresponding to the heat actuating
15 surface.

In the following examples, Example 2 is given for
illustrating the present invention. Example 1 illustrates
the invention claimed in the parent application.

Example 1

A liquid jet recording head according to the present
20 invention was manufactured as shown below.

An SiO_2 film of 5 μm thick was formed by thermally
oxidizing an Si wafer, and on the SiO_2 film, a 3,000-Å
thick resistive heater layer composed of HfB_2 was formed by
a sputtering. Then, by an electron beam deposition, a Ti
25 layer of 50Å thick and an Al layer of 10,000Å thick were
continuously deposited.

The pattern of electrodes 113 and 114 was formed by

1 a photolithographic step. Size of a heat actuating surface was 50 μ m in width and 150 μ m in length.

A 2.8- μ m thick first protective layer 111 composed of SiO₂ was deposited by a high rate sputtering.

5 Next, a second protective layer 116 was formed as follows. A 0.5- μ m thick polyimide resin as a resist for a Ta lift-off was formed except for a circumference of a cut part (400 x 300 μ m) and then, a Ta film of 0.5 μ m thick was formed by a magnetron sputtering. After forming the Ta
10 film, a lift-off patterning was performed so as to leave the Ta film on the cut part by removing polyimide resin using a liquid release agent.

Photonith (prodeced by Toray Co., Japan) was applied by a spinner coating and a patterning development
15 was performed so as to make the cut part (300 x 200 μ m) in the circumference of the heat actuating surface. Thereby, a third protective layer 112 was produced. The overlapping width of the third protective layer and the second protective layer was 50 μ m. Further, a substrate for the
20 liquid jet recording head was produced by baking.

A pulse-shaped signal having 23V, 10 μ s in pulse width and 800Hz in repetition frequency was applied to the resulting electrothermal transducer of the recording head. According to the applied signal, a liquid was jetted as
25 droplets, and flying droplets were formed stably.

To clarify the relation between the percent defective of the recording head and the overlapping width,

1 Pt electrode was introduced into an ink liquid such that
an ink potential became GND and +40V was applied to the
recording head. The percent defective was investigated
after allowing to stand for 200hr while maintaining the
5 ink liquid temperature at 80°C.

Fig. 2 shows the result of examining the rate of
disconnection due to dissolution of electrode occurring
where the overlapping width b was from minus to about zero
as shown in Fig. 1B. When the overlapping b was minus (no
10 overlapping), the electrode was dissolved from a defective
part of a inorganic insulating layer (defective step
coverage, a pinhole part) and as a result, the disconnection
occurred.

When the overlapping b was less than about 10 μ m,
15 the disconnection occurred as the result of infiltration
of the liquid into a boundary part overlapped.

When the overlapping width was plus (overlapping)
as shown in Fig. 1C, D, E, F, G and H and when the second
protective layer composed of an inorganic material was
20 underlaid the third protective layer as shown in Fig. 1C,
E and G, especially having the large overlapping region as
shown in Fig. 1E, there was caused a problem of a short
circuit between the second protective layer and the elec-
trode (the defective part of the inorganic insulating layer).
25 Especially, when b was 500 μ m or more, a yield decreased
extremely, and further, when a heat potential infiltration
test was carried out in the above-mentioned ink, a stable

1 jet was fabricated by oxidation of the surface of the
inorganic layer.

When the second protective layer is overlaid on the
third protective layer composed of an organic material as
5 shown in Fig. 1D, F and H, as shown in Fig. 3B, a film
exfoliation is caused by a stress of the second protective
layer (i.e., the upper inorganic layer), a swelling of the
third protective layer (i.e., the lower organic layer), a
stress by a difference in a thermal expansion coefficient
10 between the both layers and the like. The film exfoliation
is caused by a step of the organic layer and the defection
of the inorganic layer. Therefore, in case of the small
overlapping width, the film exfoliation occurs to some
extent, and especially, in the case of the overlapping
15 width of 500 μ m or more, a whole exfoliation occurs from a
tip portion of the inorganic layer. These problems are
serious.

Therefore, where an overlapping width of 10 - 500 μ m
is used, a liquid jet recording head excellent in reliabil-
20 ity and ink-resistance and capable of being produced in
good yield can be obtained.

Example 2

A liquid jet recording head as shown in Fig. 5 was
manufactured as shown below.

25 An SiO₂ film of 5 μ m thick was formed by thermally
oxidizing an Si wafer, and on the SiO₂ film, a 1500-Å thick
resistive heater layer composed of HfB₂ was formed by

1 sputtering. Then, by an electron beam deposition, a Ti
layer of 50^oÅ thick and an Al layer of 5,000^oÅ were
successively deposited.

5 The pattern of electrodes 113 and 114 as shown in
Fig. 5 was formed by photolithographic steps. Size of a
heat actuating surface was 30 μ m in width and 150 μ m in
length. The resistance was 150ohm, including the
resistance of Al electrode.

10 A 2.5- μ m thick first protective layer 111 composed
of SiO₂ was deposited by a high rate sputtering.

Next, a second protective layer 116 was formed
according to the following process. A 3- μ m thick polyimide
film (trade name: PIQ, produced by Hitachi Kasei Co., Japan)
as a resist for a Ta lift-off was formed by patterning and
15 thereafter, a Ta film of 10 μ m thick was formed by DC
sputtering. The PIQ film was exfoliated after forming the
Ta film to obtain a desired pattern of Ta film. Thus, a
substrate was fabricated.

20 Degree of the short between the resistive heater
member and the electrode and a second protective layer Ta
in the resulting substrate was investigated for 123
substrates, each substrate having 100 segments, and none
of them showed the resistance of 10M Ω or less.

25 Finally, a grooved glass plate for constituting
liquid flow paths, heat actuating portions and orifices was
adhered to a predetermined place such that the groove
portions were disposed fitly on heat generating portions

1 formed on the substrate.

A liquid jet experiment was carried out by applying a pulse-shaped signal having 30V, 10 μ S in pulse width and 800Hz in repetition frequency to the resulting electro-
5 thermal transducer of the recording head, As a result, a reliability equal to or higher than the prior art was obtained.

Recording heads having 8 nozzles/mm, 12 nozzles/mm and 16 nozzles/mm in nozzle density were similarly
10 manufactured. In this case, the yield by the Ta film patterning was compared with the prior art as shown in Table 1.

Table 1

15	nozzle density	Prior art	Present invention
	8 nozzles/mm	90%	98%
	12 nozzles/mm	68%	97.5%
	16 nozzles/mm	45%	96.0%

20 According to the present invention as described above, there can be provided a liquid jet recording head having high quality and high density which can be manufactured in a high yield.

Reference is directed to United Kingdom Patent
25 Application No. 2153304A, from which this application is divided.

CLAIMS:

1. A liquid jet recording head having a substrate and an upper layer; the substrate having a support, a
5 resistive heater layer and electrodes electrically connected with the resistive heater layer such that portions of the resistive heater layer located between the electrodes provide a plurality of electrothermal transducers for heating recording liquid; the upper
10 layer comprising a first protective layer comprising an inorganic insulating material, and a second protective layer comprising an inorganic material; the first and second protective layers being successively formed at least on the electrothermal transducers and
15 the second protective layer being in the form of a continuous strip which covers adjacent electrothermal transducers.
- 20 2. A head according to claim 1 in which the first protective layer is composed of material selected from inorganic oxides, transition metal oxides, metal oxides, and composites thereof.



3. A head according to claim 1 or 2, in which the first protective layer is composed of a high resistance nitride.

5 4. A head according to claim 1 or 2, in which the first protective layer is composed of a composite of two or more of inorganic oxides, transition metal oxides, metal oxides and high resistance nitrides.

10 5. A head according to any preceding claim, in which the first protective layer is composed of a thin film material.

15 6. A head according to any preceding claim, in which the second protective layer contains an element selected from Groups IIIa, IVa, Va, VIa and VIII of the Periodic Table and alloys thereof.

20 7. A head according to any of claims 1 to 5, in which the second protective layer is composed of a material selected from carbides, silicides and nitrides of metals of Groups IIIa, IVa, Va, VIa and VIII of the Periodic Table.



8. A head according to any preceding claim, in which a third protective layer is further provided on the first protective layer.

5 9. A head according to claim 8, in which the third protective layer is composed of a resin.

10 10. A head according to claim 9, in which the third protective layer is fabricated by using a photosensitive polyimide resin.

15 11. A head according to any of claims 8 to 10, in which the third protective layer is fabricated by micro-photolithography.

12. A head according to claim 1, in which a plurality of liquid flow paths are provided for the recording liquid.

20 13. A liquid jet recording head having a plurality of outlet orifices and a corresponding plurality of heating means for the application of heat pulses to liquid in respective heating chambers defined in the head for causing liquid droplets to eject from said
25 orifices, wherein each of said heating means comprises an electrothermal transducer and each said transducers



is covered by a laminated protective means, and wherein a continuous strip extending across a plurality of adjacent said transducers provides one of the layers of said protective means for those transducers.

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