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Ink Jet Recording Head and Method for Making
the Same

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This invention relates to a liquid jet recording head and a method for making the same.

10 A liquid jet recording head applicable to an ink jet recording system generally has five ink discharge orifices, ink passages and ink discharge energy-generating sections provided locally in the ink passage.

To form ink passages according to a so far known
15 method for making such an ink jet recording head, five grooves are formed by machining or etching a glass or metal plate and then the grooved plates is bonded to another appropriate plate. However, the ink passages in the head thus made may have too rough inside wall surfaces in the case
20 of the machined grooves or the head may have distortions in the ink passages due to a difference in etching ratio in the case of the etched grooves, and ink passages with a high precision is hard to obtain. That is, the ink discharge characteristics of the ink jet recording head thus made
25 are liable to fluctuate. Furthermore, the plates are liable to be broken or cracked when machined, resulting in poor product yield. On the other hand, the etching requires many production steps, increasing the production

1 cost. Furthermore, the common problem to the so far known
methods is that, when a grooved plate, i.e. a plate with
ink passage grooves, is bonded to a substrate having
driving members, such as piezoelectric members as an electro-
5 mechanical converters capable of generating an energy to
act on the ink, heat-generating members as electro-thermal
converters, etc., accurate alignment of the plate to the
substrate is hard to obtain, making the mass production
impossible.

10 To solve the problems, novel methods for making
an ink jet recording head have been proposed, for example,
as in Japanese Patent Application Laid-Open No. 43876/1982,
according to which an ink jet recording head is made by
forming ink passage walls made from cured films of photo-
15 sensitive resin on a substrate on which ink discharge
pressure-generating members are provided, and then by
providing a cover on the ink passage walls.

The ink jet recording head made by using the cured
films of photosensitive resin as ink passage walls is
20 distinguished in solving the respective problems of the
so far known ink jet recording heads, such as poor precision
of finished ink passages, complicated production steps,
and poor product yield, but still has such other problems
that, when a room temperature-curing type adhesive, a
25 thermo-setting type adhesive, etc. are used to provide
the cover on the ink passage walls, the adhesive may flow
into the ink passages during the curing to clog the ink

1 passages, considerably lowering the product yield.

To overcome said problem, Japanese Patent application Laid-Open No. 220754/1983 has proposed an ink jet recording head made by bonding a cover of photosensitive resin films
5 laminated on both surfaces of a support made of an ultra-violet-transmissible material to a substrate with ink passages, and by curing the film by irradiation of ultra-violet rays. Usually, the ink passage walls are slightly not uniform in height, and the photosensitive resin film,
10 which constitutes the cover, must be bonded even to lower parts of the walls while applying a pressure to the film. However, the pressure application conditions depend on the pressure distribution during the pressure application, the hardness of photosensitive resin film, shapes of ink
15 passage walls, etc., and the photosensitive resin may flow into the ink passages or the cover may remain unbonded to the ink passage walls. Thus, there is a problem in making an ink jet recording head in which the cover is uniformly and completely bonded to the ink passage walls
20 without impairing the ink passages.

SUMMARY OF THE INVENTION

In one aspect the present invention aims to provide a precise ink jet recording head with a high reliability
25 and a method for making the same, where said problems have been overcome.

In another aspect the present invention aims to provide

an ink jet recording head having precise ink passages and a structure faithfully and finely processed to a desired design and a method for making the same.

5 In a further aspect the present invention aims to provide an ink jet recording head having a good precision in throwing targets of ink droplets and a high response frequency and a method for making the same.

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In yet another aspect the present invention aims to provide an ink jet recording head having less susceptibility to peeling of constituent members, deformation, dislocation, etc. and a good durability and a method for making the same.

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In accordance with the present invention there is provided a liquid jet recording head in which a base is formed with a recess, and a plate attached to said base closes said recess to define a passage in the head for a recording liquid supplied to the head, said plate being so attached by means of a radiation cured film of adhesive material photosensitive to radiation which can pass through said plate, the total volume of the material in said film being no more than one tenth of the total volume of the passage, whereby the

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thickness of said film formed uncured on said plate is small enough so as not to flow into said recess, during curing, to block liquid flow therein.

5 In accordance with the present invention there is also provided a method of making a liquid jet recording head,
comprising forming a base with a recess, and attaching
a plate to the base to close the recess, thereby
10 defining a passage in the head for a recording liquid supplied to the head, wherein the plate is attached by applying to the base or to the plate a film of a radiation-curable adhesive material, the total volume of the material in the film being no more than one
15 tenth of the volume of the passage, whereby the thickness of the film is small enough not to flow into the recess during curing, to block liquid flows therein, positioning the plate on the base with the adhesive film, therebetween, and curing the adhesive
20 film by passing radiation through the plate.

Reference is made to the drawings, in which Figs. 1 to 8 are schematic views illustrating steps of making the present ink jet recording head.

Embodiments of the present invention will be described in detail below, referring to drawings.

5 Figs. 1 to 8 schematically show a procedure for making the present ink jet recording head.

In the step of Fig.1, desired numbers of ink discharge energy-generating members 2 such as head-generating members, piezoelectric members, etc. which are
10 capable of generating an energy for discharging an ink from ink discharge orifices are provided on a substrate 1 of glass, ceramic, plastic or metal, and, if necessary, are covered with a film 3 of SiO_2 , Ta_2O_5 , glass, etc. to provide an ink resistance and an
15 electric insulation.

The ink discharge energy-generating members 2 are connected to a signal input electrode, not shown in the drawing.

1 In the successive step of Fig. 2, the surface of
film layer 3 on the substrate 1 obtained from the step
of Fig. 1 is cleaned and dried, and then a dry film photo-
resist 4 having a film thickness of about 25 μm to about
5 100 μm , heated at about 80°C to about 105°C, is laminated
onto the film layer 3 at a rate of 0.5 to 4 f/min. under
a pressure of 1 to 3 kg/cm^2 , whereby the dry film photo-
resist 4 is fusion-bonded to the film layer 3. Then, as
shown in Fig. 2, a photomask 5 having a desired pattern
10 is placed on the dry film photoresist 4 on the substrate
surface, followed by light exposure from the overhead of
photomask 5. In that case, alignment of the positions
of the ink discharge energy-generating members 2 to the
position of the pattern must be made beforehand according
15 to a well known procedure.

Fig. 3 schematically shows a step of removing
unexposed parts of the exposed dry film photoresist 4 by
a developing solution comprising a desired organic solvent
such as trichloroethane, etc. through dissolution. To
20 improve the ink resistance of exposed parts 4P of dry film
photoresist remaining on the substrate 1, heat curing
(for example, by heating at 150°C to 250°C for 30 minutes
to 6 hours) or ultraviolet irradiation (for example, by
ultraviolet rays having an intensity of 50 to 200 mW/cm^2
25 or more) is then carried out to thoroughly proceed with
polymerization-curing reaction. It is also effective to
conduct the heat curing and ultraviolet irradiation curing
at the same time.

1 Fig. 4 schematically shows a case of thin lami-
nation of a photosensitive resin film 7, for example, an
ultraviolet curing-type resin film, on the surface of a
flat plate member 6 made of an electromagnetic wave-
5 transmissible material, for example, an ultraviolet-
transmissible material, so that the volume of the resin
film may be not more than one-tenth of the total volume
of the ink passages 8, to constitute a cover for the ink
passages 8. The photosensitive composition for the photo-
10 sensitive resin film can be laminated by any means, so
long as a uniform film thickness can be obtained, for
example, usually by spin coating, roll coating, dip coating,
screen spraying, printing, etc.

 Fig. 5 schematically shows a case of providing
15 a cover for the ink passage 8 formed by a method of Fig.
4 which comprises the flat plate member 6 and the ultra-
violet curing type resin film 7 by bonding under a pressure.
Since the volume of the ultraviolet curing type resin film
7 as a photosensitive composition film, which constitutes
20 the cover, is not more than one-tenth of the total volume
of the ink passages 8, a volume of the ultraviolet curing
type resin which may flow into the ink passage even if
a thorough pressure is applied thereto is at most one-
tenth of the total volume of the ink passages, giving no
25 substantial influences on discharge characteristics such
as the response frequency, precision in throwing target,
etc. of the ink jet recording head. Furthermore, thorough

1 pressure can be applied to the cover, eliminating any unbonded contact between the cover and the dry film photo-resists 4P, whereby a highly reliable ink jet recording head can be obtained.

5 Then, the dry film 7 laminated on the flat plate member 6 made of an ultraviolet-transmissible material is exposed to ultraviolet irradiation, for example, with an intensity of 50 to 200 mW/cm² or more in an oxygen-free atmosphere to thoroughly cure the dry film 7. It
10 is also effective to further heat cure the dry film 7, for example, at 130° to 250°C for 30 minutes to 6 hours.

Fig. 6 is a schematic perspective view of the head appearance after the step of Fig. 5, where numeral 8-1 is an ink supply chamber, 8-2 ink narrow passages, and 9
15 perforations for connecting ink supply tubes, not shown in the drawing, to the ink supply chamber 8-1.

After the completion to bond the grooved substrate with the ink passage cover, the resulting assembly is cut off along the line C-C' in Fig. 6 to optimize the distance
20 between the ink discharge pressure-generating members 2 and the ink discharge orifices 8-3 in the ink narrow passages 8-2. The area to be cut off can be selected as desired. The cutting is carried out by dicing usually employed in the semi-conductor industry.

25 Fig. 7 is a vertical cross-sectional view along the line Z-Z' in Fig. 6.

Then, the cut-off surface is smoothed by polishing.

1 and the ink supply tubes 10 are fixed to the perforations
9 to complete an ink jet recording head shown in Fig. 8.

In the foregoing illustrated embodiments, a dry
film type, that is, solid, photosensitive resin (photo-
5 resist) is utilized for the ink passage cover, but photo-
sensitive resin applicable to the present invention is
not restricted only thereto. That is, it is needless to
say that liquid photosensitive resin compositions can be
utilized. Furthermore, the photosensitive resin is not
10 restricted to the ultraviolet curing type, but any resin
composition can be utilized, so long as it is sensitive
to electromagnetic waves such as infrared rays, visible
light, X-rays, electron beams, laser, etc.

The dry film type photoresist applicable to the
15 present invention includes, for example, those commercially
available under the trademarks of permanent photopolymer
coatings Riston, Soldermask 730S, 740S, 730FR, 740FR and
740 SM1 (made by DuPont, U.S.A.); Photec SR-1000, SR-2000,
SR-3000, etc. (made by Hitachi Kasei Kogyo K. K., Japan).
20 Furthermore, many photosensitive resin compositions used
in the ordinary photolithographical field can be used in
the present invention as the photosensitive resin. For
example, photo-polymerization type photopolymer of diazo
resin, p-diazoquinone, or further containing, for example,
25 vinyl monomer and a polymerization initiator, a dimer-
type photopolymer comprising polyvinyl cinnamate, etc.
and a sensitizer, a mixture of orthonaphthoquinodiazide

11

1 and novolak type phenolic resin, a mixture of polyvinyl
alcohol and diazo resin, a polyether type photopolymer
of 4-glycidylethylene oxide and benzophenone or glycidyl-
chalcone as copolymerized, a copolymer of di-N,N-dimethyl-
5 methacrylamide and, for example, acrylamidobenzophenone,
unsaturated polyester-based photosensitive resin (for
example, APR (made by Asahi Kasei Kogyo K. K. Japan),
Tevista (made by Teijin K. K., Japan), Sonne (made by
Kansai Paint K. K., Japan), etc.), unsaturated urethane
10 oligomer-based photosensitive resin, a photosensitive resin
composition containing bifunctional urethane monomer and
a photopolymerization initiator, bichromate-based photoresist,
non-chromium-based, water-soluble photoresist, polyvinyl
cinnamate-based photoresist, oxidized rubber-azide-based
15 photoresist, etc. can be mentioned.

When a photosensitive dry film resist is used as
a material for forming the ink passage wall as described
in the foregoing embodiment, it may be better to use a
solution of the dry film resist in a solvent as a photo-
20 sensitive composition for lamination on the flat plate
member as the ink passage cover to make the wettability
of ink passage wall and ink passage cover uniform.

Procedure for laminating the photosensitive resin
film onto the flat plate member is not restricted to the
25 said pressure bonding, but any procedure can be used, so
long as it can uniformly laminate the photosensitive resin
film. For example, spin coating, dip coating, spraying,

1 printing, roll coating, etc. can be used. In the foregoing
embodiment, oxygen desensitization is utilized to leave
a soft layer only on the surface of the photosensitive
resin film, but it may be better to leave a soft layer
5 only on the surface by making light exposure from the back
side of the photosensitive resin film through the flat
plate member made of an ultraviolet-transmissible material
while controlling the light exposure intensity. The material
for the flat plate member as a support for the fluid
10 passage cover is not particularly restricted, so long as
it is transmissible of electromagnetic waves having an
effective wavelength for photopolymerization of the photo-
sensitive resin for forming the ink passage cover, and
is hardly susceptible to deformation due to the shrinking
15 stress of some photosensitive resin. In view of the
convenience and economy of production, glass, epoxy resin,
acrylic resin, vinylic resin, etc. are preferable.

The present invention, as described above, have
the following effects.

- 20 1) When a substrate with ink passages is bonded with an
ink passage cover, the ink passages are never clogged even
by applying a thorough pressure to the cover, because a
flat plate member laminated with a photosensitive resin
film is used as the cover and the volume of the photo-
25 sensitive resin film is as small as as not more than one-
tenth of the total volume of the ink passages.
- 2) Since a photosensitive resin is used for bonding the

- 1 cover, curing can be effected for a shorter time without heating and without flowing of the photosensitive resin, and thus the photosensitive resin can be prevented from depositing on the ink discharge energy-generating members.
- 5 An ink jet recording head with a stable discharge performance can be readily obtained.
- 3) Since the photosensitive composition is laminated in a thin layer in bonding the cover, the shrinking stress is smaller when the photosensitive composition is photo-
10 cured, and no stress remains within the head, causing no peeling of the constituent members or deformation or dislocation. The ink jet recording head thus made has a very good durability.
- 4) Since the flat plate member and the photosensitive
15 resin film as constituents for the ink passage cover have a light transmission, the state of motion of ink droplets through the head are observable by eyes and maintenance and control of the head can be readily carried out.



CLAIMS:-

- 5 1. A liquid jet recording head in which a base is formed with a recess, and a plate attached to said base closes said recess to define a passage in the head for a recording liquid supplied to the head, said plate being so attached by means of a radiation-cured film of adhesive material photosensitive to radiation which can pass through said plate, the total volume of
- 10 the material in said film being no more than one tenth of the total volume of the passage, whereby the thickness of said film formed uncured on said plate is small enough so as not to flow into said recess, during curing, to block liquid flow therein.
- 15 2. A recording head according to Claim 1, wherein the cured film of photosensitive adhesive material is a cured film of ultraviolet curing-type resin.
- 20 3. A recording head according to Claim 1, wherein the plate is transparent to, and the adhesive film is cured by, an electron beam, ultraviolet rays, infrared rays, visible light or X-rays.



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4. A recording head according to Claim 1, 2 or 3, wherein, the plate is made of glass, epoxy resin, acrylic resin or vinylic resin.

5 5. A recording head according to any preceding claim, comprising a liquid discharge energy generator.

10 6. A recording head according to Claim 5, wherein the liquid discharge energy generator is an electromechanical converter or an electrothermal converter.

7. A recording head according to any preceding claim, comprising two or more passages.

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8. A method of making a liquid jet recording head,

comprising forming a base with a recess, and attaching a plate to the base to close the recess, thereby defining a passage in the head for a recording liquid supplied to the head, wherein the plate is attached by applying to the base or to the plate a film of a radiation-curable adhesive material, the total volume of the material in the film being no more than one
20 tenth of the volume of the passage, whereby the
25 thickness of the film is small enough not to flow



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into the recess during curing, to block liquid flows therein, positioning the plate on the base with the adhesive film therebetween, and curing the adhesive film by passing radiation through the plate.

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9. A method according to Claim 8, wherein the radiation-curable adhesive material is an ultraviolet-curable resin.

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10. A method according to Claim 8, wherein the radiation is an electron beam, ultraviolet rays, infrared rays, visible light or X-rays, or a combination of these.

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11. A method according to Claim 8, 9 or 10, wherein the flat plate member is made of glass, epoxy resin, acrylic resin or vinyllic resin.

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12. A method according to any of Claims 8 to 11, wherein the radiation-curable adhesive material is of a dry film type.

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13. A method according to any of Claims 8 to 11, wherein the radiation-curable adhesive material is a liquid photosensitive resin composition.



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14. A method according to any preceding claim, wherein the radiation-cured adhesive material is further subjected to a polymerization-curing reaction, by the application of heat.

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15. A method according to any preceding claim, wherein the recesses in the base are formed from cured films of photosensitive resin.

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16. A method according to any preceding claim, wherein the recording head comprises two or more passages.

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17. A liquid jet recording head substantially as described with reference to Figure 5, or Figures 6 to 8, of the drawings.

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18. A method of making a liquid jet recording head substantially as described with reference to Figures 1 to 5, or Figures 6 to 8, of the drawings.
