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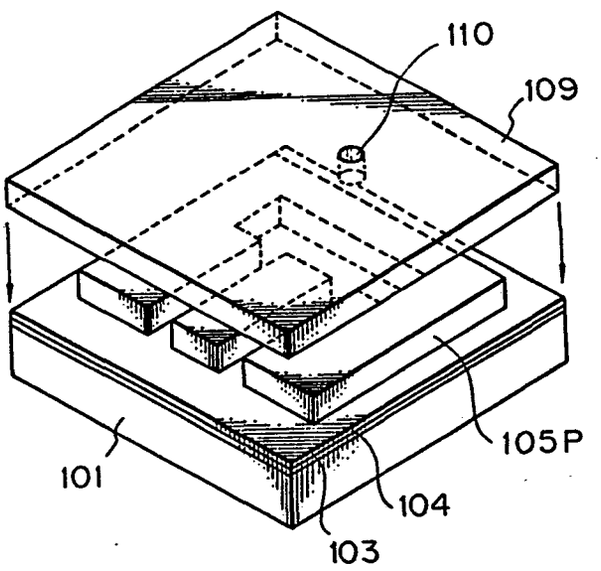
(54) Liquid jet recording head.

(57) A liquid jet recording head comprises an ejection port for ejecting liquid and a liquid path having said ejection port, a part of the wall constituting the liquid path being composed of a photosensitive resin cured film, and the pencil hardness of the photosensitive resin cured film is H or higher.



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TITLE OF THE INVENTION

LIQUID JET RECORDING HEAD

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a liquid jet recording head, and more particularly, to a liquid jet recording head for forming liquid droplets for recording used for so-called ink jet recording system.

Description of the Prior Art

Recording heads used for liquid jet recording systems generally have fine liquid ejecting ports (orifices), liquid paths and liquid ejecting energy generating members provided at a part of liquid paths.

Heretofore, as a method for fabricating such a liquid jet recording head, there are known, for example, methods by which fine grooves are formed by cutting or etching a glass or metal plate and then the grooved plate is bonded to other suitable plate to form liquid paths.

However, the heads thus produced by conventional methods have remarkable roughness on the inner walls in the liquid paths produced by cutting processing, and strains are formed in the liquid paths due to the difference in etching rate so that liquid paths having a constant liquid path resistance can be obtained with

difficulty and the liquid ejecting characteristics of the resulting recording heads are liable to fluctuate. In addition, there are drawbacks that, upon cutting processing, the plate is broken or crack is formed in the plate, and therefore, the production yield is low. Upon etching processing, many manufacturing steps are required disadvantageously resulting in a high production cost. Further, the above-mentioned prior art methods have the following common drawback, that is, it is difficult to position correctly a grooved plate having liquid path grooves and a lid plate provided with liquid ejecting energy generating members such as piezoelectric elements, heat generating elements and the like upon bonding them, and therefore, the mass production is not easy.

As a liquid jet recording head capable of solving such drawback, there is proposed a recording head produced by forming liquid path walls constituted of a photosensitive resin cured film on a substrate provided with liquid ejecting energy generating members and then mounting a covering member on the substrate, for example, in Japanese Patent Application Laid-open No 43876/1982 and West German Patent Application Laid-open (DOS) No. 3108206.

The recording head fabricated by utilizing a photosensitive resin is excellent in improving finished accuracy of liquid paths and production yield, and

solving complexity of fabricating steps.

However, in the fabrication of the recording head, upon cutting processing of the ejecting ports so as to optimize the distance between the liquid path and the ejection energy generating member, the cured film of the photosensitive resin is so soft that the hardness is not the same as that of the substrate or the lid plate and as the result, the cured film of the photosensitive resin is liable to be injured. The flaw at the ejection ports adversely changes the ejection direction of liquid resulting in degradation of the recording quality. In addition, since the liquid path walls composed of a cured film of the photosensitive resin is soft, sometimes the walls absorb the liquid ejecting energy (e.g. ejection pressure) generated by the liquid ejection energy generating member and therefore, the designed liquid ejection ability can not be obtained. That is, the ejection speed of liquid droplets is lowered and as the result, the ejection direction is not definite and the accuracy of impact area of liquid droplet is lowered resulting in degradation of recording image quality.

In addition, since the ejected liquid amount is decreased, the dot diameter on the receiving paper becomes small and the record density is lowered. For the purpose of avoiding such undesirable effect due to absorption of the liquid ejecting energy, it is

necessary to use a big element for generating a liquid ejection energy enough for generating an ejecting energy which corresponds to the total amount of ordinary ejecting energy plus the energy to be absorbed by the photosensitive resin cured film. However, such a big structure of the ejection energy generating element adversely affects the whole size of the head and disturbs to make the head compact, and further, in the case of head of multi-nozzle type, it is difficult to make a highly dense head.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the above-mentioned drawbacks.

It is another object of the present invention to provide a liquid jet recording head which is inexpensive and of high precision and can produce good image quality of high density and high quality.

It is a further object of the present invention to provide a liquid jet recording head whose head minute portions with a desirable pattern can be easily fabricated and in which a number of heads of the same structure can be simultaneously fabricated and, further, which can be produced continuously and in mass production.

It is still another object of the present invention to provide a liquid jet recording head which can

be fabricated with a relatively small number of fabricating steps in good productivity.

It is a still further object of the present invention to provide a liquid jet recording head which can be fabricated in good yield, positioning correctly main constitution members being easy and the dimension accuracy being high, and further, can be in a highly dense multi-array type.

It is still another object of the present invention to provide an inexpensive liquid jet recording head where, upon cutting for forming ejection ports, the constituting members are not liable to be cracked or broken resulting in high yield.

It is a still further object of the present invention to provide a liquid jet recording head where a sufficient ejection speed can be attained due to the low power loss of liquid ejection energy and the liquid ejection direction is definite resulting in good recording.

According to the present invention, there is provided a liquid jet recording head which comprises an ejection port for ejecting liquid and a liquid path having said ejection port, a part of the wall constituting the liquid path being composed of a photosensitive resin cured film, and the pencil hardness of the photosensitive resin cured film is H or higher.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1 - 7 are oblique views for explaining a process for fabricating a liquid jet recording head using heat generating elements in the first example of the present invention ; and

FIGS. 8 - 10 are oblique views for explaining a process for fabricating a liquid jet recording head using piezoelectric elements in the second example of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the present invention, pencil hardness of the photosensitive resin cured film is H or higher, preferably 4H or higher. This range of pencil hardness serves to prevent breakage of ejection ports, and injury of the photosensitive resin cured film which occur upon cutting for forming ejection ports, unstable ejection of liquid due to absorption of ejection energy, and the like. In addition, this range of pencil hardness can miniaturize and make highly dense the head, and further, can render the handling in the fabrication steps easy.

The pencil hardness is determined according to JIS K 5400, 6 : 14 (3) as to the preparation of test pencils and the lead, JIS K 5401 as to the testing machine, and JIS K 6894 as to the testing method.

Examples of the present invention will be ex-

plained in detail referring to the drawing in the followings.

EXAMPLE 1

FIGS. 1 - 7 are given for explaining a preferable first example of the present invention. Referring to FIG. 1, on a support 101 (a blue glass plate : 50mm x 50mm x 0.7mm thick) were provided a desired number (two in the figure) of heat generating element 102 (a kind of an electrothermal transducer) as an ejection energy generating member. The element heated the liquid in the vicinity of the element resulting in generation of a liquid ejection energy.

Heat generating elements 102 were connected to electrode for signal input (not shown). For the purpose of electrical insulation, an electrical insulating film 103 composed of SiO_2 was overlaid on the heat genrating elements. The film 103 was covered with a liquid resistant film 104 composed of Ta so as to impart liquid resistance.

The resulting substrate was cleaned and dried, and then a photosensitive resin composition as shown in Table 1 was applied to the substrate by squeezing.

Table 1

Poly (methyl methacrylate/ 2-hydroxyethyl methacrylate/ styrene) 8/1/1	850 g

Pentaerythrite triacrylate	300 g
Benzophenone	25 g
Hydroquinone	0.2 g
Methyl ethyl ketone	2000 g

The resulting coating was dried at 80°C for 20 min. to evaporate completely the solvent and there was produced a photosensitive resin film layer 105 of 50μm thick as shown in FIG. 2.

In order to form desired liquid feeding chamber and liquid flow paths, a photomask 106 was placed on the film layer 105 by registering the photomask 106 with heat generating elements 102, followed by exposure, as shown in FIG. 3.

After the exposure, the assembly was soaked in a developing liquid (1,1,1-trichloroethane) to develop.

The regions irradiated with light upon exposure became insoluble in the developing liquid as the result of photopolymerization reaction while the regions not irradiated with light was soluble in the developing liquid and removed. Therefore, a desired pattern was produced (FIG. 4).

In FIG. 4, 107 and 108 denote a liquid flow path and a liquid feeding chamber, respectively. In order to enhance the hardness of a photosensitive resin layer 105 remaining in the substrate and improve the liquid resisting property, the photosensitive resin layer

was cured. The curing was effected by heating at 150°C for one hour and then irradiating with ultraviolet ray (5J/cm^2) to enhance the hardness of the photosensitive resin to a pencil hardness of 4H. Onto the resulting photosensitive resin cured film 105P was adhered a glass cover 109 provided with a liquid feeding port 110. Adhering the glass cover 109 was carried out by diluting an epoxy type adhesive ("HP-2R, 2H": tradename, manufactured by Shinko Sha Co.) with methyl ethyl ketone, applying the diluted adhesive in the thickness of 3 - 4μm by spinner coating, drying, pressing the adhesive thus dried to the surface of photosensitive resin cured film 105P, and heating for curing.

FIG. 6 shows the cover 109 bonded to the substrate having grooves formed by using the photosensitive resin cured film 105P.

As mentioned above, after the completion of bonding cover 109 to the substrate having grooves formed by using the photosensitive resin cured film 105P, the resulting assembly was cut along a line A - A' in FIG. 6 to optimize the distance between heat generating element 102 and liquid ejecting port 111 in liquid flow path 107, and the region to be cut here may be optionally determined. Upon cutting, a dicing method usually used in semiconductor industry was employed.

When the photosensitive resin cured film is soft, the hardness does not match that of the support

and that of the cover so that the photosensitive resin cured film is injured upon cutting. However, in this example, the hardness of the photosensitive resin cured film was as hard as 4H and, therefore, the film was not injured.

FIG. 7 shows the head after cutting. By connecting a liquid introducing pipe (not shown) to the liquid feeding port and further, electric wiring (not shown) for applying signals to the heat generating elements, a liquid jet recording head was completed.

EXAMPLE 2

FIGS. 8 - 10 are given for explaining a preferable second example of the present invention. Firstly, two pieces of piezoelectric elements 202 (a kind of an electromechanical transducer) as an ejecting energy generating element were provided on a support 201 (a blue plate glass: 50mm x 50mm x 0.72mm). A liquid ejecting energy was generated by mechanical vibration (or mechanical displacement) of the elements. Elements 202 were connected to electrodes for signal input (not shown). In a manner similar to Example 1 above, an electrically insulating film composed of SiO_2 for imparting electric insulating property (not shown) and a Ta film (not shown) for imparting a liquid resistance were overlaid.

Then, liquid flow paths 207 and a liquid feeding chamber 208 (FIG. 9) were formed by using the same

photosensitive resin composition as in Example 1 and following the procedures of Example 1. For the purpose of enhancing the hardness and liquid resistance of the photosensitive resin layer 205 in a way similar to Example 1, the photosensitive resin layer 205 was heated at 150°C for one hour and then irradiated with ultraviolet ray (5J/cm^2). The resulting hardness of the photosensitive resin was as high as 4H of pencil hardness.

As shown in FIG. 10, a glass cover 209 having a liquid feeding port 210 was then adhered to the photosensitive resin layer. The adhering procedure was effected following the procedure of Example 1 using the same adhesive as that in Example 1. Then, the resulting assembly was cut along the B -B' line as indicated in FIG. 10 to optimize the relative positions of piezoelectric element 202 and liquid ejection port 211. Further, a liquid introducing pipe (not shown) was attached to liquid feeding port 210 and an electric wiring (not shown) for giving signals to the piezoelectric element was provided to complete a liquid jet recording head.

When such structure was employed, an effect similar to that of Example 1 was obtained.

EXAMPLE 3

Following the procedures of Example 1 except that a photosensitive resin composition in the following

Table 2 was employed in place of that in Table 1, a head of the same structure as Example 1 was produced.

Table 2

Poly (vinyl cinnamate/styrene/ acrylonitrile) 6/2/2	100 g
Trimethylol propane triacrylate	33 g
Benzophenone	2 g
Hydroquinone	0.02 g
Methylethyl ketone	200 g

After curing, pencil hardness of the resulting photosensitive resin was H and an effect similar to that of Example 1 was obtained.

EXAMPLE 4

Following the procedure of Example 2 except that the photosensitive resin composition in Example 3 was employed, there was fabricated a liquid jet recording head. An effect similar to that of the above-mentioned example was obtained.

Some comparative examples are shown below to compare with the head of the present invention.

COMPARATIVE EXAMPLE 1

A head was fabricated in the same manner as in Example 1 except that the materials shown in Table 3 were used as a photosensitive resin composition.

Table 3

Poly (methyl methacrylate/ butadiene/ acrylonitrile) 6/1/3	80 g
Tetraethylene glycol diacrylate	20 g
Benzophenone	2 g
Hydroquinone	0.02 g
Methyl ethyl ketone	200 g

The pencil hardness of the photosensitive resin after curing was F-grade.

COMPARATIVE EXAMPLE 2

A head was fabricated in the same manner as Example 2 except that the same photosensitive resin composition in Comparative Example 1 was used.

With respect to the heads fabricated in Examples 1 - 4 and Comparative Examples 1 and 2, the yield at the cutting step and the ejection speed of liquid droplet were evaluated by the following procedure.

The yield at the cutting step was expressed as the proportion of the photosensitive resin at the surface of the ejection port without flaw such as crack, breakage and the like when one hundred heads respectively in accordance with the above examples and comparative examples were fabricated to form ejection ports.

Subsequently, ejection was performed by using good products and an ink (20 percent of water, 78 percent of ethylene glycol and 2 percent of a black dye), and the time required to fly 1.0mm from the ejection port was measured to calculate the liquid droplet ejection speed.

The results are shown in Table 4. The yields at the cutting step of heads where a photosensitive resin having pencil hardness of H or higher after cured was used as shown in the Examples according to the present invention were 97 - 98% which is higher than 83 - 85% in the Comparative Examples by 12 - 15%. In addition, the ejection speed in the Examples of the present invention was 8.5 - 9.2 m/sec which satisfied the designed value, i.e. 9±1 m/sec.

Table 4

	Ejection energy generating member	Pencil hardness after curing	Yield at the cutting step (%)	Liquid droplet ejection speed m/sec
Example 1	HGE	4H	98	9.2
Example 2	PE	4H	97	9.0
Example 3	HGE	H	97	8.8
Example 4	PE	H	98	8.5
Comparative Example 1	HGE	F	85	6.5
Comparative Example 2	PE	F	83	6.3

HGE : Heat generating element

PE : Piezoelectric element

In the above-described examples, a blue glass plate was used as the support. It should, however, be noted that the present invention is not limited to this alone, but an appropriate material such as ceramics, plastics, metals and the like may be used as the support. On the other hand, although SiO_2 was used as the electrical insulating film, an inorganic oxide or nitride such as Ta_2O_5, Al_2O_3, glass, Si_3N_4, BN and the like may also be used. Further, as the liquid resistant film, a corrosion resistant metal such as Au, Pt, Pd and the like, a corrosion resistant alloy such as SUS, monel metal and the like, or an inorganic or organic material other than those, and the like may also be used in addition to Ta, which is employed in the above-described examples.

As the photosensitive resin composition to be used in the present invention, there may be enumerated various kinds of photosensitive compositions used in the field of ordinary photo-lithography such as photo-sensitive resins, photo-resists, etc. Actual examples are: diazo-resin; p-diazo-quinone; photo-polymerization type photo-polymers using, for example, a vinyl monomer and a polymerization initiator; dimerization type photo-polymers using polyvinyl cinnamate, etc., and a sensitizing agent; a mixture of o-naphthoquinone diazide

and a Novolac type phenolic resin; a mixture of polyvinyl alcohol and a diazo resin; polyether type photopolymers obtained by copolymerization of 4-glycidylethylene oxide with benzophenone, glycidylchalcone, or the like; copolymer of N,N-dimethylmethacryl amide and, for example, acrylamide benzophenone; unsaturated polyester type photosensitive resins such as APR(product of Asahi Kasei Kogyo K.K., Japan), TEBISUTA(product of Teijin K.K., Japan). Sonne (product of Kansai Paint K.K., Japan), and the like; unsaturated urethane oligomer type photosensitive resins; photosensitive compositions composed of a photo-polymerization initiator, a polymer, and a bifunctional acryl monomer; dichromate type photo-resists; non-chromium type water-soluble photo-resists; polyvinyl cinnamate type photo-resists; cyclized rubber-azide type photo-resists, and so forth.

In the present invention, use of a solid photosensitive composition in film form is also advantageous since the film thickness can be easily and precisely controlled although the photosensitive resin composition layers were formed by a squeezing method in the examples.

Examples of such solid photosensitive resin composition are those photosensitive resin films manufactured and sold by Dupont de Nemour & Co. under tradenames of Permanent Photopolymer Coating "RISTON" Solder Mask 730S, Solder Mask 740S, Solder Mask 730FR, Solder Mask 740FR, and Solder Mask SM1; "KAPTON" XA-A3, XA-B3, XA-A1, XA-M3 and XA-C3; those by Hitachi Kasei-Sha under tradenames of "Photec" PHT series and SR series; those by Asahi Kasei under tradenames of "DFR" E-15, P-25, P-38 and T-50; those by Nitto Denko under trandenames of "NEOTROCK" E type and T type; and those by Tokyo Oka "Thiokol" LAMINAR GT, LAMINAR GSI, LAMINAR TO and LAMINAR TA; etc..

As the cover for forming liquid paths, there may be used a metal, a ceramics, a photosensitive resin cured film or the like as well as a glass described above. Further, there may be utilized the bonding force of a photosensitive resin with or without a bonding agent described above in order to furnishing a glass plate on the cured film of a photosensitive resin for the purpose of forming said liquid paths.

The recording head of the present invention may have a structure not only that a liquid flow path and a liquid feeding chamber are provided with one ejection energy generating element but also that they are provided with plural ejection energy generating elements. Incidentally, the liquid path includes the space which

can be filled with liquid such as the above-mentioned liquid flow path, liquid chamber and the like, and liquid inlets and outlets.

As described above, in fabrication of a liquid-jet recording head where a substrate, a cured film of a photosensitive resin forming a liquid path on said substrate and a covering member of said liquid path are laminated one after another, the following effects are obtained when the pencil hardness of said hardened film of photosensitive resin is H or more, preferably 4H or more.

(1) Since the main process steps in the fabrication of the liquid jet head rely on a so-called photographic technique, highly precise and delicate portions of the head can be formed very simply by use of desired patterns. In addition, a multitude of heads having the identical constructions may be worked simultaneously.

(2) The relatively less manufacturing steps result in a high productivity.

(3) Since registration among the principal structural portions constituting the head can be done easily and reliably, the liquid jet head having high dimensional precision can be obtained with a high yield.

(4) Multi-array liquid jet heads of high density can be manufactured by a simple method.

(5) The liquid jet heads can be manufactured continuously and in an industrialized mass production.

(6) In the cutting step for forming ejection ports defects such as cracks, breakages and the like may not be produced readily resulting in an improved yield, and therefore a low-costed liquid-jet recording head can be afforded.

(7) Since the power loss of liquid ejecting energy is diminished, a sufficient discharging speed and a definite discharging direction are obtained resulting in good recording.

WHAT IS CLAIMED IS :

1. A liquid jet recording head which comprises an ejection port for ejecting liquid and a liquid path having said ejection port, a part of the wall constituting the liquid path being composed of a photosenstitive resin cured film, and the pencil hardness of the photosensitive resin cured film is H or higher.

2. A liquid jet recording head according to claim 1 in which an ejection energy generating member for generating an energy for ejecting the liquid is provided corresponding to the ejection port.

3. A liquid jet recording head according to claim 2 in which the ejection energy generating member is provided in the liquid path.

4. A liquid jet recording head according to claim 2 in which a plurality of the ejection ports are provided.

5. A liquid jet recording head according to claim 4 in which a plurality of the liquid paths are provided, and the liquid paths correspond to repective ejection ports.

6. A liquid jet recording head according to

claim 4 in which the liquid paths are a liquid chamber common to respective ejection port.

7. A liquid jet recording head according to claim 2 in which the ejection energy generating member is an electrothermal transducer.

8. A liquid jet recording head according to claim 2 in which the ejection energy generating member is an electromechanical transducer.

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Fig. 1

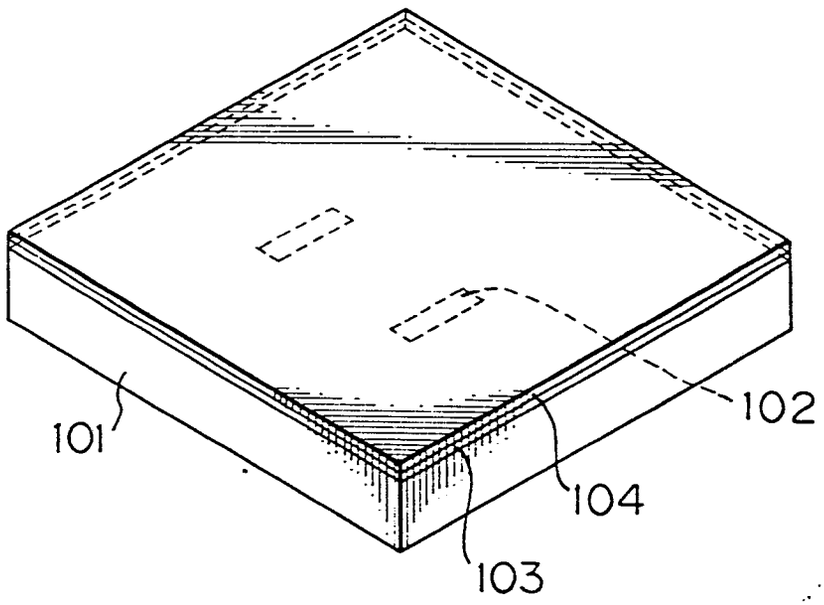

Fig. 2

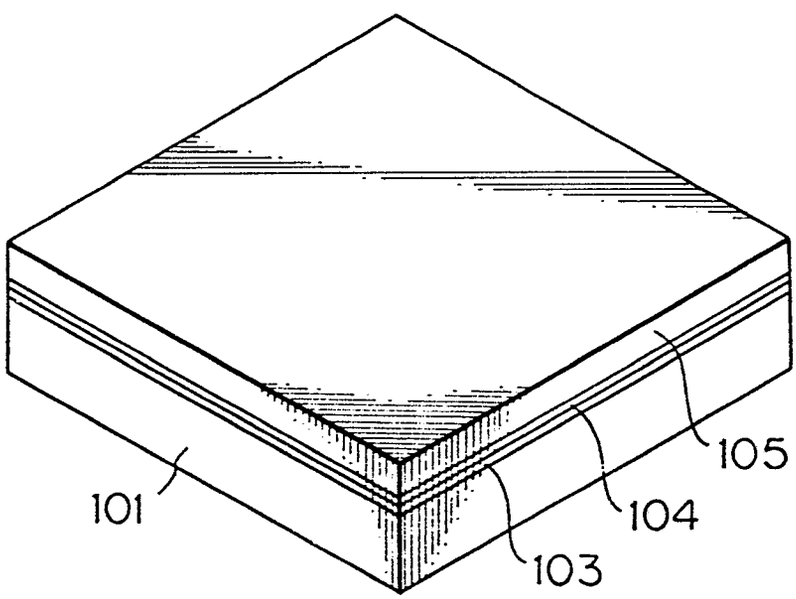

Fig. 3

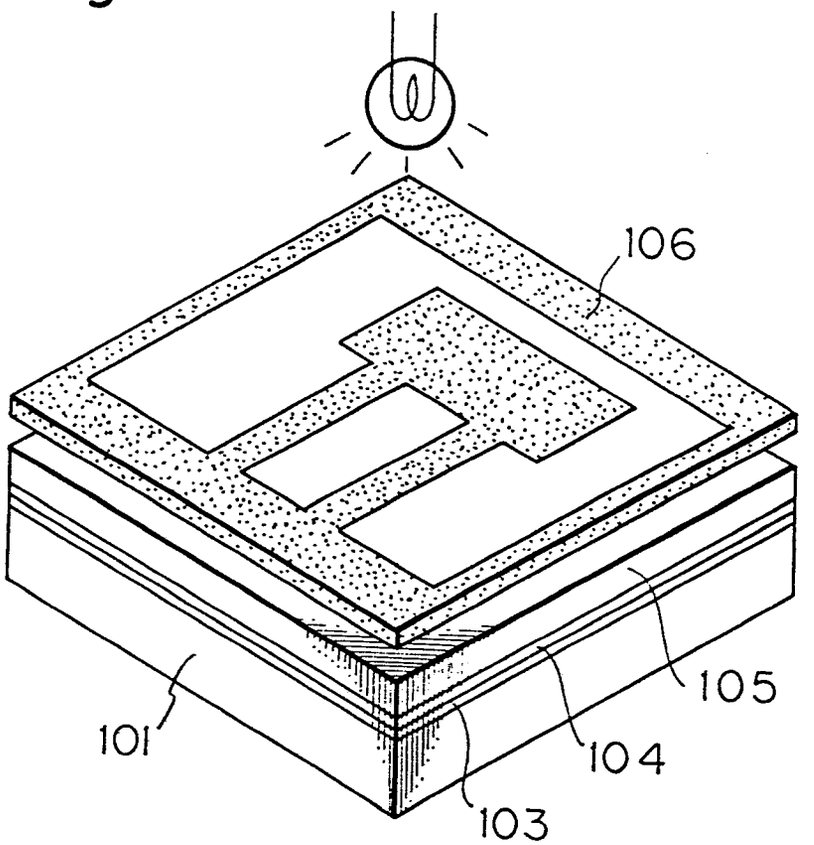

Fig. 4

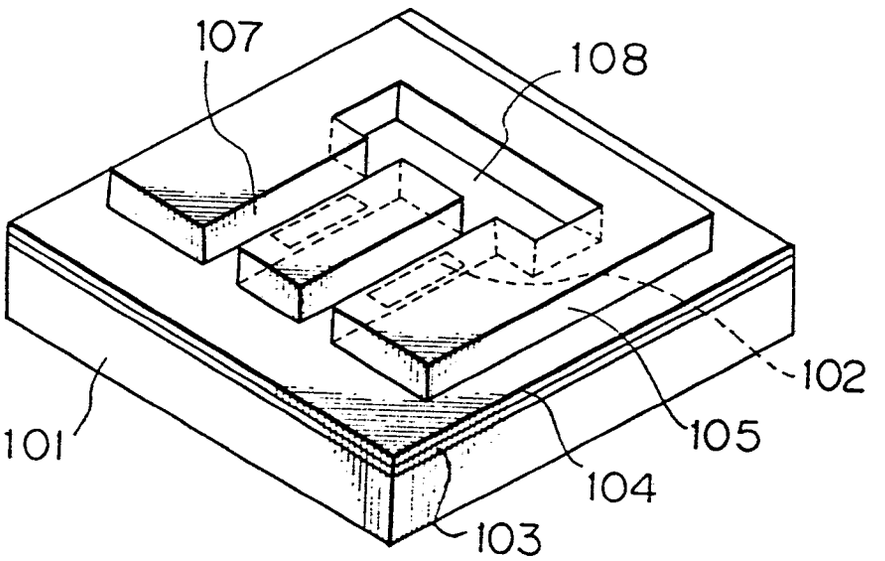

Fig. 5

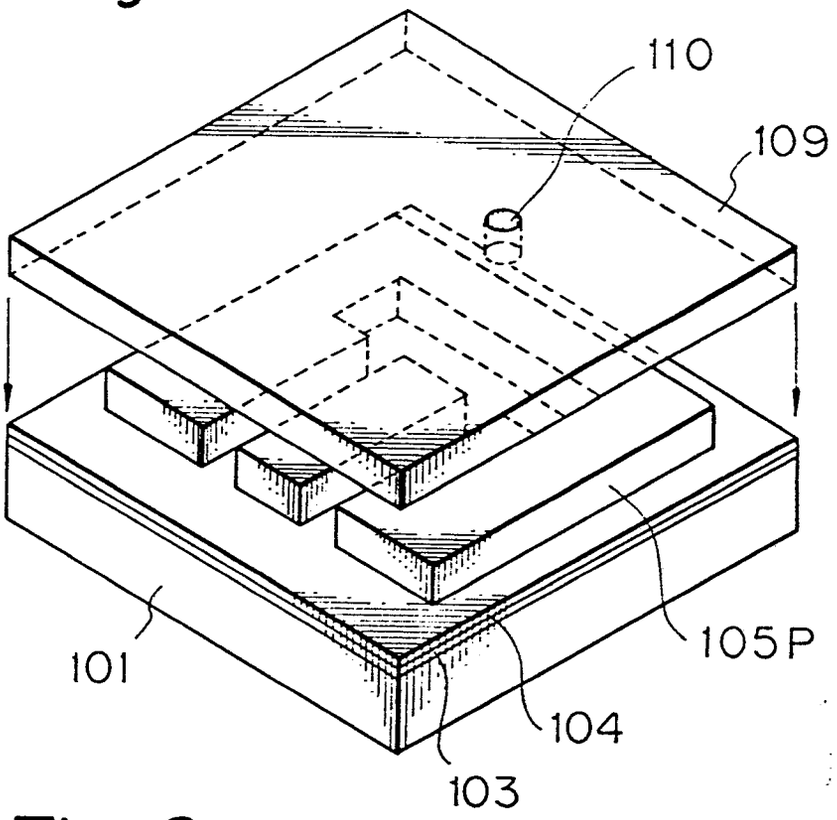

Fig. 6

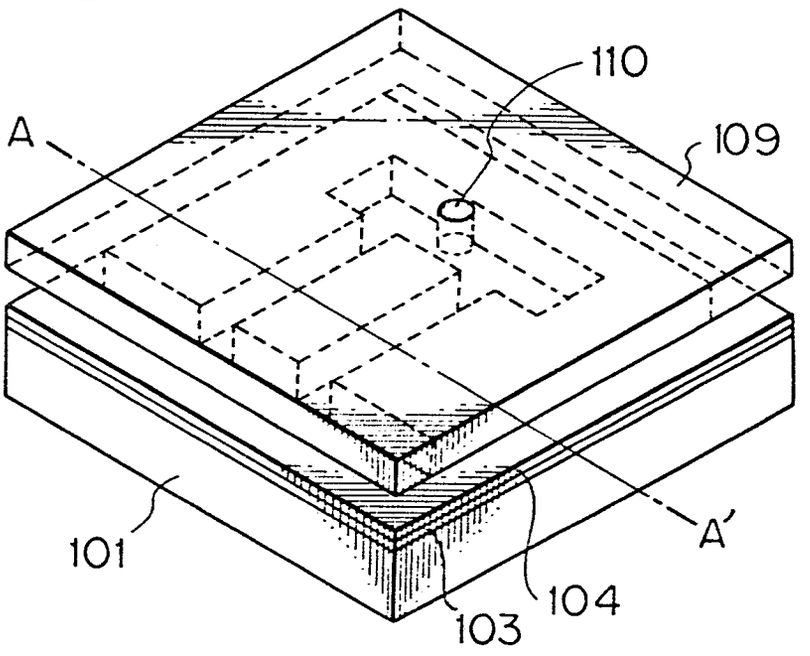

Fig. 7

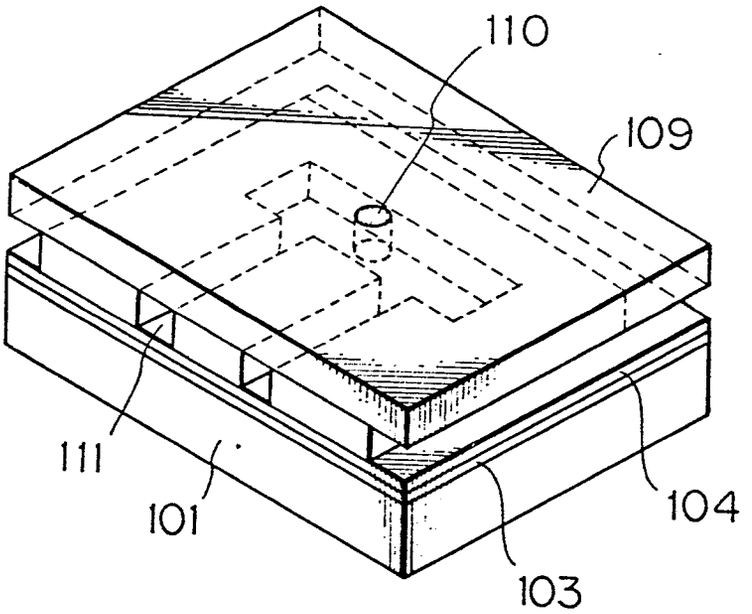

Fig. 8

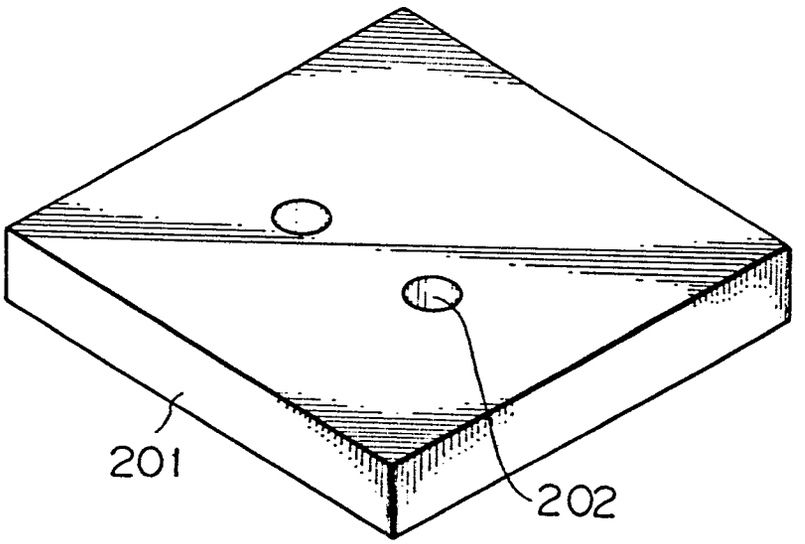

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Fig. 9

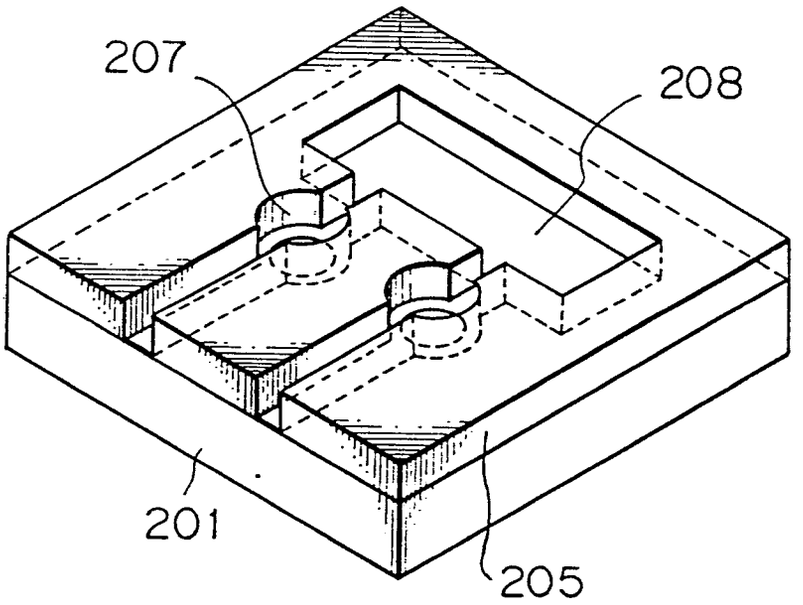

Fig. 10