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### (54) METHOD FOR MANUFACTURING INKJET HEAD

VERFAHREN ZUR HERSTELLUNG EINES TINTENSTRAHLKOPFS

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**EP 2 527 151 B1**

**Description****FIELD OF THE INVENTION**

- 5 **[0001]** The present invention relates to a method for manufacturing an inkjet head, for detail, a method for manufacturing an inkjet head using an adhesive having both of ultraviolet curable and thermosetting properties.

**TECHNICAL BACKGROUND**

- 10 **[0002]** A liquid injection head which can eject liquid in a state of fine droplet is spreading widely, for example, as an inkjet head used for an inkjet printer which records image by ejecting ink droplet onto a recording paper.

- [0003]** As a typical ink ejecting method of an inkjet head, there is a method for ejecting ink in which electrical current is applied to electric resistor arranged at a pressure chamber, water in ink is vaporized and expanded by generated heat, and the ink is ejected by the pressure, or a method for ejecting liquid from nozzle in which a part of a flow path component which constitutes a pressure chamber is made of piezoelectric element or piezoelectric element is arranged at the flow path component, piezoelectric element corresponding to a plurality of nozzles is selectively driven and the pressure chamber is distorted according to dynamic pressure of each piezoelectric element.

- 15 **[0004]** In recent years, an interval between adjacent nozzles becomes still narrower due to provide an inkjet head with high density. For example, in case of the nozzle density of 180dpi (in the present invention, dpi refer to as number of dots per 2.54 cm), the interval between adjacent nozzles is 140  $\mu\text{m}$ . In this case, when partition of pressure chamber has thickness of 70  $\mu\text{m}$  in this 140  $\mu\text{m}$ , a width of the pressure chamber will be 70  $\mu\text{m}$ . When a nozzle spreads toward the pressure chamber side from the external surface and sets the inside diameter by the side of the pressure chamber to 40  $\mu\text{m}$ , there is only 15  $\mu\text{m}$  distance from the end of the partition to the nozzle. When heat treatment is carried out for hardening adhesive in a process of bonding the nozzle plate to a recording element board or a flow path component, viscosity of adhesive falls and adhesive tends to flow easily by this heating operation. As a result, adhesive will flow into the nozzle portion existing in neighborhood and will block a part of or in the worst case, the whole region of nozzle portion. Especially when applied ink has the characteristics to swell or dissolve adhesive, adhesive has to have higher resistance to ink. For that purpose, it is effective to heat the adhesive at high temperature and to raise the glass transition point of adhesives when curing the adhesive. However, when heating adhesives at high temperature, viscosity falls and the tendency to block the above-mentioned nozzle portion increases more.

- 25 **[0005]** In the viewpoint which prevents inflow of the adhesives to such a nozzle area, when coating amount of adhesives is reduced, unevenness or adhered dust on the surface of a flow path component may cause void between a nozzle plate and a flow path component where adhesives do not exist, and ink may leak through the void. On the other hand, when the amount of adhesives is increased, the quantity of the adhesive overflowing from a gap of the components increases, and adhesive flows into a nozzle area. Thus, it is difficult to achieve a good balance between eliminating void and preventing inflow of the adhesive to such a nozzle area.

- 30 **[0006]** As a method for preventing inflow of protruding adhesive, it was disclosed a method for producing an inkjet recording head in which a flow path component and a nozzle plate are bonded with the adhesive containing a photo-cationic polymerization initiator and a specific thermal-cationic polymerization initiator, for example. The portion where adhesive protruded was irradiated by ultraviolet radiation to perform the first curing, then a portion where a light did not reach was cured by heat treatment (refer to Patent Document 1). By above procedure, prevention of inflowing the protruding adhesive and resistance for ink can be improved. However, in case of epoxy resin which contains both a photo-cationic polymerization initiator and a thermal-cationic polymerization initiator, an inhibition of photopolymerization by a thermal polymerization initiator is not completely resolved. Ejection can be carried out, but curved ejection occurred due to inflow of adhesive. Moreover, since the sensitivity to light was low, thereby long-term light exposure was required for stopping a flow of adhesive and there was a problem of poor working efficiency.

- 35 **[0007]** Bonding of a flow path component and a nozzle plate is performed by applying adhesive thinly to the flow path component by transferring, and by positioning and putting the nozzle plate on the applied adhesive side. In that case, the void between adhesive and the nozzle plate disappears with time when adhesive wets a nozzle plate.

- 40 **[0008]** However, since the adhesive of Patent Document 1 had the slow speed for disappearance of void, it had to take a long time until the void disappears, thereby there was a problem of working efficiency.

- [0009]** Moreover, in order to satisfy the resistance over the wide range solvent ink which is one of the objects of the present invention, it is further required to enhance a degree of cross-linking by advancing curing by thermal polymerization.

- 45 **[0010]** In Patent Document 2, it was disclosed that an adhesive property can be improved with the 1 liquid type epoxy adhesive in which the microcapsule of a photo-cationic polymerization initiator and a polyaddition type amine curing agent were used in combination and thermal curing is carried out after a temporary bonding by photo curing. However, when it was used for producing an inkjet head, the resistance over ink was inadequate. Especially in case of ejecting solvent ink or highly alkalic ink, high resistance was needed, but there was no disclosure about the resistance over such

highly caustic ink.

[0011] In Patent Document 3, it was disclosed that the epoxy composite which has a liquid epoxy resin containing a naphthalene based liquid epoxy, an inorganic filler, a photo-cationic polymerization initiator, and a microencapsulated thermal polymerization initiator can be cured only by low-temperature heating after irradiating a low energy ultraviolet radiation. However, there was no disclosure that fully curing can be achieved only by light irradiation.

## PRIOR TECHNICAL DOCUMENT

### PATENT DOCUMENT

[0012]

Patent Document 1: Unexamined patent application publication (hereinafter referred to as JP-A) No. 2009-148965

Patent Document 2: WO 06/115231

Patent Document 3: JP-A No. 2008-115338

## SUMMARY

### PROBLEMS TO BE SOLVED BY THE PRESENT INVENTION

[0013] One of objects of the present invention is to provide a method for manufacturing an inkjet head, which has no void of adhesive at a bonding portion of materials, has high work efficiency and excellent bonding characteristics due to no adhesive flow into an unnecessary portion, and has excellent adhesive strength to a solvent resistance.

### MEANS TO SOLVE THE PROBLEMS

[0014] The above object has been attained by the following constitutions:

1. A method for manufacturing an inkjet head, wherein a process of bonding a plurality of members with an adhesive (15) containing an epoxy resin containing a novolac type epoxy resin, a photo-cationic polymerization initiator and a microcapsulated thermosetting agent sequentially has: a step of applying the adhesive to one of the members; a step of bonding the members; a step of irradiating the protruding portion of the adhesive with light; and a heating step, wherein 5 to 50% by mass is the novolac type epoxy resin among the epoxy resins.

2. The method for manufacturing an inkjet head of item 1, wherein the adhesive (15) comprises a silane coupling agent.

3. The method for manufacturing an inkjet head of item 1 or 2, wherein the adhesive (15) comprises an alicyclic epoxy compound.

4. The method for manufacturing an inkjet head of any one of items 1 to 3, wherein the thermosetting agent comprises a thermal-anionic polymerization initiator.

5. The method for manufacturing an inkjet head of any one of items 1 to 4, wherein a thickness of the coated adhesive (15) is 1 - 25  $\mu\text{m}$  in the step of applying the adhesive (15) to one of the members.

### EFFECTS OF THE INVENTION

[0015] According to the present invention, it has become possible to provide the inkjet head, which eliminates a jet failure due to having the adhesive flow into a flow path, has a high work efficiency and excellent bonding characteristics, eliminates ink leakage from an ink flow path caused by peeling of the members and the adhesive, and has excellent resistance also to a solvent ink.

### BRIEF DESCRIPTION OF THE DRAWING

[0016]

FIG. 1: an exposed perspective view of head chip;

FIG. 2: a rear side view showing a rear surface of head chip,

FIG. 3: a cross sectional view of pressure chamber

## PREFERRED EMBODIMENT OF THE INVENTION

**[0017]** Hereafter, concrete examples of the present invention are described, however the present invention is not limited thereto.

**[0018]** In view of the foregoing, the inventors of the present invention conducted diligent investigations. As a result, the following was discovered, and the present invention was achieved. A method for manufacturing an inkjet head comprising a process of bonding a plurality of members with an adhesive containing an epoxy resin containing a novolac type epoxy resin, a photo-cationic polymerization initiator and a microcapsulated thermosetting agent, wherein the process of bonding comprises sequential steps of applying the adhesive to one of the members; bonding a plurality of the members; irradiating a protruding portion of the adhesive with light; and heating and 5 to 50% by mass is the novolac type epoxy resin among the epoxy resins. According to the method for manufacturing the inkjet head of the present invention, it has become possible to provide the inkjet head, which eliminates a jet failure due to having the adhesive flow into a channel, has a high work efficiency and excellent bonding characteristics, eliminates ink leakage from an ink channel, and has excellent resistance also to a solvent ink.

**[0019]** The inkjet recording head and the inkjet ink applied to the inkjet image recording of the present invention will now be further detailed.

(Inkjet recording head)

**[0020]** First, the following describes the fundamental embodiments of inkjet recording head of the present invention with reference to drawings.

**[0021]** FIG. 1 is a perspective view showing an example of the inkjet recording head of the present invention. FIG. 2 is a rear side view showing a rear surface of the head chip.

**[0022]** In FIG. 1, 1 is a head chip, 2 is a nozzle plate connected to the front surface of head chip 1, 3 is a wiring substrate connected to the rear surface of head chip 1.

**[0023]** In the present specification, the nozzle side of head chip 1 from which the surface where ink is jetted is defined as a "front surface", and the opposite side thereof is defined as "rear surface". Head chip 1 corresponds to a flow path component of the present invention. In FIG. 1, the ink flows in the direction from bottom to top.

**[0024]** In head chips 1 of the present invention, flow path component 11 made of a piezoelectric element and pressure chamber (ink supply path) 12 are arranged alongside alternately in each array of channels. The walls on both sides of the pressure chamber 12 are formed in parallel each other. Outlet port and inlet port of each pressure chamber 12 are arranged on the front surface and rear surface of head chip 1. Each pressure chamber 12 is a straight type channel wherein the size and shape remain almost unchanged in the direction from the inlet to the outlet ports.

**[0025]** In this head chip 1, each pressure chamber 12 constitutes two arrays of pressure chambers. Each pressure chamber array is composed of 8 pressure chambers 12, however there is no limitation to the number of pressure chambers 12 constituting the pressure chamber array in head chip 1.

**[0026]** Head chip 1 is formed by bonding piezoelectric element 101 which has a plurality of channels with lid material 102. The drive electrode is formed on the surface of the channels of piezoelectric element 101, which comprises metal layer 13 shown with hatching in FIG. 1.

**[0027]** Metal layer 13 is preferably covered with the transparent insulating layer in view of preventing from corrosion by an ink.

**[0028]** Connecting electrode 14 (electrode for applying voltage) pulled out from metal layer 13 of each pressure chamber 12 is formed in the rear surface of head chip 1. Connecting electrode 14 can be formed by vapor deposition or sputtering.

**[0029]** Nozzle plate 2 is provided with nozzle 21 at the position corresponding to outlet port of each pressure chamber 12 of head chip 1. An adhesive is used to bond nozzle plate 2 to the front surface of head chip 1 with connecting electrode 14 formed thereon. Therefore, inlet port, outlet port and nozzle 21 of each pressure chamber 12 are arranged linearly.

**[0030]** Wiring substrate 3 is a plate-formed member to connect a wire which applies driving voltage from the driving circuit (not illustrated) to each metal layer 13 of head chip 1. A substrate made of a ceramic material such as non-polarized PZT, AlN-BN and AlN, a substrate made of plastic or glass of low thermal expansion, and a substrate produced by depolarization of the same substrate material as that of the piezoelectric element used in head chip 1 can be used as the substrate used in this wiring substrate 3. So as to reduce the distortion of head chip 1 caused by the difference in thermal expansion coefficient, it is preferred to select the material having the difference in thermal expansion within the range of  $\pm 3$  ppm based on that of un-polarized PZT.

**[0031]** The substrate constituting wiring substrate 3 is not restricted to a single plate-formed substrate. It is possible to produce a substrate having a predetermined thickness by lamination of a plurality of sheet-like substrate materials

**[0032]** Wiring substrate 3 has the larger area than rear surface of head chip 1. It extends in the direction (B direction in FIG.) perpendicular to the direction wherein pressure chambers 12 of head chip 1 are arranged (direction of pressure

chamber array), and heavily extends from each surface of head chip 1. The ends of the extension are used as wiring connections 33 for connection of the FPCs (not illustrated). Further, wiring substrate 3 heavily extends in the direction of pressure chamber array 12 (A direction in FIG.) of head chip 1.

**[0033]** Opening 32 is formed by penetration through the center of wiring substrate 3. This opening 32 is formed to have such a size as to expose the inlet port side of all pressure chambers 12 facing the rear surface of head chip 1.

**[0034]** Depending on the characteristics of the substrate material, opening 32 can be formed by a method of using a dicing saw for processing, a method of using an ultrasonic processing machine, a method of molding a ceramic and sintering, or a method of forming by a sandblast.

**[0035]** Wiring electrodes 33 (electrodes for applying electric voltage) are formed on the surface side of wiring substrate 3 where head chip 1 is connected in the same number and at the same pitch ( $W1+W2$ ) as those of connection electrode 14 formed on the rear surface of head chip 1. These electrodes extend to reach from the peripheral of an opening 32 to the outer edge of the wiring substrate 3. When bonded with the FPC, this wiring electrode 33 is electrically connected with each wire formed on the FPC, and works as an electrode for applying the driving voltage from driving circuit to metal layer 13 located inside of pressure chamber 12 through connection electrode 14.

**[0036]** In addition, on the surface of the wiring substrate 3, other than the wiring electrode 33, dummy electrode 36a which does not participate in a drive is formed between wiring electrode 33, since between head chip 1 and wiring substrate 3 is sealed by adhesives. Pattern 38 for positioning is also formed for positioning head chip 1. In the case of bonding with the head chip 1, this pattern 38 for positioning is used to fit in the pattern 39 for positioning formed in the rear surface of the head chip 1, and positioning the head chip 1.

**[0037]** After applying adhesive to both adhesive sides respectively, head chip 1 and wiring substrate 3 formed as described above are positioned to overlap as shown in FIG. 1, so that each connection electrode 14 of head chip 1 and each wiring electrode 33 of wiring substrate 3 may be connected electrically, and heated and pressurized by predetermined temperature and predetermined time to cure the adhesive.

**[0038]** Moreover, nozzle plate 2 with nozzle 21 is bonded on the front surface of head chip 1 with the above-mentioned adhesive. Thereby, an inkjet recording head is obtained.

**[0039]** Besides, the adhesive concerning the present invention is applicable to an adhesion of a circuit board to a head chip, and an adhesion of manifold.

**[0040]** FIG. 3 is a sectional view showing a state where a nozzle plate and a head chip were bonded with adhesive, as one example of the present invention.

**[0041]** The production method of the inkjet recording head of the present invention is explained with reference to the accompanying FIG. 3.

#### 1) Process for bonding Flow path component and Nozzle plate

**[0042]** FIG. 3 shows a state where head chip 1 in the inkjet recording head shown in FIG. 1 and nozzle plate 2 bonded to the front surface of head chip 1 was bonded with the adhesive concerning the present invention.

**[0043]** At first, predetermined amount of the above-mentioned adhesive 15 is applied to the surface where the nozzle plate of head chip 1 is bonded to by using a transfer method. There is no limitation in particular as an applied amount of adhesive, but it is preferable that thickness of applied wetting film is  $1.0\ \mu\text{m}$  or more and  $25.0\ \mu\text{m}$  or less. When the applied amount of adhesive is  $1.0\ \mu\text{m}$  or more, the durability of adhesion between head chip 1 and nozzle plate 2 can be improved. Moreover, when it is  $25.0\ \mu\text{m}$  or less, since the applied amount of adhesive does not exceed, whereby an inflow of adhesive and a protrusion of adhesive to the nozzle area can be prevented.

**[0044]** The applied amount of adhesives can be determined as follows: the mass of the adhesive is calculated by deducting the mass of the chip from the mass of the chip having applied adhesive, the volume of adhesives is calculated by dividing the mass of the adhesives by the specific gravity of adhesive, and further the result is divided by the bonding area of the adhesion side of the chip.

**[0045]** Flow path component 11 may comprise any material, for example, such as piezoelectric material or silicone, however, in the present invention, it is preferable that an ink supply route including a flow path component comprises the piezoelectric element (piezoelectric ceramics).

**[0046]** As piezoelectric ceramics which constitute the flow path component, any well-known ceramics may be employable. However, it is preferable ceramics such as PZT and PLZT which contains a small amount of metal oxide known as a softening agent or a hardening agent, for example, oxide of Nb, Zn, Mg, Sn, Ni, La, and Cr in a mixed microcrystalline mainly made of  $\text{PbO}_x$ ,  $\text{ZrO}_x$ , and  $\text{TiO}_x$ .

**[0047]** PZT is lead zirconate titanate and is preferably used due to its high packing density, large piezoelectric constant and good workability. When temperature is lowered after calcination, crystal structure of PZT suddenly changes and atom shifts resulting in aggregate of fine crystals in the form of dipole having plus on one side and minus on the opposite side. Since directions of such intrinsic polarization are random and polarity is negated mutually, a poling process is further needed.

**[0048]** In a polarization process, thin plate of PZT is sandwiched with electrodes, soaked into silicone oil, and polarized by applying a high electric field of about 10 - 35 kV/cm. The piezoelectricity of PZT disappears by applying temperature exceeding Curie point which is generally about 200 °C.

**[0049]** In the present invention, it is preferable to perform an acid treatment, a plasma treatment, or a UV treatment to at least one of the adhesion surface of head chip 1 and nozzle plate 2. Plasma treatment is a treatment in which a nozzle plate and a head tip are placed into a vacuum chamber, by pouring at least one gas selected from Ar, N<sub>2</sub> and O<sub>2</sub>, or mixed gas thereof, and treated in a state of plasma by applying electromagnetic field from outside. It may use the fluorine based hydrocarbon gas such as CF<sub>4</sub> so as to increase surface etching effect. Acid treatment can be carried out by immersing an adhesion side in aqueous solution of such as hydrochloric acid. Moreover, UV treatment is a treatment in which UV is directly irradiated to a nozzle plate or a flow path component by ultraviolet radiation lamp. It may be carried out under O<sub>2</sub> atmosphere so as to use a cleaning effect by ozone. By plasma treatment, acid treatment, and UV treatment on the adhesion surface as above, organic contamination can be washed and removed, wetting ability of the adhesive to the entire adhesion surface is enhanced, and adhesion problem such as remaining minute bubbles can be eliminated, thereby ink leakage and poor adhesion are prevented and a stable inkjet recording head can be manufactured.

**[0050]** For example, on piezoelectric element 101, minute channel portion (for example, length: 3mm, height: 360 μm, width: 70 μm) is processed on the one surface of the substrate having thickness of 1 mm. By bonding (adhering) lid component 102 to the processed surface of the substrate, pressure chamber (length: 3mm, height: 360 μm, width: 70 μm) is formed at channel portion which are used as ink flow path. One end of a pressure chamber is connected with an ink storage member through manifold containing a circuit board and a filter unit, and the other end is connected with an ink outlet (nozzle plate).

**[0051]** In the present invention, flow path component 11 which forms an ink chamber has metal layer 13 on the ink supply route side.

**[0052]** Metal layer 13 acts as a drive electrode of the flow path component (piezoelectric element). Metal materials to form the metal layer are Ni, Co, Cu, Al, Sn and Cr. While Al and Cu are preferred from the viewpoint of electric resistance, Ni is preferably used in terms of corrosion, strength and cost. Also, a laminated structure where Au is laminated on Al can be employed.

**[0053]** While methods using a vacuum device such as an evaporation coating method, a sputtering method, a plating method and a CVD (chemical vapor deposition method) are listed as forming methods of metal layer 13, the plating method is preferred and the nonelectrolytic plating is particularly preferred. By nonelectrolytic plating, a metal coating layer can be formed which is free from pin holes and uniform in thickness. A thickness of the plating layer is preferable in the range of 0.5 - 5 μm.

**[0054]** Further, as the nozzle plate material, material is used which can be ablated by laser light or which can be anisotropic etched. For example, resin sheet such as polyimide, polyethylene terephthalate, polyamide, and polysulfone and silicone can be used preferably. It is specifically preferable to be constituted by polyimide which can bear high temperature during preparation of an ink repellency layer on the surface, and precise nozzle processing by a laser can be available.

## 2) Cure process by irradiating light from ink supply side of flow path component

**[0055]** At the above-mentioned process, after bonding nozzle plate 2 and chip 1 with adhesive 15, the first cure process is performed by irradiating optical energy to the adhesive.

**[0056]** In the present invention, in case of curing the adhesive by light irradiation, it is preferable that surface of ink supply route 12 is formed by metal layer 13. By constituting ink supply route 12 equipped with such a metal surface, as shown in FIG. 3, when light is irradiated from the light source from the direction of ink supply side shown by arrow A, since the irradiated light reflects on the metal surface and attenuation is low until it reaches to adhesive layer 15 located deeply, whereby it can supply light energy required for curing.

**[0057]** As an irradiation source used for curing adhesive, it is preferable that the source is constituted by an ultraviolet radiation lamp which can emit light in the ultraviolet radiation of the specific wavelength region with stable exposure energy, and a filter which penetrates the ultraviolet radiation of specific wavelength. As the ultraviolet irradiation lamp, a mercury lamp, a metal halide lamp, an excimer laser, an ultraviolet laser, a cold cathode pipe, a hot cathode pipe, a black light, LED (light emitting diode) are applicable. Of these, the high-pressure mercury lamp which emits ultraviolet radiation in the wavelength of 365 nm is especially preferable.

## 3) Process for curing adhesive by heat treatment

**[0058]** After performing the first cure process of adhesive layer 15 in the above mentioned process 2), the second cure process is performed by applying thermal energy so as to obtain firmer adhesive layer and to cure a portion where light did not reach. By this heating process, adhesive can have the predetermined solvent resistance.

**[0059]** The inkjet head keeps a narrow gap between the recording media and moves relatively to the recording medium. When the recording medium has unevenness such as surge, the nozzle plate may contact with the recording medium during the inkjet head moves. Especially when the inkjet head is used for a long term and the used adhesive swells with solvent in ink, the nozzle plate may be separated by such contact. In order to resolve such a problem, it is effective to enhance the adhesive strength and to reduce swelling of adhesive when the adhesive is immersed in solvent ink for a long term.

**[0060]** Heating temperature for curing adhesive may be suitably chosen by a kind of the adhesives and unless a constituting component of the inkjet recording head is impaired. The highest temperature of the heating process is in the range of 60 °C to 150 °C.

**[0061]** As means for applying thermal energy, preferable are an electric oven or a heating implement which can heat the inkjet recording head by pressure-contacting, for example, such as a hot plate, and a ribbon heater. Moreover, at the time of heat treatment, it is preferable to use a mean for cooling at least to a piezoelectric element, which cools by circulating cold water through an aluminum block. Since it is difficult to measure the temperature of the adhesive itself in this invention, temperature of the oven and the pressurization implement is measured and used as a substitute for the temperature of the heating process.

<<Adhesives>>

**[0062]** The adhesive applied in manufacturing the inkjet recording head of the present invention is characterized by comprising an epoxy resin, a photo-cationic polymerization initiator and a thermal curing agent, the above-mentioned epoxy resin comprising a novolac based epoxy resin, and the above mentioned thermal curing agent is microencapsulated.

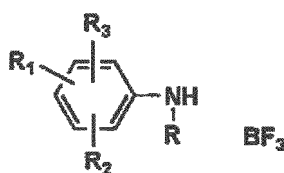
(Thermal curing agent)

**[0063]** Specific examples of the thermal curing agents according to the present invention include a primary or a secondary polyamine, a thermal-cationic polymerization initiator, and a thermal-anionic polymerization initiator for poly-addition or thermal polymerization of epoxy monomer. Of these, the thermal-cationic polymerization initiator and the thermal-anionic polymerization initiator are preferable, and the thermal-anionic polymerization initiator is still more preferable.

**[0064]** Hereafter, the addition amount of the above mentioned thermal curing agent is represented by part by mass of the added quantity to 100parts by mass of the epoxy resin.

**[0065]** As the thermal-cationic polymerization initiator, boron trifluoride amine complex, sulfonium salt, and aluminum complex are used. Of these, boron trifluoride amine complex is preferable, and the compound represented by Formula (I) is specifically preferable due to having the adhesive with high solvent resistance.

Formula (I)



**[0066]** In the above mentioned Formula (I), R represents a hydrogen atom or an alkyl group, and preferably represents a hydrogen atom. R<sub>1</sub>, R<sub>2</sub>, and R<sub>3</sub> represent a hydrogen atom, an alkyl group, an alkoxy group, an aryloxy group, or a halogen atom respectively.

**[0067]** Specific examples of an alkyl group represented by R, R<sub>1</sub> to R<sub>3</sub> include: methyl group, ethyl group, propyl group, isopropyl group, butyl group, tert-butyl group, isobutyl group, sec-butyl group, pentyl group, tert-pentyl group, hexyl group, 2-methyl pentyl group, isohexyl group, heptyl group, isoheptyl group, 1-propyl butyl group, octyl group, 2-ethyl hexyl group, isooctyl group, nonyl group, isononyl group, decyl group, isodecyl group, undecyl group, and dodecyl group.

**[0068]** Specific examples of alkoxy group represented by R<sub>1</sub> to R<sub>3</sub> include: methoxy group, ethoxy group, n-propoxy group, iso-propoxy group, n-butoxy group, and tert-butoxy group. Specific examples of aryloxy group include phenoxy group and naphthyloxy group. Moreover, specific examples of halogen atom include: chlorine atom, bromine atom, and fluorine atom.

**[0069]** Subsequently, thermal-cationic polymerization initiators represented by Formula (I) according to the present invention will be exemplified, however the present invention is not limited to the exemplified compound thereof

**[0070]** Preferable thermal-cationic polymerization initiators according to the present invention include aniline derivatives listed below and a complex compound with boron trifluoride.

<Aniline Derivatives>

**[0071]**

Compound 1: 2-chloroaniline  
 Compound 2: 3-chloroaniline  
 Compound 3: 4-chloroaniline  
 Compound 4: 3-chloro-4-fluoroaniline  
 Compound 5: 2,5-dimethylaniline  
 Compound 6: 3, 4-dimethoxy aniline  
 Compound 7: 2-ethyl aniline  
 Compound 8: 4-ethyl aniline  
 Compound 9: N-ethyl aniline  
 Compound 10: 3,4-dichloroaniline  
 Compound 11: 3,5-dichloroaniline  
 Compound 12: 3-fluoroaniline  
 Compound 13: 4-fluoroaniline  
 Compound 14: 2-fluoro-4-methylaniline  
 Compound 15: 4-fluoro-3-methylaniline  
 Compound 16: 4-methoxy-2-methylaniline  
 Compound 17: 3,4-difluoroaniline  
 Compound 18: 4-butaniline  
 Compound 19: N-methylaniline  
 Compound 20: 2,4,6-tribromoaniline  
 Compound 21: 2,3, 4-trifluoroaniline  
 Compound 22: 2, 3, 6-trifluoroaniline  
 Compound 23: 2, 4, 6-trifluoroaniline  
 Compound 24: 2, 3, 4-trifluoroaniline  
 Compound 25: 2, 4, 6-trimethylaniline  
 Compound 26: 2, 4, 5-trimethylaniline  
 Compound 27: N-benzyl aniline  
 Compound 28: 4-chloroaniline  
 Compound 29: 2-chloroaniline  
 Compound 30: 4,4'-methylene bisaniline  
 Compound 31: 3-phenoxy aniline  
 Compound 32: 4-butoxy aniline  
 Compound 33: 4-butoxy aniline  
 Compound 34: 3, 4-dimethoxy aniline  
 Compound 35: aniline

**[0072]** The thermal-cationic polymerization initiator represented by Formula (I) according to the present invention can be synthesized by a well-known synthetic method by a person skilled in the art. Moreover, a complex of Compound 35: aniline and the boron trifluoride is marketed as polyethylene glycol solution by the brand name of BAK1171 by PTI Japan.

**[0073]** Addition amount of the thermal-cationic polymerization initiator represented by Formula (I) is preferable 0.1 - 30 parts by mass based on 100 parts by mass of epoxy resin, and more preferable 0.5 - 5 parts by mass.

**[0074]** These thermal-cationic polymerization initiators are microencapsulated and added in the above-mentioned adhesive. Addition amount of the microencapsulated thermal-cationic polymerization initiator is preferable 1 - 50 parts by mass based on 100 parts by mass of epoxy resin, and more preferable 2 - 25 parts by mass.

**[0075]** As for the thermal-anionic polymerization initiator, imidazoles and tertiary amines are used. Of these, imidazole is preferably used. Specific examples of imidazoles include: 1-methyl imidazole, 1-benzyl-2-methyl imidazole, 1,2-dimethyl imidazole, 1-isobutyl-2-methyl imidazole, 1-methyl-2-ethyl imidazole, 1-ethyl imidazole, 1-cyanoethyl-2-ethyl-4-methyl imidazole, 1-cyanoethyl-2-methyl imidazole, 1-(2-hydroxy-3-phenoxypropyl)-2-ethyl-4-methyl imidazole, 1-(2-hydroxy-3-phenoxypropyl)-2-methyl imidazole, 2-methyl imidazole, and 2-ethyl-4-methyl imidazole.

**[0076]** These are microencapsulated and added in the above-mentioned adhesive.

**[0077]** As the microcapsule of the thermal-anionic polymerization initiator, for example, marketed are HXA-3932 (im-

idazole based thermal-polymerization initiator microencapsulated with MMA, average particle diameter of 2  $\mu\text{m}$ , produced by Asahi Kasei Chemicals Corp.), HX-3741 (imidazole based thermal-polymerization initiator microencapsulated with MMA, average particle diameter of 5  $\mu\text{m}$ , produced by Asahi Kasei Chemicals Corp.), and HX-3722 (imidazole based thermal-polymerization initiator microencapsulated with MMA, average particle diameter of 2  $\mu\text{m}$ , produced by Asahi Kasei Chemicals Corp.).

**[0078]** Addition amount of the microencapsulated thermal-cationic polymerization initiator is preferable 1 - 100 parts by mass based on 100 parts by mass of epoxy resin, and more preferable 10 - 80 parts by mass.

(Photo-cationic polymerization initiator)

**[0079]** In the present invention, as the photo-cationic polymerization initiator (photopolymerization initiator) for photopolymerizing the cationic polymerizable monomer, well-known photo-acid generator can be used. As the photo-acid generator, any compound used, for example, for chemical sensitization-type photoresists and compound for photo-cationic polymerization is used (refer to pages 187-192 of "Imaging Yo Yuki Zairyo (Organic Materials Used for Imaging Applications)" edited by Yuki Electronics Zairyo Kenkyukai published by Bunshin Shuppan (1993)).

**[0080]** Initially, there can be listed  $\text{B}(\text{C}_6\text{F}_5)_4^-$ ,  $\text{PF}_6^-$ ,  $\text{AsF}_6^-$ ,  $\text{SbF}_6^-$ , and  $\text{CF}_3\text{SO}_3^-$  salts of aromatic onium compounds such as diazonium, ammonium, iodonium, sulfonium, and phosphonium. Secondly, sulfonated compounds generating sulfonic acid can be listed. Thirdly, halides photolytically generating hydrogen halides are usable. Fourthly, iron-arene complexes can be listed. Specific examples include: hexafluoro phosphate, hexafluoro antimonate or pentafluoro phenyl borate salts of diaryliodonium or triaryl sulfonium. They are marketed by brand names, such as the IRUGACURE-261 (produced by BASF Japan), SP-150, SP-170 (above, produced by ADEKA), PI2074 or UVI-6992 (produced by the Dow Chemical).

**[0081]** Addition amount of the photo-cationic polymerization initiator is preferably 0.1 - 10 parts by mass based on 100 parts by mass of epoxy resin, and more preferably 2 - 6 parts by mass.

(Epoxy resin)

**[0082]** As epoxy compounds (epoxy resin) applicable to the adhesives according to the present invention, any monomers, oligomers, and polymers having epoxy group are usable. Specifically, well-known aromatic epoxides, alicyclic epoxides, and aliphatic epoxides are listed. Herein, the epoxides refer to monomers or oligomers thereof.

**[0083]** It is preferable that epoxy compound in the present invention contains 70 - 99 % by mass of an aromatic epoxy compound in the epoxy compound.

(Aromatic epoxy compound)

**[0084]** As the aromatic epoxides, listed are di- or polyglycidyl ethers produced via reaction of a polyphenol having at least one aromatic nucleus or an alkylene oxide adduct thereof with epichlorohydrin. The aromatic epoxides include novolac type epoxy resins and further include at least one of di- or polyglycidyl ethers of bisphenol A or an alkylene oxide adduct thereof, di- or polyglycidyl ethers of hydrogenated bisphenol A or an alkylene oxide adduct thereof, and bisphenol F type epoxy resins. Herein, as the polyalkylene oxide, polyethylene oxide and polypropylene oxide can be listed.

**[0085]** It is preferable that the epoxy compound in the present invention contains 70 - 99 % by mass of an aromatic epoxy compound in the epoxy compound in view of resistance for ink.

(Novolac type epoxy resin)

**[0086]** The above-mentioned novolac type epoxy resin is a compound which has a plurality of glycidyl groups in one molecule generated by a reaction of hydroxyl group of novolac resin and epichlorohydrin. The number of the epoxy groups in one molecule has distribution. Although the average of the number of epoxy groups in one molecule changes with synthetic conditions, 3 or more are preferable.

**[0087]** As commercially available products, listed are jER152 (phenol novolac epoxy resin, produced by Japan Epoxy Resin), jER154 (phenol novolac epoxy resin, produced by Japan Epoxy Resin), and EPICLON N-660 (cresol novolac epoxy resin, produced by DIC).

**[0088]** 5 - 50% by mass is the novolac type epoxy resin among the above-mentioned epoxy resins. When the novolac type epoxy resin is more than 5% by mass, resistance for ink is excellent as well as void disappears easily. When the novolac type epoxy resin is 50% or less by mass, void disappears easily.

**[0089]** As a reason for excellent elimination of void in case of the novolac type epoxy resin in case of being more than 5% by mass, it is realized that the dissolution of a microcapsule is inhibited by the novolac type epoxy content of 5% or

more, resulting in preventing a viscosity rise of the adhesive.

(Alicyclic epoxy compound)

**[0090]** In the present invention, it is preferable that the epoxy resin containing the above-mentioned novolac type epoxy resin further contains an alicyclic epoxy compound in view that high photosensitivity can be obtained.

**[0091]** As the alicyclic epoxides, listed are compounds containing cyclohexene oxide or cyclopentene oxide obtained by epoxidizing compounds having at least one cycloalkane ring such as cyclohexene or cyclopentene by using an appropriate oxidant such as a hydrogen peroxide or a peracid. Specific examples thereof include: (3, 4-epoxy cyclohexyl) methyl-3', 4'-epoxy cyclohexyl carboxylate and bis-(2, 3-epoxy cyclopentyl) ether.

**[0092]** The addition amount of the alicyclic epoxy compound is preferably 1 - 50% by mass based on the entire epoxy resins. In case of more than 1% by mass, photo sensitivity will be high, resulting in suppressing inflow in short-time irradiation. In case of the same irradiation level, the inflow will be further prevented compared to the adhesive without containing the alicyclic epoxy compound. In case of 50% or less, high resistance will be acquired.

(Silane coupling agent)

**[0093]** It is desirable that the above-mentioned adhesive contains silane coupling agent in view of enhancing resistance of adhesive strength.

**[0094]** Preferable examples of compounds for silane coupling agent include:  $\beta$ -(3,4-epoxy cyclohexyl) ethyltrimethoxy silane,  $\gamma$ -glycidoxypropyl trimethoxy silane,  $\gamma$ -glycidoxypropylmethyl dimethoxy silane, and  $\gamma$ -glycidoxypropylmethyldiethoxy silane.

**[0095]** The addition amount of silane coupling agent is preferably 0.5 - 5 parts by mass based on 100 parts by mass of the epoxy resin. In case of more than 0.5 parts by mass, excellent resistance of the adhesive strength is obtained, and in case of 5 parts by mass or less, the viscosity rise will be small at room temperature preservation, and the work life can be lengthened.

<<Inkjet ink>>

**[0096]** When an image is formed by using an inkjet recording equipment equipped with the inkjet recording head of the present invention, an aqueous inkjet ink, a non-aqueous inkjet ink, a wax ink or an actinic energy curable inkjet ink are applicable as the inkjet ink without being particularly limited thereto. Of these, in view of offering excellent properties of the inkjet recording head of the present invention, it is preferable to apply the inkjet ink whose content of the organic solvent is 50% or more and 100% or less based on all solvents. Further, it is preferable to apply the inkjet ink to the image formation which contains organic solvents more than 30% by mass and 100% or less based on all organic solvents, which have high dissolution ability to a resin component represented by solubility parameter (SP value) of 16.0 or more and 21.0 or less.

(Organic solvent)

**[0097]** In recent years, application of an inkjet recording method has increased for various uses (for example, an outdoor signboard or electronic components manufacture). For example, for outdoor signboards, the inkjet ink containing the solvent is used which dissolves vinyl chloride used as a material for a receiving sheet. In manufacturing electronic components, in order to dissolve various compounds, a solvent having high solubility to resin is used for the inkjet ink. Therefore, it is required to maintain strength as the inkjet recording head, even when it uses a solvent having such high resin solubility.

**[0098]** The inkjet recording equipment concerning the present invention preferably complies with the inkjet ink comprising organic solvent of 50% or more and 100% or less based on all solvents.

**[0099]** The term "solubility parameter of solvent (SP value)" of the present invention refers to a value indicated by the square root of the molecular cohesion energy, and is determined via a method described in "R. F. Fedors, Polymer Engineering Science, 14, p. 147 (1974)". The unit thereof is (MPa)<sup>1/2</sup>, and the value is determined at 25 °C. An organic solvent which has SP value specified by the present invention is also indicated in VII/526-539 pages in J. Brandup and E. H. Immergu jointly edited "Polymer Handbook" 3rd edition (John Wiley & Sons), 1989, for example.

**[0100]** Examples of organic solvents having a solubility parameter (SP value) of 16.0 (MPa)<sup>1/2</sup> or more and 21.0 (MPa)<sup>1/2</sup> or less are listed below, however it is not limited to these exemplified compound. Herein, the numerical value in a parenthesis represents SP value ((MPa)<sup>1/2</sup>).

**[0101]** Amyl acetate (16.0), ethyleneglycol diethylether (17.0), ethyl propionate (17.2), diethyleneglycol monoethylether acetate (17.4), methyl-2-pentanediol mono-ethyl ether (17.4), ethyleneglycol dimethylether (17.6), diethyleneglycol mon-

olaurate (17.8), ethyleneglycol monoethylether acetate (17.8), tripropyleneglycol methylether(17.8), butylpropionate (18.0), ethylacetate (18.6), ethylene glycol methylethyl acetate (18.8), tripropyleneglycol (18.8), dipropyleneglycol mono methylether (19.0), ethyl-2-hexanediol-1,3-(octyleneglycol)(19.2), butyl lactate (19.2), diethyleneglycol monobutylether (19.4), ethyleneglycol monobutylether (19.4), cyclohexanone (20.3), ethyl lactate (20.5), and anisole (19.4).

(Other ink additives)

**[0102]** The inkjet ink concerning the present invention may contain various additives other than the above-mentioned organic solvent

**[0103]** The ink concerning the present invention may contain a colorant. It is preferable to use the ink forming color of yellow, magenta, cyan, black, blue, green and red as hue of the colorant, for example.

**[0104]** With respect to the ink concerning the present invention, various inkjet inks are applicable such as a dye ink whose colorant is a dye, or a pigment ink which forms a dispersion containing fine pigment particles in which colorant is not dissolved in the solvent constituting the inkjet ink, or a dispersed ink which comprises dispersion of polymer colored by colorant.

## EXAMPLES

**[0105]** Hereafter, although concrete examples of the present invention are described, the present invention is not limited to thereto.

<<Production of Microcapsule>>

[Production of Microcapsule 1]

(Production of Imidazole epoxy adduct)

**[0106]** In 200 parts by mass of 1/1 mixed solvent of methanol and toluene, 100 parts by mass of bisphenol epoxy F type epoxy resin and 100 parts by mass of 2-methyl imidazole were reacted for 3 hours at 80 °C. Then, solvents were distilled away under the reduced pressure at 180 °C, and a solid compound was obtained.

(Production of Solid curing agent)

**[0107]** Obtained compound 100 parts by mass was melted and 1 part by mass of 2-methyl imidazole was mixed thereto. After cooling to a room temperature, the resultant was pulverized and solid curing agent with an average particle diameter of 2 μm was obtained.

(Production of Microcapsulated curing agent)

**[0108]** Subsequently, to 200 parts by mass of bisphenol F type epoxy resin, 100 parts by mass of the above-mentioned solid curing agent, 2 parts by mass of water and 5 parts by mass of diphenylmethane diisocyanate (MDI) were added and agitated at ordinary temperature for 3 hours. Then, reaction was performed at 45 °C for 24 hours, and Microcapsule 1 was obtained.

[Production of Microcapsule 2]

(Preparation ofPrepolymer)

**[0109]** Into 150 parts by mass of distilled water, 100 parts by mass of 37% formaldehyde aqueous solution, 33 parts by mass of melamine, 15 parts by mass of sodium hydrogencarbonate and 15 parts by mass of sodium carbonate were added, and reacted at 70 °C for 30 minutes, thereby melamine prepolymer was prepared.

(Production of Microcapsulated curing agent)

**[0110]** Subsequently, 50 parts by mass of the liquid prepared by adding 25 parts by mass of boron trifluoro aniline complex into 25 parts by mass of toluene was added into mixture liquid of 95 parts by mass of distilled water and 5 parts by mass of polyvinyl alcohol (PVA). Resultant was emulsified to be in emulsion state. After emulsification, 20 parts by mass of above-mentioned melamine prepolymer was added and interfacial polymerization was carried out at 70 °C for

3 hours, thereby suspension was obtained. This suspension was filtered, dried and Microcapsule 2 was obtained.

<<Preparation of Inkjet recording head>>

[Preparation of Inkjet recording head 1]

(Preparation of Head chip)

**[0111]** Head chips having constitution shown in FIG. 1 to FIG. 3 were prepared according to the following method.

**[0112]** PZT (lead zirconate titanate, thickness: 700  $\mu\text{m}$ , Curie temperature: 210  $^{\circ}\text{C}$ ) and PZT (thickness: 150  $\mu\text{m}$ , Curie temperature: 210 $^{\circ}\text{C}$ ) were bonded by using adhesive so that the polarization direction of each PZT is in the opposite direction. Subsequently, after preparing a resist layer by transferring the resist layer on the surface side and the back side of 150  $\mu\text{m}$  thickness PZT, channels with a depth of 300  $\mu\text{m}$  from the surface, a width of 70  $\mu\text{m}$  and a length of 30mm were provided in 140  $\mu\text{m}$  pitch, and 512 channels for pressure chamber were formed. Subsequently, the 1  $\mu\text{m}$  thickness of nickel layer was formed on the surface of the channels by the plating method. Subsequently, the resist at summit of the pressure chamber and at the back side were removed together with the nickel plating layer on the resist

**[0113]** A cover plate (depolarized PZT with 700  $\mu\text{m}$  thickness) was bonded to the surface where resist was removed at the summit of the pressure chamber and a chip having a plurality of ink flow paths was formed. These two chips were bonded so that a cover plate became outside and the ink flow paths become parallel mutually, and the chip which has two rows of flow path sequence was formed. Subsequently, it was cut by interval of 2 mm along with the direction perpendicular to the direction of the flow path, and formed a plurality of head chips having  $L = 2\text{mm}$ .

**[0114]** Thus, in above produced chip, the drive walls and the flow paths consisting of the piezoelectric element were provided in parallel by turns.

**[0115]** In order to be able to connect the wiring substrate for applying the drive voltage from the drive circuit to the drive electrode in each flow path, each drive electrode was pulled out on the external surface of the chip. That is, on the rear surface of the above-mentioned cutting planes, after transferring the resist and forming a pattern by exposure and development, aluminum was vapor deposited and the electrode was formed by removing the resist.

**[0116]** Moreover, a wiring substrate was prepared as a tabular component for connecting a wiring which applies the drive voltage from the drive circuit which is not illustrated to each drive electrode of the head chip. As the substrate used for this wiring substrate, selected was a glass board so that the difference of a coefficient of thermal expansion with the head chip may be set to less than  $\pm 1$  ppm, in order to suppress generating of distortion of the head chip caused by the difference between coefficients of thermal expansion.

**[0117]** Moreover, an opening was formed to penetrate through at mostly center of the wiring substrate. This opening was formed in the size which can expose an entrance side of all the channels of the head chip. By preparing this opening, all the drive walls, all the channels, and all the drive electrodes of the head chip can be looked into, in a state of bonding the wiring substrate to the rear surface of the head chip.

**[0118]** Moreover, on the surface which becomes a bonding side of the wiring substrate with the head chip, the wiring electrode were formed in the same number and the same pitch as those formed in the rear surface of the head chip and extended to each wiring connecting area. In case of bonding FPC, these connecting electrodes connected to each wiring formed on FPC electrically, and functioned as electrodes for applying the drive voltage from the drive circuit supplied through wiring of FPC to the drive electrode in the channel through the connection electrode.

**[0119]** The wiring substrate was positioned and bonded to the rear surface of the chip via the adhesive with anisotropy conductivity so that each wiring electrode may connect electrically with each connecting electrode of the chip and the opening may expose all the flow path of chip. Thereafter, the wiring electrode where FPC will be bonded later was protected with the masking tape, a protective layer comprising polyparaxylylene was formed on the inside of the pressure chamber including the drive electrode and an exposed cross section including extraction electrode. Thus, the head chip was produced.

(Adhesion of Nozzle plate)

**[0120]** On the front surface of the head chip produced above, the following adhesive 1 was transfer coated by thickness of 5  $\mu\text{m}$ . Subsequently, the nozzle plate (a nozzle hole of 30  $\mu\text{m}$  in diameter was formed on polyimide of 100  $\mu\text{m}$  thickness) was bonded to the predetermined position on the surface of head chip1 where the adhesive was applied under observing with an optical microscope. Subsequently, after irradiating via a high-pressure mercury lamp from the head chip rear surface at the room temperature and at an irradiation amount of 5000  $\text{mJ}/\text{cm}^2$ , adhesive 1 were cured by the following curing condition 1.

**[0121]** Herein, this irradiation amount is a value calculated as follows: before applying adhesive to the head chip, an actinometer which can measure a light of 365 nm was placed in front of the chip, the amount of light was determined

by irradiating via the high-pressure mercury lamp from the rear surface of the head chip, and the determined amount of light was divided by the open area ratio of the chip. This value corresponds to the irradiation amount which is received by the nozzle plate at the time of bonding of the nozzle plate.

**[0122]** FPC was bonded to the wiring electrode of the wiring substrate and the common ink chamber was bonded to the rear surface of the wiring substrate, thereby Inkjet recording head 1 was prepared. Ink was introduced into the pressure chamber of the chip through the opening of the wiring substrate from the common ink chamber, and it enabled to apply the drive voltage through FPC from the external drive circuit

(Adhesive 1)

**[0123]**

|                                                                             |                  |
|-----------------------------------------------------------------------------|------------------|
| jER807 (Bisphenol F type epoxy resin; produced by Japan epoxy resin)        | 90 parts by mass |
| jER152 (Novolac type epoxy resin; produced by Japan epoxy resin)            | 10 parts by mass |
| UVI6992 (Photo-cationic polymerization initiator; produced by Dow Chemical) | 4 parts by mass  |
| Microcapsule 1 (Microcapsule type thermal-anionic polymerization initiator) | 40 parts by mass |

(Curing conditions 1)

**[0124]** The adhesive was supplied to an oven of 100 °C for 1 hour and heat-cured.

(Measurement of Required irradiation amount for curing)

**[0125]** The adhesive was coated on PET film by the same thickness as coated on the front surface of the above mentioned head chip, and ultraviolet radiation was irradiated by the high-pressure mercury lamp with changing an irradiation time. Stainless spatula was pushed to the adhesive and a required irradiation amount for curing was determined by the minimum time whose tackiness was lost.

**[0126]** Lower required irradiation amount mentioned above means the higher sensitivity.

(Evaluation of Void disappearance in adhesive)

**[0127]** In the above adhesion process of the nozzle plate, after bonding the nozzle plate to the predetermined position of the chip, it was observed that the adhesive between the chip and the nozzle plate wetted the nozzle plate and the void between the nozzle plate and the adhesive disappeared.

A: The adhesives permeated within 3 minutes and the void disappeared.

B: The void disappeared exceeding 3 minute but within 30 minutes.

C: The void did not disappear even exceeding 30 minutes.

[Preparation of Inkjet recording heads 2 to 24]

**[0128]** In preparation of Adhesive 1, the kind and the addition amount of epoxy resin, photo-cationic polymerization initiator, thermal curing agent and silane coupling agent were changed as shown in Tables 1 and 2, and Adhesives 2 to 21 were prepared. Herein, the addition amount listed in Tables 1 and 2 represents part by mass.

**[0129]** Inkjet recording heads 2 to 24 were prepared in the same manner as the preparation of the above-mentioned Inkjet recording head 1, except for changing the adhesives and the coating thickness as shown in Tables 1 and 2.

**[0130]** Herein, Adhesives 21 was used to Inkjet recording head 24 and after irradiation of ultraviolet radiation, it was heated at 110 °C for 3 hours.

**[0131]** Epoxy resin, polymerization initiator, and silane coupling agent used for Adhesives 2 to 21 are described below.

jER807: Bisphenol F type epoxy resin, produced by Japan Epoxy Resin  
 jER828: Bisphenol A type epoxy resin, produced by Japan Epoxy Resin  
 jER152: Phenol novolac epoxy resin, produced by Japan Epoxy Resin  
 jER154: Phenol novolac epoxy resin, produced by Japan Epoxy Resin  
 EPICLON N-660: Cresol novolac epoxy resin, produced by DIC

## EP 2 527 151 B1

CELLOXIDE2021: 3, 4-epoxy cyclohexenyl methyl-3', 4'-epoxy cyclohexene carboxylate, produced by Daicel Chemical Industries, Ltd.

UVI6992: Photo-cationic polymerization initiator, produced by Dow Chemical Co.

ADEKA OPTOMER SP-170: Photo-cationic polymerization initiator, produced by ADEKA

ADEKA OPTON CP-77: Thermal-cationic polymerization initiator, produced by ADEKA

Microcapsule 1 (produced by the above procedure)

Microcapsule 2 (produced by the above procedure)

2-methyl imidazole (thermal-anionic polymerization initiator)

Boron trifluoride aniline (thermal-cationic polymerization initiator)

Silane coupling agent  $\gamma$ -glycidoxy propyl trimethoxy silane

**[0132]** With respect to the prepared head mentioned above, evaluations were carried out based on the following evaluation criteria and the results were listed in Table 3.

<<Evaluation of Ejection>>

**[0133]** Into each inkjet recording head prepared above, an ink which consisted of 70 : 30 mixed solution of butoxyethyl acetate and cyclohexanone was introduced and the ink was ejected by a pulse signal sent from the drive circuit to the head. Ink ejection state from nozzles was observed.

A: Ink was ejected from all nozzles. All ejection angles were within  $\pm 1$  degree.

B: Ink was ejected from all nozzles.

Ejection angle from some nozzle exceeded the range of  $\pm 1$  degree.

C: No ink ejection was observed in some nozzles due to the adhesive inflow.

<<Durability evaluation of Adhesive strength>>

**[0134]** Ink which consisted of cyclohexanone (SP value: 20.3) or anisole (SP value: 19.4) was filled into the head. Ink inlet was plugged and the nozzle surface was capped, so that the ink filled in the head may not be lost by evaporation during storage. Head was stored in oven at 60 °C for one month. The head was taken out from the oven and the end of the nozzle plate of each inkjet recording head was grasped and pulled by using tweezers. The head on which the nozzle plate did not separate was stored further 1 month (total of 2 months) in the same condition. The head on which the nozzle plate did not separate after 2 months was stored further one month (total of 3 months) in the same condition by filling up with the same ink. Then head was examined by the pulling test by tweezers.

A: Nozzle plate did not separate after storage of 3 months due to slippery of tweezers.

B: Nozzle plate did not separate after storage of 2 months, but separated after 3 months.

C: Nozzle plate did not separate after storage of 1 month, but separated after 2 months.

D: Nozzle plate separated after storage of 1 month.

Table 1

| Inkjet head | Adhesive | Epoxy resin |        |        |        |               |                | Photo-cationic initiator |                      | Remarks |
|-------------|----------|-------------|--------|--------|--------|---------------|----------------|--------------------------|----------------------|---------|
|             |          | JER807      | JER827 | JER152 | JER154 | EPICLON N-660 | CELLOXIDE 2021 | UVI6992                  | ADEKA OPTOMER SP-170 |         |
| 1           | 1        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 2           | 2        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 3           | 3        | 40          | -      | 15     | -      | -             | 45             | 4                        | -                    | Inv.    |
| 4           | 4        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 5           | 5        | 70          | -      | 30     | -      | -             | -              | 4                        | -                    | Inv.    |
| 6           | 6        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 7           | 7        | 94          | -      | 6      | -      | -             | -              | 4                        | -                    | Inv.    |
| 8           | 8        | 55          | -      | 45     | -      | -             | -              | 4                        | -                    | Inv.    |
| 9           | 9        | 40          | -      | 60     | -      | -             | -              | 4                        | -                    | Comp.   |
| 10          | 10       | 90          | -      | -      | 10     | -             | -              | 4                        | -                    | Inv.    |
| 11          | 11       | 90          | -      | -      | -      | 10            | -              | 4                        | -                    | Inv.    |
| 12          | 12       | 83          | -      | 15     | -      | -             | 2              | 4                        | -                    | Inv.    |
| 13          | 1        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 14          | 1        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 15          | 1        | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 16          | 13       | -           | 90     | 10     | -      | -             | -              | 4                        | -                    | Inv.    |
| 17          | 14       | 96          | -      | 4      | -      | -             | -              | 4                        | -                    | Comp.   |
| 18          | 15       | 100         | -      | -      | -      | -             | -              | 4                        | -                    | Comp.   |
| 19          | 16       | 100         | -      | -      | -      | -             | -              | 4                        | -                    | Comp.   |
| 20          | 17       | 50          | -      | -      | -      | -             | 50             | 4                        | -                    | Comp.   |
| 21          | 18       | 100         | -      | -      | -      | -             | -              | 4                        | -                    | Comp.   |
| 22          | 19       | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Comp.   |
| 23          | 20       | 90          | -      | 10     | -      | -             | -              | 4                        | -                    | Comp.   |
| 24          | 21       | 50          | -      | -      | -      | -             | 50             | -                        | 2                    | Comp.   |

Table 2

| Inkjet head | Adhesive | Thermal curing agent |                |                    |                                 |                   | Silane coupling agent | Adhesive thickness (μm) | Remarks |
|-------------|----------|----------------------|----------------|--------------------|---------------------------------|-------------------|-----------------------|-------------------------|---------|
|             |          | Microcapsule 1       | Microcapsule 2 | 2-Methyl imidazole | Boron trifluoride aniline based | ADEKA OPTON CP-77 |                       |                         |         |
| 1           | 1        | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 2           | 2        | -                    | 10             | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 3           | 3        | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 4           | 4        | 40                   | -              | -                  | -                               | -                 | 5                     | 5                       | Inv.    |
| 5           | 5        | 40                   | -              | -                  | -                               | -                 | 10                    | 5                       | Inv.    |
| 6           | 6        | 40                   | -              | -                  | -                               | -                 | 0.7                   | 5                       | Inv.    |
| 7           | 7        | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 8           | 8        | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 9           | 9        | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Comp.   |
| 10          | 10       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 11          | 11       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 12          | 12       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 13          | 1        | 40                   | -              | -                  | -                               | -                 | -                     | 0.5                     | Inv.    |
| 14          | 1        | 40                   | -              | -                  | -                               | -                 | -                     | 20                      | Inv.    |
| 15          | 1        | 40                   | -              | -                  | -                               | -                 | -                     | 27                      | Inv.    |
| 16          | 13       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Inv.    |
| 17          | 14       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Comp.   |
| 18          | 15       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Comp.   |
| 19          | 16       | -                    | 20             | -                  | -                               | -                 | -                     | 5                       | Comp.   |
| 20          | 17       | 40                   | -              | -                  | -                               | -                 | -                     | 5                       | Comp.   |
| 21          | 18       | 40                   | -              | -                  | -                               | -                 | 5                     | 5                       | Comp.   |
| 22          | 19       | -                    | -              | 10                 | -                               | -                 | -                     | 5                       | Comp.   |
| 23          | 20       | -                    | -              | -                  | 5                               | -                 | -                     | 5                       | Comp.   |
| 24          | 21       | -                    | -              | -                  | -                               | 0.4               | 3                     | 5                       | Comp.   |

Table 3

| Inkjet head                                         | Adhesive | Evaluation                                                  |                                |          |                                 |             | Remarks |
|-----------------------------------------------------|----------|-------------------------------------------------------------|--------------------------------|----------|---------------------------------|-------------|---------|
|                                                     |          | Required irradiation amount for curing (J/cm <sup>2</sup> ) | Void disappearance in adhesive | Ejection | Durability of Adhesive strength |             |         |
|                                                     |          |                                                             |                                |          | Cyclohexanone ink               | Anisole ink |         |
| 1                                                   | 1        | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 2                                                   | 2        | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 3                                                   | 3        | 2                                                           | A                              | A        | A                               | B           | Inv.    |
| 4                                                   | 4        | 5                                                           | A                              | A        | A                               | A           | Inv.    |
| 5                                                   | 5        | 10                                                          | A                              | B        | A                               | A           | Inv.    |
| 6                                                   | 6        | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 7                                                   | 7        | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 8                                                   | 8        | 2                                                           | A                              | A        | A                               | A           | Inv.    |
| 9                                                   | 9        | 2                                                           | B                              | A        | A                               | A           | Comp.   |
| 10                                                  | 10       | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 11                                                  | 11       | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 12                                                  | 12       | 3                                                           | A                              | A        | A                               | B           | Inv.    |
| 13                                                  | 1        | 5                                                           | A                              | B        | B                               | B           | Inv.    |
| 14                                                  | 1        | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 15                                                  | 1        | 10                                                          | A                              | B        | A                               | B           | Inv.    |
| 16                                                  | 13       | 5                                                           | A                              | A        | A                               | B           | Inv.    |
| 17                                                  | 14       | 5                                                           | A                              | B        | B                               | B           | Comp.   |
| 18                                                  | 15       | 10                                                          | C                              | B        | D                               | D           | Comp.   |
| 19                                                  | 16       | 5                                                           | C                              | B        | D                               | D           | Comp.   |
| 20                                                  | 17       | 10                                                          | C                              | C        | D                               | D           | Comp.   |
| 21                                                  | 18       | 10                                                          | C                              | C        | D                               | D           | Comp.   |
| 22                                                  | 19       | 10                                                          | C                              | C        | D                               | D           | Comp.   |
| 23                                                  | 20       | 5                                                           | C                              | B        | D                               | D           | Comp.   |
| 24                                                  | 21       | 5                                                           | C                              | B        | D                               | D           | Comp.   |
| Inv.: Inventive Example, Comp.: Comparative Example |          |                                                             |                                |          |                                 |             |         |

[0135] The results described in Tables 1 to 3 clearly show that by using the adhesive and the method for manufacturing an inkjet head of the present invention, excellent work efficiency of bonding nozzle plate, no ejection failure caused by the adhesive inflow into an unnecessary portion, and excellent durability of adhesive strength to a solvent ink in long term use can be provided.

#### DESCRIPTION OF THE ALPHANUMERIC DESIGNATIONS

[0136]

- 1 Head chip
- 11: Flow path component
- 12 Pressure chamber

- 13 Metal layer
- 14 Connecting electrode
- 2 Nozzle plate
- 21 Nozzle
- 5 3 Wiring substrate
- 31 Wiring taminal area
- 32 Opening
- 33 Wiring electrode
- 36a Dummy electrode
- 10 35 Bonding area

## Claims

- 15 1. A method for manufacturing an inkjet head, wherein a process of bonding a plurality of members with an adhesive (15) containing an epoxy resin containing a novolac type epoxy resin, at least another epoxy resin, a photo-cationic polymerization initiator and a microcapsulated thermosetting agent sequentially has:
  - 20 a step of applying the adhesive to one of the members;
  - a step of bonding the members;
  - a step of irradiating the protruding portion of the adhesive with light; and
  - a heating step;
  - and wherein 5 to 50% by mass is the novolac type epoxy resin among the epoxy resins.
- 25 2. The method for manufacturing an inkjet head of claim 1, wherein the adhesive (15) comprises a silane coupling agent.
3. The method for manufacturing an inkjet head of claim 1 or 2, wherein the adhesive (15) comprises an alicyclic epoxy compound.
- 30 4. The method for manufacturing an inkjet head of any one of claims 1 to 3, wherein the thermosetting agent comprises a thermal-anionic polymerization initiator.
5. The method for manufacturing an inkjet head of any one of claims 1 to 4, wherein a thickness of the coated adhesive (15) is 1 - 25  $\mu\text{m}$  in the step of applying the adhesive (15) to one of the members.

## Patentansprüche

- 40 1. Verfahren zur Herstellung eines Tintenstrahlkopfes, wobei ein Vorgang zum Verbinden einer Vielzahl von Elementen mit einem Klebstoff (15), der ein ein Epoxidharz der Art Novolac aufweisendes Epoxidharz, zumindest ein weiteres Epoxidharz, einen photo-kationischen Polymerisationsinitiator und ein mikroverkapseltes wärmehärtendes Mittel enthält, nacheinander die folgenden Schritte aufweist:
  - 45 einen Schritt zum Aufbringen des Klebstoffs auf eines der Elemente;
  - einen Schritt des Verbindens der Elemente;
  - einen Schritt zur Bestrahlung des überstehenden Bereichs des Klebstoffs mit Licht; und
  - einen Erwärmungsschritt;
  - und wobei 5 bis 50 Masse-% von dem Epoxidharz der Art Novolac bei den Epoxidharzen gebildet sind.
- 50 2. Verfahren zur Herstellung eines Tintenstrahlkopfes gemäß Anspruch 1, wobei der Klebstoff (15) einen Silanhaftvermittler aufweist.
3. Verfahren zur Herstellung eines Tintenstrahlkopfes gemäß Anspruch 1 oder 2, wobei der Klebstoff (15) eine alizyklische Epoxidverbindung aufweist.
- 55 4. Verfahren zur Herstellung eines Tintenstrahlkopfes gemäß irgendeinem der Ansprüche 1 bis 3, wobei das wärme-aushärtende Mittel einen thermischanionischen Polymerisationsinitiator aufweist.

5. Verfahren zur Herstellung eines Tintenstrahlkopfes gemäß irgendeinem der Ansprüche 1 bis 4, wobei eine Dicke der Klebstoffschicht (15) in dem Schritt des Aufbringens des Klebstoffs (15) auf eines der Elemente 1 - 25  $\mu\text{m}$  beträgt.

## Revendications

1. Procédé de fabrication d'une tête à jet d'encre, dans lequel une opération de relier une pluralité d'éléments par moyen d'un adhésif (15) contenant une résine époxy contenant une résine époxy du type novolaque, au moins une autre résine époxy, un initiateur de polymérisation photo-cationique et un agent thermodurcissable micro-encapsulé comprend successivement :

une étape d'application de l'adhésif sur un des éléments ;  
 une étape de liaison des éléments les uns aux autres ;  
 une étape d'irradiation de la partie saillante de l'adhésif avec de la lumière ; et  
 une étape de chauffage ;  
 et dans lequel 5 à 50 % en masse des résines époxy sont formées par la résine époxy du type novolaque.

2. Procédé de fabrication d'une tête à jet d'encre selon la revendication 1, dans lequel l'adhésif (15) comprend un agent de couplage de silane.

3. Procédé de fabrication d'une tête à jet d'encre selon la revendication 1 ou la revendication 2, dans lequel l'adhésif (15) comprend un composé époxy alicyclique.

4. Procédé de fabrication d'une tête à jet d'encre selon l'une quelconque des revendications 1 à 3, dans lequel l'agent thermodurcissable comprend un initiateur de polymérisation thermique-anionique.

5. Procédé de fabrication d'une tête à jet d'encre selon l'une quelconque des revendications 1 à 4, dans lequel une épaisseur de la couche d'adhésif (15) est comprise entre 1 et 25  $\mu\text{m}$  dans l'étape d'application de l'adhésif (15) sur un des éléments.

FIG. 1

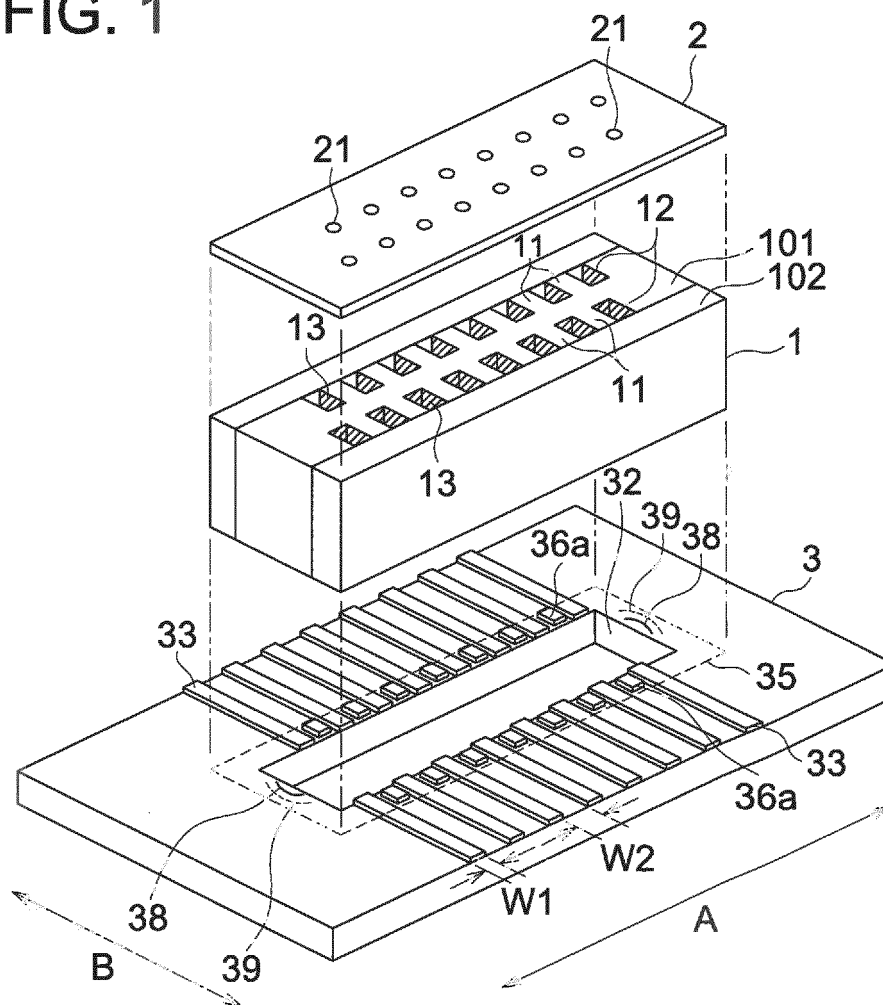


FIG. 2

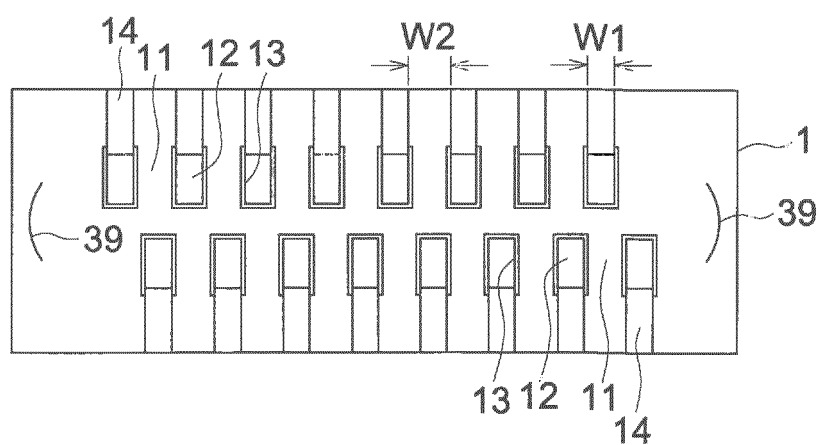
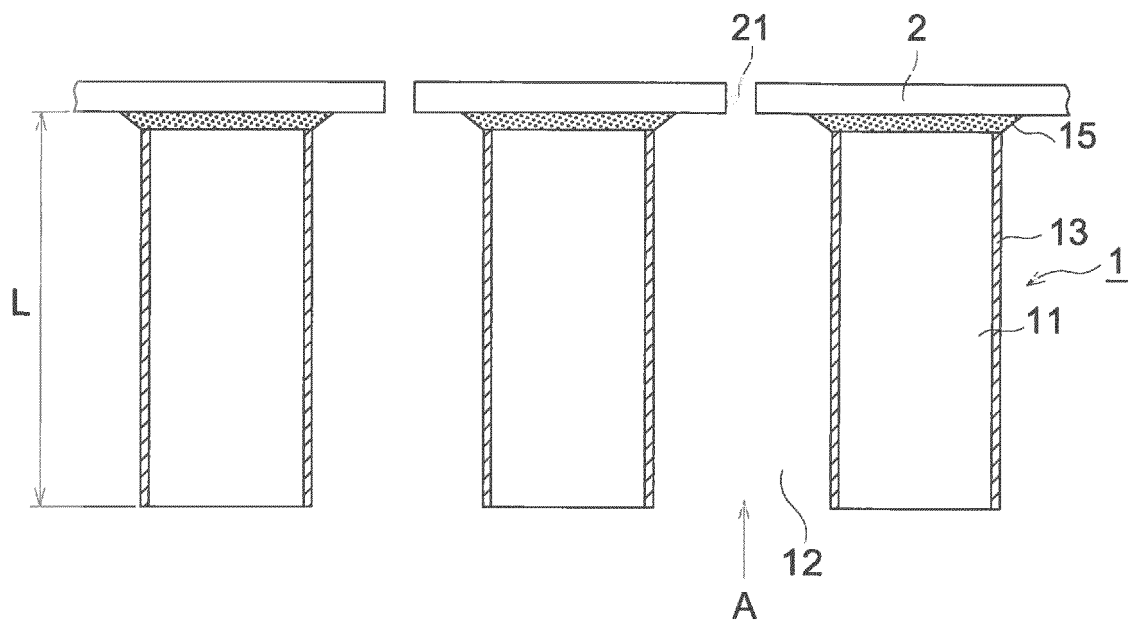


FIG. 3



## REFERENCES CITED IN THE DESCRIPTION

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