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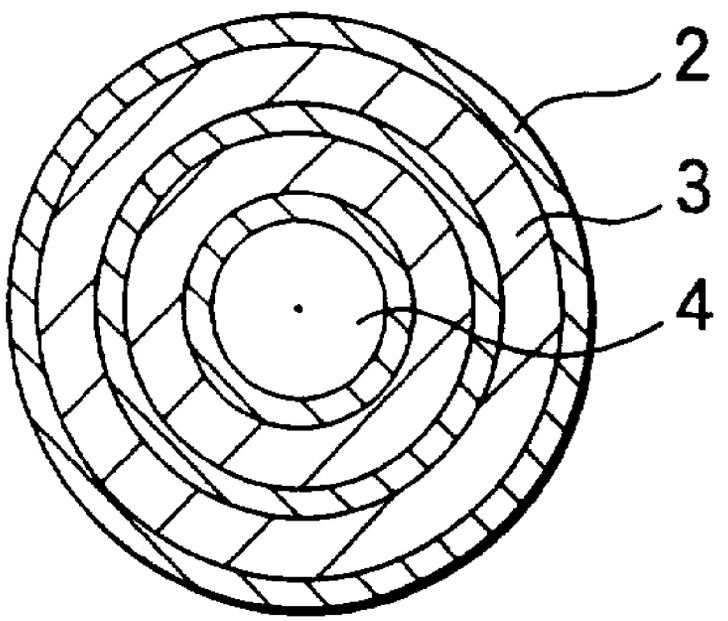
(54) Ink jet recording head and method for manufacturing the same

(57) An ink jet recording head is formed by the steps of dipping a cavity pattern member alternately in a solution of an electrode material and in a solution of a piezoelectric material, with a drying step interposed therebetween, to form a unitary body of the cavity pattern member and a laminate of the electric material and the piezoelectric material, and removing the cavity pattern member from the unitary body to form an ink cavity inside the laminate. The ink cavity has a circular cross-section and has a dimensional accuracy. The piezoelectric films can apply a uniform pressure for jetting of ink. A simple process for manufacturing the ink jet recording head reduces the costs thereof.

FIG. 5



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Description

The present invention relates to an ink jet recording head and, more particularly, to an ink jet recording head of a printer including a laminated piezoelectric element, and a method for manufacturing the same.

As well known, an ink jet recording head of a printer including laminated piezoelectric elements utilizes a piezoelectric effect for jetting ink droplets through a plurality of ink jet nozzles from pressure chambers each forming an ink cavity.

Fig. 1 is a flowchart showing a conventional method for manufacturing a conventional ink jet recording head, while Fig. 2 is a partial cross-sectional view of the conventional ink jet recording head at consecutive steps effected by the process of Fig. 1. A number of cavity pattern members 5 made of a photosensitive resin as shown in Fig. 2A and each having a shape of a rectangular prism are prepared in step S10. In step S11, the cavity pattern members 5 are arranged and bonded, in a row extending horizontally as viewed in the drawing, to a surface of an elongate sheet of a piezoelectric material (first piezoelectric sheet) by thermocompression, following which a resin of the piezoelectric material is applied to the surfaces of the cavity pattern members 5 and the piezoelectric sheet to thereby form a body in which a row of the cavity pattern members 5 are enclosed by the piezoelectric material 6a, as shown in Fig. 2B.

In step S12, a plurality of second piezoelectric sheets 6b each having a row of electrode films 7 printed thereon and having a shape similar to that of the first piezoelectric sheet are layered on the both surface of the body, as shown in Fig. 2C, and bonded thereto by compression to form a sub-assembly. In S13, a heat treatment is conducted to the sub-assembly for removing a binder and the cavity pattern members 5, the binder being contained in the piezoelectric sheets for bonding the piezoelectric sheets to corresponding one of the electrode films. The cavity pattern members 5 are then removed to form ink cavities 8 inside the sub-assembly. Subsequently, the sub-assembly is sintered to obtain the product as shown in Fig. 2D in step S14. A plurality of the resultant products are further layered one on another to form an assembly of an ink jet recording head.

With the conventional method for manufacturing an ink jet recording head of the type as described above, however, the number of steps in the process is large so that it is difficult to reduce the costs of the manufacture. Moreover, after the piezoelectric sheets and the cavity pattern members made of the photosensitive resin are bonded together by compression, a gap is often formed between th piezoelectric material and the cavity pattern members, as a result of which a problem arises that each of the resultant ink cavities does not have a dimensional accuracy.

In view of the foregoing, an object of the present invention is to provide an ink jet recording head which is easy to manufacture, which has a higher dimensional accuracy, and which can reduce costs, and to provide a method for manufacturing the same.

According to the present invention, there is provided an ink jet recording head having an ink jet cavity surrounded or defined by a surface of a laminate of a plurality of electrode films and a plurality of piezoelectric films formed alternately with the plurality of piezoelectric films.

The present invention also provides a method for manufacturing an ink jet recording head including the steps of: repeating consecutively dipping a cavity pattern member into a first solution of an electrode material, drying the resultant cavity pattern member, dipping the resultant cavity pattern member into a second solution of a piezoelectric material, and drying the resultant cavity member, to thereby form a unitary body of the cavity pattern member and a laminate of electrode films and piezoelectric films surrounding the cavity pattern members; removing the cavity pattern member from the unitary body to form an ink cavity inside the laminate.

In accordance with the ink jet recording head of the present invention, each of the ink cavities has a dimensional accuracy and is easy to manufacture so that the costs of the ink jet recording head can be reduced.

The above and other objects, features and advantages of the present invention will be more apparent from the following description, taken in conjunction with the annexed drawings.

Fig. 1 is a flowchart showing a conventional process for manufacturing a conventional ink jet recording head;

Figs 2A, 2B, 2C and 2D are cross-sectional views showing the conventional ink jet recording head at the consecutive steps of the conventional process of Fig. 1;

Fig. 3A is a perspective view of cavity pattern members used for manufacturing a ink jet recording head according to an embodiment of the present invention;

Fig. 3B is schematic cross-sectional view of tanks used for the process of manufacturing the ink jet recording head according to the embodiment;

Fig. 4 is a flowchart showing a process for manufacturing the ink jet recording head by using the cavity pattern members of Fig. 3A; and

Fig. 5 is a cross-sectional view of a portion around an ink jet cavity of the ink jet recording head manufactured by the process of Fig. 4.

The present invention will now be described in more detail with reference to the preferred embodiment.

Referring to Fig. 3A, there are schematically shown cavity pattern members 1 as used for manufacturing an ink jet recording head according to an embodiment of the present invention. The cavity pattern members 1 are made of, for example, a photosensitive resin. Each of the cavity pattern member 1 is comprised of a pressure chamber forming portion 1a, which defines a cylindrical

pressure chamber at the outer surface thereof, and cylindrical passage forming portions 1b, which are formed at both ends of the pressure chamber forming portion 1a and have a smaller diameter to define a passage for an ink flow at the surface thereof. A number of cavity pattern members 1 are arranged at a predetermined pitch by fixing members 1c with the passage forming portions 1b fixed thereto.

Fig. 4 shows a procedure for manufacturing the ink jet recording head according to the embodiment of the present invention. First, in step S1, cavity pattern members 1 as shown in Fig. 3A are formed from a photosensitive resin and fixed to fixing members 1c. Subsequently, the cavity pattern members 1 are dipped into a solution 12 including an electrode material such as platinum (Pt) contained in a first tank 2a as shown in Fig. 3B for a predetermined period of time. The solution further includes a solvent of a binder for bonding the electrode material to the cavity pattern members 1. The resultant members are taken out from the first tank 2a for drying in step S3. Thus the cavity pattern member is coated by an electrode film.

Thereafter, in step S4, the resultant members are further dipped for a predetermined period of time in a solution 13 of a piezoelectric material including a combination of, for example, PbO_3, $PbTiO_3$ and $PbZrO_3$ contained in a second tank 3a, and then taken out from the second tank 3a for subsequent drying in step S5. Thus, a piezoelectric film is formed on the electrode film. The steps S2 through S5 are repeated a plurality of times, for example three times. Thus, unitary bodies of the cavity pattern member and a laminate of the electrode films and the piezoelectric films are obtained. A group of unitary bodies are arranged in a matrix to form an assembly for the ink jet recording head. Each of the resultant matrix of the unitary bodies does not have substantially any gap between the cavity pattern member and the laminate.

Subsequently, in step S6, a heat treatment is conducted at a temperature of about 500°C for a relatively long period of time to melt the photosensitive resin and to melt the solvent of the binder. Thus, the cavity pattern members 1 are removed from the assembly to form an arrow of ink cavities 4 each including a pressure chamber and passages. At a final step S7, sintering is conducted for the resultant assembly at a temperature of 1200°C to obtain an ink jet recording head according to the present embodiment.

Fig. 5 shows a cross-section of a portion of one of the ink cavities in the ink jet recording head obtained by the process as described above. In this example, a central, circular ink cavity 4 is surrounded by a concentric laminate of three electrode films 2 and three piezoelectric films 3 formed alternately with the electrode films 2. The radius of the cavities is, for example, between 0.02 and 0.1 mm.

As described above, the laminate of the electrode films 2 and the piezoelectric films 3 is formed around the cavity pattern members 1, substantially without any gap therebetween. As a result, after the cavity pattern members 1 are removed, each of the resultant ink cavities 4 has an accurate dimension. Also, since the electrode films 2 and the piezoelectric films 3 are layered merely by dipping in solutions and subsequent drying, the process is quite simple, thereby reducing costs of the ink jet recording head.

In operation of the ink jet recording head as described above, a control signal for the ink jet recording head is supplied through the electrode films to operate the piezoelectric films for a piezoelectric function. The piezoelectric films 3 are concentrically formed around the ink cavity 4, so that a uniform pressure for jetting of ink can be applied from the entire circumferential wall of the ink cavity 4. This enables a smooth jetting of the ink.

The cavity pattern member may have any three-dimensional shape such as a cylinder or a rectangular prism. The three-dimensional configuration of the ink cavity allows ink to smoothly flow therein.

In the above embodiment, the cavity pattern members are formed of a photosensitive resin. However, the material of the cavity pattern members is not limited to a photosensitive resin, but may be any of materials, such as carbon, provided that the material can be removed after formation of the laminate. If carbon is used for the material, the cavity pattern member can be removed by the sintering step (S7 in Fig.2).

Since above embodiment is described only for examples, the present invention is not limited to such an embodiment and it will be obvious for those skilled in the art that various modifications or alterations can be easily made based on the above embodiment within the scope of the present invention.

Claims

1. An ink jet recording head having a laminate including a plurality of electrode films (2) and a plurality of piezoelectric films (3) formed alternately with said plurality of electrode films (2), characterized in that an inner surface of said laminate defining an ink cavity (4) for flowing ink therein.

2. An ink jet recording head according to Claim 1, wherein said ink cavity (4) is of a cylinder.

3. An ink jet recording head according to Claim 1, wherein said ink cavity (4) is of a rectangular prism.

4. A method for manufacturing an ink jet recording head characterized by the steps of: repeating consecutively dipping a cavity pattern member (1) into a first solution (12) of an electrode material, drying the resultant cavity pattern member, dipping the resultant cavity pattern member into a second solution (13) of a piezoelectric material, and drying the resultant cavity member, to thereby form a unitary body of the cavity pattern member (1) and a laminate of electrode films (2) and piezoelectric films (3); removing the cavity pattern member (1) from the uni-

tary body to form an ink cavity (4) inside the laminate (2,3).

5. A method as claimed in Claim 4 wherein the cavity pattern member (1) is made of a photosensitive resin.

6. A method for manufacturing an ink het recording head as claimed in Claim 4 wherein the cavity pattern member (1) is made of carbon.

7. A method as claimed in Claim 4, 5, or 6, wherein the electrode material includes a metal and a binder for bonding the metal to the piezoelectric material.

FIG. 1

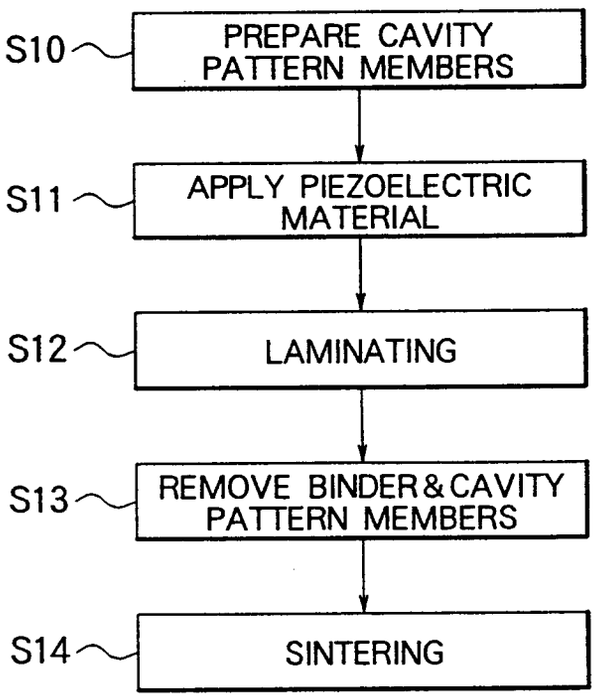


FIG. 2A

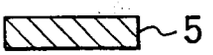


FIG. 2B

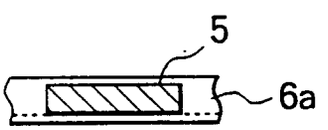


FIG. 2C

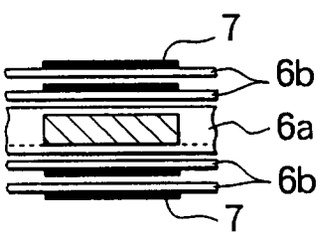


FIG. 2D

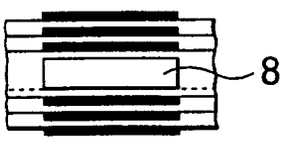


FIG. 3A

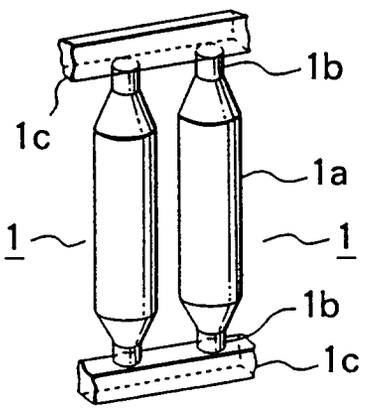


FIG. 3B

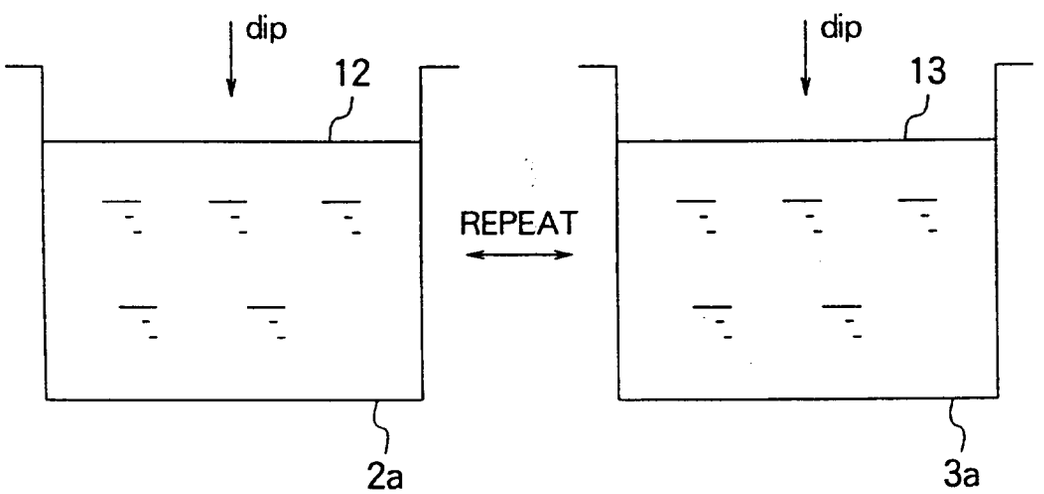


FIG. 4

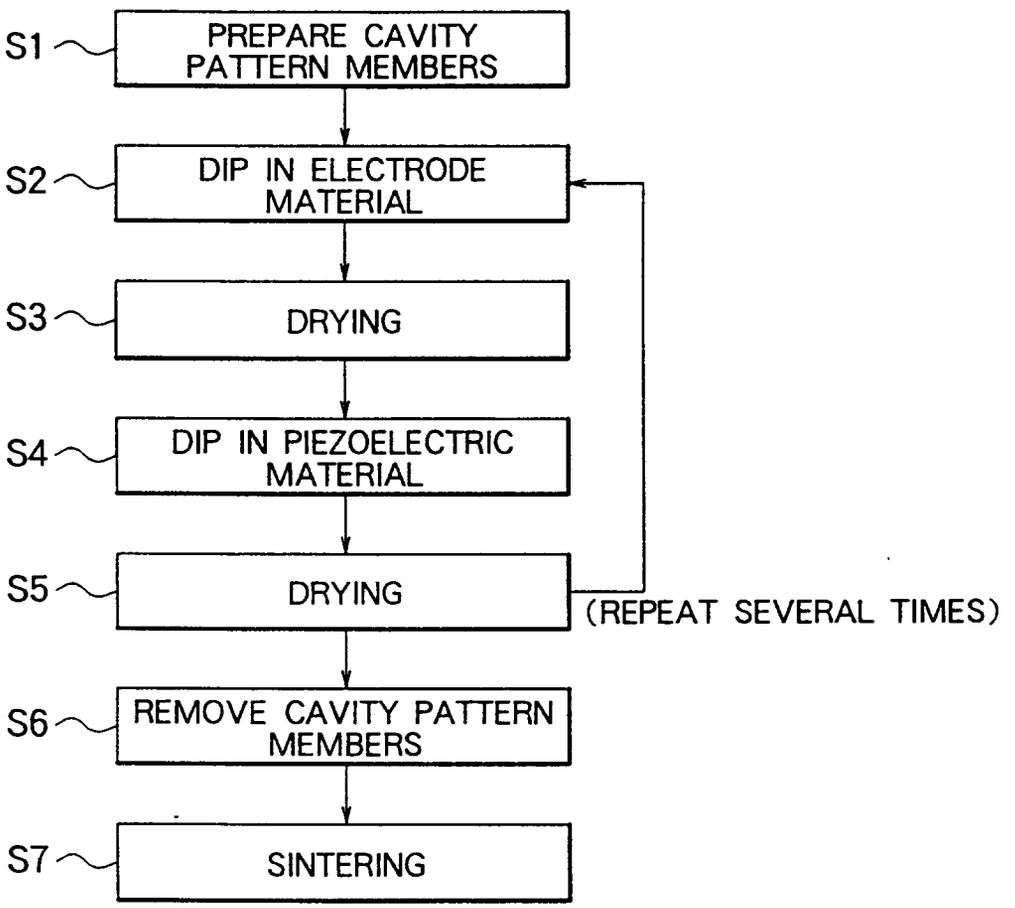
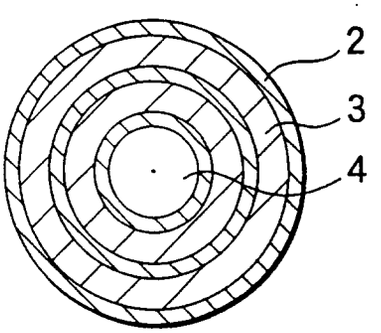

S1
PREPARE CAVITY PATTERN MEMBERS
S2
DIP IN ELECTRODE MATERIAL
S3
DRYING
S4
DIP IN PIEZOELECTRIC MATERIAL
S5
DRYING
(REPEAT SEVERAL TIMES)
S6
REMOVE CAVITY PATTERN MEMBERS
S7
SINTERING

FIG. 5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3
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