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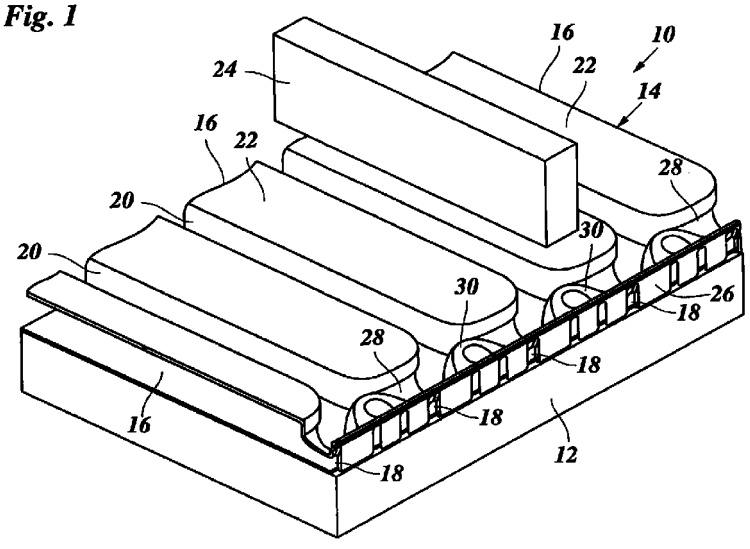
(54) Inkjet printhead

(57) Ink jet printhead comprising:

- at least one ink channel (16) connected to a nozzle (18) and defined between to opposed side walls (20);
- a membrane (22) interconnecting the side walls; and
- actuating means (24) arranged adjacent to the membrane (22) for deflecting the same,

characterized in that the side walls (20) and the membrane (22) are formed by a one-piece member (14).

Fig. 1



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Description

[0001] The invention relates to an ink jet printhead comprising at least one ink channel connected to a nozzle and defined between two opposed side walls; a membrane interconnecting the side walls; and actuating means arranged adjacent to the membrane for deflecting the same.

[0002] A conventional printhead of the type, which is disclosed for example in EP-A-0 819 524, comprises a plurality of ink channels which are arranged side by side so that the associated nozzles form a linear nozzle array. The ink channels and the nozzles are formed by grooves cut into the surface of a substrate which may for example be made of silicon. The membranes for the various ink channels are formed by a continuous thin sheet which is overlaid on the substrate so that it covers the open top sides of the grooves. This sheet has to be firmly bonded to the regions of the substrate defining the side walls of the ink channels. The actuators are formed by piezo-electric fingers which are supported by a common backing plate and have their respective free ends bonded to the top surfaces of the membranes, so that, when a voltage is applied to an individual one of the piezo-electric fingers, the corresponding membrane is flexed into the volume of the associated ink channel which is filled liquid ink, so that an ink droplet is expelled from the nozzle.

[0003] US-A-4 657 631 discloses another type of printhead in which the ink channels are formed by groove-like structures in a metal layer which is formed on the flat surface of the substrate. Thus, the bottom wall of each ink channel is formed by a portion of the substrate, and rigid side walls and a rigid top wall are formed by the metal layer. The actuators are disposed inside of each ink channel and are disposed on the surface of the substrate, so that they are directly exposed to the ink liquid without a membrane intervening between the actuator and the ink. This type of printhead can be manufactured by forming a photo-sensitive layer on the surface of the substrate and by exposing and developing this layer, thereby to form a pattern of ridges which have a shape complementary to that of the ink channels, then forming a metal layer on the surface of the substrate by sputtering and subsequent electronic plating, until the ridges are buried in the metal layer, and then removing the photo-sensitive material, so that the ink channels are formed in the metal layer.

[0004] It is an object of the invention to provide an ink jet printhead according to the preamble of claim 1, which can be manufactured more easily and with a higher production yield.

[0005] This object is achieved with the features indicated in claim 1.

[0006] According to the invention, the side walls and the membrane are formed by a one-piece member.

[0007] This construction has the advantage that, on the one hand, the membrane can be made very thin so that it has a higher flexibility, and, on the other hand, the member forming this membrane and the side walls of the ink channels can, as a whole, have a comparatively high structural strength. This greatly facilitates the manufacturing process and makes it possible to achieve a high production yield.

[0008] More specific features of the invention are indicated in the dependent claims.

[0009] Preferably, the one-piece member forming the membranes and the side walls of a plurality of ink channels is a metal foil which is obtained in a growth process such as electroforming. This has the advantage that the membrane can be made very thin and the thickness thereof can be controlled with high accuracy. Further, since the foil can be formed directly on the surface on the substrate, no assembly process nor a separate bonding step is required for forming a complete channel plate including the substrate and the metal foil which forms the membrane and the side walls of the ink channels.

[0010] By forming the metal foil on the surface of a photoresist which has appropriately been shaped by means photolithographic techniques, it is possible to obtain a three-dimensional structure of the foil which forms not only the membrane and the side walls of the ink channels but also the nozzles with appropriate sizes and shapes. The cross-section of the foil in a plane normal to the axis of the ink channels has a meander-like shape, with a space formed between the portions of the foil which define the side walls of two adjacent ink channels. This construction greatly reduces the amount of mechanical or acoustic coupling between the adjacent ink channels, so that cross-talk among the various channels of the printhead is reduced significantly. In addition, this cross-sectional shape of the foil has the effect that the thermal expansion of the channel plate is controlled only by the material of the substrate, e.g. silicon, which is particularly useful when the printhead is used for hot-melt ink and, accordingly, operates and high temperatures.

[0011] Since the nozzles are formed directly by the three-dimensionally structured foil, no mechanical finishing of the nozzle front of the printhead is necessary.

[0012] By providing a thin metal layer on the surface of the substrate on which the foil is applied in a later manufacturing step, it is possible to obtain a design in which the ink channels and, more important, also the nozzles are completely surrounded by only one type of material, i.e. metal, so that the directionality of the droplet-formation process will not be influenced by differences in the adhesiveness of the walls defining the nozzles.

[0013] Preferred embodiments of the invention will now be described in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view of essential parts of an ink jet printhead according to the invention;

Fig. 2 is a perspective bottom view of the printhead with parts of a substrate being removed for illustration purposes;

Fig. 3 is a cross-sectional view of a member defining the ink channels of a printhead according to a modified example; and

Fig. 4-9 illustrate a sequence of steps for manufacturing the printhead according to the invention.

[0014] As is shown in figure 1, an ink jet printhead comprises a channel plate 10 which has a substrate 12 made of silicon, and a three-dimensionally structured metal foil 14 formed on the flat top surface of the substrate 12. The foil 14 defines a plurality of parallel ink channels 16 which are arranged side-by-side and each converge to a nozzle 18, so that the nozzles form a linear array along the front side of the substrate 12. Each ink channel 16 has a pair of opposed side walls 20 which are interconnected by a membrane 22, so that the membrane 22 forms a top wall of the ink channel opposite to the substrate 12. The side walls 20 and membranes 22 of all the ink channels 16 are integrally formed by a one-piece member, i.e. by the metal foil 14.

[0015] The printed further comprises a plurality of piezo-electric actuators 24 only one of which is shown in Fig. 1. The actuators 24 are disposed on each of the membranes 22, so that, when they are electrically energized, they perform expansion stroke, and the membrane 22 flexes into the interior of the ink channel. Thus, when the ink channel is filled with liquid ink, an ink droplet will be expelled from the nozzle 18.

[0016] The foil 14 also forms a front wall 26 in which the nozzles 18 are defined. Each nozzle is connected to the associated ink channel 16 by a funnel portion 28 which is also an integrated part of the foil 14. Further, the foil 14 forms crater-like reinforcement members 30 which are partly cut by the front wall 26 and are provided between the nozzles 18 for improving the structural strength of the front wall 26.

[0017] As can be seen more clearly in Figs. 2 and 3, the foil 14 has a meander-like cross-sectional shape in a plane normal to the longitudinal direction of the ink channels 16, with V-shaped concave spaces 32 formed between the side walls 20 of each pair of adjacent ink channels. Thus, when an individual actuator 24 is energized and an acoustic pressure wave is generated in the ink liquid contained in the associated ink channel 16, the space 32 will prevent this pressure wave from being transmitted to the neighboring ink channels, so that cross-talk among the various channels is avoided. In addition, due to its meander-like cross-section, the foil 14 can behave like an expansion bellow and can adapt itself to thermal expansions of the substrate 12 without causing a distortion of the channel plate 10 as a whole. On the other hand, when exposed to vertical pressure, the foil 14 has a comparatively high strength and is surprisingly robust, even when the thickness of the foil is only in the order of several μm.

[0018] In a typical embodiment, the thickness of the foil in the portion forming the membranes 22 is between 3 and 30 μm, preferably 15 μm, with an accuracy of ±1 μm. This assures a high flexibility of the membranes 22 so that the mechanical energy of the actuators 24 is readily transmitted to the ink liquid. The high level of accuracy in the membrane thickness assures a uniform performance of all the ink channels.

[0019] Fig. 3 illustrates a modified embodiment in which an outwardly projecting ridge or bump 34 is formed along the longitudinal center line of each membrane 22 which allows for a high amount of deflexion of the membrane with little strain on the foil material, even when the width of the actuator 24 is comparatively large.

[0020] A process of manufacturing the channel plate 10 will now be described in conjunction with Figs. 4 - 9.

[0021] At first, as is shown in Fig. 4, a thin layer 36 of metal, e.g. of nickel or nickel alloy is formed on the flat top surface of the substrate 12. The layer 36 covers the whole surface of the substrate with the exception of a portion 38 directly adjacent to the nozzle side of substrate and with the exception of a hole 40 near the rear end of each ink channel. Then, a three-dimensionally structured photoresist 42 is applied on the substrate and on the layer 36 by means of photolithographic techniques. The shape of the photoresist 42 is complementary to the relief of the bottom side of the foil 14 shown in Fig. 2.

[0022] In the next step, the foil 14 is formed on the surface of the layer 36 and on the surface of the photoresist 42 by means of a nickel-electroforming process. The result is shown in Fig. 6. Then, as is shown in Fig. 7, an ink feed channel 44 is formed in the substrate 12 by etching, laser drilling, powder blasting or the like.

[0023] In order to form the nozzle face 46 of the channel plate Fig. 8, a dicing cut is performed in the substrate 12, the photoresist 42, and the foil 14. The plane of this dicing cut is slightly offset from the front wall 26 of the foil 14, so that a small horizontal flange 48 is formed along the upper edge of the front wall 26.

[0024] Finally, the photoresist 42 is removed, so that the ink channel 16 and the nozzle 18 are formed, as is shown in Fig. 9. The ink channel communicates with the ink feed channel 44 through the hole 40 formed in the layer 36. As is also shown in Fig. 9, the front edge of the layer 36 is located in the same longitudinal position as the upper and outer edge of the wall of the nozzle 18, so that the mouth of the nozzle 18 lies in a plane normal to plane of the substrate 12 and is slightly recessed from the main part of the front wall 26. As a result, the droplets will be expelled in a direction strictly aligned with the longitudinal direction of the ink channel, and no finishing needs to be applied to the nozzle face.

Claims

1. Ink jet printhead comprising:

- at least one ink channel (16) connected to a nozzle (18) and defined between to opposed side walls (20);
- a membrane (22) interconnecting the side walls; and
- actuating means (24) arranged adjacent to the membrane (22) for deflecting the same,

characterized in that the side walls (20) and the membrane (22) are formed by a one-piece member (14).

2. Ink jet printhead according to claim 1, wherein the one-piece member (14) is made of metal.

3. Ink jet printhead according to claim 1 or 2, wherein is said one-piece member (14) is a member that has been obtained by a growth process.

4. Ink jet printhead according to claims 2 and 3, wherein is said one-piece member is a metal foil (14) that has been obtained by electroforming.

5. Ink jet printhead according to claim 3 or 4, wherein a side of the ink channel (16) opposite to the membrane (22) is closed by a substrate (12) on which the one-piece member (14) is grown.

6. Ink jet printhead according to any of the preceding claims, wherein the nozzle (18) and a funnel portion (28) connecting the ink channel (16) to the nozzle (18) are also defined by said one-piece member (14).

7. Ink jet printhead according to claims 5 and 6, wherein a portion of the substrate (12) delimiting the ink channel (16), the funnel portion (28) and the nozzle (18) is covered by a layer (36) made of the same material as the one-piece member (14).

8. Ink jet printhead according to any of the preceding claims, comprising a plurality of ink channels (16) arranged side-by-side, so that the associated nozzles (18) from a linear array, wherein said one-piece member is a continuous metal foil (14) forming the side walls (20) and the membranes (22) of the plurality of ink channels and having a meander-shaped cross-section in a plane normal to the ink channels.

9. Ink jet printhead according to claim 8, wherein the metal foil (14) forms a front wall (26) in which the linear array of nozzles (18) is defined and wherein the mouths of the individual nozzles (18) are recessed relative to the front wall (26).

10. Ink jet printhead according to any of the preceding claims, wherein the actuating means (24) engage an outwardly projecting bump (34) formed in a central portion of the membrane (22).

Fig. 1

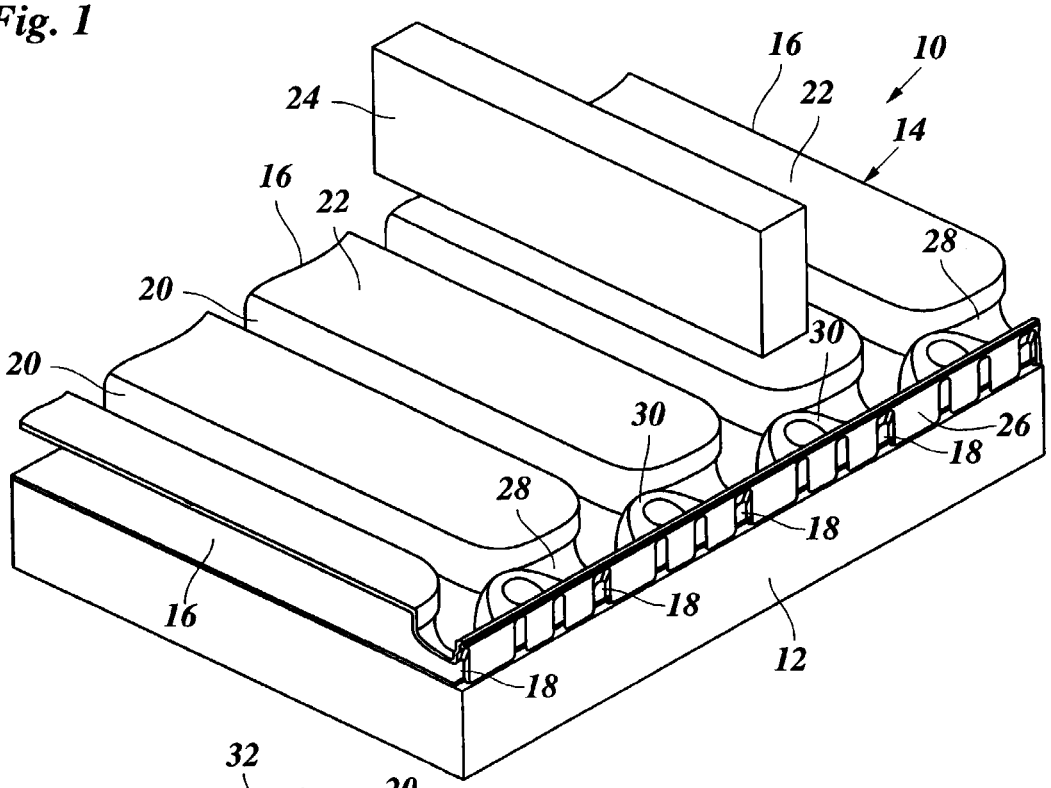


Fig. 2

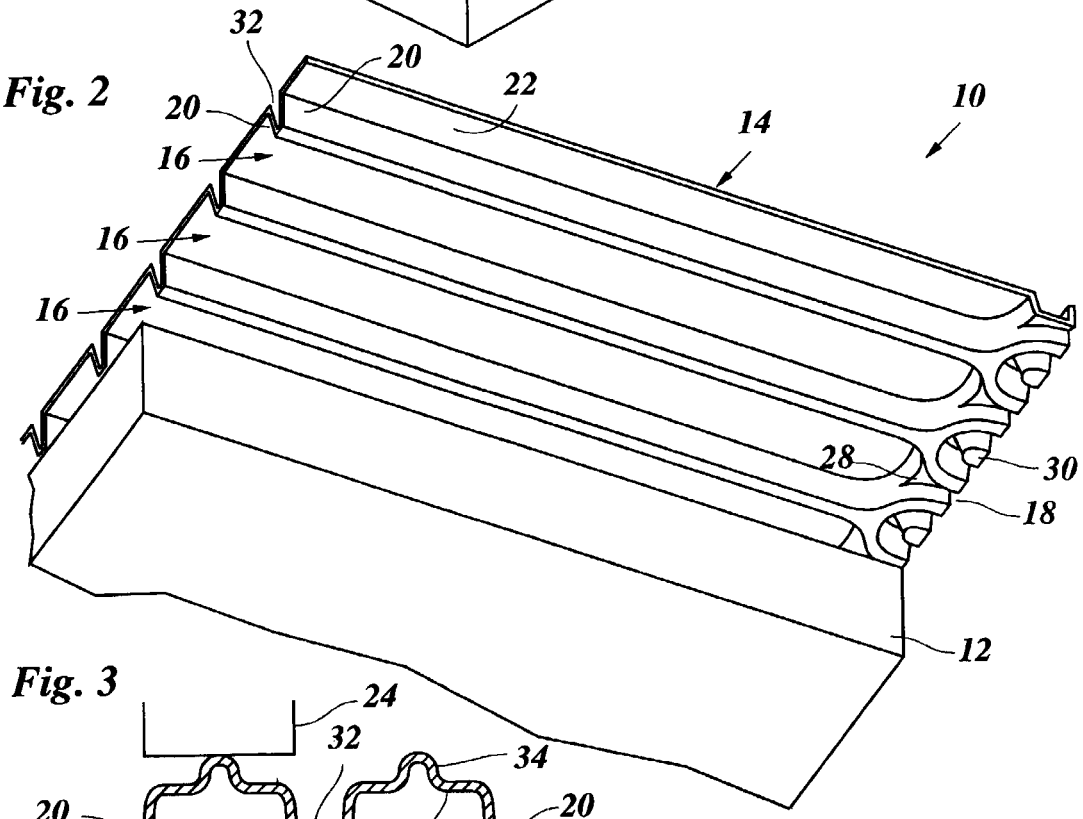


Fig. 3

Fig. 4

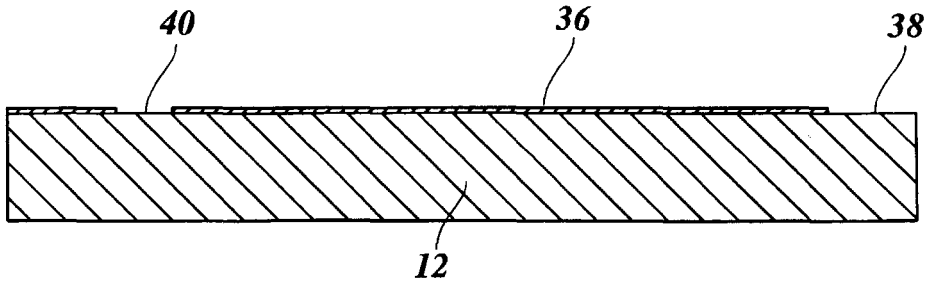


Fig. 5

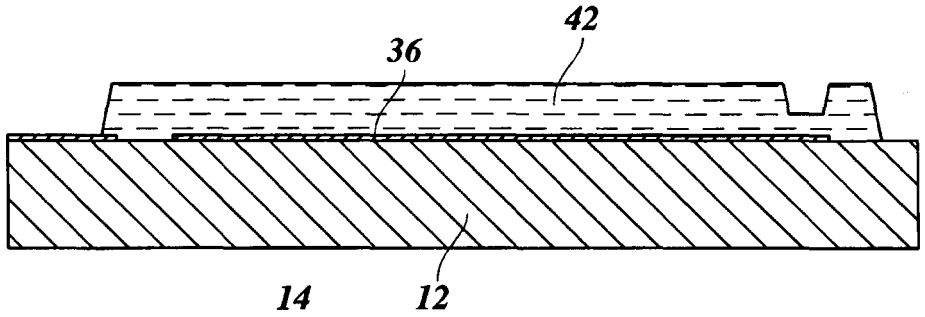


Fig. 6

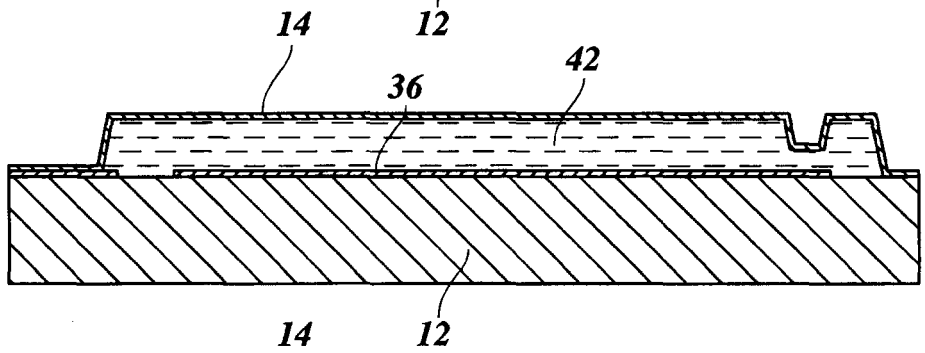


Fig. 7

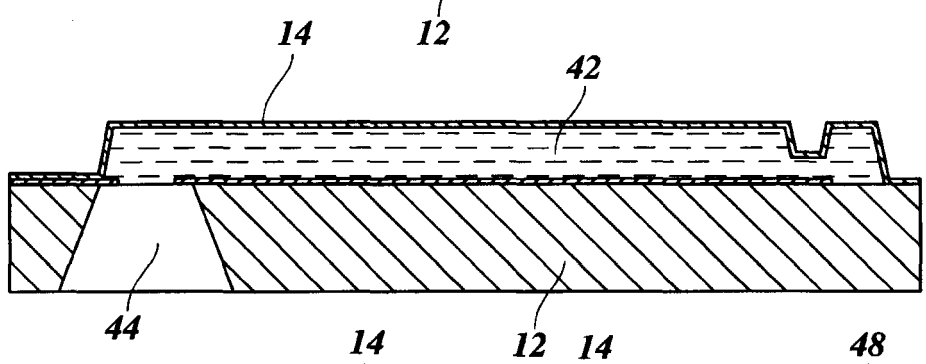


Fig. 8

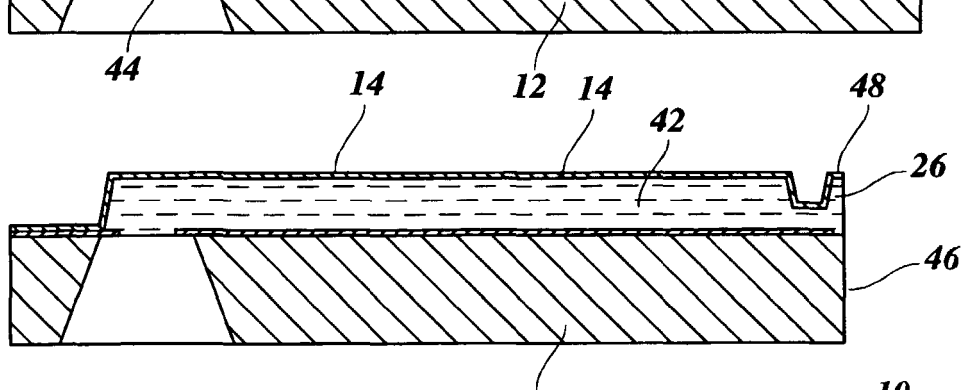
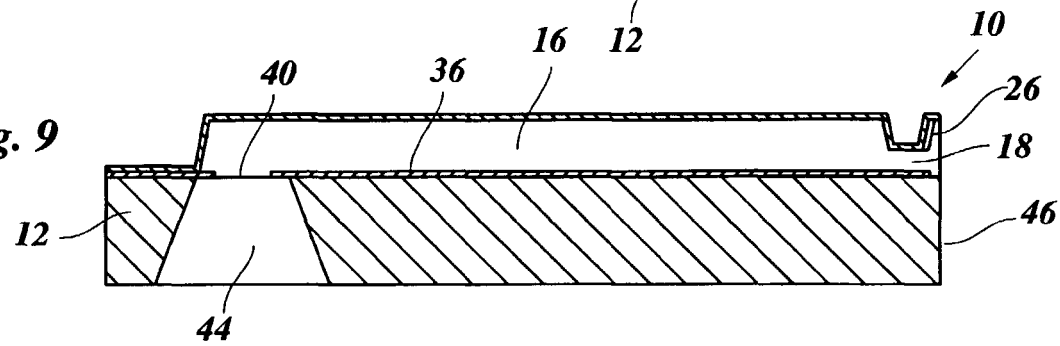


Fig. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 00 20 1374

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 876 582 A (FRAZIER A BRUNO) 2 March 1999 (1999-03-02) * column 5, line 14 - column 7, line 12; figures * * column 8, line 7 - line 37 *	1	B41J2/14
A	EP 0 827 833 A (TOPAZ TECH INC) 11 March 1998 (1998-03-11) * the whole document *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 356 (M-644), 20 November 1987 (1987-11-20) & JP 62 135377 A (NEC CORP), 18 June 1987 (1987-06-18) * abstract *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 August 2000	Meulemans, J-P

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11-08-2000

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