

REMOVAL OF MATERIAL FROM INKJET PRINTHEADS

Technical Field of the Invention

The present invention relates to inkjet printheads, and in particular removal of material from elements of inkjet printheads, at least part of the material being removed by ablation.

Background Art

The process of ablation - also known as photoablative decomposition - is known: see, for example, R. Srinivasan, J. Vac. Sci. Technol. B, Vol 4, page 923 (1983).

Ablation in the context of an inkjet printhead is known from EP-A-0 367 541. In particular, figures 23-28 of this document disclose the manufacture by ablation of nozzles in an inkjet printer nozzle plate prior to the application of a non-wetting coating to the nozzle plate. Such non-wetting coatings, which are well known in the art, have a low surface energy, are ink repellent and thus help to prevent the build-up of ink around the nozzle opening. The nozzle plate has an adhesive layer which is used to bond the nozzle plate to the printhead body. This adhesive layer is protected prior to bonding by a backing layer of polyether or Mylar. During the nozzle formation process, both the adhesive layer and backing tape are removed from those areas where the nozzles are formed.

Ablation in the context of an inkjet printhead is also known from EP-A-0 576 007. According to this document, nozzles are formed in a nozzle plate after application of a non-wetting coating by ablation of the nozzle plate material using a laser beam which impinges on the opposite surface of the nozzle plate to that on which the non-wetting coating is located. A problem associated with this method is shown in figure 4a of the document: where the non-wetting coating layer has a thickness less than 20 nm, a portion of the layer at the periphery of the nozzle is blown away in the course of ablation, leaving an area where no non-wetting layer exists. As a solution to this problem, the document proposes using a thicker non-wetting coating, ablating it with the aid of a covering layer so as to achieve a satisfactory nozzle shape.



EP-A-0 309 146, WO92/16822 and WO93/15911 - belonging to the same applicant as the present invention - also relate to ablation in the context of inkjet printheads. All three documents disclose methods of removing material from an element of an inkjet printhead - in this case a nozzle plate - using a laser beam which impinges on a surface forming or intended to form part of the external surface of the printhead - in this case a surface having a non-wetting coating. Since, in these examples, the laser beam does not ablate the non-wetting coating from the rear, the above-mentioned problem with the non-wetting coating being blown away does not occur.

However, when employing such a method, the originators of the present invention have encountered problems with damage to that surface which is intended to form part of the external surface of the printhead. In the particular case where the surface is the non-wetting coating located around the nozzle exit opening of a printhead, the damage has impaired the performance of the nozzle. Whilst not wishing to be bound by this theory, the originators of the present invention believe that the damage is caused by high energy free radicals and other highly reactive chemical species, liberated during the ablation process, diffusing back onto that surface intended to form part of the external surface of the printhead. Even when a contact mask is located adjacent the surface as per the abovementioned EP-A-0 309 146 and WO 92/16822, the mask lying flush against the surface or having contact pads which surround the area to be ablated, damage still occurs. This would suggest that the aforementioned diffusion is still taking place.

The present invention allows the damage referred to above to be avoided.



Summary of the Invention

According to the present invention, there is provided a method of removing material from an element of an inkjet printhead, said element including an ablatable material and having a surface intended to form part of the external surface of the printhead, the method being characterised by the steps of:

- a) applying a protective layer to be in sealing engagement with said surface;
- b) directing a high energy beam at said protective layer from that side of said element to which said protective layer is applied, thereby removing material from said protective layer and said element having said surface, at least part of the material removed from said element being removed by ablation;
- c) removing said protective layer from said surface.

Applying a protective layer to be in sealing engagement with that surface intended to form part of the external surface of the printhead effectively protects the surface, in particular at the periphery of the zone in which material removal takes place, from the high energy free radical ablation products discussed above.

The protective layer may be of such a constitution - for example a gel - that it establishes by itself a sealing engagement with the surface to be protected. Alternatively, the protective layer may be releasably bonded to said surface, advantageously by the use of an adhesive layer.

Such an adhesive layer may be transparent to the high energy beam. However, it has been discovered that such an adhesive layer can be lifted away from the surface which it is desired to protect around the periphery of the zone of material removal. This is due to the pressure generated underneath the adhesive layer in the course of the ablation of the element of the inkjet printhead, the high energy beam having passed through the transparent adhesive layer without removing it. Whilst this problem can be mitigated by reducing the thickness of the adhesive layer, careful metering of the amount of adhesive applied is nevertheless necessary, since an adhesive layer that is too thin will not provide the level of adhesion necessary for the protective



layer to remain attached to the surface to be protected during the rigours of the process of material removal by high energy beam.

Thus the adhesive layer is advantageously ablatable. This prevents the above-mentioned problem of lifting of the adhesive layer and avoids the requirement that the amount of adhesive applied be carefully metered. Furthermore, the originators of the present invention have discovered that this property prevents refraction of the high energy beam to a location outside of the zone of material removal and the resultant damage to that exterior surface of the printhead located outside of the zone. The UV absorbing characteristic may be an intrinsic property of the adhesive or may be achieved by the use of a UV absorbing additive.

Although not essential to the performance of the invention, the protective layer will advantageously comprise ablatable material. This will allow the protective layer to be removed by the high energy beam during the material removal process and yet be of sufficient thickness that it will effectively protect the surface from the effects of high energy radicals as described above.

The element of the inkjet printhead may be an integral part of the printhead or a separate entity which is attached to the printhead. In the latter case, material removal from the element may take place before or after attachment of the element to the printhead.

The element of an inkjet printhead in question may be of homogeneous construction or may comprise at least two layers. In the former case, the whole element will necessarily be of ablatable material. Although in the latter case only one of the inner layers need be ablatable, if the outer layer is not ablatable it should be sufficiently thin that it will be removed by the high energy beam. Another possibility is for material to be removed from the outer layer only.

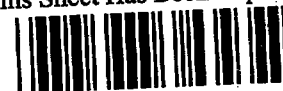
Removal of the protective layer following ablation may be effected mechanically e.g. by peeling, or chemically e.g. by dissolving the layer using a solvent such as acetone, or by a combination of both.



That surface intended to form part of the external surface of the printhead may have non-wetting and/or conductive properties.

It should be noted that there are constraints to the use of the method according to the present invention with a high-energy beam and masking means located adjacent the surface from which material is to be removed, as known for example from EP-A-0 309 146 and WO92/16822 relating to the creation of nozzles in the nozzle plate of an ink jet printhead. In such an application, the separation of the masking means and the surface of the nozzle plate caused by the interposition of a protective layer reduces the angle of taper of the nozzle and/or the nozzle density that can be achieved. These constraints are advantageously avoided by the use of high energy beam that is focussed and/or masked by means located remote of the protective layer. In particular, the mask may be located such that it is the image of the mask that is projected onto the protective layer via an optical focussing system. Such an arrangement is known from WO93/15911, belonging to the applicant of the present invention and incorporated herein by reference.

The present invention is also directed to a protective layer for use in the method of removing material discussed above, the protective layer comprising an ablatable material having an adhesive coating, the adhesive coating being ablatable. Use of such a protective layer solves the problems of metering the adhesive and refraction of the high energy beam, as discussed above. The ablatable property may be an intrinsic property of the adhesive or may be achieved by the addition of a UV absorbing additive. Conveniently, the layer of ablatable material may comprise polyester or polyimide.



Example

The invention will now be described by way of the example of a nozzle plate of an inkjet printhead, the nozzle plate having a surface provided with a non-wetting coating which in turn forms part of the external surface of the completed printhead. Reference is made to the accompanying figures - which are diagrammatic and not to scale - in which

Figure 1 shows the nozzle plate having a non-wetting coating;

Figure 2 shows the nozzle plate having a non-wetting coating and protective layer according to the present invention;

Figure 3 shows the nozzle plate/ non-wetting coating/ protective layer arrangement of the present invention after material removal;

Figure 4 shows the nozzle plate and non-wetting coating after removal of the protective layer.

In figure 1 there is shown a nozzle plate (4) having a non-wetting coating (6) which forms part of the external surface of the printhead. The nozzle plate and non-wetting coating may be of the types disclosed, for example, in EP-A-367 438 belonging to the present applicant and incorporated in the present application by reference. The nozzle plate is attached to a body (2) of an inkjet printhead having ink ejection channels (12). It is noted that correct positioning of each of the nozzles relative to its respective ink ejection channel is conveniently facilitated by attaching the nozzle plate to the printhead body prior to formation of the nozzles.

The nozzle plate may comprise any ablatable material - for example plastics material such as polyimide, polycarbonate, polyester, polyetheretherketone, acrylics or non-vitreous inorganic material such as metal, in particular aluminium, or ceramics. Where a plastics material is used, this may include additives of the kind normally employed with plastics, including organic and/or inorganic fillers.

The non-wetting coating may be of the kind comprising fluorocarbon functional silane and may be formed by the method described in the above-mentioned EP-A-0 367 438, whereby an adherent first layer comprising cured siloxane is formed on the surface of the nozzle plate,

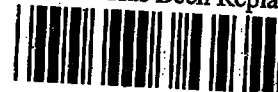


followed by a second layer derived from at least one fluorosilane having a silicon atom to which is attached at least one hydrolysable group and at least one fluorine-containing organic group which donates non-wetting properties to the layer.

Figure 2 shows the nozzle plate and non-wetting coating of figure 1 when provided with a protective layer (10) as per the present invention. This layer is preferably polyester film, for example the polyethylene terephthalate (PET) film sold by ICI under the trade name Melinex (trade mark), or polyimide (PI) film, for example that sold by UBE under the name Upilex (trade mark). Both these materials are ablatable and have a high absorbance of ultra-violet radiation in the region of 248 nm wavelength. The protective layer is attached to the non-wetting coating by a layer (8) of pressure sensitive adhesive. The adhesive is preferably applied first to the protective layer (rather than the non-wetting surface) by any suitable means e.g. a wire-wound meter bar, the adhesive-coated protective layer then being applied to the non-wetting coating using pressure. The adhesive is preferably ablatable - this property being either intrinsic or obtained by means of an ultra-violet radiation absorbing additive.

It is noted that application of the protective layer need not take place immediately prior to the material removal process. In the case of a nozzle plate, for example, a protective layer may be applied to a sheet of nozzle plate material to which a non-wetting coating has been applied. Such a sheet is subsequently cut up to form individual nozzle plates, each of which is attached to a printhead. Only then would the step of material removal - in this case nozzle formation - take place.

Material removal is effected by directing a high energy beam - such as an excimer laser beam - at that side of the nozzle plate (4) on which the non-wetting coating (6) is located such that material is removed from the nozzle plate by ablation. Such methods of material removal are known in the art - see, for example, those documents mentioned at the beginning of the description. As mentioned in WO92/16822 in particular, the wavelengths of laser light chosen are typically 193, 248 or 308 nm, corresponding to photon emission at the excimer line of argon fluoride (ArF), krypton fluoride (KrF) or xenon fluoride (XeCl) respectively.



Furthermore, in the present example, the material of the protective layer (10) is also ablated away (Figure 3). Generally, the non-wetting coating is sufficiently thin - no greater than 1 micron for example - that it may be removed without necessarily being made of an ablatable material.

Material may be removed from the nozzle plate to create not only nozzles of the types mentioned in the aforementioned documents but also solvent wettable areas of the type disclosed in EP-A-0 389 217 or nozzles having a formation provided within the bore serving to control the nozzle ink meniscus as per WO93/15911 - both of these documents belonging to the present applicant and being incorporated herein by reference. Material removal may take place with the nozzle plate remote from the rest of the printhead or attached to the printhead. The latter method avoids problems with both registration of the nozzles in the nozzle plate with the channels of the inkjet printhead and alignment of the nozzle axes in the plane of the channels.

On completion of material removal, the protective layer is removed from the surface of the non-wetting coating (6) to leave the arrangement shown in figure 4. Any ablation products that might have diffused back towards the printhead are also removed in this step, leaving a nozzle plate having well-formed nozzles surrounded by an undamaged non-wetting coating.

As has already been pointed out, the present invention is also applicable to the case where the element to be ablated is an integral part of the printhead e.g. where nozzles are created directly in the printhead as per EP-A-0 595 654.

It will be clear that both the method of removing material and the protective layer arrangement described in the present document are not restricted to the manufacture of nozzles or nozzle plates but are applicable to any element of an inkjet printhead which includes an ablatable material and which has a surface intended to form part of the external surface of the printhead.

Claims

1. Method of removing material from an element of an inkjet printhead, said element including an ablatable material and having a surface intended to form part of the external surface of the printhead, the method being characterised by the steps of:
 - a) applying a protective layer to be in sealing engagement with said surface;
 - b) directing a high energy beam at said protective layer from that side of said element to which said protective layer is applied, thereby removing material from said protective layer and said element having said surface, at least part of the material removed from said element being removed by ablation;
 - c) removing said protective layer from said surface.
2. Method according to claim 1 wherein the protective layer is releasably bonded to said surface.
3. Method according to claim 2 wherein the protective layer is releasably bonded to said surface by an adhesive layer.
4. Method according to claim 3 wherein the adhesive layer is transparent to the high energy beam.
5. Method according to claim 3 wherein the adhesive layer is ablatable.
6. Method according to claim 5 wherein the ablatable property is an intrinsic property of the adhesive.
7. Method according to claim 5 wherein the adhesive layer includes an ultra-violet-radiation-absorbing additive.



8. Method according to any of the previous claims wherein the protective layer comprises ablatable material.
9. Method according to any of the previous claims wherein the element is of homogeneous construction.
10. Method according to any of the previous claims wherein said element comprises at least two layers.
11. Method according to claim 10 wherein the element comprises a body portion comprising ablatable material and a surface layer of a different material to that of the body portion.
12. Method according to claim 10 or 11 wherein material is removed only from one layer.
13. Method according to any of the previous claims wherein said surface intended to form part of the external surface of the printhead has a non-wetting and/or a conductive property.
14. Method according to any of the previous claims wherein material removal takes place with said element integral with said inkjet printhead.
15. Method according to any of claims 1-13 wherein material removal takes place with said element remote from said inkjet printhead.
16. Method according to any of the previous claims wherein said high energy beam is an excimer laser beam.
17. Method according to any of the previous claims wherein removal of the protective layer is effected mechanically and/or chemically.



This Sheet Has Been Replaced


18. Method according to claim 17 wherein removal of the protective layer entails dissolving the layer using acetone.
19. Method according to any of the previous claims wherein the high energy beam is focussed and/or masked by means located remote of the protective layer.
20. Method according to claim 19 wherein masking means are located remote of the protective layer and are imaged onto the protective layer by means of an optical focussing system.
21. A protective layer arrangement for use in the method according to claim 1 and comprising a layer of ablatable material having an adhesive coating, the adhesive coating being ablatable.
22. A protective layer arrangement according to claim 21 wherein the ablatable property is an intrinsic property of the adhesive.
23. A protective layer arrangement according to claim 21 wherein the adhesive layer includes an ultra-violet-absorbing additive.
24. A protective layer arrangement according to any of claims 21-23 wherein the layer of ablatable material comprises polyester or polyimide.