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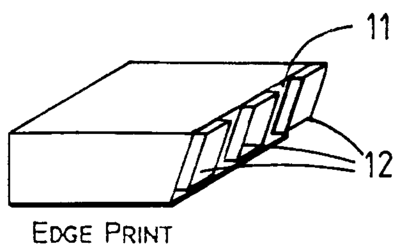
(54) Charge plate fabrication process

(57) A charge plate fabrication process uses conventional methods to fabricate the charge plate. Initially, a non-conductive charge plate substrate is provided, the substrate having an edge and a top. The substrate is then edge patterned to define a charging face on the edge of the non-conductive charge plate substrate. The conductive path from the charging face to the top of the non-conductive charge plate substrate is completed to create a charge plate. The charge plate is then top patterned.

FIG. 2



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Description

Technical Field

The present invention relates to continuous ink jet printers and, more particularly, to improved construction for the charge plate in such printers.

Background Art

In continuous ink jet printing, electrically conductive ink is supplied under pressure to a manifold region that distributes the ink to a plurality of orifices, typically arranged in a linear array(s). The ink discharges from the orifices in filaments which break into droplet streams. Individual droplet streams are selectively charged in the region of the break off from the filaments and charge drops are deflected from their normal trajectories. The deflected drops may be caught and recirculated, and the undeflected drops allowed to proceed to a print medium.

Drops are charged by a charge plate having a plurality of charging electrodes along one edge, and a corresponding plurality of connecting leads along one surface. The edge of the charge plate having the charging electrodes is placed in close proximity to the break off point of the ink jet filaments, and charge is applied to the leads to induce charges in the drops as they break off from the filaments.

In U.S. Patent No. 4,560,991, issued December 24, 1985, to W. Shutrum, one method of fabricating a charge plate is described. The charge plate taught by Shutrum is fabricated by electro-depositing the charging electrodes and leads on a flat sheet of etchable material, such as copper foil, to form a so-called "coupon." The coupon is bent in a jig at approximately a 90° angle. The leads are then bonded to a dielectric material, such as aluminum oxide, and then the etchable substrate is removed by chemical etching. Such a charge plate fabrication method is a "lead transfer" method, in which the formation of electrodes on an etchable substrate is required.

Another "lead transfer" charge plate fabrication method is described in commonly assigned application Serial No. 08/229,114, which also requires the formation of electrodes on an etchable substrate. This electroformed coupon is then bent at approximately 90 degrees, bonded to a dielectric material, such as aluminum oxide, and then the etchable substrate is removed by chemical etching.

Unfortunately, several problems exist with prior art charge plate fabrication techniques, such as the complexity of fabrication stemming from the relatively large number of manufacturing steps required to make a usable charge plate, as well as the cost associated with these manufacturing steps. In addition, nickel is commonly used as the electroformed electrodes and as such, it can become electrochemically removed (etched) during the operation of the printhead during the ink jet printing process.

It is seen then that there exists a need for an improved charge plate fabrication which overcomes the problems associated with the prior art.

Summary of the Invention

This need is met by the charge plate fabrication process according to the present invention, wherein the charge plate fabrication technique allows for fabrication by conventional methods, such as thin film and thick film patterning. Past efforts to utilize these methods failed due to the inability to pattern over an edge. The present invention overcomes previous failures because in the subject method the patterning of the top and the edge are separated, which allows for more flexibility in manufacturing. In addition, materials which are available for fabrication with the new technique have a lower etch rate.

In accordance with one aspect of the present invention, a method of fabricating a charge plate for an ink jet printer allows for fabrication by conventional methods. Initially, a non-conductive charge plate substrate is provided, the substrate having an edge and a top. The substrate is then edge patterned to define a charging face on the edge of the non-conductive charge plate substrate. The conductive path from the charging face to the top of the charge plate substrate is completed by top printing on the top surface to define a wrap around. This can be accomplished by any suitable method such as by a thick film process. When the conductive path from the charging face to the top of the charge plate substrate is completed, a charge plate is created. The charge plate is then top patterned, such as by photo sensitive thick film paste, to connect top electrical connections to the front edge for charging and deflecting.

Accordingly, it is an object of the present invention to provide a charge plate wherein fabrication by conventional methods, such as thick film and thin film patterning, is allowed. It is a further object of the present invention to provide such a charge plate fabrication method which overcomes previous attempts at similar fabrication by separating the patterning of the top and the edge, or front face, of the charge plate. Finally, it is an object of the present invention to allow for more flexibility in manufacturing.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

Brief Description of the Drawings

Fig. 1 is a perspective view of a charge plate substrate;

Fig. 2 is a perspective view of the substrate of Fig. 1, edge patterned in accordance with the present invention;

Fig. 3 is a perspective view illustrating a wrap around conductive path on the edge patterned substrate of Fig. 2; and

Fig. 4 is a perspective view illustrating top patterning of the view in Fig. 3.

Detailed Description of the Preferred Embodiments

Referring to the drawings, a charge plate substrate 10 of Fig. 1, capable of being assembled into a charge plate coupon to form a charge plate assembly, is illustrated. The charge plate substrate 10 is a non-conductive material, such as a dielectric or insulator material. In a preferred embodiment of the present invention, the charge plate substrate 10 is ceramic and fabricated from 96% aluminum oxide having a coefficient of thermal expansion (CTE) of 8.2×10^{-6}/°C. Preferably, a front surface or edge 11 of the substrate 10 is tapered away from perpendicularity with a top surface 14 by 2.5° such that in an assembled charge plate, the electrodes do not interfere with the trajectory of any deflected and/or caught droplets. The front surface 11 is preferably flat to provide optimum charge and deflection.

Referring now to Fig. 2, initially the substrate 10 of Fig. 1 is edge patterned on its front edge 11 to define charge surfaces or charging face 12. In a preferred embodiment of the present invention, the charge surfaces 12 are defined by passing thick film conductive ink through an opening in a screen, i.e., silk screen printing, and/or thin metal foil, i.e., stencil printing, using standard processes in the thick film processing art. In accordance with standard thick film processes, the edge patterned substrate is dried and fired, for conductivity and durability. Drying typically occurs for approximately twenty minutes, at 150°C. A typical recommended firing profile has the conductor layer fired in a belt furnace. A sixty minute firing cycle with a peak temperature of 850°C for ten minutes is recommended. Silk screening has the advantage of allowing for the creation of unusual patterns; while stenciling has the advantage of providing improved quality of printed lines and spaces without the wire mesh which can create problems when pushing ink through at high resolutions. A gold thick film paste, such as commercially available DuPont 5715 Gold Thick Film Paste, is preferable over nickel because gold is more chemically inert than nickel.

Referring now to Fig. 3, subsequent to defining the charge surfaces 12, a conductive path is continued to top surface 14, to create a wrap around conductive path 16. The wrap around 16 is also defined by thick film paste or printing techniques, such as printing, drying and firing steps. Hence, the present invention applies thick film processing to make the electrical connection between the top surface 14 and the charging face 12. Electrical connection from top surface 14 to the front surface 11 is achieved using electrical connection wrap arounds 12 and 16 during the wrap around process, which connects the front face electrical connections 12 to the top electrical connections 16. This involves direct metal to metal diffusion during the step of firing, prior to the step of top patterning, and following the steps of printing and drying, of the substrate.

Referring now to Fig. 4, top patterning 18 of the substrate is illustrated, subsequent to the steps of printing, drying, firing, and metal to metal diffusion, to create a charge plate. Top patterning of the substrate can be by any suitable means, such as use of Fodel photoimageable materials as described in Proceedings of the 1993 International Symposium On Microelectronics incorporated herein by reference. Fodel technology is an extension of thick film paste technology, developed by combining inorganic components, metal powders, glass powders, metal oxides and refractory powders, used to make thick film dielectrics and conductors with the organic components, polymers, photoinitiators, monomers and stabilizers, used to make photoresist films for the printed wiring board industry. This combination results in photoimageable ceramic material that combines the well known reliability of ceramic materials with the ease of processing in conventional equipment, using mild aqueous chemistries, currently used in the printed wiring board industry.

The Fodel process, like the component materials, is a combination of the conventional thick film and printed wiring board processes. As will be obvious to those skilled in the art, conventional thick or thin film processes and conventional printed circuit board processes can be used independently or in any suitable combination to achieve the patterning of the charge plate of the present invention. The Fodel process is described herein for purposes of example only, and is not to be considered as limiting the invention.

The Fodel process begins with the application of a photoactive paste, such as a commercially available Fodel paste, to the desired substrate by blank screen printing. The paste is allowed to level at room temperature and is then dried, for example at a temperature of 80°C. After drying, the paste is exposed in UV light (with a typical maximum wavelength of approximately 360 nm) through the appropriate photomask to form a latent image. Following exposure, the latent image in the materials is developed such as in a conveyorized, spray processor, for example using 1% aqueous Na_2CO_3 solution. The developed paste is then fired by conventional thick film methods.

After the top patterning process illustrated in Fig. 4, the top patterned surface is coated with a material that has a high breakdown voltage and is pinhole free. A preferred material is a dielectric material which sinters to the top patterned surface to make a good dielectric coating. The dielectric coating may be any suitable dielectric such as commercially available DuPont 5704 Dielectric.

Separating the patterning of the top surface 14 and the front surface 11, in accordance with the present invention, allows for more flexibility in manufacturing, in that it allows different materials to be used. As will be obvious to those skilled in the art, changing the material of the charge surfaces changes the electrical properties. With the present invention, different materials can be selected to achieve the overall desired electrical and electro-chemical properties.

In accordance with the present invention, a charge plate fabrication process is provided for fabricating a charge plate for an ink jet printer. Initially, the non-conductive charge plate substrate 10 is provided and edge patterned to define a charging face on the edge of the substrate. The patterned substrate is then dried and fired, before a conductive path is completed from the charging face to the top of the non-conductive charge plate substrate to create a charge plate. The charge plate is then top patterned, such as by photoimageable thick film or thin film, to allow an electrical connection to the charge plate. The top patterned surface is then coated with a dielectric material. Additionally, electrodes can be formed on the non-conductive charge plate substrate. Also, heat can be applied to the charge plate to maintain the charging electrodes at a predetermined differential temperature than the temperature of ink. This creates a condition where condensation, hence premature electrochemical etching, is avoided. For example, a resistor can be incorporated on the bottom surface of the charge plate to apply current and voltage for heating, thereby providing a resistive heater which is integral to the charge plate. Such an arrangement allows for improved transfer of heat to the charging electrodes.

Industrial Applicability and Advantages

The present invention is useful in the field of ink jet printing, and has the advantage of allowing for direct formation of a charge face. This provides the advantage of simplification of charge plate fabrication. Once the wrap around is complete, top patterning of the charge plate can be achieved by a variety of techniques such as etchable thick film process, traditional thin film process, hybridization of thick and thin film processes, and photoimageable thick film techniques.

Having described the invention in detail and by reference to the preferred embodiment thereof, it will be apparent that other modifications and variations are possible without departing from the scope of the invention defined in the appended claims.

Claims

1. A method of fabricating a charge plate for an ink jet printer comprising the steps of:

a. providing a non-conductive charge plate substrate having an edge and a top;
b. edge patterning the non-conductive charge plate substrate to define a charging face on the edge of the non-conductive charge plate substrate;
c. completing a conductive path from the charging face to the top of the non-conductive charge plate substrate to create a charge plate;
d. top patterning the charge plate to allow an electrical connection to the charge plate; and
e. coating the top patterned surface with a dielectric material.

2. A method of fabricating a charge plate as claimed in claim 1 wherein the step of top patterning the charge plate comprises the step of top patterning by photoimageable thick film.

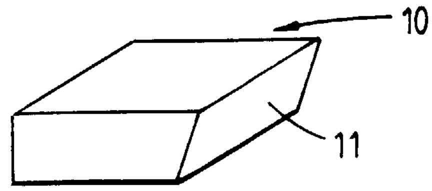
3. A method of fabricating a charge plate as claimed in claim 1 wherein the step of top patterning the charge plate comprises the step of top patterning by thin film.

4. A method of fabricating a charge plate as claimed in claim 1 wherein the non-conductive charge plate substrate comprises 96% aluminum oxide.

5. A method of fabricating a charge plate as claimed in claim 1 further comprising the step of forming electrodes on the non-conductive charge plate substrate.

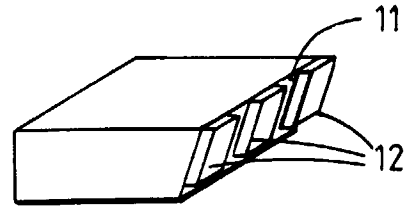
6. A method of fabricating a charge plate as claimed in claim 5 further comprising the step of providing an integral resistive heater to the charge plate.

FIG.1



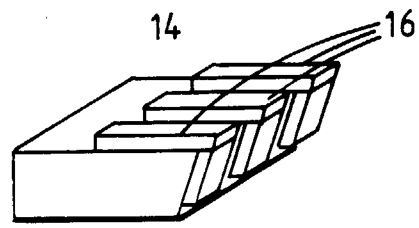
CP SUBSTRATE

FIG.2



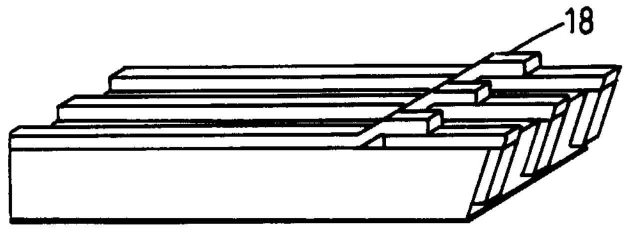
EDGE PRINT

FIG.3



WRAP AROUND

FIG.4



TOP PATTERNING