

Description

Field of the Invention

The invention relates to the field of electroplating. In particular, this invention relates to the field of manufacturing mandrels using thin film processes. Additionally, this invention manufactures devices by electroforming a metal layer on to the mandrel.

Background of the Invention

U.S. Patent No. 3,703,450 describes a method for making a precision conductive mesh screen. First, this method constructs a mandrel. The prior-art mandrel is constructed by placing a master plate with the screen pattern on the glass substrate and by vapor depositing a thin film through the interstices of the master plate to form the screen's pattern on the glass. After removing the master plate from the glass substrate, the method deposits photoresist over the entire glass plate. Next, the method exposes and develops the photoresist to produce a layer of thin film in a screen pattern covered with a layer of photoresist in the same screen pattern. Next, the method deposits silicon monoxide on the entire glass substrate and removes the silicon monoxide and photoresist from the thin film pattern. This non-reusable mandrel is now ready for manufacturing the screen. This prior-art mandrel has several disadvantages. It cannot manufacture small geometry devices as pointed out in U.S. Patent No. 4,549,939 discussed below. Also, the complicated prior-art process for making this mandrel has low yields.

U.S. Patent No. 4,549,939 and EP 0 163 130 describe another type of prior-art thin film mandrel and the method of making it. This prior-art process constructs the prior-art mandrel by forming a stained pattern shield on a glass substrate and depositing a conductive and transparent thin film onto the substrate. Next, the prior-art method coats the thin film with resist and shines a light through the glass substrate and the transparent thin film to expose the unshielded photoresist. Finally, the photoresist is developed and forms the mold for electroforming. The prior-art mandrel formed by this process has several disadvantages. It is non-reusable and of poor quality due to resist broken after the electro-forming cycle. Additionally, it requires the use of a conductive thin film that is transparent; a costly and exotic material. U.S. Patent No. 4,528,577 describes another prior-art mandrel and the method of making it. This prior-art method of manufacturing orifice plates for thermal ink jet printheads electroforms nickel onto a stainless steel mandrel plate that contains either a pre-

etched orifice pattern or a photoresist orifice pattern. Unfortunately, stainless steel mandrel plates always contain a large number of scratches and defects. These scratches and defects arise from characteristics of the stainless steel material and from the manufacturing process. The scratches and defects, which can not be eliminated, degrade the quality of the orifice plates manufactured from stainless steel mandrels. These inferior orifice plates produce inferior print quality. The method and apparatus in accordance with the present invention obviate these problems with mandrels in the prior art.

JP-A-53 864 discloses a method of making a mandrel, comprising the steps of depositing a conductive layer on a substrate; depositing a photoresist layer on the conductive layer; and etching the conductive layer to form a mandrel comprising a pattern of projections on the surface of the substrate.

The photoresist is printed on to the conductive layer in a pattern corresponding to the pattern of projections.

According to the invention there is provided a method of making a mandrel for use in a deposition process, comprising the steps of depositing a conductive layer on a substrate; depositing a dielectric layer on the conductive layer; depositing a photoresist layer on the dielectric layer; exposing and developing the photoresist; and etching the dielectric layer through the resulting patterned layer to form a mandrel comprising a pattern of projections on the surface of the first layer.

According to the present invention, the reusable mandrel has a glass substrate with a conductive film layer and dielectric layer. The dielectric layer has been etched to form a mold. According to the present invention, the method of making a reusable mandrel deposits a conductive film, such as a metal film, on a smooth substrate such as a polished silicon wafer, a glass substrate, or plastic substrate. Next, the method forms a mold by depositing a dielectric film on the metalized substrate, by using a standard photolithography process to define a resist pattern on the dielectric film, and by removing the unmasked dielectric film with a plasma etching process. Finally, the method strips the photoresist away and the mandrel is ready to use.

A thin film mandrel has the advantage of producing high quality precision devices. This advantage results from the defect free surface of the thin film and the precision molds created by standard photolithography and etching processes. Additionally, the thin film mandrel has the advantage of producing high quality precision devices cheaply. This advantage results from the low cost procedures used to produce the mandrel and the low cost procedures for using the mandrel. The thin

film mandrels are capable of producing a wide variety of devices. Devices traditionally manufactured by precision machining techniques such as laser machining, mechanical machining, and chemical etching can be manufactured by an electroforming process using the thin film mandrel. The electroforming process using the thin film mandrel produces devices having the same or better quality as those produced by precision machining and the thin film process produces the devices at a much lower cost.

Ink jet printhead performance depends on the quality of the orifice plates. High quality orifices yield high quality printing. Thus, this invention has the advantage of producing high quality precision orifice plates for ink jet printers that result in higher print quality. Additionally, the thin film mandrel can be used to manufacture components for other types of printers or for medical devices.

Brief Description of the Drawings

Figures 1A - 1B show a reusable mandrel.

Figures 2A - 2G show the steps used to manufacture a reusable mandrel.

Figures 3A - 3B show a device being manufactured by the reusable mandrel.

Figures 4A - 4C show an orifice plate being manufactured by the reusable mandrel.

Figures 1A and 1B show the reusable mandrel 1-9. It has a conductive thin film layer 1-3 deposited on a glass substrate or a polished silicon wafer or a plastic substrate 1-7. This conductive thin film 1-3 can range from 10 nanometres (100 Angstroms) to 200 micrometres (200 microns). In alternate embodiments of the reusable mandrel a conductive thick film layer could be used in place of a conductive thin film layer. The thick film layers can range from 25 micrometres (25 microns) to 10 millimeters in thickness, however layers having other thickness ranges are possible. The film layer 1-3 has a layer of chrome 1-11 and a layer of stainless steel 1-5. The chrome layer 1-11 bonds firmly to the substrate 1-7 and provides a surface that the stainless steel layer 1-5 can adhere to. A dielectric layer 1-1 resides on top of the film layer 1-3. This dielectric layer 1-1 has been patterned and etched to form a mold.

The process for manufacturing a reusable mandrel shown in Figures 2A-2G starts with a glass substrate or a silicon wafer, or a polished silicon wafer, or a plastic or any smooth, nonconducting surface 2-1 as shown in Figure 2A. A vacuum deposition process, such as the planar magnetron process, deposits a conductive thin film 2-3. This thin film 2-3 is constructed from chrome and stainless steel materials. However, alternate embodiments could use different conductive materials. An-

other vacuum deposition process deposits a dielectric layer 2-5 on to the thin film layer 2-3. Alternatively, the dielectric layer may be deposited by spin coating. The preferred embodiment of the present invention uses a plasma enhanced chemical vapor deposition process to deposit a dielectric layer 2-5 of silicon nitride. However, alternate embodiments could use different nonconductive materials. Next, a photoresist layer 2-7 is applied to the dielectric layer 2-5. Depending on the photomask 2-11, either positive or negative photoresist is applied to the dielectric layer 2-5. Next, the photomask 2-11 is placed next to the photoresist layer 2-7 and exposed to ultra violet light as shown in Figure 2E. Next, the photoresist layer 2-7 is developed to obtain the photomask 2-11 pattern into the photoresist layer 2-7. This patterned photoresist layer 2-7 serves as a mask for the dielectric layer 2-5. Next, an etching process, such as plasma etching, removes the unmasked dielectric film 2-5. After removing the remaining photoresist, the reusable mandrel 2-9 has a patterned dielectric layer 2-13 resting on a stainless steel layer 2-3 as shown in Figure 2G. This reusable mandrel is ready for fabricating devices.

In order to manufacture a device using the reusable mandrel, insert the mandrel into an electroforming bath 3-1 shown in Figure 3A. This reusable mandrel becomes the cathode 3-9. The source material plate 3-5 which supplies the electroforming material is the anode. In the preferred embodiment of the invention, the metal plate 3-5 is composed of nickel. During the electroforming process metal is transferred from the anode metal plate 3-5 to the cathode mandrel 3-9. The metal attaches to the conductive areas of the cathode mandrel 3-9. Thus, metal attaches to the conductive film layer 3-11, but not to the patterned dielectric areas 3-13. The electroforming process is continued until the device 3-7 has the desired thickness. When that point is reached, the device 3-7 is separated from the cathode mandrel 3-9 as shown in Figure 3B.

A reusable mandrel 4-9 for fabricating orifice plates 4-7 is shown in Figure 4A. The mandrel 4-9 has a chrome/stainless steel thin film 4-3 (not shown in Figure 3B). Upon this film 4-3 lies the silicon nitride pattern 4-5 for forming the orifice plates 4-7. Once this mandrel has been formed, the orifice plate 4-7 is formed as shown in Figure 4B. Figure 4C shows a cross section of the orifice plate 4-7 with the orifice 4-1.

Claims

1. A method of making a mandrel for use in a deposition process, comprising the steps of depositing a conductive layer (2-3,) on a sub-

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Claims

1. A method of making a mandrel for use in a deposition process, comprising the steps of depositing a conductive layer (2-3,) on a sub-



strate (2-1); depositing a dielectric layer (2-5) on the conductive layer; depositing a photoresist layer (2-7) on the dielectric layer; exposing and developing the photoresist; and etching the dielectric layer (2-5) through the resulting patterned layer (2-7) to form a mandrel (2-9) comprising a pattern of projections (2-13) on the surface of the first layer.

2. A method as claimed in claim 1, wherein the conductive layer (2-3) is deposited by vapour deposition.
3. A method as claimed in claims 1 or 2, wherein the dielectric layer (2-5) is deposited by spin coating.
4. A method of producing an apertured product comprising producing a mandrel (4-3) by the method of any of claims 1 to 3, depositing metal (4-7) over the mandrel such that a layer is formed which has apertures over the projections (4-5), and stripping the layer off the mandrel (4-3).

Patentansprüche

1. Verfahren zum Herstellen einer Patrize zur Verwendung bei einem Ablagerungsprozeß, mit den Schritten des Ablagerns einer leitenden Schicht (2-3) auf einem Substrat (2-1); Ablagern einer dielektrischen Schicht (2-5) auf der leitenden Schicht; Ablagern einer Photoresist-Schicht (2-7) auf der dielektrischen Schicht; Belichten und Entwickeln der Photoresist-Schicht und Ätzen der dielektrischen Schicht (2-5) durch die erhaltene gemusterte Schicht (2-7), um eine Patrize (2-9) mit einem Muster von Vorsprüngen (2-13) auf der Oberfläche der ersten Schicht zu formen.
2. Verfahren nach Anspruch 1, bei dem die leitende Schicht (2-3) durch Aufdampfen abgelagert ist.
3. Verfahren nach Anspruch 1 oder 2, bei dem die dielektrische Schicht (2-5) durch Spin-Beschichten abgelagert ist.
4. Verfahren zum Herstellen eines gelochten Produktes, bei dem eine Patrize (4-3) mit einem Verfahren nach einem der Ansprüche 1 bis 3 hergestellt wird, Metall (4-7) auf der Patrize so abgelagert wird, daß eine Schicht mit Öffnungen über den Vorsprüngen (4-5) geformt wird und die Schicht von der Patrize (4-3) abgestreift wird.

Revendications

1. Procédé de fabrication d'une matrice à utiliser dans un procédé de placage, comprenant les étapes de placage d'une couche conductrice (2-3) sur un substrat (2-1); placage d'une couche diélectrique (2-5) sur la couche conductrice; placage d'une couche d'agent photorésistant (2-7) sur la couche diélectrique; exposition et développement de l'agent photorésistant; et morsure chimique de la couche diélectrique (2-5), à travers la couche (2-7) à motifs résultante, pour former une matrice (2-9) comprenant un motif de saillies (2-13) sur la surface de la première couche.
2. Procédé selon la revendication 1, dans lequel la couche conductrice (2-3) est plaquée par condensation de vapeur.
3. Procédé selon la revendication 1 ou 2, dans lequel la couche diélectrique (2-5) est plaquée par revêtement centrifuge.
4. Procédé de production d'un produit doté d'ouvertures, comprenant la production d'une matrice (4-3) par le procédé selon l'une quelconque des revendications 1 à 3, le placage d'un métal (4-7) sur la matrice, de manière à former une couche dotée d'ouvertures sur les saillies (4-5), et l'élimination de la couche de la matrice (4-3).



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