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Zesch et al.

(54) **SYSTEMS AND METHODS FOR FILLING VOIDS AND IMPROVING PROPERTIES OF POROUS THIN FILMS**

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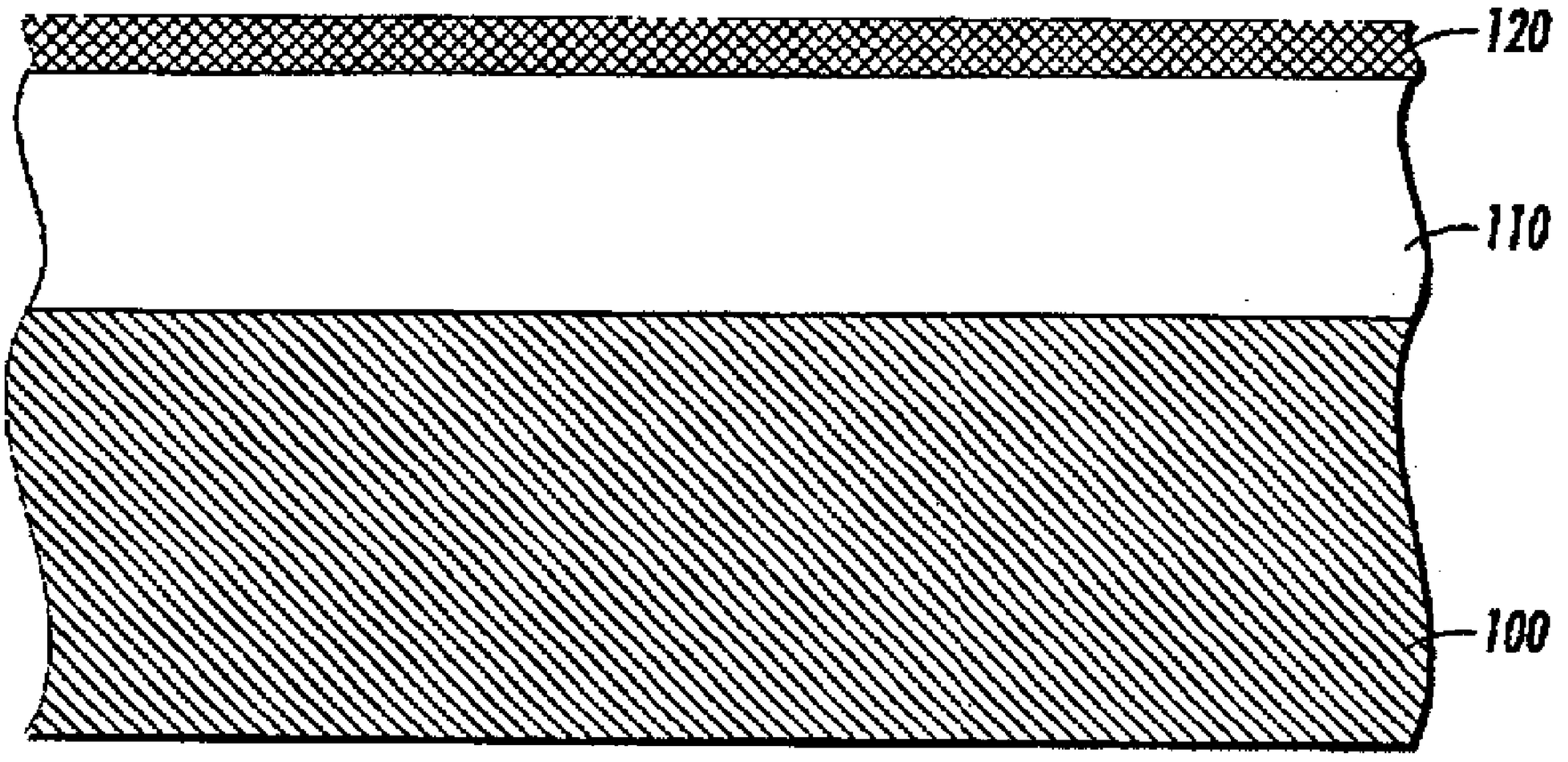
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(57) **ABSTRACT**

A treated thin film that reduces the intrusions or migrations of photolithography materials is achieved by introducing a sol-gel layer onto a porous thin film prior to applying the photolithography/photoresist material layer. Curing the sol-gel layer results in the sol-gel layer merging or unifying with the underlying porous thin film layer so that the combined sol-gel/thin film layer exhibits substantially the same properties as the untreated porous thin film layer before the sol-gel was applied. As a result, a greater etching accuracy is achieved.



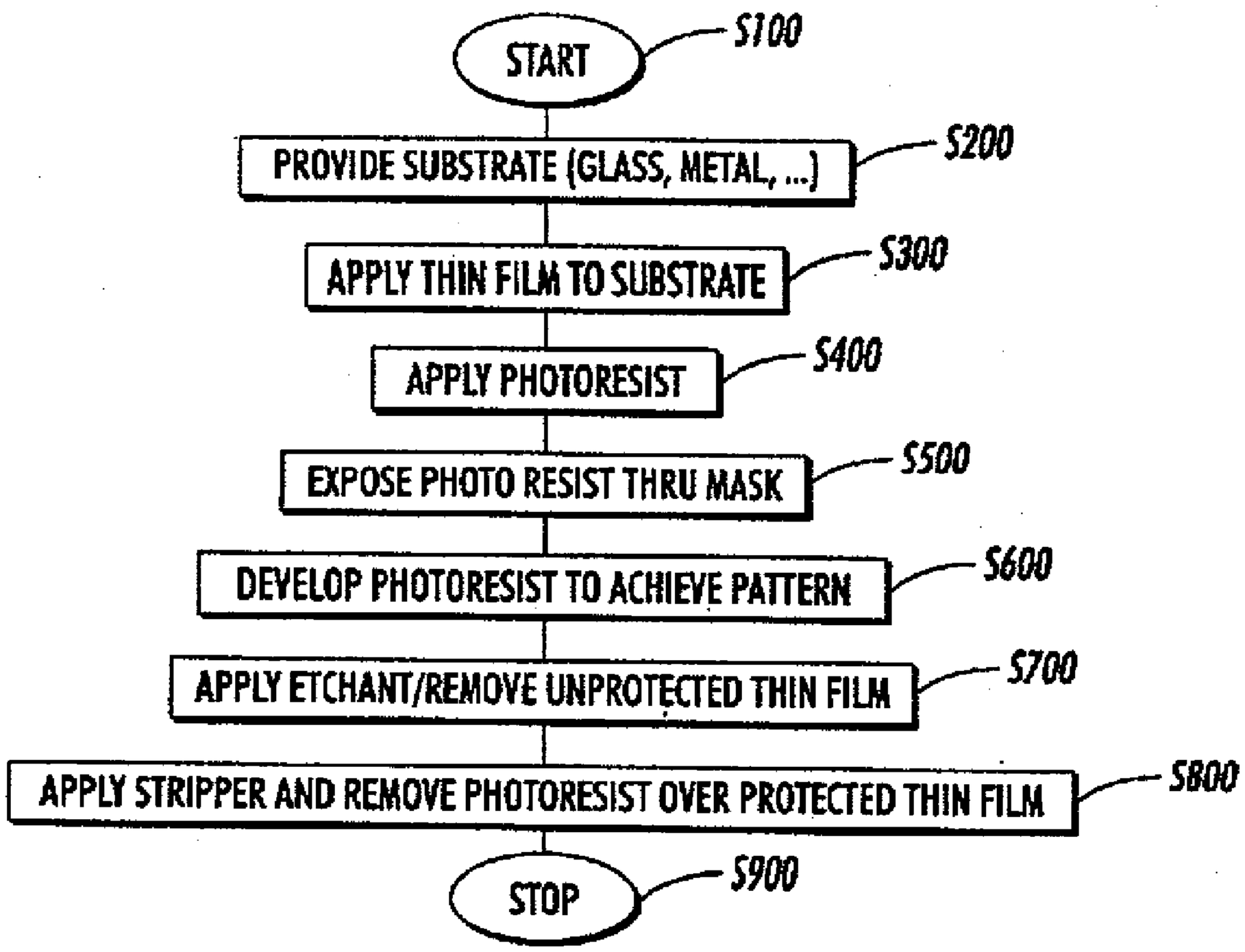

START
S100
PROVIDE SUBSTRATE (GLASS, METAL, ...)
S200
APPLY THIN FILM TO SUBSTRATE
S300
APPLY PHOTORESIST
S400
EXPOSE PHOTO RESIST THRU MASK
S500
DEVELOP PHOTORESIST TO ACHIEVE PATTERN
S600
APPLY ETCHANT/REMOVE UNPROTECTED THIN FILM
S700
APPLY STRIPPER AND REMOVE PHOTORESIST OVER PROTECTED THIN FILM
S800
STOP
S900

FIG. 1

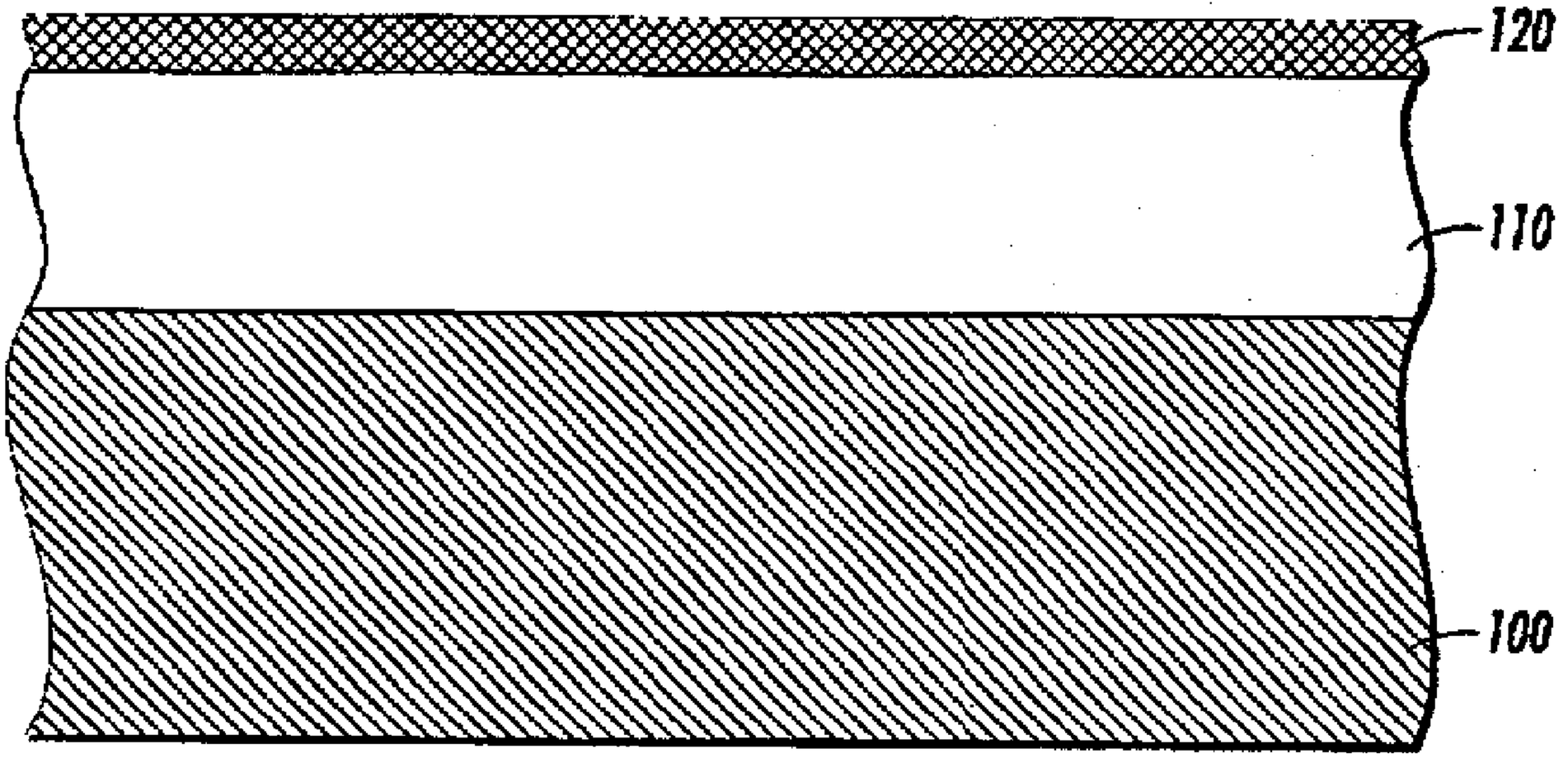


FIG. 2

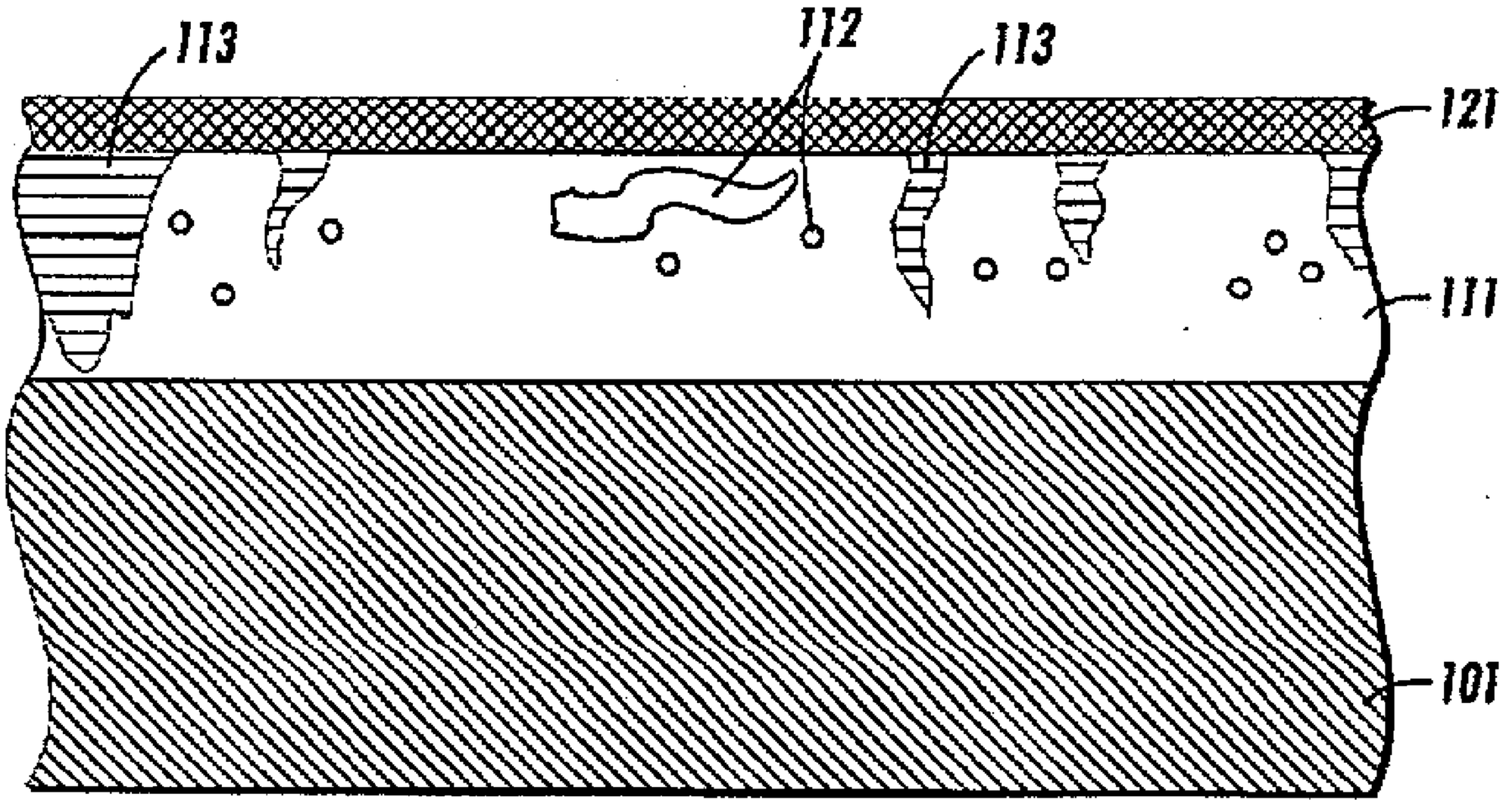


FIG. 3

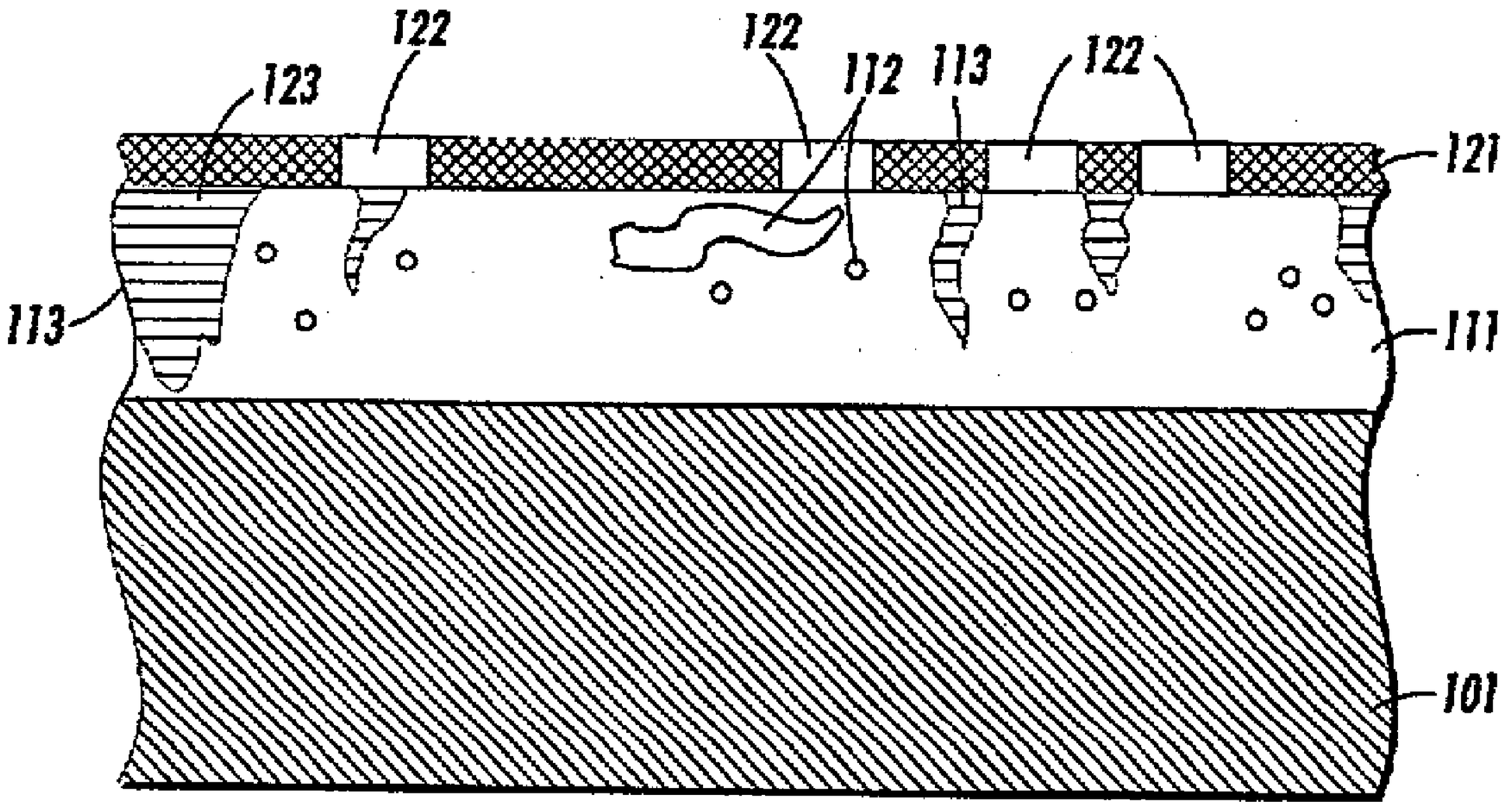


FIG. 4

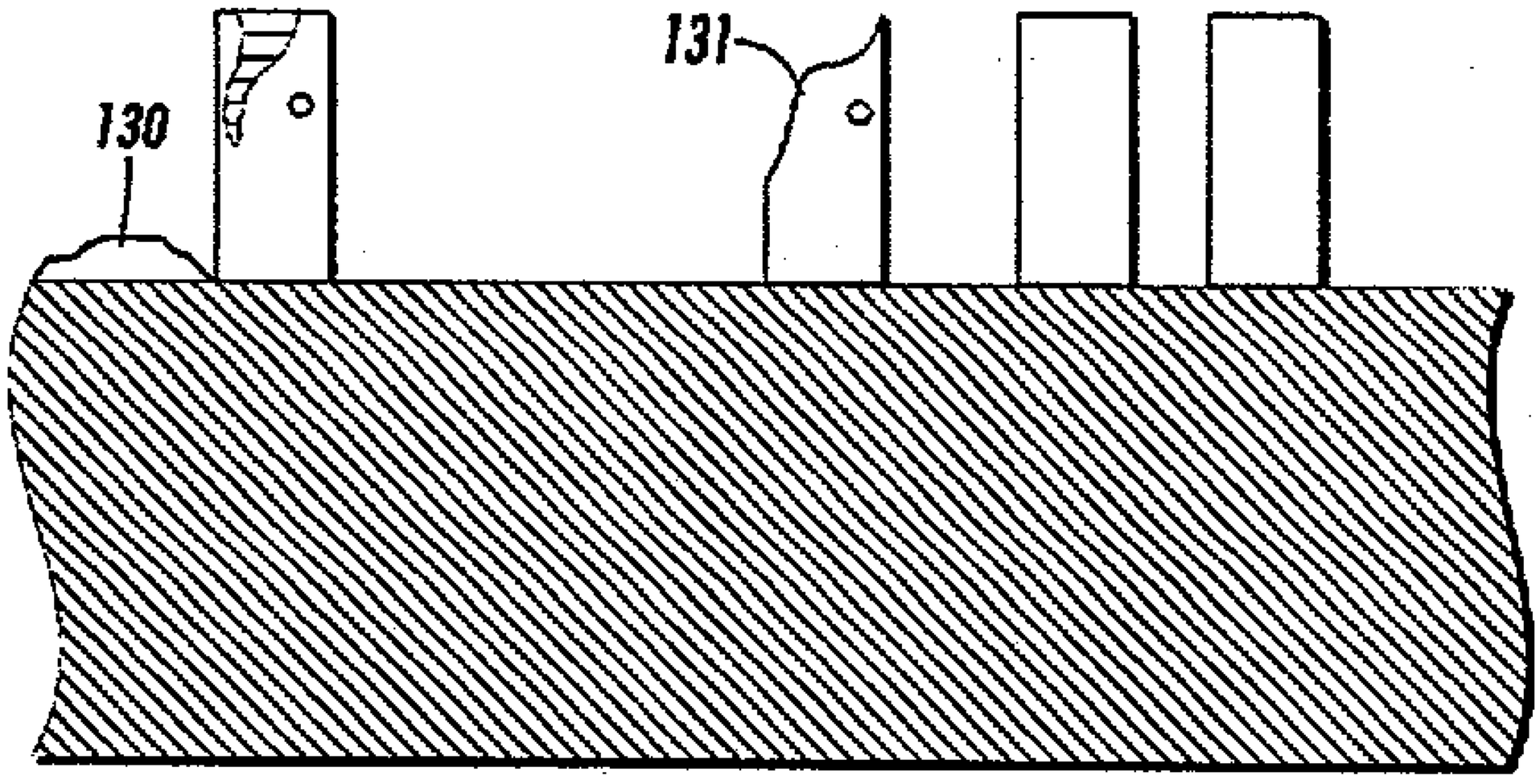


FIG. 5

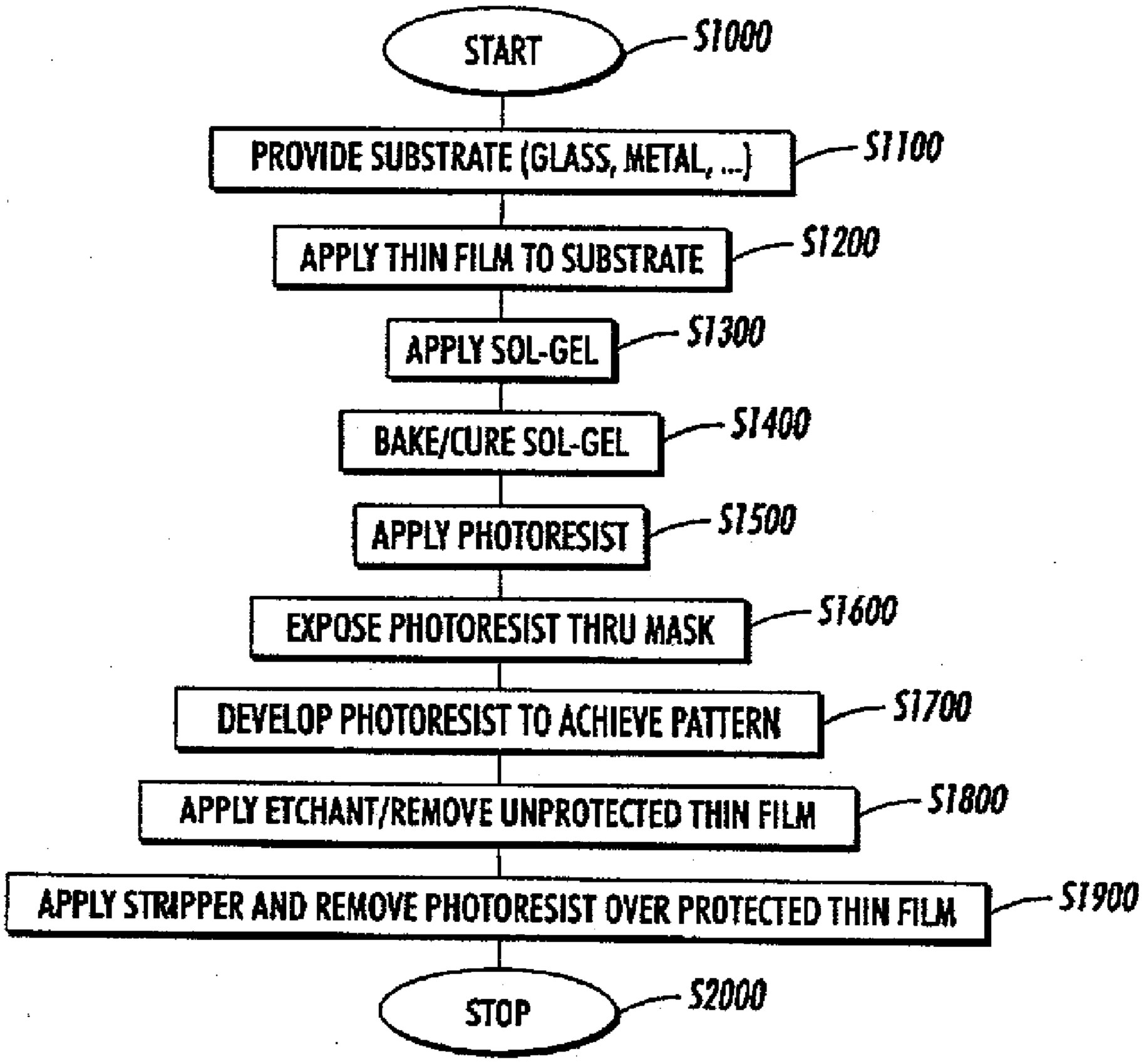

START
S1000
PROVIDE SUBSTRATE (GLASS, METAL, ...)
S1100
APPLY THIN FILM TO SUBSTRATE
S1200
APPLY SOL-GEL
S1300
BAKE/CURE SOL-GEL
S1400
APPLY PHOTORESIST
S1500
EXPOSE PHOTORESIST THRU MASK
S1600
DEVELOP PHOTORESIST TO ACHIEVE PATTERN
S1700
APPLY ETCHANT/REMOVE UNPROTECTED THIN FILM
S1800
APPLY STRIPPER AND REMOVE PHOTORESIST OVER PROTECTED THIN FILM
S1900
STOP
S2000

FIG. 6

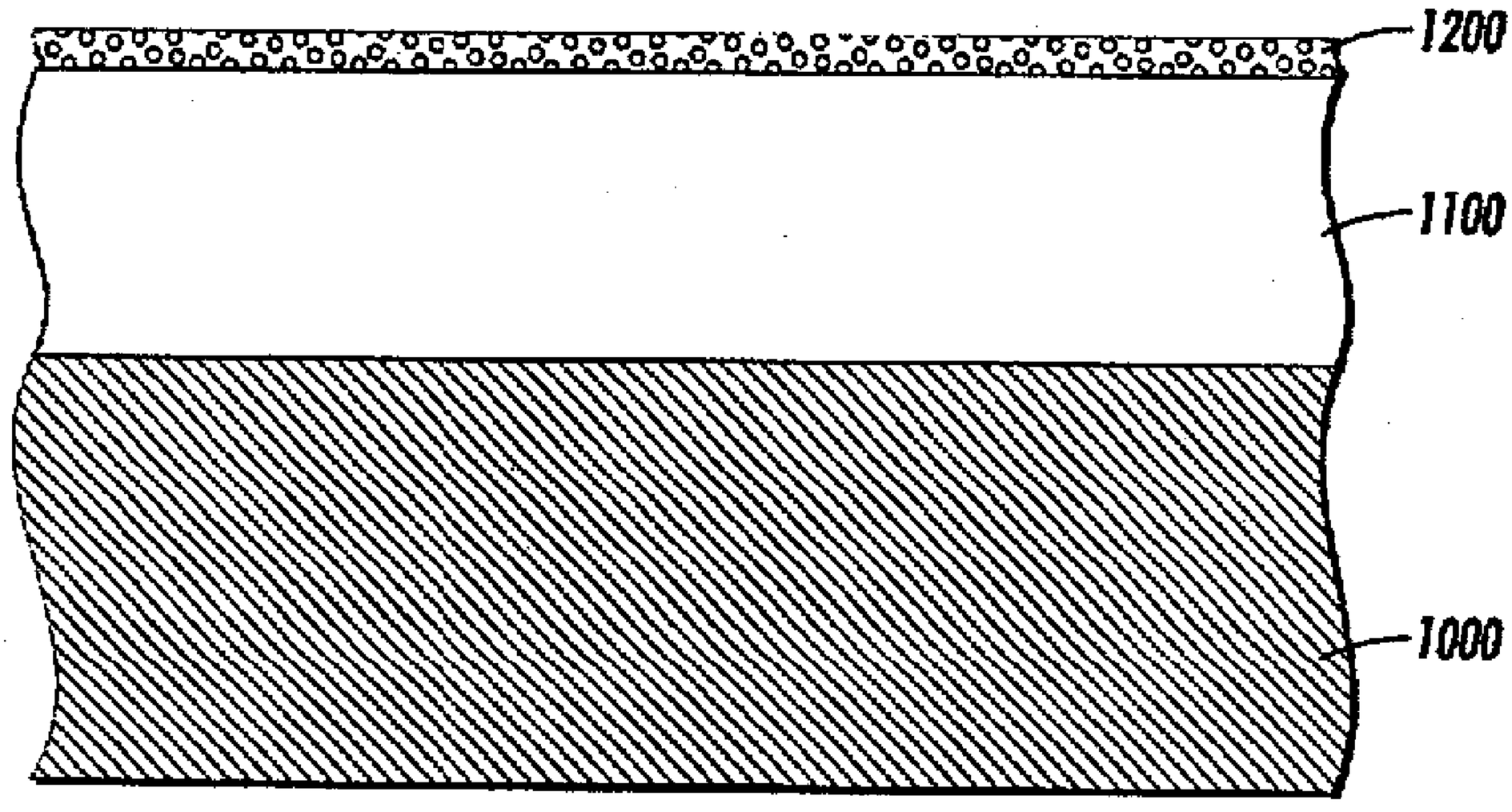


FIG. 7

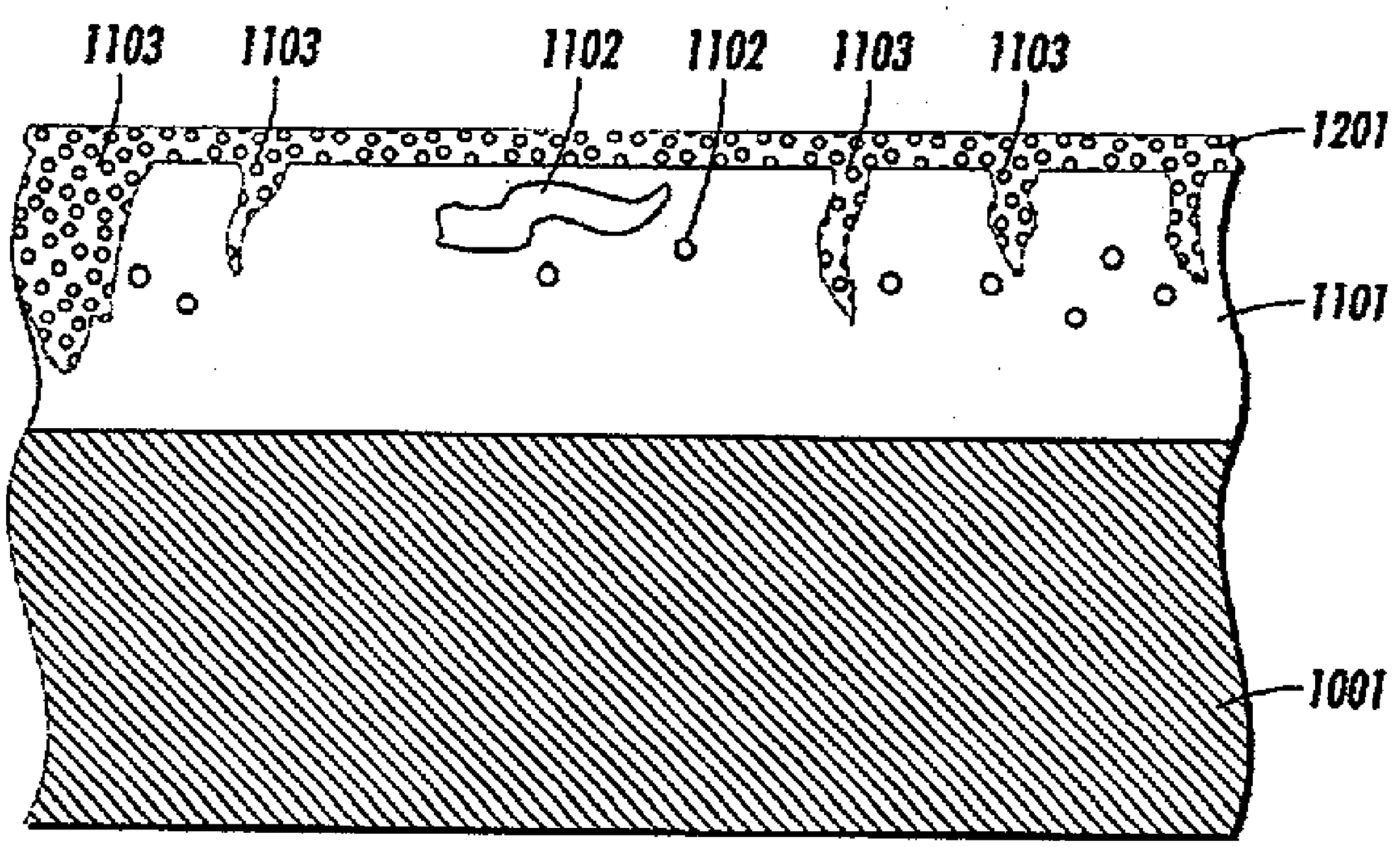


FIG. 8

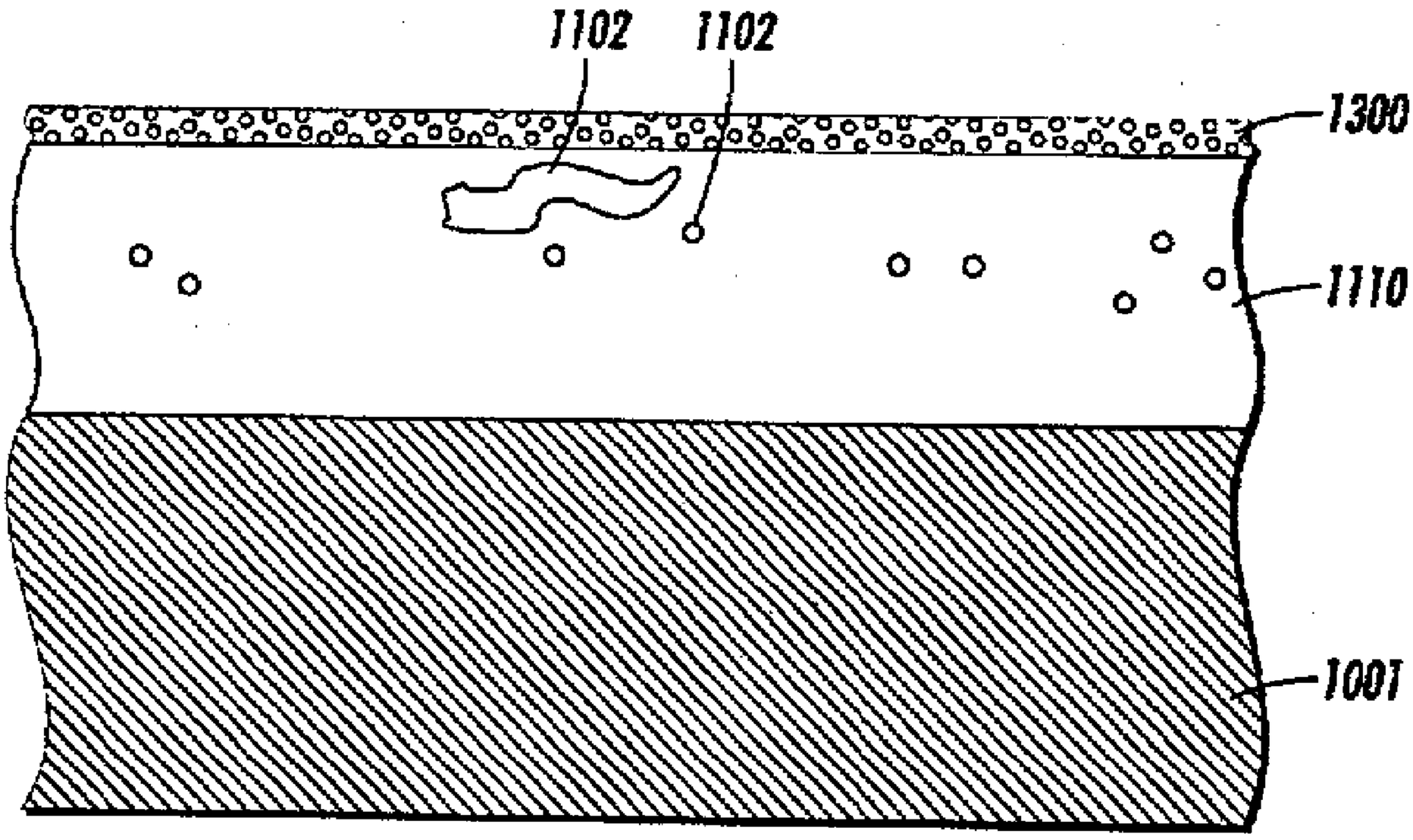


FIG. 9

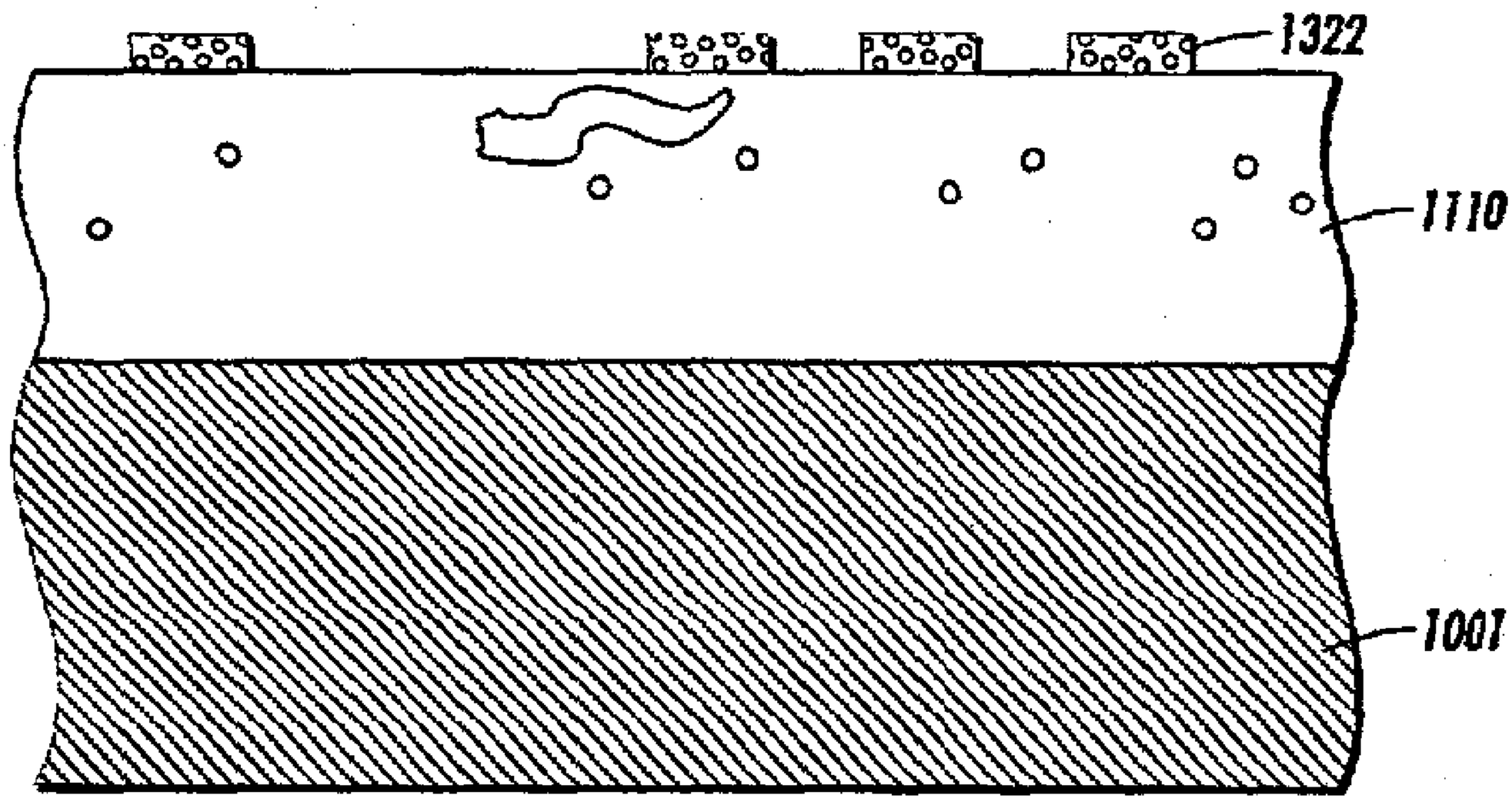


FIG. 10

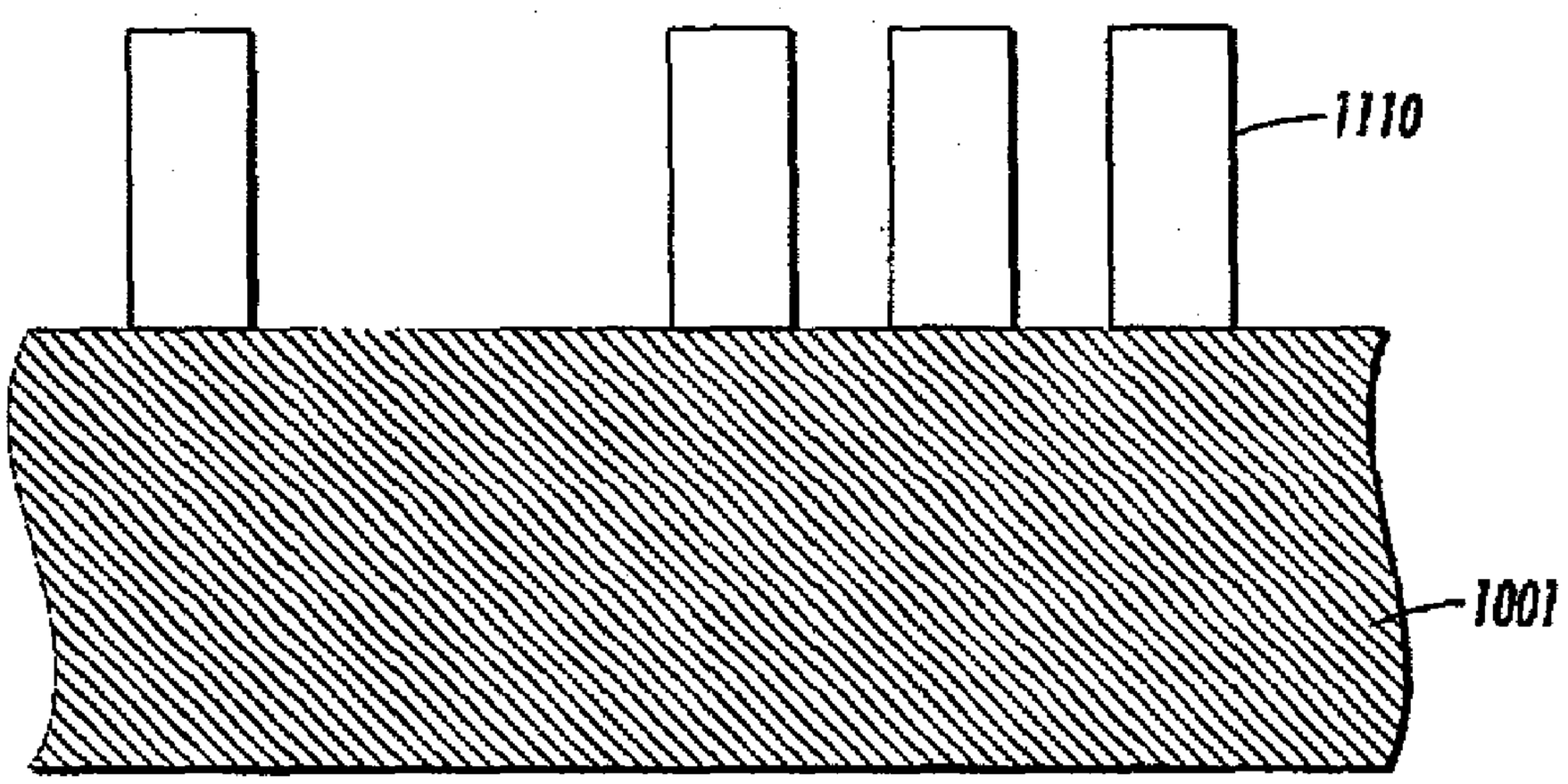


FIG. 11

SYSTEMS AND METHODS FOR FILLING VOIDS AND IMPROVING PROPERTIES OF POROUS THIN FILMS

BACKGROUND OF THE INVENTION

[0001] 1. Field of Invention

[0002] This invention relates to reducing the porosity of porous thin films.

[0003] 2. Description of Related Art

[0004] Substrates having thin films are used commonly in many applications. Thin films are deposited upon substrates used routinely, for instance, in integrated circuits. Likewise, substrates having thin films are used in a multitude of micro-electro-mechanical devices. Substrates having thin films are also used in the semiconductor industry, where great precision in the patterns formed in, and/or locations of, the thin film formed upon the substrates is necessary. The specific patterning and/or positioning of the thin film formed upon a substrate is typically achieved by controllably etching away the thin film material from the substrate using a photoresist mask, such that the thin film material remains in only those areas covered by the photoresist mask.

[0005] **FIG. 1** shows steps corresponding to earlier methods of depositing thin films on substrates. The substrate may be any known or later-developed suitable material, such as glass, metal, or the like. In general, the substrate material will be appropriate for the application the thin film device will be used with. The thin film is formed by sputtering a layer of material used to form the thin film onto the substrate, applying a layer of photoresist materials over the sputtered thin film layer, masking and developing the photoresist material layer to a desired pattern, and then etching away the unwanted photoresist materials and portions of the thin film layer to achieve the desired pattern in the thin film. Often, the resulting thin film layer tends to be porous. That is, the thin film will have voids, pores, holes, cracks and/or other surface penetrating defects.

[0006] Porosity in sputtered thin films is a common occurrence. Such porosity in sputtered thin films contributes to problems, such as photoresist intrusions, that render subsequent photolithography difficult. Porosity in sputtered thin films also contributes to lateral etchant intrusions into sidewalls of a thin film, thus rendering subsequent thin film etching difficult with respect to the precision required in thin films. Likewise, porosity in sputtered thin films results in a decreased mechanical thin film strength. Because of the weakened nature of the thin film, wire-bonding becomes difficult or unreliable. Further, porosity in sputtered thin films results in a lack of lateral film cohesion, which unfavorably compromises the physical properties of the thin film. For example, the transverse electro-mechanical coupling co-efficient of a thin film may be compromised by the lack of lateral film cohesion that occurs in porous thin films.

[0007] After the thin film is deposited on the substrate, a photolithography/photoresist material layer is applied over the thin film layer. The photolithography/photoresist material layer is commonly formed by spin-casting the photolithography/photoresist material layer onto the thin film. Because the thin film has surface-penetrating defects, the photolithography/photoresist material penetrates into the porous thin film. The photolithography/photoresist material is then exposed through a mask to achieve a desired pattern of exposed/unexposed portions of the photolithography/photoresist material layer on the thin film.

[0008] Thereafter, the exposed, or unexposed, portion of the photolithography/photoresist material layer is washed away or otherwise removed to leave the desired pattern of photolithography/photoresist material layer on the thin film. An etchant to which the thin film, but not the photolithography/photoresist material layer, is sensitive is then applied to remove the portions of the thin film that are not protected by the photolithography/photoresist material layer. The remaining patterned photolithography/photoresist material layer is then removed, without damaging the underlying thin film to leave a patterned thin film layer.

[0009] While the above-described process is common, it also is inherently flawed in that the photoresist material, which is initially applied to the thin film and that penetrate the voids or pores of the porous thin film, is often not successfully completely removed in areas intended to be etched prior to etching the thin film. In this case, portions of the thin film that were not to be protected by the photolithography/photoresist material layer are not fully etched away by the etchant because some photoresist remains in the unintended areas. Alternatively, the voids or other surface penetrating defects can allow the etchant to penetrate under the patterned layer of the photolithography/photoresist material layer. In this case, portions of the thin film that were to be protected by the patterned layer of photolithography/photoresist material layer are nonetheless etched away. This results in the thin film pattern upon the substrate being not as accurate or precise as would be ideally provided by the patterned photolithography/photoresist material layer. Furthermore, any etchant that laterally intruded or migrated into unintended areas of the thin film may have weakened the thin film and substrate, and also results in a thin film pattern that is not as accurate or precise as desired.

SUMMARY OF THE INVENTION

[0010] This invention provides systems and methods that reduce the porosity of thin film materials.

[0011] This invention separately provides systems and methods for improving the quality of photoresist-patterned thin films.

[0012] This invention separately provides systems and methods that reduce the incursion of photolithography/photoresist material into thin films.

[0013] This invention separately provides systems and methods that reduce the ability of thin film etchants to intrude into thin films under patterned photoresist layers.

[0014] This invention separately provides systems and methods that coat and penetrate a thin film with a sol-gel preparation to yield the combinant sol-gel/thin film layer having physical properties substantially the same as the original untreated thin film only layer.

[0015] In various exemplary embodiments, the systems and methods of this invention result in a treated thin film that reduces the ability of the photolithography/photoresist materials to intrude into voids or other surface penetrating defects in the thin film. In various exemplary embodiments, the systems and methods of this invention additionally or alter-

natively provide a treated thin film that is better able to resist etchant migrations or intrusions into the thin film that would otherwise disrupt or destroy the desired thin film pattern on the substrate.

[0016] In various exemplary embodiments of the systems and methods of this invention, the treated thin film is formed by applying a sol-gel layer on the porous thin film after the porous thin film is formed on or over the substrate, but before the photolithography/photoresist materials are applied to the thin film. By applying the sol-gel to the porous thin film according to the systems and methods of this invention, the porous thin film can be solidified to remove many, if not all, of the various surface-penetrating defects. That is, the initially porous thin film and sol-gel combination forms a uniformly strong treated thin film layer. Generally, the sol-gel material, or a pre-cursor of the sol-gel material, is applied to the thin film in liquid form and then converted by post application processing, such as by baking or curing the sol-gel material onto the thin film. In general, the sol-gel material, and thus the treated thin film layer, will also have the same etch rates and the same co-efficient of thermal expansion as the original, untreated, porous thin film.

[0017] As a result, after the photolithography/photoresist materials have been applied and patterned according to the mask pattern, the etchant will more accurately remove the unprotected areas of the treated thin film relative to the protected areas of the treated thin film over which the photolithography/photoresist materials have been patterned. Migrations or intrusions of the photoresist materials and/or the etchant into the thin film are reduced. Finally, because the thin film and sol-gel have similar co-efficients of thermal expansion, the strength and durability of the substrate and thin film is increased as the voids, pores and/or other surface-penetrating defects are not as susceptible to cracking or otherwise failing under the force of energy transmission from the thin film to a counterpart device or under heating in subsequent processing steps.

[0018] These and other features and advantages of this invention are described in, or are apparent from, the following detailed description of various exemplary embodiments of the systems and methods according to this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Various exemplary embodiments of the systems and methods of this invention will be described in detail with reference to the following figures, wherein:

[0020] **FIG. 1** is a flowchart illustrating a conventional method for depositing a thin film on a substrate;

[0021] **FIG. 2** represents a substrate having an ideal thin film layer formed on or over the substrate and a photoresist material layer formed over the thin film;

[0022] **FIG. 3** illustrates a substrate having a thin film layer on the substrate and a photoresist material layer that has seeped into cracks or other surface defects of the thin film layer;

[0023] **FIG. 4** illustrates the photoresist material layer of **FIG. 3** after exposing the photoresist layer through a mask;

[0024] **FIG. 5** illustrates the thin film layer of **FIG. 4** after the etching and removal of the patterned photoresist layer;

[0025] **FIG. 6** is a flowchart outlining one exemplary embodiment of a method for forming a thin film layer on or over a substrate according to the systems and methods of this invention;

[0026] **FIG. 7** illustrates a substrate having a thin film formed on or over the substrate and a sol-gel layer formed on the thin film layer;

[0027] **FIG. 8** illustrates the sol-gel layer seeping into and filling cracks and/or surface defects in the thin film layer;

[0028] **FIG. 9** illustrates a photoresist material layer applied on top of the combined sol-gel/thin film layer after the sol-gel has been cured;

[0029] **FIG. 10** illustrates the photoresist material layer of **FIG. 9** after exposing and developing the photoresist layer through a mask; and

[0030] **FIG. 11** illustrates the combined sol-gel/thin film layer of **FIG. 10** according to the systems and methods of this invention after etching and removal of the patterned photoresist layer.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0031] This invention is directed to reducing the porosity in porous thin films and improving the accuracy and quality of photoresist-patterned thin films. Altering conventional methods of making thin films by adding a sol-gel layer to the thin film layer prior to applying a photoresist material layer reduces the number of cracks or other surface defects in the thin film layer. Baking or curing the sol-gel layer after applying the sol-gel layer to the thin film layer results in the sol-gel and thin film layers substantially combining to form a single unified layer of similar properties. As a result, the combined sol-gel/thin film layer has, for example, a co-efficient of thermal expansion or an etch rate that is substantially the same as that of a continuous non-porous thin film of the same material, which the thin film ideally would have had without the sol-gel layer. Generally, the sol-gel material, or a precursor of the sol-gel material, is applied to the thin film in liquid form and then converted by post application processing such as baking or curing to form a unified sol-gel/thin film layer.

[0032] It should be appreciated, of course, that the application of a sol-gel layer to a porous thin film may be used in applications other than a photolithography/photoresist material etching application, which is set forth and described herein as an exemplary illustration only of some of the benefits and advantages of reducing the effects of porosity defects in a thin film layer by adding and combining the sol-gel layer with the thin film layer.

[0033] Other exemplary benefits and/or advantages of the combined sol-gel/thin film layer having reduced porosity defects include an increased mechanical integrity of the sol-gel/thin film layer. As a result, more uniform strength or stability exists in the sol-gel/thin film layer rendering wire bonding, for example, more reliable. For instance, the sol-gel/thin film layer provides greater mechanical strength than non-sol-gel treated thin films.

[0034] Further, the uniformity and lateral cohesion of the sol-gel/thin film layer renders a medium having substantially the same velocity of sound which improves the transmission

reliability of acoustic sound waves through the sol-gel/thin film layer. Likewise, because of the lateral cohesion of the sol-gel/thin film layer, electro-mechanical properties of the sol-gel/thin film layer are less likely to be compromised than non-sol-gel treated thin films. Photoresist intrusions and/or lateral etchant intrusions are also reduced due to the application of the sol-gel layer upon the thin film layer.

[**0035**] Further, the sol-gel/thin film combinant layer will exhibit substantially the same coefficient of thermal expansion as the untreated thin film layer, while at the same time reducing the porosity defects that otherwise often occur in sputtered thin films as discussed above. Other benefits and advantages, such as the planarization of the thin film layer by the sol-gel, for example, may also result from the sol-gel/thin film layer of the invention.

[**0036**] **FIG. 1** shows a flowchart outlining a conventional method for producing thin films on substrates. As shown in **FIG. 1**, after beginning the process in step S**100**, operation continues to step S**200**, where a substrate is provided. Then, in step S**300**, a thin film is deposited on or over the substrate. Next, in step S**400**, a photoresist material layer is applied over the thin film. Operation continues to step S**500**.

[**0037**] In step S**500**, the photoresist material layer is exposed through a mask. Next, in step S**600**, the photoresist material layer is developed. Masking and developing the photoresist material layer in steps S**500** and S**600** results in a patterned photoresist material layer. Then, in step S**700**, an etchant is applied to remove the thin film over which no remaining photoresist material layer remains. A stripper is subsequently applied in step S**800** to remove the remaining patterned portion of the photoresist material layer over the thin film layer portion. Operation then continues to step S**900**, where the method ends.

[**0038**] **FIG. 2** shows a substrate **100** having a thin film layer **110** and a photoresist layer **120** formed according to steps S**200**, S**300** and S**400**. Ideally, the thin film layer **110** would have no voids, cracks or other surface defects, as shown in **FIG. 2**. However, when a thin film layer such as thin film layer **110** is deposited upon a substrate, such as the substrate **100**, voids, cracks or other surface defects typically occur in the thin film layer **110**. The thin film layer **110** may be one of an oxide and a metallic salt, although it should be appreciated that other materials may be used to form the thin film layer **110** as well. For example, the oxide may be zinc. An exemplary list of other materials the thin film layer **110** may be formed of includes nitrides, sulfides, selenides, tellurides, arsenides, phosphides, borides, bromides, carbides, chlorides, cyanides, disulfides, fluorides, hydroxides, iodides, monoxides, oxyfluorides, oxynitrides, pentoxides, peroxides, titanides, aluminates, antimonides, silicates, silicides, stannates, titanates, and tungstates. Of course, it should be appreciated that any other known or later-developed material may also be used in the thin film layer

[**0039**] **FIG. 3** shows a thin film layer **111** on a substrate **101**, where the thin film layer **111** exhibits a variety of voids **112**, and cracks or other surface defects **113**. As a result of the cracks or other surface defects **113**, the photoresist material layer **121**, when applied, seeps into the cracks or other surface defects **113**.

[**0040**] **FIG. 4** shows the result of masking and developing the photoresist material layer **121** according to steps S**500** and S**600** of **FIG. 1**. Specifically, as shown in **FIG. 4**, after masking and developing the photoresist material layer **121**, portions of the photoresist material layer **121** are removed, or washed away, except in those areas **122** where it is desired to continue to cover and protect the thin film layer **111**. However, in addition to the photoresist remaining in the protection areas **122**, where the photoresist material is intended or desired to remain, to protect the corresponding areas of the thin film layer **111**, some photoresist material also remains in other, desirably-unprotected, areas of the thin film layer **111**, such as in the cracks or other surface defects **113**. This occurs because masking and developing the photoresist material layer **121** typically removes only those parts of the photoresist material layer **121** that are on the surface of the thin film layer **111**. As a result, the remaining portions **123** of the photoresist material located in the cracks and other surface defects **113** of the thin film layer **111** pose problems when the etchant is applied, as described above with respect to step S**600** of **FIG. 1**.

[**0041**] However, as can be readily seen from **FIG. 5**, applying an etchant to a thin film layer **111** having cracks or other surface defects **113** filled with the remaining portions **123** of the photoresist material layer **121** results in not all of the thin film layer **111** being removed where it was desired that all of the thin film layer **111** be removed. The photoresist material interferes with or contaminates the etching process when the photoresist material contaminates the voids or other surfaces defects **113** in the thin film layer **111**. Thus, undesirable thin film portions **130** remain on the substrate **100** even after etching. Moreover, the voids **112** permit unpredictable etching to occur underneath the protection portions **122** of the patterned photoresist material layer **121**. Such unpredictable etching may result in, for example, the removal of a portion of the thin film layer **111** that was intended to remain after etching. This occurs as the etchant penetrates under or around a location such that the void **112** is located. As a result, an etched portion **131** of the film **111** may occur such that a portion of the thin film layer **111** that was intended to be fully present is missing.

[**0042**] **FIG. 6** is a flowchart outlining a first exemplary embodiment of a method for forming a thin film on a substrate according to this invention. The thin film contemplated is a porous thin film that poses the problems and disadvantages illustrated above with respect to FIGS. **1-5**, particularly the unpredictable etching resulting in the removal of portions of the thin film layer that were intended to remain, and portions of the thin film layer that were intended to be removed remaining after etching the thin film. Reducing the porosity defects in porous thin films according to this invention improves the quality and accuracy of the patterned thin films produced.

[**0043**] As shown in **FIG. 6**, beginning in step S**1000**, operation continues to step S**1100**, where a substrate is provided. The substrate may be, for example, glass, metal, or other material known or later developed that is suitably appropriate to the application the thin film is to be used with. Then, in step S**1200**, a thin film layer is applied on or over the substrate. Next, in step S**1300**, a sol-gel layer is applied on the thin film layer. Generally, the sol-gel layer, or a precursor of the sol-gel material, is applied in liquid form and converted by post application processing, such as by baking or curing, to the thin film layer. Applying the sol-gel layer thus differs from forming the thin films represented in

FIGS. **1-5** and permits a reduction of the porosity defects in the thin film layer to be obtained. Operation then continues to step S**1400**.

[**0044**] In step S**1400**, the sol-gel layer is cured, by baking or any other appropriate known or later developed curing techniques, to substantially merge and unify the sol-gel layer with the underlying thin film layer. Next, in step S**1500**, a photoresist material layer is applied over the top of the combined sol-gel/thin film layer. Then, in step S**1600**, the photoresist material layer is patterned using any appropriate known or later-developed patterning technique such as exposing the photoresist material through a mask. Operation then continues to step S**1700**.

[**0045**] In step S**1700**, the photoresist material layer is developed to produce a desired pattern in the photoresist material layer over the combined sol-gel/thin film layer. Then, in step S**1800**, an etchant is applied to remove the combined sol-gel/thin film layer, except in those areas where the photoresist material layer remains to protect the combined sol-gel/thin film layer. Subsequently, in step S**1900**, a stripper is used to remove the protection portions of the photoresist material layer to yield the patterned thin film with improved accuracy and minimal porosity defects. Next, in step S**2000**, the method ends.

[**0046**] **FIG. 7** illustrates a substrate **1000** having a thin film layer **1100** on or over the substrate **1000** and a sol-gel layer **1200** formed on the thin film layer **1100**. Ideally, as shown in **FIG. 7**, the thin film layer **1100** has no voids, crack or other surface defects. Thus, the sol-gel layer **1200** lies flat atop the upper surface of the thin film layer **1100**. However, thin film layers deposited, or otherwise formed, on a substrate typically have voids and other defects due to their porous nature.

[**0047**] **FIG. 8** shows a substrate **1001** with a more typical porous thin film layer **1101** in which a number of voids **1102**, and a number of cracks or other surface defects **1103** are present. **FIG. 8** also shows that in such thin films **1101**, the sol-gel layer **1201**, applied on or over the upper surface of the porous thin film layer **1101**, seeps into and fills the cracks or other surface defects **1103** present in the porous thin film layer **1101**.

[**0048**] **FIG. 9** shows the substrate **1001** after the sol-gel layer **1201** and the thin film layer **1101** have been cured and merged to form a combined sol-gel/thin film layer **1110**. The combined sol-gel/thin film layer **1110** exhibits substantially similar properties to that which were originally associated with the porous thin film layer **1101**. A photoresist material layer **1300** is placed on or over the surface of the combined sol-gel/thin film layer **1110**. As a result of the combined sol-gel/thin film layer **1110**, masking and etching become more reliable as the combined sol-gel/thin film layer **1110** is patterned. Further, the physical properties of the combined sol-gel/thin film layer become substantially the same as the original thin-film-only layer. Thus, the sol-gel/thin film layer has a co-efficient of thermal expansion substantially the same as that of the thin-film-only layer.

[**0049**] As can be seen from **FIG. 10**, the combined sol-gel/thin film layer **1110** presents a smooth, generally defect-free (or at least defect-reduced) upper surface. Thus, the portions of the photoresist material layer **1300** that are to be removed can be removed accurately, so that only the protection portions **1322** of the patterned photoresist material layer **1300** remain. This patterning accuracy improves the accuracy in etching away only the unwanted portions of the combined sol-gel/thin film layer **1110**.

[**0050**] **FIG. 11** illustrates the patterned combined sol-gel/thin film layer **1110** remaining after etching. As shown in **FIG. 11, a** reduced number of, and ideally no, remaining portions of combined sol-gel/thin film layer **1110** exist on top of the substrate **1001** other than those areas of the combined sol-gel/thin film layer **1110** that were under the protection portions **1322** of the patterned photoresist layer **1300**. Likewise, the unpredictable surfaces that occurred as a result of etchant seepage underneath or around voids present in the combined sol-gel/thin film layer are reduced and ideally eliminated. Accordingly, more accurate thin film patterning and etching of the combined sol-gel/thin film layer **1110** is achieved. Likewise, because curing the sol-gel in step S**1400** renders the combined sol-gel/thin film layer **1110** substantially the same as the initially-provided porous thin film layer **1101** alone, the desired properties of the thin film device are generally obtained. As a result, according to the systems and methods of this invention, a more reliable and more accurate thin film device is achieved at minimal expense.

[**0051**] It should be appreciated that in some embodiments, steps S**1500**-S**1900** can be omitted if further processing of the sol-gel/thin film layer **1110** is not necessary or desirable, or that other processing in addition to, or instead of, photoresist patterning is to performed on the sol-gel/thin film layer **1110**. This may be especially so where an additional layer, different than, or to the exclusion of, the photoresist material layer is applied on or over the combined sol-gel/thin film layer **1110**. Such a combinant sol-gel/thin film layer has a reduced number of porosity defects as compared to the original untreated thin film layer, so that a subsequent layer, or layers, other than photolithography/photoresist materials may be applied to the sol-gel/thin film layer **1110** without the risks a high number of porosity defects would otherwise pose. Accordingly, increased stability, strength and structural integrity may be advantageously achieved in any device having a sol-gel/thin film layer to reduce porosity defects otherwise present in an untreated thin film.

[**0052**] Further, it should be appreciated that in still other embodiments, the steps S**1500**-S**1900** may be omitted after the sol-gel/thin film layer **1110** is formed so that further processing other than, or in combination with, etching may occur with advantages of the reduced porosity defects resulting form the sol-gel/thin layer **1110**. Other exemplary benefits and/or advantages of the combined sol-gel thin film layer having reduced porosity defects include an increased mechanical integrity of the sol-gel/thin film layer. As a result, more uniform strength or stability exists in the sol-gel/thin film layer, rendering wire bonding, for example, more reliable. Further, the uniformity of the sol-gel/thin film layer creates a medium having substantially the same velocity of sound which improves the transmission reliability of acoustic sound waves in the sol-gel/thin film layer. Photoresist intrusions and/or lateral etchant intrusion are also reduced due to applying the sol-gel layer on the thin film layer. Other benefits and advantages may also result from the sol-gel thin film layer of the invention.

[**0053**] While this invention has been described in conjunction with the specific embodiments above, it is evident

that many alternatives, combinations, modifications, and variations are apparent to those skilled in the art. Accordingly, the preferred embodiments of this invention, as set forth above are intended to be illustrative, and not limiting. Various changes can be made without departing from the spirit and scope of this invention.

What is claimed is:

1] A method of reducing the effects of surface penetrating defects in a substrate having a thin film, comprising:

providing a substrate;

applying a thin film on or over the substrate;

applying a sol-gel layer on or over the thin film, the sol-gel layer filling at least some voids, cracks or other surface penetrating defects present in the thin film; and

curing the sol-gel layer to combine the sol-gel layer and the thin film layer into a sol-gel/thin film layer.

2] The method of claim 1, wherein the sol-gel is a liquid.

3] The method of claim 1, wherein curing the sol-gel yields the sol-gel/thin film layer that exhibits at least one property that is substantially the same as the corresponding property in the thin film layer resulting from the applying step.

4] The method of claim 3, wherein the at least one property is at least one of a coefficient of thermal expansion and an etch rate.

5] The method of claim 4, wherein the at least one property includes, in addition, an increased mechanical strength.

6] The method of claim 4, wherein the at least one property includes, in addition, a substantially uniform medium for transmitting acoustic waves.

7] The method of claim 1, further comprising

applying a photoresist material layer to the sol-gel/thin-film layer;

exposing the photoresist material layer through a mask;

developing the photoresist material layer to achieve a pattern of protected portions of the sol-gel/thin film layer;

applying an etchant to remove unprotected portions of the sol-gel/thin film layer; and

removing the photoresist material layer remaining over the protected portions of the sol-gel/thin film layer.

8] A treated thin film having reduced effects of porosity voids or other surface penetrating defects, the treated thin film comprising:

a substrate;

a porous thin film layer formed on or over the substrate; and

a sol-gel layer that fills voids, cracks or other surface penetrating defects in the porous thin film layer.

9] The method of claim 7, wherein the sol-gel is a liquid.

10] The treated thin film layer of claim 8,

wherein curing the sol-gel layer results in the sol-gel layer combining with the porous thin film layer to form the treated thin film layer.

11] The treated porous thin film of claim 10, wherein the treated thin film layer exhibits at least one property substantially similar to the corresponding property in the porous thin film layer before the sol-gel layer was applied.

12] The treated porous thin film of claim 10, wherein the at least one property is at least one of mechanical strength, coefficient of thermal expansion, etch rate, and velocity of sound.

13] The treated thin film of claim 11, further comprising a photoresist material layer applied on or over the sol-gel/thin film layer, wherein the photoresist material layer is patterned and developed to produce a patterned photoresist material layer defining protected and unprotected portions of the treated thin film layer.

14] The treated porous thin film of claim 13, wherein the unprotected portions of the treated thin film layer are removed using an etchant such that a patterned treated thin film is obtained.

15] A treated thin film layer having reduced effects of porosity voids or other surface penetrating defects, the treated thin film comprising:

a substrate;

a porous thin film layer formed on or over the substrate; and

a sol-gel material that fills voids, cracks or other surface penetrating defects in the porous thin film layer.

16] The treated thin film of claim 15, wherein the sol-gel is a liquid.

17] The treated thin film of claim 15, wherein the treated thin film includes at least one of an oxide and a metallic salt.

18] The treated thin film layer of claim 15, wherein the sol-gel material includes at least one material selected from the group consisting of oxides, nitrides, sulfides, antimonides, arsenides, borides, bromides, carbides, chlorides, cyanides, disulfides, fluorides, hydroxides, iodides, monoxides, nitrides, oxyfluorides, oxynitrides, pentoxides, peroxides, phosphides, selenides, tellurides, titanides, aluminates, silicates, stannates, titanates and tungstates.

19] The thin film layer of claim 17, wherein the treated thin film layer includes a metallic salt that includes zinc.

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