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(54) **PROCESS METHOD OF USING EXCIMER LASER FOR FORMING MICRO SPHERICAL AND NON-SPHERICAL POLYMERIC STRUCTURE ARRAY**

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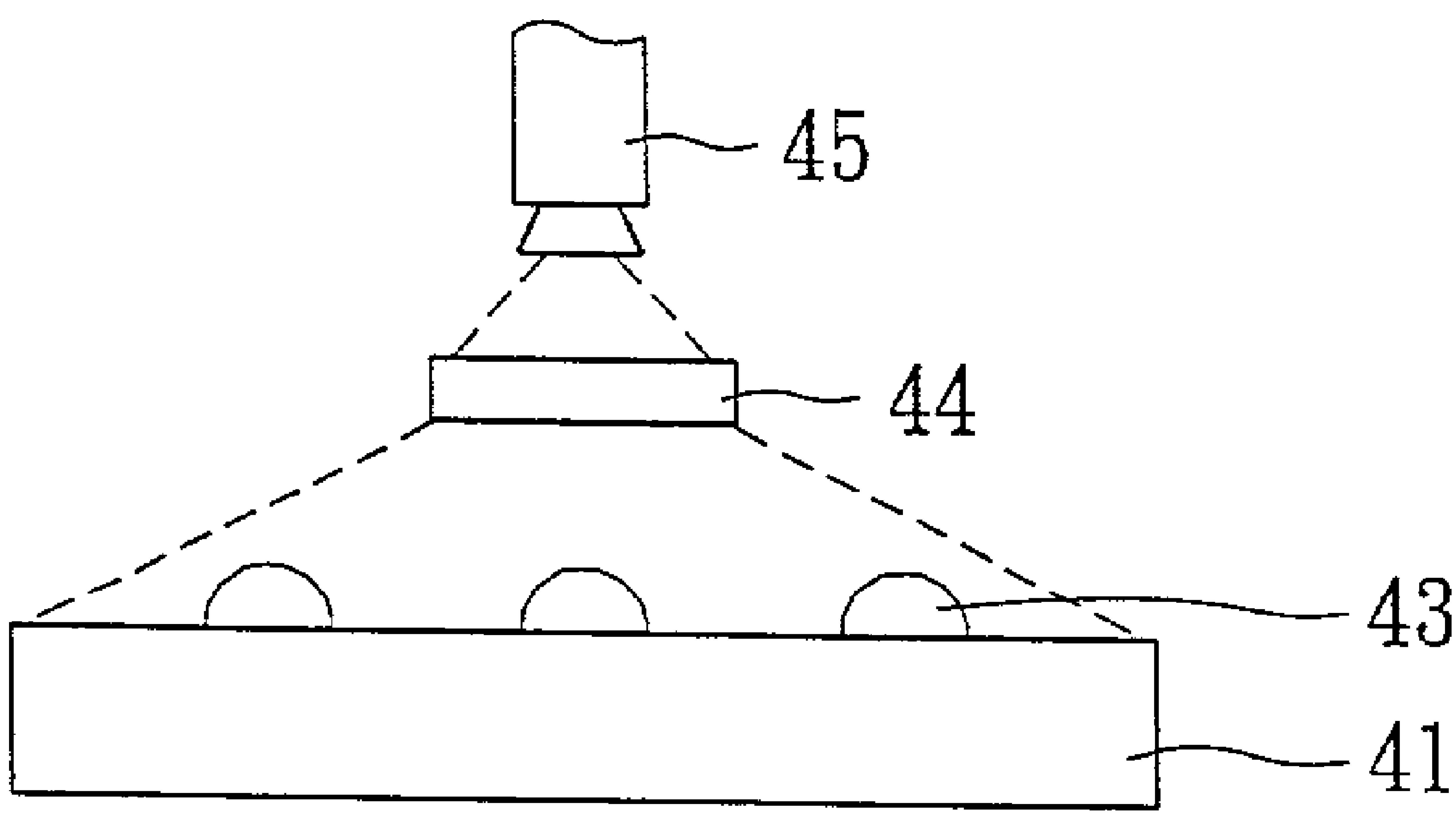
(57) **ABSTRACT**

A process method of using excimer laser for forming micro spherical and non-spherical polymeric structure array includes a photomask which has a selected curved pattern formed thereon. The curved pattern has non-constant widths along a straight line direction. An excimer laser beam source is deployed to project through the photomask on a substrate coated with a polymeric material while the substrate is moving in a direction normal to the straight line direction for the polymeric material to receive laser beam projection with different time period. The polymeric material thus may be etched to different depth to form a three dimensional pattern desired. By projecting and etching the polymeric material two times at different directions or through different photomask patterns, a sphere like or non-sphere like surface of micro array structure may be obtained.



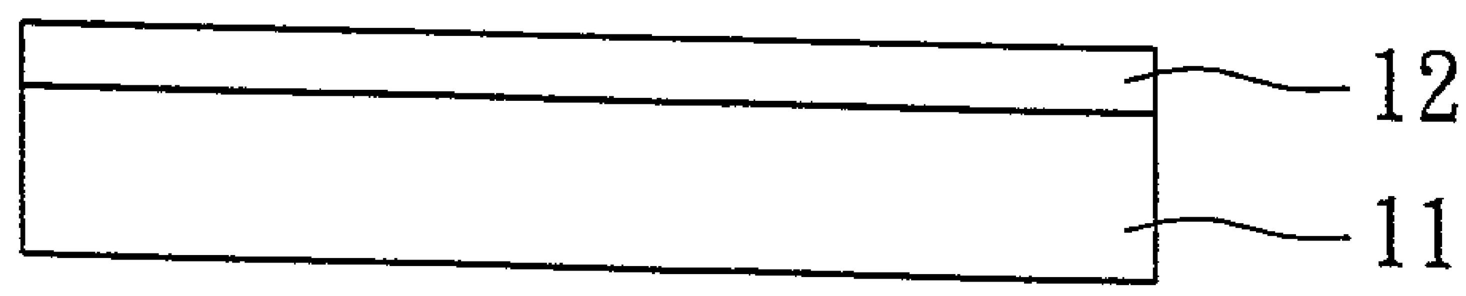



FIG. 1A
(PRIOR ART)

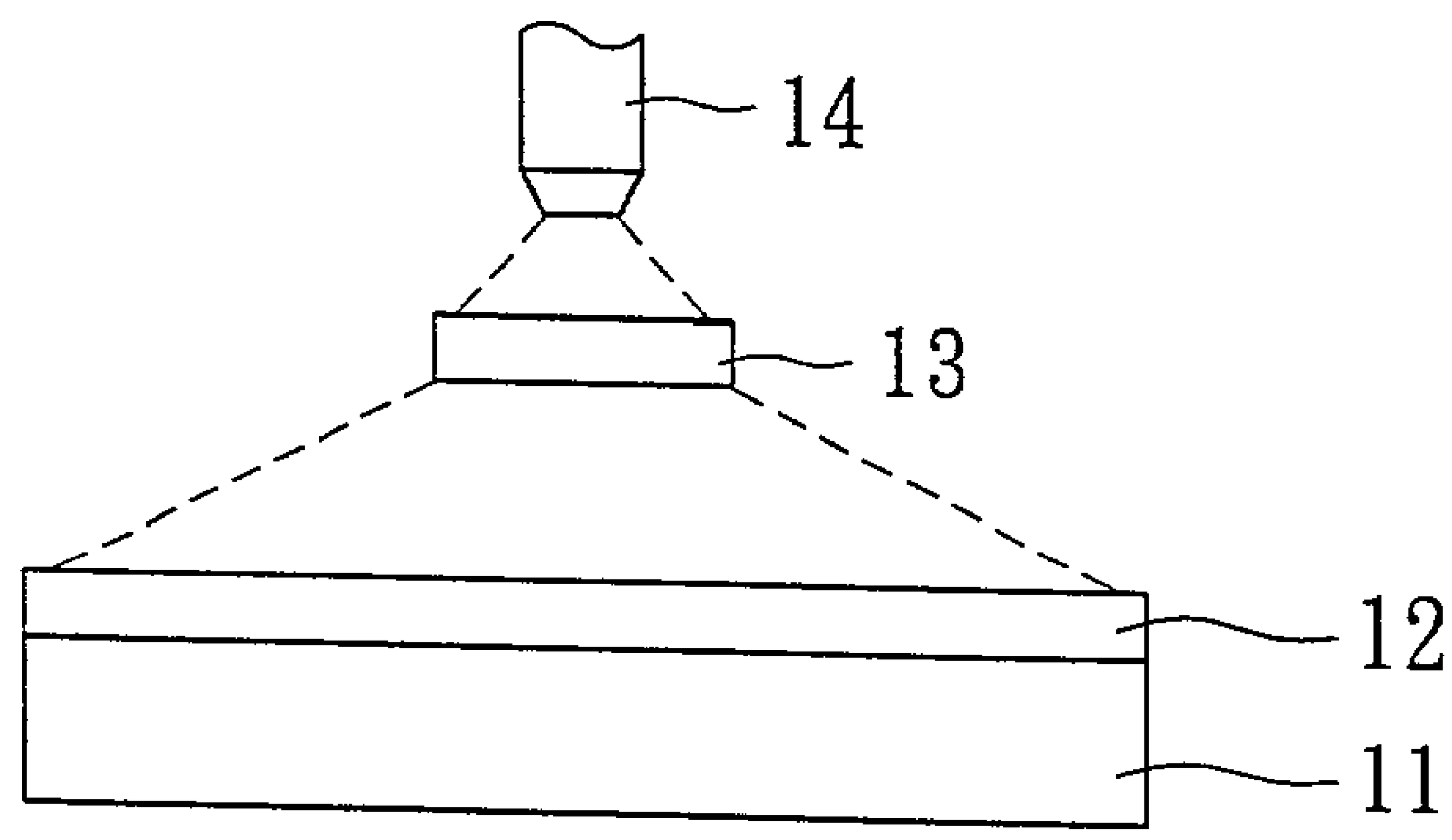



FIG. 1B
(PRIOR ART)

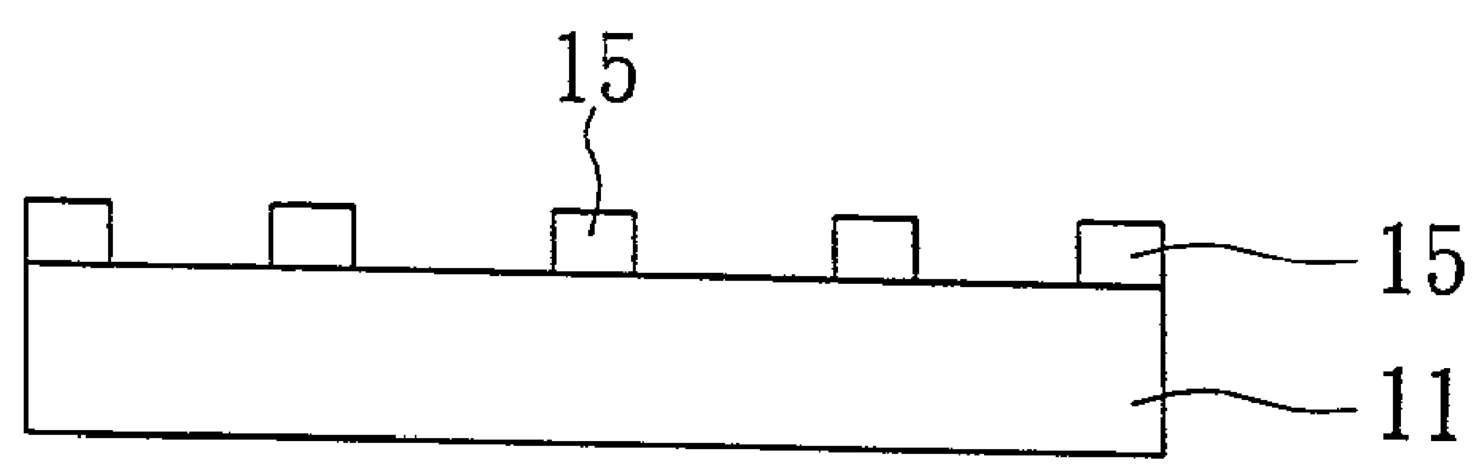



FIG. 1C
(PRIOR ART)

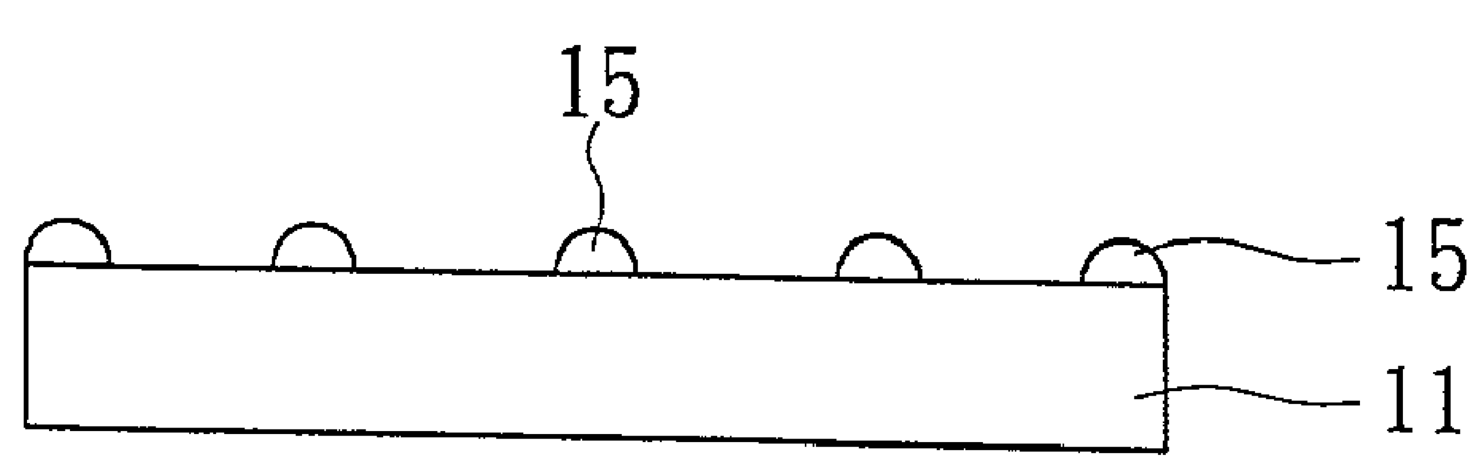



FIG. 1D
(PRIOR ART)

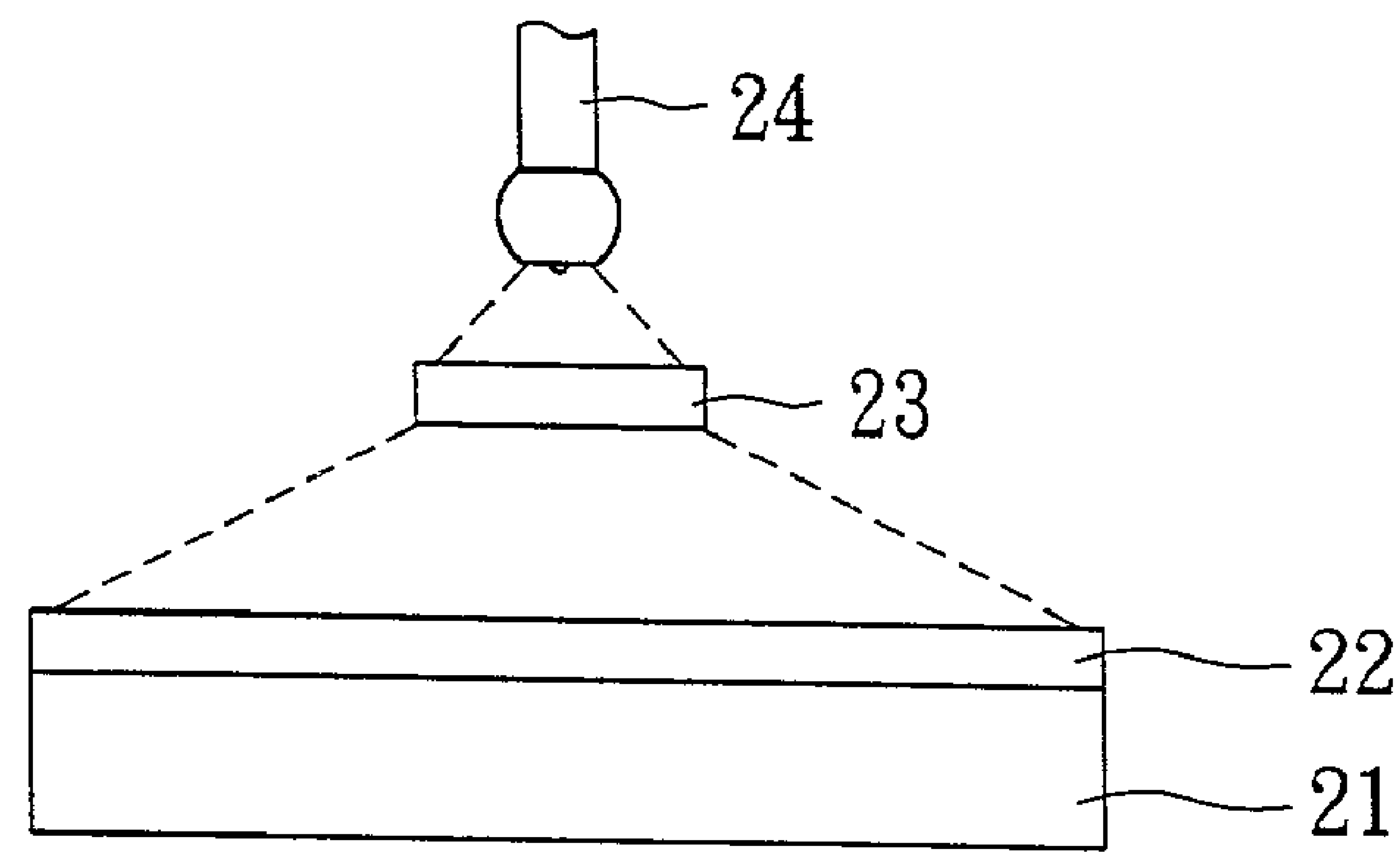



FIG. 2A
(PRIOR ART)

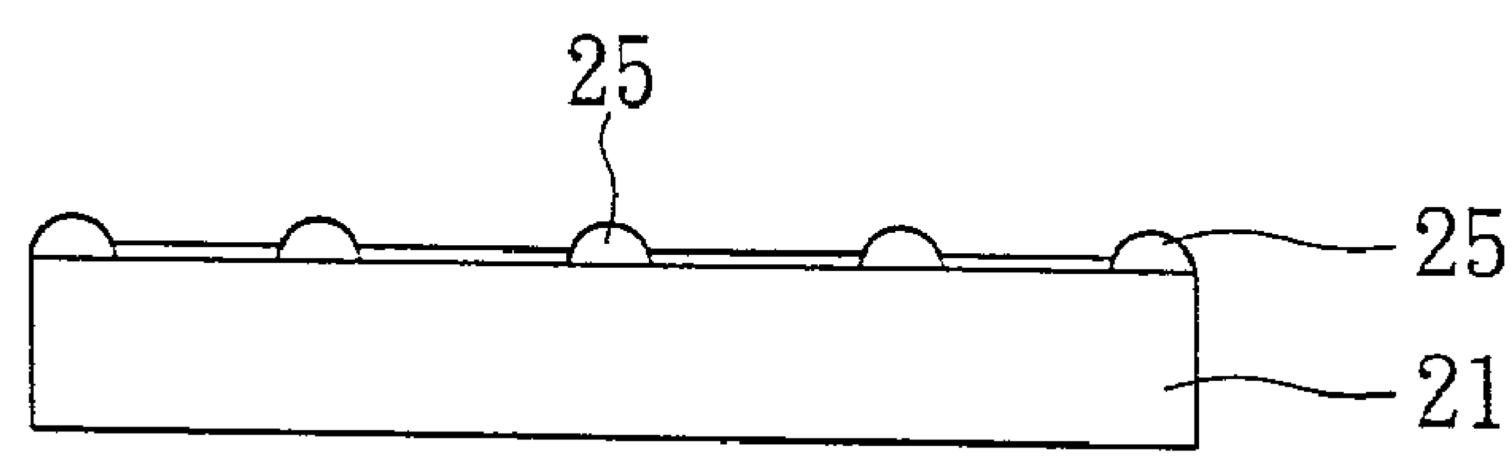



FIG. 2B
(PRIOR ART)

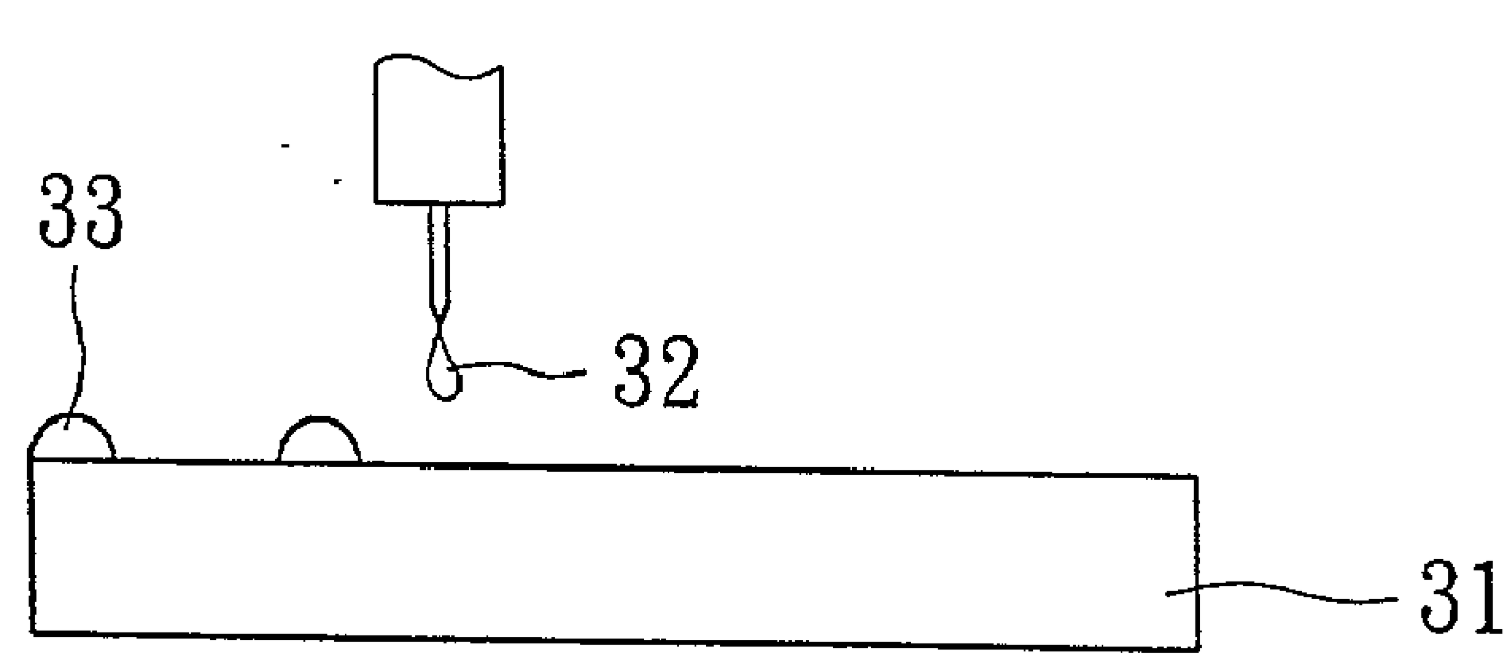



FIG. 3
(PRIOR ART)

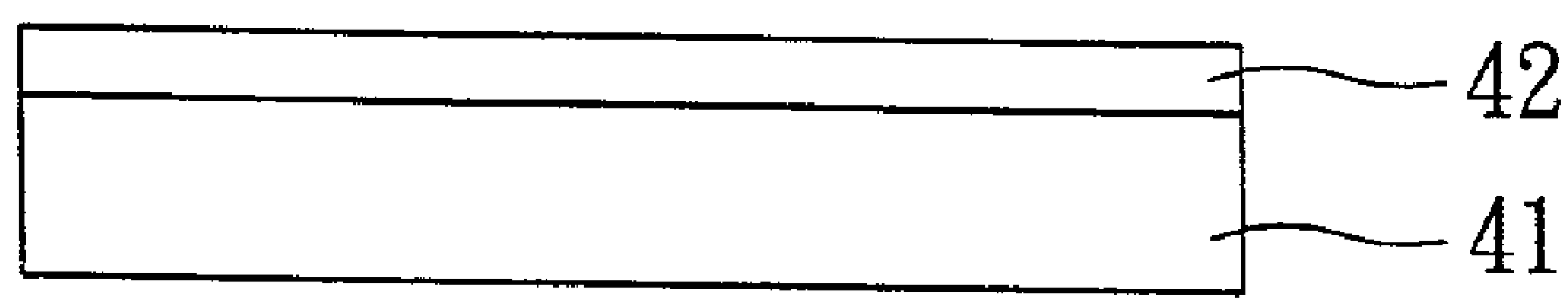



FIG. 4A

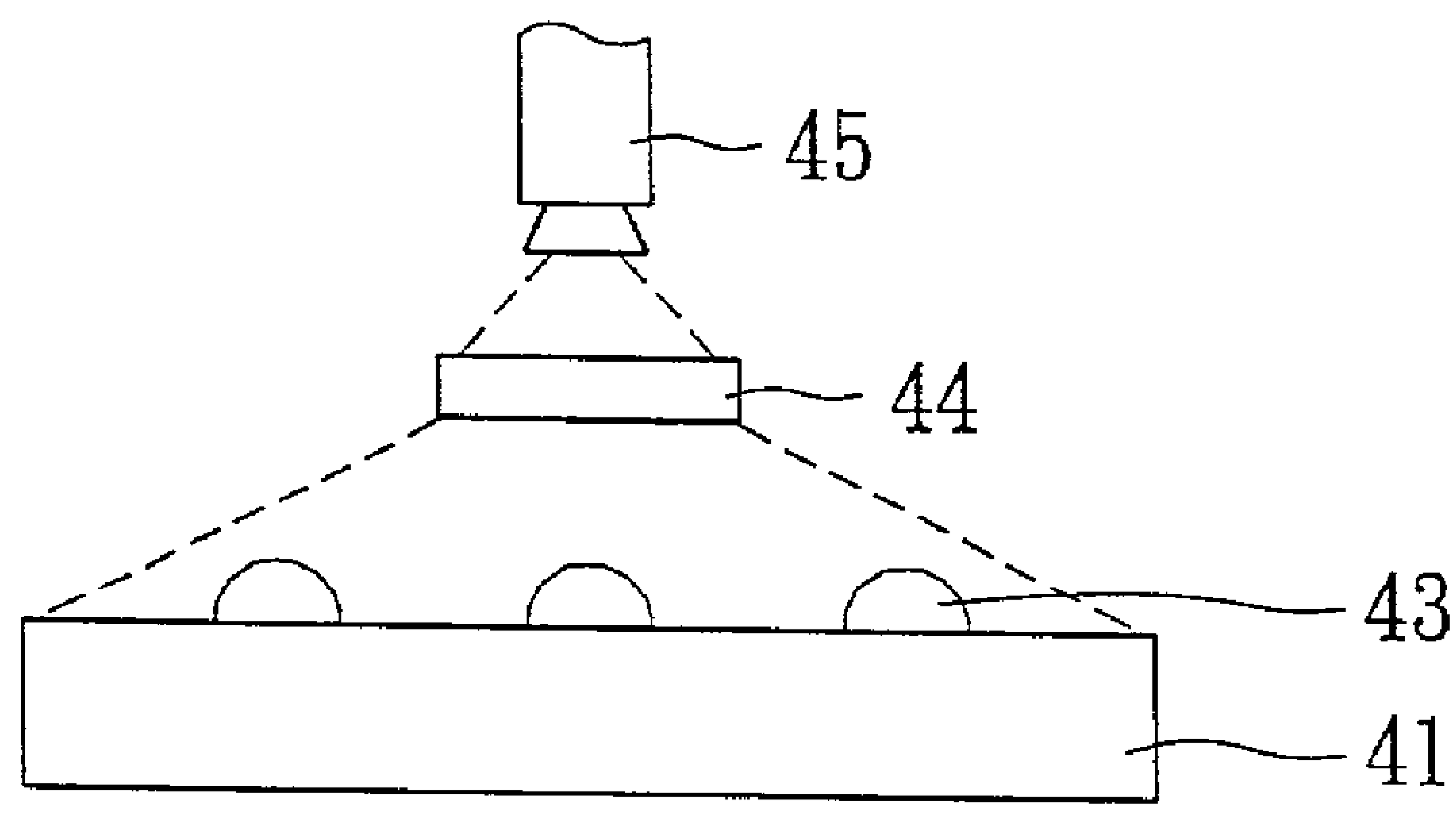



FIG. 4B

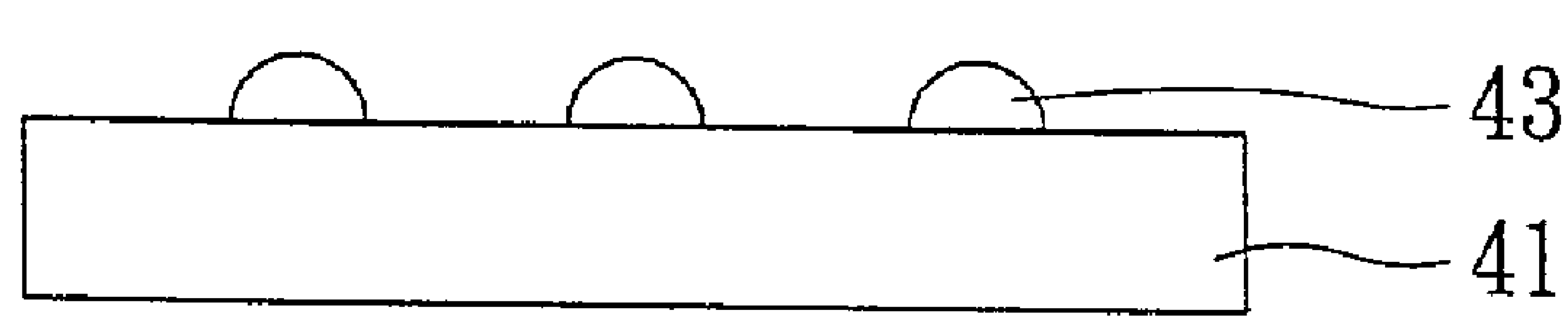



FIG. 4C

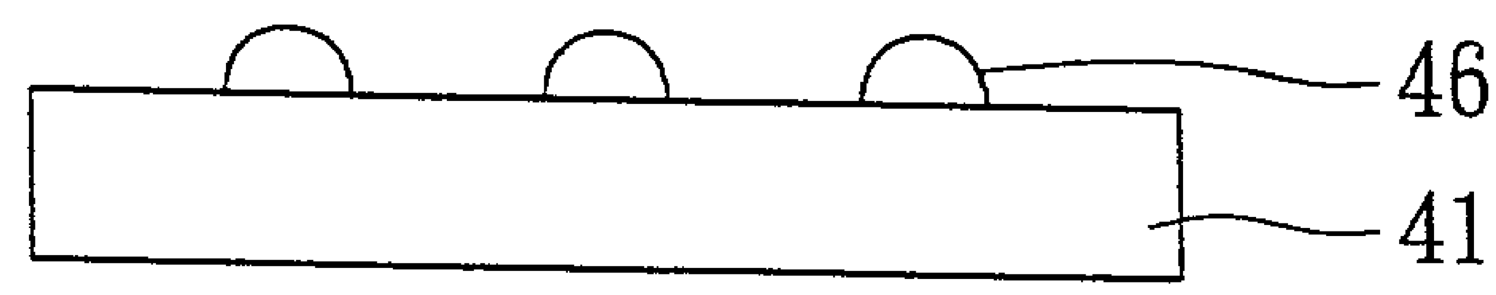



FIG. 4D

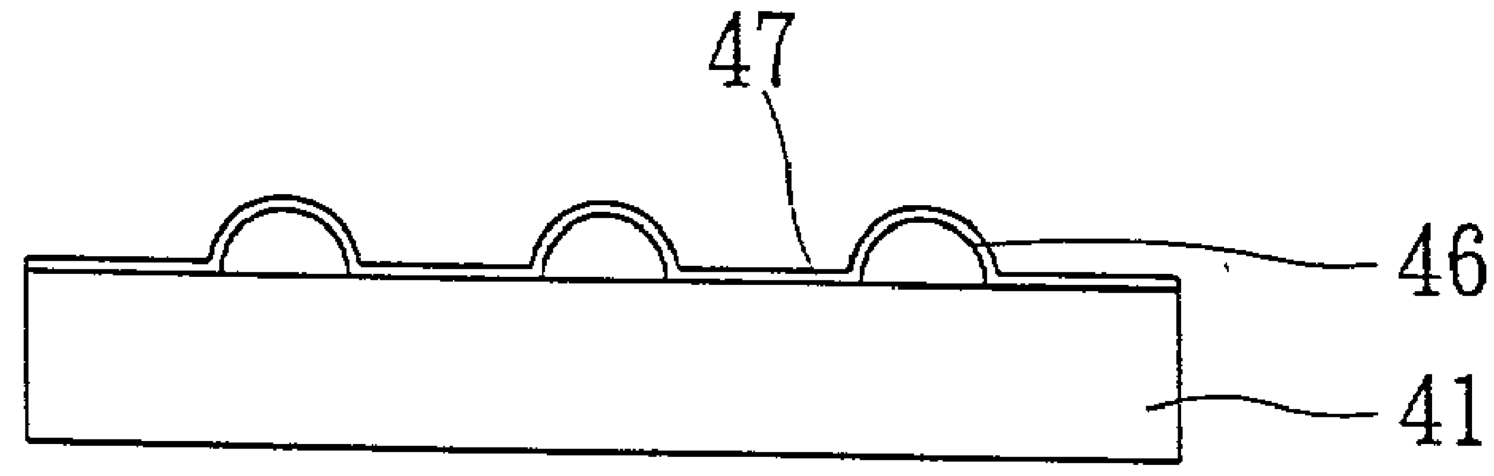



FIG. 4E

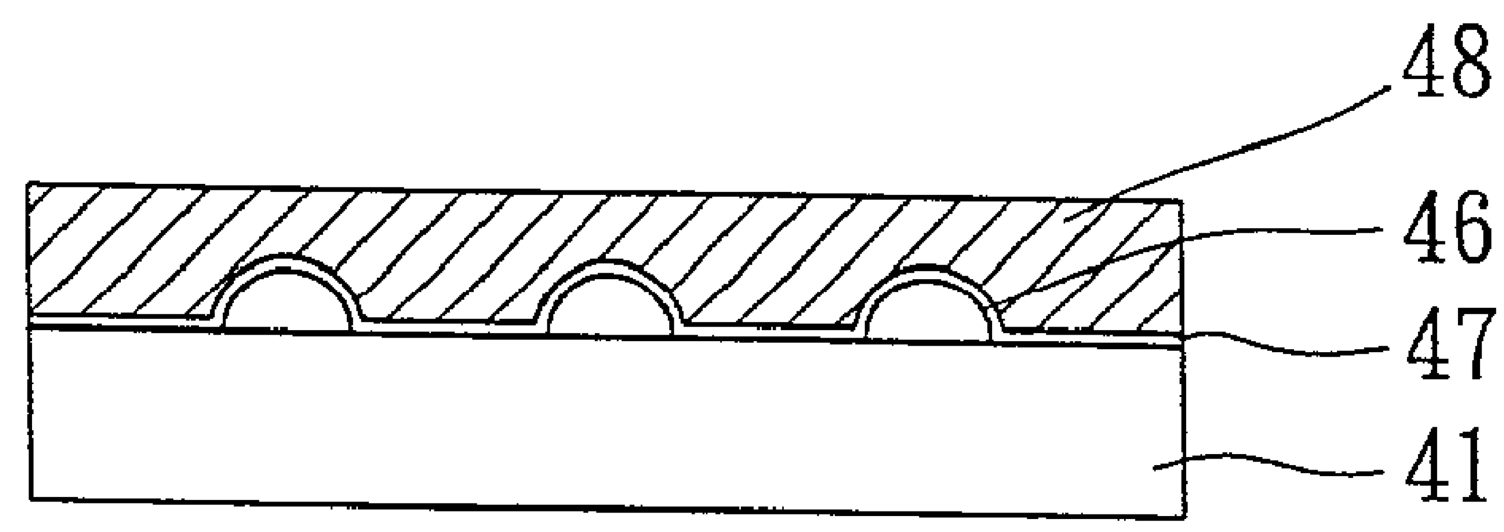



FIG. 4F

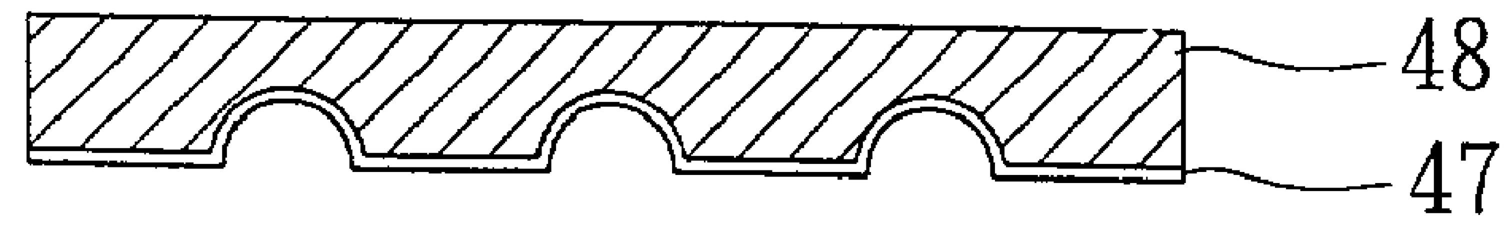



FIG. 4G

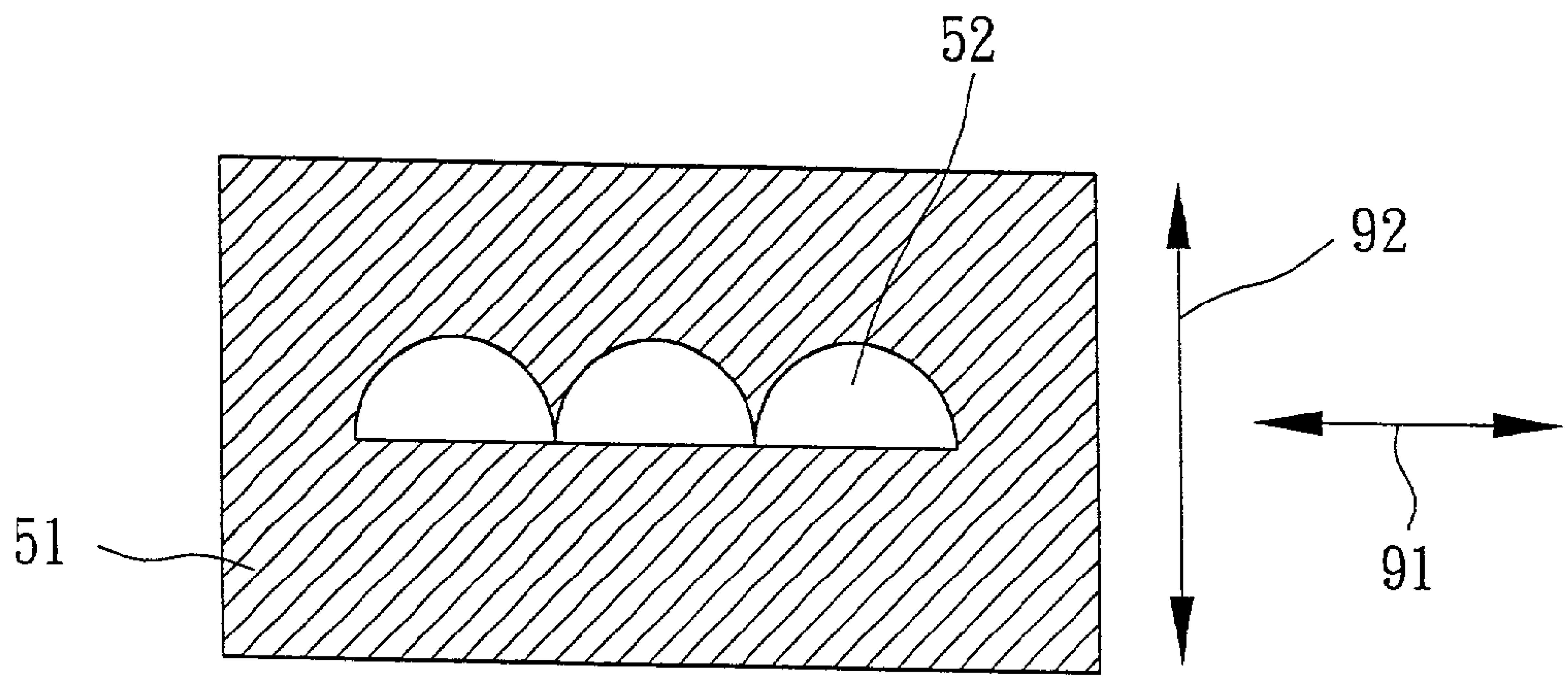



FIG. 5A

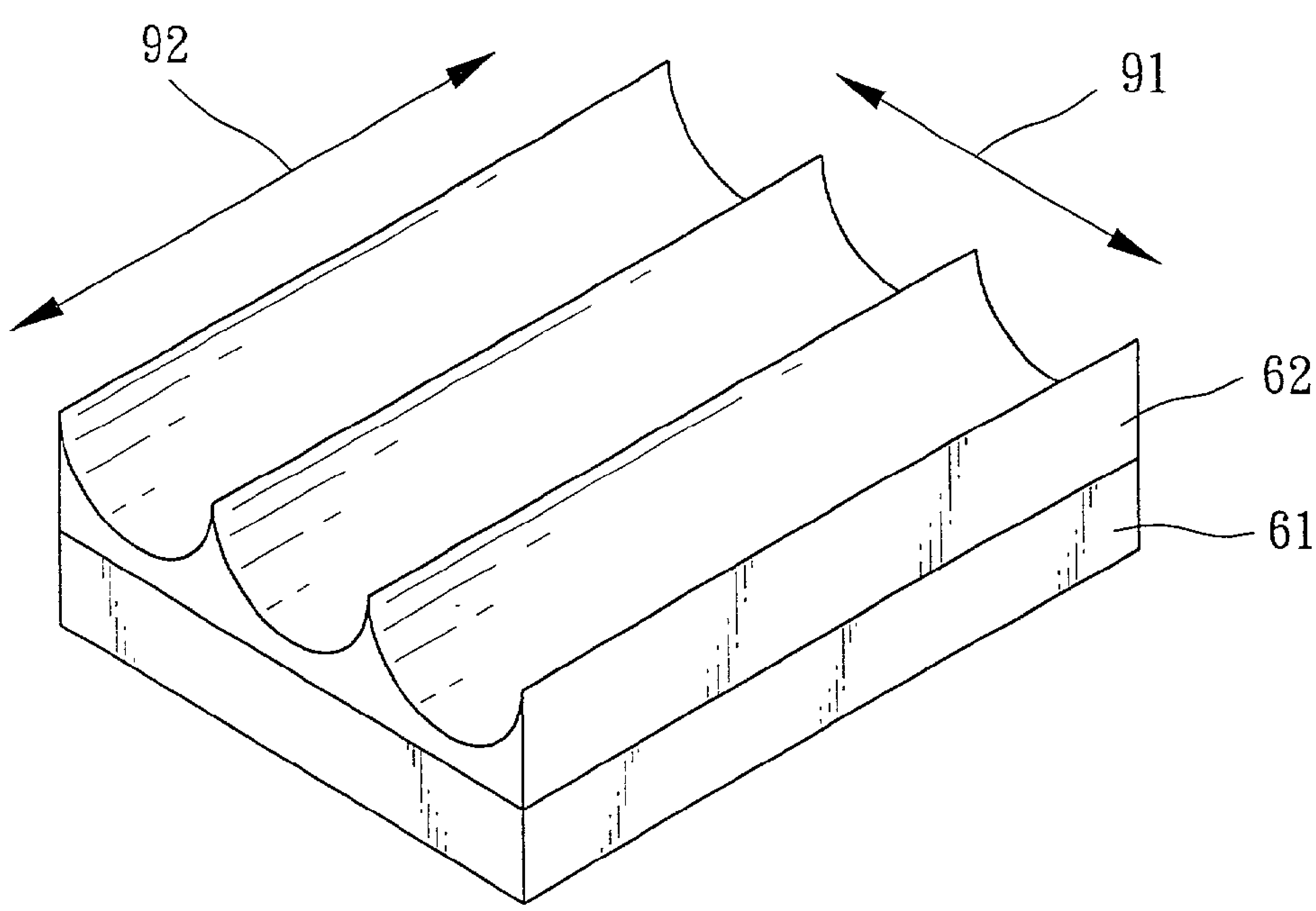



FIG. 5B

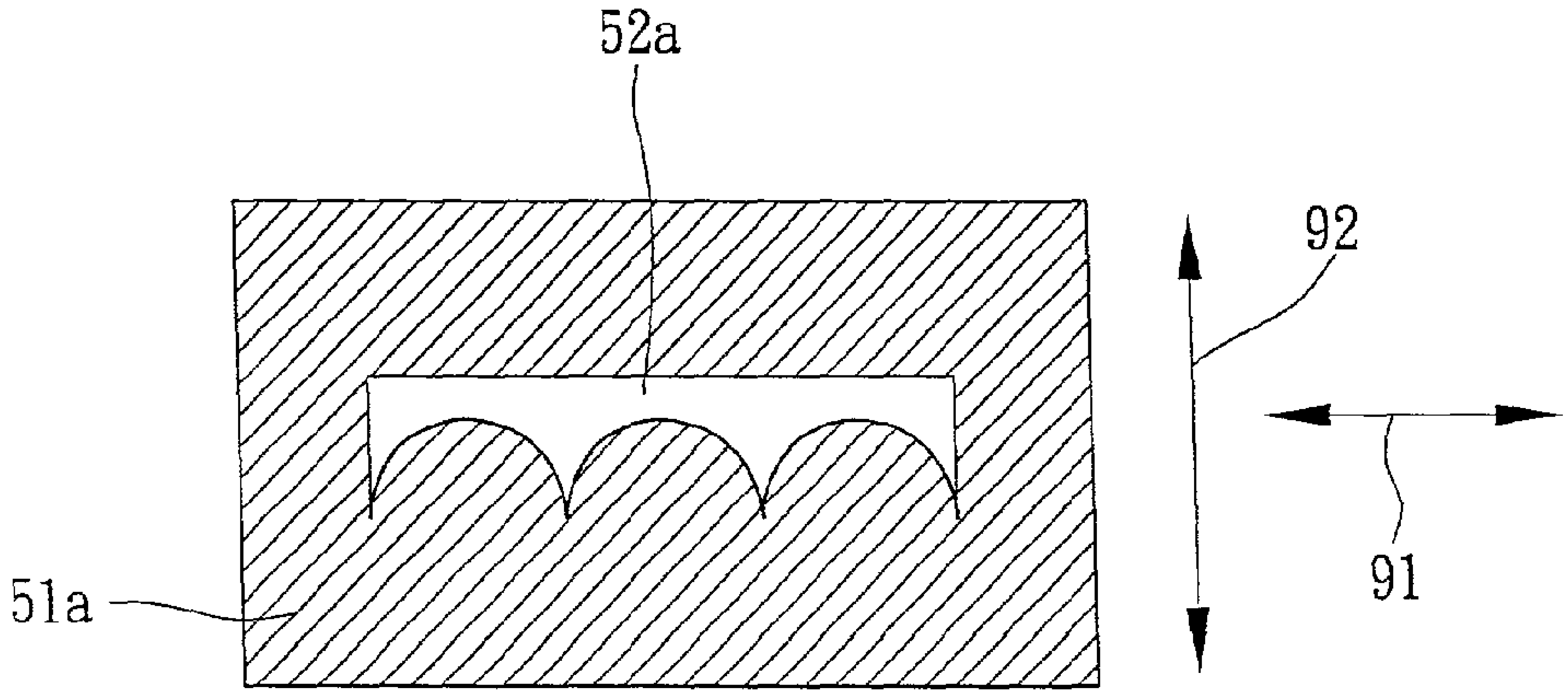



FIG. 6A

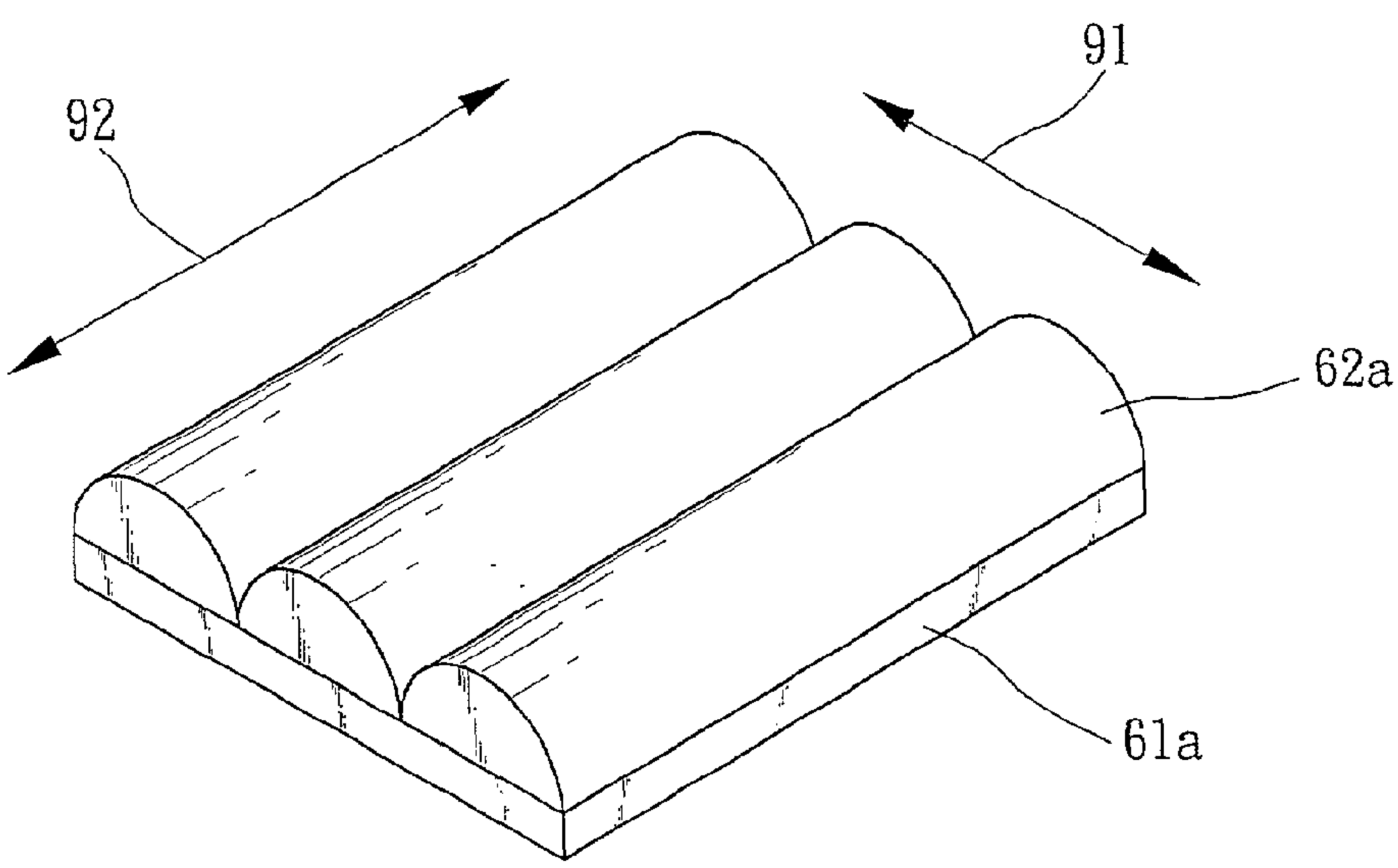



FIG. 6B

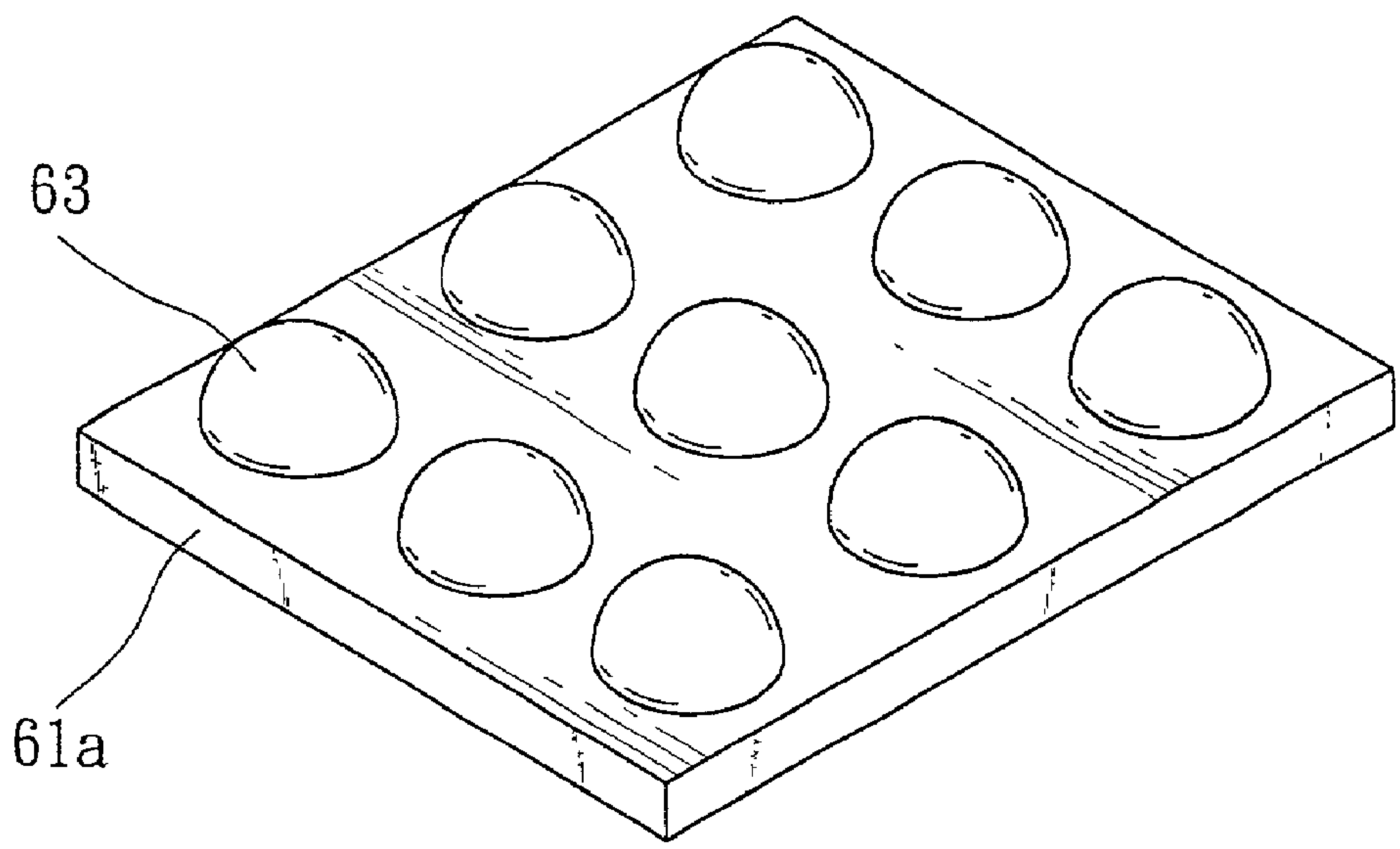



FIG. 7

# PROCESS METHOD OF USING EXCIMER LASER FOR FORMING MICRO SPHERICAL AND NON-SPHERICAL POLYMERIC STRUCTURE ARRAY

## BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to a process method of using excimer laser for forming micro spherical and non-spherical polymeric structure array and particularly a excimer laser process to form a micro spherical array structure on a substrate for producing a metal mold to fabricate liquid crystal display (LCD) face plate or photosensitive face plate.

[0003] 2. Description of the Prior Art

[0004] In order to increase visibility angle of LCD screen or other photosensitive plate, the face plate of these devices generally has to form a plurality of bulged micro spherical array structure to enhance light condensing (or dispersing) property. This micro spherical array structure usually is made by means of pressing of a metal mold. The metal mold (pressing mold) is formed by spray plating a metal layer on a main mold, then peeling off the metal layer from the main mold.

[0005] Conventionally, fabricating the main mold include the following methods:

[0006] 1. Using Single Stepper Exposure and High Temperature Reflow Process:

[0007] As shown in **FIGS. 1A through 1D**, this process firstly prepares a substrate **11** coated with a photoresist layer **12** (**FIG. 1A**). Then using a stepper **14** to proceed single stepping exposure by zones on the substrate **11** through a photomask **13** (**FIG. 1B**). Afterward, the non-exposure portion of the photoresist **12** is cleared through chemical agents and resulting in a micro-struts photoresist **15** array structure (**FIG. 1C**). Thereafter, using high temperature reflow process to heat the substrate around or exceeding the photoresist melting temperature to melt the surface of the micro-struts photoresist **15** for forming a curve shaped surface **16** (**FIG. 1D**).

[0008] This method has the following disadvantages: 1. It needs high temperature reflow process. The process is time consuming and highly unstable. It is difficult to precisely control the spherical surface formation. 2. Stepping exposure process can only produce two dimensional (2D) strut structure, but not spherical or non-spherical three dimensional (3D) curved surfaces.

[0009] 2. Multiple Stepping Exposure Micro Photo Process.

[0010] In the multiple stepping exposure micro process, the step **1B** and **1C** set forth above are repeatedly performed with different photomasks to gradually expand the exposure area of the photoresist until a pyramid-shaped photoresist structure is formed. Then the high temperature reflow process is proceeded. The reflow process may be done at a lower temperature and shorter time period. The spherical surface is also easier to control. However it has more and complicated process steps. It takes more process time and costs higher. To clean the photoresist needs a lot of chemicals and may result in severe environmental pollution problem.

[0011] 3. Photosensitive Glass Process:

[0012] As shown in **FIGS. 2A and 2B**, this process firstly uses an ultraviolet light source **24** (UV) to perform stepping exposure on a photosensitive glass **21** through a photomask **23** (**FIG. 2A**). The photosensitive glass **21** is coated with a different type of photosensitive material **22** which will be hardened and expanded upon the projection of ultraviolet light. The non-exposure portion of the photosensitive material will be squeezed and to form a bulged structure **25** (**FIG. 2B**).

[0013] However this process also has disadvantages. For instance, the photosensitive glass is very expensive and difficult to procure. The bulged structure is also difficult to control accurately.

[0014] 4. Heated Dripping Process:

[0015] As shown in **FIG. 3**, this process forms the bulged 3D structure **33** by means of dripping heated photoresist **32** one by one (or multiple drops at a time) on the substrate **31**. Th drawback of this process is that it totally cannot control the micro spherical array structure formation.

[0016] All the conventional techniques set forth have their share of shortcomings. There is still room for improvement.

## SUMMARY OF THE INVENTION

[0017] It is therefore an object of this invention to provide a process method of using excimer laser for forming spherical and non-spherical polymeric structure array that may precisely form micro spherical or non-spherical surface array structure on a substrate in a simpler and lower cost way.

[0018] It is another object of this invention to provide a process method of using excimer laser for forming spherical and non-spherical polymeric structure array that uses a photomask which has a selected curved pattern to receive excimer laser beam projection upon a polymeric material coated on a substrate. The curved pattern has different width along a straight line. The excimer laser beam hits the polymeric material and peels the material to create etching effect. During the laser beam projection and etching process, the substrate may be moved normally against the straight line direction so that the polymeric material may receive projection of different time period along the straight line direction to obtain different depth of etching for forming the 3D pattern desired.

[0019] For achieving aforesaid objects, the process of this invention includes the follow steps:

[0020] a. preparing a substrate which has a surface coating with a polymeric material and at least one photomask having a selected curved pattern formed thereon,

[0021] b. using a excimer laser beam source to project through the photomask on the polymeric material on the substrate and moving the substrate along a first corresponding direction for etching and forming a first 3D pattern on the polymeric material,

[0022] c. moving the substrate along a second corresponding direction and projecting the excimer laser beam through the photomask on the first 3D pattern to form a second 3D pattern in spherical-like manner.

[0023] In another aspect, this invention may further include the following steps:

[0024] d. using chemical etching method to remove debris of the polymeric material,

[0025] e. performing surface process to smooth the surface of the second 3D pattern,

[0026] f. spray plating a seed layer on the substrate and second 3D pattern,

[0027] g. electroplating the spray plated seed layer to form a metal layer to a selected thickness,

[0028] h. separating the metal layer from the substrate and second 3D pattern to make the metal layer become a metal mold for pressing a micro array structure.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The invention, as well as its many advantages, may be further understood by the following detailed description and drawings, in which:

[0030] FIGS. 1A-1D are schematic views of process steps of a conventional single stepper exposure and-high temperature reflow process.

[0031] **FIGS. 2A and 2B** are schematic views of process steps of a conventional photosensitive glass process.

[0032] **FIG. 3** is schematic view of the process of a conventional heated dripping process.

[0033] FIGS. 4A-4G are schematic views of the process steps of an embodiment of this invention for forming micro spherical and non-spherical surface in polymeric structure array.

[0034] **FIG. 5A** is a front view of a selected curved pattern on a photomask for this invention.

[0035] **FIG. 5B** is a perspective view of a first 3D pattern formed by means of the photomask shown in **FIG. 5A**.

[0036] **FIG. 6A** is a front view of another selected curved pattern on a photomask for this invention.

[0037] **FIG. 6B** is a perspective view of a first 3D pattern formed by means of the photomask shown in **FIG. 6A**.

[0038] **FIG. 7** is a schematic perspective view of a spherical micro array structure, after the polymeric material subjects to photo etching for two times.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0039] This invention aims at providing a process method of using excimer laser for forming spherical and non-spherical polymeric structure array. The process employs a photomask which has a selected curved pattern formed thereon. The curved pattern has various width along a straight line direction. When an excimer laser beam projects through the photomask on a substrate coated with a polymeric material, the polymeric material will be peeled off to produce etching result. During the projection and etching process, the substrate is moved along a normal direction against the straight line direction for the polymeric material to receive laser beam projection of different time period along the straight line direction. Then the polymeric material will be etched to different depth to form a 3D pattern desired.

[0040] **FIGS. 4A through 4G** show a preferred embodiment of this invention. It includes the following steps:

[0041] a. Preparing a substrate **41** which has a surface coating with a polymeric material **42** and preparing at least one photomask **44** which has a selected curved pattern formed thereon **(FIG. 4A)**. The polymeric material **42** is preferably selected from the group which has relatively lower key link energy, such as photoresist material, so that the key link may be broken down by laser beam projection for etching purpose. The polymeric material **42** may be coated on the substrate **41** by means of rotary spindle, printing, chemical deposition and the like. The substrate **41** is preferably made from material which may resist excimer laser etching and may become a stop layer of etching, such as silicon.

[0042] The curved pattern has a plurality of transparent zones in geometric forms along a straight line direction. The transparent zones have different widths along the straight line direction.

[0043] b. Using an excimer laser beam source **45** to projecting the laser beam through the photomask **44** to the polymeric material **42** on the substrate **41**, in the mean time (during laser beam projection) moving the substrate **41** along a first corresponding direction to form an etching first 3D pattern on the polymeric material **43 (FIG. 4B)**. This process is different from conventional stepping exposure process using a stepper.

[0044] The first corresponding direction is normal to the straight line. Hence when the excimer laser beam source **45** projects the moving substrate **41** through the photomask **44**, the polymeric material **42** receives laser beam projection with different time period along the straight line direction, and may result in different degree of etching for forming the first 3D pattern **43**.

[0045] c. When necessary (depending on the finishing 3D pattern desired), the excimer laser beam source **45** may be deployed to project the first 3D pattern through the photomask **45** again while moving the substrate **41** along a second corresponding direction to form a second 3D pattern. In a preferred embodiment of this invention, the second corresponding direction is normal to the first corresponding direction. The curved pattern on the photomask **44** used at the step b and c may be the same or different.

[0046] In another embodiment of this invention, the second corresponding direction at the step c may be taken by turning the substrate **41** ninety degree after the step b, then performing the step c process along the first corresponding direction. It may also produce the second 3D pattern with same result as the relative moving corresponding direction in the step c and b is also normal against each other.

[0047] In yet another embodiment, multiple laser beam projections may be done if projection by two times is not adequate. The relative moving corresponding direction between the photomask **44** and substrate **41** may be the same or different for every laser beam projection, or the photomask **44** of different curved pattern may be used (in such a case, the moving corresponding direction may be the same) until a desired 3D pattern is obtained.

[**0048**] d. Clearing the polymeric material debris by means of a chemical etching process as shown in **FIG. 4C**. As the etching process through the excimer laser beam projection might produce some peeled off debris of polymeric material scattering on the substrate **41** or 3D pattern **43**, these debris may be cleared and removed rapidly be means of the chemical etching process.

[**0049**] e. Smoothing the surface **46** of the 3D pattern **43** (the first or second 3D pattern) (**FIG. 4D**). As the second 3D pattern is already sphere-like, this step may be done by means of a low temperature process to melt a small amount of the surface for producing the smooth surface desired. For instance, by performing low temperature reflow diffusion at a temperature lower than the melting point (Tg) of the polymeric material, rapid processing using high energy beam, or rapid tempering annealing (RTA) and the like.

[**0050**] f. Spray plating metallic material on the substrate **41** and 3D pattern to form a seed layer **47** (**FIG. 4E**). The seed layer material is preferably nickel or its alloy.

[**0051**] g. Electroplating a metallic material on the seed layer **47** to a selected thickness to form a metal layer **48** (**FIG. 4F**). The metal layer **48** is preferably nickel or its alloy.

[**0052**] h. Separating the metal layer **48** from the substrate **41** and second 3D pattern to become an independent component (**FIG. 4G**). The separated metal layer **48** then may be used as the mold for producing the micro array structure desired.

[**0053**] **FIGS. 5A and 5B** show respectively an embodiment of a curved pattern on the photomask and a first 3D pattern which might be formed therewith. The photomask **51** has a plurality of semicircle transparent zones **52** in the straight line direction **91**. The width of the transparent zones **52** in the straight line direction **91** is not a constant value (**FIG. 5A**). When the substrate **61** is moved along a first corresponding direction **92** (normal to the straight line direction **91**) for receiving laser beam projection and etching, the polymeric material on the substrate **61** receives projection of different time period and forms a first 3D pattern **62** which consists of a plurality of semicircle concave troughs (**FIG. 5B**).

[**0054**] **FIGS. 6A and 6B** show respectively another embodiment of a curved pattern on the photomask **51**a and a first 3D pattern which might be formed therewith. By means of similar processes shown in **FIGS. 5A and 5B**, the photomask **51***a* has a selected pattern which includes transparent zones **52***a* for forming a first 3D pattern **62***a* of protrusive semi cylindrical structure on the substrate **61***a*. When the substrate **61***a* is turned ninety degree and be etched one more time using the photomask **51***a*, a second 3D pattern **63** as shown in **FIG. 7** may be obtained which nearly becomes semispherical structure.

[**0055**] Of course, besides the semispherical 3D pattern structure, this invention may be used to produce other types of 3D pattern structure such as ellipsoidal surface, corrugated surface and the like. It may be done by using different curved pattern desired on the photomask and projecting laser beam by different times or moving at different corresponding directions.

[**0056**] In summary, this invention offers the following advantages over conventional techniques:

[**0057**] 1. Using excimer laser beam source to project through the photomask to perform process may easily and accurately form sphere-like micro structure. Then using a low temperature reflow diffusion process may obtain a smooth surface desired.

[**0058**] 2. Resolving the problem incurred in conventional technique which needs high temperature reflow process after forming circle strut structure through the single step micro photo process.

[**0059**] 3. Comparing with complex and lengthy process of conventional multiple steps micro photo process for forming pyramid type structure, this invention has simpler process and shorter process time.

[**0060**] 4. This invention may have different process parameters for forming different types of non-spherical micro structure, such as changing the pattern on the photomask, changing moving corresponding direction during laser beam projection process.

[**0061**] 5. This invention may accurately produce sphere or non-sphere surface micro structure. Process control is much more easier and precise than conventional technique which uses bulging or heated dripping process.

[**0062**] 6. This invention is lower cost than conventional technique that uses photosensitive glass.

[**0063**] It may thus be seen that the objects of the present invention set forth herein, as well as those made apparent from the foregoing description, are efficiently attained. While the preferred embodiments of the invention have been set forth for purpose of disclosure, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of this invention.

What is claimed is:

**1**. A process method of using excimer laser for forming polymeric structure array, comprising:

a. preparing a substrate which has a surface coated with a polymeric material, and setting up at least one photomask which has a selected curved pattern formed thereon,

b. deploying an excimer laser beam source to project through the photomask on the polymeric material and moving the substrate along a first corresponding direction for forming a first three dimensional pattern on the polymeric material, and

c. moving the substrate along a second corresponding direction and projecting the laser beam source through the photomask on the first three dimensional pattern to form an etched second three dimensional pattern thereon.

**2**. The process method of claim 1, wherein the polymeric material is a photoresist material.

**3**. The process method of claim 1, wherein the polymeric material is coated on the substrate by means of a process selected from the group consisting of rotary spindle, printing, and chemical deposition.

**4**. The process method of claim 1, wherein the substrate is a semiconductor substrate.

**5**. The process method of claim 1, wherein the curved pattern includes a plurality of transparent geometric zones along a direction normal to the corresponding direction.

**6**. The process method of claim 5, wherein the transparent geometric zones along the direction normal to the corresponding direction have non-constant widths such that the laser beam source projects through the photomask on the polymeric material when the substrate is moving, the polymeric material receives laser beam source projection with different time period in a direction normal to the corresponding direction to form different degree of etching for forming the three dimensional pattern.

**7**. The process method of claim 1, wherein the first corresponding direction is normal to the second corresponding direction.

**8**. The process method of claim 7, wherein the substrate is turned ninety degree after the step (b) for the laser beam source projecting along the first corresponding direction at the step (c) so that the first corresponding direction be normal to the second corresponding direction.

**9**. The process method of claim 1, wherein the curved pattern is same for the step (b) and (c).

**10**. The process method of claim 1, wherein the curved pattern at the step (b) is different from that at the step (c).

**11**. The process method of claim 10, wherein the first corresponding direction is same as the second corresponding direction.

**12**. The process method of claim 1, wherein the second three dimensional pattern is sphere-like structure.

**13**. The process method of claim 1, wherein the step (c) is followed by the following step:

d. clearing polymeric material debris by means of chemical etching process.

**14**. The process method of claim 1, wherein the step (c) is followed by the following step:

e. performing surface smoothing process on second three dimensional pattern surface.

**15**. The process method of claim 14, wherein the surface smoothing process is choosing from a group consisting of: high energy beam rapid process, rapid tempering annealing process, and reflow diffusion process done at a temperature lower than the melting point of the polymeric material.

**16**. The process method of claim 1, wherein the step (c) is followed by the following steps:

f. spray plating a seed layer on the substrate and second three dimensional pattern,

g. electroplating a metal layer to a selected thickness on the seed layer, and

h. separating the metal layer from the substrate and second three dimensional pattern for forming a metal mold for pressing micro array structure.

**17**. A process method of using excimer laser for forming micro spherical and non-spherical polymeric structure array, comprising:

a. preparing a substrate which has a surface coated with a polymeric material, and setting up at least one photomask which has a selected curved pattern formed thereon, the curved pattern having a plurality of transparent zones in selected geographic forms along a straight line direction, the transparent zones having non-constant widths along the straight line direction, and

b. deploying an excimer laser beam source to project through the photomask on the polymeric material and moving the substrate along a first corresponding direction for forming a first three dimensional pattern on the polymeric material.

**18**. The process method of claim 17, wherein the step (b) is followed by the following step:

c. the substrate is turned ninety degree and moved along the first corresponding direction for the laser beam source to projecting through the photomask on the first three dimensional pattern to form a second three dimensional pattern by etching.

**19**. The process method of claim 17, wherein the curved pattern on the photomask used in the step (b) is different from that in the step (c).

**20**. The process method of claim 17, wherein the step (b) is followed by the following steps:

d. clearing polymeric material debris by means of chemical etching process;

e. performing surface smoothing process on the three dimensional pattern surface.

**21**. The process method of claim 20, wherein the surface smoothing process is choosing from a group consisting of: reflow diffusionv process done at a temperature lower than the melting point of the polymeric material, high energy beam rapid process, and rapid tempering annealing process.

**22**. The process method of claim 17, wherein the step (b) is followed by the following steps:

f. spray plating a seed layer on the substrate and second three dimensional pattern,

g. electroplating a metal layer to a selected thickness on the seed layer, and

h. separating the metal layer from the substrate and second three dimensional pattern for forming a metal mold for pressing micro array structure.

* * * * *