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(54) **POLYMER MICRONEEDLES**

(75) Inventors: **Yehoshua Yeshurun**, Haifa (IL); **Meir Hefetz**, Mitzpe Harashim (IL); **Erwin Berenschot**, Winterswijk (NL); **Meint de Boer**, Enscheda (NL); **Dominique Maria Altpeter**, Hengelo (NL); **Gerrit Boom**, Vriezenveen (NL)

Correspondence Address:
DR. MARK FRIEDMAN LTD
C/O BILL POLKINGHORN
DISCOVERY DISPATCH
9003 FLORIN WAY
UPPER MARLBORO, MD 20772 (US)

(73) Assignee: **Nano Pass Technologies Ltd.**

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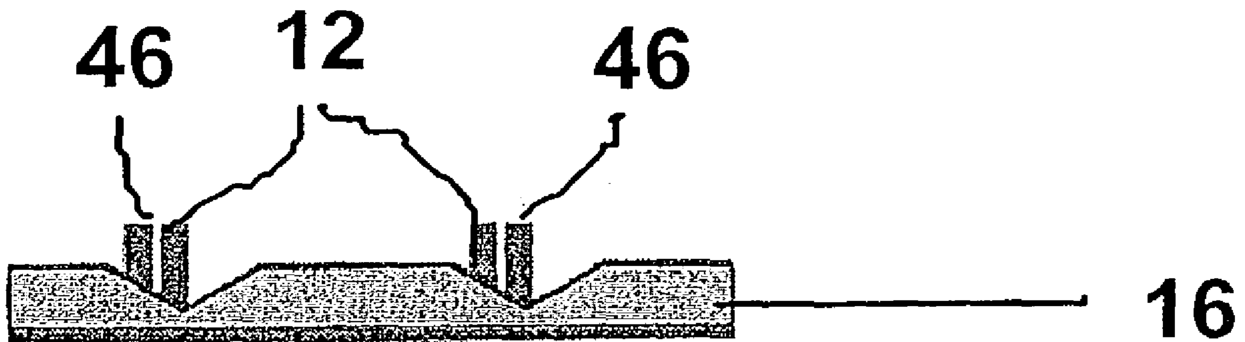
(57) **ABSTRACT**

A method for producing microneedles. The method including disposing a first layer of a radiation sensitive polymer on to a working surface and selectively irradiating the first layer such that the first layer has at least one irradiated region and at least one non-irradiated region. The method also including developing the first layer so as to selectively remove one of the at least one irradiated region and the at least one non-irradiated region such that, at least part of at least one remaining region at least partially defines a form of at least part of a microneedle structure. A microneedle structure including a plurality of microneedles at least partially formed from a radiation sensitive polymer.



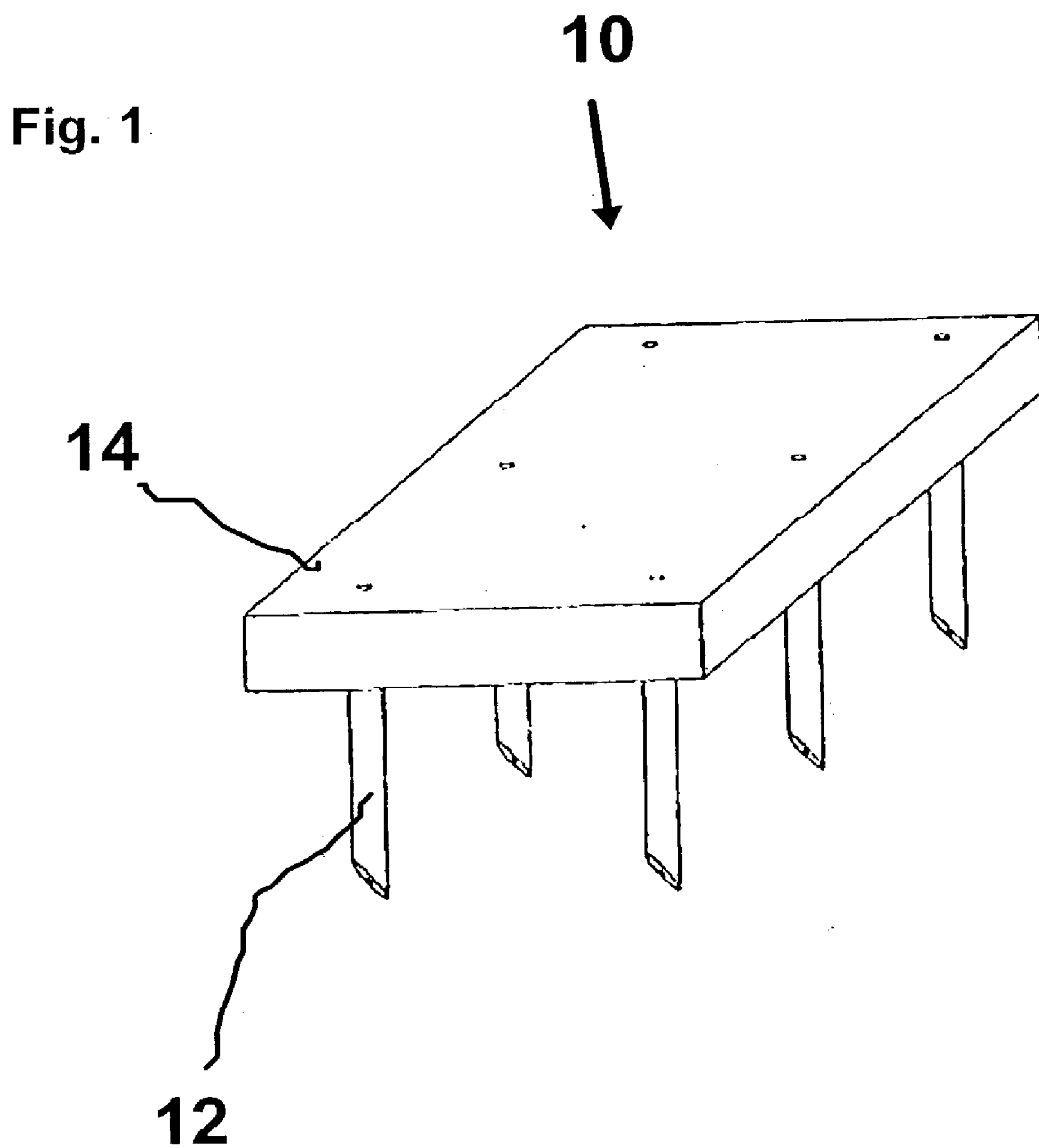


Fig. 1
10
14
12

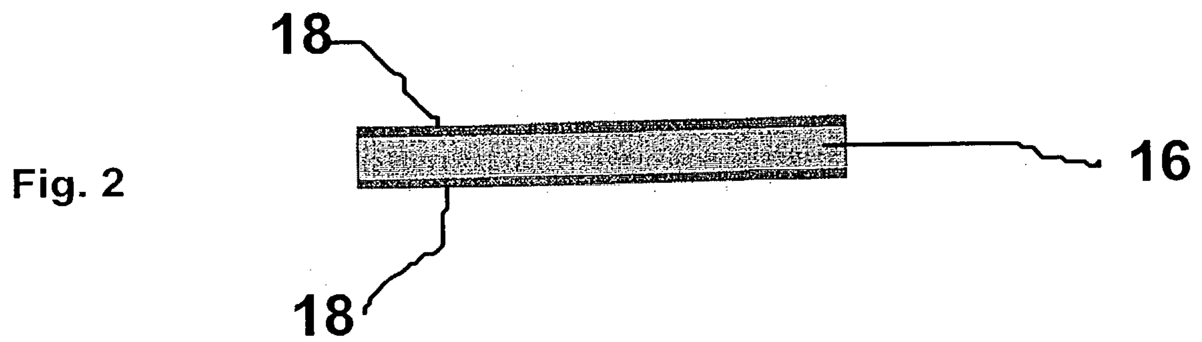


Fig. 2

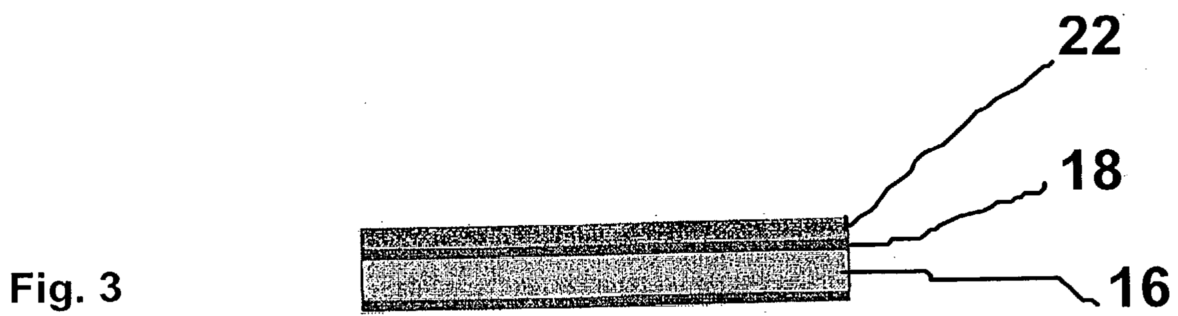


Fig. 3

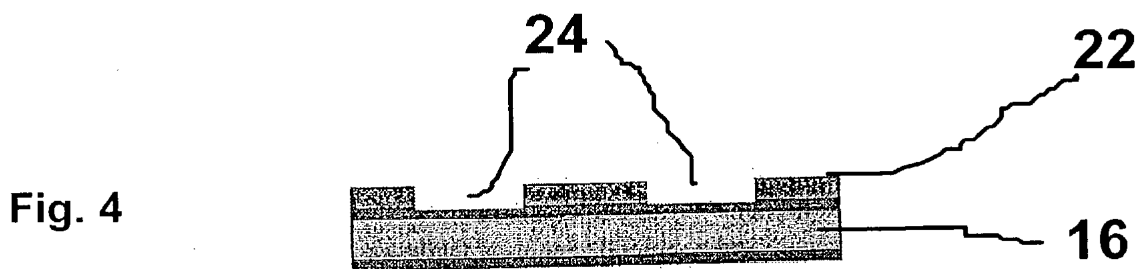


Fig. 4

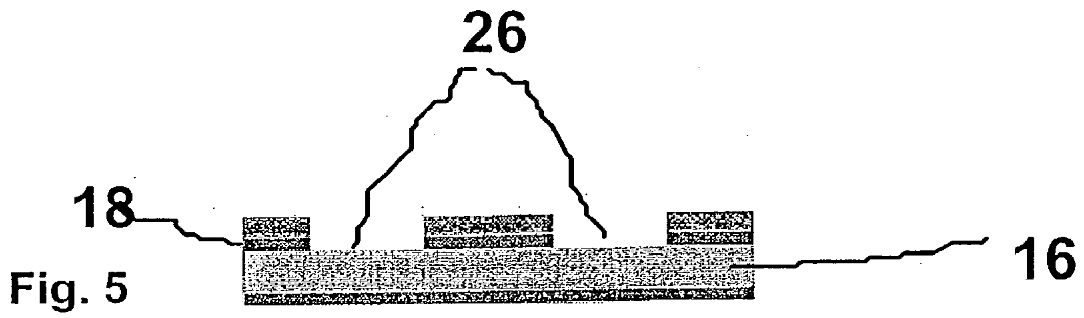


Fig. 5

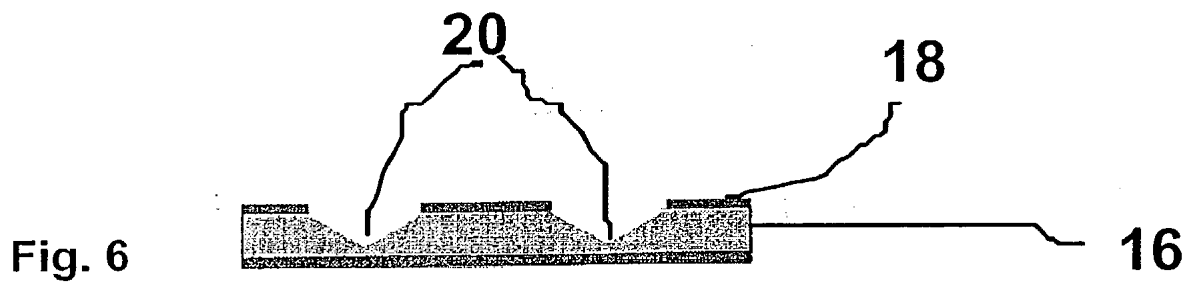


Fig. 6

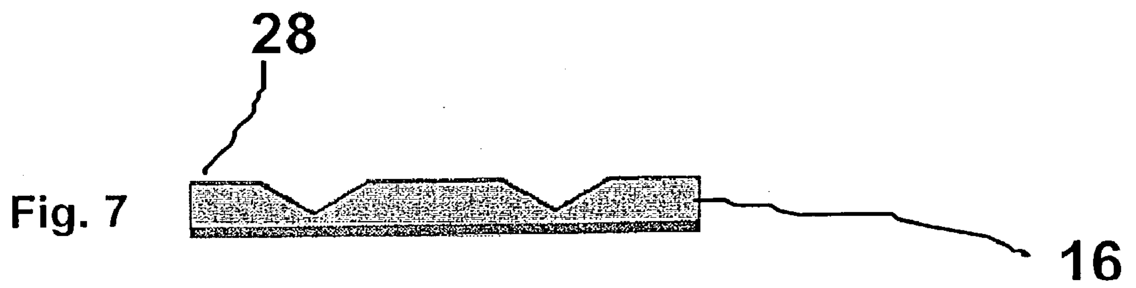


Fig. 7

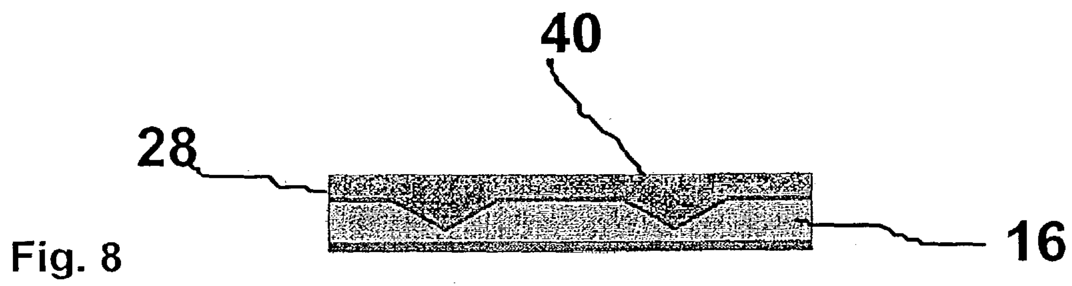


Fig. 8

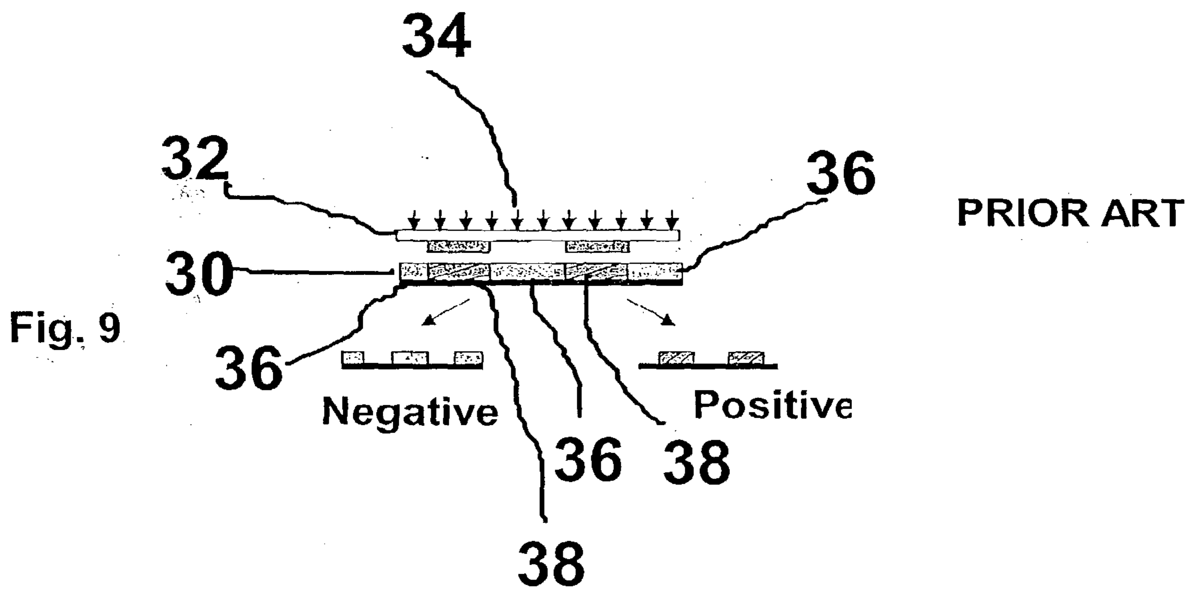


Fig. 9

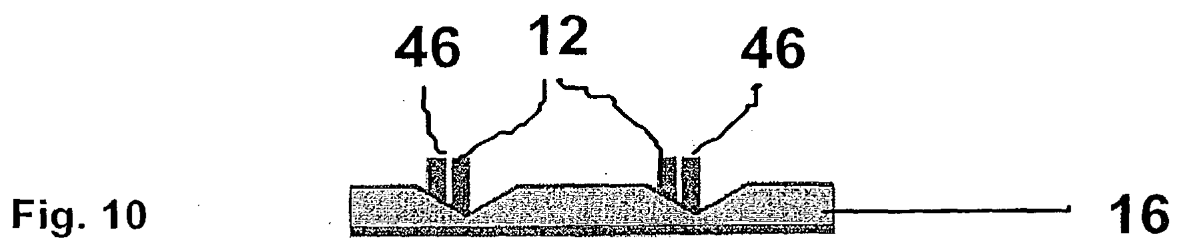


Fig. 10

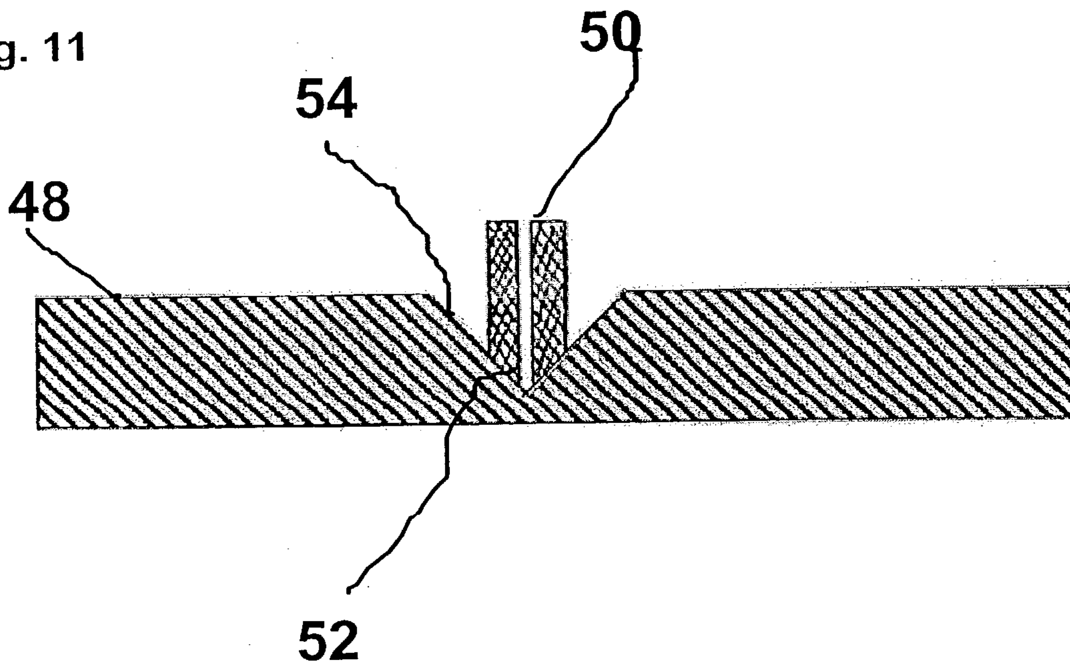


Fig. 11
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48
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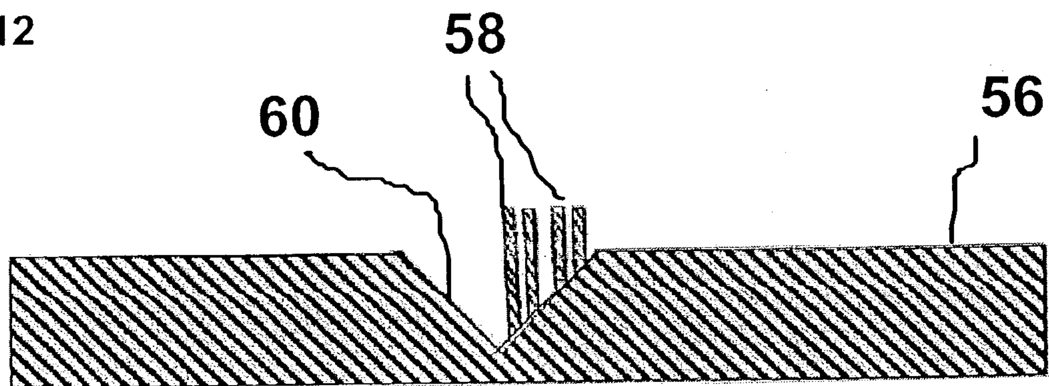


Fig. 12
58
60
56

Fig. 13

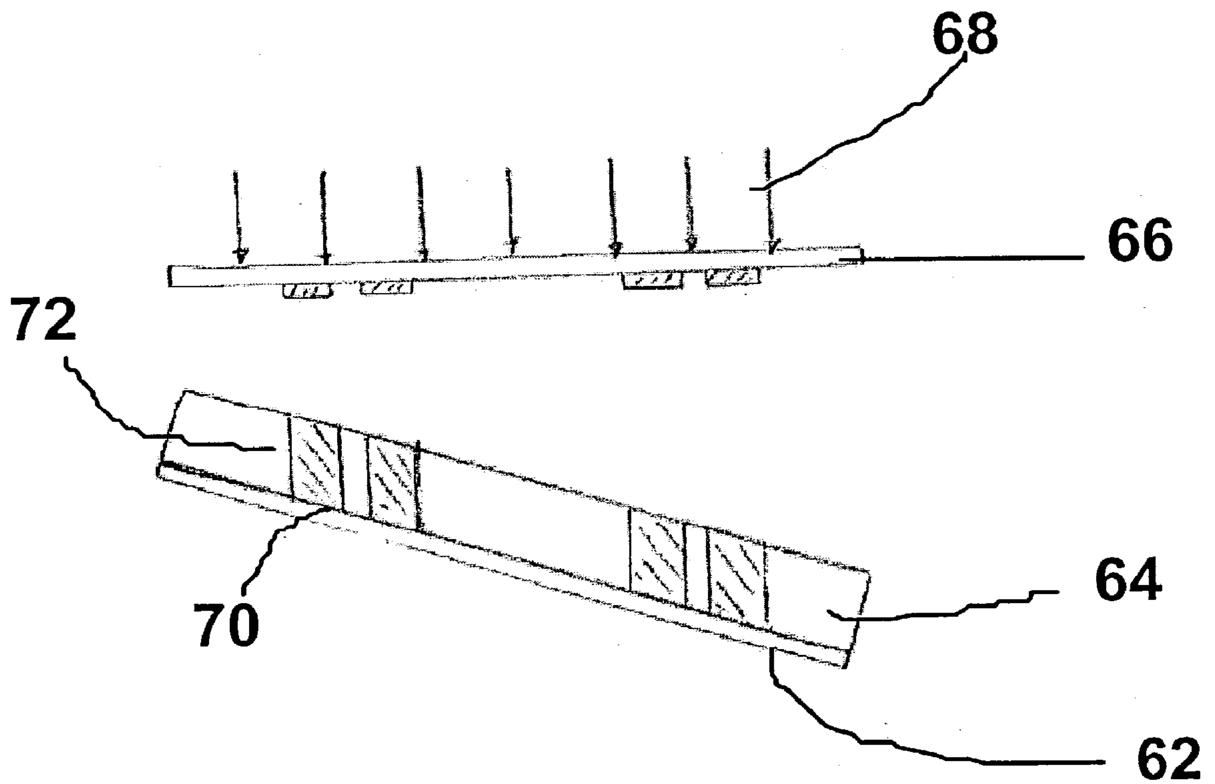
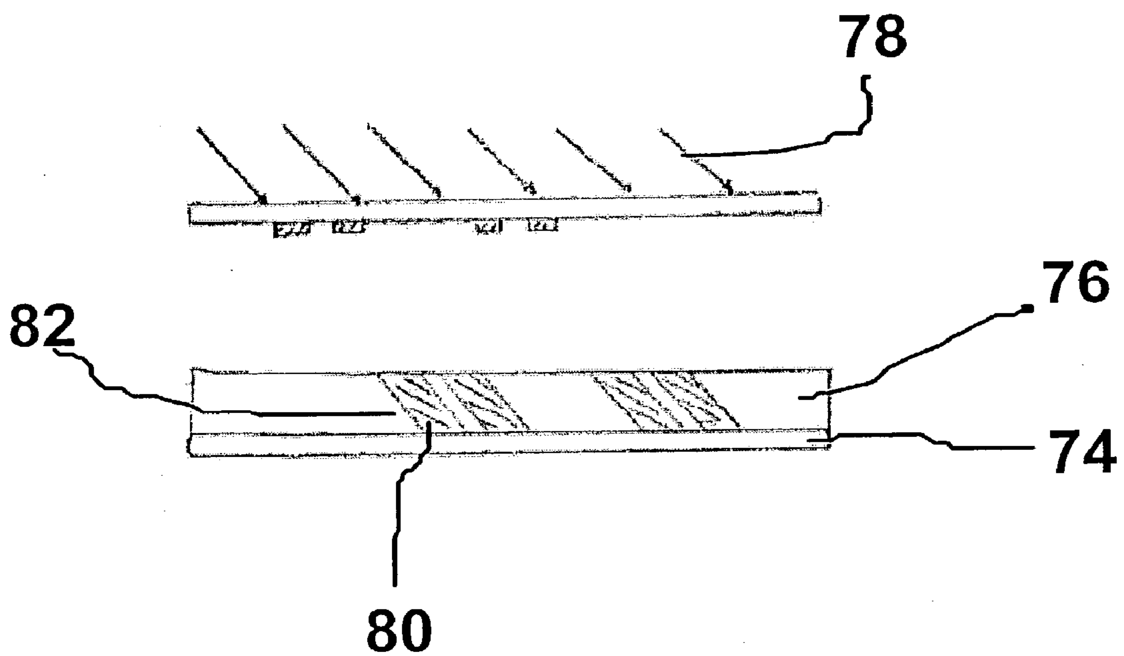
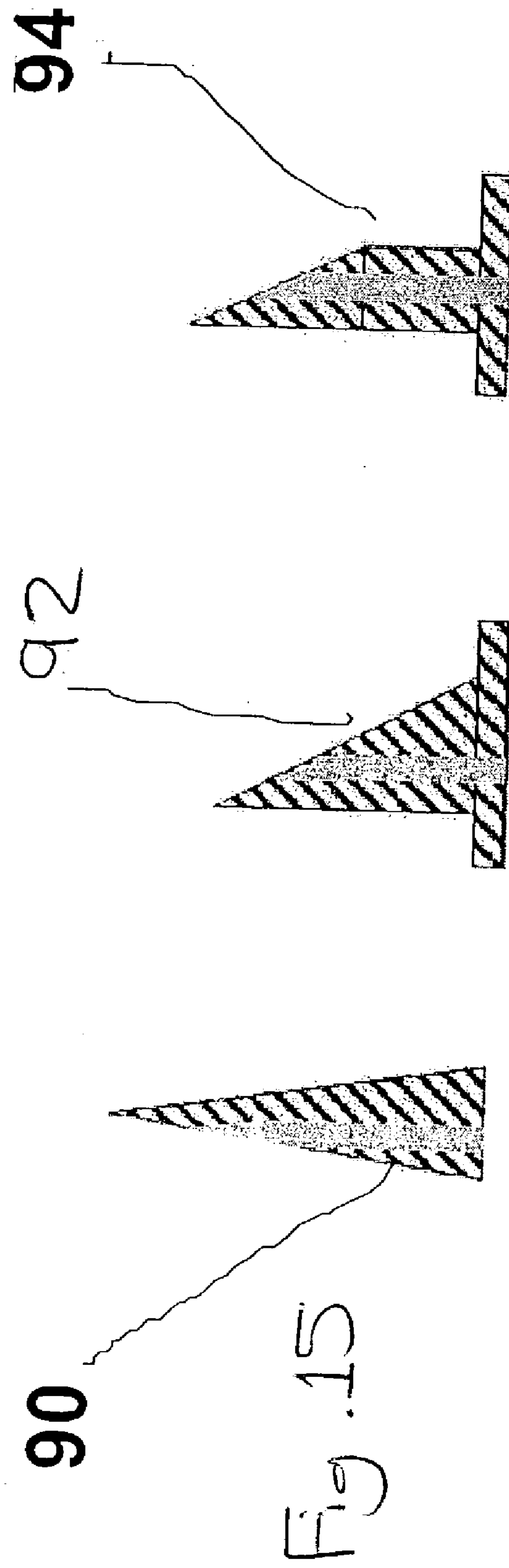


Fig. 14




94
92
90
Fig 15

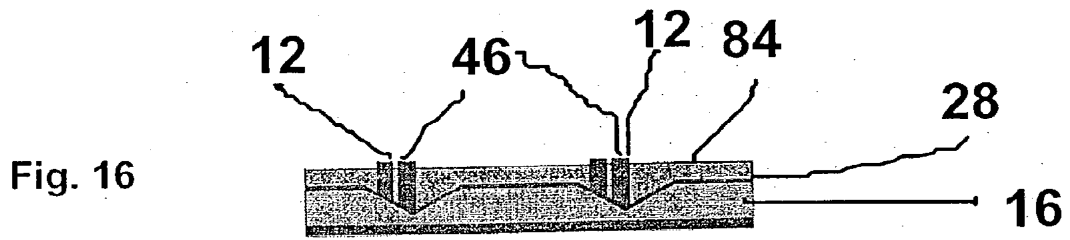


Fig. 16

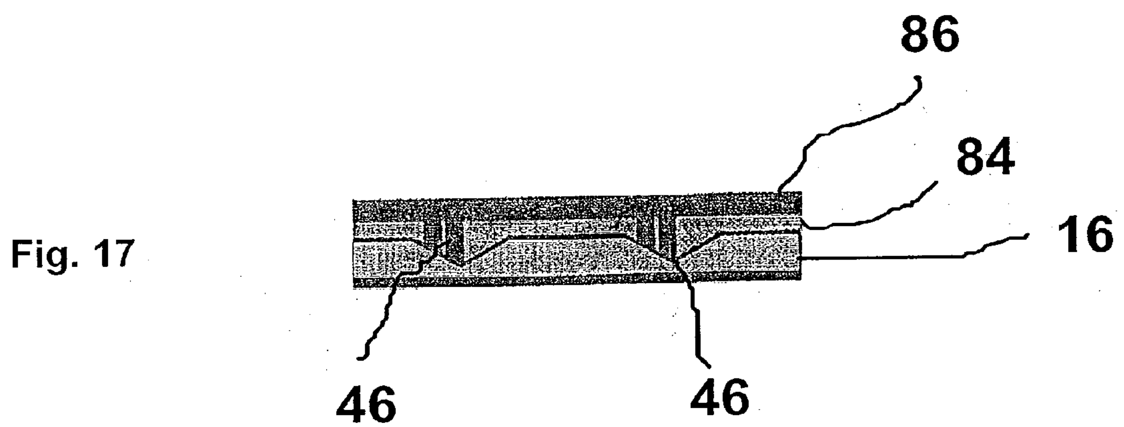


Fig. 17

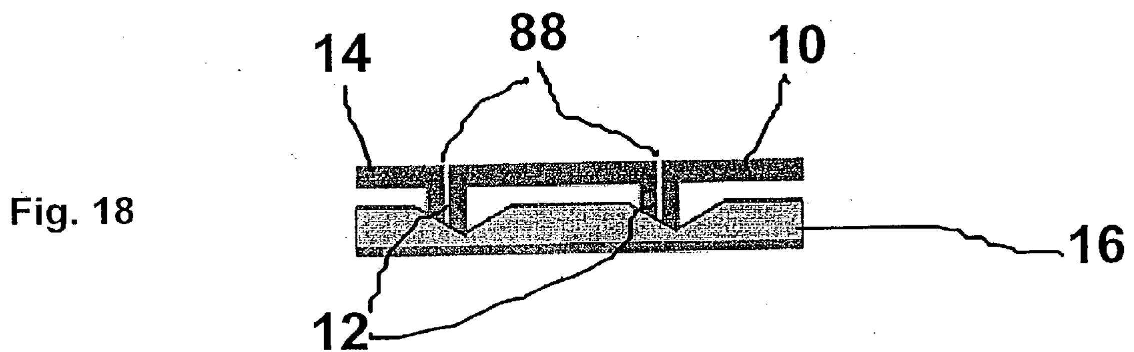


Fig. 18

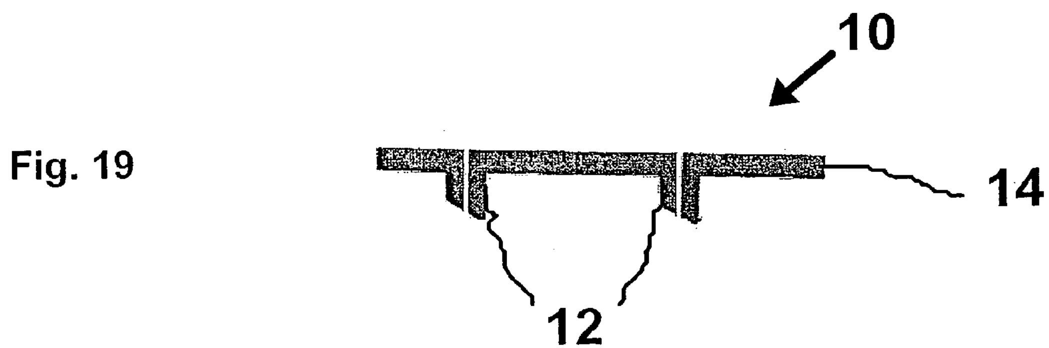


Fig. 19

POLYMER MICRONEEDLES

[0001] This application claims priority from Israeli application no. 152,271 filed 13 Oct. 2002.

FIELD AND BACKGROUND OF THE INVENTION

[0002] The present invention relates to microneedles and, in particular, it concerns microneedles formed from radiation sensitive materials.

[0003] Microneedles have been known for many years, first being taught by U.S. Pat. No. 3,964,482 to Gerstel, filed June 1976. However commercialization of microneedle technology has been difficult due to lack of an inexpensive production method as well as difficulty in finding suitable production materials which produce strong microneedles that will overcome tissue penetration problems and that will not break easily. Polymer microneedle production currently employs techniques using molds to form the needle structure. These methods have inherent difficulties relating to the formation of hollow microneedles and thus are less useful for fluid transfer. Prior art methods are typically expensive and the produced microneedles are relatively fragile. Generally, prior art microneedles used in transdermal applications are not robust enough and therefore break upon entering the skin or the microneedles are not sharp enough and thus do not penetrate the skin effectively.

[0004] Therefore there is a need for a method to produce an inexpensive, robust, sharp, hollow as well as non-hollow array of microneedles, typically for drug delivery and diagnostics.

SUMMARY OF THE INVENTION

[0005] The present invention is a polymer microneedle construction and method of production thereof.

[0006] According to the teachings of the present invention there is provided, a method for producing microneedles, comprising the steps of: (a) disposing a first layer of a radiation sensitive polymer on to a working surface; (b) selectively irradiating the first layer such that the first layer has at least one irradiated region and at least one non-irradiated region; and (c) developing the first layer so as to selectively remove one of the at least one irradiated region and the at least one non-irradiated region such that, at least part of at least one remaining region at least partially defines a form of at least part of a microneedle structure.

[0007] According to a further feature of the present invention, the at least part of the microneedle structure includes a plurality of at least partially formed microneedles.

[0008] According to a further feature of the present invention, each of at least two of the at least partially formed microneedles have a channel therein.

[0009] According to a further feature of the present invention, each of at least two of the at least partially formed microneedles have an oblique end surface.

[0010] According to a further feature of the present invention, at least two of the at least partially formed microneedles are different heights.

[0011] According to a further feature of the present invention, the at least part of the microneedle structure includes an at least partially formed microneedle having a channel therein.

[0012] According to a further feature of the present invention, the at least part of the microneedle structure includes an at least partially formed microneedle having an oblique end surface.

[0013] According to a further feature of the present invention, there is also provided, after the step of developing, the steps of: (a) disposing a filler at least partially around the at least one remaining region; (b) disposing a second layer of a radiation sensitive polymer on to: (i) at least part of the at least one remaining region; and (ii) at least part of the filler; (c) irradiating the second layer; and (d) developing the second layer such that, the second layer forms a base for at least part of the microneedle structure.

[0014] According to a further feature of the present invention, the base has at least one channel therein.

[0015] According to a further feature of the present invention, the step of irradiating the second layer is performed by selectively irradiating the second layer.

[0016] According to a further feature of the present invention, there is also provided the step of forming at least one groove in the working surface, such that the at least part of the microneedle structure is formed within the at least one groove, the at least one groove defining at least one oblique end surface of the microneedle structure.

[0017] According to a further feature of the present invention, the step of irradiating is performed using a light source producing visible light.

[0018] According to a further feature of the present invention, the step of irradiating is performed using ultraviolet light.

[0019] According to a further feature of the present invention, the step of irradiating is performed using a x-ray radiation.

[0020] According to a further feature of the present invention, there is also provided disposing a radiation source, which is used in the step of irradiating, and the working surface such that, the relative positioning of the radiation source and the working surface at least partially defining at least one oblique end surface of the microneedle structure.

[0021] According to the teachings of the present invention there is also provided, a microneedle structure, comprising a plurality of microneedles, each of the microneedles being at least partially formed from a radiation sensitive polymer.

[0022] According to a further feature of the present invention, a majority of each of the microneedles is formed from the radiation sensitive material.

[0023] According to a further feature of the present invention, there is also provided a substructure configured to form a base for the microneedles, the substructure being at least partially formed from a radiation sensitive polymer.

[0024] According to a further feature of the present invention, the substructure has at least one channel therein.

[0025] According to a further feature of the present invention, each of at least two of the microneedles have a channel therein.

[0026] According to a further feature of the present invention, each of at least two of the microneedles have an oblique end surface.

[0027] According to a further feature of the present invention, at least two of the microneedles are different heights.

[0028] According to the teachings of the present invention there is also provided, a microneedle structure, comprising a microneedle, the microneedle being at least partially formed from a radiation sensitive polymer, the microneedle having a channel therein.

[0029] According to a further feature of the present invention, a majority of the microneedle is formed from the radiation sensitive material.

[0030] According to the teachings of the present invention there is also provided, a microneedle structure, comprising a microneedle, the microneedle being at least partially formed from a radiation sensitive polymer, the microneedle having an oblique end surface.

[0031] According to a further feature of the present invention, a majority of the microneedles is formed from the radiation sensitive material.

[0032] According to the teachings of the present invention there is also provided, a method for producing microneedles, comprising the steps of: (a) disposing a layer of a material on to a working surface; and (b) processing the layer so as to selectively remove one of at least one irradiated region and at least one non-irradiated region, such that, at least part of at least one remaining region at least partially defines a form of at least part of a microneedle structure, wherein the processing includes a sub-step of selectively acting upon the layer with radiation so as to effect at least one of a physical and a chemical change selectively in material of the layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

[0034] **FIG. 1** is a schematic isometric view of a microneedle structure that is constructed and operable in accordance with a preferred embodiment of the present invention;

[0035] **FIG. 2** is a schematic cross-sectional view of a wafer coated with a thin layer of Silicon Nitride that is used in the construction of the microneedle structure of **FIG. 1**;

[0036] **FIG. 3** is a schematic cross-sectional view of the wafer of **FIG. 2** with a layer of photoresist coating the layer of Silicon Nitride;

[0037] **FIG. 4** is a schematic cross-sectional view of the wafer of **FIG. 3** after a series of parallel strips have been formed on the layer of photoresist;

[0038] **FIG. 5** is a schematic cross-sectional view of the wafer of **FIG. 4** after plasma etching, creating a series of parallel in the Silicon nitride layer;

[0039] **FIG. 6** is a schematic cross-sectional view of the wafer of **FIG. 5** after wet etching creating grooves therein;

[0040] **FIG. 7** is a schematic cross-sectional view of the wafer of **FIG. 6** having a thin layer disposed Silicon Nitride thereon;

[0041] **FIG. 8** is a schematic cross-sectional view of the wafer of **FIG. 7** having a thick layer of photoresist spin coated thereon;

[0042] **FIG. 9** is a schematic cross-sectional view of a layer of photoresist being irradiated through a mask in accordance with the prior art;

[0043] **FIG. 10** is a schematic cross-sectional view of the wafer of **FIG. 8** after selective irradiation and developing of the thick layer of photoresist, defining a form of microneedles;

[0044] **FIG. 11** is a schematic cross-sectional view of a wafer having a microneedle disposed thereon, the microneedle having two oblique end surfaces that is constructed and operable in accordance with a first alternate embodiment of the present invention;

[0045] **FIG. 12** is a schematic cross-sectional view of a wafer having two microneedles disposed thereon, the microneedles being different heights that is constructed and operable in accordance with a second alternate embodiment of the present invention;

[0046] **FIG. 13** is a schematic cross-sectional view of a wafer having a thick layer of photoresist disposed thereon being selectively irradiated by a radiation source wherein the relative positioning of the radiation source and the wafer at least partially defines the oblique end surface of each microneedle that is constructed and operable in accordance with a third alternate embodiment of the present invention;

[0047] **FIG. 14** is a schematic cross-sectional view of a wafer having a thick layer of photoresist disposed thereon being selectively irradiated by a radiation source wherein the relative positioning of the radiation source and the wafer at least partially defines the oblique end surface of each microneedle that is constructed and operable in accordance with a fourth alternate embodiment of the present invention;

[0048] **FIG. 15** is a schematic cross-sectional view of possible microneedle structures that is constructed and operable in accordance with a fifth alternate embodiment of the present invention;

[0049] **FIG. 16** is a schematic cross-sectional view of the wafer of **FIG. 10** having a filler layer of a polymer resist material disposed thereon surrounding the microneedles;

[0050] **FIG. 17** is a schematic cross-sectional view of the wafer of **FIG. 16** having a spin coated layer of photoresist disposed on top of the resist material and the microneedles;

[0051] **FIG. 18** is a schematic cross-sectional view of the wafer of **FIG. 17** after selectively irradiating and developing the layer of photoresist to define a base for the microneedles; and

[0052] **FIG. 19** is a schematic cross-sectional view of the microneedles and the base of **FIG. 18** after being released from the wafer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0053] The present invention is a polymer microneedle construction and method of production thereof.

[0054] The principles and method of production of the polymer microneedle construction according to the present invention may be better understood with reference to the drawings and the accompanying description.

[0055] A publication entitled "Process development for polymer needles by using SU-8 technology and silicon molding techniques" by Dominique Maria Altpeter of Mesa+ Institute, University of Twente, Enschede, Netherlands is incorporated by reference for all purposes as if fully set forth herein.

[0056] Reference is now made to **FIG. 1**, which is a schematic isometric view of a microneedle structure **10** that is constructed and operable in accordance with a preferred embodiment of the present invention. Microneedle structure **10** includes a plurality of microneedles **12** and a substructure **14** which acts as a base for microneedles **12**. At least part of, and typically a majority of, each microneedle **12** and substructure **14** are formed from a radiation sensitive polymer, in that the form of microneedles **12** is typically wholly formed from a radiation sensitive material. Optionally, depending on the radiation sensitive polymer being used, microneedles **12** are coated with a material to make microneedles **12** biocompatible. Optionally, microneedles **12** are coated, using electrochemical techniques, with electrically conducting materials such as, titanium, gold and aluminum. These electrically conducting coated microneedles can be used for diagnosis, whereby microneedles **12** act as electrodes. Alternatively, these coated needles can be used to enhance drug delivery by employing electrophoresis by passing an electric current between microneedles **12**. Radiation sensitive materials are discussed in more detail with respect to **FIG. 10**. Each microneedle **12** typically has a channel therein. However, it should be noted that optionally, microneedle **12** is formed without a channel therein. Substructure **14** typically has a channel therein for each channel of microneedles **12**, such that therapeutic substances can be passed via the channels in substructure **14** through to the channels of microneedles **12** into the skin of the patient. Additionally, the channels can be used to remove biological fluids for sampling and/or collection from a patient. Additionally, each microneedle **12** has at least one oblique end surface giving microneedle **12** a sharp point for use in skin penetration. However, it should be noted that optionally, microneedle **12** is formed without an oblique end surface. Optionally, microneedles **12** of microneedle structure **10** are formed such that microneedles **12** have different heights. These and other features and their method of manufacture are described in more detail with respect to FIGS. **2** to **19**.

[0057] Reference is now made to **FIG. 2**, which is a schematic cross-sectional view of a silicon wafer **16** coated with a thin layer of Silicon Nitride **18** that is used in the construction of microneedle structure **10** of **FIG. 1**. By way of introduction, wafer **16** is used as a working surface on which to form microneedle structure **10**. At least one groove **20** (**FIG. 7**) is formed in wafer **16**, such that said the end portion of microneedle **12** is formed within groove **20**. Groove **20** defines the one or more oblique end surfaces of microneedle **12**. The formation of groove **20** is described in more detail with respect to **FIG. 2** to **7**. Initially wafer **16** is cleaned to remove all dust and contamination. The cleaning is done with alcohol based materials and drying with air. Layer of Silicon Nitride **18** is disposed on wafer **16**. The thickness of layer of Silicon Nitride **18** is typically 300 nanometers. This coating is performed using a LPCVD process. Layer of Silicon Nitride **18** is used later as a mask for wet etching (**FIG. 6**).

[0058] Reference is now made to **FIG. 3**, which is a schematic cross-sectional view of wafer **16** of **FIG. 2** after the following step is performed. A layer of photoresist **22** is coated on top of layer of Silicon Nitride **18**. Materials suitable for layer of photoresist **22** are known to those skilled in the art.

[0059] Reference is now made to **FIG. 4**, which is a schematic cross-sectional view of wafer **16** of **FIG. 3** after the following steps are performed. Layer of photoresist **22** is exposed to light (photolithography process) through a KOH mask (not shown). The KOH mask is configured such that when layer of photoresist **22** is developed, a series of parallel strips **24** are formed on wafer **16** in layer of photoresist **22**. Radiation sources suitable for this step as well as developing techniques are known to those skilled in the art.

[0060] Reference is now made to **FIG. 5**, which is a schematic cross-sectional view of wafer **16** of **FIG. 4** after the following step is performed. Plasma etching is performed creating a series of parallel strips **26** in layer of Silicon Nitride **18**.

[0061] Reference is now made to **FIG. 6**, which is a schematic cross-sectional view of wafer **16** of **FIG. 5** after the following step is performed. Wet etching of wafer **16** is performed creating grooves **20** at the locations of parallel strips **26** (**FIG. 5**) where there is no protective layer of Silicon Nitride **18**. The wet etching process is performed by placing wafer **16** in a chemical bath for a short time. For example, by using chemicals such as THEMA or KOH. This wet etching process etches wafer **16** in its crystallographic plans to create grooves **20** in silicon wafer. As described above with respect to **FIG. 2**, groove **20** act as a working surface on which to form the tips of microneedles **12** to give the tips at least one oblique end surface.

[0062] Reference is now made to **FIG. 7**, which is a schematic cross-sectional view of wafer **16** of **FIG. 6** after the following steps are performed. A thin layer of Silicon Nitride **28** is now disposed thereon in order to protect wafer **16** during later stages where a KOH chemical is used. A layer of polysilicon (not shown) is then deposited on top of layer of Silicon Nitride **28** using a LPCVD process. This latter layer helps release of microneedle structure **10** from wafer **16** as will be described in more detail with respect to **FIG. 19**.

[0063] Reference is now made to **FIG. 8**, which is a schematic cross-sectional view of wafer **16** of **FIG. 7** after the following step is performed. A thick layer of a radiation sensitive polymer **40** (photoresist), such as SU8, is disposed, typically by spin coating, on to the working surface of wafer **16** on top of layer of Silicon Nitride **28**. Other examples suitable materials for layer of radiation sensitive polymer **40** are listed below in Table 1.

[0064] Reference is now made to **FIG. 9**, which is a schematic cross-sectional view of a layer of photoresist **30** being irradiated through a mask **32** in accordance with the prior art. Arrows **34** represent the radiation incident on mask **32**. Irradiation through mask **32** creates irradiated regions **36** in layer of photoresist **30** and non-irradiated regions **38** in layer of photoresist **30**. Developing of layer of photoresist **30** removes either irradiated regions **36** or non-irradiated regions **38** depending on whether layer of photoresist **30** is a positive or negative photoresist. If layer of photoresist **30**

is a negative photoresist then non-irradiated regions **38** are removed on developing. If layer of photoresist **30** is a positive photoresist then irradiated regions **36** are removed on developing. It will be apparent to those ordinarily skilled in the art that the radiation sensitive polymer used in the method of the present invention is either positive or negative.

[**0065**] Reference is now made to **FIG. 10**, which is a schematic cross-sectional view of wafer **16** of **FIG. 8** after processing of layer of radiation sensitive polymer **40** (**FIG. 9**) defining a form of microneedles **12**. This processing includes selectively acting upon layer of radiation sensitive polymer **40** with radiation so as to effect a physical and/or chemical change selectively in the material of layer of radiation sensitive polymer **40**. This processing typically includes selective irradiation and developing of layer of radiation sensitive polymer **40**. These steps are described in more detail below. First, layer of a radiation sensitive polymer **40** (**FIG. 9**) is selectively irradiated, typically using a mask, such that layer of radiation sensitive polymer **40** has one or more irradiated regions (not shown) and one or more non-irradiated regions (not shown). The irradiating is typically performed using a light source producing visible light, ultraviolet light or by x-ray radiation. It will be apparent to those skilled in the art that the radiation source depends on the material used for layer of radiation sensitive polymer **40**. Other radiation sources and materials are known to those skilled in the art. It should be noted that a radiation insensitive material could be embedded with a radiation sensitive material (such as PDMS, Polydimethsiloxane and PCB) acting as a precursor to make the combined material react when exposed to a radiation source. The term "radiation sensitive material" used in the claims includes combined materials which are sensitive to a radiation source.

[**0066**] Table 1, below, is an example of suitable radiation sources and their corresponding radiation sensitive materials.

Radiation Source	Materials
Ion Radiation (Xenon)	Polyimide (such as PI2732 by DuPont)
UV or near UV	Epoxy based materials such as SU8, BenzoCycloBute (BCB), Polynorbornenes (made by B F Goodrich), UV polymer- PVK
X-ray	PMMA
Electron beam	PMMA
Light	Photoresist materials such as Poly(Benzoxazole) BPO, PDMS (Polydimethsiloxane)
Laser	Photoresist materials such as PBO

[**0067**] It should be noted that PDMS, PMMA and BCB are biocompatible as well as being used in the microfabrication technology and are therefore very suited to microneedle manufacture.

[**0068**] After layer of radiation sensitive polymer **40** is exposed to the radiation, a post exposure bake is performed on layer of radiation sensitive polymer **40**. Then, layer of radiation sensitive polymer **40** is developed so as to selectively remove either the irradiated regions or non-irradiated regions of layer of radiation sensitive polymer **40**, depending on the type of polymer used (positive or negative) such that, at least part of one or more remaining regions **46** at least partially defines a form of at least part of microneedles **12**. The developing process is described as defining "a form" of at least part of microneedles **12** in that further processing is typically needed to make microneedles **12** usable. Remaining regions **46** are then rinsed and dried and then generally baked. The above process defines the outer surface of microneedle **12** as well as the surface of the channel within microneedle **12**. It will be appreciated by those skilled in the art that the above process may be used to create one or more microneedles with or without channels therein. It will also be appreciated by those skilled in the art that the above process may be used to create one or more microneedles with or without one or more oblique end surfaces. The steps described with respect to **FIGS. 8 and 10** are repeated as necessary depending on the height of microneedles required.

[**0069**] Reference is now made to **FIG. 11**, which is a schematic cross-sectional view of a wafer **48** having a microneedle **50** disposed thereon that is constructed and operable in accordance with a first alternate embodiment of the present invention. Microneedle **50** has two oblique end surfaces **52**. Oblique end surfaces **52** are defined by forming microneedle **50** at the middle of a groove **54** in the surface of wafer **48**.

[**0070**] Reference is now made to **FIG. 12**, which is a schematic cross-sectional view of a wafer **56** having two microneedles **58** disposed thereon that is constructed and operable in accordance with a second alternate embodiment of the present invention. Wafer **56** has a groove **60** in the surface of wafer **56**. Microneedles **58** are formed at differing locations on groove **60** such that microneedles **58** have different heights. Microneedle arrays having microneedles of different heights are known as three-dimensional microneedle arrays. Three-dimensional microneedle arrays provides a three-dimensional dispersion of injected substances for drug delivery applications as well as enhanced sampling efficacy for diagnostic applications.

[**0071**] Reference is now made to **FIG. 13**, which is a schematic cross-sectional view of a wafer **62** having a thick layer of photoresist **64** disposed thereon being selectively irradiated by a radiation source (not shown) through a mask **66** that is constructed and operable in accordance with a third alternate embodiment of the present invention. Wafer **62** typically has a substantially flat surface. Incident radiation is represented by arrows **68**. The relative positioning of the radiation source and wafer **62** at least partially defines an oblique end surface **70** of a microneedle **72**. The relative positioning of the radiation source and wafer **62** is described as "at least partially defines" in that if the surface of wafer **62** is not flat then the contours of the surface of wafer **62** will also define oblique end surface **70** of microneedle **72**.

[**0072**] Reference is now made to **FIG. 14**, which is a schematic cross-sectional view of a wafer **74** having a thick layer of photoresist **76** disposed thereon being selectively irradiated by a radiation source (not shown) that is constructed and operable in accordance with a fourth alternate embodiment of the present invention. Incident radiation is represented by arrows **78**. The relative positioning of the radiation source and wafer **74** at least partially defines an oblique end surface **80** of each microneedle **82**. The examples of both **FIG. 13** and **FIG. 14** have been brought to show that the relative positioning of the radiation source

and the wafer define the shape of the end of the microneedles. The orientation of the mask defines the width of the microneedles.

[0073] Reference is now made to **FIG. 15**, which is a schematic cross-sectional view of possible microneedle structures that is constructed and operable in accordance with a fifth alternate embodiment of the present invention. It will be appreciated by those skilled in the art that the shape of the microneedle including the outside shape as well as the shape of the inner channel is unlimited. These shapes are only based upon the configuration of the mask, the relative positioning of the radiation source and the working surface, as well as the shape of the working surface. Typical shapes include tubes, pyramids and cones with or without channels. Microneedles **90**, **92**, **94** have channels which are not aligned with the tip of the needle. Therefore, if a greater flow of fluids is needed, the channels can be enlarged without effecting the size of the tip or the forces needed for skin penetration. Additionally, the fact that the structure and position of the tip can be manipulated allows for developing discrete applications, such as using needles for piercing, cutting and fixing arrays on tissue. The microneedle structure can be configured to meet the requirements of various types of applications. By way of a first example, drug delivery requires sharp needles to make holes. By way of a second example, balloon mounted microneedles need cutting knife or blade-type tips. By way of a third example, vaccination applications may require enlargement of the surface area of the penetrating object necessitating making jagged edged tips and channels.

[0074] Reference is now made to **FIG. 16**, which is a schematic cross-sectional view of wafer **16** of **FIG. 10** after the following step is performed. A filler layer **84** of a polymer resist material is disposed at least partially, typically completely, around remaining regions **46**. The term "around" includes around the outside of microneedles **12** as well as in the channel of microneedles **12**. Filler layer **84** acts as a filling material on which to build substructure **14** (**FIG. 1**). Filler layer **84** extends from layer of Silicon Nitride **28** to just below the base of microneedles **12**. Optionally filler layer **84** is used to define the length of microneedles **12**.

[0075] Reference is now made to **FIG. 17**, which is a schematic cross-sectional view of wafer **16** of **FIG. 16** after the following step is performed. A layer of radiation sensitive polymer **86**, such as SU8, is disposed, typically by spin coating, on top of filler layer **84** and remaining regions **46** (microneedles **12**).

[0076] Reference is now made to **FIG. 18**, which is a schematic cross-sectional view of wafer **16** of **FIG. 17** after the following steps are performed. Layer of radiation sensitive polymer **86** (**FIG. 17**) is selectively irradiated, typically using a mask (not shown). This mask is configured to define a form of channels **88** in substructure **14** which join up with the channels in microneedles **12**. Then, layer of radiation sensitive polymer **86** is developed such that layer of radiation sensitive polymer **86** forms a base for microneedle structure **10**. Generally, layer of radiation sensitive polymer **86** is baked after the developing step.

[0077] Reference is now made to **FIG. 19**, which is a schematic cross-sectional view of microneedle structure **10** having microneedles **12** and substructure **14** of **FIG. 18** after the following step is performed. Microneedle structure **10** is released from wafer **16** (**FIG. 18**) using a KOH etching material.

[0078] The above method has been described with reference to using a radiation sensitive polymer to form microneedles **12**, typically using a process including the steps of selective irradiation, developing and baking. It will be appreciated by those skilled in the art that some of these processing steps may not be needed depending on the chosen radiation sensitive polymer. It will also be appreciated by those skilled in the art that, optionally, microneedle **12** are formed at least partially using micro-ablation techniques. For example, but not limited to, the form of microneedles **12** being defined by selectively irradiating a material using a high power radiation source which ablates unwanted material, leaving behind the form of microneedles **12**.

[0079] It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and sub-combinations of the various features described hereinabove, as well as variations and modifications thereof that are not in the prior art which would occur to persons skilled in the art upon reading the foregoing description.

What is claimed is:

1. A method for producing microneedles, comprising the steps of:

(a) disposing a first layer of a radiation sensitive polymer on to a working surface;

(b) selectively irradiating said first layer such that said first layer has at least one irradiated region and at least one non-irradiated region; and

(c) developing said first layer so as to selectively remove one of said at least one irradiated region and said at least one non-irradiated region such that, at least part of at least one remaining region at least partially defines a form of at least part of a microneedle structure.

2. The method of claim 1, wherein said at least part of said microneedle structure includes a plurality of at least partially formed microneedles.

3. The method of claim 2, wherein each of at least two of said at least partially formed microneedles have a channel therein.

4. The method of claim 2, wherein each of at least two of said at least partially formed microneedles have an oblique end surface.

5. The method of claim 2, wherein at least two of said at least partially formed microneedles are different heights.

6. The method of claim 1, wherein said at least part of said microneedle structure includes an at least partially formed microneedle having a channel therein.

7. The method of claim 1, wherein said at least part of said microneedle structure includes an at least partially formed microneedle having an oblique end surface.

8. The method of claim 1, further comprising, after said step of developing, the steps of:

(a) disposing a filler at least partially around said at least one remaining region;

(b) disposing a second layer of a radiation sensitive polymer on to: (i) at least part of said at least one remaining region; and (ii) at least part of said filler;

(c) irradiating said second layer; and

(d) developing said second layer such that, said second layer forms a base for at least part of said microneedle structure.

9. The method of claim 8, wherein said base has at least one channel therein.

10. The method of claim 8, wherein said step of irradiating said second layer is performed by selectively irradiating said second layer.

11. The method of claim 1, further comprising the step of forming at least one groove in said working surface, such that said at least part of said microneedle structure is formed within said at least one groove, said at least one groove defining at least one oblique end surface of said microneedle structure.

12. The method of claim 1, wherein said step of irradiating is performed using a light source producing visible light.

13. The method of claim 1, wherein said step of irradiating is performed using ultraviolet light.

14. The method of claim 1, wherein said step of irradiating is performed using a x-ray radiation.

15. The method of claim 1, further comprising disposing a radiation source, which is used in said step of irradiating, and said working surface such that, the relative positioning of said radiation source and said working surface at least partially defining at least one oblique end surface of said microneedle structure.

16. A microneedle structure, comprising a plurality of microneedles, each of said microneedles being at least partially formed from a radiation sensitive polymer.

17. The structure of claim 16, wherein a majority of each of said microneedles is formed from said radiation sensitive material.

18. The structure of claim 16, further comprising a substructure configured to form a base for said microneedles, said substructure being at least partially formed from a radiation sensitive polymer.

19. The structure of claim 18, wherein said substructure has at least one channel therein.

20. The structure of claim 16, wherein each of at least two of said microneedles have a channel therein.

21. The structure of claim 16, wherein each of at least two of said microneedles have an oblique end surface.

22. The structure of claim 16, wherein at least two of said microneedles are different heights.

23. A microneedle structure, comprising a microneedle, said microneedle being at least partially formed from a radiation sensitive polymer, said microneedle having a channel therein.

24. The microneedle structure of claim 23, wherein a majority of said microneedle is formed from said radiation sensitive material.

25. A microneedle structure, comprising a microneedle, said microneedle being at least partially formed from a radiation sensitive polymer, said microneedle having an oblique end surface.

26. The microneedle structure of claim 25, wherein a majority of said microneedles is formed from said radiation sensitive material.

27. A method for producing microneedles, comprising the steps of:

(a) disposing a layer of a material on to a working surface; and

(b) processing said layer so as to selectively remove one of at least one irradiated region and at least one non-irradiated region, such that, at least part of at least one remaining region at least partially defines a form of at least part of a microneedle structure, wherein said processing includes a sub-step of selectively acting upon said layer with radiation so as to effect at least one of a physical and a chemical change selectively in material of said layer.

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