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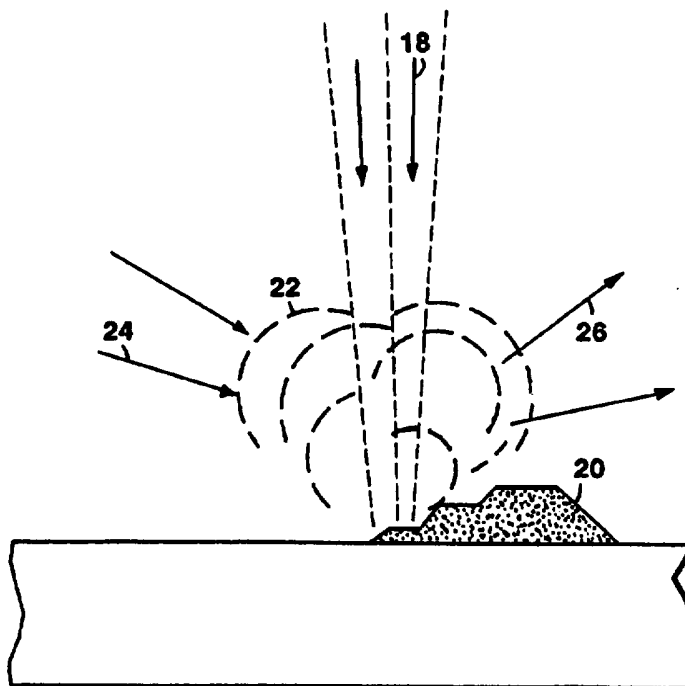
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08/428,667 25 April 1995 (25.04.95) US**(71) Applicant:** UVTECH SYSTEMS, INC. [US/US]; One Longfellow Center, 526 Boston Post Road, Wayland, MA 01778 (US).**(72) Inventors:** ELLIOTT, David, J.; 147 Rice Road, Wayland, MA 01778 (US). HOLLMAN, Richard, F.; 79 Robin Hill Road, Chelmsford, MA 01824 (US). YANS, Francis, M.; 49 Willard Common, Concord, MA 01742 (US). SINGER, Daniel, K.; 11 Indian Rock Drive, Natick, MA 01778 (US).**(74) Agent:** FEIGENBAUM, David, F.; Fish & Richardson P.C., 225 Franklin Street, Boston, MA 02110 (US).**(81) Designated States:** AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).**Published***With international search report.***(54) Title:** SURFACE MODIFICATION PROCESSING OF FLAT PANEL DEVICE SUBSTRATES**(57) Abstract**

A method for performing surface processing of flat panel display substrates at various points during manufacturing. Such processing is required, for example, to remove photoresist after a photolithography step. Cleaning of glass substrates at the beginning of the manufacturing sequence is also required. Some layers of the device, for example color filters and polyimide alignment layers, may be patterned by this method by the use of a mask (54) in the surface processing. A high intensity pulsed beam of radiation (18) is swept across the surface to be processed (21), while a reactive gas (24) is flowed across the surface where the beam strikes it. In a cleaning or material removal process, the beam of radiation (18) causes the material to react with the gas, resulting in gaseous products (26) which are drawn away from the surface. In a curing process, for polyimide or spin-on dielectric, for example, the beam of radiation (60) causes the polymer to cross-link, while the flowing gas (64) assists in the reaction and removal of species which are released in the cross linking process. Processing of a substrate (74) can be accomplished by translating the substrate (74) under a beam (60) which is larger than the width of the substrate. Processing may be accomplished by multiple scans of the surface or by scanning with multiple beams.



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SURFACE MODIFICATION PROCESSING OF
FLAT PANEL DEVICE SUBSTRATES

Background

5 This application is a continuation-in-part of United States Patent Application Serial Number 08/298,023, filed on August 29, 1994, which is a continuation-in-part of Serial No. 08/118,806, filed September 8, 1993, now abandoned.

10 This invention relates to surface modification processing of flat panel device substrates.

 Flat panel displays have applications in appliances, personal computers, and many other areas where alphanumeric displays are used. Their use is
15 steadily increasing as technology improvements allow flat panel displays increasingly to be used in place of cathode ray tubes.

 Most flat panel displays in use today are of the liquid crystal type. As shown in Figure 1, the cross
20 section of a liquid crystal device contains the liquid crystal 2 in a "sandwich" between two sheets of electrodes. The electrode 4 is typically a feature formed on a thin film of a transparent conducting material such as indium tin oxide (ITO), on a glass
25 substrate 6. The electrode is covered by an insulating layer 8 to prevent arcing through the liquid crystal, and an alignment layer 10, typically of polyimide, to orient the liquid crystal molecules. Polarizing layers 12, oriented perpendicular to one another, are applied to the
30 outside of the glass substrates so that transmitted light is normally blocked.

 When a voltage is applied to the electrodes, the region of liquid crystal between the electrodes rotates the plane of polarization so that light is transmitted
35 through the device in this region. The voltages are applied from an external controller (not shown), which

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charges selected electrodes in the proper sequence to form the desired alphanumeric characters.

There are several technical issues in the fabrication process for flat panel displays. One issue
5 is the initial cleaning of the glass substrates, or of the ITO layer prior to further processing. Present cleaning methods use large quantities of solvents and acids, which are costly to dispose of, and are unable to
10 clean all of the types of contamination which may accumulate during shipping and storage of the plates. Equipment for wet cleaning also tends to be large and expensive.

Another issue is stripping photoresist from the substrate following a photolithographic patterning step.
15 There are several methods for doing this, including plasma ashing and solvent rinses. Current methods are either costly due to chemical usage, or time consuming, or both. Another issue is the curing of both the polyimide alignment layer and the spin-on dielectric used
20 for insulation over the electrodes. Current methods involve a time consuming and energy consuming oven bake cycle.

The use of conventional lithography techniques for patterning several of the device layers adds considerably
25 to the overall fabrication cost. For each layer that must be patterned, photoresist must be applied and prebaked, the pattern must be exposed, and the resist developed and postbaked, and stripped after an etch process. Each of these steps requires a costly piece of
30 capital equipment, and demands considerable space on the production floor.

Summary

In general, in one aspect, the invention features processing a surface of a flat panel display substrate by
35 providing a moving fluid, including a reactant, and

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delivering pulsed radiation to the surface of the flat substrate in the presence of the fluid, such that a surface modification reaction takes place.

Implementations of the invention may include the following features. The surface modification reaction may include removal of material to clean the surface. The surface may be glass or ITO. A thin layer of less than 100 Angstroms of ITO may be removed. The material to be removed may be particles or films, e.g., organic films such as oil, or a contaminated layer of the substrate. The surface modification reaction may include cleaning the surface, curing a material, or patterning a material. The radiation source may be an excimer laser. The radiation source may be a solid state laser, such as a frequency-multiplied Nd:YAG laser. The radiation source may be a solid state laser. The radiation is optically shaped into a blade, and relative motion is induced between the optics and the surface to be processed so that the blade scans the entire surface. The blade may be used to cure or bake photoresist. The intensity of a pulse of radiation at the surface to be processed may be between 20 mJ/cm² and 1000 mJ/cm², in the case of glass preferably between 200 mJ/cm² and 1000 mJ/cm², in the case of ITO preferably between 400 mJ/cm² and 1500 mJ/cm², in the case of photoresist preferably between 100 mJ/cm² and 800 mJ/cm². The surface to be processed or the moving fluid may be heated. The surface to be processed may be a spin-on dielectric which is being cured. Then the intensity of a pulse of radiation at the surface may be between 10 mJ/cm² and 100 mJ/cm². The surface to be processed may include polyimide which is being cured. Cleaning may be accomplished by removing a fractional thickness of the indium tin oxide layer containing contaminants.

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Patterning may be done using a mask to process in selected areas only. The mask may be held within 10mm of the surface, or more than 10 mm away. The flow of gas may be provided above the mask, or between the mask and
5 the surface. The mask may be a scaled replica of the pattern to be formed on the surface. The mask may have one or more opaque objects which can be moved into and out of the beam path. The surface to be patterned may be a polyimide, and the flowing gas may then include an
10 oxidant.

The surface to be patterned may include a color filter layer, and then the flowing gas may include an oxidant, e.g., oxygen or ozone. The surface to be patterned may be a planarization layer. The beam may be
15 split into two or more beams on the surface. The moving fluid may be a liquid.

A sequence of surface modification processes may be performed, and the process conditions may be changed between one process and the next.

20 The advantages of the invention may include one or more of the following. The surface processing has broad applicability and may include: removal of photoresist; removal of particles and organic contamination; patterning (i.e. the removal from selected areas) of
25 various device layers such as ITO, polyimide and color filters by the use of a mask; curing of polyimide and spin-on dielectric; and removal of a thin contaminated surface layer of the ITO to reveal a better quality surface for further processing. Material to be removed
30 is ablated or otherwise activated by the radiation to cause it to react with the flowing gas, leaving only gaseous reaction products which are carried away by the gas flow. Material to be modified in other ways, such as curing, are activated by the radiation to effect or
35 accelerate the desired reaction, while any unwanted

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byproducts produced in the reaction, such as solvent vapors, are reacted or otherwise removed by the gas flow. The invention also offers opportunities for improvements in the device and the fabrication process. For example, 5 the use of photoreactive surface processes in place of high temperature processes can enable the use of plastic substrates for the device, resulting in lower cost and greater durability. Another opportunity lies in the ability to replace costly and complex photolithographic 10 patterning steps with photoreactive surface processes using stencil or projection masks, to dramatically reduce the cost of patterning certain device layers.

Other advantages and features will become apparent from the following description and from the claims.

15 Description

Figure 1 is a schematic cross section of a liquid crystal display device.

Figure 2 illustrates the ablation and reaction mechanism for removal of photoresist or organic 20 contaminants.

Figure 3 illustrates the optical formation of a focused blade of light.

Figure 4 illustrates the scanning of the entire substrate surface by the beam.

25 Figure 5 illustrates the scanning process, with a stencil mask interposed between the beam and the surface.

Figure 6 illustrates the scanning process used to clean a surface of particles and contaminant films.

Figure 7 illustrates the photoreactive curing of a 30 thin film, such as polyimide or spin-on dielectric, used in a flat panel display.

Figure 8 illustrates a patterned removal process where a stencil mask is held far enough from the surface to permit a flow of gas between the mask and the surface.

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Figure 9 illustrates the use of a projection shadow mask for patterned material removal.

Figure 10 illustrates the use of linear masks for patterned material removal.

5 Figure 11 illustrates photoreactive surface processing where a flowing liquid is used as the reactant.

Figure 12 illustrates the removal of a contaminated portion of the ITO layer from a flat panel
10 display substrate.

As shown generally in Figure 2, foreign material 20 on the surface of a workpiece 21 is processed to form a reaction product 26, by the combination of providing a directed flow of a fluid 24, including a reactant, in the vicinity of the foreign material, and delivering a beam of radiation 18 to aid the reactant to react with the foreign material to form the reaction product. The beam may be deep ultraviolet radiation in the wavelength range from 155 nm to 405 nm. The source of the radiation may
20 be an excimer laser, for example a KrF excimer producing radiation at 248 nm wavelength, or an ArF excimer producing radiation at 193 nm wavelength. Alternatively the source may be a solid state laser such as a frequency-quadrupled Nd:YAG laser, producing radiation at
25 266 nm wavelength, a frequency-tripled Nd:YAG at 355 nm, or a frequency-tripled Alexandrite laser producing radiation with a tunable wavelength in the range 240 nm to 266 nm. Other high intensity ultraviolet light source may be used, such as a pulsed xenon lamp, or a high
30 pressure mercury vapor lamp. Other wavelengths of light may be present in addition to the ultraviolet light. For example, the beam from a frequency-multiplied Nd:YAG laser may combine the light of the fundamental wavelength

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1064 nm and the second harmonic 532 nm along with the fourth harmonic at 266 nm wavelength.

The reactant may be a gas flowing at a velocity preferably between 20 mm/sec and 500 mm/sec. The gas may
5 include one or more members of the group of oxidants consisting of oxygen, fluorine and chlorine, and molecules containing oxygen, fluorine and chlorine. When the foreign material includes organic material, the reactant may include an oxidant and the beam may include
10 ultraviolet radiation.

The reactant may be a flowing liquid in which the workpiece is immersed. For example, the material to be removed may be spin-on dielectric, and the liquid may include a chlorine-containing species such as HCl or
15 NaClO. As shown in Figure 11, the work surface 110 is covered by a layer of flowing liquid 112, including a reactant. The depth of this layer may be preferably between 0.5 mm and 10 mm, and the velocity may be preferably between 10 mm/sec and 500 mm/sec. The beam
20 112 is transmitted through the layer of flowing liquid to the work surface, where it heats, ablates or otherwise excites the foreign material 114 to react with the liquid, forming reaction products 116 which are carried off in the liquid flow.

25 In one example, a layer of spin-on dielectric was stripped from a flat panel display substrate using excimer laser pulses at 248 nm wavelength. The substrate was immersed in a dilute solution of HCl (approximately 5% concentration) at a depth of 5 mm. The beam was
30 formed into a focused stripe with an energy of 4 mJ per cm of length, pulsing at a rate of 100 Hz. The spin-on dielectric was removed from glass substrate with a patterned ITO layer, using a single pass at 1 mm/sec. The resulting ITO surface was free of visible residue.

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As shown in Figure 3, the beam may be delivered by receiving a source laser beam 28 and focusing the cross-sectional size of the beam in one dimension by using a converging cylindrical lens 34 and broadening the cross-sectional size in the other dimension using a diverging cylindrical lens 30 to form a narrow rectangular beam 38 at the surface to be processed. The size of the beam in the broadened dimension may be at least as great as the width of the substrate to be processed. Other optical configurations may be used which can provide a similar narrow rectangular beam. For example, reflecting elements (i.e. cylindrical mirrors) may be used in place of one or both of the lenses. A narrow rectangular beam may also be obtained by using a converging spherical lens in combination with a diverging cylindrical lens, a diverging spherical lens in combination with a converging cylindrical lens, or any of numerous other arrangements.

As shown in Figure 4, the entire surface of a flat panel display substrate 40 may be scanned by placing it on a linear translation stage or conveyor (not shown). The stage or conveyor moves the substrate in the direction 48 under the beam 42 while a flow of gas 44 containing a reactant is provided by a nozzle 46. The outgoing gas flow 50 containing reaction products is drawn through an exhaust duct (not shown) and conveyed to a filter (not shown) which removes particles, reaction products and other contaminants from the gas stream before releasing or recirculating the gas. The gas may be heated by heater 132 before being delivered to the surface in order to improve the efficiency of the reaction. The translation stage or conveyor may also include a heating element (not shown) to raise the temperature of the substrate, for the same purpose.

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As shown in Figure 6, the material to be removed may be a particle 70, or a thin film 72 of grease or other contaminant. The material to be removed may alternatively be an applied film such as photoresist, polyimide or a planarization layer.

In one example, a layer of polyimide approximately 250 nm thick was stripped using 248 nm wavelength light pulses from a KrF excimer laser. The pulses were formed into a focused stripe with an energy of 3 mJ per cm of stripe length, and pulsed at a rate of 100 Hz. The substrate was scanned under the beam using two passes at a scan velocity of 4 mm/sec while a volume flow of oxygen of 50 SCFH was maintained across the substrate surface. In another example, a planarization layer approximately 1 micron thick was stripped using 248 nm wavelength light pulses from a KrF excimer laser. The pulses were formed into a focused stripe with an energy of 4 mJ per cm of stripe length, and pulsed at a rate of 200 Hz. The substrate was scanned under the beam at a velocity of 4 mm/sec, and 8 passes were used to strip the entire thickness. A flow of oxygen of 50 SCFH was maintained over the surface during scanning. These process conditions were effective at stripping the planarization layer without damaging the underlying ITO.

The material to be removed may include one or more of the device layers, and the material may be removed from selected areas only, leaving a patterned device layer. Patterned removal may be accomplished using a stencil mask in contact or close proximity with the surface, as illustrated in Figure 5. A stencil mask is interposed between the beam and the substrate. As the substrate and mask are conveyed together in direction 56, the beam and the flowing gas 64 remove material from areas 68 of the substrate which lie directly beneath open areas of the mask. In the figure,

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one such open region is beneath the beam, which has ablated a portion of the layer 58 to form a cloud 62 which reacts with the flowing gas 64 to form reaction products 66. More than one pulse may be needed to remove
5 all of the material from an open region.

In one example of patterning, a layer of polyimide approximately 250 nm thick was patterned using 248 nm wavelength light pulses from a KrF excimer laser. The pulses were formed into a focused stripe with an energy
10 of 3 mJ per cm of stripe length, and pulsed at a rate of 100 Hz. A single scan at a velocity of 4 mm/sec was performed with a metal stencil mask held about 0.5 mm above the surface, and a volume flow of oxygen of 50 SCFH was maintained across the surface.

15 As shown in Figure 8, the stencil mask 90 may be held at a sufficient height above the work surface 92 to permit a flow of gas 94 or liquid between the mask and the surface to react with the ablated material 96. The stencil mask may be held at a height above the surface
20 preferably between 0.5 and 10 mm.

Patterned removal may alternatively be accomplished by the use of a projection shadow mask as illustrated in Figure 9. The shadow mask 98 may be placed between the beam forming optics 100 and the work
25 surface 102, as shown in the figure. Alternatively the shadow mask may be placed in other locations along the beam path. The shadow mask includes areas transparent to the beam and areas opaque to the beam. The opaque areas may preferably be formed from a thin film of a material
30 resistant to ablation, such as copper or aluminum. The pattern of transparent and opaque areas on the mask may be a scaled version of the desired pattern on the work surface, and linear motion may be induced between the mask and the beam which is synchronized with the motion
35 of the flat panel display substrate. The scale factor

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for the mask pattern along the long dimension of the beam may be different from the scale factor along the short dimension.

As shown in Figure 10, patterned removal may
5 alternatively be accomplished by the use of one or more linear masks 106 which may be moved in and out of the beam 108 as the substrate is scanned under the beam. A linear mask, as shown in the insert in figure 10, is a comb-shaped object consisting of a bar approximately the
10 same length as the beam, and projections which block portions of the beam. By positioning such a linear mask, the material to be removed may be removed along the entire width of the beam (retracted mask), or removed from selected areas (mask extended into beam). A linear
15 mask may include more than one pattern, so that the pattern of material removal may be changed according to the position of the mask. Linear masks may be an efficient patterning method for layers with highly repetitive patterns, such as color filters.

20 Photoreactive processing may also be used to cure thin films of materials such as polyimide, photoresist and spin-on dielectrics. Curing does not remove the film but changes its properties by causing chemical reactions within the layer, typically cross-linking of a polymer.
25 As shown in Figure 7, a film 78 of material to be cured on a substrate 74, is conveyed in direction 76 beneath a beam 60 in the presence of flowing gas 64. The beam initiates chemical reactions in the illuminated portion 80 of the film, resulting in a film 82 with changed
30 physical and chemical properties. Some species 84, such as water vapor, organic solvents and other organic molecules, may be ejected from the surface during this process, and are carried off by the outgoing gas flow 66.

Photoreactive surface processing may be used to
35 remove a fraction of the thickness of the ITO conductor

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layer, as shown in Figure 12. This may be useful in preparing the substrate for further processing steps in cases where a portion of the ITO layer is contaminated. The beam 120 is formed in such a way that a pulse has
5 insufficient intensity to remove the entire ITO layer 122. The flowing gas 124 (alternatively, a liquid may be used) contains species such as hydrogen, chlorine or fluorine, or molecules containing hydrogen, chlorine or fluorine, which will react with the ITO layer where it is
10 illuminated by the beam. As the substrate is scanned under the beam, the contaminated portion 126 of the ITO layer is removed, leaving a clean surface 128 for further processing.

Other embodiments are within the scope of the
15 following claims.

What is claimed is:

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Claims

1. A method for processing a surface of a flat panel display substrate comprising providing a moving fluid, including a reactant,
5 and
delivering pulsed radiation to the surface of the flat substrate in the presence of the fluid, such that a surface modification reaction takes place.
2. The method of claim 1 wherein the surface
10 modification reaction comprises removal of material to clean the surface.
3. The method of claim 2 wherein the surface comprises glass.
4. The method of claim 2 wherein the surface
15 comprises ITO.
5. The method of claim 2 wherein the material being removed comprises particles.
6. The method of claim 2 wherein the material being removed comprises films.
- 20 7. The method of claim 2 wherein the material being removed comprises a contaminated layer of the substrate.
8. The method of claim 1 wherein the surface modification reaction comprises curing a material.
- 25 9. The method of claim 1 wherein the surface modification comprises patterning a material.
10. The method of claim 1 wherein the radiation is in the wavelength range 150 nm to 405 nm.
11. The method of in claim 2 wherein the radiation
30 source comprises an excimer laser.
12. The method of claim 11 wherein the radiation source comprises a solid state laser, such as a frequency-multiplied Nd:YAG laser.

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13. The method of claim 11 wherein the radiation is optically shaped into a blade, and relative motion is induced between the optics and the surface to be processed so that the blade scans the entire surface.

5 14. The method of claim 8 wherein the blade of radiation is used to cure or bake photoresist.

15 15. The method of claim 10 wherein the intensity of a pulse of radiation at the surface to be processed is between 20 mJ/cm² and 1000 mJ/cm².

10 16. The method of claim 1 wherein the surface to be processed or the moving fluid is heated.

17. The method of claim 1 wherein the surface to be processed comprises spin-on dielectric and the process comprises curing.

15 18. The method of claim 17 wherein the intensity of a pulse of radiation at the surface is between 10 mJ/cm² and 100 mJ/cm².

19. The method of claim 1 wherein the surface to be processed comprises polyimide and the process
20 comprises curing.

20. The method of claim 19 wherein the intensity of a pulse of radiation at the surface is between 10 mJ/cm² and 100 mJ/cm².

21. The method of claim 1 wherein the surface to
25 be cleaned comprises glass.

22. The method of claim 21 wherein the reactant includes an oxidant and the beam is ultraviolet light with wavelength between 150 and 405 nm.

23. The method of claim 1 wherein the surface to
30 be cleaned comprises indium tin oxide.

24. The method of claim 23 wherein cleaning is accomplished by removing a fractional thickness of the indium tin oxide layer containing contaminants.

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25. The method of claim 14 wherein the beam comprises ultraviolet light with wavelength between 150 nm and 405 nm.

26. The method of claim 1 wherein the surface is
5 patterned by the use of a mask to process in selected areas only.

27. The method of claim 26 wherein the mask is held within 10mm of the surface.

28. The method of claim 27 wherein a flow of gas
10 is provided above the mask.

29. The method of claim 27 wherein a flow of gas is provided between the mask and the surface.

30. The method of claim 26 wherein the mask is located more than 10 mm from the surface.

31. The method of claim 30 wherein the mask
15 comprises a scaled replica of the pattern to be formed on the surface.

32. The method of claim 26 wherein the mask comprises one or more opaque objects which can be moved
20 into and out of the beam path.

33. The method of claim 26 wherein the surface to be patterned comprises indium tin oxide.

34. The method of claim 26 wherein the surface to be patterned comprises polyimide, and the flowing gas
25 includes an oxidant.

35. The method of claim 26 wherein the surface to be patterned comprises a color filter layer, and the flowing gas includes an oxidant.

36. The method of claim 26 wherein the surface to
30 be patterned comprises a planarization layer.

37. The method of claim 1 wherein the beam is split into two or more beams on the surface.

38. The method of claim 1 wherein the moving fluid comprises a liquid.

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39. A method for cleaning a glass or ITO surface of a flat panel substrate comprising

delivering pulsed radiation to the glass or ITO surface to cause a modification reaction with particles,
5 films, or contaminated layers on the surface to produce a reaction product, and

removing the reaction product.

40. A method for cleaning polyimide, photoresist, or spin-on dielectric from the surface of a flat panel
10 display substrate comprising

delivering pulsed radiation to the surface to cause a modification reaction with the polyimide, photoresist, or spin-on dielectric to produce a reaction product, and

15 removing the reaction product.

41. A method for patterning an ITO, polyimide, color filter, or planarization layer on a flat panel display substrate comprising

providing a moving fluid, including a reactant,
20 and

delivering a pattern of pulsed radiation to the layer through a mask in the presence of the fluid, such that a surface modification reaction takes place.

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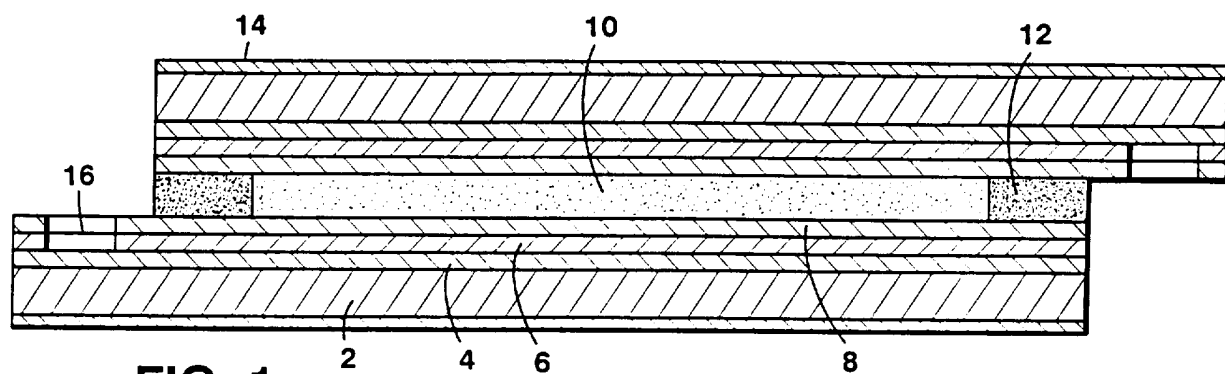


FIG. 1

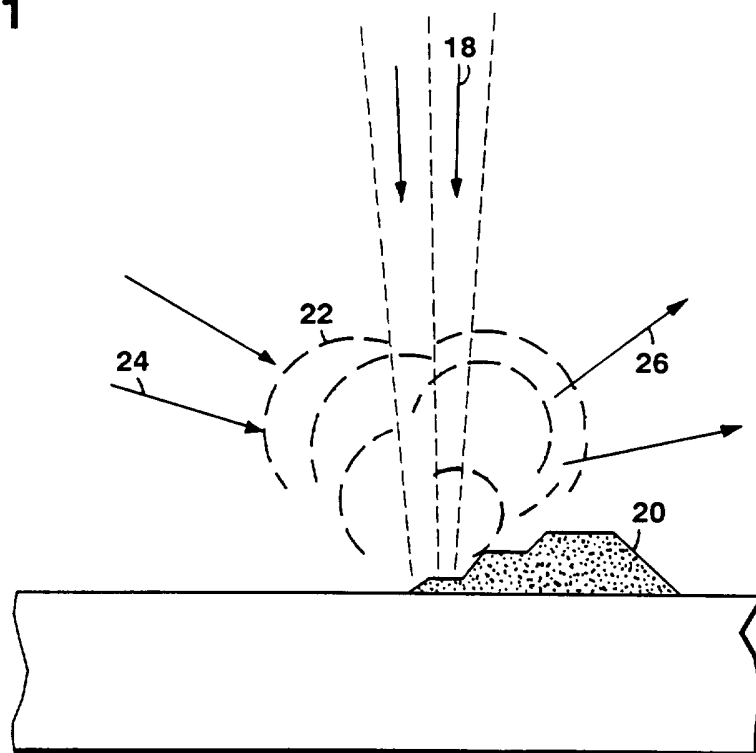


FIG. 2

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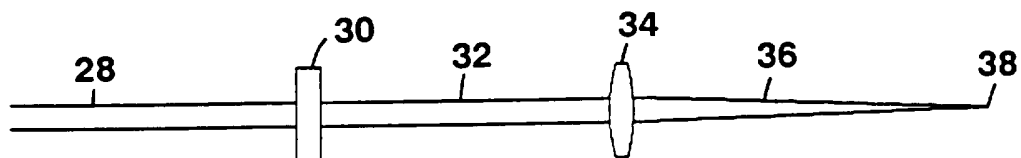


FIG. 3A

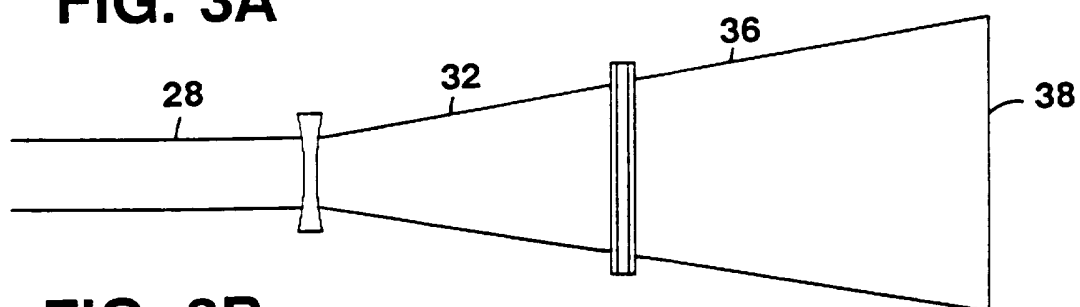


FIG. 3B

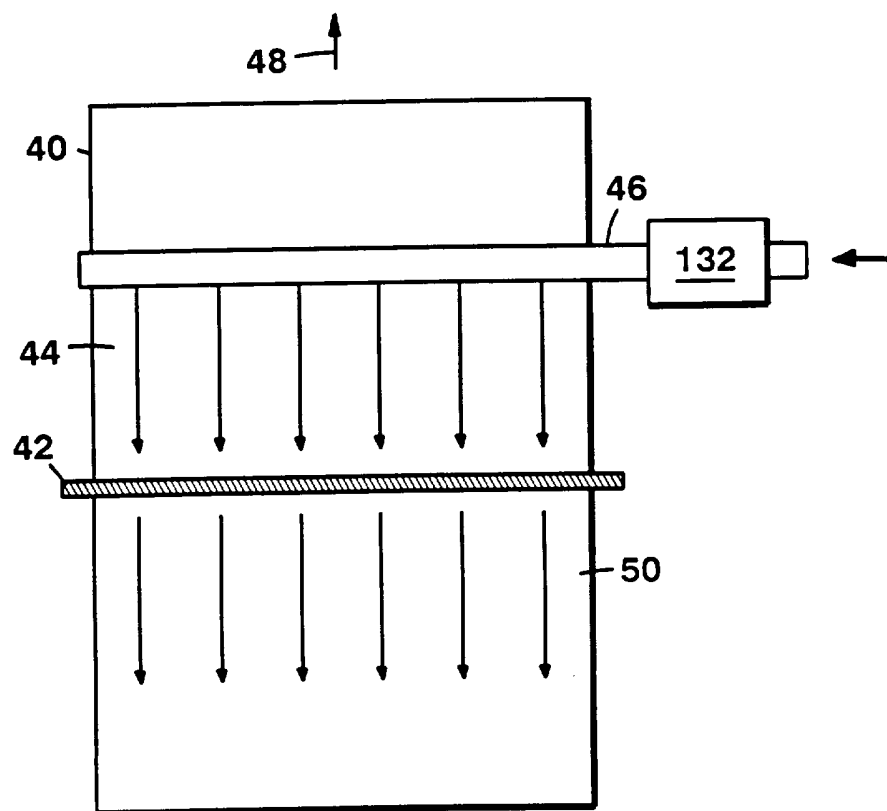


FIG. 4

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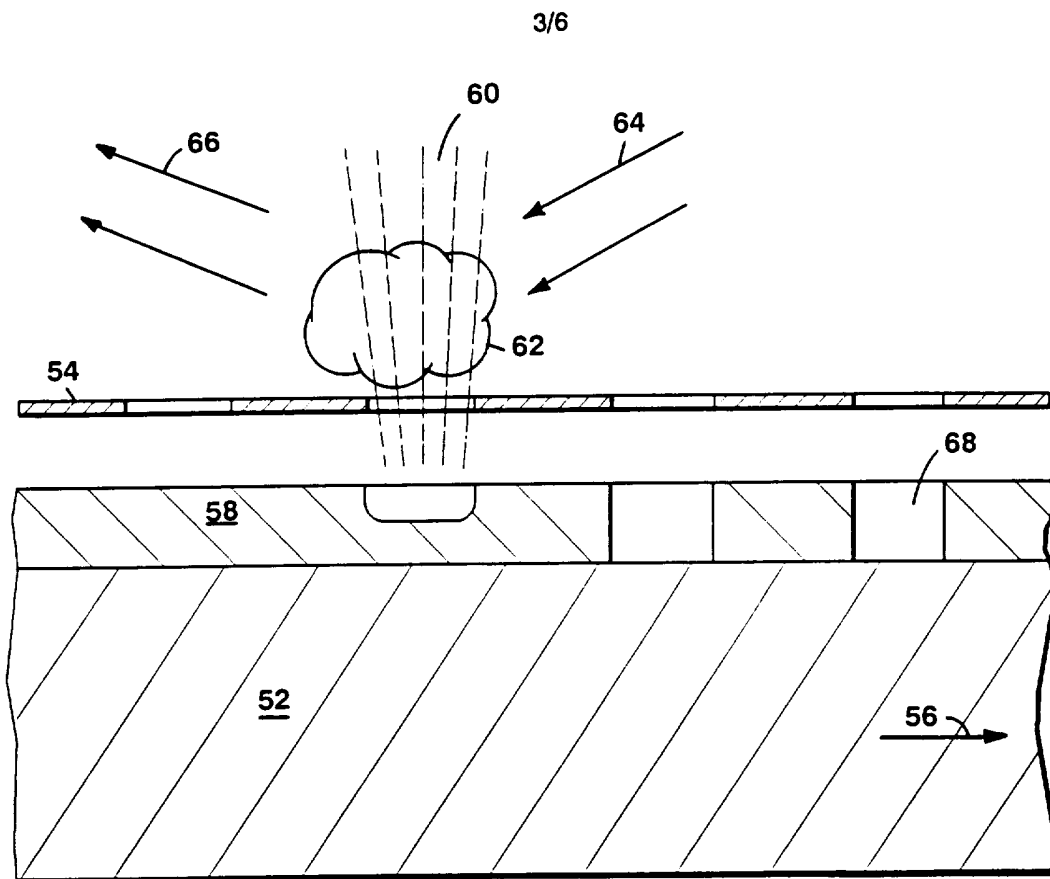


FIG. 5

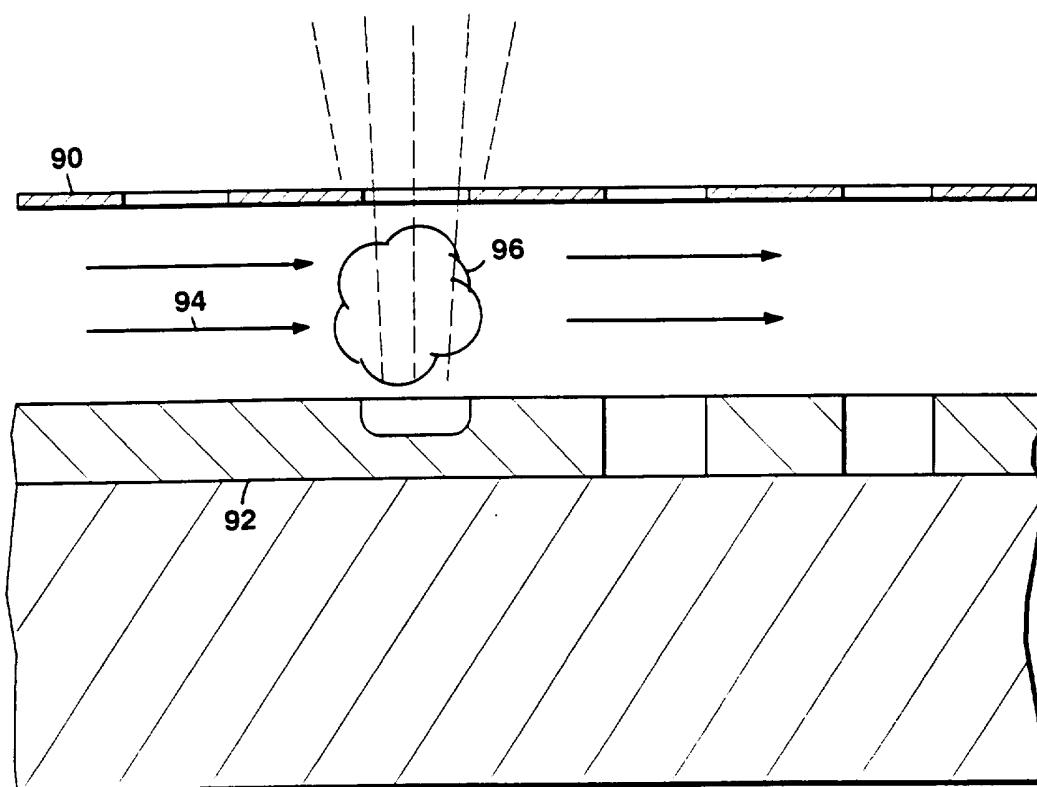
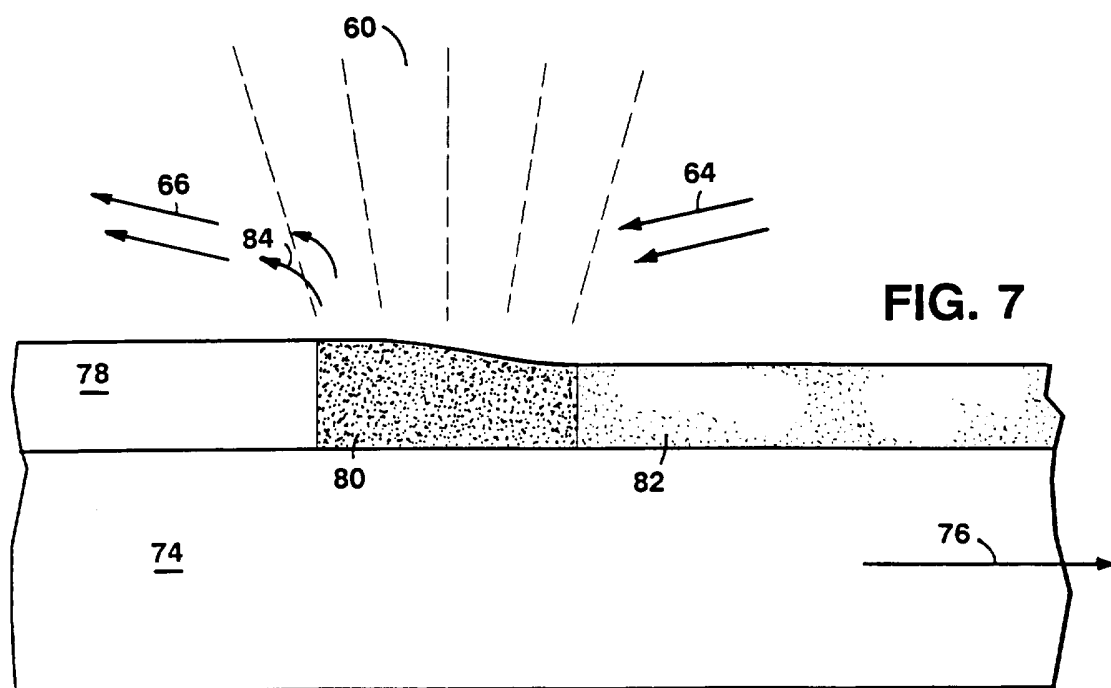
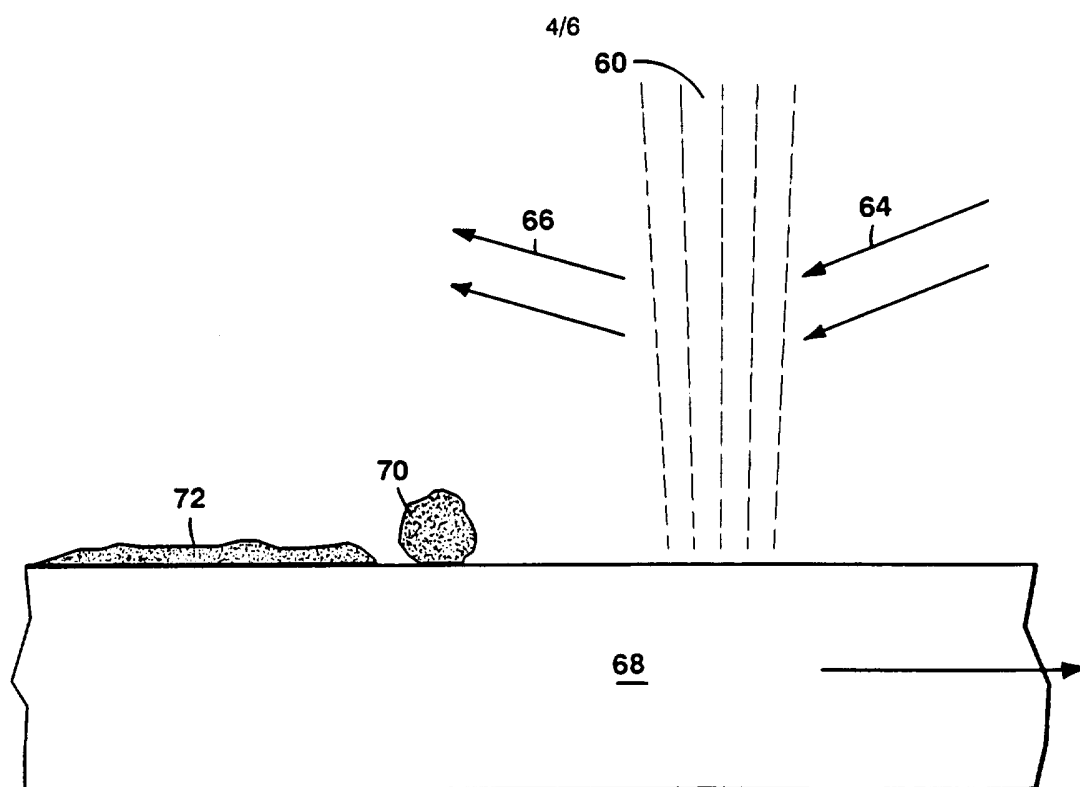


FIG. 8



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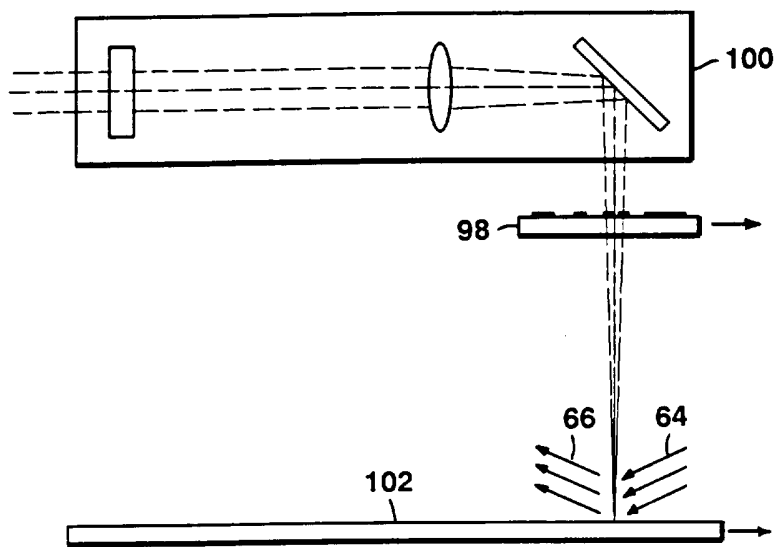


FIG. 9

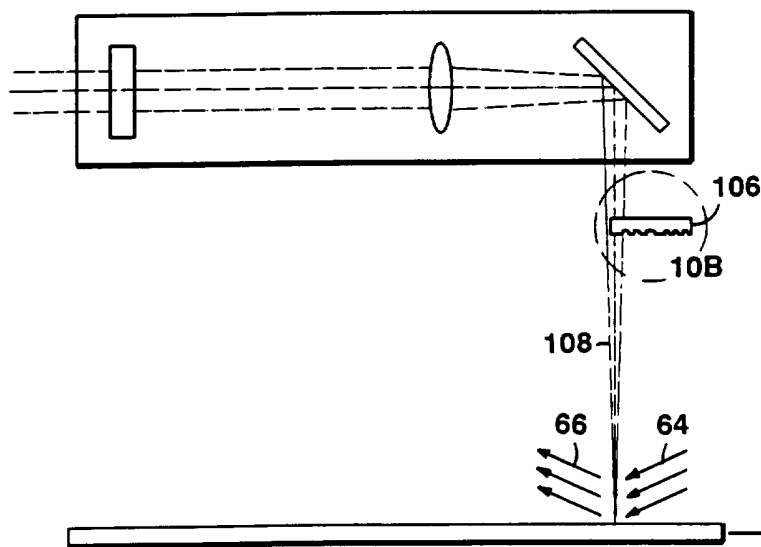
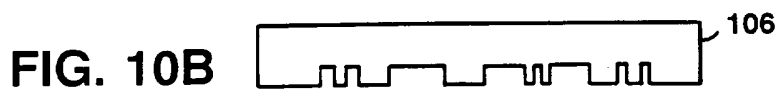


FIG. 10A



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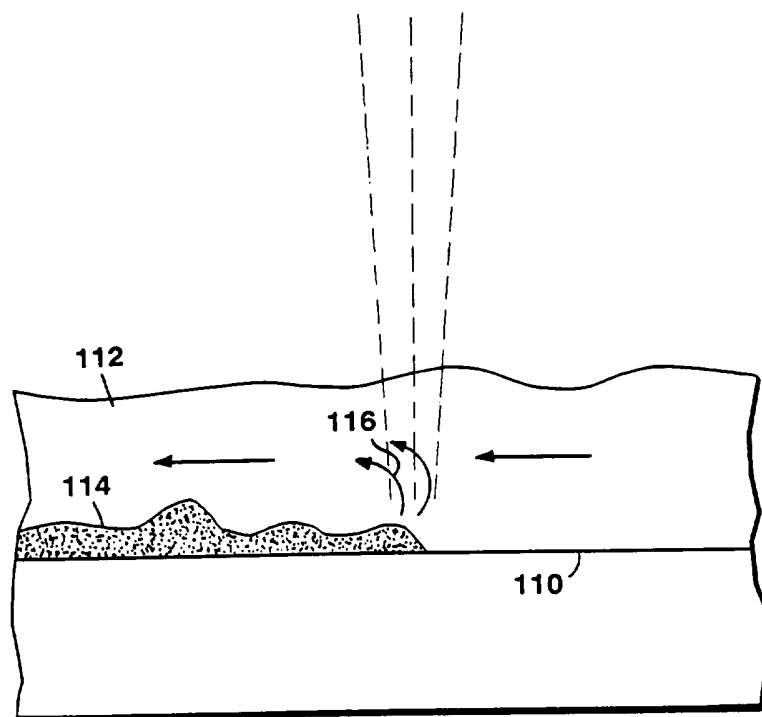


FIG. 11

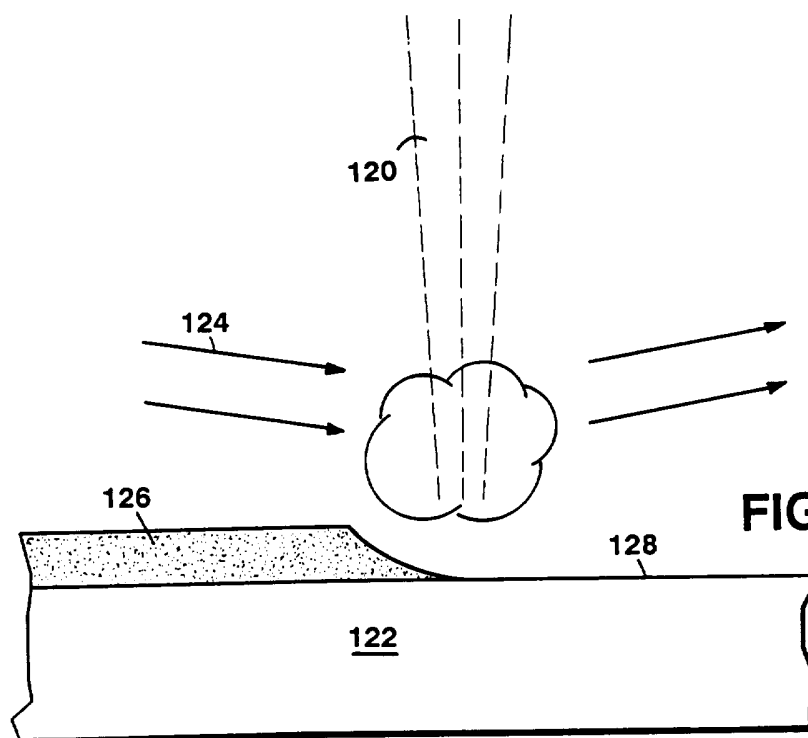


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/11002**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : Please See Extra Sheet.

US CL : 134/1, 1.1, 1.2, 1.3, 2, 26; 156/643, 646

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 134/1, 1.1, 1.2, 1.3, 2, 26; 156/643, 646

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	John R. Vig, "Ultraviolet - Ozone Cleaning of Semiconductor Surfaces", U.S. Army Electronics Technology and Devices Laboratory, JANUARY 1992, See pages 1, 9, 12-15, 19-23, 27-28 and the document in general.	1 - 3, 5 - 7, 21 - 22, 38-40
Y	US, A, 5,151,135 (MAGEE ET AL.) 29 SEPTEMBER 1992, See col. 4, lines 6-46, col. 4, line 65 - col. 5, line 57, col. 6, lines 17-37, Example 3, The abstract and claim 1.	10-12, 15, 23-24, 37
Y	US, A, 5,024,968 (ENGELSBERG) 18 JUNE 1991, See col. 4, line 39 - col. 5, line 29, table II, col. 6, lines 13-27 and Example 1.	10-12, 15, 23-24, 37



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"A"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

06 NOVEMBER 1995

Date of mailing of the international search report

12 DEC 1995

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/11002

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, 3,890,176 (BOLON) 17 JUNE 1975, See claims 1-6, the abstract and the document in general.	1-2, 5-7, 16
Y	US, A, 5,114,834 (NACHSHON) 19 MAY 1992, See cols. 2-3, col. 4, line 58 - col. 5, line 10, the abstract and the claims.	1-2, 5-7, 13-14, 36-37
Y	US, A, 5,151,134 (BOQUILLON ET AL.) 29 SEPTEMBER 1992, See the document in general.	1-2, 5-7, 13-14, 36-37
Y	US, A, 4,414,059 (BLUM ET AL.) 08 NOVEMBER 1983, See cols. 5, 6 and the claims.	1, 8-9, 17-20, 26-36, 41
Y	US, A, 4,508,749 (BRANNON ET AL.) 02 APRIL 1985, See col. 4, lines 15-66, col. 3, lines 3-50, col. 8 and the claims.	1, 8-9, 17-20, 26-36, 41
Y	US, A, 4,568,632 (BLUM ET AL.) 04 FEBRUARY 1986, See claims 1-21 and the document in general.	1, 8-9, 17-20, 26-36, 41
Y	US,A, 4,946,763 (SNAKENBORG) 07 AUGUST 1990, See the abstract and cols. 1, 2.	1, 8-9, 17-20, 26-36, 41

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/11002

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (6):

B08B 3/08, 3/10, 3/12, 7/00, 7/00, 7/02; B44C 1/22; C03C 15/00, 25/06