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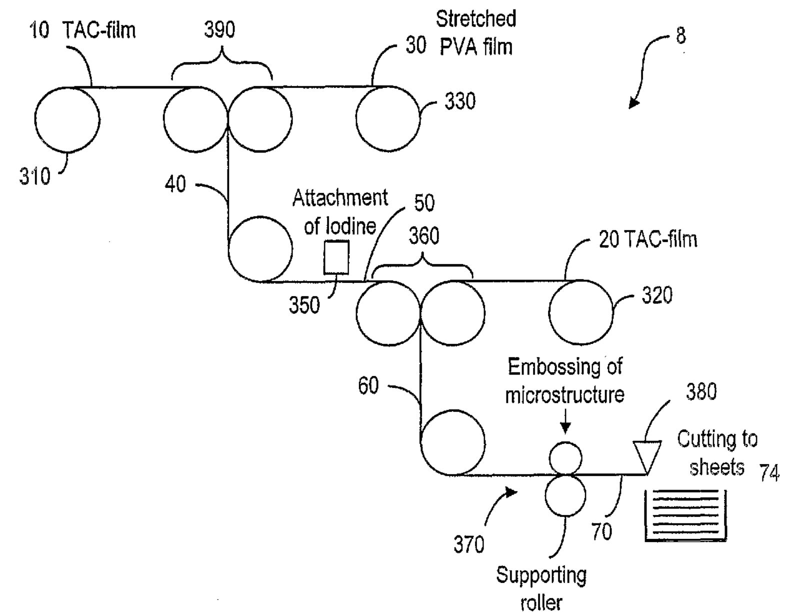
(54) Title: ANTI-REFLECTION STRUCTURE FOR MOBILE PHONE DISPLAY AND WINDOW



(57) Abstract: A method of producing an antireflection structure for use on a display or a window surface or both in an electronic device, such as a mobile phone. The display can be an LCD with a top polarizer and a bottom polarizer. The antireflection structure is imparted on the top polarizer by a roller embossing process. In particular, the embossing is carried out in the same manufacturing process when the polarizer is produced. The antireflection structure has a plurality of sub-wavelength periodic grooves. The antireflection structure on the window surface can be imparted using an embossing process or an injection molding process.

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ANTI-REFLECTION STRUCTURE FOR MOBILE PHONE DISPLAY AND WINDOW

Field of the Invention

The present invention relates generally to an antireflection structure imparted on a surface of a display or window and, in particular, to the antireflection structure used on a mobile phone.

Background of the Invention

When a mobile phone is used in a bright ambient light environment, the reflection of the ambient light from the display can be very disruptive, making the content of the display difficult to read. Reflection of ambient light can occur at a number of surfaces, especially at the dense-rare boundaries of an optical component. As shown in Figure 1, reflection can occur at a number of surfaces of the display and the window on top of the display. Incoming light beam L1 can reflect at the top and the bottom dense-air boundaries of the window. The reflected light from the first reflection at the top dense-rare boundary is denoted by R1. The reflected light from the second reflection at the bottom dense-rare boundary is denoted by R2. Similarly, light can also reflect from the top dense-rare boundary of the display, resulting in reflected light R3. It is advantageous and desirable to reduce or substantially eliminate the reflections.

Antireflection coatings are known in the art. Usually one or two thin films of coating material are coated on a substrate surface in a vacuum chamber to reduce the reflection by destructive interference. Antireflection coatings are generally expensive because of the cost involved in the vacuum evaporation process and the low yield of the coating. It is advantageous and desirable to provide a method of producing an antireflection surface that is cost-effective.

Sub-wavelength periodic structures have been used for antireflection purposes. A typical antireflection grating is shown in Figure 2. As shown in Figure 2, a surface structure **2** having a pitch P can be imparted on a substrate **5**. To be used as an antireflection structure, the pitch P of the surface structure **2** must be smaller than the wavelength of the ambient light. *Ophey et al.* (U.S. Patent No. 5,694,247, hereafter referred to as *Ophey*) discloses that a grating is imparted on optical components such as lenses and beam-splitters. In particular, *Ophey* discloses that in an optical transmissive device having an entrance surface and an exit surface for light transmission, the antireflection grating imparted on one surface is perpendicular to the antireflection grating imparted on another surface to avoid birefringent. *Ophey* discloses a molding technique combined with UV curing that is used to impart the grating on synthetic material layers comprised of poly-methyl methacrylate (PMMA) or polycarbonate (PC). *Gaylord et al.* (U.S. Patent No. 5,007,708, hereafter referred to as *Gaylord*) discloses a number of techniques for producing antireflection grating surfaces on dielectrics, semiconductors and metals. In particular, *Gaylord* discloses surface-relief grating being formed by reactive ion etching, electron beam lithography, or holography.

While the prior art techniques have many advantages for their intended applications, they may not be applicable or cost-effective when the antireflection structure is used on a display that requires one or more polarization components.

Summary of the Invention

It is a primary objective of the present invention to provide a cost-effective process for producing an optical structure on a display or window in an electronic device, such as a mobile phone, for reducing the boundary reflection on the top of the display or window or both. This objective can be achieved by using a roller embossing process to impart the optical structure directly onto an optical polarizer for use on a liquid-crystal display. This objective can also be partially achieved by using an injection molding process to impart the optical structure on a window.

Accordingly, the first aspect of the present invention provides a method of realizing a light reflection reduction structure on at least one surface of a display, wherein the display has at least one optical polarizing component disposed on top thereof, wherein the reflection reduction structure comprises a plurality of sub-wavelength periodic grooves, and wherein the polarizing component comprises an impressible film and a directional optical filter sheet. The method is characterized by

attaching the impressible film to the directional optical filter sheet for forming a laminated sheet, and by

imparting the periodic grooves on the impressible film.

Advantageously, the attaching of the impressible film to the filter sheet is carried out prior to or after the imparting of the periodic grooves.

Advantageously, the directional optical filter sheet has a first side and an opposing second side and the impressible film is attached to the first side of the filter sheet. The method is further characterized by

attaching a further film to the filter sheet on the second side thereof.

Preferably, the directional optical filter sheet comprises a stretched film. The method is further characterized by

applying iodine molecules onto the stretched film for affecting optical polarization.

Advantageously, the display comprises a liquid-crystal display and the display has a first side facing a user and an opposing second side, wherein the optical polarizing component is disposed on the first side.

Preferably, the imparting step is carried out using an embossing process using an embossing roller.

The second aspect of the present invention provides an optical component for use in an optical device. The optical component is characterized by:

a directional optical filter sheet, and by

an impressible film, wherein the impressible film has a first side and an opposing second side attached to the directional optical filter sheet, and the first side of the impressive film includes a sub-wavelength periodic structure embossed thereon for reducing light reflection from the first side of the impressive film.

Advantageously, the optical device comprises a liquid-crystal display.

The third aspect of the present invention provides a mobile terminal, which comprises:

means for communicating with a network component in a communications network,

a display for displaying information,

a surface having a microstructure positioned relative to the display for reducing light reflection, and

at least one optical polarizing component disposed between the surface and the display, wherein the microstructure comprises a plurality of sub-wavelength grooves.

The surface can be spaced from the optical polarizing component and can be used as a window, but the surface can also be attached to the optical polarizing component as part of the display. The sub-wavelength grooves on the window can be imparted by a roller embossing process or an injection molding process.

The present invention will become apparent upon reading the description taken in conjunction with Figures 3 to 6.

Brief Description of the Drawings

Figure 1 is a schematic representation illustrating the reflections of ambient light from a number surfaces of an optical device.

Figure 2 is a schematic representation illustrating an antireflection surface structure, which is a grating with sub-wavelength periodic grooves.

Figure 3 is a schematic representation illustrating a mobile phone having a display.

Figure 4 is a schematic representation illustrating a typical liquid-crystal display (LCD).

Figure 5a is a schematic representation illustrating the preferred method of producing a polarizer sheet with an antireflection surface structure, according to the present invention.

Figure 5b is a schematic representation illustrating a different embodiment of the present invention.

Figure 5c is a schematic representation illustrating another embodiment of the present invention.

Figure 5d is a schematic representation illustrating yet another embodiment of the present invention.

Figure 6 is a schematic representation illustrating the details of the embossing process, according to the present invention.

Best Mode to Carry Out the Invention

A mobile phone **100**, as shown in Figure 3, has an antenna for communicating with another network component in a communications network, a display **120** for displaying information, and a window **110** on top of the display **120** for protecting the display **120** or for decorative purposes. It is desirable to impart an antireflection structure, such as that shown in Figure 2, on both the top and the bottom dense-rare boundaries (see Figure 1) of the window **110**. The antireflection structure on the window can be imparted by an embossing process or an injection molding process. Furthermore, it is desirable to impart a similar antireflection structure on top of the display **120**, as shown in Figure 4. In particular, if the display is a liquid-crystal display (LCD) or the like, it is preferable to impart an antireflection structure on the top surface of the display. As shown in Figure 4, the display **120** comprises a liquid crystal cell **90**. Typically the liquid crystal cell comprises an upper plate **92** and a lower plate **94** forming a gap therebetween to accommodate a layer of liquid crystal material **96**. The liquid crystal cell **90** is placed between two polarizers **70**, **72**. LCDs are known in the art and are not part of the invention. According to the present invention, an antireflection structure **80** is provided on top of the LCD **120** in order to reduce the reflections of ambient light from the top the LCD. In particular, the antireflection structure **80** is imparted on the top surface of the top polarizer **70**. Typically, the polarizer **70** (or **72**) comprises a stretched polymer film **50** attached with iodine. The polymer film **50** can be made of polyvinyl alcohol (PVA), for example. The stretched polymer film **50** attached with iodine is used as a directional optical filter to produce linearly polarized light from natural unpolarized light. This filter is laminated between two polymer sheets or films **10, 20**, for example. The polymer films **10, 20** can be made of triacetyl cellulose (TAC), for example. According to the present invention, the antireflection structure **80** can be directly imparted on the top TAC film **20**.

It is preferred that the antireflection structure **80** is imparted on the TAC film **20** when the polarizer **70** is produced, as shown in Figures 5A - 5D. As shown in Figure 5A, the TAC film **10** is provided in a roll **310** and the mechanically stretched PVA film **30** is provided in a roll **330**. Through a pair of laminating rollers **390**, the TAC and the stretched PVA film **30** are laminated together into a laminated film **40**. An iodine attachment apparatus **350** is then used to attach iodine molecules onto the stretched PVA film. The stretched PVA film with iodine attached is denoted by reference numeral **50**. The TAC film **20** is also provided in a roll **320**. Through a pair of laminating rollers **360**, the iodine-attached film **50**, and the TAC film **20** are laminated into a polarizer sheet **60**. As the laminated sheet **60** passes through an embossing station **370**, the PVA film **20** side of the laminated sheet **60** is embossed with the antireflection structure **80**, preferably using a hot-embossing process. It is preferred that the embossed, laminated sheet **70** in a roll form is cut by a cutter **380** into cut sheets **74**. In general, the width of the material rolls **310, 320** and **330** is much wider than the dimension of a typical display on the mobile phone. For example, the width of the rolls can be about 1 meter (approximately 3 feet), and the cut sheets can be 1 meter by 1 meter, for example. The producing method, as shown in Figure 5A, is referred to as a roll-to-roll process **8**. This process is suitable for large volume production and is, therefore, cost effective.

In the preferred fabricating process, as shown in Figure 5A, the embossing step is carried out after the iodine-attached stretched film is laminated with two protective TAC films **10**, **20**. However, the embossing step can be carried out differently. For example, the embossing of the top film can be carried out on the film itself prior to lamination. As shown in Figure 5B, the TAC film **20** is first embossed with the antireflection structure **80**. The embossed TAC film **22** is then laminated with the stretched PVA film **30** into an embossed, laminated film **42** before iodine is attached on the stretched PVA film **30**. The embossed, laminated film with iodine attached is denoted by reference number **52**. The embossed film **52** is further laminated with the bottom TAC film **10**.

Alternatively, the embossing step is carried out after the top TAC film **20** and the stretched PVA film **30** are laminated into a laminated film **44**. However, the embossing step is carried out before the iodine attachment process. As shown in Figure 5C, the laminated film **44** is embossed into an embossed, laminated film **46** before it is attached with iodine. The iodine- attached film is denoted by reference number **48**. The laminated film **48** and the bottom TAC film **10** are then lamination into the polarizer sheet **70**.

Another variation of the roll-to-roll process **8** of Figure 5A is shown in Figure 5D. As shown, the top TAC film **20** is embossed prior to the film **20** being laminated with the iodine-attached PVA film **50** and the lower TAC film **10** to become the polarizer sheet **70**.

Figure 6 is a schematic representation illustrating the embossing station **370**. As shown, the embossing station comprises mainly an embossing roller **372** and a supporting roller **374**. On the surface of the embossing roller **372**, a pattern is provided for embossing the antireflection structure **80**. Typically, the pattern is made on a substrate by holographic lithography or electron-beam lithography and etched into a surface-relief structure. An electroforming process is then employed to generate a nickel plate (the so-called mother shim). Using the same electroforming process, this original nickel plate can be used to make the surface of the embossing roller **372**. Using such an embossing roller to impart an antireflection structure directly on a polarizer during the same manufacturing process is advantageous in terms of manufacturing cost and product consistency. In particular, the roller embossing process for producing an antireflection structure is continuous and repeatable. Other methods for producing an antireflection surface, such as vacuum deposition or evaporation, reactive ion etching and electron beam lithography, are not continuous and repeatable.

As shown in Figure 4, the antireflection structure **80** is imparted only on one side of the top polarizer **70**. However, it is also possible to impart a similar antireflection structure **80** on the other side of the top polarizer **70**. Furthermore, it is also possible to have one or two additional antireflection structures **80** imparted on the window **110** (Figure 3). Preferably, the antireflection structure **80** has a pitch in the range of 150-400nm, and the depth of the structure is in the range of 75-2000nm. The preferred grating profile, as shown in Figure 2, is binary. However, the profile can be triangular or sinusoidal or another periodic form.

Although the invention has been described with respect to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the scope of this invention.

What is claimed is:

1. A method of realizing a light reflection reduction structure on at least one surface of a display, wherein the display has at least one optical polarizing component disposed thereon and the reflection reduction structure comprises a plurality of sub-wavelength periodic grooves, and wherein the polarizing component comprises an impressible film and a directional optical filter sheet, said method characterized by

attaching the impressible film to the directional optical filter sheet for forming a laminated sheet, and by

imparting the periodic grooves on the impressible film.

2. The method of claim 1, characterized in that the attaching of the impressible film to the filter sheet is carried out prior to the imparting of the periodic grooves.

3. The method of claim 1, characterized in that the imparting of the periodic grooves is carried out prior to the attaching of the impressible film to the filter sheet.

4. The method of claim 1, characterized in that the directional optical filter sheet has a first side and an opposing second side, wherein the impressible film is attached to the first side of the filter sheet, said method further characterized by

attaching a further film to the filter sheet on the second side thereof.

5. The method of claim 1, characterized in that the directional optical filter sheet comprises a stretched film, said method further characterized by

applying iodine molecules onto the stretched film for affecting optical polarization.

6. The method of claim 1, characterized in that the display comprises a liquid-crystal display.

7. The method of claim 6, characterized in that the display has a first side facing a user and an opposing second side, and that the optical polarizing component is disposed on the first side.

8. The method of claim 7, characterized in that the display further has a further optical polarizing component disposed on the second side of the display.

9. The method of claim 1, characterized in that the imparting step is carried out using an embossing process.

10. The method of claim 9, characterized in that the imparting of the periodic grooves on the impressible film is carried out using a roller having a surface with a pattern for imparting the periodic grooves.

11. An optical component for use in an optical device, characterized by:

a directional optical filter sheet, and by

an impressible film, wherein the impressible film has a first side and an opposing second side attached to the directional optical filter sheet, and the first side of the impressive film includes a sub-wavelength period structure embossed thereon for reducing light reflection from the first side of the impressive film.

12. The optical component of claim 11, characterized in that the optical device comprises a display.

13. The optical component of claim 12, characterized in that the optical device comprises a liquid-crystal display.

14. A mobile terminal characterized by:

means for communicating with a network component in a communications network,

a display for displaying information,

a surface having a microstructure positioned relative to the display for reducing light reflection, and

at least one optical polarizing component disposed between the surface and the display, wherein the microstructure comprises a plurality of sub-wavelength grooves.

15. The mobile terminal of claim 14, characterized in that the surface is spaced from the optical polarizing component.

16. The mobile terminal of claim 14, characterized in that the surface is attached to the optical polarizing component.

17. The mobile terminal of claim 16, characterized in that optical polarizing component comprises a direction optical filter sheet and the surface comprises an impressible film imparted with the sub-wavelength grooves.

18. The mobile terminal of claim 14, characterized in that the sub-wavelength grooves are imparted on the surface by a roller embossing process.

19. The mobile terminal of claim 15, characterized in that the sub-wavelength grooves are imparted on the surface by an injection molding process.

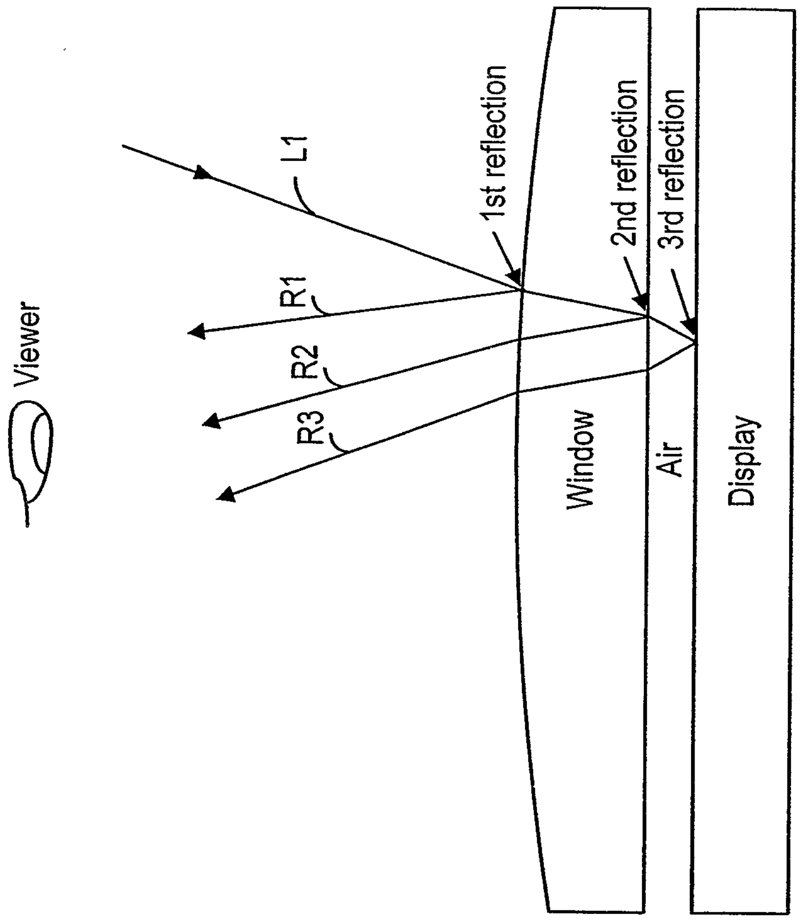
Viewer
L1
R1
R2
R3
1st reflection
2nd reflection
3rd reflection
Window
Air
Display

FIG. 1

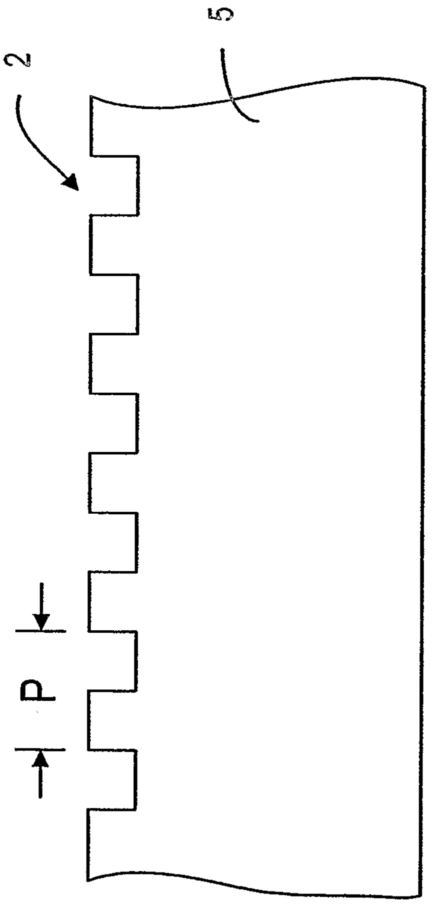

FIG. 2

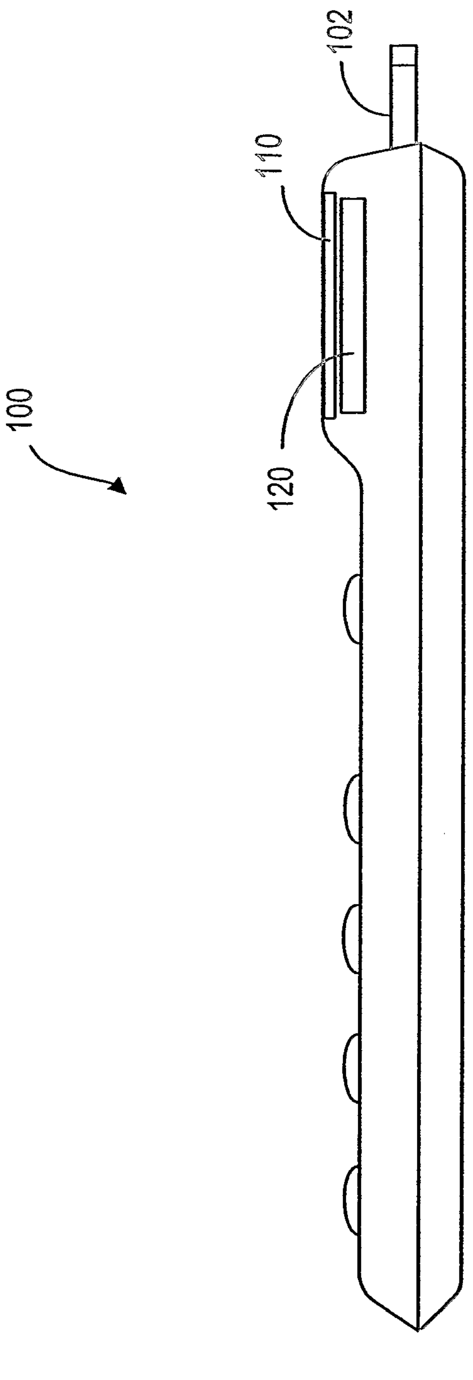

FIG. 3

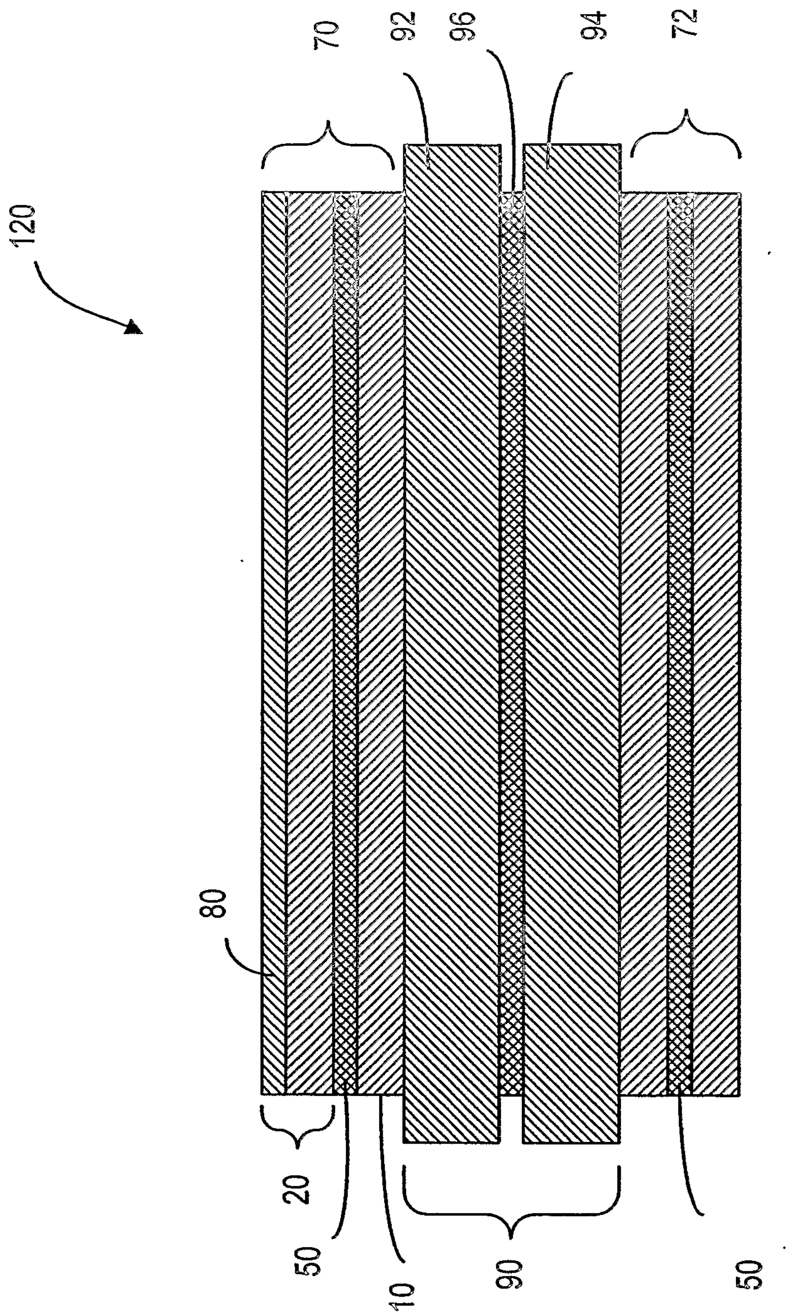

FIG. 4

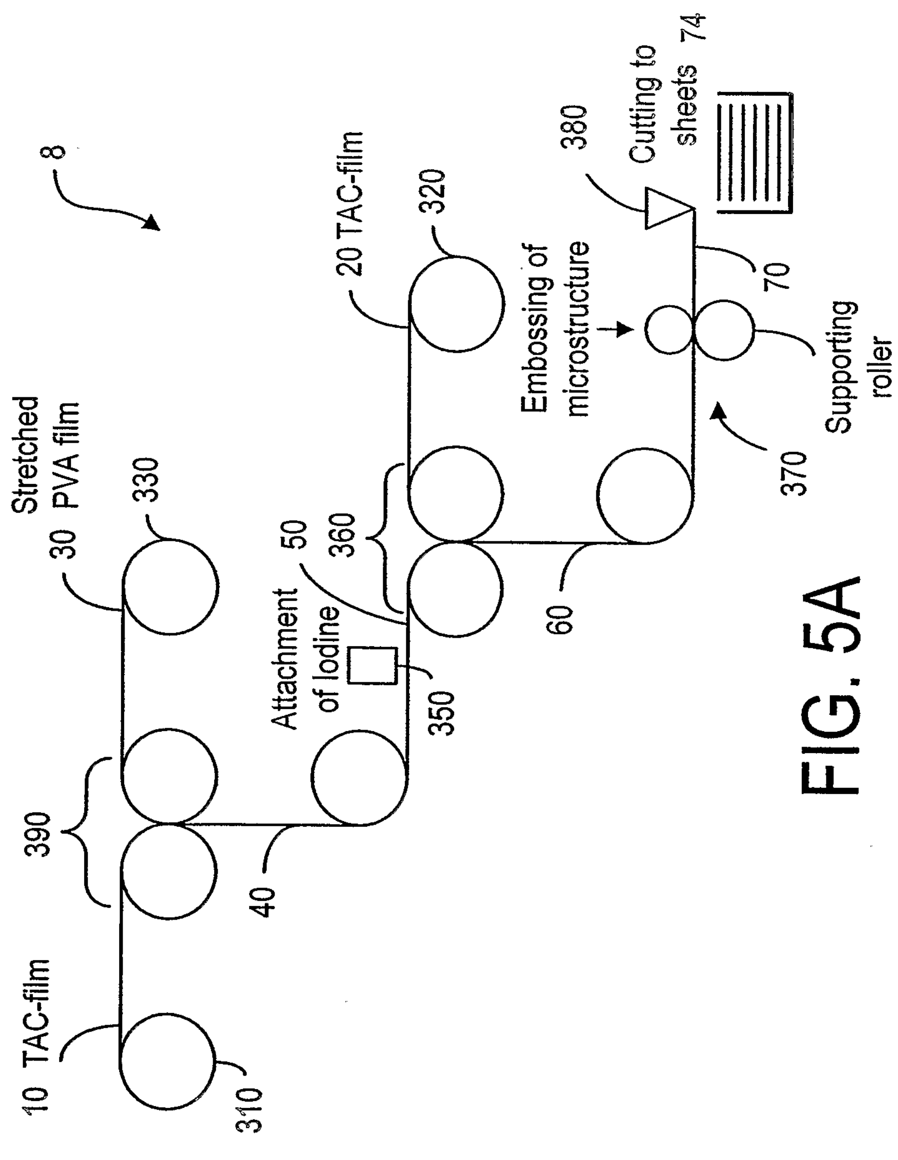
8
10 TAC-film
310
390
40
Stretched PVA film
30
330
Attachment of Iodine
350
50
360
60
20 TAC-film
320
Embossing of microstructure
Supporting roller
370
70
380
Cutting to sheets
74

FIG. 5A

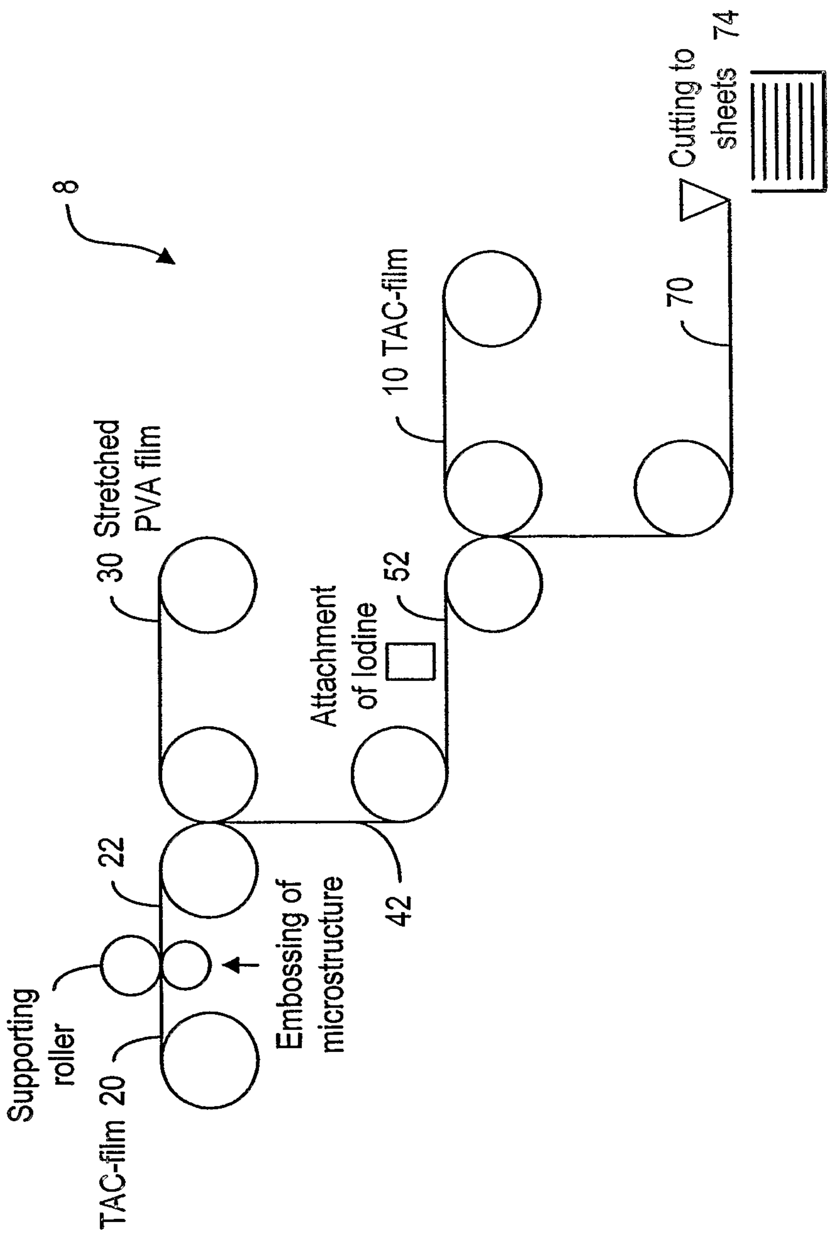
8
Supporting roller
TAC-film 20
22
Embossing of microstructure
42
30 Stretched PVA film
Attachment of Iodine
52
10 TAC-film
70
Cutting to sheets
74

FIG. 5B

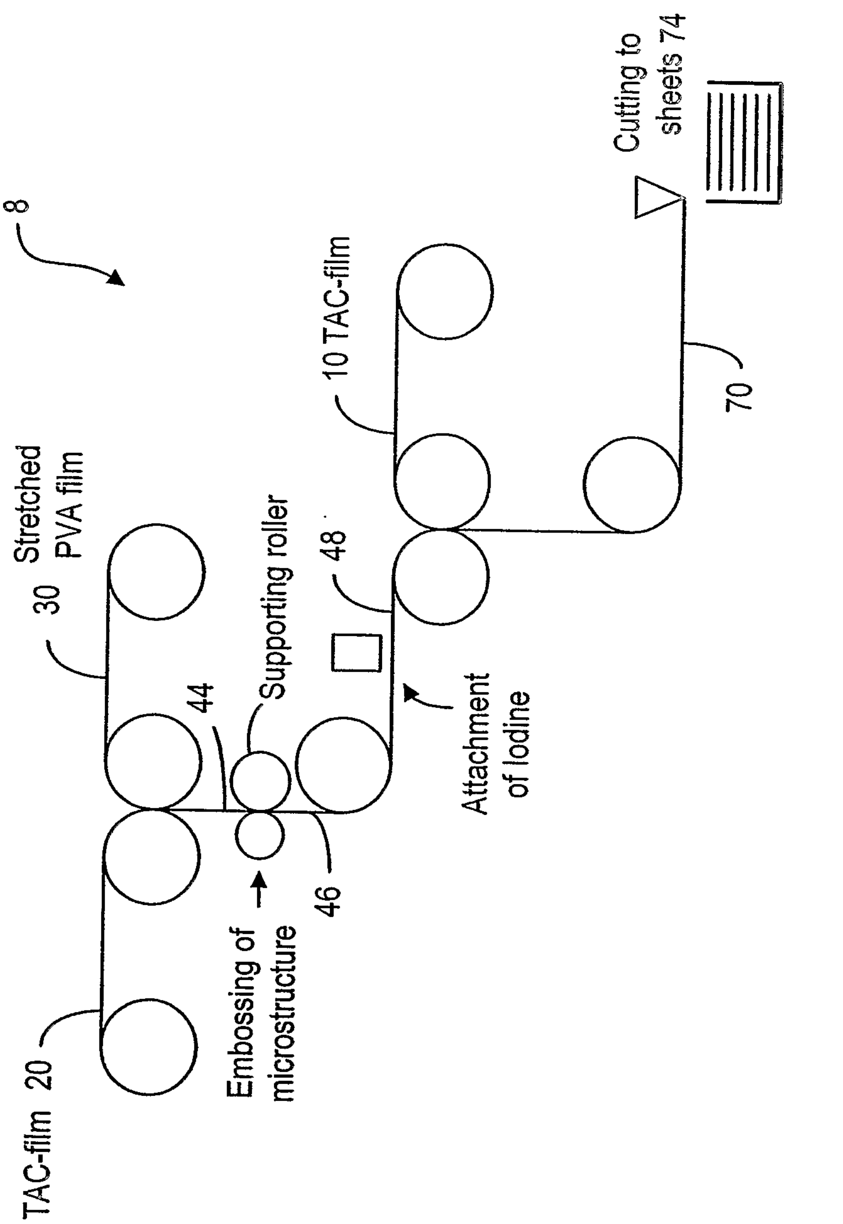
8
TAC-film 20
Stretched PVA film
30
Embossing of microstructure
44
46
Supporting roller
48
Attachment of Iodine
10 TAC-film
70
Cutting to sheets 74

FIG. 5C

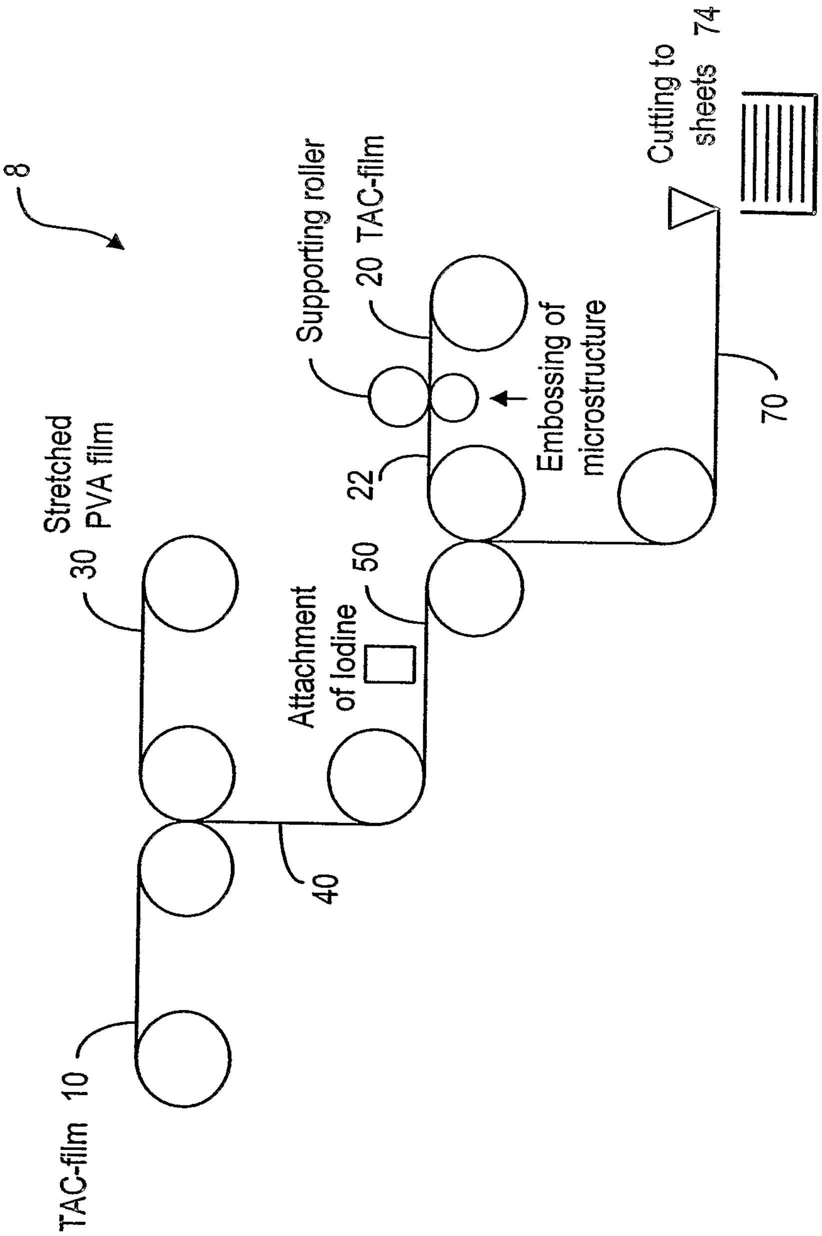
8
TAC-film 10
30
Stretched PVA film
40
Attachment of Iodine
50
22
Supporting roller
20 TAC-film
Embossing of microstructure
70
Cutting to sheets
74

FIG. 5D

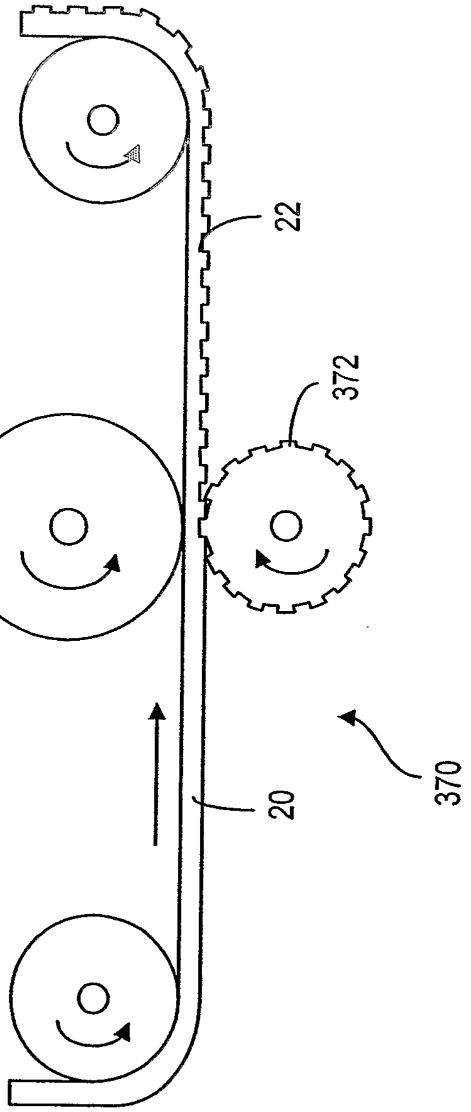

FIG. 6