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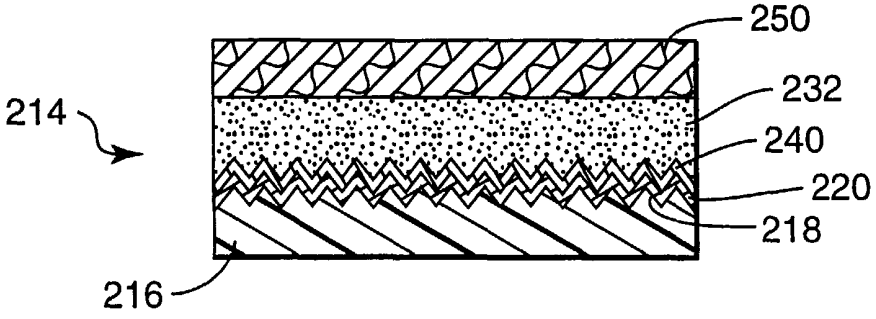
(54) Title: HOLOGRAPHIC REFLECTOR




(57) Abstract: A holographic reflector including a substrate with a holographic pattern thereon and a coating on the holographic pattern, wherein the coating includes at least one layer of a dielectric material.

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# Holographic Reflector

## TECHNICAL FIELD

This invention relates to holographic reflectors for display devices.

## BACKGROUND

Fig. 1 shows a display device 10 with a screen 12 and a brightness enhancing holographic reflector 14. The holographic reflector includes a substrate 16 embossed on a surface with a holographic interference pattern 18. The holographic interference pattern 18 is coated with a metallic layer 20 to enhance efficiency and transform the transmission hologram into a hologram that may be viewed by reflection. In operation, ambient light 22 enters the display screen 12 and is diffusely reflected from the metallic layer 20 and steered into an achromatic viewing zone 24 determined by the holographic interference pattern 18. The holographic reflector 14 decouples the peak brightness of the display background from the glare off the front surface 13 of the screen 12 and provides to an observer 26 enhanced and more uniform display brightness, more defined display characters, and a more uniform white display background compared to a display with a conventional, non-holographic metallic reflector.

Referring to Fig. 2, a typical liquid crystal display (LCD) 110 is shown that includes a backlight 130 and a holographic reflector 114. The holographic reflector 114 includes a substrate 116 embossed on a surface with a holographic interference pattern 118. The interference pattern 118 is coated with a metallic layer 120. The metallic layer 120 is in contact with an adhesive layer 132. The adhesive layer 132 is attached to a conventional LCD apparatus including a back polarizer 134, a front polarizer 136, and a liquid crystal assembly 138.

Careful design of the holographic interference pattern 118 and very thinly deposited metallic layers 120 provide a reasonably acceptable compromise between good reflectance and transmittance in the holographic reflector 114. If the metallic layer 120 is made thicker, reflectance is enhanced, but the reflector 114 becomes more opaque and cannot effectively transmit light emitted by the backlight 130.

## SUMMARY

To create a bright, sharp and easily viewed display, the holographic reflector must be highly reflective to control glare in bright ambient light and highly transmissive to light emitted from the backlight to provide enhanced brightness in low ambient light.

In one aspect, the invention is a holographic reflector including a substrate with a holographic pattern thereon; and a coating on the holographic pattern. The coating includes at least one layer of a dielectric material.

In another aspect, the invention is a display device including a display unit, a backlight, and a holographic reflector between the display and the backlight. The holographic reflector includes a substrate with a holographic pattern thereon; and a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

In yet another aspect, the invention is a method for providing a colored display in a display device with a display unit and a backlight, including providing between the display and the backlight a holographic reflector. The holographic reflector includes a substrate with a holographic pattern thereon; and a coating on the holographic pattern, wherein the coating includes at least one layer of a dielectric material.

In another aspect, the invention is an electronic device including a display, wherein the display has a display unit, a backlight; and a holographic reflector between the display and the backlight. The holographic reflector includes a substrate with a holographic pattern thereon; and a coating on the holographic pattern, wherein the coating includes at least one layer of a dielectric material.

In another aspect the invention is a method for increasing the brightness of a display device with a display unit and a backlight, including providing between the display and the backlight a holographic reflector. The holographic reflector includes a substrate with a holographic pattern thereon; and a coating on the holographic pattern, wherein the coating includes at least one layer of a dielectric material.

In another aspect the invention is a method of enhancing the transmittance of a holographic reflector including a substrate with a holographic pattern thereon and a metallic coating on the holographic pattern. The method includes replacing at least a

portion of the metallic coating with a dielectric coating including at least one layer of a dielectric material.

The invention provides the following advantages compared to conventional holographic reflectors with a metallic reflective layer: enhanced control of display color, and increased backlight transmission.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

## DESCRIPTION OF DRAWINGS

Fig 1 is a schematic cross sectional view of a holographic reflector in a display device.

Fig. 2 is a schematic cross sectional view of a holographic reflector in a liquid crystal display (LCD) device.

Fig. 3 is a schematic cross sectional view of a holographic reflector with metallic and dielectric layers.

Fig. 4 is a schematic cross sectional view of a polarized holographic reflector with a dielectric layer.

Fig. 5 is a schematic cross sectional view of a holographic reflector with a multi-layer dielectric coating.

Fig. 6 is a schematic cross sectional view of a holographic reflector with an anti-reflective layer in a liquid crystal display (LCD) device.

Like reference symbols in the various drawings indicate like elements.

## DETAILED DESCRIPTION

Referring to Fig. 3, a holographic reflector 214 is shown that includes a substrate 216 having a surface or surface layer embossed with a holographic interference pattern 218. Holographic reflectors and methods for their manufacture are described in, for example, U.S. Patent No. 5,659,408. Typically, to make a holographic reflector, an UV or solvent curable embossable polymeric coating layer (not shown in Fig. 3) is applied on a substrate and subsequently embossed with a holographic pattern. The embossable coating

may also include a metallic layer, or, the metallic layer may be applied after the embossing step.

Any known embossing procedure may be used to create the interference pattern 218 in the embossable layer on a surface of the substrate 216, such as, for example, mechanical embossing with a tool, laser etching, and the like. The holographic interference pattern 218 may include two-dimensional or three-dimensional images that may be used for graphic design, identification or serialization, or the prevention of counterfeiting.

The materials used for the substrate 216 may vary widely depending on the intended application, and any material with sufficient structural integrity to substantially maintain its shape during and after embossing procedures may be used. Typically, the substrate 216 is a polymeric material, and may or may not be birefringent. A polymeric film such as, for example, polyethylene terepthalate (PET), has been found to work well in LCD applications. The thickness of the substrate 216 is typically about 0.050 mm.

A metallic layer 220 is coated on the interference pattern 218 in the substrate 216, or may be applied to the embossable layer on the substrate prior to the embossing step. The metallic layer may be made of any highly reflective metal, such as, for example, silver, gold, aluminum and the like. Aluminum is generally preferred on the basis of its high reflectivity and low cost. The metallic layer may be deposited using any known thin film deposition process, such as, for example, sputtering, vapor deposition, chemical vapor deposition, or electroplating.

A dielectric layer 240 is deposited on the metallic layer 220. The dielectric layer 240 may be any material with a refractive index of about 2 to about 4, but, typically, the dielectric layer 240 is a high refractive index oxide such as $TiO_2$, $MnO_2$, $ZnO_2$ and mixtures and combinations thereof. The dielectric layer 240 typically has a thickness of about 600 Å to about 1200 Å. The material in the dielectric layer may be deposited using any known thin film deposition process. The dielectric layer 240 allows the metallic layer 220 to be made thinner, which maintains or even increases the reflectance of the holographic reflector 214, while enhancing the transmittance of the reflector 214 to light from the display backlight.

The holographic reflector 214 may also include an optional adhesive layer 232 for attachment of the reflector 214 to a LCD display apparatus (not shown in Fig. 3). The

adhesive used in the adhesive layer 232 may vary widely depending on the intended application, but a pressure sensitive adhesive is typically used. An optional removable release liner 250 may be provided to protect the adhesive layer 232.

Referring to Fig. 4, a holographic reflector 314 is shown that includes a substrate 316 having a surface embossed with a holographic interference pattern 318. The embossed pattern 318 has deposited thereon a layer of a dielectric material 340. The dielectric layer 340 is typically a high refractive index oxide such as $TiO_2$, $MnO_2$, $ZnO_2$ and mixtures and combinations thereof. The material in the dielectric layer may be deposited using any known thin film deposition process. The dielectric layer 340 maintains or even increases the reflectance of the holographic reflector 314, while enhancing the transmittance of the reflector 314 to light from the display backlight by as much as about 60%.

The holographic reflector 314 includes an adhesive layer 332, preferably a pressure sensitive adhesive layer, for attachment of the reflector 314 to an optional polarizer 360. The polarizer may include an optional hard polymeric coating (not shown in Fig. 4) on either or both sides. A second adhesive layer 370 may be used to adhere the reflector 314 to an LCD display apparatus (not shown in Fig. 4), and an optional removable release liner 350 may be provided to protect the adhesive layer 370. An optional anti-static layer 380 may be adhered to the substrate 316.

Referring to Fig. 5, a holographic reflector 414 is shown that includes a substrate 416 having a surface embossed with a holographic interference pattern 418. The embossed pattern 418 has deposited thereon a multi-layer dielectric coating 444. The coating 444 includes a first layer of a dielectric material 440. Deposited on the first dielectric layer 440 is a second dielectric layer 442. The dielectric layers 440 and 442 are high refractive index oxide such as $TiO_2$, $MnO_2$, $ZnO_2$ and mixtures and combinations thereof. The thicknesses and the refractive indices of the dielectric layers 440 and 442 may be varied to achieve a particular color or range of colors in reflection. In transmission mode, the reflector 414 maintains high transmission efficiency due to the transparent nature of the coating 444, while the design of the coating 444 transmits an emission spectrum of the backlight to attain a specific color when the backlight is activated. Manipulation of the thicknesses and the refractive indices of the layers 440 and 442 cause a specific desired color or colors to appear to the display observer.

The reflector 414 may further include an optional adhesive layer 432 to adhere the reflector 414 to an LCD display apparatus (not shown in Fig. 5). An optional removable release liner 450 may be provided to protect the adhesive layer 432. The reflector 414 may also optionally include a metallic layer (not shown in Fig. 5) above, below or between the dielectric layers 440 and 442.

Referring to Fig. 6, a LCD display device 510 is shown that includes a holographic reflector 514. The reflector 514 includes a substrate 516 having a surface embossed with a holographic interference pattern 518. The embossed pattern 518 has deposited thereon at least one layer of a dielectric material 540. On a surface of the substrate 516 opposite the interference pattern 518 an anti-reflection layer 590 is applied. The anti-reflection layer, typically a polymeric film such as, for example, polyethylene, increases the transmission of the reflector 514 by reducing the amount of reflected light. If a polyethylene anti-reflection layer 590 is used in a LCD, an increase in transmission of about 4% has been observed from the reduction of reflected light at the air interface between the anti-reflection layer 590 and the backlight 530.

The anti-reflection layer may be applied to any of the embodiments of the invention discussed above.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, the embodiments above reference embossed holograms, but volume transmission holograms may also be used. Accordingly, other embodiments are within the scope of the following claims.

**WHAT IS CLAIMED IS:**

1. A holographic reflector comprising:

a substrate with a holographic pattern thereon; and

a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

2. The reflector of claim 1, wherein the coating further comprises a metallic layer.

3. The reflector of claim 1, further comprising an adhesive layer on the coating.

4. The reflector of claim 3, further comprising a removable release liner on the adhesive.

5. The reflector of claim 3, further comprising a polarizer on the adhesive layer.

6. The reflector of claim 5, wherein the polarizer further comprises at least one hard coat layer.

7. The reflector of claim 5, further comprising a second adhesive layer on the polarizer.

8. The reflector of claim 7, further comprising a removable release liner on the second adhesive layer.

9. The reflector of claim 1, further comprising an anti-static layer on a side of the substrate opposite the holographic pattern.

10. The reflector of claim 1, wherein the substrate is a polymeric material.

11. The reflector of claim 10, wherein the polymeric material is PET.

12. The reflector of claim 1, wherein the coating comprises oxides selected from the group consisting of $TiO_2$, $MnO_2$ and $ZnO_2$ and mixtures thereof.

13. The reflector of claim 12, wherein the oxide is $TiO_2$.

14. The reflector of claim 2, wherein the metallic layer comprises aluminum.

15. The reflector of claim 1, wherein the coating comprises a single dielectric layer.

16. A display device comprising:

a display unit;

a backlight; and

a holographic reflector between the display and the backlight, the holographic reflector comprising:

a substrate with a holographic pattern thereon; and

a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

17. The display device of claim 16, wherein the coating further comprises a metallic layer.

18. The display device of claim 16, further comprising an anti-reflective layer on a surface of the substrate opposite the holographic pattern and adjacent to the backlight.

19. The display device of claim 16, wherein the coating comprises a plurality of dielectric layers, and said dielectric layers are selected to provide a predetermined color to an observer of the display.

20. The display device of claim 16, wherein the dielectric materials in the coating are selected to transmit an emission spectrum of the backlight.

21. The display device of claim 16, further comprising a polarizer on at least one surface of the display unit.

22. A method for providing a colored display in a display device comprising a display unit and a backlight, comprising providing between the display and the backlight a holographic reflector, the holographic reflector comprising:

a substrate with a holographic pattern thereon; and

a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

23. The display device of claim 22, wherein the coating further comprises a metallic layer.

24. The display device of claim 22, further comprising an anti-reflective layer on a surface of the substrate opposite the holographic pattern and adjacent to the backlight.

25. The display device of claim 22, wherein the coating comprises a plurality of dielectric layers, and said dielectric layers are selected to provide a predetermined color to an observer of the display.

26. The display device of claim 22, wherein the dielectric materials in the coating are selected to transmit an emission spectrum of the backlight.

27. An electronic device comprising a display, wherein the display comprises:

a display unit;

a backlight; and

a holographic reflector between the display and the backlight, the holographic reflector comprising:

a substrate with a holographic pattern thereon; and

a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

28. The electronic device of claim 27, wherein the coating further comprises a metallic layer.

29. The electronic device of claim 27, further comprising an anti-reflective layer on a surface of the substrate opposite the holographic pattern and adjacent the backlight.

30. The electronic device of claim 27, wherein the coating comprises a plurality of dielectric layers, and said dielectric layers are selected to provide a predetermined color to an observer of the display.

31. The electronic device of claim 27, wherein the dielectric materials in the coating are selected to transmit an emission spectrum of the backlight.

32. The electronic device of claim 27, further comprising a polarizer on at least one surface of the display unit.

33. A method for increasing the brightness of a display device comprising a display unit and a backlight, comprising:

providing between the display and the backlight a holographic reflector, the holographic reflector comprising:

a substrate with a holographic pattern thereon; and

a coating on the holographic pattern, wherein the coating comprises at least one layer of a dielectric material.

34. The method of claim 33, wherein the coating further comprises a metallic layer.

35. The method of claim 33, further comprising an anti-reflective layer on a surface of the substrate opposite the holographic pattern and adjacent the backlight.

36. The method of claim 33, wherein the coating comprises a plurality of dielectric layers, and said dielectric layers are selected to provide a predetermined color to an observer of the display.

37. The method of claim 33, wherein the dielectric materials in the coating are selected to transmit an emission spectrum of the backlight.

38. A method of enhancing the transmittance of a holographic reflector comprising a substrate with a holographic pattern thereon and a metallic coating on the holographic pattern, the method comprising:

replacing at least a portion of the metallic coating with a dielectric coating comprising at least one layer of a dielectric material.

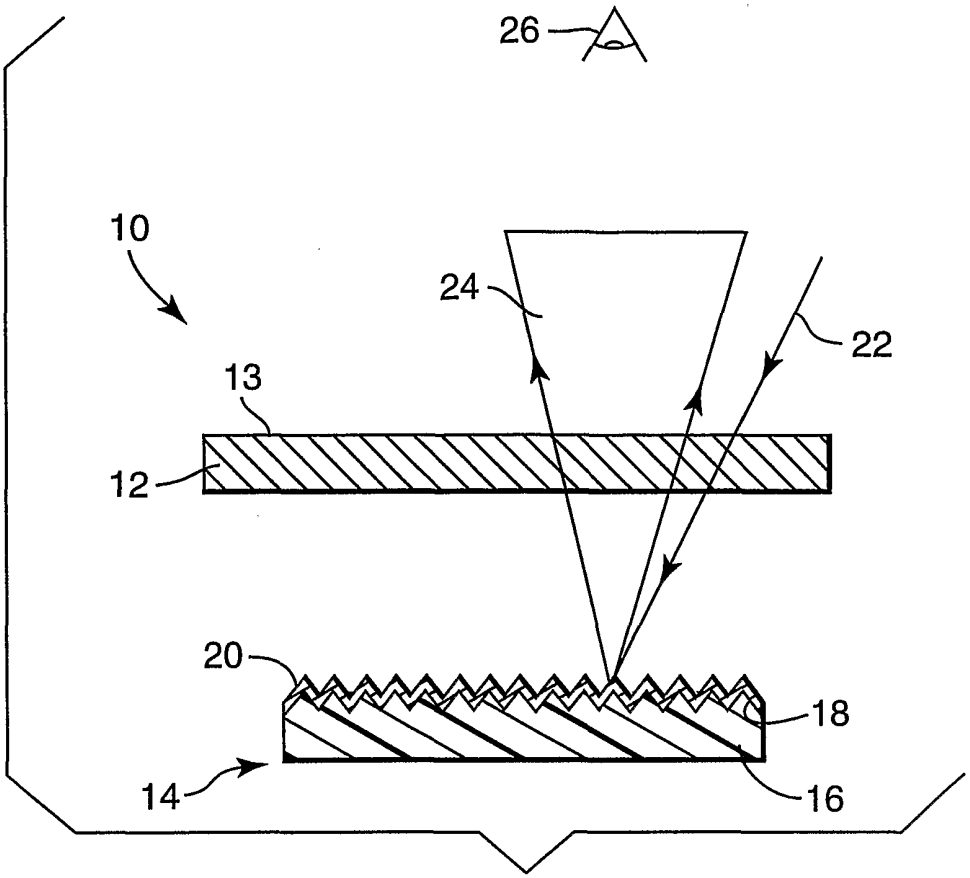



FIG. 1

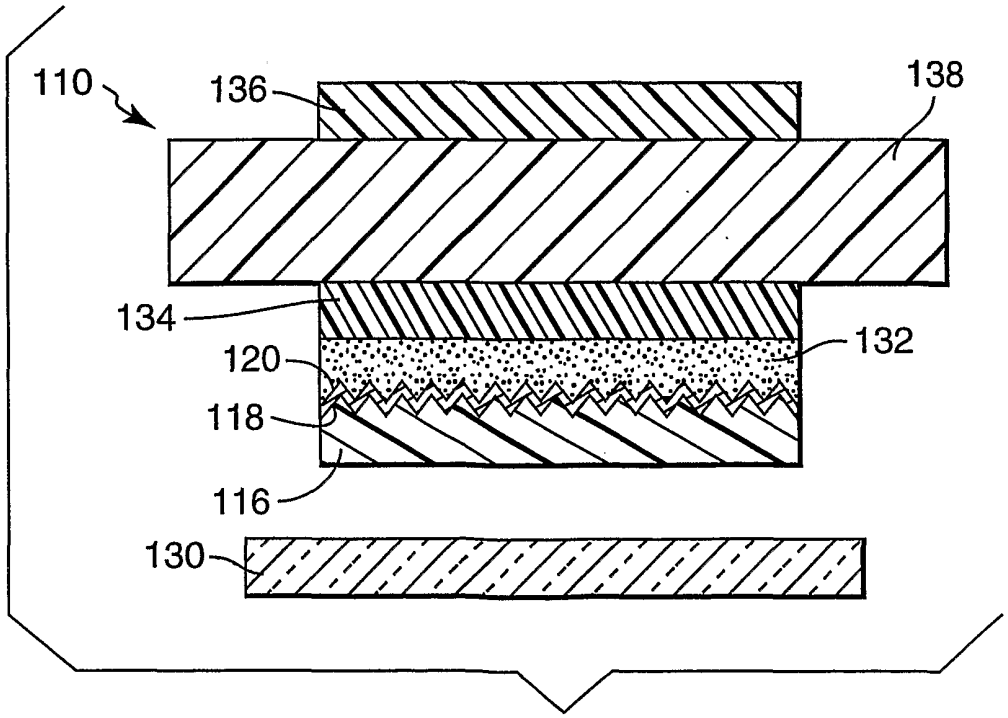
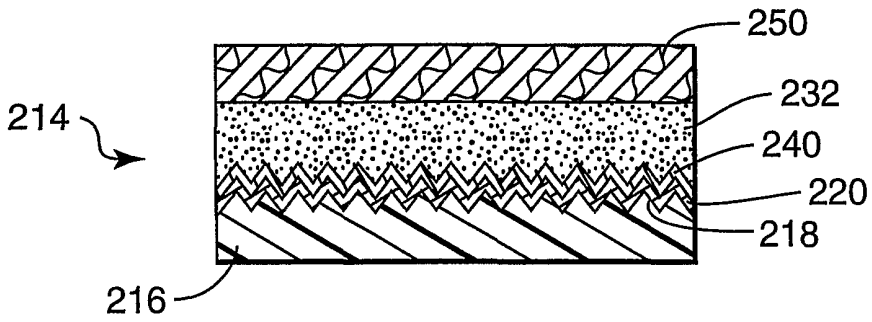



FIG. 2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218
216

FIG. 3

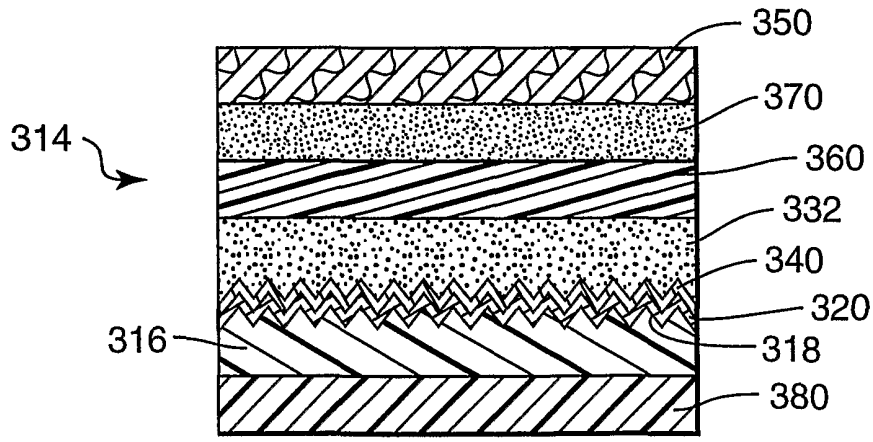
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FIG. 4

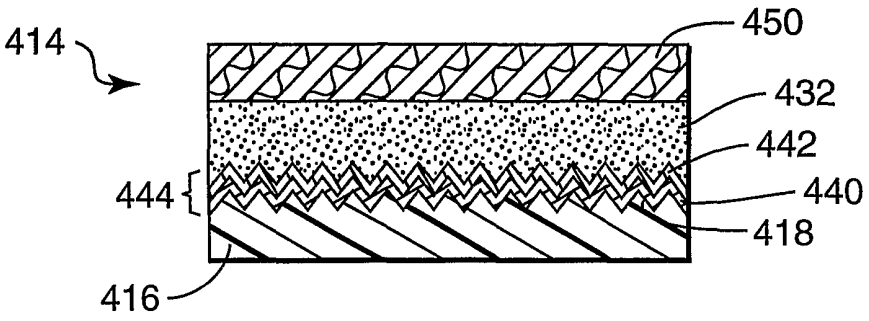
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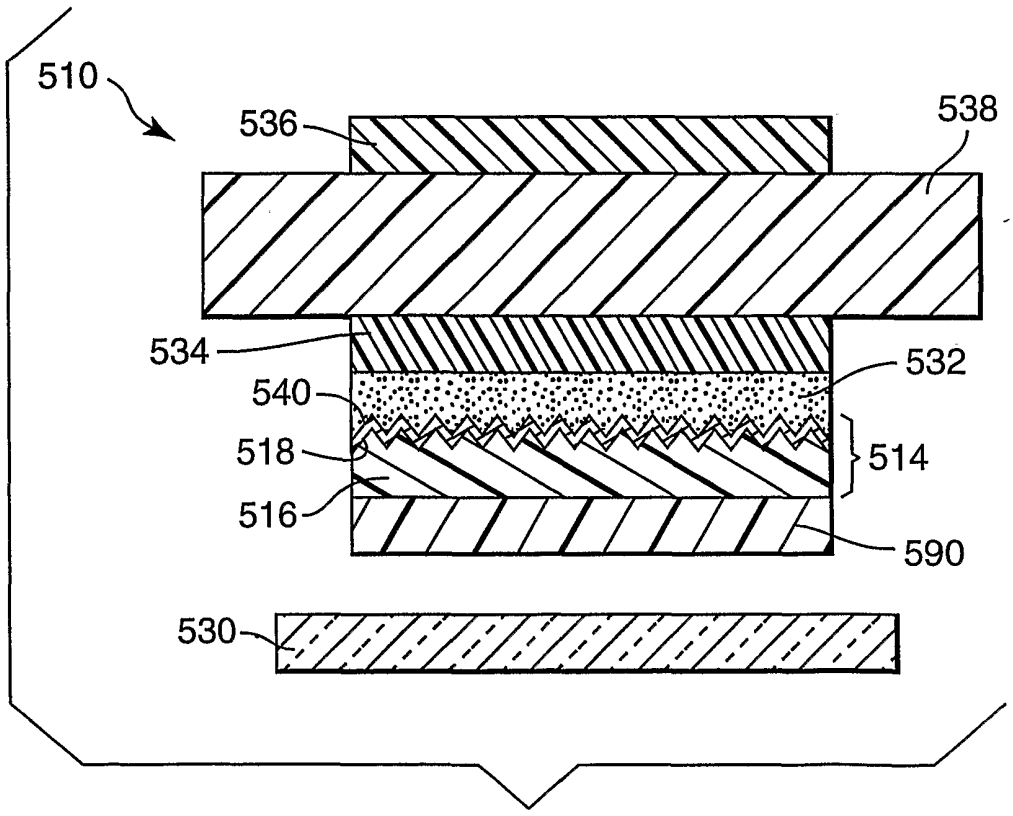
FIG. 5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530

FIG. 6