

A Method of Exposing Photo-Resist on an Optical Substrate

The invention relates to a method of exposing photo-resist on an optical substrate, such as a glass panel for a cathode ray tube (CRT).

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During the manufacture of CRTs a photo-resist is applied to a surface of a glass panel, which in the finished CRT will be the inside surface of the screen of the CRT. The photo-resist is exposed in stripes across the screen using ultraviolet light. The photo-resist is then developed to form carbon stripes where the
10 photo-resist has been exposed, and the non-exposed photo-resist after being developed is optically transparent. Phosphor is then deposited onto the surface and the carbon stripes form windows in the phosphor. The purpose of these phosphor windows is to provide a tolerance for the landing of the electron beams on the inside surface of the screen in a colour CRT, so that an electron
15 beam for one phosphor colour does not accidentally illuminate phosphor of one of the other colours and cause a colour deviation in the image displayed on the screen.

The photo-resist that is used is typically, polyvinyl alcohol (PVA). However,
20 PVA does not absorb ultraviolet light and so the ultraviolet light incident on the photo-resist is transmitted through the photo-resist into the glass panel. As the angle of incidence of the ultraviolet light on the photo-resist is not precisely perpendicular, after entering the glass panel some of the ultraviolet light is reflected back from the glass-air interface on the opposite side of the glass
25 panel back towards the photo-resist. As the reflected light is reflected non-

perpendicularly to the surface of the glass panel, the reflected light exposes photo-resist at a location that is different to the location at which the incident ultraviolet light beam exposes the photo-resist. This exposure by the reflected ultraviolet light causes broadening of the carbon stripes. The change in width of the carbon stripes is not equal across the panel but is approximately periodic and can be detected by the human eye, and so is undesirable.

Some proposals have been made to minimise the broadening of the carbon stripes by the reflected ultraviolet light. One proposal is to use polyvinyl pyrrolidone (PVP), instead of PVA, as the photo-resist. However, PVP is more expensive than PVA and using PVP would significantly increase the production costs of the CRT.

Another solution is to change the design of the CRT by modifying certain parameters of the CRT, such as the curvatures of the inner and outer surfaces of the glass panel, the thickness of the glass panel, the distance between the panel inner surface and the colour selection mechanism, the curvature of the colour selection mechanism and the arrangement pitch of the openings of the colour selection mechanism to minimise the broadening of the photo-resist exposure.

However, this has the disadvantage that it requires the CRT to be designed specifically to minimise this problem and cannot be applied to existing CRT designs.

In accordance with a first aspect of the present invention, a method for exposing a photo-resist on an optical substrate comprises applying a photo-resist to a first surface of an optical substrate, applying a coating to a second surface of the optical substrate, the second surface being opposite the first surface, the
5 coating having a refractive index less than the refractive index of the optical substrate and a refractive index greater than the refractive index of the atmosphere surrounding the optical substrate, and exposing the photo-resist to optical radiation.

10 In accordance with a second aspect of the present invention, a method for exposing a photo-resist on an optical substrate comprises applying a photo-resist to a first surface of an optical substrate, applying a coating to a second surface of the optical substrate, the second surface being opposite the first surface, the coating having a surface which is not optically smooth, and
15 illuminating the photo-resist with optical radiation.

The term "optical radiation" as used herein means electromagnetic radiation in the ultraviolet, visible or infrared regions of the electromagnetic spectrum.

20 An advantage of the invention is that by providing a coating on a second, opposite surface of the optical substrate, internal reflection from the interface between the optical substrate and the atmosphere in which the optical substrate is located is reduced, thereby reducing the exposure of the photo-resist by reflected light.

Preferably, the optical substrate is a transparent substrate.

The photo-resist may be applied to the first surface before or after the coating is applied to the second surface.

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Preferably, the coating is removed from the optical substrate after exposure.

Typically, the coating may be a liquid or a solid. For example, the coating may comprise a gas, for example water vapour, which is condensed on the second
10 surface, or an adhesive film applied to the second surface.

In another example of the invention, the coating may comprise a substance that is applied to the second surface as a liquid that solidifies after application.

Typically, the solidified coating may be dissolved by a solvent to remove the
15 coating from the second surface. Preferably, the coating is soluble in water.

In a further example of the invention, the coating substance may comprise a gel, or a liquid with high viscosity, such that the coating remains on the second surface, at least partially due to the viscosity of the coating substance, during
20 exposure.

In accordance with a third aspect of the present invention, a method for manufacturing a panel for a CRT comprises a process in accordance with the first or second aspects of the invention, wherein the optical substrate forms the
25 panel, and further comprising, after exposing the photo-resist, developing the

photo-resist, removing undeveloped photo-resist from the panel, depositing phosphor on to the first surface of the panel and the developed photo-resist.

Preferably, the coating is removed from the panel after the photo-resist has
5 been exposed and more preferably, after the photo-resist has been developed.

Typically, the panel is a panel for a colour CRT.

Examples of a method for exposing photo-resist on an optical substrate will now
10 be described with reference to the accompanying drawings, in which:

Figure 1 shows a conventional process for exposing photo-resist on a panel for a CRT; and

Figure 2 shows a method for exposing photo-resist on a panel for a CRT
15 in accordance with the invention.

Figure 1 shows a glass panel 1 that has a layer of photo-resist 2 applied to an inner surface 3 of the glass panel 1. Ultraviolet light 4 is used to expose parallel stripes 5 of the photo-resist. After development of the photo-resist layer 2, and
20 washing away of the non-exposed photo-resist 2, carbon stripes remain on the surface 3 of the glass panel 1 corresponding to the exposed photo-resist.

Phosphor is then applied over the still exposed areas of the surface 3 and the carbon stripes 5. After application of the phosphor, the carbon stripes 5 define windows in the phosphor where the phosphor is not visible from an outer
25 surface 6 of the glass panel 1.

However, the ultraviolet light 4 is transmitted by the photo-resist 2 during exposure so that the ultraviolet light 4 is transmitted into the glass panel 1. The transmitted ultraviolet light 9 is reflected from the glass air interface defined by the surface 6, as internally reflected ultraviolet light 7. The internally reflected light 7 then exposes additional sections 8 of the photo-resist 2, which causes unwanted broadening of the carbon stripes 5. Across the panel face, in a direction perpendicular to the carbon stripes 5, the broadening of the width of the carbon stripes 5, by the internally reflected light 7, is not equal but is approximately periodic across the panel and can be detected by the human eyes. This causes degradation in the image displayed in the finished CRT.

Figure 2 is a cross-sectional view through a portion of a glass panel 10 having an inner surface 13 and an outer surface 16. A photo-resist layer 12 is applied to the inner surface 13 and a removable coating 19 is applied to the outer surface 16.

The coating 19 may, for example, be a layer of adhesive or a layer of condensed water vapour. The coating 19 has two important features: (i) an external surface 20 of the coating 19, that is the surface which is not adjacent to the surface 16 of the panel 10, is not optically smooth; and, (ii) the refractive index of the coating 19 should be less than the refractive index of the glass panel but greater than the refractive index of air.

Hence, when the photo-resist 12 is exposed by the ultraviolet light 4, the transmitted light 9 undergoes less internal reflection at the surface 6 due to the coating 19 having a refractive index greater than air. Furthermore, due to the non-optically smooth surface 20, ultraviolet light 17 transmitted into the coating
 5 19 is reflected from the coating-air interface defined by the external surface 20 in an approximately random or pseudo-random direction 21. This effectively disperses the reflected light 21.

Hence, there is no effective secondary exposure of the photo-resist 12 by
 10 internal reflection from the surface 16 or the surface 20.

This can be explained from a derivation of Fresnel's laws of reflection, as explained below. For small angles of incidence, reflectance is defined as follows:

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$$\begin{aligned}
 \text{Reflectance} &= \frac{\text{Intensity of reflected light}}{\text{Intensity of incident light}} \\
 &= \left(\frac{R}{E} \right)^2 \\
 &= \left(\frac{n_1 - n_2}{n_1 + n_2} \right)^2
 \end{aligned}$$

20 Where, E = the amplitude of incident light, R = the amplitude of reflected light, then for the conventional system shown in Figure 1 for internal reflection from the surface 6, as n_1 = the refractive index of glass ≈ 1.5 and n_2 = the refractive

index of air = 1.0, the reflectance = 4%. At this level of reflected light secondary exposure of photo-resist layer 2 occurs and the effects of the secondary exposure and the broadening of the carbon stripes 5 by the additional exposed sections 8, is visible to the human eyes.

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However, if an adhesive film with a reflective index of approximately 1.3 is applied to the surface 16, such that the adhesive film forms the coating 19, using the above equation for reflectance, the reflectance from the glass-coating interface defined by the surface 16 is 0.28%. This is too low to produce any effective secondary exposure of the photo-resist layer 2, and the ultraviolet light 17 which is transmitted into the coating 19 is subsequently dispersed at the surface 20 due to the non-optically smooth surface 20.

Where the coating 19 is condensed water vapour, this can be applied by dispensing steam from a nozzle adjacent to the surface 16 at a temperature of 72 or 100° C. The panel is at a lower temperature, such as 40 to 50° C, and so the steam condenses onto the surface 16 to form a layer of moisture which forms the coating 19. In this example, n_2 = the refractive index of water (n_{water}) = 1.33. Therefore, the reflectance at the glass-coating interface defined by the surface 16 is approximately 0.36%. An intensity of reflectance of only 0.36% is insufficient to produce effective secondary exposure of the photo-resist layer 2. The ultraviolet light 17 that is transmitted into the coating 19 is dispersed by random reflectance or refraction from the surface 20 of the coating 19 formed by the moisture on the panel surface 16.

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Alternative coatings and the methods of application may include spraying chemicals onto the surface 16 to form a fine layer of droplets on the surface 16, to apply a relatively high viscosity liquid, or apply a liquid, for example by spraying liquid, onto the surface 16 and permitting the liquid to solidify. An
5 advantage of having a high viscosity or solid coating 19 is that it permits easier handling of the panel 10 during exposure and development of the photo-resist.

In addition, preferably, the coating 19 is easily removable from the surface 16 of the panel 10. For example, the coating 19 may be peelable from the surface 16
10 and/or may be soluble in water.

An advantage of the invention is that it reduces secondary exposure of the photo-resist 2 without requiring the CRT to be redesigned and does not require expensive chemicals, such as PVP, to be used for the photo-resist to absorb
15 the ultraviolet light 4.

CLAIMS

1. A method for exposing a photo-resist on a transparent substrate comprises applying a photo-resist to a first surface of a transparent substrate, applying a coating to a second surface of the transparent substrate, the second surface being opposite the first surface, the coating having a refractive index less than the refractive index of the transparent substrate and a refractive index greater than the refractive index of the atmosphere surrounding the transparent substrate, and exposing the photo-resist to optical radiation from the first surface of the transparent substrate.
2. A method according to claim 1, wherein the coating has a surface which is not optically smooth.
3. A method for exposing a photo-resist on a transparent substrate comprises applying a photo-resist to a first surface of a transparent substrate, applying a coating to a second surface of the optical substrate, the second surface being opposite the first surface, the coating having a surface which is not optically smooth, and exposing the photo-resist to optical radiation.
4. A method according to claim 3, wherein the coating has a refractive index less than the refractive index of the transparent substrate and a refractive index greater than the refractive index of the atmosphere surrounding the transparent substrate.



5. A method according to any of the preceding claims, wherein the coating is removed from the transparent substrate after exposure.

5 6. A method according to any of the preceding claims, wherein the coating is a liquid.

7. A method according to claim 6, wherein the coating is applied by condensing a gas onto the second surface.

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8. A method according to any of claims 1 to 5, wherein the coating is a solid.

9. A method according to claim 8, wherein the coating is an adhesive film.

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10. A method for manufacturing a panel for a CRT comprises a method in accordance with the first or second aspects of the invention, wherein the transparent substrate forms the panel, and further comprising, after exposing the photo-resist, developing the photo-resist, removing undeveloped photo-resist and the coating from the panel, and depositing photosensitive phosphor on to the first surface of the panel and the developed photo-resist.

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11. A method according to claim 10, wherein the coating is removed from the panel after the photo-resist has been exposed.

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12. A method according to claim 11, wherein the coating is removed after the photo-resist has been developed.

13. A method according to any of claims 10 to 12, wherein the panel is a
5 panel for a colour CRT.

