A New Photo-addressable Electronic Paper Using An Electrophoretic Device

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Abstract

We present a novel photo-addressable electronic paper using an electrophoretic device, which can show and sustain the 2D images transferred by the UV illumination. The device consists of the organic photoconducting layer reacting with the UV illumination and the electronic ink (white particles and blue dye) dispersing in a suspending medium. The voltage impression under illuminating of UV make an image be transferred to the electrophoretic cell. The transferred image can be maintained by the bistability of the electrophoretic device.

1. Introduction

Recently, paper-like displays have attracted much attention. As far as the usual properties of paper are concerned, the paper-like display needs to be lightweight, flexible, cheap and bistable. The "bistable" means that even if the external power turns off, the recorded image has to remain. The bistability is one of the most important factors for low power consumption, and it is one of the most important properties for the "paper-like" display.

As another important property, the paper-like display should be rewritable with sufficient cycles. In general, the writing method is electrical one. But, the photocopy may be one of the writing methods. By an illumination of UV light onto the recordable template (in this case, electrophoretic device) through the image for transferring, an illuminated region can be differentiated from an illuminated one. Two regions have different electrical properties, by which we can obtain the transferred image of the original one [1].

The reflective paper-like displays involve a microcapsule-type electrophoretic display [2-4], a twisting ball display [5], an in-plane type electrophoretic display [6], and a cholesteric liquid crystal display [7]. Among them, microcapsule-type electrophoretic display, which showing image and text using moving charged particles by applied voltage, might be one of the most promising candidate because it offers novel advantages such as ink-on-paper appearance, high reflectance, good contrast ratio, wide-viewing angle, image stability in the off state, and extremely low power consumption.

Most of the above ones have used the electrical method for recording texts or images on them. On the other hand, S. Yamamoto et. al. [1], developed a photoaddressable electronic paper (PAEP) using two technologies, the microencapsulated cholesteric liquid crystal and the organic photoconductor which are simply stacked on the thin plastic films. But, the operating voltage was as high as 250 V and the viewing angle was not wide.

In this study, we present a novel photo-addressable electronic paper using an electrophoretic device (EPD). The device consisted of an electrophoretic cell and an organic photoconducting layer. The EPD has an excellent contrast ratio and has no problem of viewing angle. Also, the operating voltage can be reduced below 50 V. The UV illumination through an image onto the EPD combined with an organic photoconducting layer brings about the different conductivity [8] between the illuminated and non-illuminated regions. So, It is possible to transfer an image onto the EPD.

2. Device Structure

Figure 1 shows the structure of our photo-addressable electrophoretic device. The electronic ink consisting of white particles and blue dye dispersed in a suspending medium was sandwiched between the ITO and PVK/ITO coated glasses.

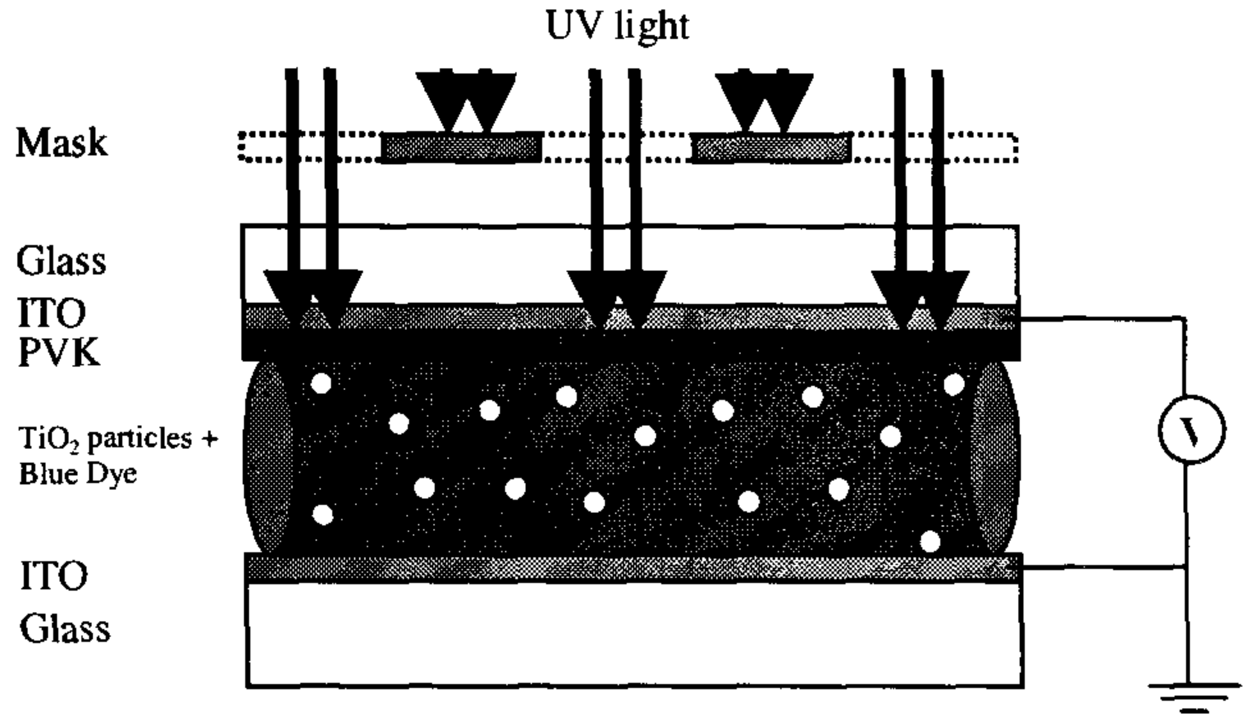


Fig. 1. A schematic diagram for the novel photo-addressable EPD.

The white particles were made of polymer-coated TiO_2 pigments, and were dispersed with a blue dye (Oil blue N) in the suspending medium (Halocarbon oil). The particles wore negative charges by the incorporation of a charge control agent during the fabrication of the electronic ink.

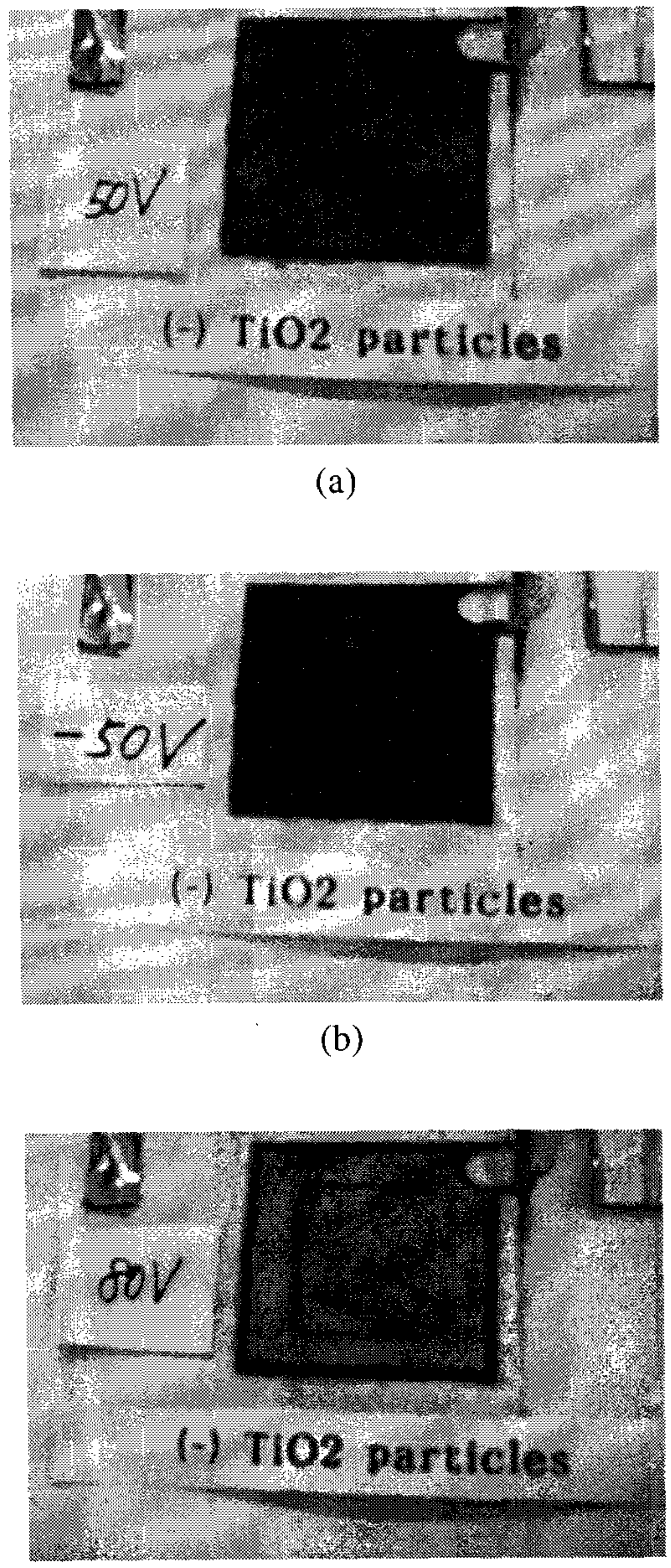
The above fabricated electronic ink was inserted between the ITO and photoconducting polymer-coated ITO glasses. The gap between the front and the rear panels was kept about 200 ㎛.

We used poly-vinyl carbazole (PVK) as an organic photoconducting layer, which was very famous as a photoconducting organic material. The PVK is easily dissolved in usual organic solvents and we used toluene as a solvent. The PVK layer was spin-coated on the ITO glass and the resultant thickness of the layer was 160 nm.

We used Keithly 408 as a DC voltage source and a UV lamp with the wavelength of 365 nm.

3. Device Operation

Electrophoretic displays have good characteristics such as high reflectance, good contrast ratio, wide viewing angle and image stability. These properties are very effective for the application as a photoaddressable device. In the case of the devices using liquid crystal (LC) materials, the viewing angle is not good due to the liquid crystals. Also, PAEP using electrophoretic devices has a relatively low operating voltage for writing compared to PAEPs using cholesteric LC. The low writing voltage can make portable batteries be used for the power source of the writing apparatus.



(a)

(b)

(c)

Fig. 2. An image transfer process of the photo-addressable EPD.

Figure 2 presents an image transfer process of our device. The white particles wearing the negative charge moves to the front electrode by the positive bias (Fig. 2(a)). And the reverse biasing caused the white particles to move the rear panel and we can see a blue color by the dye. After the particles are moved to the rear electrode by biasing negatively, the shadow mask for an image is put on the device (b). The image mask was a cartoon printed by a laser printer onto OHP film. Although this mask does not perfectly block UV light because of usual dot size of a laser printer, it can play a role of a mask to some extent.

A UV light with 365 nm is illuminated with a positive bias at the same time. The light of 365 nm transmitted the OHP film but was blocked by the image. After this process, we could obtain the transferred image from the shadow mask (c).

In the transferred image, the thin lines were not perfectly copied, because the thickness of the front glass is a little thick and so the diffraction was not prohibited. Also, as described above, the black-printed image used as a mask does not perfectly block the UV light.

It can be expected that the transmitted UV light should generate charge carriers in the illuminated PVK layer, and enhance the conductivity of the layer. In general, the photoconductivity of PVK without dopant

4. Summary

In this study, we have presented a new photoaddressable electronic paper using an electrophoretic device. We can easily copy an image onto the device with a relatively low voltage. It has good contrast ratio and viewing angle. So, it is expected that this device should be used for a simple re-writable coping tool and other applications of electronic paper.

5. Acknowledgements

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6. References

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