

New Toner Display Device Using Conductive Toner and Charge Transport Layer

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Abstract

A new toner display device using a conductive toner and charge transport layer has been developed. In this new toner display device, the toner movement is controlled by a switch of electric field polarity between two transparent electrodes. Two plates with the charge transport thin layer, CTL, are placed opposing each other, leaving a certain distance in between by using spacer. The charge transport materials are used as same as an organic photoreceptor in an electrophotography. The conductive toners on the CTL were charged by the hole injection from CTL to toner particles, and move to the front electrode. The toner particles are fixed on the front electrode due to the coulombic force between the toner and electrode across the CTL. The toner particles can be removed and moved toward to the back electrode by applying reverse electric field. The image can be recorded and erased easily by switching of electric field polarity.

Introduction

In recent years, the interface between human and computer was so important in the network society, which there are large amounts of information on the computer network. Usually, the CRT and the liquid crystal display were used as softcopy, and the paper with mostly easy to handle was used as hardcopy.

However, it is necessary to reuse and recycle hard copy for the protection of environment. At this point, rewritable marking technologies were widely investigated as the digital paper, an electronic paper, and the display board, etc. [1-7]

In this paper, we report the principle of toner display using the movement of electronic conductive toner and hole conductivity of charge transport layer.

Principle

The principle of white and black display using conductive toner and charge transport layer is shown in figure 1. This device was the display white and black images by movement of toners between two transparent electrodes. The hole charge transport layer was coated on the each transparent electrode. The display cell was made using an insulating spacer and two ITO glass plates with charge transport thin layer.

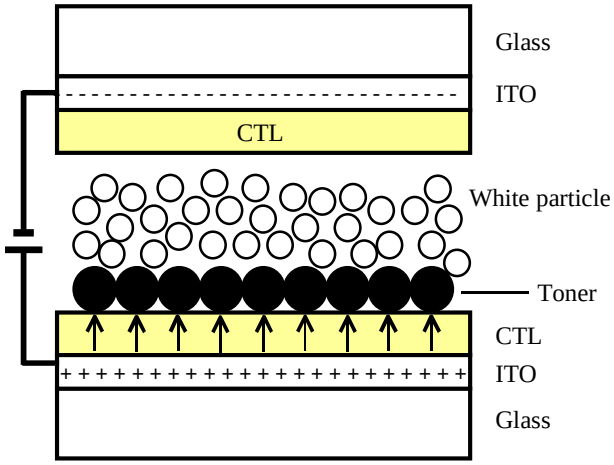


Figure 1. Toner Display Device.

The conductive toner and white particles are put in the cell is shown in figure 1. When the back electrode was an applied plus voltage, the conductive toners on the CTL were charged positively by the hole injection from CTL, and move to the front electrode due to the coulombic force between the toner and front electrode.

Since than, the conductive toner is kept on the charge transport layer is shown in figure 2(a). The charge transport

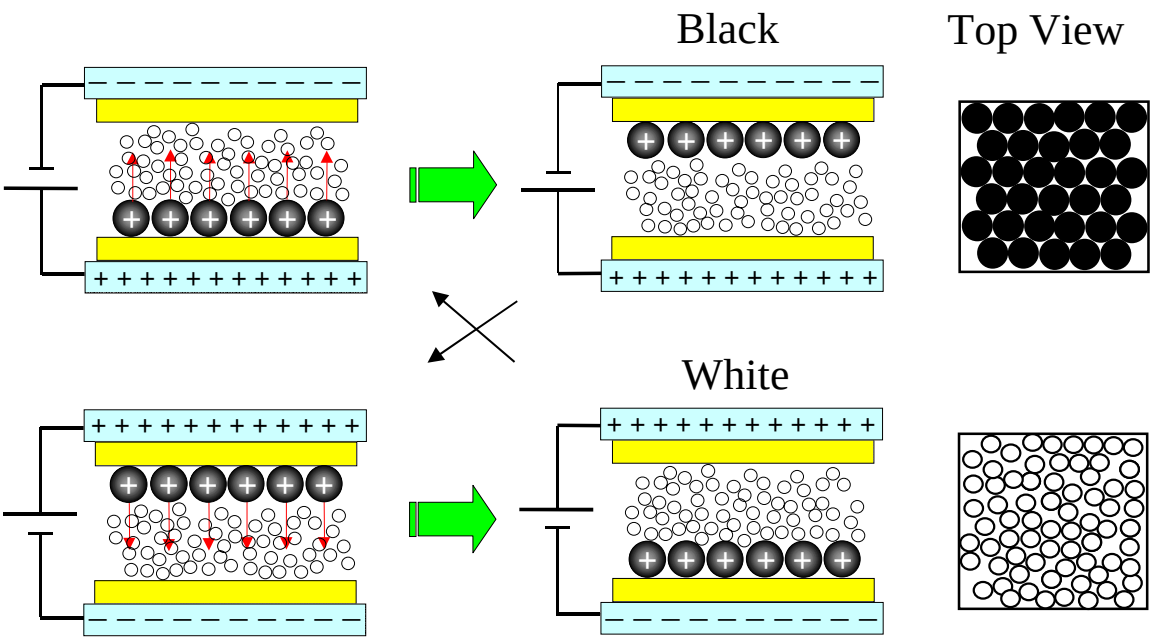


Figure 2. Black and white display by switching of electric field polarity.

layer acts on insulating layer due to the blocking contact between the toner and CTL.

The conductive toner is kept on CTL when power off. The conductive toner is kept on CTL when power off. In the region of the cell in which the toner has been packed on the front electrode, the black solid image will be seen by the observer through the front electrode.

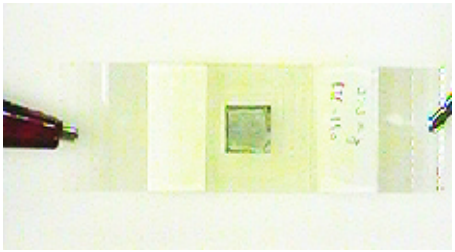
When the polarity of an applied field is reversed, the conductive toners are moved and packed on the opposite electrode and the white particles will be seen by the observer is shown in figure 2(b).

Experimental

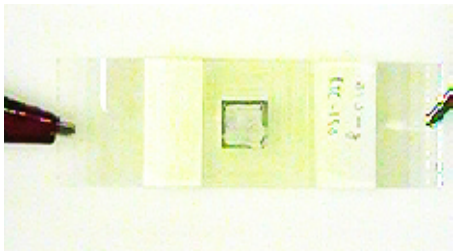
In this study, the toner display cell consists of conductive toners, white particles, and charge transport layer. The mixture of conductive toner and white powder are sandwiched by the transparent electrode surfaces of two glass plates. The thickness of spacer is 110μm. The mixture the charge transport material, p-diethyl amino-benzaldehyde(diphenyl hydrazone) and polycarbonate polymer (PC, Teijin chemicals Ltd., Panlite k-1300) in a 1:1 weight ratio was coated on transparent electrode. The layer thickness of CTL is 5μm. The ordinarily magnetic conductive toner (Hitachi metals, Ltd.,) and fluoride carbon (Nihon carbon Co.) were used as black and white particles, respectively. The contrast of image was using the reflection density values of black and white.

Results and Discussion

The photographs of black and white image are shown in figure 3.



(a) Black



(b) White

Figure 3. Photograph of black and white.

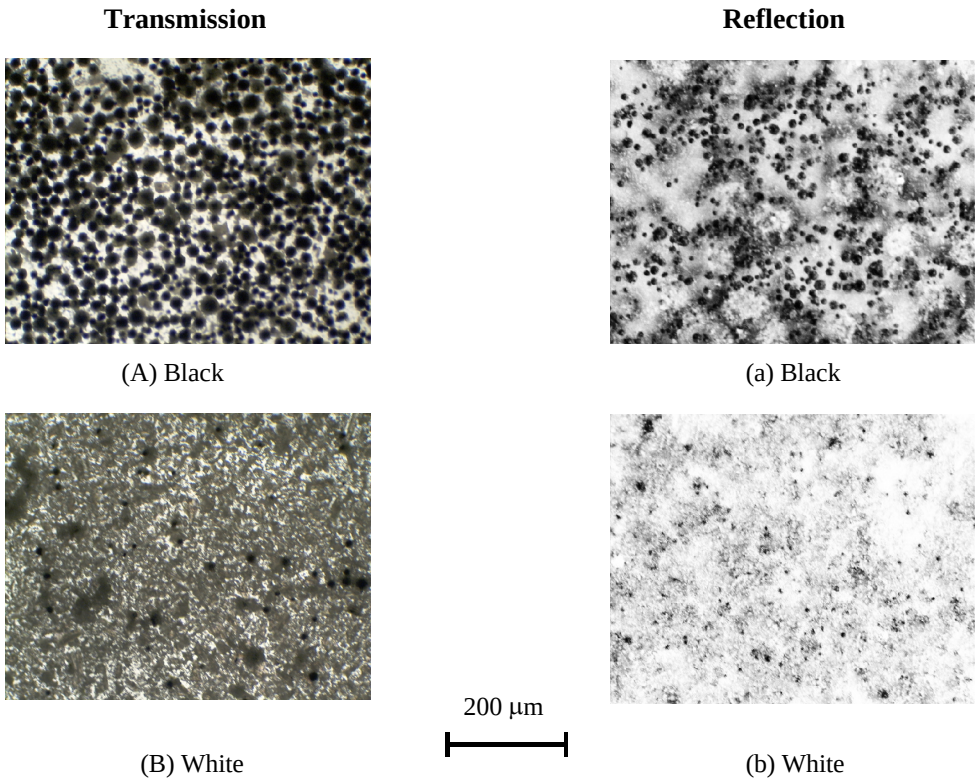


Figure 4. Microphotograph of black and white.

The black is shown when the toners are moved and packed on the front electrode and the white is shown when the toners are moved to opposite electrode. An applied voltage between the two electrodes with 110µm gap is 300V,and the weight ratio of conductive toner and white particle is 1:1wt.

Figure 4 shows reflection and transparent microphotographs of black and white solid area for toner display devices. In figure 4, photograph (A) and (B) show the black image area and white non-image area at transmission mode. The photograph (A) and (a) show the toner layer kept on the front electrode as is shown in figure 2(a). The toner on front electrode remains on the surface even removal of an applied voltage due to van der Waals attractive force between the toner and the electrode. The photograph (B) and (b) show the white powder layer on the front electrode as is shown figure 2(b) when the polarity of an applied voltage is reversed. However, the toner on electrode is not moved completely the opposite electrode.

Figure 5 shows relationship of reflection density and an applied voltage. The toners and white particles are mixed in a 1:1 weight ratio. The density of 0.8 is a mixture of the conductive toner and fluoride carbon. The conductive toners move firstly to front electrode when an applied voltage was 80V. When an applied voltage is lower than 200V, the difference in the density of the black and white was small due to the toners on upper electrode were not enough charge up. When an applied voltage is higher than 200V, the toners were enough charge up and shown a fixed contrast value.

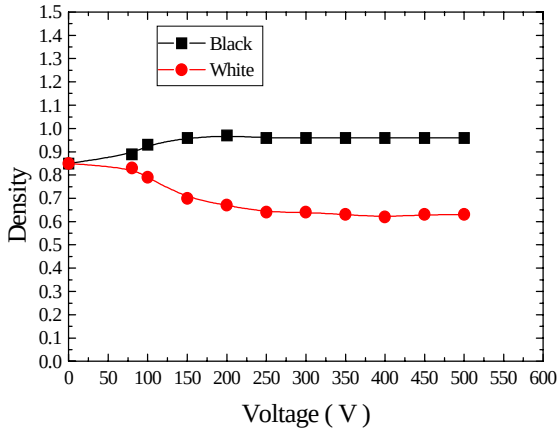


Figure 5. Reflection density vs applied voltage.

Figure 6 shows relationship between an optical contrast and toner concentration. The total amounts of the toner and white particle were fixed to 6mg. When an applied voltage is 100V, the contrast was low without regard to amount of toner, which was the same result in figure 5.

Generally, when an applied voltage is higher than 200V, the contrast show the peak at a 1:1 ratio of the toner and white particle. As we can see from this figure, when a ratio

is 1:1, the toner movement and concealment force by white particle were very fine.

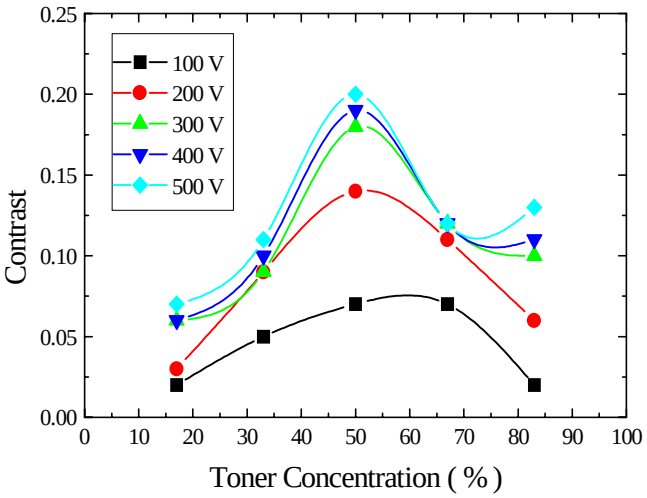


Figure 6. Relationship between contrast and toner concentration.

On the other hand, this toner display device has a memory function because the toner deposited on the surface of the electrode remain on the surface even after removal of an applied voltage mainly due to the CTL acts to insulating layer.

Conclusions

A new toner display using the conductive toner, white powder and charge transport layer has been developed. The conductive toners were charged by the hole injection from CTL and move to front electrode, and when switching the polarities of an applied voltage, the toner move to opposite electrode as well. The black and white solid image can be recorded and erased by switching of polarity of applied voltage.

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Biography

Gugrae-Jo received his B.S. and M.S. degrees in graphic art engineering from Pukyoung National University in 1993 and 1996, respectively. He has been a tutor at Pukyong National University. He is a student in doctor course in Graduate School of Science and Technology, Chiba University. His research interest is in reversible recording system.