Improvement of Image Contrast in Toner Display

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Abstract

Image contrast in toner display based on an electrical movement of black and white charged particles has been improved. Two types of black and white particles charged different electric polarity are enclosed between a two transparent electrodes. The black and white solid images are displayed by the switch of polarity of applied voltage in toner display cell. The image contrast ratio of reflectance of white to black solid image has been increased when the new type of white and black toner particles are used in toner display cell.

Introduction

Two types of black toner and white particles charged in the different electric polarity are enclosed between a two electrodes coated with insulating layer in toner display.[1,2] The particle movement is controlled by the external electric field applied between two transparent electrodes. Toner display has the feature of wide viewing angle, image memory and low power consumption and etc. Toner display is one of candidate for an electric paper. The display characteristics of two particles migration type toner display using black toner and fused silica as white particle were reported.[3-5] Low reflectivity of the white display was a problem. In this paper, the improvements of reflectivity and image contrast in toner display were tried using positive charged black toner and negative charged white particle.

Toner Display

The structure of toner display cell using black toner and white particle is shown in Figure 1. The display device is the sandwich type cell structure that is enclosed in two ITO transparent electrodes using an insulating spacer. The insulating polymer layer is coated on the each transparent electrode. The black toner and white particle are been built-in in this cell. The black toner and white particle were charged tribo-electrically in positive and negative, respectively. The black toners and white particles move to the each of two electrodes of which the negative and positive voltage was applied, respectively. The cell displays white or black pattern by the change of applied voltage caused by the movement of black toner and white particle between two transparent electrodes as is shown in Fig. 2.

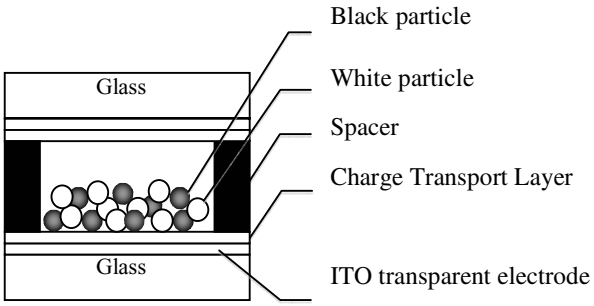

Figure 1. Sample structure of toner display cell.

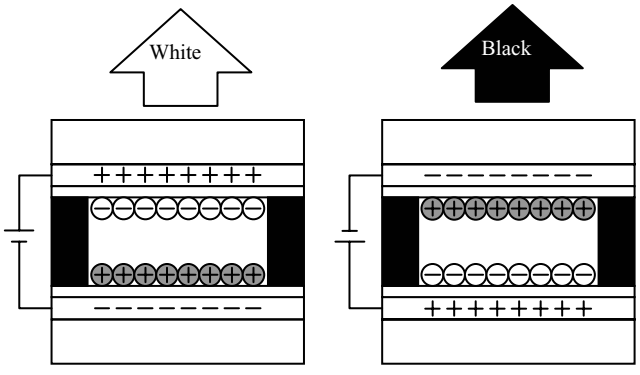

Figure 2. Toner movement by application of external voltage and display black and white patterns.

Experimental

Sample

The toner display cell consists of black toners, white particles, and transparent electrode. The mixture of black toner and white particle are sandwiched by the transparent electrode surfaces of two glass plates. The insulating polymer layer is coated on the each transparent electrode. The thickness of spacer is 100μm and the size of one pixel is 10mm x 10mm. The black toner and white particle (Denshi Kako Co., Ltd.) were used in this display cell. The toner particle is almost spherical in shape and its size is 10μm. The white particle is elliptical shaped particle with a size of 10μm and has a high electric resistance. The polycarbonate polymer (Teijin chemicals Ltd., Panlite k-1300) was coated on transparent electrode. The layer thickness is 3 μm. The response of the display to alterations in applied voltage was monitored with an optical microscope (Olympus Optical Co., Ltd., BH2-UMA), and the optical reflection density of the image was measured with a reflection densitometer (Ihara Electronic Ind. Co., Ltd., Ihac-11).

Results and Discussion

Display Characteristics

The relation between reflection density and applied voltage for toner display cell using black toner and white particle in comparison with using fused silica as is shown in Fig. 3. The reflection density of white solid pattern for toner display cell using white particle is lower than that using fused silica. The high reflection density of fused silica is due to high transparency of fused silica. The low reflection density of white particle is due to high whiteness of white particle. The threshold voltage of 200 volts exists clearly for toner display cell using white particle. This is because the particle size distribution of the white particle is narrow and the tribo-electric charge of particle is constant.

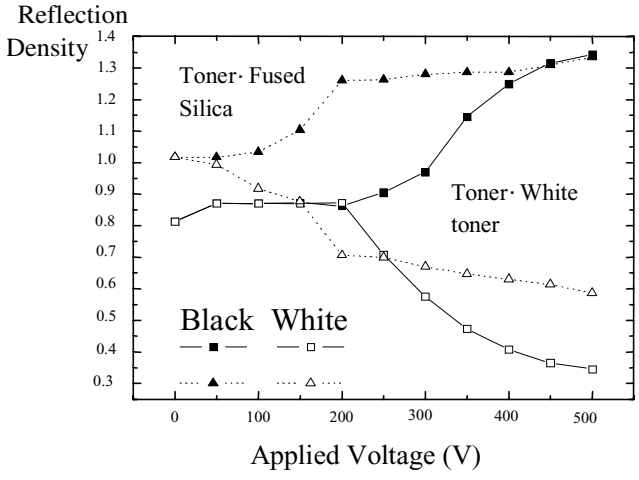

Figure 3. Relation between reflection density and applied voltage for toner display cells using fused silica and white particle.

Mixture Ratio of White Particle and Black Particle

The display characteristics depend on the mixture weight ratio of white particle and black toner in toner display. The reflection density and image contrast for samples prepared in the mixture ratio of white and black particle of 1:1, 1:2, 1:3 and 1:4 were measured in order to obtain the optimum mixture ratio. The reflection density of toner display cell depends on the mixture ratio of white particle and black particle as is shown in Fig. 4. The reflection densities of white and black patterns depend on the amount of white particle and black toner in the display cell. Figure 5 shows the image contrast of toner display cell. The image contrast of display shows over 10 for the sample in the mixture ratio of white and black particle of 1:1, 1:2, and 1:3. The reflectivity is 60% and the contrast is 14 for the toner display cell in the mixture ratio of white and black particle of 1:3.

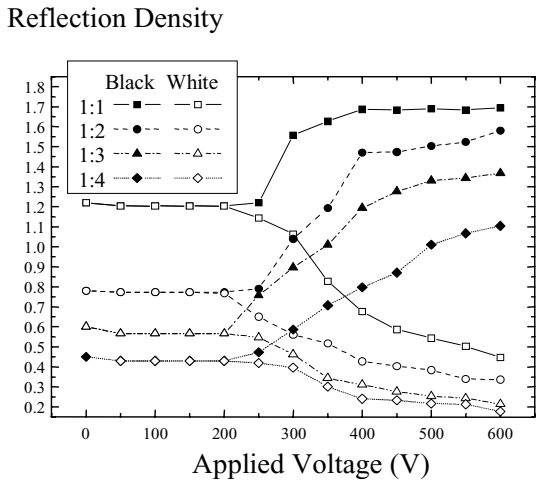

Figure 4. Display characteristics of toner display cells as the function of mixture ratio of white particle and black toner.

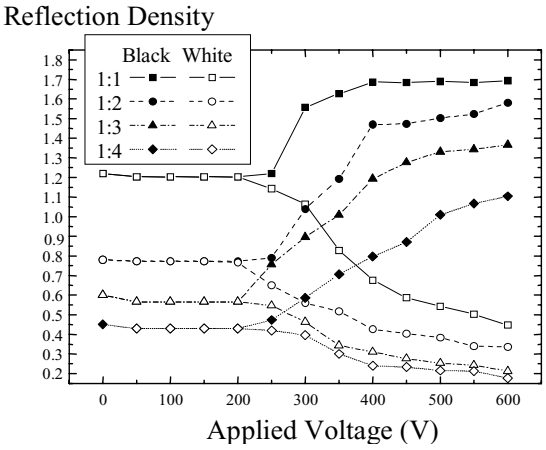

Figure 5. Image contrast as the function of mixture ratio of white particle and black toner.

Cell Gap

It is the important problem that the driving voltage is very high for toner display. It is necessary to lower the drive voltage for electric paper. The controlling factor of the driving voltage and threshold voltage was examined. The effect of cell gap on the display characteristics was investigated because the driving voltage depends on the cell gap. The reflection density and image contrast of display for samples having cell gap of 100um, 75um and 50um is shown in Fig. 6. The threshold voltage decreases with the decreasing of cell gap.

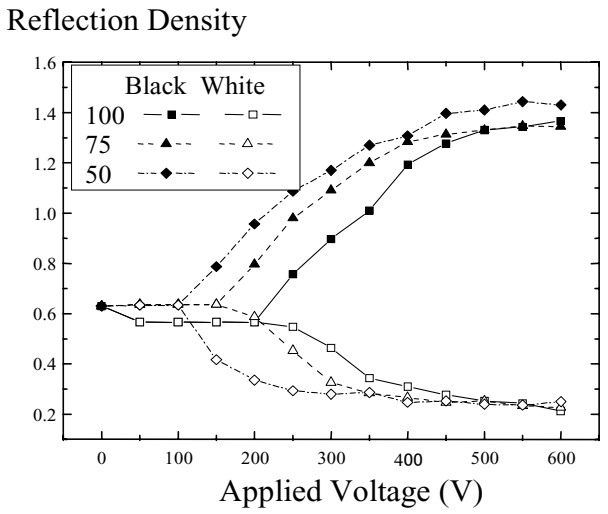

Figure 6. Display characteristics of toner display cell as the function of cell gap.

Conclusion

The white display property was greatly improved for toner display by the selection of the white particle. The reflectivity of white pattern is 60% and the image contrast is 14 for the toner display cell in the mixture weight ratio of white particle and black toner of 1:3. The threshold voltage decreases with the decreasing of cell gap.

References

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Biography

Takashi Kitamura received the B.S. and M.S. degrees in graphic engineering from Chiba University in 1970 and 1972, respectively, and the Dr. Eng. Degree from Tokyo Institute of Technology in 1983. I was a Research Associate at Chiba University from 1972 to 1985, doing work on Electrophotography. I was a Associate Professor from 1985 to 1997 and have been Professor in Information and Image Sciences Department, Chiba University since 1997.