Driving Voltage for Electrical Particle Movement in Toner Display

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Abstract

The mechanism of toner display based on an electrical movement of black and white charged particles has been investigated. Two types of black toner and white particles charged in the different electric polarity are enclosed between two electrodes. The particle movement is controlled by the external electric field applied between two transparent electrodes. The toner is collected to the electrode by an electrostatic force across the insulating layer to display a black image. The toners can be put back to the counter electrode by applying a reverse electric field, and white solid image is displayed. The threshold and driving voltage to move the particle depend on the electric charge and fluidity of particles.

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 white particle were reported.[3-5] In this paper, the effect of fluidity of particles on the threshold and driving voltage to move the particle.

Toner Display

The structure of toner display device using black and white particles 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 black and white particles are been built-in in this cell. The black and white particles were charged tribo-electrically in positive and negative, respectively. The device displays black pattern due to movement of black particles to negative electrodes due to the coulomb force between the particle charge and negative charge on the electrode. When the polarity of an applied voltage is reversed, the negative charged white particles move to the top electrode and covered on the top electrode and then the white pattern is seen through the top electrode. Black and white patterns can be changed by the polarity of applied voltage caused by the movement of toner and white particle between two transparent electrodes.

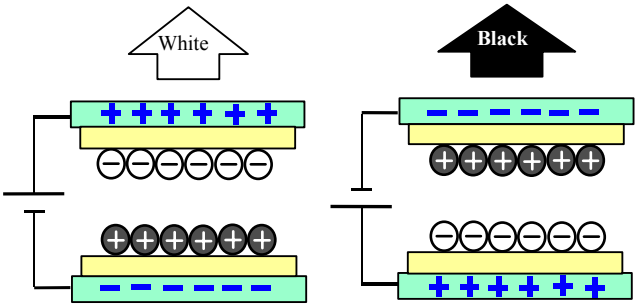

Figure 1. Black and white toner movements by applied voltage and the device displays black or white patterns.

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 100 micro-meter 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 10 micro-meter. The white particle is elliptical shaped particle with a size of 10 micro-meter 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 micro-meter. 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 black toner and white particle were mixed in a 1:1 weight ratio, was enclosed in the display cell. Figure 2 shows relationship of reflection density and an applied voltage. The black toners move firstly to front electrode when an applied voltage was 200V. When an applied voltage is higher than 500V, the toners were enough charge up and shown difference of reflection density, 1.0. The difference of reflection density for the two particles movement type display cell is larger than the one particle movement type display cell. For samples having two types of toners, the image contrast is 12.3 higher than for sample using the conductive toner and fused silica.

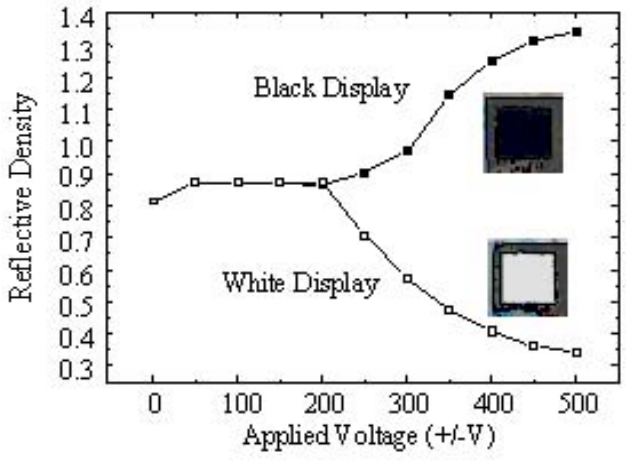

Figure 2. Display characteristics for toner display.

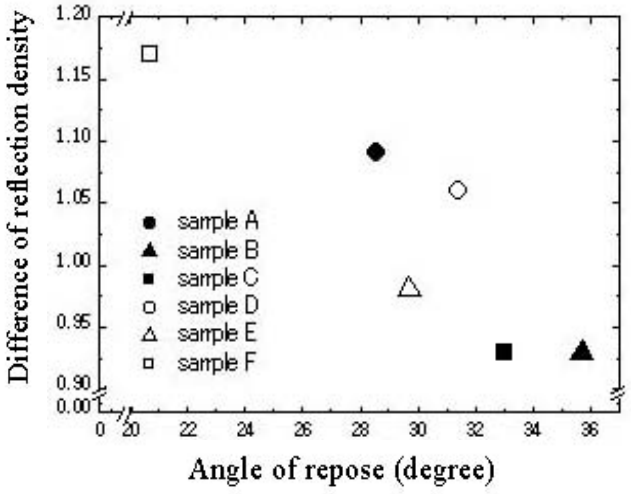

Figure 3. The relation between the angle of repose of white particles and the difference of reflection density between the black and white displays.

Angle of Repose of the Particle

The angles of repose of particles were measured by conventional method. Figure 3 shows the relation between the angle of repose of white particles and the difference of reflection density between the black and white displays for the samples having six different type of white particles. The difference of reflection density increases with decreasing of the angle of repose of white particles. When the particles with the good fluidity were used for toner display, the display cell exhibits good display characteristics.

The Fluidity of the Particle and Display Characteristics

Figure 4 shows the display characteristics for two toner display samples having different type of particles. The sample F and B were prepared using the particles with the good and low fluidity, respectively. There are large difference of reflection density of black display and threshold voltage. The sample F using the particles with the good fluidity shows low threshold voltage. It is smooth to move the particles when the low voltage is applied to the display cell.

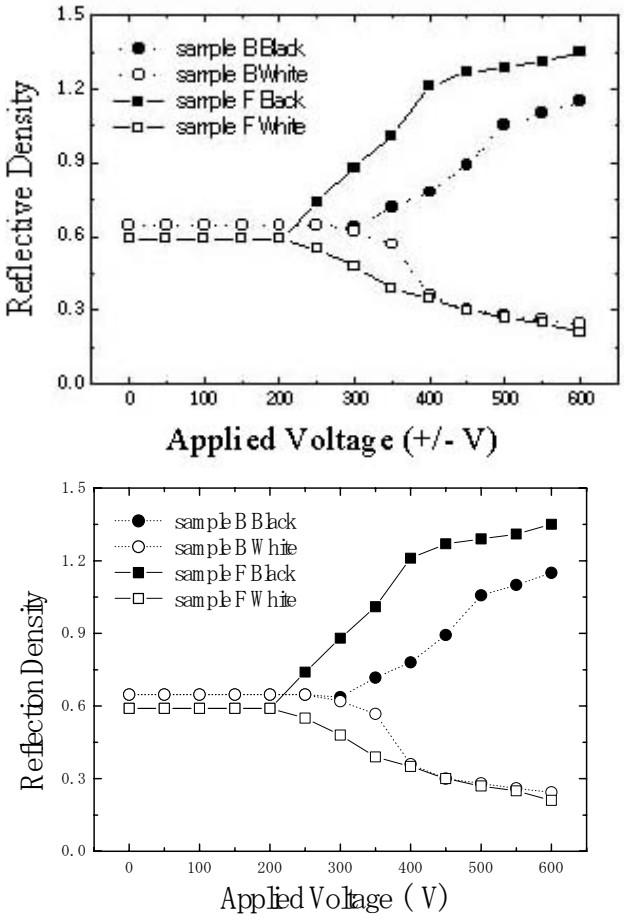

Figure 4. Display characteristics for two toner display samples having different type of particles.

Flexible Toner Display

Figure 5 shows flexible toner display sample. The image was patterned on the flexible print circuit. The black and white particles were in to the air space between the flexible printed circuit and transparent ITO film. The gap distance is about 100 micron meter.

Figure 5. Flexible toner display sample

Conclusion

The relation between the fluidity of particles and display characteristics for Toner Display was investigated. The improvement of display contrast and low threshold voltage were obtained by using the good fluidity of particles

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Author Biography

Daisuke Takahashi received the B.S. degree in information engineering from Chiba University in 2004. I am a student in Graduate School of Science and Technology, Chiba University since