

Dependence of Photoreceptor Charging Characteristics on Pre-Exposure Conditions

Chun- Wei Lin, Toshinori Nozaki and Yasushi Hoshino*
Gentec Co., Ltd. Tokyo Japan
****Nippon Institute of Technology***

Abstract

In the response of photoreceptor, trapping phenomenon is important factor, and the many studies on this factor have been reported. In our previous paper, by measuring the charging characteristics of photoreceptor between with and without pre-exposure, the information about the traps in photosensitive materials was analyzed. The trapping phenomenon in photoreceptor depends on the photosensitive materials and is affected the exposure conditions such as light power, wavelength, and temperature, charging-light induced fatigue, and so on. In this study, the results measured on these factors are reported.

Introduction

The trapping phenomenon of photoreceptor has an affect on the speed of electrophotographic printing process. The part of carriers activated with light exposure are captured by traps of photoconductive layer, then liberated from the traps by electric field and thermal energy. The carrier liberation rate $1/\tau$ is usually expressed by the following equation (1),

$$1/\tau \propto e - (Et - \Delta\varepsilon (E))/ k T \qquad (1)$$

where Et is the potential depth of trap, $\Delta\varepsilon (E)$ is the trap potential depth decreased by electric field E, k is Boatsman constant, and T is absolute temperature.[1,2)]

The corona charging characteristics of photoreceptor drum are measured by measuring system (CYNTHIA_59 GENTEC Co.,) between with and without pre-exposure.[3,4)] The pre-exposure is carried out: the photoreceptor drum is irradiated with proper light about ten minutes before charging.[5)] Comparing two measured results, the difference between two charging characteristics was obtained. Because of liberation of light activated carriers generated by pre-exposure from traps in photoreceptor, the corona charging characteristics curve is delayed in the charging curve. Then the absorption current $J_a (V_s ,t)$ by the detrapping is calculated with the following equations,

$$(\varepsilon/d)\, dV_s/dt = J_c (V_s) , \qquad (2)$$

$$(\varepsilon/d)\, dV_s^{irr}/dt = J_c (V_s) - J_a (V_s ,t) , \qquad (3)$$

$$J_a (V_s ,t) = J_c (V_s) - (\varepsilon/d)\, dV_s^{irr}/dt , \qquad (4)$$

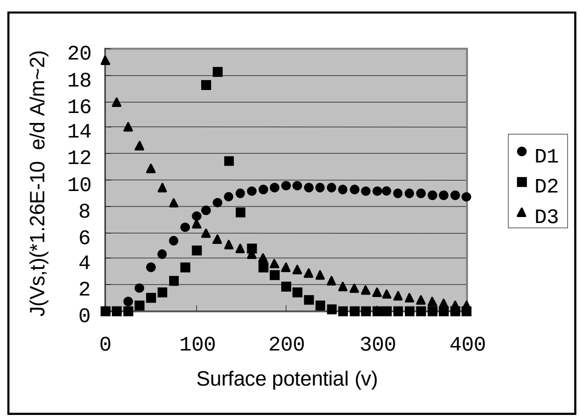
where $J_c (V_s)$ is the current density of corona current, d is the thickness of photoconductive layer, ε is the dielectric constant of its layer, V_s is the surface potential of photoreceptor and V_s^{irr} is the surface potential with pro-exposure.

It is remarked that J_c and the surface potential of photoreceptor drum V_s and V_s^{irr} are obtained from the measurements, and the information on the traps were investigated.

In this study, the dependence on charging characteristics for the three typical drum of different photosensitive materials on the exposure conditions, such as light power, wavelength, and temperature, charging-light induced fatigue, and so on, were measured.

1. Trapping Phenomenon Dependence on Photosensitive Materials

The trap influence on charging characteristics of photoreceptor and the differences of traps are due to the differences of photoconductive material and structure. The absorption current $J_a (V_s,t)$ for three kinds of drum samples are estimated and shown in Figure 1.



D1 As_2Se_3 photoreceptor drum
D2 OPC photoreceptor drum
D3 a-Si photoreceptor drum

Figure 1. Absorption current $J_a(V_s,t)$ for photoreceptor drum samples.

As shown in Figure 1, In the case of As_2Se_3 drum, the carrier liberation spectrum is broad, and the current magnitude is not small. In the case of *OPC* drum, carrier liberation arises at the surface potential around 120v and the spectrum is sharp. In the case of *a-Si* drum, it is found that the spectrum has a peak and is relatively broad.

2. Charging Characteristics Dependence on Pre-Exposure Power

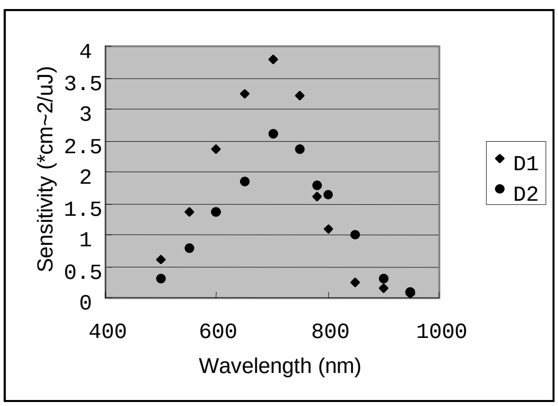
The dependence of charging characteristics to light power of pre-exposure for the example of two kinds photoreceptor drum was expressed in our previous paper. [5)]

It is known that the charging curve is found to delay according to the increase of pre-exposure light power and the shift of curve shows saturation tendency versus irradiation power. It is due to filling of traps by activated carriers.

3. Trapping Phenomenon Dependence on Spectral Sensitivity of Photoreceptor Drum

The trapping phenomenon depended on the wavelength of pre-exposure light. This dependence for a-Si photoreceptor drum sample is shown in Figure 2 and spectral sensitivity for same sample is also shown in this same figure.

Comparing two measured results in Figure 2, it is found that the spectral response of the trapping absorption current due to the pre-exposure light is nearly same as the spectral sensitivity of photoreceptor sample.



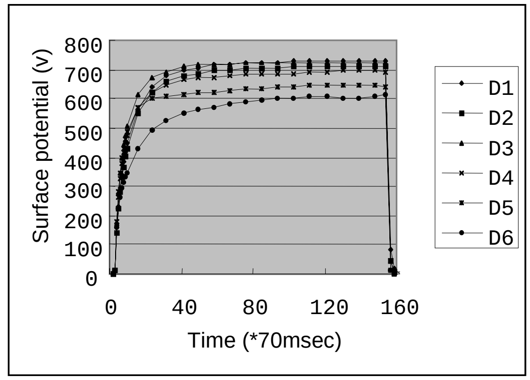
D1 Sensitivity ($cm^2/\mu J$)
*D2 $J(V_s,t)$ (1.26E-10 ε/d A/m^2)*4*

Figure 2. The trapping phenomenon depends on pre-exposure light wavelength.

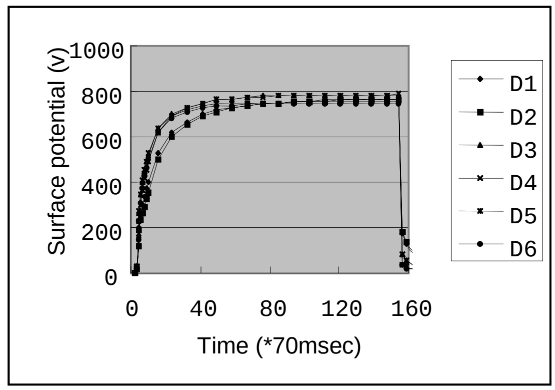
4. Trapping Phenomenon Dependence on Temperature of Environment

As expressed In Eq.(1), the carrier liberation rate $1/\tau$ depends on temperature. At the temperature of 0°C, 20°C, 40°C, the change of charging characteristics between with and without pre-exposure are measured respectively, and the change of charging surface potential by the detrapping are shown in Figure 3.

From the Figure 3 it is confirmed that the liberation of traps activated as the temperature become higher.



(a) As_2Se_3 photoreceptor drum



(b) OPC photoreceptor drum

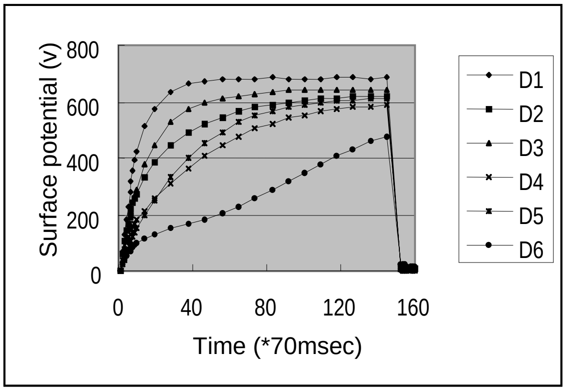
D1 without pre-exposure at 0^0C,
D2 with pre-exposure at 0^0C,
D3 without pre-exposure at 20^0C,
D4 with pre-exposure at 20^0C,
D5 without pre-exposure at 40^0C,
D6 with pre-exposure at 40^0C.

Figure 3. The absorption current Ja (Vs ,t) at the temperature of 0^0C, 20^0C, 40^0C.

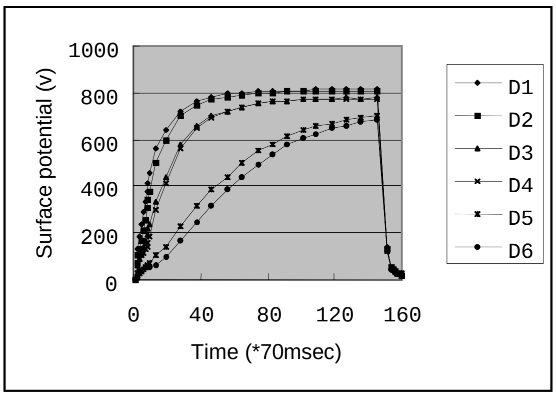
5. Trapping Phenomenon Dependence on Charging Conditions

It was known that, when photoreceptor is exposed by light, a part of carriers was captured by the traps of photoconductive layer, and then liberated from the traps by electric field. These carriers neutralize surface charge and delay the charging curve at the charging time. To examine the trapping phenomenon, rise time was controlled and these measuring results for three kind samples are shown in Figure 4.

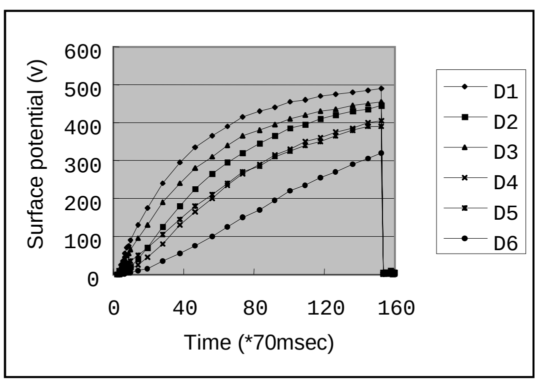
It is found that the liberation of traps current is inverse proportion to charging curve rise time and when the rise time is fast, the trapping phenomenon is smaller, contrarily it is large as so in Figure 4. It was recognized that the liberated traps current is similar under the same light power of pre-exposure.



(a) As_2Se_3 photoreceptor drum



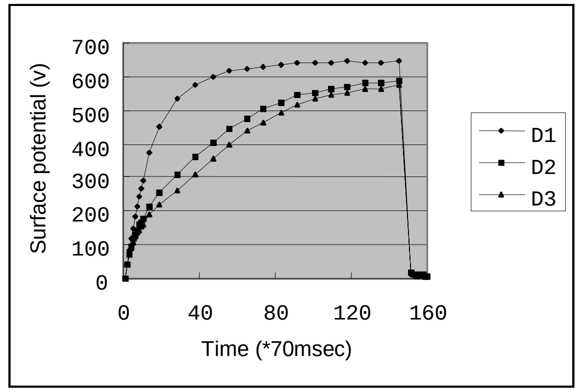
(b) OPC photoreceptor drum



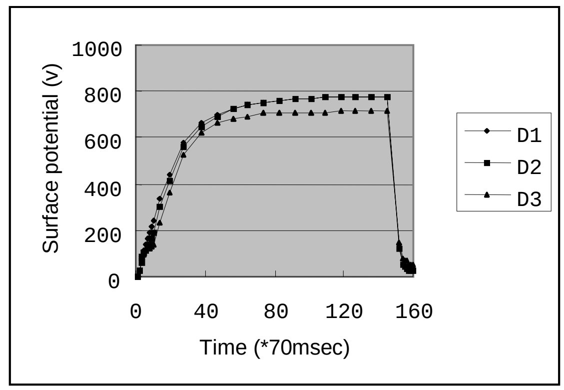
(c) a-Si photoreceptor drum

D1 without pre-exposure at 6000v charging voltage
D2 with pre-exposure at 6000v charging voltage
D3 without pre-exposure at 5500v charging voltage
D4 with pre-exposure at 5500v charging voltage
D5 without pre-exposure at 5000v charging voltage
D6 with pre-exposure at 5000v charging voltage

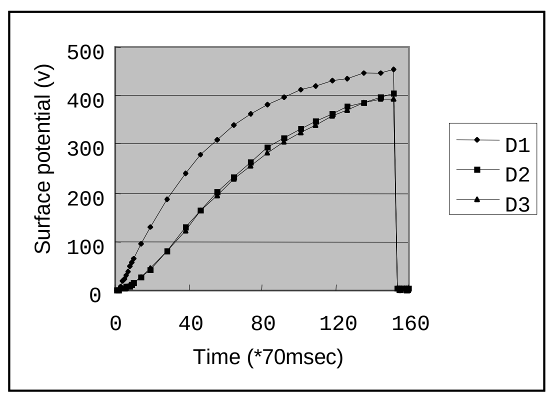
Figure 4. Charging curve for three kind samples.



As_2Se_3 photoreceptor drum



(b) OPC photoreceptor drum



(c) a-Si photoreceptor drum

D1 Without pre-exposure
D2 With pre-exposure
D3 With pre-exposure for fatigued drum

Figure 5. Charging characteristics of fatigued photoreceptor.

6. Trapping Phenomenon Dependence to Charging-Light Induced Fatigue of Conductor Drum

The photoreceptor drum rotates at the speed 60 rpm, charging and erasing were made every turn repeatedly during 2 hours. After this term, the charging characteristics with and without pre-exposure were measured in the same way. The measured results of three kinds of drum samples are shown in Figure 5.

As shown in Figure 5, after photoreceptor is fatigued, charged surface potential was dropped and the current liberated time of traps was prolonged. This is because the charge retentivity has declined by fatigue. At the case of a-Si photoreceptor, this effect is smaller in three kinds of drum samples.

Summary

Using the method, in which the corona charging characteristics between with and without pre-exposure are compared under the various conditions of pre-exposure and charging, such as light power, wavelength, temperature, light induced fatigue, and so on. The information about the trapping phenomenon in photoreceptor drum was obtained and the photoconductive characteristics were estimated. This method is thought to be useful to estimate photoreceptor.

Acknowledgements

The authors would like to express their sincere thanks to Mr. T. Murata and Dr. S. Kitakubo for their support during this study.

References

1. R. M. Schaffert, Electrophotography, *Focal Press, London*, 1975. (photoconductive discharge in xerography) pp.408-440.
2. M. Abkowitz and R C. Enck, Xerographic spectroscopy of gap state in amorphous semiconductors, *Phys. Rev.* , **B35** p.2567 (1982).
3. C-W Lin and T. Nozaki, The measurement of photoconductive characteristics on micro-area surface of photoreceptor drum, *IS&T 11th international congress on advances in non-impact printing technologies* , p.139 (1995).
4. Y. Hoshino and K. Arishima, Measuring Method for Electric Field Ionization from Trapping Levels, *J. Phys.*, **E16** P.427 (1983).
5. C-W Lin and T. Nozaki, Analysis of Traps in Photosensitive Materials from the Dependence of Corona Charging Characteristics on Exposure, *IS&T 13th international congress on advances in non-impact printing technologies* , p.270 (1997).

Biography

Chun-Wei Lin graduated from Shanghai Institute of Technology in 1987, and received Dr. degree from Nippon Institute of Technology in 1995. He works for Gentec Co., having charge of research section now. He has been engaged in the studies of electrophotographic process and image analysis, and the production of measuring system for photoconductor drums.

Toshinori Nozai is the president of Gentec Co.

Hoshino Yasushi is Professor of Nippon Institute of Technology. He gained Bs., Ms. And Dr. degrees from University of Tokyo, 1970, 1972, and 1984 respectively. After he gained Ms. Degree, he joined Electrical Communication Laboratories of NTT and developed LED printer firstly, high speed laser printer, color laser printer by using ultra elliptical laser beam scanning, photo-induced toning technology and ion flow printing. He moved to Nippon Institute of Technology on 1994. He published more than 20 papers and several papers also in IS&T's Journal. He attended almost NIP congresses.

E-mail: hoshino@nit.ac.jp.