Development of OPC for high speed digital monochromatic MFP

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Abstract

In February, 2006, RICOH Company, Ltd. launched the Ricoh imagio MP9000/1100/1350 series (Aficio MP9000/1100/1350) designed for a high speed digital monochromatic Multi Functional Printer. The Organic Photo Conductor (OPC) applied to this machine had a life of two millions prints (Letter). The durability of the OPC had been dramatically increased than ever before. In attempting to increase durability of OPC, we tried to prevent the occurrence of background fouling, which deteriorates with long term of use and largely influences on the life of OPC. As a result of our study, we developed the following three methods to achieve our object: (I) Adopting blocking layer to improve hole-blocking ability. (II) Increasing the thickness of charge transport layer (CTL). (III) Optimizing cleaning condition to minimize CTL abrasion rate.

Introduction

In these years, the copying speed of high-speed digital monochromatic multi functional printers has been enhanced, and such printers are applied to various fields such as on-demand printing. Therefore, the OPC is required to have high durability so as to respond to a demand of producing a large number of prints, and many companies have been actively engaged in the development of a long life OPC as shown in Figure 1. [1-3]

In this paper, we show an outline of the technologies adopted to new OPC (100mm in diameter) with a life of two millions prints (Letter). This OPC is applied to the Ricoh imagioMP9000/1100/1350 series (AficioMP9000/1100/1350) launched by RICOH Company, Ltd. in February, 2006.

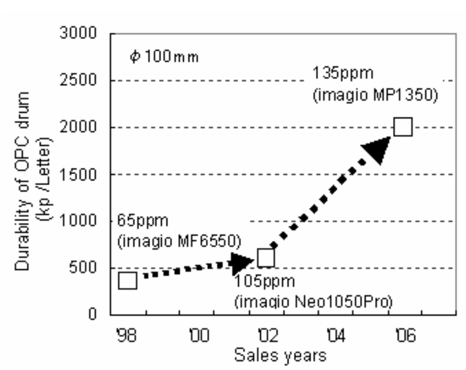

Figure 1. *Trends in a OPC life at high speed digital monochromatic MFP launched by Ricoh Co, Ltd.*

Technology of OPC with high durability

Factor of OPC life

The life of the OPC for use in the reversal development system largely depends on the occurrence of background fouling in that the background portion of an image is soiled with toner particles. The background fouling occurs as follows. At first, the surface of the OPC is uniformly charged, but the charge locally decays. In the portion where the charge decays, the toner tends to be developed, resulting in occurrence of background fouling.

The mechanism of the local charge decay is considered as follows (refer to Figure 2).

(A). Positive charges (Holes) induced by dielectric polarization present in the substrate are injected into the photosensitive layer and erase the surface charges.

(B). Thermo-induced-charges in present in the photosensitive layer are transported to the surface of the OPC and erase the surface charges.

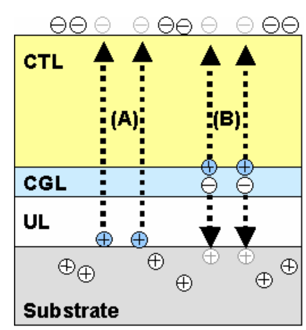

Figure 2. *Schematic view illustrating assumed mechanism of occurrence of background fouling: (A) Hole injection from substrate (B) Transportation of thermo-induced-charges in photosensitive layer.*

To verify these assumed models, we studied whether the under layer (UL) is effective for preventing the charge injection from the substrate into the photosensitive layer. As shown in Figure 3, the OPC with UL increases the level of background fouling. Therefore, we presume that the background fouling is mainly caused due to the positive charge (hole) injection from the substrate.

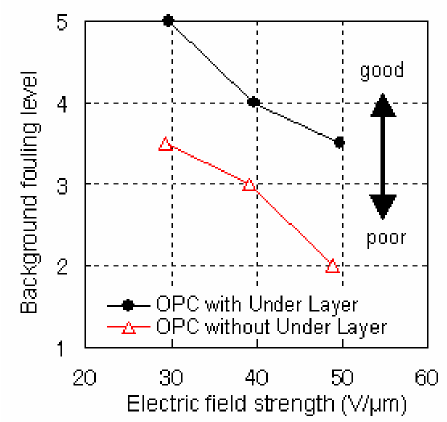

Figure 3. *Electric field strength dependence of background fouling level of conventional OPC with UL and without UL.*

In addition, we studied the effect of the electric field strength on the occurrence of background fouling. The electric field strength is varied by changing the thickness of the CTL of the OPC. As shown in Figure 4, the level of background fouling perfectly correlated with the electric field strength. As the electric field strength increase, the level of background fouling deteriorates.

Consequently, we consider that the following methods are effective for preventing the occurrence of background fouling.

1. Improving hole-blocking ability to prevent the hole-injection from the substrate.
2. Decreasing the electric filed strength to prevent the hole-injection from the substrate.

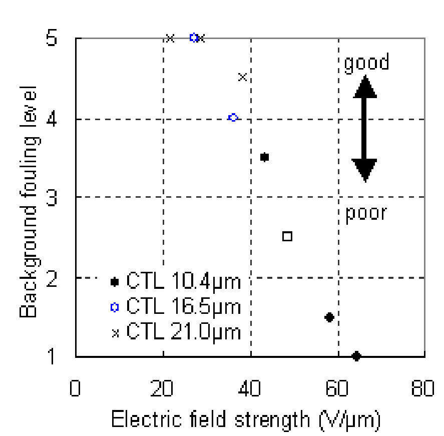

Figure 4. *Electric field strength dependence of background fouling level of conventional OPC, taking thickness of CTL as a parameter.*

Blocking Layer

As mentioned above, one of the main factors causing the background fouling is the increase of hole-injection from the substrate. In the new OPC illustrated in Figure 5, a blocking layer (BL) composed of a resin is arranged between the substrate and the UL in which an inorganic pigment (filler) is dispersed. The BL prevents the hole-injection from the substrate, which increases with repeated use of the OPC. We prepared a new OPC having a BL to which the most suitable materials, layer structures and thickness are applied, and the new OPC is subjected to an electrostatic fatigue test. The result is shown in Figure 6. As shown in Figure 6, the new OPC greatly increases the resistance to the background fouling without causing side effects such as the increase of residual potential. Since the hole-injection from the substrate is prevented by the BL, the maximum thickness of the CTL below which the background fouling seriously occurs can be minimized. (In other words, background fouling does not seriously occur even if the thickness of the CTL decreases by abrasion.) For this reason, usable thickness range of the CTL increases, resulting in lengthening the life of OPC.

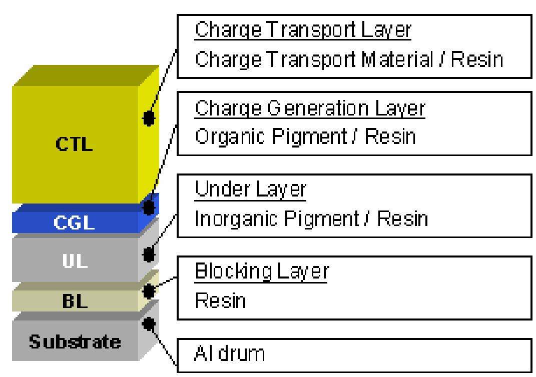

Figure 5. *Schematic structure of new OPC with high durability.*

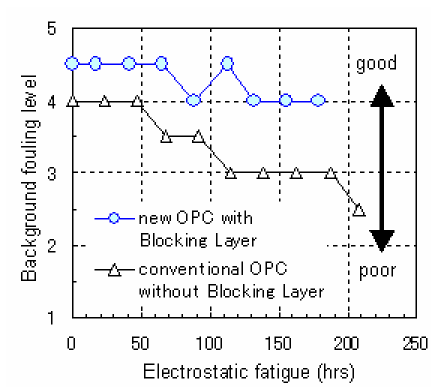

Figure 6. *Electrostatic fatigue test of new OPC.*

Charge Transport Layer

As mentioned above, the other factor causing the background fouling is the increase of the electric field strength. The CTL has the maximum thickness below which the background fouling seriously occurs. In order to increase durability, the new OPC has a CTL including a high-molecular-weight polycarbonate resin which is thicker than that of the conventional OPC.

However, it is technically difficult to form a uniform thick CTL layer. When the OPC is prepared by a dip coating method, it is especially important to prevent a coating liquid from sagging from the upper end of an OPC drum. [4] A layer having a uniform thickness can be obtained by designing a suitable coating device, controlling the viscosity of a coating liquid contained in a coating tank, and optimizing a coating rate.

Optimum cleaning condition

The cleaning system of the Ricoh imagioMP9000/1100/1350 series includes a cleaning brush roller and two cleaning blades configured to remove residual toner particles remaining on the OPC drum rotating at a high speed. The structure is shown in Figure 7.

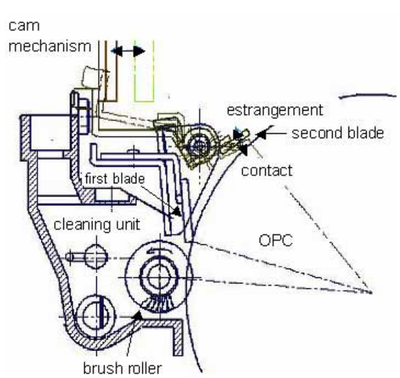

Figure 7. *Cleaning unit of imagioMP1350series.*

Because the cleaning brush roller rotates in contact with the OPC drum, the abrasion of the CTL is accelerated and the life of OPC is largely influenced thereby. In the conventional cleaning system, the cleaning brush roller and the OPC drum rotate in the reverse direction at the contact point thereof. In contrast, in the new cleaning system, these rotate in the same direction at the contact point thereof. Thereby, the abrasion of the OPC is prevented. As shown in Figure 8, the abrasion loss of the CTL can be decreased when the cleaning brush roller and the OPC drum rotate in the same direction at the contact point thereof.

Since the rotation speeds of the cleaning brush roller and the OPC drum are slightly different, the ability to remove toner particles can be maintained. Besides, an attach/detach mechanism configured to move the second cleaning blade toward or away from the OPC is arranged.

Since the second cleaning blade contacts the OPC only at a specific interval, the photoreceptor is prevented from being abraded while residual substances remaining on the OPC is completely removed. As shown in Figure 9, the new cleaning system hardly produces abnormal images even after two millions prints of the image are produced, without deteriorating smoothness of the surface of the OPC.

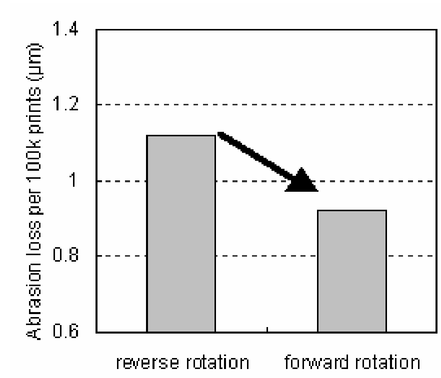

Figure 8. *Abrasion loss of the two cleaning system.*

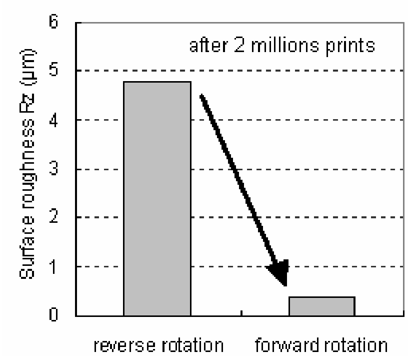

Figure 9. *Surface roughness Rz of the two cleaning system.*

Charge difference in the first rotation

In an attempt to enhance durability of OPC, there is another problem other than the background fouling that the charge amount of the OPC in the first rotation is smaller than that in the second rotation, as the OPC is repeatedly used. The phenomenon is shown in Figure 10.

The assumed mechanisms of the phenomenon as shown in Figure 11 are as follows.

1. Electrons are accumulated in the UL as the OPC fatigues.
2. Holes, which are counter-charges of the electrons, are discharged to the surface of the OPC while the surface is charged in the first rotation.

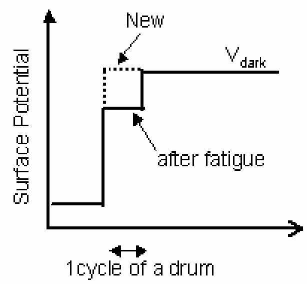

Figure 10. *Schematic illustration of charge difference in the first rotation.*

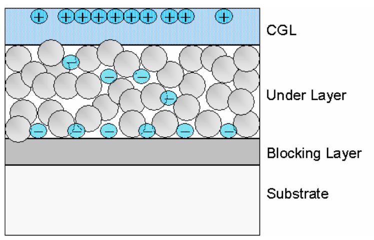

Figure 11. *Schematic view illustrating assumed mechanism of occurrence of charge difference in the first rotation.*

As has been mentioned, the occurrence of background fouling can be prevented by forming the BL which prevents the hole-injection from the substrate.

However, the BL is obstructive when electrons generated in the CGL are discharged to the substrate. As a result, the BL tends to accelerate decreasing the charged amount of the OPC in the first rotation. In the new OPC, the above problem is solved by improving electric conductivity by optimizing the amount of the filler (inorganic pigment) in the UL.

The result is shown in Figure 12. In addition, The charging system in the Ricoh imagio MP9000/1100/1350 series includes two scorotron chargers, that is to say a main scorotron charger and a pre-scorotron charger so as to maintain the charge stability of the OPC.

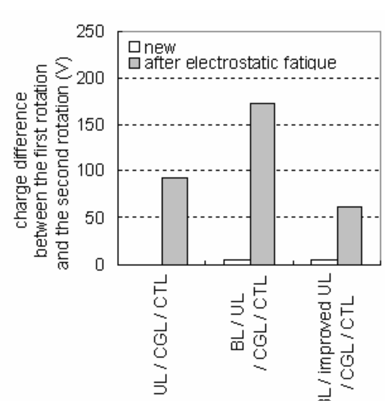

Figure 12. *Charge difference in the first rotation of new OPC.*

Conclusion

We developed a new OPC applied to the Ricoh imagio MP9000/1100/1350 series. The OPC has a life of two millions prints (Letter). The durability of the OPC had been dramatically increased than ever before.

In attempting to increase durability of OPC, we tried to prevent the occurrence of background fouling, which deteriorates with long term of use and largely influences on the life of OPC.

Consequently, our object to lengthen the life of OPC is achieved with the following four concepts:

1. Adopting the blocking layer to prevent the hole-injection from the substrate. Thereby, the maximum thickness of the CTL below which the background fouling seriously occurs can be minimized. (In other words, background fouling does not seriously occur even if the thickness of the CTL decreases by abrasion.) For this reason, usable thickness range of the CTL increases, resulting in lengthening the life of OPC.
2. Increasing the thickness of the CTL so as to decrease the electric field strength. Thereby, the hole-injection from the substrate is prevented, resulting in lengthening the life of OPC.
3. Increasing the thickness of the CTL. Thereby, usable thickness range of the CTL increases, resulting in lengthening the life of OPC.
4. Optimizing the cleaning conditions so that the cleaning brush roller and the OPC rotate in the same direction at the contact point thereof. Thereby, the abrasion rate of the CTL decreases, resulting in lengthening the life of OPC.

References

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Author Biography

Naohiro Toda received the Master of Science in Physics from Keio University, Yokohama Japan in 1997. Since 1997 he has been with the research and development division, Ricoh Company, Ltd., in Numazu, Japan, where he is occupied in for designing photoconductors for new imaging systems.