Analysis of registration measurement method to improve overlay accuracy in offset printing system

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Extended Abstract

In order to shorten the cycle time and cost reduction of manufacturing the electronic devices, printing technology has been studied for the past two decades. In the production of the electronic devices, several layers must be able to be printed step by step and the overlay accuracy between layers is one of important parameters.

In this paper, we investigate the effect of the shape deformation of the printed overlay marks on the printing overlay accuracy using roll to plate type gravure offset printing. As shown in Fig. 1, the printed marks are distorted from the designed marks such as 'o' and '+' due to the printing quality and the deviation of the printed marks from the designed marks results in registration measurement errors.[1]

First of all, the effect of the measurement algorithms is evaluated. For the investigation, two layers are printed as shown in Fig. 2. The second layer is printed at the predetermined distance apart from the first layer using the same printing master to remove the effect of the registration errors caused by printing master. Then, the overlay error is measured by calculating the distance between two marks which were printed by the same mark of the printing master in each layer. Generally, there are two algorithms to calculate the distance between two marks. In the first method, which is called by "edge based method", the position of the mark is calculated as the centroid of the mark boundary that is fitted by the least square method using the edge points of the printed mark. The other algorithm is the image correlation method in which the master image of the marks is registered and the position of the marks is calculated by the best correlated position with the master image. Figure 3 shows the measured overlay error in the test given in Fig. 2 and the measured overlay is varied by the algorithms and mark types even though the overlay is measured using the same printing result. The difference between the measured overlay errors is the smallest in the image correlation method and we can conclude that the image correlation method is more insensitive to the shape deformation of the marks than the edge based method.[2]

In addition, the simulation is performed to find out the mark type which is less sensitive to the shape deformation of the mark due to the printing quality. Because the shape deformation of the marks is occurred randomly, it is assumed that the averaging can be helpful to reduce to the effect of the mark deformation on measuring the position of the mark. For the simulation, the line and space patterns were printed and the pitch is calculated by the image correlation method. As shown in Fig. 5, the distribution of the estimated pitches is larger in the CD (Cross-direction) lines than in the MD (Machine-direction) lines because the printing quality of the MD lines is better than that of the CD lines. The averaging is effective to reduce the effect of the mark deformation and the number of lines is more effective than the line length. Therefore, the pattern like grating is recommended to reduce the effect of the mark deformation.

In conclusion, the shape deformation of the marks due to the printing quality results in the overlay measurement error. The measurement accuracy of the overlay is dependent on the measurement algorithm and the mark type. The image correlation algorithm and the grating mark are less sensitive to the shape deformation of the mark.

[1] T. M. Lee, J. H. Noh, I. Kim, D. S. Kim, and S. Chun, J. Appl. Phys. **108**, 102802 (2010).
[2] M. Bartzsch, et. al., Proc. Digital Fabrication, (2006) 13-16.

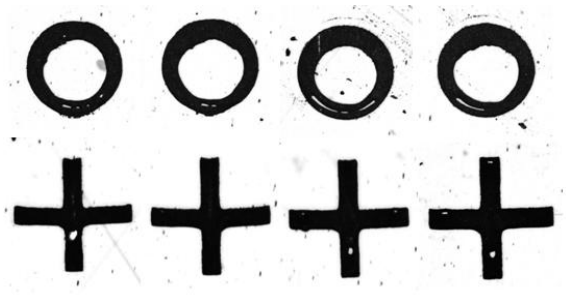

Figure 1 Gravure offset printed overlay marks. The successive printed marks are different every time due to the printing quality.

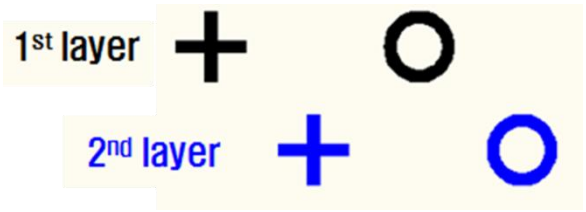

Figure 2. Design of the overlay marks used in the gravure offset printing.

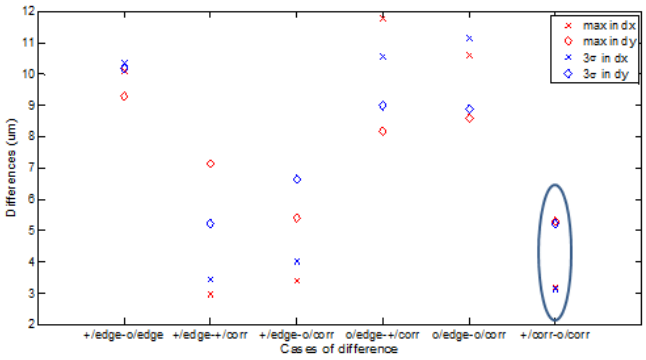

Figure 3. Effect of mark deformation on measuring the printing overlay. Two mark types of ‘o’ and ‘+’ and two algorithms of the edge based method and the image correlation are evaluated.

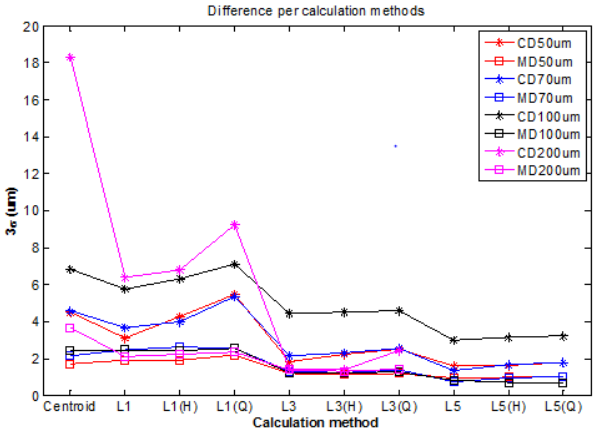

Figure 4. The simulation to find out the mark type which is less sensitive to the shape deformation of the mark.

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