

# Photosensitive Film for HDI Optimized for DI

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## 1 Abstract

Direct imaging (DI) has been introduced into the patterning process of HDI instead of conventional mask contact exposure method. To achieve high throughput equivalent to conventional method, DI needs photosensitive films with high sensitivity. And recent increasing density of HDI requires properties of higher resolution and adhesion. We have been developing and marketing photosensitive films with these properties. In this report, we discuss the design concepts of our products for DI, and the new product (DL-3600 series) featuring less development sludge and smaller stripped flakes.

## 2 Product Features

- A product lineup for various types of DI exposure equipment contributes to increasing throughput.
- Rectangular resist profile has a large margin for resolution and adhesion and improves the yield.
- Less amount of development sludge helps to reduce the maintenance for the developing line.
- Smaller stripped flakes help to reduce the maintenance of the stripping line.

## 3 Background of Development

Layer alignment precision is a critical issue in the patterning process as HDI becomes denser and more multilayered in recent years. DI, which allows high-precision alignment with correction of exposure data based on the substrate dimensions, has been increasingly used. To produce a pattern of [line/space = 40/40  $\mu\text{m}$ ] with a high throughput equivalent to that of the mask contact exposure method, photosensitive DI films for HDI patterning must have resist film thickness of 20 to 30  $\mu\text{m}$ , exposure energy quantity of 10 to 25  $\text{mJ}/\text{cm}^2$ , and resolution of 20 to 25  $\mu\text{m}$  after development. At the same time, they should also meet the requirements for less development sludge and smaller stripped flakes, as conventional photosensitive films, to reduce the frequency of line maintenance.

## 4 Details of Technology

### 1. Optimizing the amount of photo initiator

When the amount of photo initiator is increased, sensitivity is improved. However, the absorbance of the film increases, resulting in an inverted trapezoidal resist which decreases adhesion (**Figure 1**). Our product provides excellent adhesion and high throughput by optimizing the type and amount of photo initiator according to the DI exposure equipment used.

### 2. Optimizing Tg and acid value of hydrophobic binder polymer

Hydrophobic binder polymers can effectively improve resolution and reduce the resist foot (**Figure 2**). Increases in the glass transition temperature (Tg) of hydrophobic binder polymer tend to improve resolution, but decrease the diffusion into the developer and increase the development sludge dose (**Figure 3**). Moreover, decreases in the acid value increase hydrophobicity and improve resolution, on the other hand, stripped flakes become bigger, which may entwine conveying rolls (**Figure 4**). Our new DL-3600 series uses hydrophobic binder polymers with optimized Tg and acid values to provide higher resolution and shorter resist foot while achieving less development sludge dose and smaller stripped flakes.

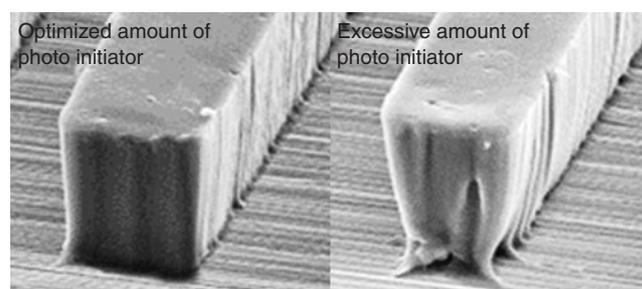


Figure 1 Relationship between amount of photo initiator and resist profile

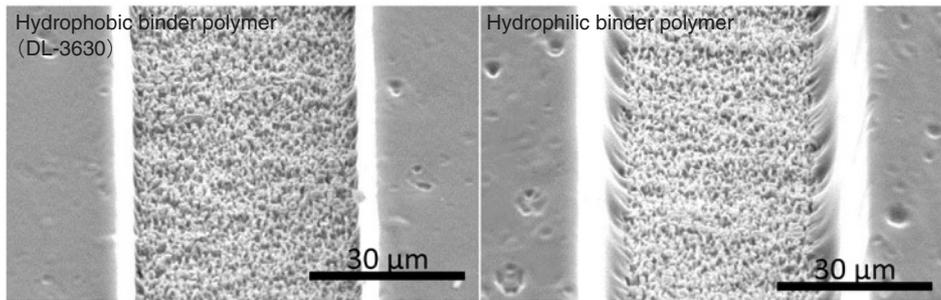


Figure 2 Relationship between hydrophobicity of binder polymer and resist foot length

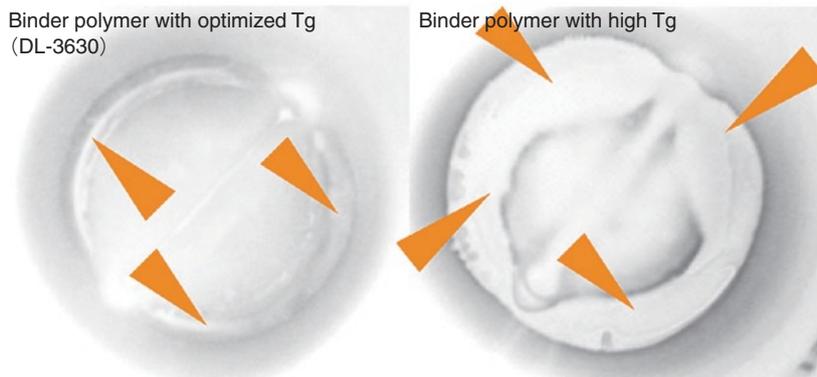


Figure 3 Relationship between Tg of binder polymer and development sludge dose (▶ sludge)

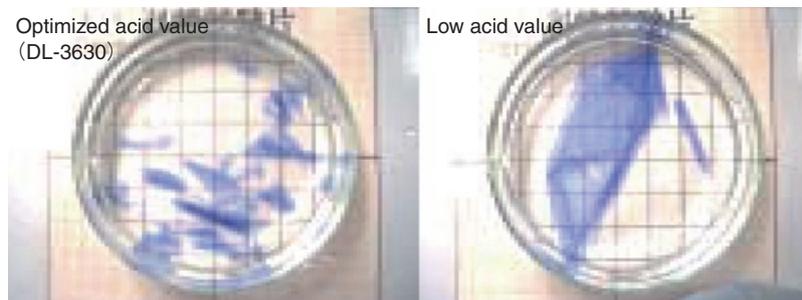


Figure 4 Relationship between acid value of binder polymer and stripped flake size

## 5 Future Developments

Development of DI photosensitive films for next-generation HDI (wiring pattern of line/space = 30/30 μm)

### [References]

- 1) Hirakawa: In-Depth Discussion of Direct Imaging Technology, 12, (2013), Electronics Journal