High Refractive Index Positive Tone Photo-sensitive Coating

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1. Introduction
High refractive index photosensitive coating is developed. It shows fine patterning feature and good round shape. The coating is ideal for micro lens on CCD and CMOS image sensors due to those patterning properties.

CCD and CMOS image sensors are getting popular for image processing applications such as digital camera, PC, car sensors and so on. Recently photo detective area of those CCD and CMOS sensors are small due to requirements of fine pixel resolution and fine feature size. In order to obtain good sensitivity, photon to the sensors should be concentrated on its photo detector area. To concentrate on the photon, fabricating micro-lens on the photo detective area is investigating [1]. To make good lens, high refractive index compound is desired. To meet those requirements, inorganic compound, such as silicon nitride, titain oxide is popular. However those inorganic compounds are difficult to obtain good lithographic pattern. Photo imagable high refractive index coating is desired to save manufacturing processes.

There is some high refractive index photo sensitive coatings were reported [2]. Most of them show 1.55-1.7 refractive indices. Comparing to titan oxide, and silicon nitride, those refractive indices are still small.

We developed polyimide base high refractive index positive acting photo imagable coating with good transparency at visible wave length range.

2. Method
2.1 Refractive index measurement
FE-3000 (Otsuka) was used to measure the refractive index. TE and TM mode of refractive indices were obtained by the machine.

2.2 Patterning processes of posi PSPI
The obtained PSPI solution was coated by spin coater (Tokyo-electron Mark-7) on 6inch Si wafer.
The coated wafers were baked at hot plate (120 °C for 120 sec, Tokyo-electron Mark-7)
The baked wafer was exposed UV energy through a reticle by DSW-8750 i-line stepper (GCA).
The exposed wafer was developed by 2.38% tetrarmethyl-ammonium solution (TMAH) using Mark-7.
Film thickness of coated wafer was about 5 μm. After baking, thickness was measured by STM-802 (Dainippon Screen MFG).

Table 1 Curing temperature dependence on refractive index and transparency

<table>
<thead>
<tr>
<th>Curing conditions (#)</th>
<th>R.L. (632nm)</th>
<th>Transparency (%/4um)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200°C × 5min</td>
<td>1.76</td>
<td>93</td>
</tr>
<tr>
<td>220°C × 5min</td>
<td>1.79</td>
<td>97</td>
</tr>
<tr>
<td>250°C × 5min</td>
<td>1.79</td>
<td>97</td>
</tr>
<tr>
<td>280°C × 5min</td>
<td>1.80</td>
<td>95</td>
</tr>
</tbody>
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*In atmosphere: Lower curing temp possible because of HP cure

Fig. 1 Wavelength dependency on refractive index

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The baked wafer was exposed by broad band aligner (Canon PLA-501) with 1000 mJ/mm² (at 365 nm) through a gray-scale mask.

After the development thickness was measured by STM-802. Developed pattern was observed by optical microscopy.

The developed wafer was treated at 140 °C for 30 min then heating to 280 °C with a rate of 5 °C/min. Then the wafer was treated by 280 °C for 1 hr by using INH-21CD (Koyo-thermosystem).

Typical patterning process is summarized in Table 3.

**Scanning Electron Microscopy (SEM)**

SEM measurement was carried out after curing the developed wafer to obtain cross-sectional view of lithographic pattern.

## 3. Results

**Photolithographic properties**

As shown in Table 1, the coating shows quite high refractive index with good transparency. Fig. 1 shows the wavelength dependency on its refractive index. Fig. 2 shows wavelength dependency on its transparency. The coating shows high refractive index with good transparency.

We obtained a good positive tone lithography pattern by ordinary photo lithographic process. As shown in Table 2, the coating shows high refractive index and good round pattern profile. This is suitable for micro lens application for CCD and CMOS image sensors area. The typical patterning process is summarized in Table 3. Fig. 4 is rotation speed dependency on its film thickness.

The coating shows high refractive index as well as good transparency. In addition, the coating shows good pattern profile for micro-lens application for CCD and CMOS image sensor.

**References**

1. Japanese patent No.2000-164837
2. Japanese patent No.1994-18702