P-136: Novel In-cell Retarder of Alkali Development Type

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Abstract
A patterned retarder is important in LCDs and 3D displays. As for the patterning method of retarder, developing in Alkali aqueous solution was very difficult. We have developed the patterned retarder consisting of UV-curable liquid crystal materials of the new type that developing is possible in Alkali aqueous solution.

1. Introduction
Retarder films are very important to make high performance liquid crystal displays (LCDs). Recently, a lot of efforts have been made to put retarders in LCDs (VA LCDs, IPS LCDs), and make it possible to replace the external retarder with in-cell retarder. Furthermore patterning of in-cell retarder makes it to improve brightness and contrast ratio of LCD panels [1-8].
In addition, patterning of retarder can apply to micro-retarder for 3D displays.
The patterned retarder can be obtained by in-situ photo-polymerization of UV-curable liquid crystal materials through a photo mask then developing of non-polymerized region by using the solvent.
An organic solvent is the most effective to a solvent of the development process, and development by using Alkali aqueous solution was very difficult. However from the viewpoint of environment and safety, the Alkali aqueous solution which seems to be used in color filter process is an ideal.
We have developed the retarder consisting of UV-curable liquid crystal materials (RO-001) of the new type that the developing was possible in alkali aqueous solution. In this paper, we will show the properties of patterned retarder by using Alkali development.

2. Results

2.1. Processes of patterned retarder
Figure 1 presents process to make the retarder. The detailed process was prepared by the following procedures.

1) UV-curable liquid crystal materials (RO-001) were coated with spin coater.
2) The coated substrate was dried on a hot plate.
3) After dried, the obtained layer was cooled to room-temperature, and exposed UV-light with photo mask in air.
4) Non-polymerization region is developed by using an Alkali aqueous solution ($NaHCO_3$aq).
5) The obtained patterned layer was heated high temperature (Post bake).

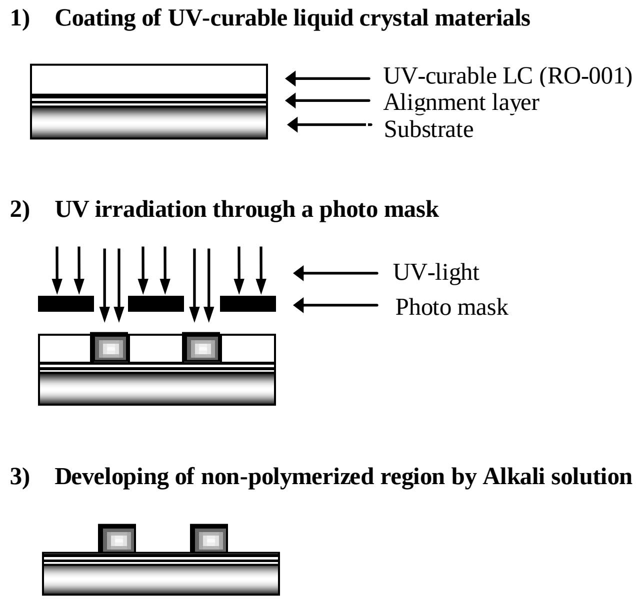

Figure 1. Preparation processes of the Patterned retarder.

2.2. Properties of retarder materials
Table 1 shows the properties of the retarder of Alkali development type that we developed. The development of the alkali development type of Positive C-plates, Negative C-plates and O-plates in addition to positive A-plates retarder is also possible.
Figure 2 shows the value of spin speed against retardation. Retardation such as quarter wave or half wave can be adjusted by control of spin speed.

Table 1. Properties of the UV-curable LC materials.

Name	RO-001
Clearing point	90 ℃
Δn (Re/d $_{550nm}$)	0.12
Firm optical geometries	Homogeneous
Solvent	Cyclopentanone
Remarks	Alkali development type

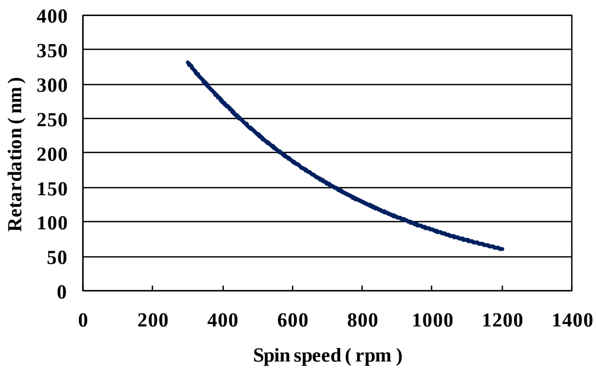

Figure 2. Dependence of spin speed on retardation of the retarder.

2.3. Photolithography properties of retarder

We confirmed whether patterning of retarder was possible with $NaHCO_3$ aqueous solution as an alkali developer. The concentration of $NaHCO_3$ aqueous solution is 0.1 %.

Figure 3 shows residual thickness ratio against expose dose. In low expose dose, the film thickness is maintained > 90%, and even if the developing time is changed, the tendency is similar.

Figure 4 shows Retardation against expose dose in quarter wave film. It saturates it with a low expose dose as well as residual thickness ratio, and the influence on Retardation by the change in the developing time is not seen. In these results, we confirmed that patterning of retarder was possible with $NaHCO_3$ aqueous solution.

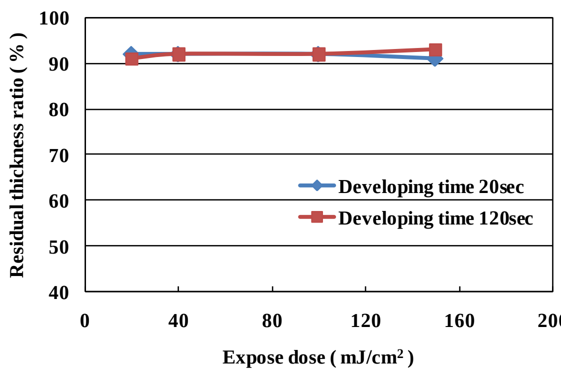

Figure 3. Dependence of residual thickness ratio on Expose dose in change of developing time.

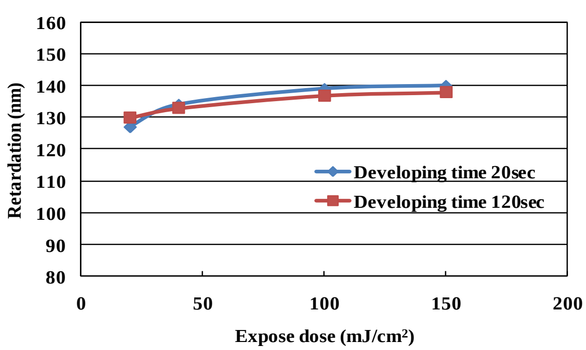

Figure 4. Dependence of retardation on expose dose in change of developing time.

2.4. Thermal stability of retarder

We measured thermal stability of retarder made of RO-001 at high temperature.

Figure 5 plots retardation normalized by initial value against heating time at 230℃. In the results, we confirmed high thermal stability > 95% after 120 minutes.

In addition to thermal stability, we measured transmittance of retarder made of RO-001 at high temperature.

Figure 6 plots transmittance against heating time at 230℃. In the results, we confirmed high transmittance > 95% after minutes (Film thickness is ca. 2.5 μm).

In these results, it is possible enough to use retarder of RO-001 as in-cell retarder.

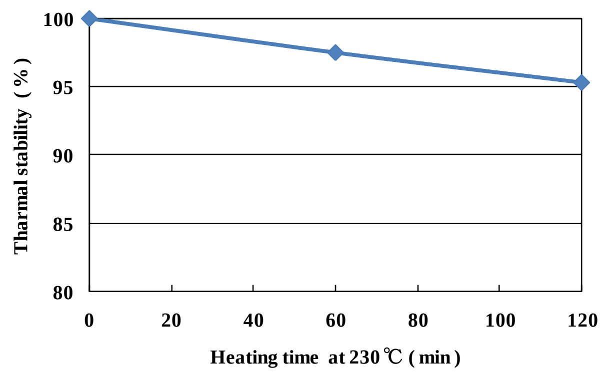

Figure 5. Thermal stability of the retarder at 230 ℃.

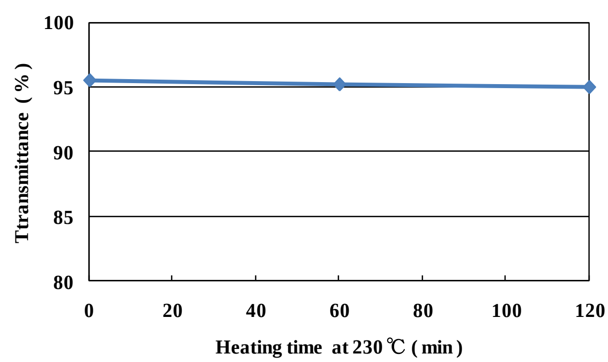

Figure 6. Transmittance (400 nm) of the retarder at 230℃.

2.5. Patterned of RO-001 retarder

Figure 7 shows example of Polarizing microscopic photograph of patterned retarder with various width of pattern (Line / Space = 1 / 1). The resolution of the pattern is about 15μm. It is thought that resolution improves further when processes condition and modify materials are optimized.

Figure 8 shows example of SEM image of patterned retarder. In the results, we confirmed that patterning shape of retarder, and patterning was possible with Alkali aqueous solution.

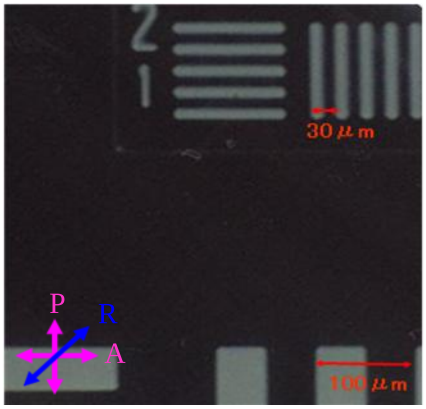

Figure 7. Polarizing microscopic photograph of the Patterned retarder prepared by Alkali development under crossed polarizers.

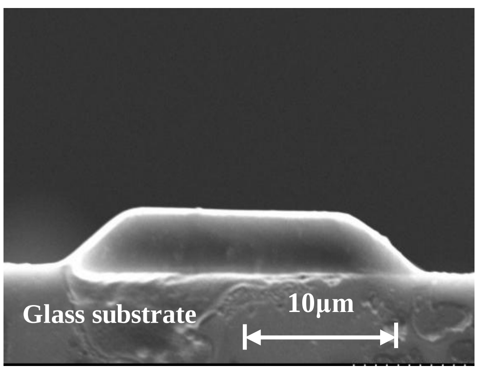

Figure 8. SEM image of cross sectional shape of patterned retarder.

3. Conclusions

We have developed the retarder consisting of UV-curable liquid crystal materials of the new type that the developing is possible in Alkali aqueous solution.

The photolithography properties of the retarder were goods, and it was able to be confirmed that the value of thermal stability and transmittance were also high.

The Patterned retarder that we developed can apply to in-cell retarder for transflective LCDs, and to micro-retarder for 3D displays.

4. References

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