NANOIMPRINTING MATERIAL FOR LIQUID CRYSTAL ALIGNMENT

Dong Ho Kim, Jin Hyuk Kwon and Jin Seog Gwag

Department of Physics and Institute of Photonics and NanoTechnology, Yeungnam University, Gyeongsan 712-749, Korea

Introduction

Nano-imprinting lithography (NIL) has been applied to various areas of electronics, photonics, and magnetic device such as nanoelectronic device, thin-film transistors, organic lasers, and organic electro luminescent display, and magnetic disc because it can produce more easily and simply nanosize patterns with high-throughput and high precision [1, 2].

The surface grooves with a suitable pitch and depth align liquid crystal (LC) very well [3]. NIL can generate the grooves stably and precisely with such a pith and depth to align LC. Thus, NIL enables us to precisely control the surface anisotropic direction and the surface anchoring strength by controlling the pitch and the depth on a mold, which is hardly possible in the conventional rubbing process. We also can easily obtain optically excellent muti-domain shapes in a pixel of a LC panel resulting in a nematic LC bistability [4, 5] by using NIL. A crucial issue to promote LC application of NIL is the choice of appropriate material, which should have good imprinting characteristics under lower pressure and temperature and good LC alignment characteristics with high anchoring energy.

A new material for the application of NIL to liquid crystal devices has been developed. For the application of liquid crystal devices using the process of NIL, new NIL materials are required; the surface layer should have a property of strong LC anchoring as an LC alignment layer and the bulk layer should be soft enough for NIL. We have proposed a hybrid type functionally graded material tailored for LC alignment. The material composed of a polyimide (PI), a polyester amic acid (PEA) and an epoxy resin (ER), perfectly fulfills such required properties.

In this report, we will report the results of nanoimprint lithography experiment using the hybrid polymer (HP) the practical applicability as an LC alignment layer. We also examine the potential LC applications of the HP material through electro-optic characteristics in twisted nematic mode (TN) with the nanoimprinted grooves on the HP surface.

Experimental

A new polyimide material was spun on a general slide glass with the size of 2 cm x 2 cm. The hybrid type material consisted of polyester amic acid and a kind of epoxy resin with solvents of N-Methylpyrrolidone/Ethylene glycol butyl ether/γ-Butyrolactone= 59/33/8. After spin coating, the substrate with the new polymer film was baked on hot plate at 80 °C for 3 min for removal of solvents and prebaked at 165 °C for 10 min for epoxy resin cross-linking reaction. The post baking for polyimidization reaction was performed for 30 min at 220 °C on the hard and flat metal plank upholding the sample in imprinting equipment. The thickness of the new polymer film was in 800~1000 nm in the condition of 20 seconds in 3000 rotations per minute on spinner.

Result and Discussion

Figure 1 illustrates the pitch and the height of the patterns on the HP substrate transferred from the mold with 200 nm in pitch and 110 nm in height for linear-type pattern. The mold patterns were clearly imprinted into the film having the mirror image of the mold. Therefore, we know

HP film shows excellent capability as a nanoimprinting material.

Figure 2 shows the microscopic optical images of a dark state and a bright state in a TN and IPS LC cells made of nanosized groove pattern on the HP film substrate. The image in Fig. 3 shows very uniform darkness indicating that the nano-size grooves in this system well align the LC molecules. One of the most important issues in LC alignment by NIL is pretilt angle control. The pretilt angle of LC cell with HP alignment layer treated by NIL might be not zero because we could not find any discrimination lines in the dark state under electric field in TN cell. Perhaps, it may be the nature of the polyimide in HP film raising LC. Addition of hydrophobic side chain which has been used for higher LC pretilt angle into polyamic acid may be a useful method to get higher LC pretilt angle in NIL. Consequently, this material shows an excellent capability compatible with NIL and LC alignment.

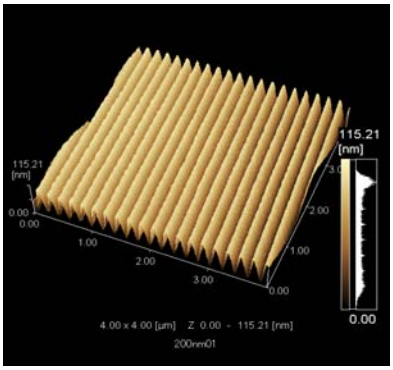

Fig. 1 AFM image of a linear nano-groove on the HP film

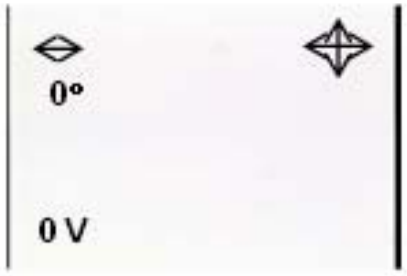

Fig. 2 Bright image of TN cell

Fig. 3 Dark image of TN cell

Conclusion

As a new approach for nanoimprint lithography (NIL), we report that a hybrid type polymer (HP) nanoimprinting material is suitable for the LC alignment on a grooved surface. LC cell using a HP material showed stable electro-optic characteristics in twisted nematic mode suggesting that HP film has an excellent capability compatible with NIL and LC alignment.

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References

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