Fabrication of V-grooved Mold for the Light Guide Plate of TFT-LCD with MEMS Technology

Woonseob Lee, Manhee Han, Sung-Keun Lee, and Seung S. Lee

Department of Mechanical Engineering, Pohang University of Science and Technology
Pohang, Kyungbuk 790-784, Korea
Phone : +82-54-279-8210, E-mail : wslee@postech.ac.kr

Abstract

We present a novel fabrication method for a V-grooved mold of the light guide plat of TFT-LCD with MEMS technology. This method is performed by the inclined UV lithography and Ni electroplating unlike the previous mechanical processing technique. V-grooves with different dimension can be made simultaneously with single photomask.

1. Introduction

In recent years, liquid crystal display (LCD) is applied to information devices and visual devices including personal computers, cellular phones, etc., because of thin, light, and low power-consuming properties of flat panel displays. Now, LCD is an indispensable component for the progress of visual-information society, and the market of LCD is expanding rapidly[1-5].

Unlike CRT, PDP, and EP, LCD is unable to emit by itself; hence, requires an alternative light source, a back light unit (BLU). Fig. 1 shows the structure of a side light type BLU. In the BLU, a light source is arranged on the end surface of the light guide plate (LGP), made of acrylic resin and etc.. A light is irradiated from the end surface of the same plate, and the light reflected from the dot pattern or V-grooves on the LGP bottom surface or the reflection sheet, attached to the bottom, goes out to the top surface of the LGP[6].

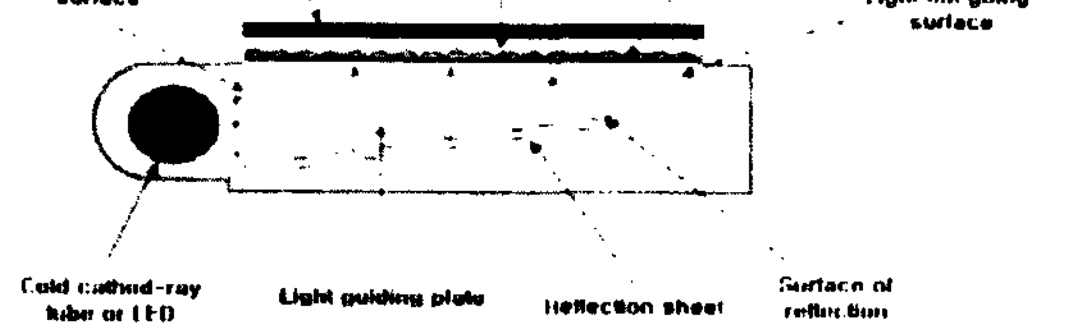


Figure 1. Structure of side light type BLU.

Methods for producing LGP is divide into two categories: print type LGP and printless type LGP. The print type LGP includes screen print and etc., and the printless type includes direct mold injection, scattered LGP, and etc.. Recently, there is the demand to produce multifunctional LGP, which includes the prism sheet as well as the basic components of BLU. To produce the multifunctional LGP, it is necessary to develop a printless type LGP using an injection molding technique. Since conventional screen print and V-cutting method would not be able to yield the satisfactory result.

However, it is extremely costly and time consuming to produce V-grooves by precision mechanical processing, and the precision of products would not merit these effort[7].

Therefore, we report a new method for fabrication V-grooved mold by inclined UV lithography. The inclined UV lithography is used for the fabrication of 3D microstructures in MEMS field[8], and it is expected to be the more effective method to produce a precise mold than other mold processing techniques.

2. Fabrication

This process, the inclined UV lithography, is similar to a LIGA process. LIGA is the German acronym for X-ray lithography (X-ray LIthographie), electroplating (Galvanoformung), and molding (Abformtechnik). The process involves a thick layer of X-ray resist , which is ranged from ㎛ to cm, and high-energy X-ray radiation exposure and development to arrive at a 3D resist structure. Following electro-deposition, electro-plating fills the resist mold with a metal and, a free standing metal structure results after resist removal. The metal shape may be a final product or serve as a mold insert for precision plastic injection molding[9]. Fig. 2 shows typical LIGA process and inclined LIGA process.

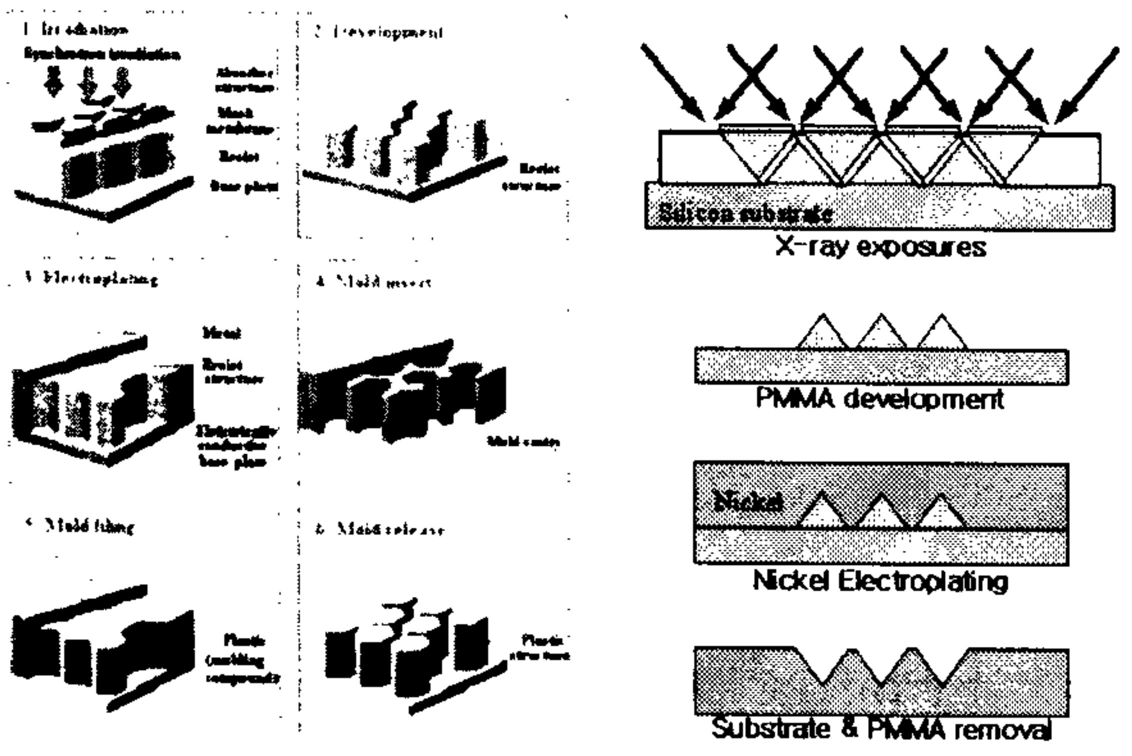


Figure 2. LIGA process.

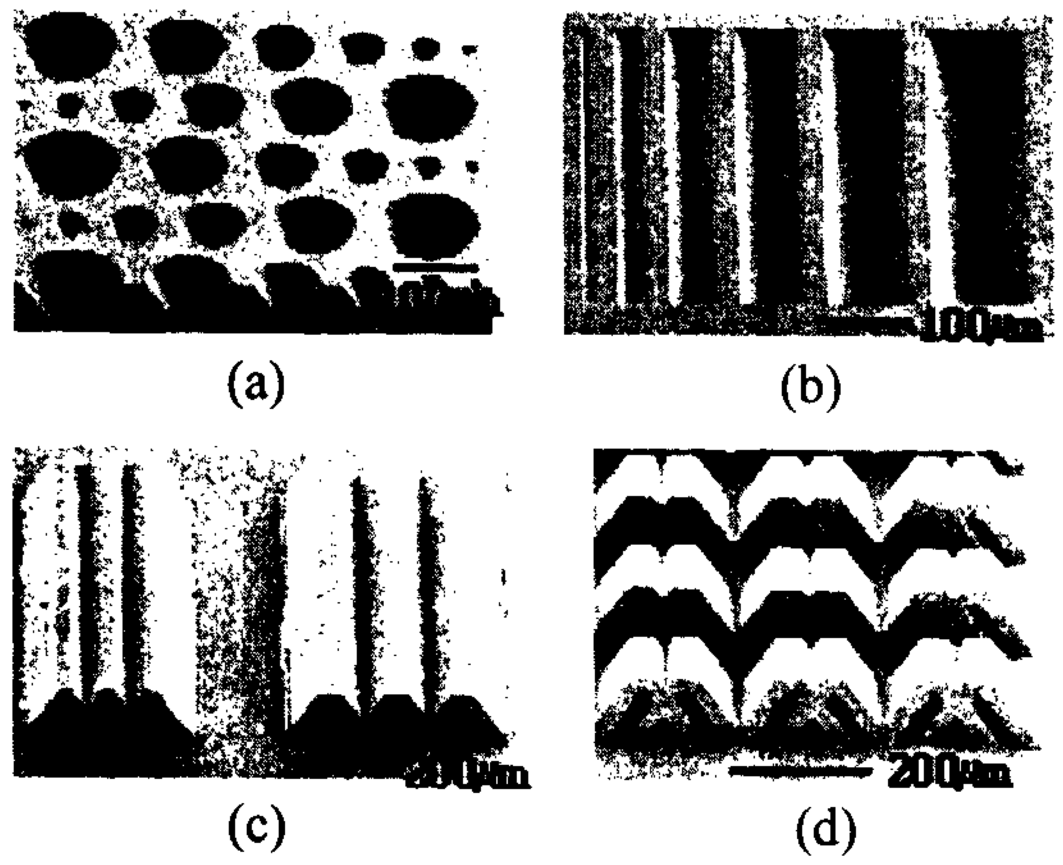


Figure 3. Results of the microfabrication of 3D positive oblique structures.

The difference between the LIGA process and the inclined UV lithography is a source for exposure. A deep X-ray is used as a source for the LIGA, and a UltraViolet ray (UV) is used for the inclined UV lithography. Although the intensity of UV is weaker than X-ray, the better surface roughness can be achieved for producing inclined structures.

Fig. 3 shows the results of the microfabrication of 3D negative(a, b) and positive(c, d) oblique structures. It can be affirmed that very fine microstructures including V-groove could be produced by the inclined UV lithography.

Fig. 4 shows a fabrication process of V-grooved mold for LGP of TFT-LCD. The process starts with 4 inch, N-type(100) wafer. The substrate is coated with SU-8 negative photoresist of 60~70 ㎛ thickness.

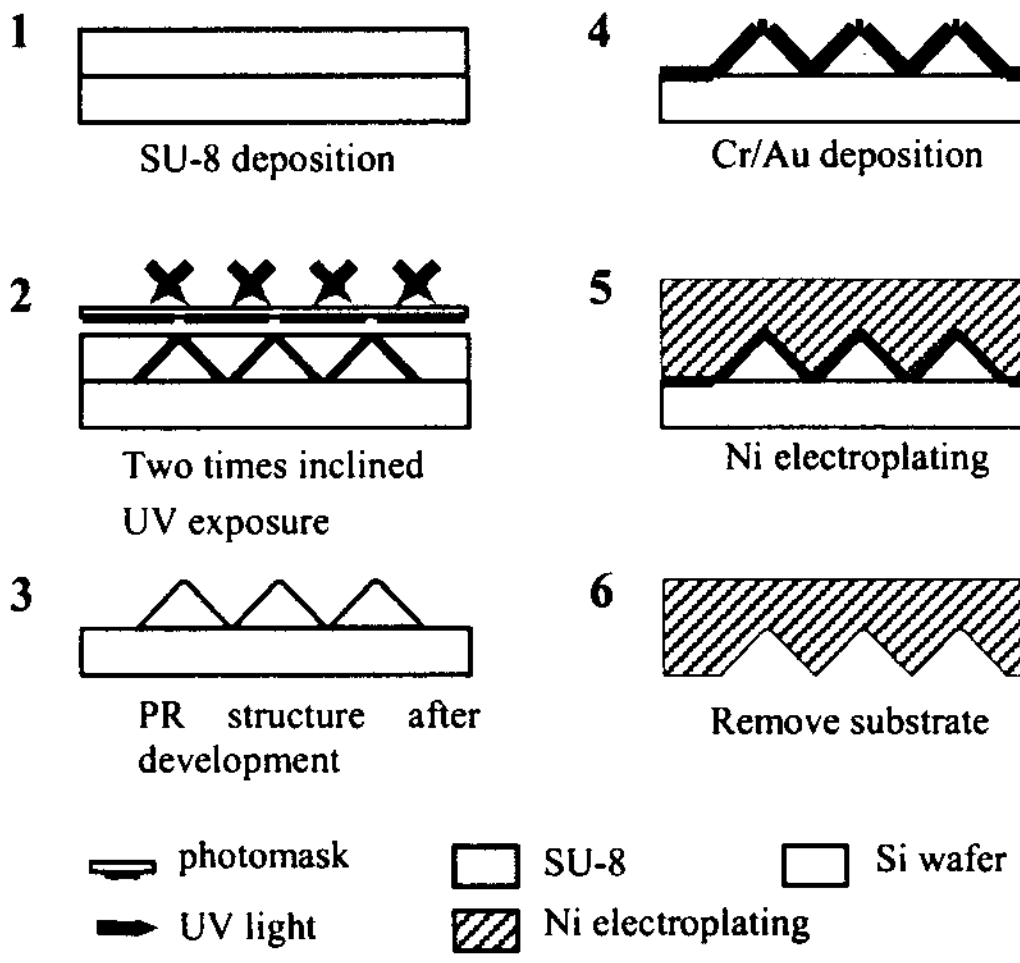


Figure 4. Fabrication sequence of V-grooved mold insert for LGP.

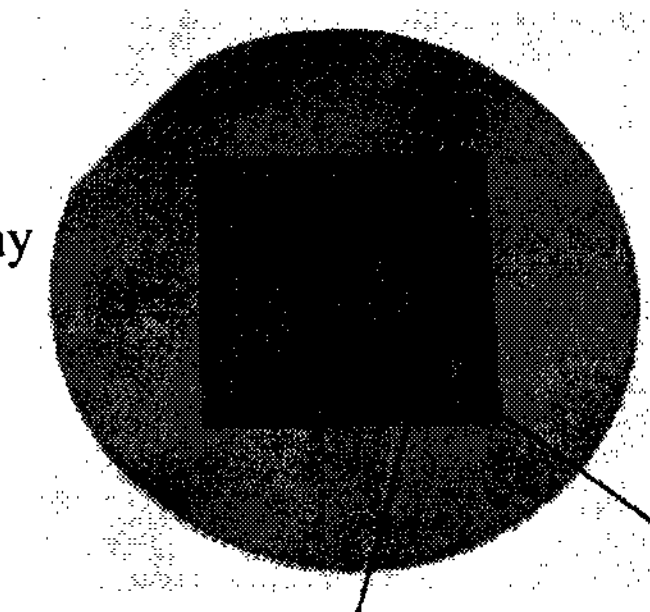
UV light expose two times with angle 40~70°. After exposing the UV light, the unexposed SU-8 is developed with AZ400K. On the developed SU-8 layer, 0.1 ㎛ thick gold(Au) layer is thermally evaporated as a seed layer for electroplating after 0.03 ㎛ thick adhesion layer of Chromium is thermally evaporated. Based on this structure, the Nickel mold will be electroplated.

3. Results

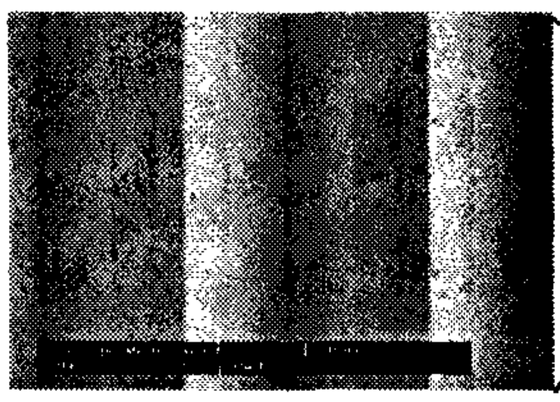
It is impostant to know what are main parameters in V-grooves fabrication process in order to design the configuration of V-grooves. It is revealed by experiments that the shape of V-grooves depends on the dose on SU-8. The SU-8 with 60~70 ㎛ thickness is exposed to doses from 360 mJ/cm^2 to 480mJ/cm^2. Increasing the dose, the width of top side becomes broader more and more, but the shape of V-groove is destroyed during development as the dose is less than necessary dose. In this research, the optimizing condition is 420 mJ/cm^2.

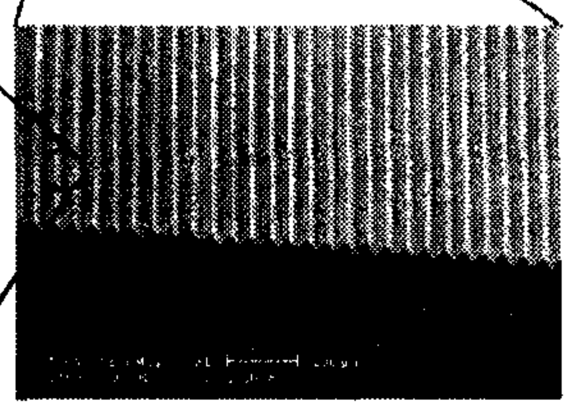
V-grooves with eight different dimensions are manufactured with single photomask. Fig. 5 shows results of the fabricated V-grooves and their SEM images. A smooth surface is observed with SEM image in Fig. 5 (b). Fig. 6 shows SEM images of V-grooves with different pitches between 12~60 ㎛. The configuration is not clear in the pattern under 10 ㎛ as shown in Fig. 6 (d). Based on the present research, it is possible to fabricate the pattern with more than 30 μm-sized pitch.

A height of V-grooves is changed though the variation of an inclined angle from 55° to 75° in Fig. 7. The V-grooves with various angle could be produced by using this method.



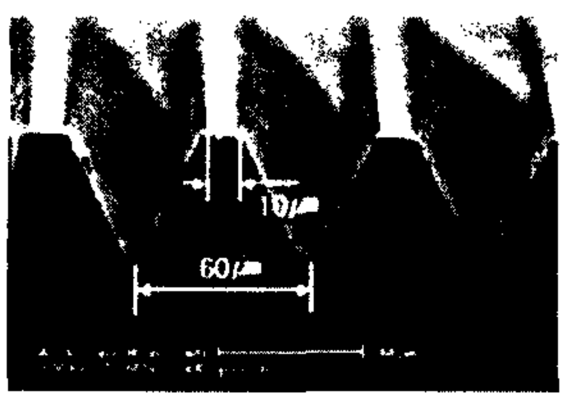
(a) Photography (4" wafer)



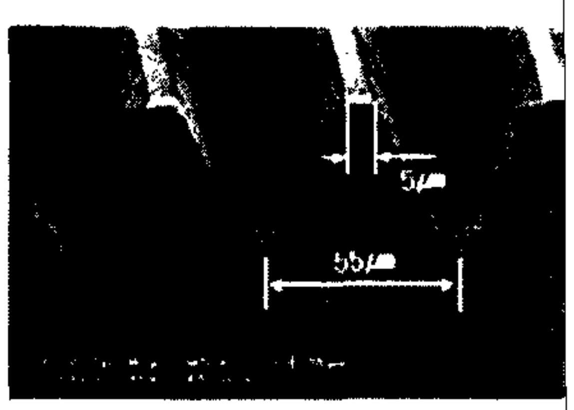


(b) SEM Image(1000x) (c) SEM Image(80x)

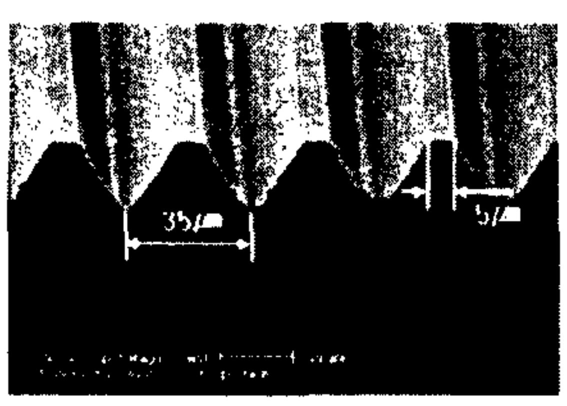
Figure 5. Images of the fabricated V-groove.



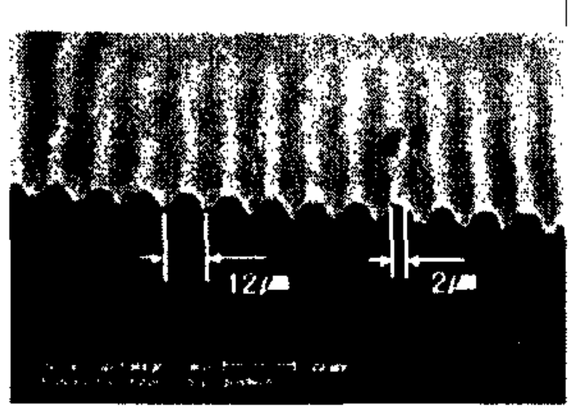
(a) 650x



(b) 800x

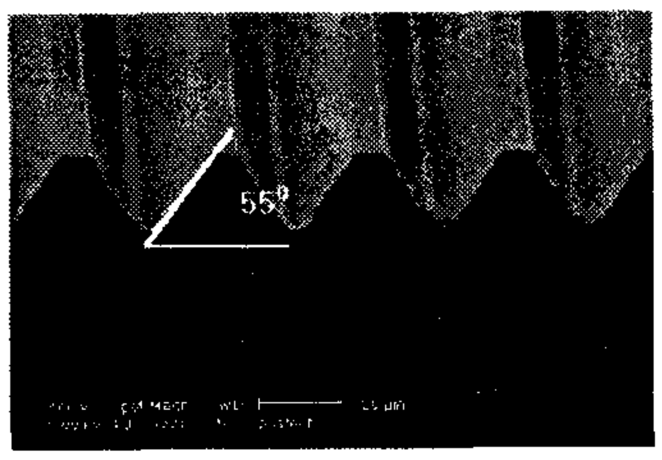


(c) 800x

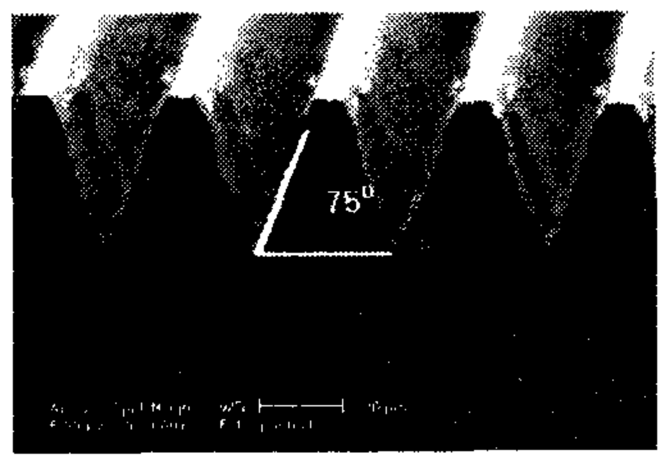


(d) 800x

Figure 6. Images of the V-groove with different dimensions.



(a) 800x



(b) 800x

Figure 7. Images of the V-groove with different angle.

4. Conclusion

The V-grooved mold has been developed with inclined UV lithography for TFT-LGD. V-grooves with different dimensions are manufactured with single photomask. It is possible to fabricate the different pattern with more than 30μm-sized pitch. A height of V-grooves is changed though the variation of an inclined angle: 55° to 75°.

5. Acknowledgement

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6. References

[1] M. Katayama, Thin Solid Films, 341, 1999, 140
[2] S. Hotta et al., Japan Display, 1986, PD3
[3] T. Unate et al., Japan Display'89 Digest, 1989, P434
[4] C. Tombling, Synthetic Metals, 122, 2001, 209
[5] S. Naemura, Displays, 22, 2001, 1
[6] S. S. Kim et al., Display technology Ⅰ, Cungbum Press, 2000, 269
[7] Optomine Co. Ltd., Semiconductor Monthly, 6, 2002, 19
[8] C. Beuret, G.-A. Racine, J. Gobet, R. Luthier, and N. F. de Rooij, MEMS'94, 1994, 81
[9] E. W. Becker et al., Naturwissenschafien, 69, 1992, 520