Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Fine Structure of Micro-Groove for the Display System Ruled by Ruling Engine

Matsuo Sato [a] , Tomohiro Tanaka [a] , Isao Nakamura [a] , Hidehiro Seki [b] & Makoto Ishiyama [b]

[a] Department of Mechanical Engineering

[b] Department of Electrical and Electronic Engineering, Hachinohe Institute of Technology, 88-1, Myo-Ohbiraki, Hachinohe, JAPAN, 031-8501

Version of record first published: 24 Sep 2006

To cite this article: Matsuo Sato, Tomohiro Tanaka, Isao Nakamura, Hidehiro Seki & Makoto Ishiyama (2001): Fine Structure of Micro-Groove for the Display System Ruled by Ruling Engine, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 367:1, 779-784

To link to this article: http://dx.doi.org/10.1080/10587250108028700

Mol. Cryst. and Liq. Cryst., 2001, Vol. 367, pp. 779-784
Reprints available directly from the publisher
Photocopying permitted by license only

Fine Structure of Micro-Groove for the Display System Ruled by Ruling Engine

MATSUO SATO[a*], TOMOHIRO TANAKA[a], ISAO NAKAMURA[a], HIDEHIRO SEKI[b] and MAKOTO ISHIYAMA[b]

[a]*Department of Mechanical Engineering and* [b]*Department of Electrical and Electronic Engineering, Hachinohe Institute of Technology, 88-1, Myo-Ohbiraki, Hachinohe, JAPAN, 031-8501, URL*

In recent years, liquid crystal display with less power of the display consumed is very important problem. In this paper, it is denoted that the front light system for emitting the daily light with the ultra-low power consumption type is developed. It is a purpose of this paper to apply to the front light by cutting of the minute groove (optical grating), and scratching on the ITO film. In the experimental method, ultra precise cutting machine called "RULING ENGINE" is used. Micro-groove of high-density marked line is cut on aluminum thin film (evaporated), copper film (plated) and ITO film (sputtered) which are prepared on the glass substrates.

Diamond cutter with the profile specially shaped in the cross section is prepared. The cross section of the diamond cutter shape is accurately transferred to the micro-groove.

Marked line is succeeded in the groove of 0.4 μm pitch (2500 lines per mm) in the minimum, and of 0.2 mm pitch (5 lines per mm) in the maximum in pitch length. Using Michelson interferometer and feedback control system, the accuracy of the feed step completed 0.078 μm in pitch length. It is shown that characteristics of reflective light distribution by the groove are flat under adaptive condition in front light.

Keywords: fine structure; micro-groove; ruling engine; front light

1 INTRODUCTION

Though the optical grating which is ruled the minute groove (name is abbreviated with the micro-groove in the following) cut by diamond tool in a metallic thin film is developed in order to use for spectrum analysis of spectro-

* http://www.hi-tech.ac.jp, E-mail; sato@hi-tech.ac.jp

scopy, etc. It is denoted that a standard groove in this study is to prove the optical and electronic characteristics of the liquid crystal device.

The fine processing of such micro-groove is carried out, and the mechanism of fine processing is analyzed according to the finite element program. The groove for the front light of LCD is produced using high-density marked ruling machine (ruling engine).

Diamond cutter installed in this ruling engine is shown in FIGURE 1. In this figure, on a detail drawing of the edge of the diamond, tip radius of the cutter is 100nm or less, and the surface roughness is less than nano meter. The cutter is shaped as the ship bottom type at circular arc radius 100 mm.

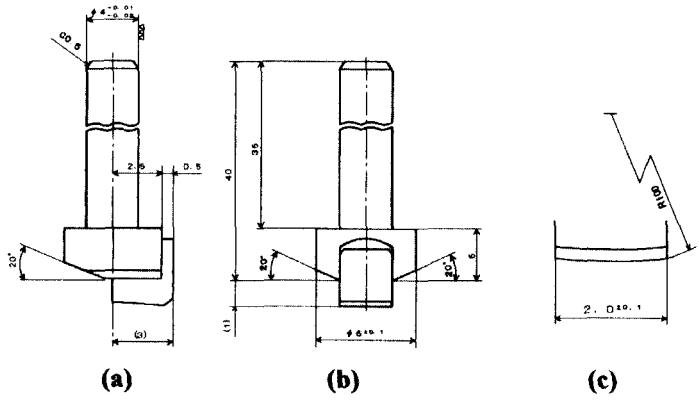


FIGURE 1 (a) Front view of diamond cutter
(b) Side view of the cutter
(c) Enlarge of the cutter edge

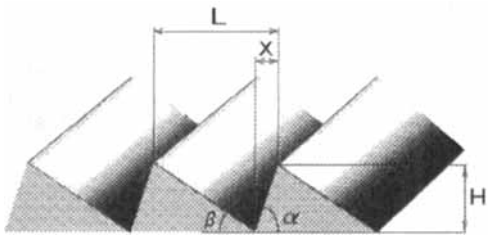


FIGURE 2 Schematic diagram of micro-groove

2 CROSS SECTION OF GROOVE

As shown in FIGURE 2, the profile of groove is the same as saw-tooth with groove pitch L, the groove height H, two slopes with angle of the steep slope α and gentle slope β.

3 RESULTS OF GROOVE CUTTING

TABLE 1 shows the materials tested in this study.

3-1 Aluminum Film Evaporated

The micro-groove on aluminum film observed by differential interference microscope is shown in FIGURE 3. In the figure, minimum groove pitch of 0.79 μm are able to be realized as a result of confirming an extreme pitch in this study.

3-2 Copper Plated Film

FIGURE 4 is processing example of the front light groove.
Shapes conditioned as micro-groove for the front light are next 4 items.

1. There is no burr on all edge portions.
2. Slopes with the angles α and β in FIGURE 2 are the roughness of nanometer order.
3. Groove pitch L is made to be any of 50 μm, 100 μm and 200 μm.
4. Cross sectional shape of the groove continues as saw-tooth.

TABLE 1 Tested materials

Materials	Processing	Film Thickness	Dimension [mm]
Al	Evaporation	2μm	50*50*4.8
Cu	Plated	15μm	50*50*4.8
Cu	Sputter	15μm	50*50*4.8
Acrylic resins	———	———	50*70*2.9
ITO	Sputter	Less than 100nm	50*50*2.8

FIGURE 4 (a) and FIGURE 4 (b) are examples of front light groove processed in copper plated thin film.

FIGURE 5 is the sputtered film of 200 μ m pitch that is the best groove for the front light.

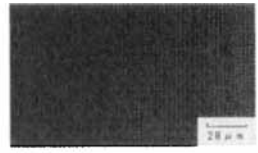
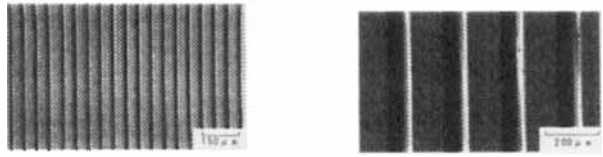


FIGURE 3 Example of aluminum evaporated (Minimum pitch ; 0.79 μ m)



(a) (b)

FIGURE 4 Example of copper plated (Pitch ; (a) 50 μ m (b) 200 μ m)

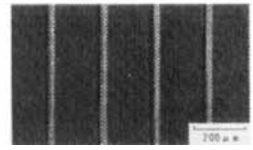


FIGURE 5 Example of copper sputtered (Pitch ; 200 μ m)

4 INTENSITY DISTRIBUTION OF REFLECTION ON GROOVE

Intensity distribution reflected from the grooves is obtained by lock-in amp.

4-1 Aluminum Evaporated Film

On aluminum evaporated film, four kinds of pitch as 1.6 μ m, 3.2 μ m, 4.8 μ m and 6.4 μ m are tested.

As shown in FIGURE 6, groove pitch is 1.6 μ m, there are four peaks, and the interval has also narrowed in the angle of reflection in proportion to incident angle. The peak number is proportional to the pitch. It seems not to suit for the front light system, because many sharp peaks in the reflection beams are remarkable.

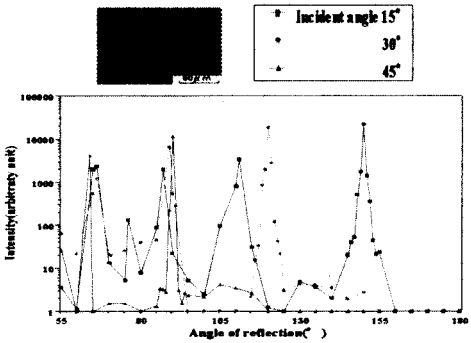


FIGURE 6 Intensity distribution of aluminum film

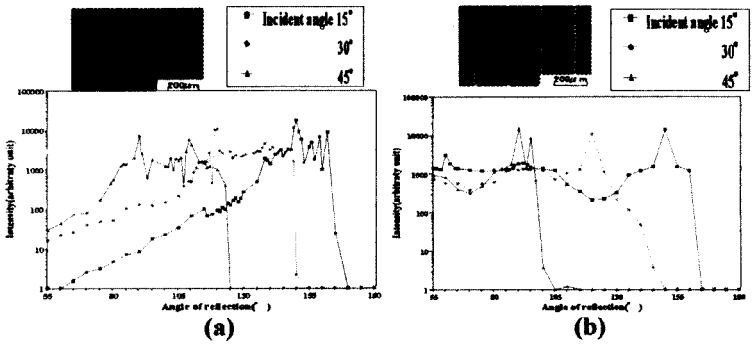


FIGURE 7 Intensity distribution of copper (a) 100 μ m (b) 200 μ m

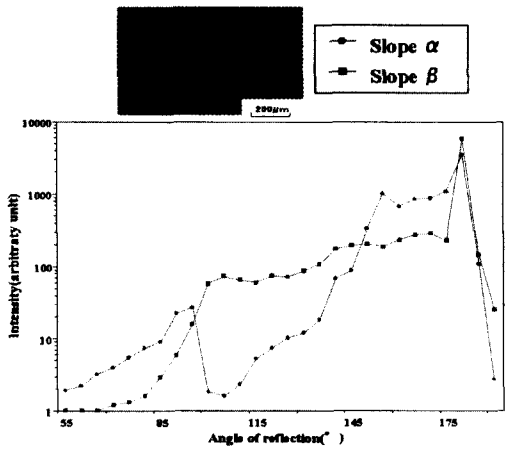


FIGURE 8 Intensity distribution of acrylic resin

4-2 The Copper Film Sputtered

The copper sputter films are compared two of 100 μ m and 200 μ m. In FIGURE 7 (a), intensity gradually drops in less incident angle. On the contrary, as shown in FIGURE 7 (b), the numerical value does not drop.

Finally, the copper sputtering film of 200 μ m seems to be suitable for front light system for being present experiment purpose.

4-3 Acrylic Resin

The micro-groove on transparent acrylic resin is directly used to evaluate the reflection plate for the front light. FIGURE 8 is the example of the reflective distribution of front light.

Test is made on 200 μ m pitch. The sharp He-Ne laser beam is injected toward steep slope and gentle slope.

5 CONCLUSION

Conclusions are as follows.

It is shown that pitch of the ruled line is controlled under 0.08 μ m accuracy and fine structure of the surface of the micro-groove are very smooth in nm order.

The ruled micro-groove are useful in prospect to apply to the front light reflect display.