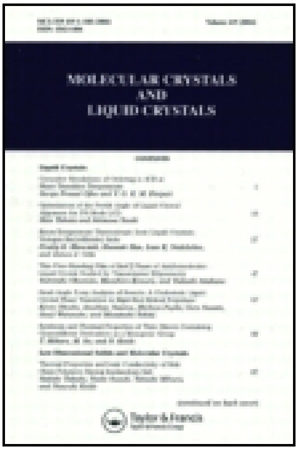

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Optimization of Morphology of Reflector for Reflective LCDS

Jae Chang Kim [a], Won Sang Park [a], Hong-Chul Kim [a], Gidong Lee [a], Kwan-Young Han [b] & Tae-Hoon Yoon [a]

[a] Depurtment of Electronics Engineering, Pusan Nutional University, San 30, Jangjeon-dong Kumjung-ku, Pusan, 609-735, Koru

[b] Samsung SDI Co., Yangsan, 626-600, Korea

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 368, pp. 175-182
Reprints available directly from the publisher
Photocopying permitted by license only

Optimization of Morphology of Reflector for Reflective LCDS

JAE CHANG KIM[a], WON SANG PARK[a], HONG-CHUL KIM[a], GIDONG LEE[a], KWAN-YOUNG HAN[b] and TAE-HOON YOON[a]

[a]*Department of Electronics Engineering, Pusan National University, San 30, Jangjeon-dong, Kumjung-ku, Pusan, 609-735, Koea and* [b]*Samsung SDI Co. Yangsan, 626-600, Korea*

In this work, we propose a new surface profile of a reflector, which provides uniform reflectance within the whole viewing angular range. We show also the parameters to achieve uniform reflectance in the proper reflection range specified by user even if the incident angle of light is given arbitrarily. By using the Beckmann's scattering theory, we verify that the proposed surface structure shows more enhanced reflective property than that of CUSP.

Keywords: Reflector; Surface structure; Reflective LCD; Beckmann's scattering theory

1. Introduction

Recently, reflective LCDs are most suitable for portable devices because of their advantages such as lightweight and low power consumption. In general, optical characteristics of reflective LCDs depend mainly on the reflector and the optical configuration of LCDs. Especially, optical performance of the reflector is determined by the design of its geometrical morphology. A reflective LCD which applies a reflector with random roughness has the demerit: the narrower the viewing angle range is, the stronger the viewing angle dependence of the reflected light intensity becomes[1]. To increase the optical performance of a reflective LCD, therefore, well-designed reflector that exhibits uniform reflectance within designed viewing angular range is required. In order to solve this problem, Uchida et al. have already reported that the uniform distribution near to ideal is achieved by applying the cusp surface profile to the reflector morphology[1-2].

In this work, we propose a new surface profile of a reflector through analytic approach. It provides almost uniform reflectance within the whole viewing angular range. We show also the parameters to achieve uniform reflectance in the proper reflection range specified by user even if the incident angle of light is given arbitrarily.

2. Theory

If a surface is to be manufactured for the specific purpose of preventing specular reflection or scattering to a certain direction, it is necessary to make the roughness periodic. The problem of scattering from a periodic surface was investigated by Kirchhoff, Beckmann and others[3]. Among these scattering theories, we use the Beckmann's scattering theory [3] and try to find optimized surface profile which

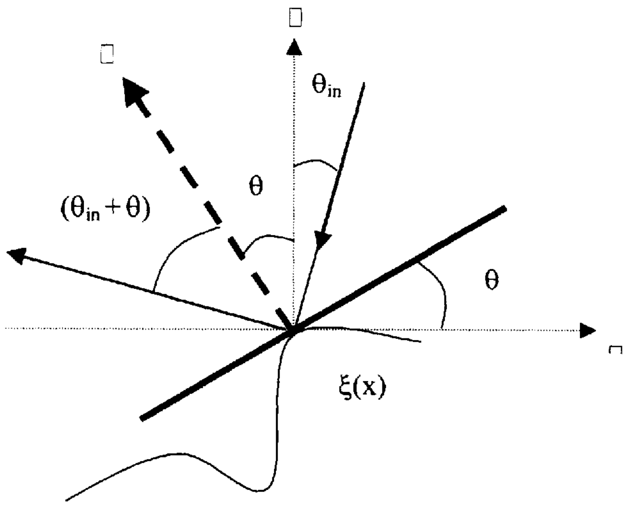

FIGURE 1. Principle of reflective angle control at a surface profile

provides uniform reflectance within viewing angular range.

Figure 1 shows the "local" scattering geometry on $\xi(x)$, which is the function of a surface profile. $\theta_{in}+\theta$ is the "local" angle of incidence with respect to the normal □ at the considered point. And θ_{in} is the "overall" angle of incidence defined with respect to □ and constant for the whole surface. Then, the reflective angle(θ_{re}) is $\theta_{in} + 2\theta$, where θ is $\tan^{-1}(\xi'(x))$, that is, "local" inclination angle of surface.

An ideal reflective property for reflective LCDs is considered to have uniform reflectance within a certain viewing angular range but no reflection outside the range. If the viewing angular range is required from θ_L to θ_H for an arbitrary incident angle(θ_{in}), the ideal reflective property is obtained by designing the micro-surface structure with uniform distribution of inclination angle in the viewing angular range.

Therefore, Uchida et al considered that the ideal reflective property is obtained by designing the surface structure with uniform distribution of

$\xi'(x)$ as shown in Fig. 2 (a)[2]. Such surface profile is CUSP and expressed by

$$\xi(x) = \pm (\tan\xi_{max}\, x^2) / \Lambda \qquad (1)$$

Where Λ and ξ_{max} is the period of roughness and the maximum inclination angle, respectively.

However, inclination angle having uniform distribution as function of x is not $\xi'(x)$ but $\theta(x)$. So, as shown in Fig. 2 (b), we designed the surface structure with uniform distribution of $\theta(x)$ to obtain the ideal reflective property. The surface profile is expressed by

$$\xi(x) = (\ln(\cos(Ax + B)))/A \qquad (2)$$

Where $A = (\theta_L - \theta_H)/(2\Lambda)$ and $B = (\theta_L + \theta_H + 2\theta_{in}) / 4$. By designing the surface micro-structure with uniform distribution of inclination angle($\theta(x)$) in a suitable range and no distribution outside the range, it was confirmed that such a reflector can be realized. This fact indicates that the reflected light is concentrated in a certain angular range and therefore high brightness can be obtained.

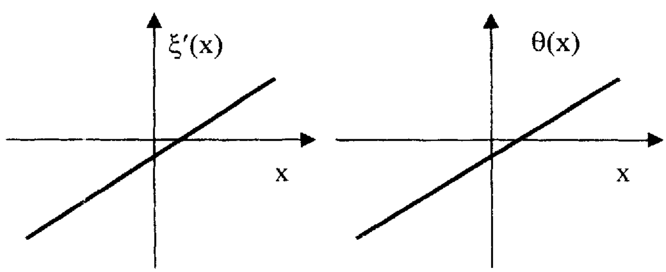

FIGURE 2. Design method (a) with uniform distribution of $\xi'(x)$, and (b) with uniform distribution of $\theta(x)$

In addition, if a reflector can reflect the image toward the normal angle and misalign it from the glare at the oblique incident angle, the surface structure of CUSP profile must overlap with the blazed grating structure[4-6], but that of LNCOS profile given by Eq. (2) is able to obtain any desired reflective properties by designing parameters(A, B) with the specification of θ_L, θ_H and θ_{in}.

3. Results

Figure 3 shows CUSP profile and new profile expressed by Eq. (1) and Eq. (2), respectively. By using the Beckmann's scattering theory, the reflective property of these surfaces is calculated and the results is shown in Fig. 4 (a). The problem of CUSP profile is that the intensity of the reflected light is relatively poor around viewing angle 0 ° at the normal incidence. On the other hand, the new profile shows more uniform intensity distribution than CUSP profile at the normal incidence as shown in Fig. 4 (b).

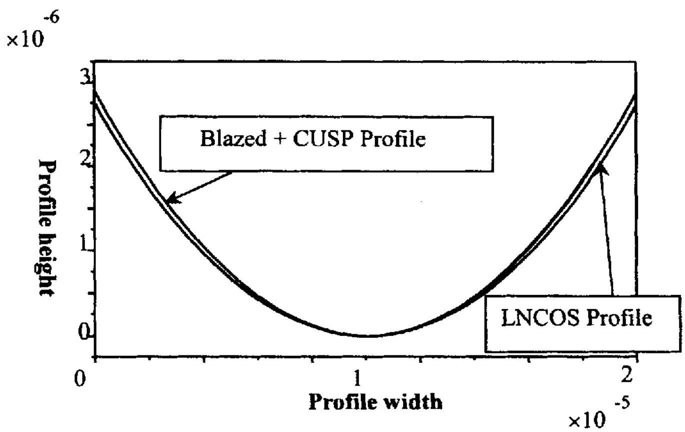

FIGURE 3. Surface structures of CUSP profile and LNCOS profile at the normal incidence

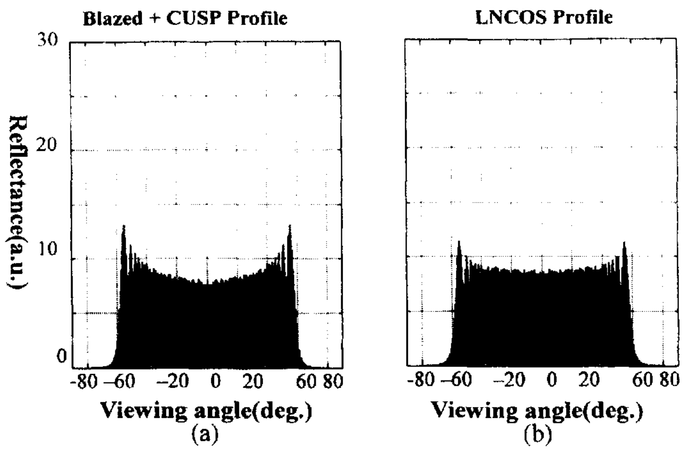

FIGURE 4. Comparison between two profiles for the reflective property at the normal incidence (a) CUSP profile and (b) LNCOS profile

Figure 5 shows CUSP profile overlapped with the blazed grating and new profile at the oblique incidence angle of 30 °, respectively. This profile also shows more uniform intensity distribution than the profile overlapped with the blazed grating as shown in Fig. 6 (a) and (b).

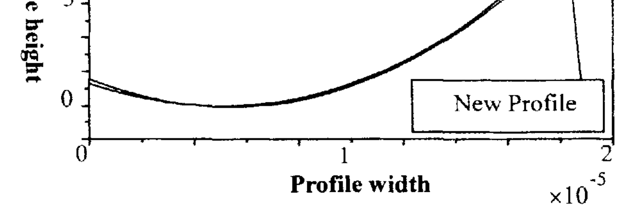

FIGURE 5. Surface structures of CUSP profile overlapped with the blazed grating and LNCOS profile at the oblique incidence angle of 30 °

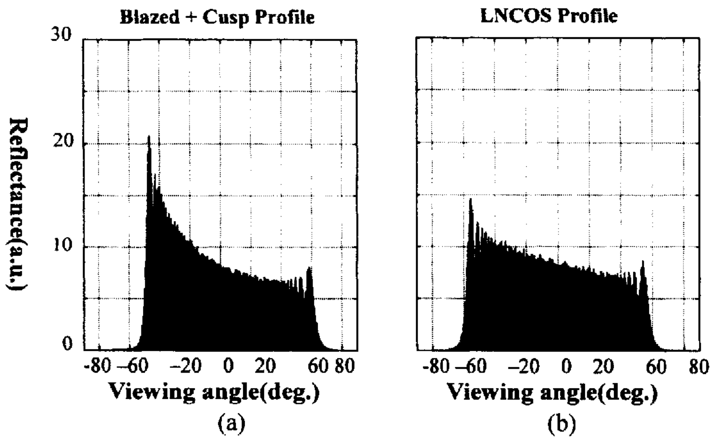

FIGURE 6. Comparison between two profiles for the reflective property at the oblique incidence angle of 30 ° (a) CUSP profile overlapped with the blazed grating (b) and LNCOS profile

4. Conclusion

We have developed an ideal reflector, which has a uniform reflectance within the required viewing angular range and no reflection outside of that range. Also, we were able to obtain the parameters to achieve uniform reflectance in the proper reflection range specified by user even if the incident angle of light is given arbitrarily. By using the Beckmann's scattering theory, we verified that the developed surface structure shows more enhanced reflective property than that of CUSP.

Acknowledgments

This work is performed as part of G7 project and supported by the the Ministry of Information and Communication, Korea.

References

[1] N. Sugiura and T. Uchida, *AM-LCD '95 DIGEST*, pp. 153 (1995).
[2] N. Sugiura and T. Uchida, *SID '97 DIGEST*, pp. 1011 (1997).
[3] P. Beckmann and A. Spizzichino, *"The Scattering of Electro-magnetic Waves from Rough Surface"*, pp. 3-69, (Pergamon/Macmillan, N.Y., 1963).
[4] I. Hiyama, O. Itou and K. Kondo, SID 97 DIGEST, pp. 655-658 (1997).
[5] H. Baek, S. Woo, G. Lee, T. Yoon, E. Lee and J.C. Kim, *Optical Society of Korea*, **9**, No 6, pp. 355-361 (1998).
[6] S. Woo, H. Baek, G. Lee, T. Yoon, J. Jang and J. C. Kim, *Optical Society of Korea*, **10**, No 1, pp. 27-31 (1998).