Measurement Method for Cell Gap and Twist Angle of Reflective LCD

A polarization insensitive, electrically tunable Gooch-Tarry ' s first minimum condition is demonstrated . When the light passes through the TN medium an even number of times . Furthermore, some properties of this method are discussed and an analysis by theoretical calculation is undertaken. We proposed a cell gap measurement method to determine the cell thickness by simulation values of the transmitted light for arbitrary wavelength regions.

Kun Shan University of Technology
e-mail :anderson880@yahoo.com.tw
Chia -Fu,Chang **Si-Wen,Wan** **Zou-ni,Wan**

1.Introduction

For small anchoring energies this leads to the propagation of light in the Mauguin regime[1]. The actual twist angles in NLC cells are obtained ,which differ from the angle between two boundary rubbing directions [2].This is because the incident light traverses the boundary layers twice in a reflective cell[3]. We can calculate the twist angle and the different between the actual twist angle and the angle of two rubbing directions[4]. The optical field propagating normally in a uniformly twisted nematic structure can be represented by two mutually orthogonal elliptically polarized normal modes[5]. By measuring the transmission of the twisted or supertwisted NLC cells, It is possible to simultaneously obtain high reflectance and image contrast and also a moderate degree of multiplexing [6].

2. Theory

A polarizing plane of linearly polarized light passes through the first polarizer and rotates according to the twisted orientation of the liquid crystal molecules.this is called optical rotation[7]. We can obtain its $d\Delta n$ value by simply measuring the $R_\perp$,according to(4). After measuring the transmission under different conditions. Using the Jones matrix, it is very easy to describe the optics of the two metastable twist states as both have a uniform twist angle and a small tilt angle[8]. For LC cell,right-handedness twist angle is positive and left-handedness twist angle is negative. If its twist angle is known we can choose two different b angles at which the normalized reflectance $R_\perp$ is relatively large (usually greater than 0.5) and the error of twist angle has minimum effect on determining $d\Delta n$ [10] .

A normal incident light beam on the cell will have transmission components as a function of wavelength. Electro- optic transmitt ance curves of a conventional TN mode. Results of the LCD cell simulation using the Jones matrix method and shown in(1)

$$\begin{pmatrix} V_e' \\ V_o' \end{pmatrix} = \begin{pmatrix} \cos x - i\frac{\Gamma \sin x}{2x} & f\frac{\sin x}{x} \\ -f\frac{\sin x}{x} & \cos x + i\frac{\Gamma \sin x}{2x} \end{pmatrix} \begin{pmatrix} V_e \\ V_o \end{pmatrix}$$

…………………………………………………………………..(1)

The dispersion effects on the optical transmission can be minim Iz ed in a multi gap LCD when each cell thickness is optimized for the re spective color to give zero transmission[9].

$$|R_{\perp}|^{2}=|\cos b \sin b|\begin{vmatrix}\cos x-i\frac{\Gamma}{2}\frac{\sin x}{x} & -f\frac{\sin x}{x}\\ f\frac{\sin x}{x} & \cos x+i\frac{\Gamma}{2}\frac{\sin x}{x}\end{vmatrix}\times\begin{vmatrix}\cos x-i\frac{\Gamma}{2}\frac{\sin x}{x} & f\frac{\sin x}{x}\\ -f\frac{\sin x}{x} & \cos x+i\frac{\Gamma}{2}\frac{\sin x}{x}\end{vmatrix}\begin{vmatrix}-\sin b\\ \cos b\end{vmatrix}$$

....(2)

Surface reflections ,reflectivity of the reflector ,and aperature ratio are not relevant to $R_{\perp}$ shown in(3).Thus, for a given RTN LC cell, Such application of field guarantee the director on the reference substrate be parallel to the reference easy axis.

$$R_{\perp}=(\Gamma\frac{\sin X}{X})^{2}(\sin 2b\cos X-\frac{f}{X}\cos 2b\sin X)^{2}$$

....(3)

3. Simulation results

In this case, finer transmittance oscillations due to the thick glass substrates have been smeared out and the period of the observed Fabry-Perot oscillation can directly be used to derive the value of the cell gap with accuracy. For an odd number of passes, the validity of these equations is restricted to a region adjacent to the Mauguin limit.It is interesting to notice that shown in (2) remains the same as with the interference effect included since the interference factors shown in (1) and cancel out each other show in Fig.1.

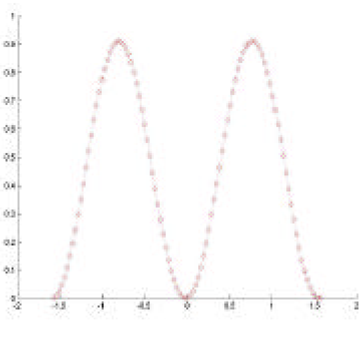


Figure1. The simulated dependent transmittance of the polarization switch at $l=632.5nm$.The parameters used for simulations are listed in the text.

A normal incident light beam on the cell will have transmission components as a function of wavelength. Electro- optic transmittance curves of a conventional TN mode. Results of the LCD cell simulation using the Jones matrix method and shown in(2)..There is the cell transmission as a function of the $f=90^{0}$ and $b=30°$.

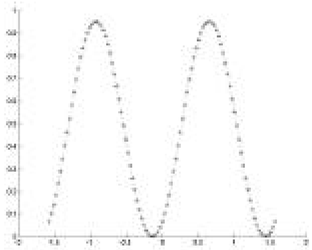


Figure2. The simulated transmittance spectra of the proposed polarization Switch(solid lines),Gooch-Tarry 90^{0} TN-LC(dashed lines)and a broadband polarization rotator(dotted lines)between crossed polarizers.

At this $d\Delta n$ value, the relationship between $R_{\perp}$ and b angle is described in Fig.Then ,we can choose two different b angles at which the normalized reflectance $R_{\perp}$ is relatively large(usually greater than 0.5)and the error of twist angle has minimum effect on determining $d\Delta n$.

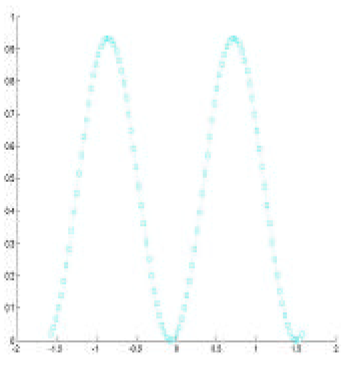


Figure3.cell gap tolerance of the polarization switch.Solid line indicate optimal values,and dotted lines optimal values

The normalized transmittance of a TN cell can be described by the following Jones matrix method as this is the ideal case of the transmissive -mode TN cell satisfying the Gooch-Tarry 's law. The first $T_{\perp} = 1$ occurs at $d\Delta n / l = \sqrt{3}/2$. We can obtain its $d\Delta n$ value, if its twist angle is known show in Fig.4. A normal incident light beam on the cell will have transmission components as a function of wavelength . Electro-optic transmittance curves of a conventional $90°$ TN mode.The TN LCD is operated in the first minimum.

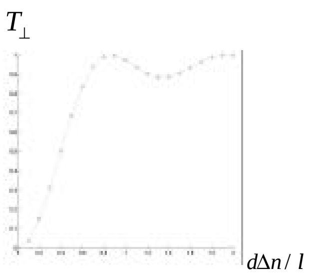


Figure4. The calculated values of $\Delta nd / l$ and twist angle of $f = 90°, b = 0°$.

From Fig5, the maximum light efficiency appears at and $b = 15°$. For a given $d\Delta n$, light efficiency is strongly dependent and it is necessary to adjust b to maximize the light efficiency.On the other hand, incidence angle generates more phase retardation which b boosts the light modulation efficiency.

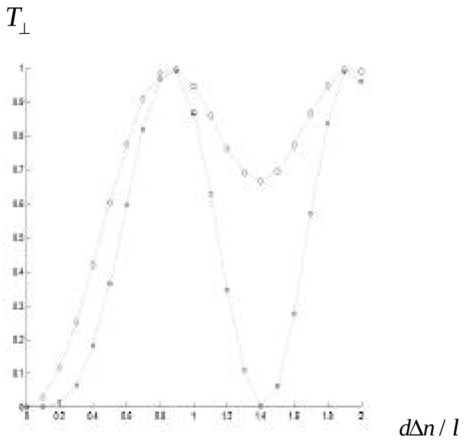


Figure5. The calculated values of $\Delta nd / l$ and twist angle of $f = 90°, b = 15°, 45°$.

Results of the cell simulation using the Jones matrix method and the approach proposed by us are show in Fig.6 The color dispersion (i.e the wavelength dependency of the light transmittance) strongly depends on $f = 40^0$.The following explains how to properly choose these two different b angle forgetting more accurate $d\Delta n$ results.

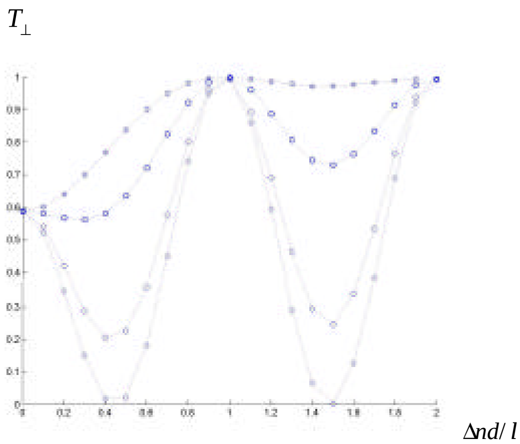


Figure6. The calculated values of $\Delta nd / l$ and twist angle of $f = 40^0, b = 0^0, 15^0, 30°, 45°$.

If $d\Delta n / l$ departs too far away from $f = 70^0$ of Fig.7.The light efficiency will remain low even if the device is set the optimal rotation angle.

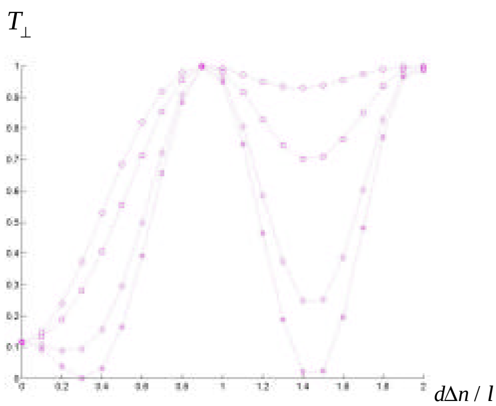
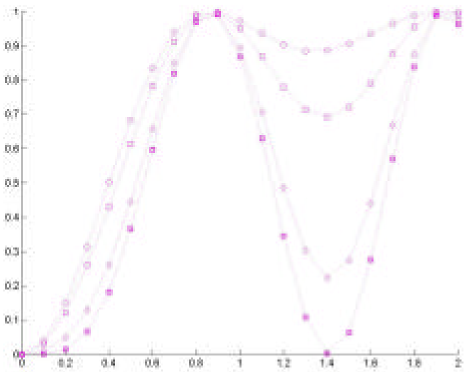


Figure7. The calculated values of $\Delta nd / l$ and twist angle of $f = 70^0, b = 0^0, 15^0, 30°, 45°$.

A normal incident light beam on the cell will have transmission componentsas a function of wavelength.For 90^0 TN cell of Fig8. corresponding to the first minimum of the Gooch-Tarry transm ission curve .For projection displays using three 90^0 TN-LC panels, each cell can be optimized with a different LC while keeping the same cell gap. Under this circumstance,the advantage of bisector approach is clear. In the two-bottle LC system we used, the LC mixtures have very similar physical properties in dielectric anisotropy ; the only difference is their birefringence.

$T_{\perp}$



$\Delta nd/l$

Figure8.The calculated values of $\Delta nd/l$ and twist angle of $f = 90^0$, $b = 0^0, 15^0, 30°, 45°$.

4.Conclusion

We have demonstrated a broadband polarization switch using an TN-LC cell and two passive uniaxial compensation films.We used the conjugate gradient method to optimize the device parameters. Such a polarization switch exhibits a broad bandwidth and high contrast ratio.

Its response time depends on the choice of LCmaterial and cell gap ,twist angle and compensation films thickness are analysed and results are quite acceptable.By rotating a LC cell, we can measure not only the cell gap,but also wavelength dependence of retardation $\Delta n \cdot d$ of a cell.

References

[1] D.ANDRIENKO and A.DYADYUSHA: Mol.Cryst.Liq.Cryst, 321, pp.271-281,1998

[2] MinJiang and Zongkai Wang :Jpn.J.Appl.Phs.Vol.33(1994)pp.L1242-L1244

[3] Shin -Tson Wu and Chiung-ShengWu:Jpn.J.Appl.Phs.Vol.37 (1998) pp.L1497-L1500

[4] Zongkai Wang and Ruipeng Sun:Jpn.J.Appl. Phs.Vol. 33(1994) pp.L1242-L1244

[5] Hiap Liew Ong :P.O.Box 218,Yorktown Heights, New York 10598.

[6] G.V.Simonenko and V.G.Chigrinov:Opticheskil Zhurnal 69,65-70

[7] Mitsuhiro Koden : Ecological Technology Development Center Corporate research and Development Group.

[8] J.X.Guo and H.S.Kwok,Nanyang Avenue,Singapore 639798

[9] Hiap Liew Ong :P.O.Box 218,Yorktown Heights, New York 10598.

[10] Xinyu Zhu and Wing-Kit Choi: IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL, 49,NO.11,NOVEMBAR 2002