Low Power Consumption in Twisted Nematic Mode Using Novel Liquid Crystal Mixture

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Abstract

Recently, Note PCs have being widely used due to their features such as good mobility and low power consumption. In order to ensure the current market position, further improvement is required. Especially, the lower operating voltage is essential for the long operating time of Note PCs. For the achievement of lower operating voltage, possible contributions from LC materials side are to lower the viscosity and to increase the dielectric constant without sacrificing the reliability. In order to achieve lower driving voltage, new LC mixtures have been developed, optimizing theirs physical properties.

1. Introduction

Over the last several years, qualities of Liquid Crystal Displays (LCDs) have dramatically improved and portion of LCD in the display markets also have increased. Especially, recent note PC market became the arena of competition for several major LCD makers. Therefore, LCD makers pull out all the stops for getting the upper hand on the other makers through cost reduction and development of new technologies.

Among the several technologies, especially, low power consumption technology is one of the most important and basic technologies in the battery-operated application for long operation time of battery. Macroscopically, recent researches for achievement of low power consumption can be divided in three methods. First, in backlight unit part, lower power consumption can be achieved through development of material, optimize of the structure, combination of optical sheets and improvement of lamp efficiency. Second, in circuit part, low power consumption achieved through reduction of Vdd through optimizing of buffer and reduction of panel load.[1] Finally, in panel part, using of compensation film, development of new materials like a liquid crystal can attribute of low power consumption.[2,3]

In this paper, we will describe new LC which has high dielectric anisotropy for low operating voltage.

2. Experimental

Generally, liquid crystal is composed of about 10~15 single components which have deferent properties. These single components are mixed together for specific ratio and the combination of single components make LC properties such as dielectric anisotropy, rotational viscosity and optical birefringence. That is, properties of LC can be modified by adjustment of single mixing ratio or introduction of new single components.

In the TN mode, the operating voltage is given as below.

$$V_{th} = \pi \left(\frac{K_{eff}}{\varepsilon_0 \Delta\varepsilon} \right)^{\frac{1}{2}} \quad (1)$$

In above equation, K_{eff} is an effective elastic constant ε_0 is a dielectric constant in vacuum condition and $\Delta\varepsilon$ is a dielectric anisotropy of LC. According to the above equation, operating voltage is affected by effective elastic constants and dielectric anisotropy. In case of the TN mode, as you can see in above-mentioned equation (1), both of K_{eff} and $\Delta\varepsilon$ are

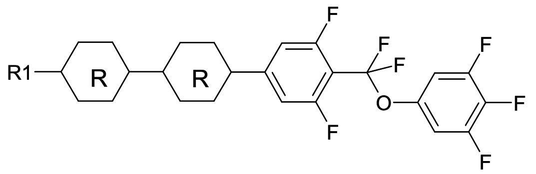

Fig. 1. An example of extremely high polarity single component of LC.

affecting operating voltage. However, K_{eff} is hard to control easily through adjustment of mixing ratio of single components. Therefore, low power consumption achieved through modify of dielectric anisotropy mainly.

Figure 1 shows an example of high polar single among the several newly introduced singles to new LC for low power consumption. Generally, high polar singles have several fluorines which are substituted along the specific direction like a figure 1. and these singles have a big dielectric anisotropy between the major and minor axis is increased. Consequently, these high polar singles can attribute low power consumption due to big reactivity by external electric field.

We measured properties of LC which is using high polar single component and not using. Table 1 shows a comparison of properties between new and conventional LC. Although new LC has higher dielectric anisotropy than conventional about 10%, rotational viscosity is maintained. This result means that high polar single makes advantage of power consumption without increasing of response time. Beside, we can expect that new LC is more stable for thermal influence.

High dielectric anisotropy can aggravate electrical properties and lead to image sticking, flickering and crosstalk. Therefore we measured voltage holding ratio (VHR) and ion density of new and conventional LC. As you can see in Figure 2, VHR and ion density

Table 1. Measured properties of conventional and new LC. [Tni : clearing point, LTS : melting point, △ε : dielectric anisotropy, △n : optical birefringence]

	Conventional LC	New LC
Tni [℃]	75.8	77
LTS [℃]	-30	-30
Δε	10	11.9
Δn	0.102	0.102
Rotational Viscosity [mPa·s]	79	78.9

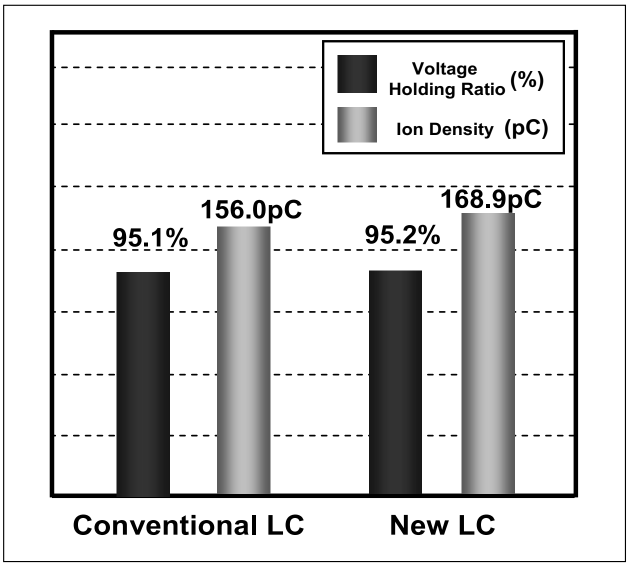

Fig. 2. Measured VHR and ion density of conventional and New LC.

of conventional and new LC are almost same. So we can expect that the electrical stability of new LC is almost same as conventional LC.

We measured voltage dependent transmittance curves of new and conventional LC. As you can see in figure 3, Voltage dependent transmittance curves of new LC is shifted to lower voltage area. This means that introduction of high polar single makes lower threshold and operating voltage.

We made 15.4 inch Wide XGA notebook panel which is using new and conventional LC and measured electro optical properties. Table 2. shows measured electro-optical characteristics such as luminance, contrast ratio and response time. This measurement performed at room temperature. As you

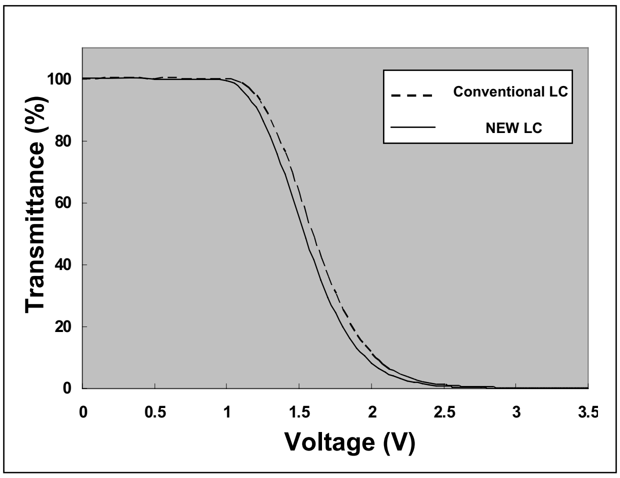

Fig. 3. A comparison of voltage dependent transmittance between conventional and new LC.

Table 2. A comparison of electro-optical properties between conventional and New LC.

	Conventional LC	New LC
White Luminance [nit]	273	277
Contrast Ratio	374 : 1	456:1
Response Time [ms]	17.1	15.9
Viewing Angle [degree] (Left/Right/Up/Down)	50/50/20/50	50/50/20/50

can see in table 2, contrast ratio of new LC panel is higher then conventional LC about 22% in same voltage. Beside, response time of new LC is also improved.

$$\tau_{on} = \frac{\gamma_1 d^2}{\varepsilon_0 \Delta\varepsilon (V^2 - V_{th}{}^2)} \quad (2)$$

Because, as you can see in equation (2), increase of dielectric anisotropy attribute to rising response time. According to measurement and calculation results, new LC panel shows same contrast ratio with operated with lower voltage than conventional LC panel about 10%. Viewing angle and white luminance of new LC are almost same as conventional LC.

3. Results and discussion

In this paper, we described about new LC which has high dielectric anisotropy. High dielectric anisotropy achieved through introduction of new single component to the conventional various single components. Electro-optical characteristics of 15.4 inch Wide XGA notebook panel are measured. Power consumption and response time of new LC panel are improved than conventional LC panel. However, high reactivity of high polar single can cause of operation instability. Therefore, research for stable high polar LC is important.

4. Acknowledgement

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5. Reference

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