LCD Modules for Portable Terminals

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Abstract

The progress of the ubiquitous information society has led to the debut of various portable terminals such as the PDA, SmartPhone and PND (Personal Navigation Device). This paper will describe the SR-NLT technology, which is a display technology suitable for LCD modules for use in portable terminals. It also introduces some products based on this technology.

Keywords

portable terminal, LCD, NLT technology, SR-NLT technology, outdoor visibility

1. Introduction

The recent dissemination of networks and the progress of the ubiquitous information society have made it possible for anyone to obtain needed information at the required timing and at the required place. This trend is accompanied with the appearance of various portable terminals such as the PDA, SmartPhone and PND (Personal Navigation Device). Most of these employ LCD (Liquid Crystal Display) modules as the user interface. In the same way as with the diversity of portable terminals, the LCD modules used in these devices are also subject to diverse performance requirements.

This paper discusses the SR-NLT (Super-Reflective NLT) technology. This is one of the NLT (Natural Light TFT) technologies and is a core technology of the NEC LCD Technologies that relate to the performance requirements for LCD modules of portable terminals. It also introduces some products based on the SR-NLT technology.

2. Performance Requirements for LCD Modules for Portable Terminals

To meet performance needs, which include portability, design, display capability (impact), long battery-life operation and high visibility for multiple scenes, LCD modules for portable terminals are required to support the following performance standards;

1) slim design and light weight;
2) high luminance;
3) wide color range;
4) wide viewing angle;
5) outdoor visibility;
6) low power consumption.

As described above portable terminals are used in diverse applications, so key performances are variable and depend on the user. Among the performance requirements listed above and in consideration of the variety of usage locations, including indoors as well as outdoors under both cloudy and fine weather conditions the outdoor visibility 5) is regarded as being the most important. As the SR-NLT technology is effective for ensuring outdoor visibility, it is being used more and more often for portable terminals.

3. SR-NLT Technology

3.1 Features of the SR-NLT Technology

In general, the transmissive LCD has a very high indoor display performance, but its visibility drops in outdoor use due to the effect of extraneous light. On the other hand, the reflective LCD has an excellent visibility in outdoor or other environments under strong ambient light. However, due to its low brightness characteristic it cannot offer a satisfactory display performance at night or in an environment with low ambient light.

The SR-NLT technology features two display modes. These include the “transmissive mode” using backlight (B/L) as the light source and the “reflective mode” using ambient light as the light source. In an environment with low ambient light, e.g. at night or outdoors, images are displayed in the “transmissive mode.” Whereas, in an environment with high ambient light, e.g. outdoors in the daytime, it can turn the B/L off and display images in the “reflective mode,” which utilizes the ambient light.

Fig. 1 shows the variations in visibility of each type of LCD depending on the brightness of the ambient light. In an indoor environment such as a household living room or an office, the

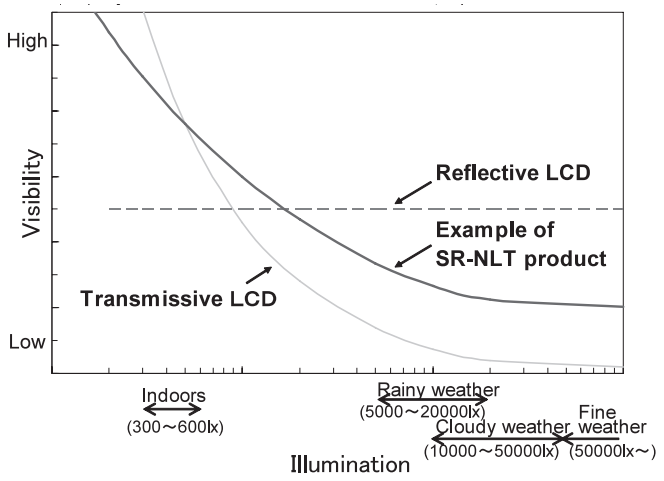

Fig. 1 Image of visibility change due to ambient light of various LCD modules.

transmissive LCD can achieve the highest visibility. On the other hand, in an environment with strong ambient light such as outdoors, the reflective LCD or an SR-NLT technology-based LCD product can offer higher visibility. It is because the surface reflection component from the polarizing plate on the LCD surface increases while the LCD brightness is constant that the visibility of transmissive LCD decreases in an environment with strong ambient light.

On the other hand, the reflective LCD can maintain visibility because the display brightness increases at the same time as the increase in the surface reflection.

SR-NLT technology-based LCD products have the characteristics of both a transmissive and reflective LCD. They can make high visibility available under any extraneous light condition.

The features of the SR-NLT technology-based product range are evident not only in their display performances. The major part of the power consumption of the LCD is consumed by the B/L, so use in the "reflective mode" in which the B/L is turned off can greatly reduce the power consumption.

3.2 Structure and Operation of SR-NLT Technology

Fig. 2 shows the cross-sectional structure of the unit pixel fabricated with the SR-NLT technology. Each pixel is composed of reflective and transmissive sections. The reflective section is given an irregular surface shape by an organic film in order to scatter reflections of extraneously incident light, and the reflecting electrode is formed on its surface. The transmissive section has a transparent electrode formed with ITO. Signal voltages are applied to the reflecting and transmitting electrodes through a thin-film transistor fabricated for each unit pixel.

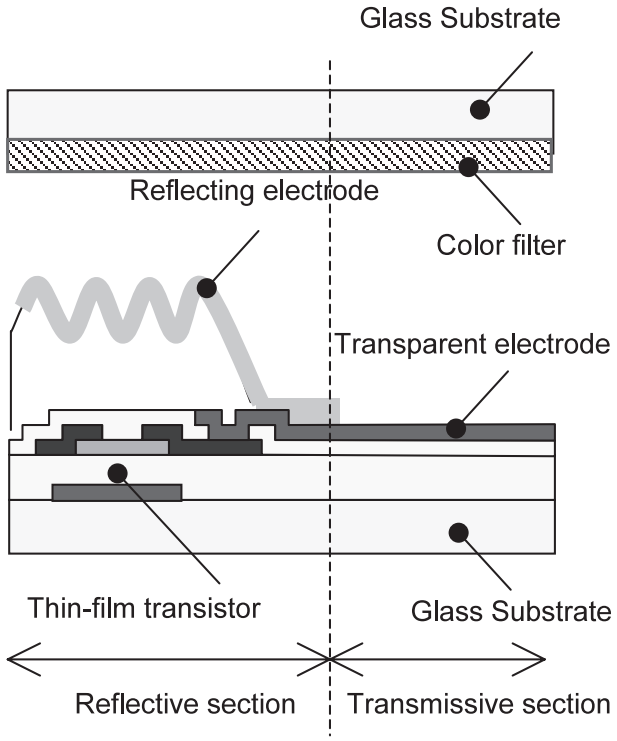

Fig. 2 Structure of SR-NTL technology.

In the transmissive mode, the LCD displays images using the transmissive section, by employing the B/L as the light source (**Fig. 3**).

In the reflective mode, the LCD displays images using the reflective section, using the extraneous light reflected by scattered reflections of the reflecting electrode (**Fig. 4**).

The reflecting electrode adopts our original irregular surface shape, which has an optical design that can always maintain frontal brightness to a high degree, regardless of the position of the light source.

3.3 SR-NLT Technology Responding to User Needs

As described above, the SR-NLT technology has the characteristics of both the "transmissive mode" and the "reflective mode." Since the area of each unit pixel on an LCD module is determined by the screen size and resolution, the balance between the characteristics of the two modes is determined by the ratio between the transmissive section area and the reflective section area on each pixel. This balance can be set freely

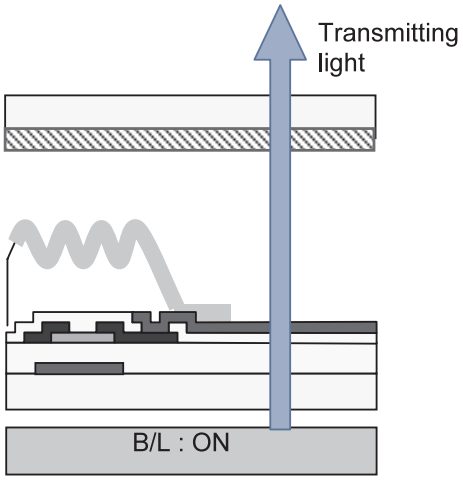

Fig. 3 Transmissive mode.

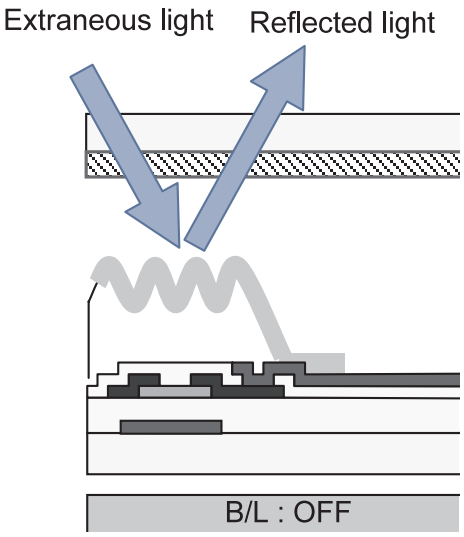

Fig. 4 Reflective mode.

in accordance with the scenes in which the LCD module is assumed to be used.

For instance, when the main operating environment is indoors, the LCD module may be used mostly in the "transmissive mode" because ambient light cannot be expected. In this case, it is possible to propose an LCD module based on the concept of assigning a larger area ratio to the transmissive section so that the LCD can offer a bright display with a low B/L intensity in order to reduce the overall power consumption (see the transmission-weighted design in **Fig. 5**).

In contrast, when the main operating environment is outdoors, the LCD module may be used mainly in the "reflective mode" because the ambient light is sufficient and long hours of battery operation are necessary. In this case, it is possible to propose an LCD module based on the concept of assigning a larger area ratio to the reflective section. The LCD can thus offer a bright display even under relatively low extraneous light as in cloudy weather conditions etc. and reduce the overall power consumption by turning the B/L off for most of the operating period (see the reflection-weighted design in Fig. 5).

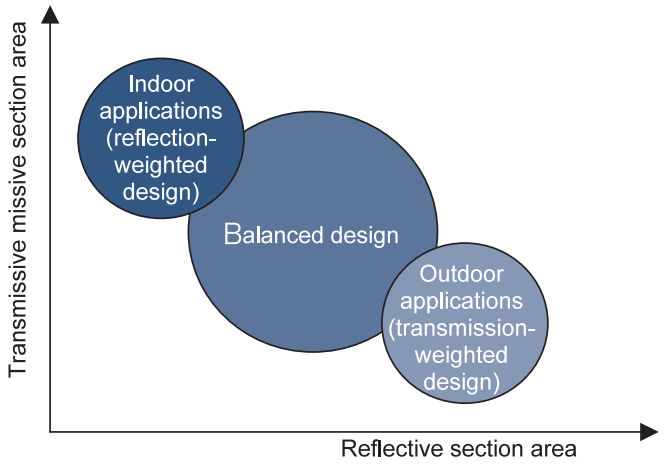

Fig. 5 Example of balancing between transmissive and reflective sections according to user needs.

Balancing the reflective and transmissive sections in this way allows us to enable optimum LCD modules for the application of each user.

4. SR-NLT Technology-Based Products

This section introduces a product applying the SR-NLT technology called the "NL2432HC17-04B" (**Table**). This product has been developed for outdoor PND application to be used with an appliance for mostly outdoor use and the balance between the transmissive and reflective sections is set to the "reflection-weighted" design. While maintaining the standard luminance of 120cd/m^2, the LCD achieves a reflectance of 35%, which is the highest level in the industry for a product of this size and resolution. It offers high visibility in the main operating environment of outdoors even when the B/L is turned off. It also consumes low power thus making it suitable for long periods of use.

Table Specifications of a SR-NTL technology-based product.

Model	NL2432HC17-04B
Screen size	2.7”
Pixels	240 × RGB × 320
Pixel pitch	0.171 × 0.171 mm
Display colors	262,144 colors
Luminance	120cd/m²
Reflectance	35%
Contrast ratio	150:1 (Transmissive mode) 15:1 (Reflective mode)
Color gamut (NTSC comparison)	40%
Power consumption	45mW (panel) 256mW (B/L)
Dimensions	50.54 (H) × 68.62 (V) × 4.12 (D) mm
Other	Built-in controller Built-in DC/DC converter Touch panel

5. Conclusion

As discussed above, the SR-NLT technology is a display technology optimized for portable terminals that offers high visibility in any environment.

In the future, we are planning to advance the SR-NLT technology further by making improvements in the reflectance and contrast and by developing products that can meet the diversifying needs of users.

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