Monochrome LCD for Medical Applications

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Abstract

The advancement of IT applications in the medical field has increased the need for digital display devices. An LCD for use in interpretation should provide a high quality display that is equivalent to or better than traditional X-ray photo films. It is also required to achieve high degrees of brightness, contrast ratio, viewing angle characteristics and uniformity of brightness as well as consistent reliability. In support of such challenging display quality criteria for medical monitors, NEC LCD Technologies is able to offer LCD monitors composed of LCD panels based on SFT technology. These units feature low color shift, higher aperture ratio and high definition and have a direct backlight type panel that features a high degree of brightness and improved brightness uniformity.

Keywords

medical image display monitor, LCD monitor, monochrome, interpretation, display quality, high brightness, high definition

1. Introduction

The recent rapid advancement in the applications of IT at medical facilities has promoted the digitalization of medical systems. This may be seen with the electronic medical chart system and PACS (Picture Archiving and Communication System). As the film-less environment has spread the need for digital display devices has become more evident. Such display devices are generally LCD monitors because these can save space and they are suitable for arranging two or more monitors side by side.

Compared to general PC monitors, the medical image display monitors (hereinafter abbreviated to medical monitors) are expected to offer a higher display quality.

At NEC LCD Technologies, we are developing the SFT (Super Fine TFT) technology that achieves low color shifting, high brightness and high definition based on the IPS (In-Plane Switching) wide viewing angle technology. We are also applying the STF technology in accordance with the high display quality requirements as the core product for the field of medical monitors.

This paper discusses the display quality requirements for medical monitors and introduces our technological innovations applied in the field of image quality improvement.

2. Display Quality and Performance Required for Medical Monitors

The display quality check for general PC and TV monitors consists only of the initial device check during the pre-shipment inspection at the factory. However, in addition to this the necessity for regular inspections and management aimed at quality maintenance during use is included in the guidelines for medical monitors. It is because doctors diagnose lesions based on slight shadows or anomalies in the displayed images that ongoing quality maintenance is essential after the start of equipment use.

Monitors used in the medical fields are also subjected to different display quality requirements that depend on the purpose and environment of use.

In particular, radiographic interpretation monitors are required to display fine shades accurately in mammography or thoracic CR (Computed Radiography) and the display quality required for them should be equivalent to or better than traditional X-ray films.

The following sections will deal with the background to the display quality required for the medical monitors. The display quality and performance requirements are shown in **Table**.

(1) High Resolution

The resolution should be adequate for matching the amount of information in the displayed medical images. In particularly, high definition so that fine shades can be accurately reproduced is required for interpretation purposes. For example, interpretation of CT (Computerized Tomography),

Table Display quality and performances requirements for medical monitors.

Item	Quality/Performance Requirements	
Resolution	5M (QSXGA: 2560 x 2048)	Mammography
	3M (QXGA: 2048 x 1536)	Radiogram interpretation, CT image interpretation diagnosis
	2M (UXGA: 1600 x 1200)	Value model/modality diagnosis
	1M (SXGA: 1280 x 1024)	Modality diagnosis
Brightness	800 cd/m² or more	
Contrast ratio	600:1 or more	
Brightness uniformity	In-plane luminance difference: Min. value/Max. value ≥ 80%	
Color uniformity	In-plane color difference: $\Delta u',v' < 0.01$	
Image retention	Should not hinder interpretation.	
Gamma characteristic (Gradation-to-brightness characteristic)	DICOM curve (The gradation should be represented using the minimum brightness differences distinguishable by the human eye.)	
Viewing angle	Considering the parallax between two adjacently installed monitors and that between the eyes of the patient and the doctor, no color deviation should be observed when viewed from oblique directions.	
Other	There should be no Bright defect.	
	Long service life (50,000 hours or more)	
	No mura(No irregular or hazy image)	

MRI (Magnetic Resonance Imaging) and X-ray radiograms need high definition displays of 1M (one million) or more pixels. Furthermore, ultrahigh definition of 5M pixels or more is needed for digital mammography.

(2) High Brightness

Usually, medical monitor performance is under warranty for 3 to 5 years. It is critical that it is usable in diagnoses by offering the same display quality throughout the period, and the backlight of the LCD must be capable of maintaining constant brightness even if the brightness tends to degrade due to ageing. This means that the medical LCD should provide more than twice the light intensity of an ordinary LCD used in PC monitors.

(3) Contrast Ratio

Correct, faithful identification of low gradations is important for correct interpretation. This is the reason why a high contrast ratio is required.

(4) Viewing Angle

In consideration of two or more monitors often being installed side by side, it is necessary to prevent any difference in brightness, color tones or a sudden drop in contrast ratio due to parallax. Also, when the doctor and patient are examining the same image from different angles for diagnosis, they should be able to view the image with equal display definition regardless of a difference in the viewing angle.

(5) Uniformity

Uniformity in brightness all over the screen and into the corners is necessary in order to enable effortless interpretation of shades. Uniformity in chromaticity should also be guaranteed in order to display colors without variation in any part of the screen. In addition, when two or more monitors are installed side by side monitors used simultaneously should display colors in the same way and without variation.

(6) Gamma Characteristic

Monitors for use in interpretation diagnoses are required to represent gradations in the minimum brightness differences distinguishable by the human eye[2]. It is also essential that the brightness levels are not inversely proportional to the gradations.

(7) Reliability

A monitor is sometimes under warranty for as long as 5 years and is sometimes used continuously for 24 hours. It should be able to maintain quality for long periods.

(8) Elimination of Bright Defects

The LCD is often accompanied with the problem of bright luminescent defects (which are lit permanently) due to a production fault. To prevent this phenomenon from hindering interpretation, the monitor should not contain too many luminescent defects.

3. Improvement Technology for High Quality Image

In the following, we will describe our technological efforts made to achieve each of the display quality requirements above.

(1) Technology for Assuring Compatibility between High Resolution and High Brightness

If the resolution is simply improved, a decrease in the aperture ratio of the LCD elements and the resulting decrease in the light transmission efficiency would cause the image brightness to be reduced. At NEC LCD Technologies we have applied our core SFT technology in order to improve the brightness of the backlight while offering both high definition and a high aperture ratio. We have thus succeeded in achieving the high brightness value of 1300cd/m² or greater with a 3M-pixel monochrome LCD. **Fig. 1** shows the lineup of products according to their resolution values.

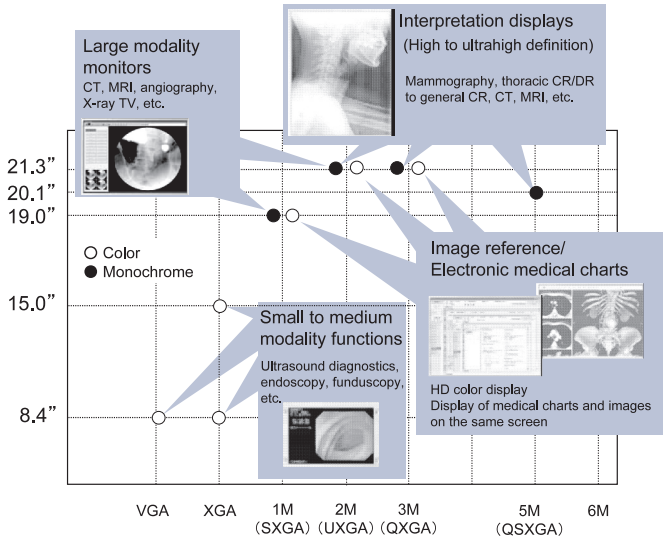

Fig. 1 Product lines and main applications.

(2) Technology for Improved Contrast Ratio and Viewing Angle

To improve the contrast ratio, it is essential to reduce light leakage during the display of black as well as to increase the light transmission efficiency of the panel. Our SFT panel reduces the diffuse reflection of light by masking the element sections where the light may be reflected. The IPS panel is the mode in which the liquid crystal drive system rotates in the horizontal direction (**Fig. 2**) and features little shifting in chromaticity or brightness when the panel is viewed from an oblique direction. In addition, our LCD modules designed for medical monitors adopt a newly developed polarizer in order to minimize brightness errors, even when the dark screen is viewed obliquely (**Fig. 3**). This has enabled improvements in contrast ratio for oblique as well as for frontal views.

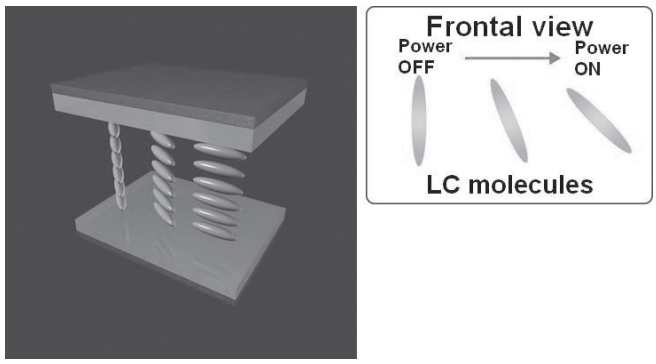

Fig. 2 Liquid crystal molecules of SFT system.

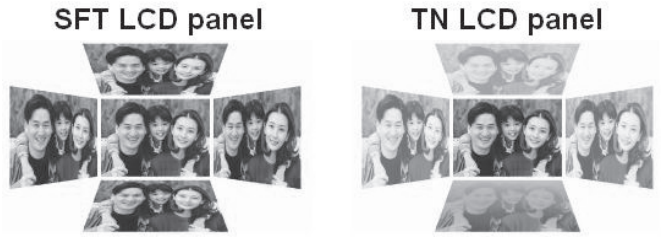

Fig. 3 Difference in views between SFT and TN systems.

(3) Technology for Improved Uniformity

To improve uniformity in brightness and chromaticity on the screen it is essential that the light reaches the peripheral parts of the screen. This is made possible by optimizing the in-plane brightness distribution of the backlight, which is the light source. Our newly developed high brightness direct backlight panel has succeeded in improving the in-plane uniformity compared to our previous products thanks to the optimization of the lamp layout and optical sheet configuration (**Fig. 4**).

(4) Gamma Characteristic

Display of slight shade changes is not possible without the capability of representing fine changes in gradation. To represents gradations, the LCD adjusts the amount of transmitted light by applying voltages to the liquid crystal molecules of each pixel to vary their arrangements and orientations. Our monochrome LCD modules control the voltages finely to represent 766 gradations per pixel, thereby meeting the required gamma characteristic. In addition, we are also continuing efforts for increasing the gradation in order to represent shades in an even finer manner, for example by adopting a 10-bit display drive IC with finer control, aiming at representation of 3070 gradations per pixel.

(5) Reliability

Since the brightness of medical LCD is higher than ordinary

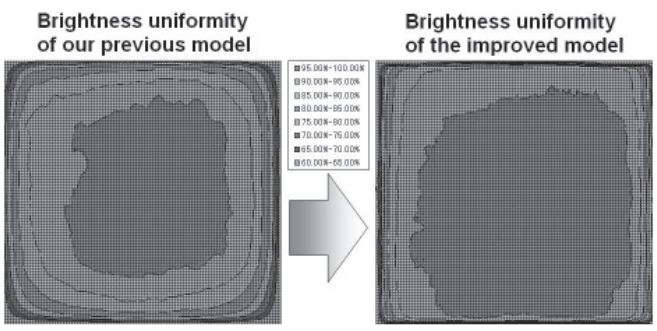

Fig. 4 Brightness uniformity improvements resulting from backlight improvement.

LCD used in PCs, the backlight generates more heat than ordinary LCD. This fact makes it necessary to improve the reliability of each material in order to ensure the long-term reliability of the LCD panel. For this purpose, we have reviewed the materials aiming at improving their reliability.

(6) Bright Defect Countermeasures

In the LCD panel fabrication process bright defects are produced by the penetration of foreign matter such as dust and dirt of the order of a few microns. With monochrome LCD panels light transmittance is higher than for color LCD panels and even very minute foreign matter tends to cause easily recognizable luminescent defects. We have made thorough efforts in order to reduce penetration of foreign matter during fabrication and have succeeded in the fabrication of panels without bright defects.

4. Conclusion

The advancement of IT applications in the medical field is expected to lead to diversification in environments and functions of medical monitors and their quality requirements are expected to continue to increase. In order to contribute to the further development of LCDs for medical applications, we aim to improve the brightness, contrast ratio, gradation and service life of color LCD products by comprehensively optimizing cell structures, materials and fabrication processes based on our proprietary SFT technology.

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Related URLs
SFT technology:
http://www.nec-lcd.com/jp/technology/sft_viewing_angles.html
Press release NL204153AM21-07A:
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Press release NL160120AM27-13A:
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