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 particular, high definition so that fine shades can be accurately reproduced is required for interpretation purposes. For example, interpretation of CT (Computerized Tomography),...
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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 1300 cd/m² or greater with a 3M-pixel monochrome LCD. Fig. 1 shows the lineup of products according to their resolution values.

<table>
<thead>
<tr>
<th>Table</th>
<th>Display quality and performance requirements for medical monitors.</th>
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</thead>
<tbody>
<tr>
<td>Item</td>
<td>Quality/Performance Requirements</td>
</tr>
<tr>
<td>Resolution</td>
<td>5M (UXGA: 2560 x 2048)</td>
</tr>
<tr>
<td>Brightness</td>
<td>800 cd/m² or more</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>600:1 or more</td>
</tr>
<tr>
<td>Brightness uniformity</td>
<td>In-plane luminance difference: Min. value/Max. value ≥ 80%</td>
</tr>
<tr>
<td>Color uniformity</td>
<td>In-plane color difference: Δu',v' &lt; 0.01</td>
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<tr>
<td>Image retention</td>
<td>Should not hinder interpretation.</td>
</tr>
<tr>
<td>Gamma characteristic</td>
<td>DICOM curve (The graduation should be represented using the minimum brightness differences distinguishable by the human eye.)</td>
</tr>
<tr>
<td>Viewing angle</td>
<td>Considering the parallax between two adjacent installed monitors and that between the eyes of the patient and the doctor, no color deviation should be observed when viewed from oblique directions.</td>
</tr>
<tr>
<td>Other</td>
<td>There should be no Bright defects.</td>
</tr>
</tbody>
</table>
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 represent 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...
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.

References
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The details about this paper can be seen at the following.
Related URLs
SFT technology: http://www.nec-lcd.com/jp/technology/sft_viewing_angles.html