Development of a 30-in. wide-QXGA+ TFT-LCD for High-Information-Content Displays

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Abstract

A 30-inch WQXGA+ TFT-LCD Monitor has been developed based on in-plane switching mode with multi-domain. This product adopts Cu electrode which, in spite of low resistivity, was not applied to TFT LCD products because of productivity and reliability problems etc. This low resistivity material makes it possible to clear the problem caused by line delay in such high resolution TFT-LCDs. As a results of successful adoption of innovative materials and technologies, our world's largest TFT-LCD Monitor has best performance for high information display

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1. Introduction

Rapid progress in PC system and O/S demands that information display device LCD become larger in size and finer in resolution. And wide monitor becomes more popular than 4:3 monitor in accordance with popularity of MFM (Multi Function Monitor). Figure 1 shows a trend of the panel size and resolution of TFT-LCD monitors. There are many activities for large size panel development in TV application. As shown in the figure 1, in monitor application, the studies for high resolution monitor development are also very active to meet the growing needs to the special field like medical systems, displays for control center and surveillance systems which can be classified as high information content displays. To meet customer's large size and fine resolution trend, our cut-edge technologies are used to make the world's largest 30.0" fine resolution (WQXGA+) monitor.

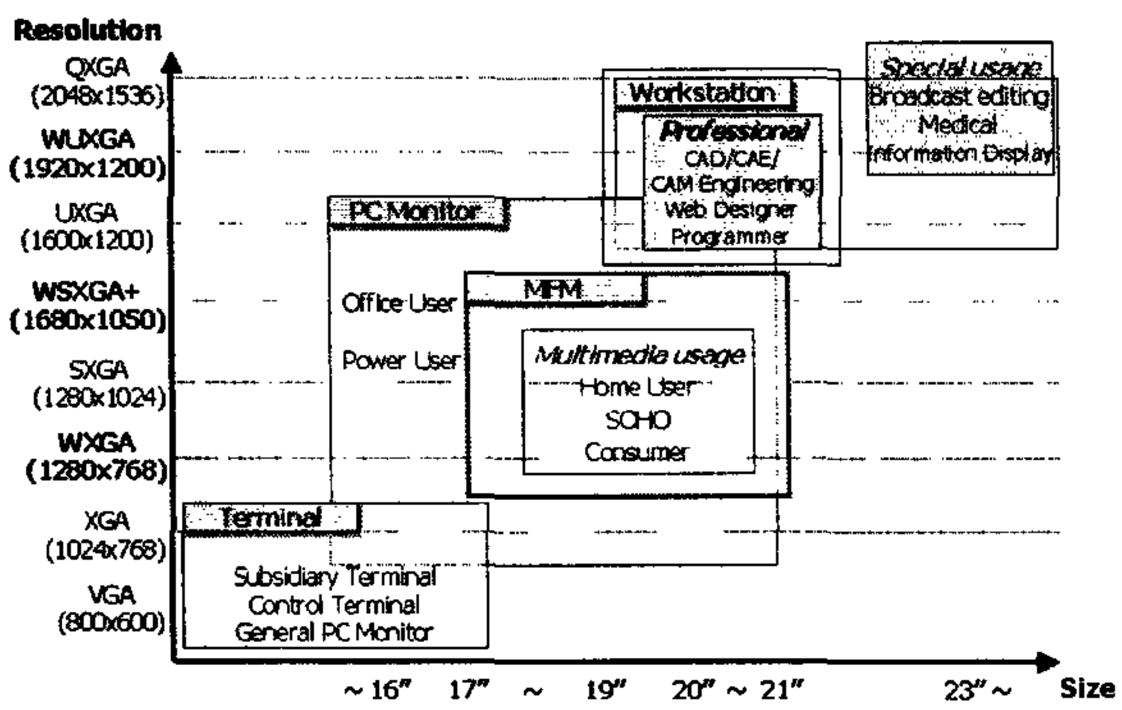


Figure 1. A trend of the panel size and resolution of wide TFT-LCD products

2. Summary of technical issues

Main technical issues to develop the world's largest 30.0" fine resolution (WQXGA+) monitor are signal delay caused by long addressing line to cover large screen, and chronic issues like contrast ratio and response time. TMDS dual driving is necessary for driving for such a high resolution (WQXGA+) and to add the function to shift the resolution, scaler was embedded inside the LCD. Table 1 lists technical issues and their solutions for 30" WQXGA+.

Technical issues	Solutions
Viewing angle	Super IPS
RC Delay	Cu Bus Line
Response Time	New LC and Optimal Cell design
Contrast Ratio	Surface Morphology
Driving for High Resolution	TMDS Dual Driving
Intelligent Resolution Change	Embedded Scaler

Table 1. Technical issues and the solutions of 30" WQXGA+ TFT-LCD

2.1 Super IPS for high information content displays

Super IPS (In plane switching mode with multi-domain) provides true wide viewing angle. Moreover, it represents additional advantage over VA (Vertical alignment mode) in case of higher resolution and larger screen size. As resolution increases, the data and gate line capacitance rapidly increase in both of VA and IPS mode. But as shown in figure 2 due to the inherent vertical electric-field LC-operation which imposes additional capacitance on the data line, VA mode has larger data capacitance value than IPS mode. Such large capacitance of VA mode deteriorates RC delay characteristics and imposes severe restrictions to designing large screen and high resolution LCD monitor.

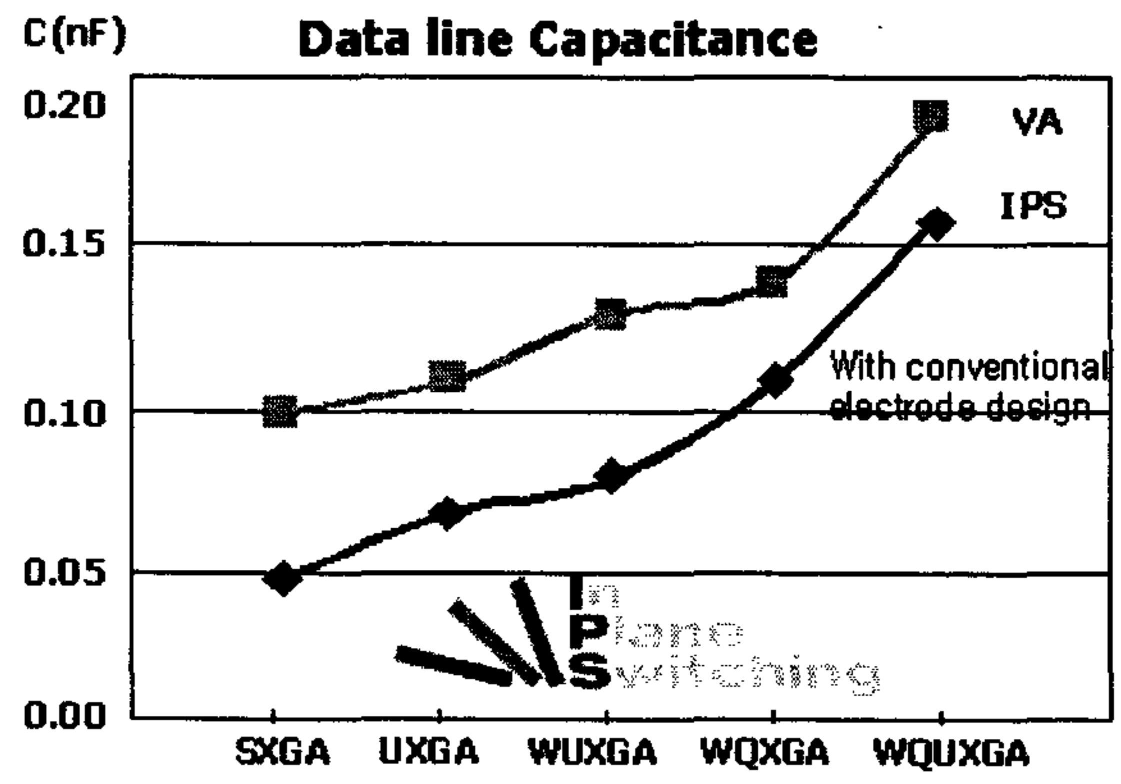
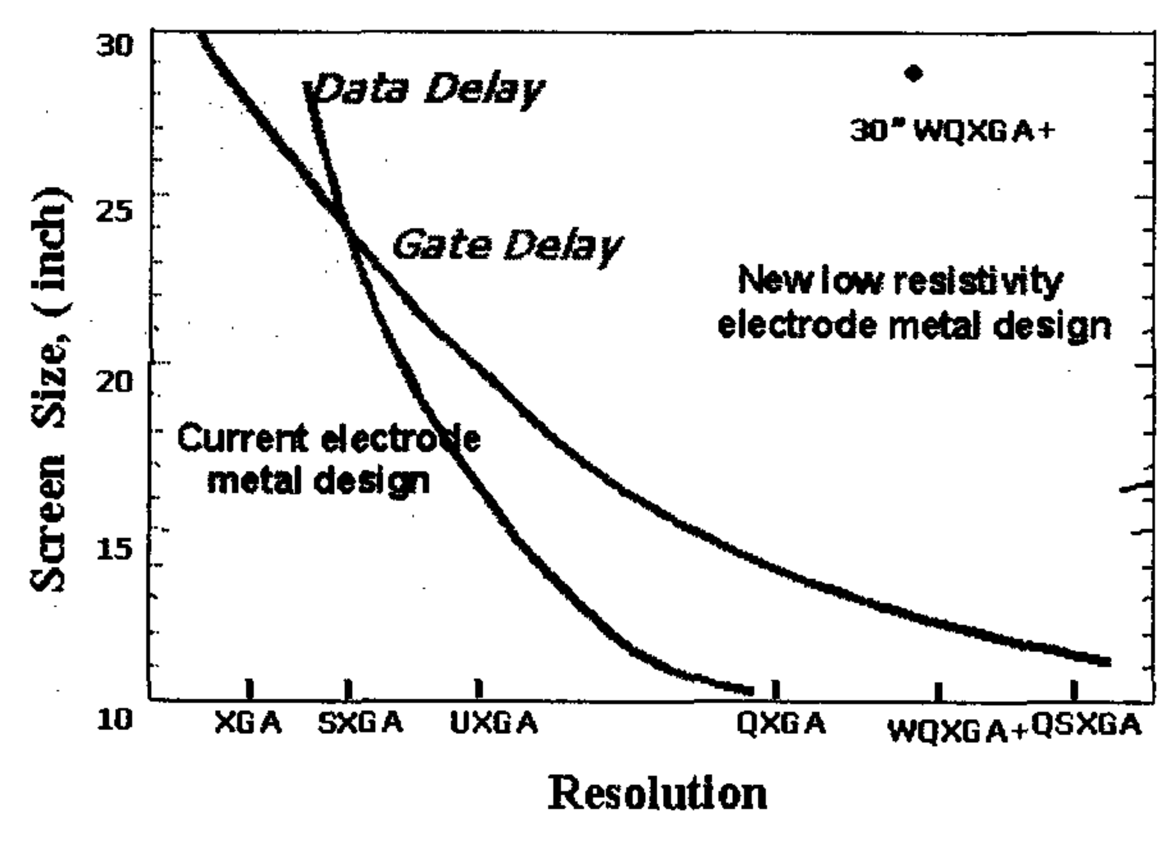


Figure 2. Data and gate bus line capacitance of IPS and VA mode as a function of screen resolution with conventional electrode design. Triangles represent IPS

2.2 RC delay of high resolution monitors

The one-frame data size rapidly increases in proportion to screen size and resolution. for example, XGA screen has only 2mega pixels which should be charged in 16.7u sec. But in the case of WQXGA screen we need 12mega data to fill the screen. So, we need numerous data lines and data addressing lines, that is to say, longer and thinner electrode and more capacitors. However, if we use general design rule and conventional materials, the WQXGA display will suffer severe charging problem caused by RC delay of gate bus line. The RC delay in data line makes it difficult for D-IC to compensate the voltage fluctuation on data signal and causes screen image degradation. To compensate data and gate RC delay in LCD display panel, we can optimize data-gate signal timing or increase slew rate and gate-on voltage of D-IC. But the efficiency of proper timing and high slew rate and high gate-on voltage are limited by absolute gate on-time and power consumption, so to develop large and high resolution display, we need innovative low RC-delay panel. IPS mode has structural advantage to RC-delay problem compared to VA mode, but as shown fiqure 3, in the case of 30" WQXGA monitor, IPS also suffer severe date charging problem unless resitivity is lowed. As shown in figure 3. data and gate RC delay limits the availability of current electrode metals for high resolution monitor. To overcome this problem, we came up with new metal electrodes which have lower resistivity than that of AlNd.



Fiqure 3. Data and gate RC-delay limits availability of current electrode metal design

2.3 Cu based TFT Process

In spite of advantage, Cu has not been used for mass products in TFT-LCD because of many process-related problem. The main problem of Cu electrode application is inter-layer diffusion & adhesion and finding proper Cu etchant & striper. To prevent Cu inter-layer diffusion into a-Si layer, barrier metal is deposited below Cu electrode. Newly developed Cu etchant & Striper are used to remove residual Cu ion on TFT channel. In Cu electrode application, the residual Cu ion increases TFT off-current and causes threshold voltage shift, so deteriorates the property of TFT device. New Cu etchant & Striper are very effective to solve those problems and make mass production with Cu electrode possible.[1]

2.4 Contrast Ratio

We achieved 500:1 by innovative material change and manufacturing process improvement based on thorough study of main factors of contrast ratio. High contrast ratio color filter adapting dispersion-reduced new color pigments increases polarity of incident light and LC alignment uniformity enhancement by rubbing optimization and Ion beam/UV alignment improves the optical property of LC and reduces pre-tilt angle. Morphology improvement by Cu taper characteristic makes black color to be more black, and new optical back light system by new optical film increases collimation of light. These technologies all are combined to improve IPS mode' contrast ratio and make it possible to obtain 500:1 contrast ratio. Figure 4 shows detail of contrast ration improvement technologies.

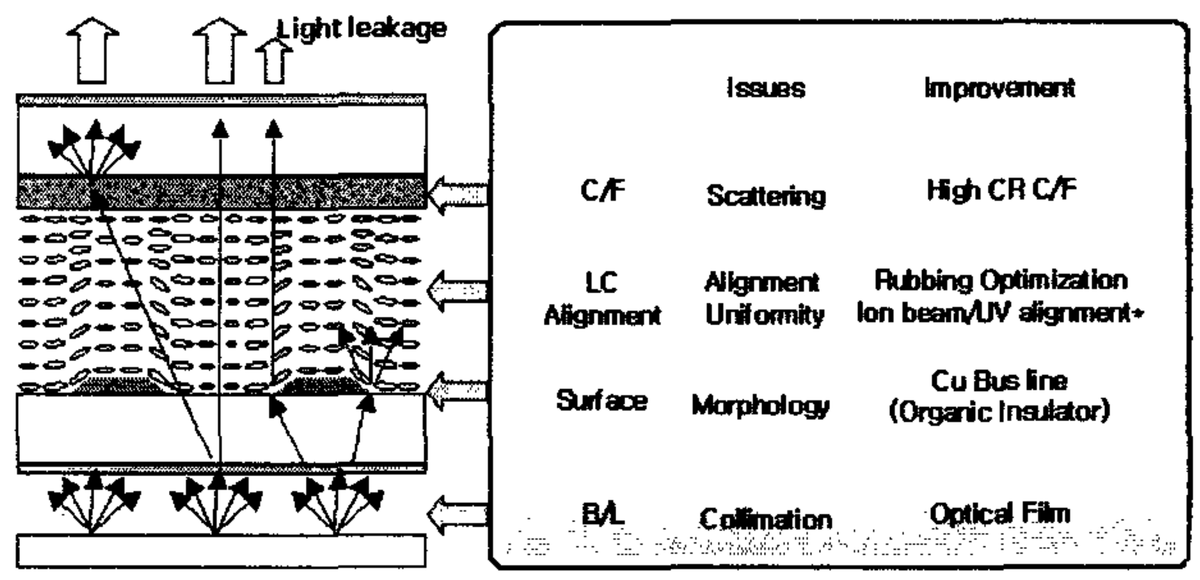


Figure 4. Technical Issues to achieve High C/R in IPS

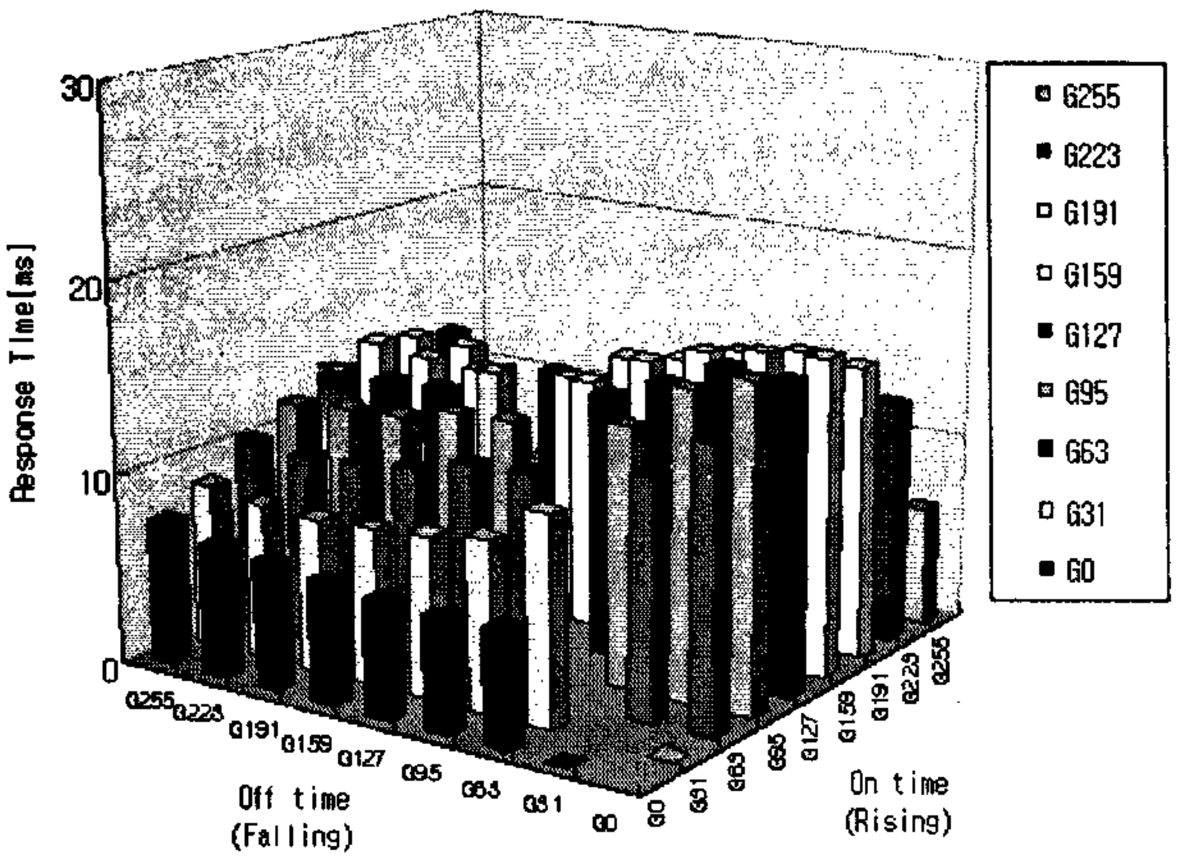


Figure 5. Response time as a function of gray level without ODC

2.5 Fast Response

To improve response time, we attempted to reduce the rotational viscosity γ1 and at the same time decreasing the cell gap by applying patterned spacer technology. However the decrease of the cellgap increase the threshold voltage, and this should be compensated by increasing Δε. Therefore we need relatively high Δε LC mixtures without decreasing the viscosity. But usually, an increase of polarity which is needed to reduce the voltage level, in turn, will increase rotational viscosity, The new LC materials, however, overcome this drawback, possessing a good combination of Δε (~25) and γ1 (~70-90 mPas).[2] By using the newly developed liquid crystal mixtures we have obtained a sufficiently low operating voltage with a low cell gap that maintains a low viscosity and as result, 16m sec response time in black to white and gray to gray without additional driving circuit such as ODC. (see figure 5)

2.6 LCD panel driving

High frequency driving technology is another essential key technology to develop large size and high resolution display. As shown in figure 6, for system data input of the world's largest 30" WQXGA+ monitor, 135MHz dual link TMDS is used and for TMDS receiver & TCON, 135MHz dual link TTL is adopted. And embedded scaler enables the intelligent resolution mode change between 2560x1600(dual mode) and 1280x800 (single mode).

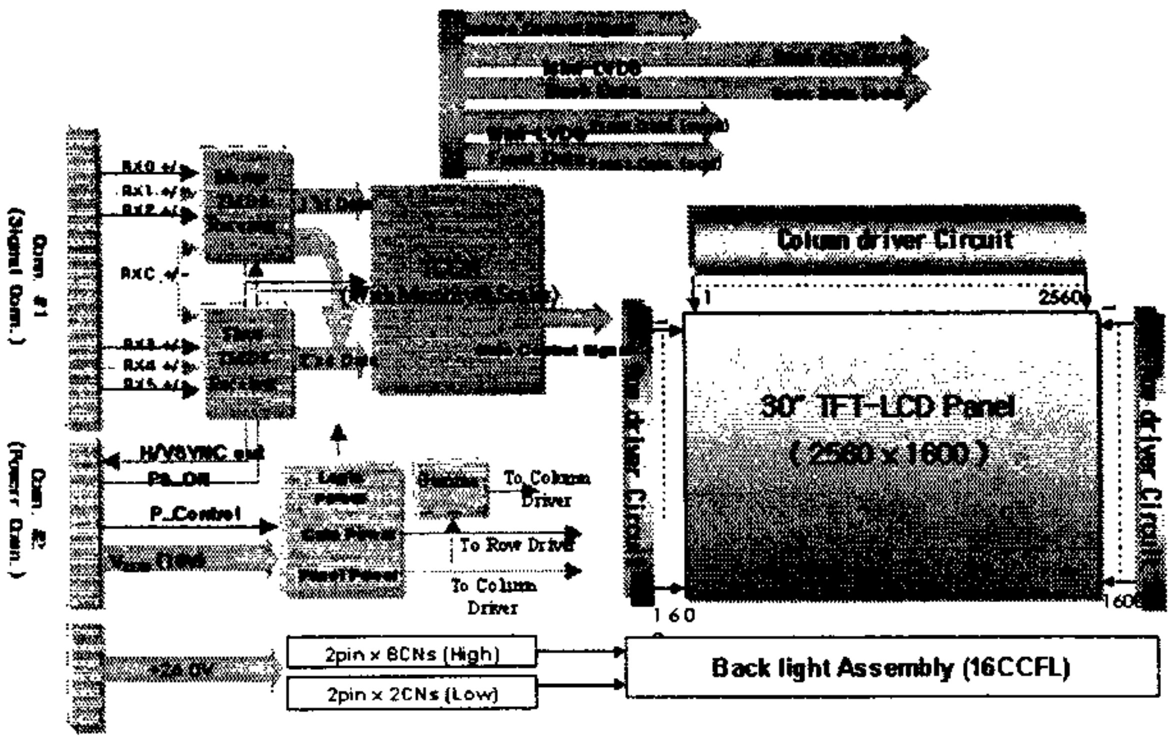


Figure 6. Block Diagram of 30-inch wide QXGA+

3. TFT-LCD Module

Figure 7 shows our company's 30-inch wide QXGA+ TFT-LCD Monitor. This large size and fine resolution monitor shows core of Multi-function by displaying huge information and providing large space for multi-tasking. This monitor can show six web browsers at one time. Monitor user can really enjoy the efficiency of our large size screen by typing word process, surfing web and watching multimedia contents at one time. If you want to do same thing with 17"LCD, you need three monitors.

As mentioned in key technology review, our new product shows excellent performance in all specifications described in following table and provides best screen quality to consumer. Large size and high resolution monitor based on new material and manufacturing process will be a trend of next generation information display. The specifications of 30-inch TFT-LCD module with 2560*RGB*1600 resolution are shown in Table 2.

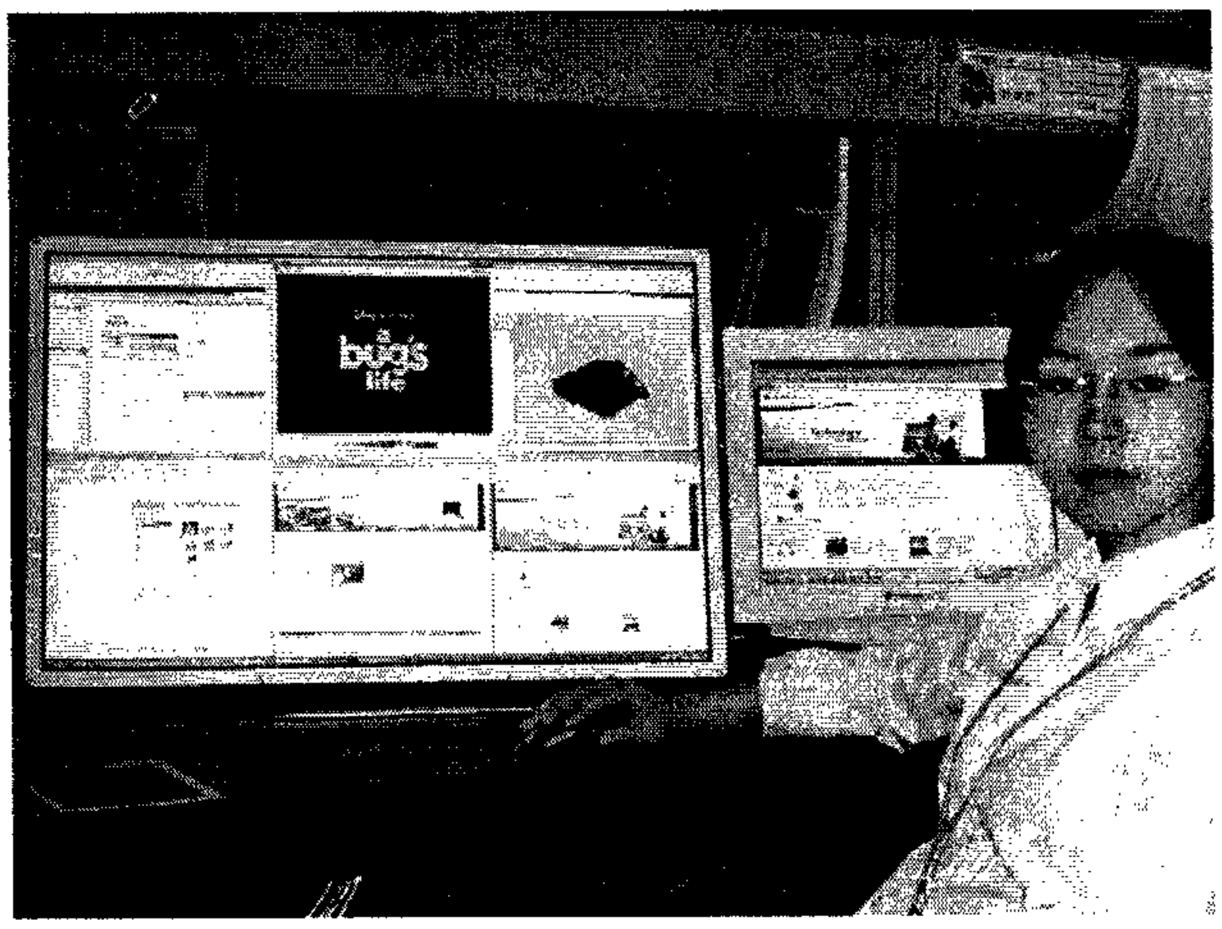


Figure 7. 30-inch wide QXGA+ TFT-LCD Monitor for multi-tasking

Item	Specification
Display size (diagonal)	30-inch Diagonal
Resolution	Wide QXGA+
Display pixel (Hor. x Ver.)	2560 x 1600
Pixel Pitch	0.2505mm x 0.2505mm
Color Gamut	72%
Color coordinate(white)	0.313, 0.329
Contrast ration	> 500:1 (max)
Brightness	250 cd/㎡
Response time	16ms
Viewing angle(CR ≥10)	>176

Table 2. The specifications of the world's largest 30.0" fine resolution (WQXGA+) monitor

4. Conclusion

To meet consumer demand for large screen and high resolution monitor information display, we developed the world's largest 30" fine resolution (WQXGA+) monitor. We developed Cu electrode technology to make the world's largest monitor to become real, and adopted new high contrast ration and fast response technology to provides vivid image to users. Our monitor suggests new standard for multi-function and multi-task monitor.

5. References

[1] C.W. Park, W.H. Cho, K.T. Kim, H.C. Choi and C.H. Oh, IMID '03 Digest, pp661~663.

[2] C.S Lim, J.H. Lee, C.H. Oh, H.C. Choi, Seung-Eun Lee, Min-Ok Jin, M. Klasen-Memmer, K. Tarumi, IMID '03 Digest, pp69~71.

[3] H.C. Choi, S.G. Hong, B.H. Lim, S.W. Lee, S.D. Yeo, SID '04 Digest, pp119~121