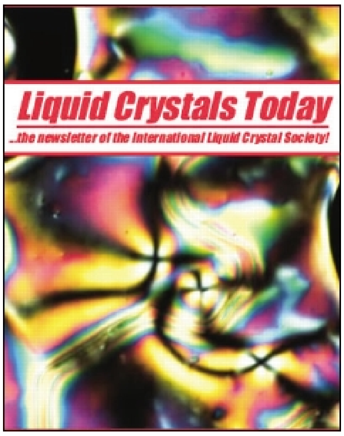

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FLCDs: the route to Market

A. Mosley[a]; B. M. Nicholas[a]
[a] GEC-Marconi Ltd., Hirst Research Centre, Borehamwood, Herts

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FLCDs: the route to Market

from A Mosley and B M Nicholas, GEC-Marconi Ltd., Hirst Research Centre, Elstree Way, Borehamwood, Herts, WD6 1RX

Ferroelectric LCDs represent one of the latest liquid crystal technologies, the main attributes of which are very fast switching, typically <100μs and bistability. This combination of properties enables ferroelectric LCDs potentially to provide complex, alphagraphic displays for a variety of applications.

It was R Meyer in 1975 who predicted that chiral tilted smectic liquid crystals would exhibit ferroelectricity and hence possess a large spontaneous polarisation oriented perpendicular to the director. The chirality required to induce ferroelectricity also promotes a helical structure, which (as noted by Meyer) has to be removed in order to provide a useful device. This was first done by shearing the glass substrates that enclosed the ferroelectric liquid crystal and is now achieved by the use of rubbed polyimide surface alignment layers, similar to those used in nematic-based LCDs. In both cases, the spacing between the two substrates is ideally less than 2μm.

The structure and fabrication of ferroelectric LCDs is very similar to that of a supertwist LCD. The two main differences are the use of a 2μm, compared with 5-6 μm for supertwist LCDs, cell spacing and the requirement to heat both the ferroelectric liquid crystal and the display cells to 80-100°C during the vacuum filling process. The impact of these two differences is that the volume manufacturing costs of ferroelectric LCD glass are likely to be ~10% higher than those for supertwist LCDs. The cost of the drive electronics for ferroelectric LCDs is likely to be similar to that for supertwist displays. Although the cost of the drivers for complex alphagraphic ferroelectric LCDs with frame times of ≤50ms will probably be higher, because of the need for a voltage swing of 100V compared with 35V, the higher multiplexing

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Ferroelectrics & Antiferroelectrics enter the Display market

from S T Lagerwall, Chalmers University of Technology, Physics Dept, Liquid Crystal Gp, S-412 96 Göteborg, Sweden

During the recent FLC' 93 Conference in Tokyo some impressive demonstrations were given of the present state and the future potential of the FLCs in various types of display.

Canon decided in 1985 to make major investments in the FLC technology after a couple of years of corporate research. At the FLC'89 in Göteborg, Sweden, they showed the first A4 size monochrome FLC display for PC application. In 1993 Canon presented a second generation of displays at shows held in New York and Paris. Some of these could also be seen at the FLC'93 exhibition. The first product on the market is a desk-top publishing system containing keyboard, screen, computer and laser printer. The screen is a monochrome ferroelectric vertical A4 size (15 inch) with 1280 x 1024 picture elements each capable of 4 grey levels. The complete system sells for $15,000. The corresponding colour screen is made for horizontal format and, with the same number of pixels, can produce 16 colours in every pixel. There is also a super high resolution monochrome version of the latter one with 2560 x 2048 picture elements. The contrast is better than 40:1 in all cases. The two most interesting screens (not displayed at FLC'93 but in the New York and Paris Shows) are perhaps the 24 inch (A3 size) black and white and the 21 inch 64 colour version. Both of these are made with a new alignment technique and using a layer thickness of only 1.1 μm. The colour screen can be driven at video speed if using half the vertical resolution, i.e. by scanning the screen as if it had 512 lines. The successive development of a shock-proof tech-

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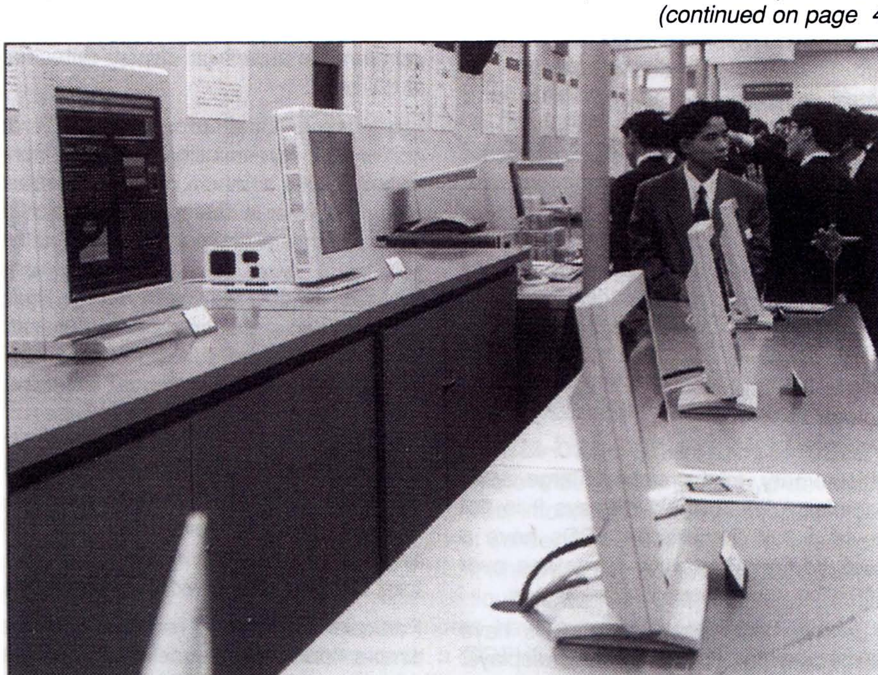

A variety of Canon FLC displays at a recent trade exhibition

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capability of this technology will result in the use of fewer column drivers. Therefore, one can conclude that the selling price of ferroelectric LCDs should be slightly higher than that of supertwist displays.

The performances of these two technologies are compared in Table 1 for a colour VGA display. As a result of the different mode of operation and the thin cell spacing, ferroelectric LCDs have a much lower dependence of contrast ratio on viewing angle. In principle, the bistability of ferroelectric LCDs makes the contrast ratio independent of the multiplex level, consequently, relatively high contrast ratios can be achieved in complex displays.

Table 1: A comparison of the characteristics of colour VGA ferroelectric and supertwist LCDs.

	FERRO ELECTRIC LCD	SUPER TWIST LCD
Contrast Ratio	25:1	15:1
Viewing Angle	Very good	Limited
Frame Time	35 ms	>100 ms
Grey Levels	0	~16
Robustness	?*	Very good
Operating Temperature	?*	0 to +50°C
Storage Temperature	?*	-20 to +60°C

** Not well established*

Ferroelectric LCDs are driven both on and off, unlike supertwist and other nematic-based LCDs which are driven 'on' but relax 'off'. This leads to reduced total on + off times, a typical line address time for a ferroelectric LCD is 70µs. The main, established disadvantage of ferroelectric LCDs is their inability to display greyscale; grey levels can be achieved by spatial or temporal dither, but both of these techniques increase the complexity, and hence the cost, of the display module. Ferroelectric LCDs have attracted a reputation for being sensitive to mechanical shock, but improvements in the cell technology have led to a reduction in this problem.

In summary, in the case of large area, complex, alphagraphic displays it is not obvious that ferroelectric LCDs have a cost: performance ratio advantage over other flat panel display technologies.

It is clear that ferroelectric LCDs have great potential as alphagraphic displays. However, for ferroelectric LCDs to enter the marketplace as displays, say for laptops, appears to be extremely risky. Colour VGA displays are complex, expensive and have a large area, and will thus require a large investment, e.g. $50,000,000, in plant and machinery to avoid low initial yields. In addition, supertwist and active matrix displays are already very well established in this marketplace and both have strong infrastructures of finance, people, knowledge and materials. Ferroelectric LCD technology does not have this infrastructure, but needs to establish it in order to grow. To do this, it requires a high volume product, but does such a product exist?

Ferroelectric LCDs exhibit bistability and under the correct conditions they can exhibit memory at zero field, i.e. they can be non-volatile. Again, under the right conditions this non-volatility can be very long term; a display at the Hirst Research Centre has kept its image at zero power for six years! No other flat panel technology currently has this capability. Therefore, it seems sensible to identify products that would benefit from having a non-volatile display, i.e. a display that can continue to display the last image without consuming power. Clearly, any portable product requiring a reflective flat panel display (the use of a permanent or semi-permanent backlight would negate any power savings) where the information is updated infrequently, i.e. an update time of >1 minute, will benefit from a greatly extended battery life through the use of a non-volatile display. For example, the power consumption of a non-volatile ferroelectric LCD, whose image was updated every minute, would be ~1/3600 of that of a comparable supertwist display refreshed at 60 Hz.

Many conventional ferroelectric LCDs do not exhibit non-volatility or exhibit non-volatility with a much reduced contrast ratio. The latter is due to the relaxation of the liquid crystal director on removal of the field as a result of the restoring force induced by the alignment of the liquid crystal molecules at the surface of the cell. Having recognised this problem in 1987 and patented ferroelectric cell structures which overcome it, GEC's Hirst Research Centre was well placed to develop a high contrast, non-volatile ferroelectric LCD. Our latest generation of technology provides a relaxed, i.e. zero power, half cone angle of 15°, resulting in bright, high contrast displays with a wide viewing angle.

Particular examples of requirements for a simple non-volatile ferroelectric LCD are autonomous electric labels, portable data loggers and personal telecommunication devices. The first of these, the autonomous electric label, could be used in an electronic shelf edge labelling system for supermarkets. Clearly, this is potentially an extremely high volume market; there are ~20,000 products in each supermarket (food store). Another application for the electronic label is as a reservation sign for train seats, again a high volume market. Indeed, all of the above identified markets have high volume requirements and, of equal importance, they all require relatively simple displays. The latter point is important, because this will reduce the required investment in plant and machinery, and hence the financial risk.

Therefore, it is concluded that ferroelectric LCDs should enter the marketplace by providing simple, low cost, non-volatile displays for high volume applications. The infrastructure established by the mass production of these simple displays will then enable ferroelectric LCD technology to grow and expand into other produce areas requiring complex non-volatile displays and ultimately allow it to compete with the other mainstream flat panel technologies. This proposed route to the marketplace, through the high volume production of simple displays having a specific advantage, is not new; after all, LCDs started off as watch displays!

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THORN EMI Central Research Laboratories have developed a new generation FLC display with distinct advantages over competing technologies, write Paul W H Surguy and Lawrence K M Chan (see IEE Review, Nov 93).

The 10.4 inch FLCD VGA resolution colour panel constructed at Thorn EMI's Central Research Laboratories has contrast ratios up to 30:1, a display luminance of 50cd/m^2 and can be viewed from a wide range of angles with little variation in contrast. The multiplexing scheme adopted by CRL is based on the positive slope region (inverse) of the pulse width/voltage switching characteristic.

FLCD's can also be used for non-display applications such as spatial light modulators, and more recently as a high resolution printhead for desktop page-printers. CRL has demonstrated a 45 page/minute 30dpi FLC printer.