

4th International Conference Photonics and Information Optics, PhIO 2015, 28-30 January 2015

## Novel FLC- Materials Open New Possibilities for FLCoS Based Microdisplays and Video Projectors

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### Abstract

A video projector with liquid crystal microdisplay based on FLCoS- structure is considered, and the new low-voltage ferroelectric liquid crystal (FLC) with a compensated helix as an electro-optical material providing physically realizable continuous gray scale hysteresis-free modulation characteristic is proposed to use in FLCoS.

As light sources in RGB color channels the laser diodes of red, green and blue light are proposed to use. To prevent the interference of light beams resulting in the speckle noise appearance in output images it is proposed to input a despeckler – single FLC cell into an optical unit of information readout, in order this cell implemented fast electrically controlled spatially-inhomogeneous phase light modulation with a depth of  $\geq \pi$ . To form on a screen the large data blocks with information capacity of  $10^8 \dots 10^9$  pixels and with different geometric configuration a two-dimensional scanner is proposed to use, which is optically coupled to a screen and optical unit of information readout.

Possible technical results - increasing the frame rate up to 600 Hz as a minimum, the color gamut expansion, increasing a brightness of images, suppression of the speckle noise, - can be used not only in new devices of information visualization and displaying, but also in systems of data storage and processing and others.

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Peer-review under responsibility of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

**Keywords:** multiple-valued logic; intelligent agent; automatic model design; minimization; consensus method; multi-parametric data processing.

### 1. Introduction

Displays as devices of information displaying are one of the key elements of information and communication systems, including television systems. The increase of bandwidth (differently informational capacity) of such

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systems is an actual task. Its solution is provided both by increasing the number of parallel channels (relative to displays - the number of elements or pixels in the display screen), and by increasing speed of information transmission (relative to the display - increasing the display frame rate).

Taking into account the relationship of both factors in the systems with a given bandwidth, one can vary every of them at the expense of another. Relative to displays, however, the frame rate should always be above a certain critical frequency, at which the screen shows flicker-free images. For many applications, such as in cinema and television, the critical frame rate of 24-60 Hz is allowed, while according to medical recommendations, and taking into account the observation of fast moving objects (like a flying ball) on a display screen the frequency of 90-100 frames per second is more preferable (for Russia the value 100 fr./sec is better agreed with the frequency 50 Hz of the electric net). It is better to retain this value and for displays with sequential (in time) change of colors – Field Sequential Color technique (FSC), promising the triple reduction of the number of display elements and observing whole (non-structured) and more bright image due to the elimination of the triad of color filters. In such a case, the refresh rate on the display screen should be of 270-300 Hz, and using the technology of three-dimensional stereovision - even twice more, up to 600 Hz.

Can liquid crystal materials and displays meet this requirement?

## 2. Informativeness of LC displays

Really the most widespread display technologies currently provide a much lower frame rate that is explained by slow processes of active or passive light modulation respectively in emitting or electro-optical material of a display screen. For example, in displays based on organic light-emitting materials - potentially up to several hundred Hz, but actually (because of the possible material degradation due to high currents) it is limited at about 200 Hz. In plasma panel displays, too, a frame rate does not exceed the frequency of 200 Hz. In the most widespread displays based on nematic liquid crystals (NLC), the maximum frame rate is only 120-160 Hz.

Concerning to the number of pixels (spatial resolution), in advanced video projectors and television displays the preferred format is the so-called "High-Definition» (HD) - 1920x1080 pixels. In personal computers the format 1024x768 (XGA) prevails till now, and screens of smart devices (primarily the screens of mobile phones) still remain 800x600 pixels (SVGA) and even a 640x480 (VGA). However, due to the constant need in increasing the throughput of information and communication systems, especially in conditions of the limited speed of displays, the general trend is the steady increase of their spatial resolution. Not only the formats XGA (about 1000x1000 or 1Kx1K pixels) and HD (of the order 2000x1000 or 2Kx1K pixels) are master, but also (2Kx2K), (4Kx2K) and even (8Kx4K) pixels.

Increasing the number of pixels, however, leads to serious technological problems and difficulties in addressing the display elements. Though modern methods of data processing and pixel addressing allow addressing in parallel the several parts of a frame and selective addressing the only changed pixels in a frame, nevertheless the task of increasing the number of pixels on the screen is associated with great difficulties. Solving the problem by using the high-resolution common composite screen composed of a few display screens, i.e. due to spatially and frequency agreed screens makes a composed display cumbersome, difficulty controlled and expensive, and therefore not effective.

Thus, the throughput of information displaying on a screen of contemporary display is restricted both in the speed, and spatial resolution.

## 3. Liquid crystal micro displays, and projection displays based on them

High resolution is especially needed in displays intended for projecting the information onto a large screen (including TV screen). Images are formed in a video projector and are projected onto a screen via an optical unit comprising a light source and projection optics. The video projectors based on a micro display with a liquid crystal matrix, which is addressed by drivers, made on silicon integrated technology, are most widespread [Chinnock (2014), Armitage et al. (2006)].

In all types of video projectors a white light source is often used, such as a compact high-pressure lamp, and the colors are selected by using filters or polarization prisms. In recent years, LEDs with RGB or white light, and even

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