PiMoD Projector-Projection Screen Display System

Wallen Mphepo[1,2*]
Chalmers University of Technology, Goteborg, Sweden
Display Institute, National Chiao Tung University, Hsinchu, Taiwan
*wallen.ge94@nctu.edu.tw

Abstract: *One of the most common approaches so far being implemented to improve the image quality of Overhead Projection Display Systems has been to try and increase the intensity and power of the systems' lighting sources. The trade-offs which include high temperatures and other drawbacks associated with this method are well documented. Thus a re-thinking of the problem has led to a realization that one major component of the Overhead Projector Display Systems is not being fully utilized, the projection screen itself. This paper is going to layout how an active projection screen or a passive color resonant projection screen could enhance the color saturation, contrast and resolution of the displayed images.*

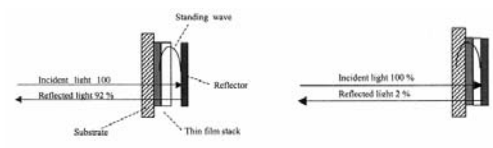
Keywords: Liquid Crystal Overhead Projector Display Systems; Active Projection Screen; Big Screen Displays; Home Theater; iMoD; PiMoD; MOEMS

Introduction

Lately, a glance at the Big Screen Displays section of major electronics stores can reveal a visible convergence in the prices of conventional Big Screen Flat Panel Displays with those of Liquid Crystal or other overhead Projection Display Systems. Indeed some Overhead Projection Display Systems cost even less than conventional Big Screen Flat Panel Displays as the diagonal sizes increase beyond certain limits. Thus, herein lays the argument that can be made for Overhead Projection Display Systems, that they can be better - better in cost per diagonal size and better in color saturation, resolution and contrast. However, this will not easily happen, at least not without a little unconventional approach. The most common approaches so far have seen mostly gradual improvements. Therefore a radical re-thinking of the problem and a focus on the projection screen might reveal a possible alternative approach.

Concepts

The basic operation of an interferometric modulator device [iMoD] can be illustrated as in the fig. 1 below. It is the selective light resonant characteristic [4] [5] of the iMoD devices that has attracted engineering interest with regards to designing a better type of projection screen for over head projector display systems. By being able to selectively choose Red, Green and Blue resonant specific iMoD structures in the screen it makes it feasible to design a synchronized sequential RGB projection display system. This, however, might be an over kill since that would mean requiring a driving system for both the projector and the screen, which is indeed possible. Another way would be to design a passive screen with the same resonant capabilities for RGB, and therein lays the technical challenge this paper is going to tackle and propose a possible solution.



iMoD in resonant (left) and absorption mode (right).

Figure 1.
[Courtesy of [1]]

Developments in Other fields & Results

The basis for the development of the iMoD element is to make a wave interfere with itself resulting in a standing wave within the air gap of the structure. This gap is designed to fit a particular desired wave thus introducing wave specificity to each element [1] [2]. In this state the element is said to be in resonant mode as it reflects a specific wavelength from the incident light as shown in Fig 1. left. By changing the air gap adjuster to a displaced, off peak performance, position a state of induced absorption is created as illustrated in Fig.1 right. The iMoD elements have been developed by various researchers and are used in different applications [3] [4]. However, it is their discrete color resonance ability that makes them particularly useful in display devices and thus shall be exploited in the proposed design elaborated below.

Bi-stability in iMoD display devices has already been demonstrated and is used in some display applications today [3] [5]. With regards to this paper the focus is mainly in two parts, the active bi-stable/multi-stable and the passive mode.

Another development that is also utilized in this paper is photolithography process. Experimental photolithography as a fabrication process is now very mature as it has been employed in various industries for a considerable length of time. Thus it is chosen as a method of fabrication for the later discussed PiMoD projection screen and it does not need much introduction.

The proposed approach for fabrication entails applying three different layers onto the back substrate as in Fig. 2 diagram step 1. The three layers are chosen for their specific different photolithographic properties that can be etched by different photo intensities or photo exposure lengths. The layers are also obviously designed to be of particular widths corresponding to the desired air gap sizes for each of the three RGB colors.

The top layer is set such that it is the softest and requires minimal photo intensity for etching and removal resulting in structure in illustration 2. of Fig. 2. The middle layer with the intermediate photo etching resistance is etched by an intermediate strength photo intensity selectively resulting in structure in Fig. 2 illustration 3. Finally the strongest bottom layer is then selectively photo etched by the highest photo intensity leading to structure in illustration 4.

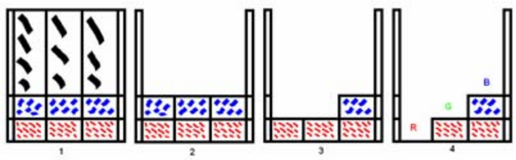


Figure 2. This figure shows a sketch of the abbreviated proposed photolithographic process

As already stated iMoD devices only reflect desired colors from white light in general, moreover they can also do the same to the various light color combinations thereof. Thus a diffused either R, G or B would be reflected in clear R, G or B by the iMoD element for that particular color. In the above illustration Fig. 2 the simulated structure behaves as a Passive iMoD [PiMoD] element requiring no power. Hence when a video image from an Over Head Liquid Crystal Projector Display System is projected onto this PiMoD projection screen the discrete desired colors are reflected resonantly while all others are in a state of induced absorption. In addition, when the image is projected sequentially in RGB, the screen will reflect the respective individual colors successively resulting in crisp and color saturated viewable images.

Fig. 3 below illustrates a simplified example of what such a PiMoD Screen structure would look like, though not to scale. The different regions would resonate the design specified colors in much the same way as shown in fig.1 above.

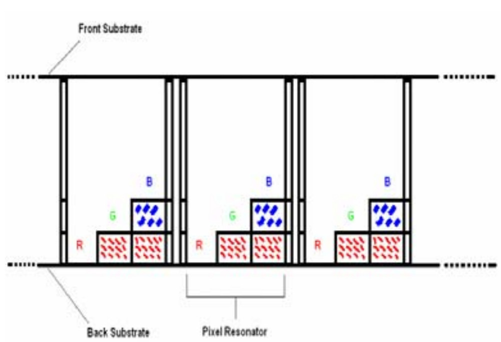


Figure 3. This figure shows the simplified internal structure of the proposed PiMoD projection Screen

In operation the specific *sub-pixel* color resonator design is to be made such that all the other waves are absorbed except for the desired wave which will be left as a standing wave. By operating in sequential RGB a fast liquid crystal over head projector will display discrete colors one at a time which then get reflected by the PiMoD internal structure one at a time with a selective reflectance of nearly 90% [1] [4] and induced absorption for all other colors of over 95%.

The operational structure of an active iMoD screen would require synchronizing the sequential RGB resonance with the sequential RGB of the over head projector display system. Clearly, this would require a power source for both the projector and screen. Moreover, it adds an extra complexity to the fabrication process as there will also be a need for TFTs to control the individual Pixel Resonators. Hence the cost could be prohibiting as the cost benefit ratio would be unbalanced. Note, by adding TFTs and individual pixel/pixel resonator control capability it effectively changes the screen to a regular standard iMoD display, though simplified.

Another method that could be applied in order to lower the cost for the active screen fabrication would be to employ Flexible Array Switches instead of regular TFTs. These have the advantages of having the same functionality and capability as TFTs but cost approximately one third less while also weighing half as much.

Consolidation of Knowledge Base & Impact

Apart from the above and also some of the recently filed US patents [4] [5], it is apparent that the more cost effective way to achieve a crisp RGB resonance is to use a PiMoD projection screen instead of the active one. Considering the added advantage that a PiMoD is a solid state structure with no mechanical parts it makes for a better unobtrusive next generation high quality projection screen.

The brighter colors due to increased selective resonance also enable projection onto even larger display screen sizes with minimal loss in resolution and brightness even though the arriving image colors might be diffused.

Summary

With the potential capability to reproduce a crisp high quality video image approaching HDTV or Digital Micromirror Device type displays plus the added bonus of a much larger cinema size diagonal screen, a PiMoD coupled Over Head Liquid Crystal Projection Display system could give consumers the best bang for their buck when it comes to Home Theater Systems. It has been argued that due to the physical properties and mechanical properties of glass, the handling and working of the substrates for conventional flat panel display technologies will become progressively if not exponentially harder with increasing linear diagonal size after a certain point. Hence the marginal costs for a diagonal inch of larger big screen conventional flat screen displays will become a prohibitive liability unless there are drastic improvements in the glass technologies in the immediate future.

On the other hand the PiMoD structure can be constructed onto any regular flat smoothened workable surface as the back substrate and/support while a clear light weight plastic would work as an effective front substrate. The physics for iMoD devices has already been proven theoretically and experimentally [1] [2] [3] [4] [5] in different types of now commercially viable small displays but it is worth noting that the concept could prove even more paradigm shifting and maybe even technologically disruptive if effectively applied in this proposed application for big screen Home Theater display systems.

Reference

1. Mark W. Miles "Interferometric Modulation: MOEMS as an Enabling Technology for High-Performance Reflective Displays" *Proceedings of SPIE*, Vol. 4985 (2003)

2. Mark W. Miles "MEMS-based interferometric modulator for display applications" September 1999, *SPIE*, Vol. 3876

3. Sunny Bains "Micromechanical display uses interferometric modulation" http://www.spie.org/app/Publications/magazines/oerarchive/july/jul00/micromech.html

4. *US Patent* No. 5 835 255

5. *US Patent* No. 6741377B2