Session 2

Posters:

Low Vision Goggles: Optical design studies

Ofer Levy[a] , Boris Apter [b] and Uzi Efron[a,b]

[a] Dept of Electro-Optical Engineering, Ben Gurion University, Beer Sheva, Israel.

[b] Dept of Electrical Engineering, Holon Institute of Technology, Holon, Israel.

Speaker's Email: oferlvy@yahoo.com

Low Vision due to Age Related Macular Degeneration (AMD), Glaucoma or Retinitis Pigmentosa (RP) is a growing problem, which will affect over 15 million people in the U.S alone in 2010. A Low Vision Aid Goggles (LVG) has been under development at Ben-Gurion University and the Holon Institute. The device is based on a unique LCOS-CMOS Image Transceiver Device (ITD), combining both functions of imaging and Display in a single chip. Using the ITD-based goggles, specifically designed for the visually impaired, our aim is to develop a head-mounted device that will allow the capture of the ambient scenery, perform the necessary image enhancement and processing, and re-direct it to the healthy part of the patient's retina. This design methodology will allow the Goggles to be mobile, multi-task and environmental-adaptive. In this paper we present the optical design considerations of the Goggles, including a preliminary performance analysis. Common vision deficiencies of LV patients are usually divided into two main categories: peripheral vision loss and central vision loss, each requiring different Goggles' design. A set of design principles had been defined for each category. Four main optical designs are presented and compared according to the design principles. Each of the designs is presented in two main optical configurations: See-through system and Video imaging system. Additional issues discussed are the incorporation of eye tracking capability, and the use of a full-color ITD. The table below shows a comparison between the suggested optical design and existing Low-Vision/Smart Goggles systems.

Parameter	Present work	Trivisio	JORDY	LVIS
Magnification	Digital zoom - x40	Digital zoom - x8	Digital zoom - x30	Optical zoom -x15
Horizontal FOV	77[degrees]	32[degrees]	25[degrees]	50[degrees]
Vertical FOV	47[degrees]	24[degrees]	20[degrees]	40[degrees]
Angular Resolution	20[cycles/degree]	12.5[cycles/degree]	4[cycles/degree]	2.5[cycles/degree]
No. of pixels	1800X1350 2,430,000 pixels	800x600 480,000 pixels	200x200 40000 pixels	250x250 62,500 pixels
Physical Size	Width - 150[mm] Height - 50[mm] Depth - 35[mm]	Width - 155[mm] Height - 50[mm] Depth - 50[mm]	Width - 165[mm] Height - 65[mm] Depth - 80[mm]	Width - 250[mm] Height - 130[mm] Depth - 120[mm]
Weight	114[grams]	122[grams]	651[grams]	1113[grams]
Eye Relief	24[mm]	18[mm]	20[mm]	2[mm]
Focal Adjustment	Eye-Glasses-Adaptable	Eye-Glasses-Adaptable	Eye-Glasses-Adaptable	+2 to-6 Diopter Adjustment
Viewing Configuration	Binocular	Bi-ocular	Bi-ocular	Bi-ocular
Optical Methodology	See-Through	Video Imaging	Video Imaging	Video Imaging
Imager	Two RGB Imagers	Single monochrom Imager	Single monochrom Imager	Single monochrom Imager
Display	Two RGB LCDs	Two RGB LCDs	Two RGB LCDs	Two monochrom CRTs

On the fundamental limits of the Electro-Optic coefficient in LCs

R. Israeli [a] , U. Efron[a] ,B. Apter [b] and B.Lembrikov [b]

Speaker's Email: roi@bgumail.bgu.ac.il

Electro-optical light modulators are key components for a number of optical systems including displays, optical interconnects, optical processing, optical beam steering and adaptive optics .

The performance of these modulators can be characterized by three main physical parameters: (1) The electro-optical coefficient, (2) The RF frequency bandwidth and (3) The optical spectral bandwidth.

A recent study [1] has shown that the product of these three parameters, which we term "Susceptibility-Bandwidth Product" (SBP), is remarkably constant within 1-2 orders of magnitude, across a wide range of different material systems, including Liquid Crystal (LC), Solid State Electro-Optical Materials (SSEO) and Multiple Quantum Well (MQW) structures. This, despite the fact that all three parameters vary over many orders of magnitude across this range of materials. The feasibility of the SBP constancy based on material stability considerations has already been proposed several years ago [2].

Following a brief description of the SBP concept, the main purpose of this study is to present a detailed study of the SBP in Nematic Liquid Crystal (NLC) systems based on the electro-optical limits of the electrically controlled birefringence effect.

The experimental results of measuring the above three parameters constituting the SBP Quantity, is found to be in good agreement with the theoretical prediction for this product.

[1] U..Efron ,"Technology and Applications of Spatial Light Modulators", in Handbook of Opto-Electronics,J.P.Dapkin and R.G.W. Brown, Editors, Taylor & Francis, London (2006),Vol.2.

[2] U.Efron, "Spatial Light Modulators and applications for optical information processing", Proc. SPIE Vol.960, pp.180-203 (1988).

(a) Dept. of Electro-Optical Engineering, Ben-Gurion University, Beer-Sheva, Israel

(b) School of Electrical Engineering, Holon Institute of Technology, Holon, Israel

HIGH RESOLUTION LIQUID CRYSTAL SPATIAL LIGHT MODULATOR WITH PATTERNED METAL LAYER SUPPORTING SURFACE PLASMONS

P. Kogan [a], **B. Apter** [b], **I. Baal-Zedaka** [b] **and U. Efron** [a, b]

[a] *Department of Electro-Optical Engineering, Ben-Gurion University, Beer-Sheva, Israel*
[b] *Department of Electrical Engineering, Holon Institute of Technology, Holon, Israel*
E-mail of the speaker: koganp@bgu.ac.il

Spatial resolution is an important performance characteristic of spatial light modulators (SLM). This parameter depends on the physical properties of the electro-optical material, as well as on the design features of the SLM. One of the key factors affecting the spatial resolution of liquid crystal (LC)-based SLM is the fringing field effect. While this effect can be reduced, it will normally be at the expense of a corresponding reduction in the electro-optical response of the SLM. An SP-based SLM using a thin LC layer was recently developed.[1] This device is based on the surface plasmon (SP) resonance phenomenon, which is extremely sensitive to minute changes of the LC refractive index in close vicinity to the metal layer guiding the SPs. Unfortunately, this device configuration is expected to have a relatively low resolution, due to the finite propagation length (several tens of micrometers) of the SPs. Our study is aimed at improving the spatial resolution of the SP-resonance (SPR)-based LC SLM. The main idea is to employ a periodic, small-scale patterning of the metal layer supporting the propagation of SPs. Such patterning will reduce the spatial blurring associated with the long propagation length of the SPs. The concept has been studied using detailed rigorous diffraction analysis based on the Finite Difference Time Domain (FDTD) method. Computer simulations were performed for an SLM structure based on the well-known prism-type, Kretschmann excitation configuration. The SLM performance for various spatial resolutions was simulated by introducing a dielectric layer with periodically modulated refractive index. It is shown, that patterning of the guiding layer enhances the efficiency of the first diffractive order, caused by spatial modulation, by a factor of 2-3, in comparison with that of a non-patterned structure. This enhancement indicates that a significant improvement of the spatial resolution can be attained in the SPR-based LC-SLM making it a viable fast, high resolution SLM configuration.

1. Caldwell M. E., Yeatman E. M. "Surface-plasmon spatial light modulators based on liquid crystal". Applied Optics, vol. 31, No 20, pp. 3880-3891, 1991.

DEEP P-WELL PIXEL TECHNOLOGY FOR BACK ILLUMINATED CMOS IMAGE SENSOR

Y. David

Dept. of Electrical Engineering, Holon Institute of Technology, 52 Golomb St., Holon, 58102, Israel. E-mail: isak@hit.ac.il

U. Efron

Dept. of Electro-optical Engineering, Ben Gurion University, P.O.Box 653, Beer-Sheva, 84105, Israel. E-mail: efron@bgu.ac.il

A new technological solution for backside illuminated CMOS imager is proposed. The novel backside-illuminated pixel structure consists of an n-well/substrate photodiode and a deep p-well region, which contains the pixel circuitry – namely the APS (Active Pixel Sensor) and additional application specific circuits. We have examined this structure, based on a 0.35 CMOS process, by means of a Silvaco's *ATLAS* silicon device simulator software. The imager Cross-talk, Internal Quantum Efficiency and Leakage Photocurrent dependences for various values of the die thickness (10 – 60 um) and p-well depth were simulated. Simulation results show that this structure provides significantly lower cross-talk, higher response and an effective shielding of the pixel circuitry from photo charges generated in substrate, as compared to the standard n-well and twin-well technologies. The analysis indicates that the minimum cross-talk level is attained for a p-well depth, which is equal to or larger than the substrate thickness. The simulated results also allow defining the optimal value of the die thickness, showing that a thickness of 30 um provides an acceptable trade-offs in the ITD performance parameters. Further increase in the die thickness results in the degradation of the critical imaging parameters namely, the spectral response and the cross-talk. This rather large die thickness level, which is higher than the 10-15 micrometers commonly used in backside imaging devices, is also beneficial in improving the mechanical ruggedness of the die following the thinning process, as well as the photo response for the red part of visible spectrum. One specific application for the improved performance deep p-well structure will be its implementation in the Image Transceiver Device [1], which combines a front side LCOS micro display with a backside imager structure.

[1] U. Efron, I. David, V. Sinelnikov and B. Apter, " A CMOS/LCOS Image Transceiver Chip for Smart Goggle Application", IEEE Transaction on Circuits and System for Video Technology, Vol. 14, No. 2, pp. 269-273 (2004).