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Design of twisted-nematic liquid crystal displays for holographic data storage

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1. Abstract

This work describes an ideal design of a nematic liquid crystal display (TN-LCD) that allows obtaining the best configuration of a hybrid ternary modulation to be applied in holographic data storage. With this purpose, the thickness of a real LCD was modified in order to change the birefringence versus gray level. With these new birefringences, simulations for different configurations were made to design an LCD having a HTM as close as possible to the ideal one.

2. Introduction

Twisted-nematic liquid crystal displays (TN-LCD) have been used in recent years as spatial light modulators (SLM). The SLM have many applications in the world of optics, since they are capable of modifying both the amplitude and phase of the incident beam [1]. One of its most important applications consists of Holographic Data Storage, where LCD can refresh the data page to be stored in the material in real time [2]. This work will focus on designing an optimized LCD for holographic data storage.

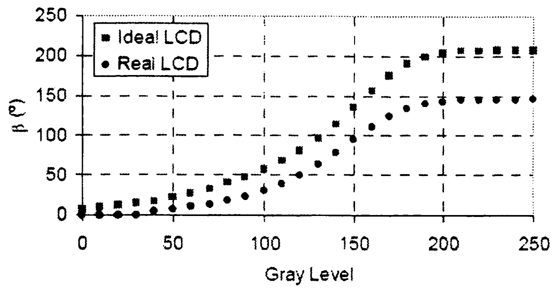
In holographic data storage devices two beams interfere in the plane where the recording material is placed: the object beam -which carries the information to be storedand the reference beam -a plane wave-. The information to be stored is introduced into the object beam through the LCD so that Fourier Transform (FT) of the object is stored where we place the material. A FT with a high zero frequency saturates the dynamic range of the material, which limits the capacity of storage. To try to homogenize the FT, different types of modulations that reduce the intensity of the zero order (for example, the HTM) are used.

3. Results

Previous studies showed that for the holographic data storage it is necessary to have a device that is able to homogenize the zero order of the FT. One of the modulation that was used is the HTM [2]. However, after calibrating and optimizing the LCD which we have in our laboratory (SONY LCD model LCX016AL-6, with 800x600 pixels and with a pixel size of 32 μm), we obtained that it was not possible to obtain the maximum degree of homogenization compared to the ideal HTM [3]. The homogenization results rare described by the parameter p (ratio between the maximum intensity of light reaching the Fourier plane and the total light reaching such plane). In Fig 1a, Real and Ideal HTM configuration results obtained in reference [3] are summarized. The parameter p is normalized to the value of the uniform modulation. As it can be seen, the Real HTM modulation is less uniform since the parameter p is 4.4 times that the ideal HTM. Moreover, maximum efficiency -which in the ideal case would be 50% - is not achieved.

	p	Efficiency
Ideal HTM	1.0	50%
Real HTM	4.4	27%
Ideal β HTM	1.0	36%

a)



b)

Fig. 1. a) Homogenization parameter p and efficiency for ideal, real and simulation β ideal cases. b) Birefringence versus gray level for simulation β ideal and real cases.

Now the question is how to design the LCD in order to achieve values close to the ideal settings. Fig. 1b shows the values of birefringence (Real LCD) obtained with our LCD and birefringence values (Ideal LCD) that the LCD should have to achieve uniformity and efficiency values close to HTM Ideal. Fig. 1a represents the values of uniformity and efficiency obtained with the values of birefringence of the Ideal LCD (Ideal β HTM). As noticed, with this birefringence it has been obtained uniformity in the FT as in the ideal case, as well as a greater efficiency than the one corresponding to the Real HTM. Therefore, if designing an LCD with a birefringence above the Real LCD was achieved (Fig. 1b, red squares), for instance increasing its thickness, we would get a more suitable LCD to be used in holographic data storage.

4. References

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