Journal of Optoelectronics Engineering, 2014, Vol. 2, No. 1, 21-23
Available online at http://pubs.sciepub.com/joe/2/1/3

DOI:10.12691/joe-2-1-3

Diffraction Efficiency Enhancement of PFG 01 Holographic Emulsion by New Chemical Processing Technique

Vadivelan V[1,*], Chandar Shekar B[2]

[1]Reseaerch and Development centre, Bharathiar University, Coimbatore, India
[2]Department of Physics, Kongunadu Arts & Science College, Coimbatore, India
*Corresponding author: vvelan@gmail.com

Received April 01, 2014; Revised May 30, 2014; Accepted June 02, 2014

Abstract In this research work, high diffraction efficiency and transmission phase holographic lens is recorded by using red sensitive commercially available fine grain PFG-01 silver halide holographic emulsion. In the preliminary stage, the exposure sensitivity is optimized and the plates were chemically developed in recommended developer of CWC2 by the supplier. In the next stage, we have modified the developer and the holographic lens was recorded for the same optimized energy level for comparison. The phase holographic lens was a result by using modified fixation-free rehalogenating bleach R10 for modified and unmodified CWC2 developer. The obtained diffraction efficiency for the holographic lens in usual processing technique is compared with our new modified CWC2 developer. As a result, the enhancement of diffraction efficiency of nearly 20% was achieved by using the new combination of modified developer and modified bleach as compare to the usual combination of developer – bleach processing technique. The experimentally obtained results are compared and explained in detail.

Keywords: *holography, Fine-Grain Holographic Emulsion, holographic optical elements, CWC2 developer, PFG-01 Holographic Plates and Films, holographic lens, Transmission hologram*

Cite This Article: Vadivelan V, and Chandar Shekar B, "Diffraction Efficiency Enhancement of PFG 01 Holographic Emulsion by New Chemical Processing Technique." *Journal of Optoelectronics Engineering* vol. 2, no. 1 (2014): 21-23. doi: 10.12691/joe-2-1-3.

1. Introduction

The CWC1, CWC2 and CW-P1 holographic fine grain developers and p-benzoquinone (PBQ) bleach combination was used for Agfa 8E56HD emulsion by D.J Cookie and A.A Ward [1], hence the name of the developer starts from the first letters CW of the inventors. After four years V. Weiss and E Millul [2] introduced the CWC2 developer with slight modification. The CWC2 developer is most suitable alternative of D-19 tanning developer for processing fine grain silver halide emulsion [3,4]. The CWC2 developer plays a pivotal role for the holographic fine grain silver halide holographic material process. In our experiment, we select easily available, cost effective and one of a very good fine grain red sensitive holographic emulsion PFG-01. The supplier recommended CWC2 developer for PFG-01 fine grain emulsion development by their technical data sheet [5]. A variation of CWC2 was published [6] and named as CWC2.5 by only omitting the Ascorbic acid and the Urea in the part A of CWC2 developer. Already several groups investigated PFG-01 with different developers like Metol Hydroquinone, Ascorbic acid based, Pyrogalol developer and other bleach combinations [7,8]. Silver Halide Sensitised Gelatin (SHSG) holographic processing technique is an interesting and very good present technique for the production of holographic optical elements [9,10]. In the beginning of our work, we have made changes in the developer, we used CWC2 developer as per the supplier to get the optimized exposure for holographic collimating lens in PFG-01. The chemical development for our particular batch of plate is processed by without changing the developer compositions of CWC2 developer and with changing or addition of chemical in part B of CWC2.

In the next stage of our work, we introduced changes in the bleach for further enhancement of the diffraction efficiency. Bleaching is one of the most popular techniques used to obtain phase holograms with high diffraction efficiencies from silver halide holographic emulsions. This technique was first developed for laser-recorded holograms by Cathey [11] and subsequently several bleaching processes were studied. Upatnieks [12] introduced Ferricyanide and Copper bleaches, whereas the popular Kodak R-10 bleach was improved by McMahon and Franklin [13]. Concerning phase reflection holograms, Cooke and Ward [1] studied bleach containing an organic oxidizing agent, Quinone, introduced by Phillips [14] in the conventional bleaches, and obtained good results. Instead of Amidol bleach recommended by the supplier, here we used fixation free rehalogenating R 10 bleach

with modification. The fixation-free bleaching method, which was improved by Crespo et al. [15] and Kostuk [16], avoids the emulsion shrinkage problem in conventional fixation rehalogenating bleach problem, because the shrinkage of the emulsion is minimum in fixation free rehalogenating bleach. In this method the hologram is bleached directly after development, without fixing, leaving the unexposed silver-halide crystals in the emulsion. The modified R 10 bleach for BB640 plates was already studied [17]. The influence of the potassium bromide (KBr), Potassium Dichromate ($K_2Cr_2O_7$) and Sulfuric Acid (H_2SO_4) concentrations in the bleach solution on the final quality of the holograms is also studied. The concentrations of the three different components of the bleach solution are adjusted to obtain the highest diffraction efficiencies with the combination of modified CWC2 developer and Exposure sensitivity.

2. Experimental Setup

A He-Ne laser of 632.8 nm CW of 25 mW power gas laser is used as a main source for transmission phase holographic lens recording on red sensitive fine grain silver halide emulsion PFG -01. The Uniblitz electronic shutter is used to control the exact exposure with accuracy of 0.1 mille second. The out coming narrow laser beam is divided into two by using the density variable beam splitter, the separated two beams reflected by the front coated broadband Aluminium mirrors into the desired direction. The reflected beams spatially cleaned by using spatial filters, the filtered and expanded beams are collimated by collimating lenses. One of a collimated beam is focused, diverged and impinged perpendicular to the holographic plate holder. The distance between the focus of the converging lens to the holographic plate decides the focal length of the recorded collimating lens. The experimental arrangement for this was shown in Figure 1.

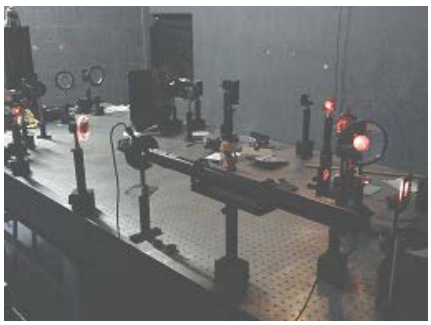

Figure 1. Holographic Lens recording setup

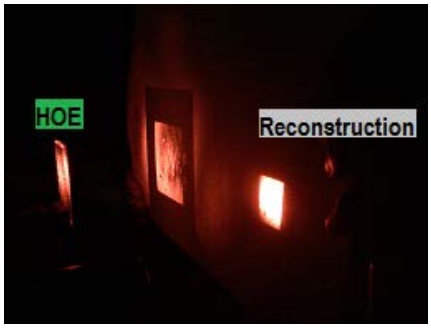

Figure 2. Holographic lens reconstruction

The reconstructed image of the collimating lens is shown in Figure 2. The ratio between the two beams was maintained as 1:1.

Two important changes have been made in the processing technique, one is in CWC2 developer and another change is in fixation free rehalogenating bleach R10.

3. Result and Discussion

The optimization of the right exposure sensitivity of the particular batch of the plate was optimized by the trail and error method by using the CWC2 Developer and R10 bleach combination. The developing time for the exposed plates is 2 minutes and continues with 3 minutes rinse in running water, after rinse in water, the plate was kept in the beach bath until it became clear without shakeup. Again the plates washed for 5 minutes in running DI water and the plates were kept vertically for drying. Drying time for the plates took 24 hours in dust free environment.

In the recording of holographic lens, the exposures varied from 80 μJ/cm^2, 15 μJ/cm^2, 250 μJ/cm^2, 500 μJ/cm^2, 750 μJ/cm^2 and 1000 μJ/cm^2 is as shown in table- I.

Table 1. Diffraction Efficiency For Various Exposures Sensitivity

Exposure Sensitivity in μJ/cm^2	80	150	250	500	750	1000	
CWC2 + R10	6.7	31.7	27.7	15.8	16	15	D η in %

After this, the important change we have made in the Part B of CWC2 developer by adding Sodium Hydroxide (NaOH) and repeated the experiment for the above said exposure values. There is a very good enhancement of diffraction efficiency by using this modified developer and it is shown in Table 2. From the Table 1, we got the right exposure sensitivity is in between 125 μJ/cm^2 and 250 μJ/cm, exposed the plates in between that range with interval of 25 μJ/cm^2. The 175 μJ/cm^2 is the right optimized exposure for this particular batch of plate. We got diffraction efficiency of 43% for this exposure value.

For the next set of experiments, we used the modified developer and we made another modification in the concentration of the bleach chemical compositions. The H_2SO_4, KBr and $K_2Cr_2O_7$ concentrations has been varied to get desired diffraction efficiency enhancement. The chemical concentration of 1 ml H_2SO_4 and KBr of 35 g and $K_2Cr_2O_7$ of 0.5 g in the R10 bleach with NaOH modified developer combination; we got 50.7% diffraction efficiency.

Table 2. Diffraction Efficiency For Various Exposures Sensitivity

Exposure Sensitivity in μJ/cm^2	80	150	250	500	750	1000	
Modified CWC2 + Modified R10	24.4	43	38.5	28.2	18	16	D η in %

Finally as a result the diffraction efficiency of the holographic lens is increased nearly 20% as compare to the unmodified and R10 bleach combination for the same exposures. The efficiency enhancement from 27.7% to 50.7% is obtained for the modified CWC2 and modified R10 bleach combination with 54% laser transmission in recorded wavelength. The recorded holographic collimating lenses are shown in Figure 3.

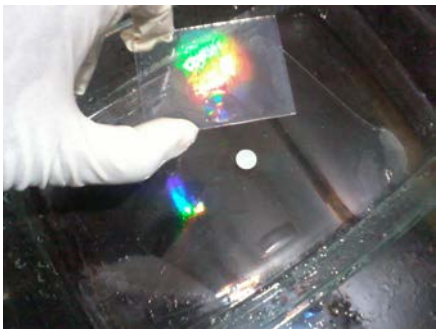

Figure 3. Recorded Holographic Lens

Here we are experimentally proved that the new chemical combination and processing technique for the diffraction efficiency enhancement. From this experimental result, we conclude that the addition of NaOH in part B of the CWC2 developer and 1 g of $K_2Cr_2O_7$, 1 ml of H_2SO_4 and 35 g of KBr to add distilled water to make 1 liter bleach solution is one the best chemical processing technique for diffraction efficiency enhancement in PFG 01 fine grain silver halide emulsion.

4. Conclusion

The first time as per our knowledge the fine grain silver halide holographic emulsion PFG 01 was chemically treated for the diffraction efficiency enhancement with modification in developer as well as in bleach. We gave equal importance for the laser transmission and diffraction efficiency because it is fit for our main research work. The experimentally optimized result for the diffraction efficiency enhancement compared to the unmodified CWC2 developer and R10 bleach with the modified developer and modified bleach is studied and the optimized result is by introducing SH in part B of the CWC2 and 1ml of SA, 0.5 g of PD and 35 g of PB in 1 litre bleach for the fine grain silver halide PFG 01 holographic emulsion. As a result, we obtained nearly 20% of diffraction efficiency enhancement by our new modified developer and bleach combination chemical processing technique.

Acknowledgement

I would like to thank Mr. Thomas Rajan, CMD of Ignetta Holographics (P) Ltd for his encouragement and support. Also I would like to thank my team members Mr. Manoj, Mr. Arun Charles and Mr. Sathish Kumar for their support.

References

[1] D. J. Cooke and A. A. Ward, "Reflection-Hologram Processing for High Efficiency in Silver-Halide Emulsions", *Applied Optics*, vol 23, No 6, pp 935-947, 1984.

[2] V.Weiss and E Millul, "Bleached Silver Halide Holographic Recording Material," *Proc. SPIE* 1026, 55-61, 1988.

[3] Michael G. A, Xin Wen, Mark J. H, "Process for preparation of high bromide tabular grain emulsion," US 5750326, May 1998.

[4] Urabe, S., Shunichi, A, " Method for making silver halide emulsion, photosensitive material using the same, and method of recoding images using the photosensitive materials," US 5264338 Sep, 1993.

[5] www.geola.it/eshop/index.php

[6] J. M. Heaton and Laszlo Solymar, "Wavelength and angular selectivity of high diffraction efficiency reflection holograms in silver halide photographic emulsion" *Applied Optics*, Vol. 24, No. 18, 1985

[7] Simova E S and Kavehrad M, "Silver –halide sensitized gelatin derived from Agfa – Gevaert holographic plates," *Applied Optics*, Vol. 33, 1875-1879, 1994.

[8] Neipp c, Belendez A, Pascual I, "The influence of the development in silver halide sensitized gelatin holograms derived from PFG -01 plates," *Optics Communications*. Vol. 173, Issues 1-6, 161-167, 2000.

[9] Hariharan P, "Silver Halide Sensitized Gelatin Holograms: Machanism of Hologram Formation." *Applied Optics*, Vol. 25, 2040, 1986.

[10] Bjelkhagen H I, "*Silver halide Recording Materials for Holography and their Processing*," Springer, Berlin, 166-288, 1993.

[11] W.T. Cathey, "Three- dimensional wavefront reconstruction using a phase hologram," *Journal of Optical Society of America*, Vol. 55, 457, 1965.

[12] J. Upatnieks, C. Leonard, "Amplitude and Phase holograms exposed on Agfa- Gevaert 10E75 Plates," *Applied Optics*, Vol. 8, 2353-2354, 1969.

[13] D.H. McMahon, A.R. Franklin, "Efficient, high – quality, R-10 bleached holographic diffraction gratings," *Applied Optics*, Vol. 8 1927 – 1929, 1969.

[14] N.J. Phillips, A.A. Ward, R. Cullen, D. Porter, *Photographic Science and Engineering*, Vol. 24, 120-124, 1984.

[15] J. Crespo, A. Fimia, J.A. Quintana, "Fixation - free methods in bleached reflection holography," *Applied Optics*, Vol. 25, 1642-1645, 1986.

[16] R. Kostuk, "Factorial optimization of bleach constituents for silver – halide holograms," *Applied Optics*, Vol. 30, 1611–1616, 1991.

[17] C. Neipp a, I. Pascual b, A. Belendez, "Fixation-free rehalogenating bleached reflection holograms recorded on BB-640 plates", *Optics Communications*, Vol. 182, 107-114, 2000.