

HOLOGRAPHIC OPTICAL ELEMENTS FOR BEAUTIFICATION

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Abstract

In this research, holographic optical element applied for beautification recorded in holographic surface relief photoresist. Various symmetric periodic structure with high diffraction efficiency in photosensitive material depends on various recording geometry parameters are explained. We used holographic dual beam multiple interference method for this pattern creation. A long range periodicity confirmed with the help of optical microscope, laser light diffraction and scanning electron microscope. Combination of symmetric structured holographic optical elements, DPSS laser source and bi-directional RPM controller results the proto type HOLO-DRIZZLER product. Our auspicious aim is to commercialize and our product is mainly meant for outdoor beautification application.

Index Terms: Holography, photoresist, holographic decoration, laser and holographic optical element

1. INTRODUCTION

The projection of interference patterns is an interesting technique for recording periodic structures because the interference pattern is three dimensional. Thus, volumetric structures with dimensions of tenths of nanometers can be recorded, simultaneously in areas of several squared centimeter [1,2]. Holography is promising and inexpensive technique to fabricate large area and defect free periodicity [3]. Dual beam multiple exposure holographic technique is one of a simplest methods for periodicity fabrication [4]. Two beams interference technique possesses many advantages over the commonly used multiple beam interference technique, such as easy to fabricate different structures using multi exposure technique, and high contrast between the minimal and maximal intensities of interference pattern due to the identical polarization of two laser beams interference area. Recently, several groups have employed this technique [5-7]. Recording and reconstruction of whole information of the objects play very important in holography for beautifications. The 3-Dimensional image recording in holographic photosensitive material paid great attention for the last few decades [8]. Our positive aim is to utilize the holograms for outdoor applications. For this, we fabricated prototype product called "HOLO-DRIZZLER" [9]. In this, we used various patterns of holographic optical elements (HOEs) combine with bi-directional RPM controller and 100mW diode pumped solid state (DPSS) 532nm laser source. HOLO-DRIZZLER is mainly used for decorating front view illumination of buildings, lawns, shopping malls, night clubs, etc from its HOEs laser light diffraction periodic symmetric patterns. Experimental procedure for recording various symmetric patterns of HOEs and its role in HOLO-DRIZZLER are explained in detail.

2. THEORY

When two sets of coherent equally polarized monochromatic optical plane waves of equal intensity intersect with each other, a standing wave pattern will be formed in the region of intersection. The combined intensity distribution forms a set of straight equally spaced bright and dark fringes. Thus holographic photosensitive materials would record fringe patterns; Dual-beam interference pattern forms a series of straight parallel fringe planes, whose intensity maxima or minima are equally spaced throughout the region of interference. So the plane grating recorded. Multiple interferences on same plate with different position generate overlapping of plane gratings will result different symmetric patterns.

3. EXPERIMENTAL ARRANGEMENT

In this experiment, He-Cd continuous wave laser of 100mW power with wavelength 441.6nm from Kimmon is used for main light source for our experiment. Shipley 1500 series photoresist is used to record the holograms in forms of symmetric patterns. The output narrow laser beam is divided into two by using variable density beam splitter (BS). This beam splitter controls the required beam ratio for optimal recording of HOEs in photoresist. These separated two beams are reflected by front coated broad band aluminum mirrors (M1&M2). The mirrors controls the laser beams for desired angle (Θ) at the recording plate. The separated beams are called object and reference beam. These object and reference beams spatially cleaned by using spatial filters (SF1 & SF2). The filtered beams are collimated by using two collimating lenses (L1 & L2). The two beams are interfered at recording plate (PR) with desired angle with equal intensity. The photosensitive Shipley photoresist plate is used to record the holographic optical elements in photoresist. We adopt dual beam multiple interference

technique in our experiment to create uniform symmetric patterns in holographic plates. The recording plate holder was fixed with rotational stage (PH), this precision control rotational stage is used for many symmetric patterns creation. Uniblitz electronic shutter (ES) controls the exact exposure of laser beam on recording plate. Circular, square and hexagonal symmetric patterns creation depends on number of exposures on holographic plates with desired angular rotation. The detail description of the patterns was explained in the next part. The whole experimental arrangement was placed on the top of vibration free isolation table and recording done in dark room condition. The whole experimental arrangement is shown on Fig -1.

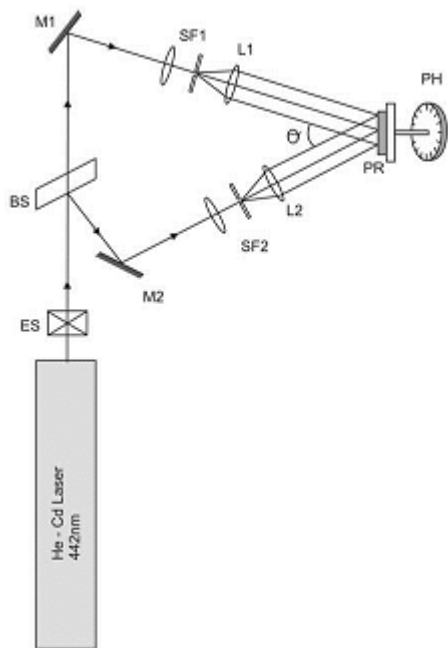


Fig -1: Experimental arrangement for the fabrication of holographic symmetric patterns

After exposing the photoresist plate with optimized power of the laser source, the plates were chemically treated. Photoresist gratings are chemically developed by commercially available developer after exposure. During chemical development, photoresist that have been exposed to laser light are dissolved and surface relief pattern is formed. The hologram is shown in Fig -2. These holograms reflect and diffract the laser beam into symmetric periodic patterns.

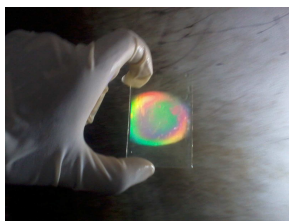


Fig -2: Recorded hologram after chemical development

4. RESULT AND DISCUSSION

The different symmetric patterns like square, hexagonal and circular are shown on below figures. The square periodic symmetries Laser Light Diffraction Patterns, Optical Microscopic Image and Scanning Electron Microscopic Image are shown in Fig - 3, Fig -4 and Fig -5 respectively.

4.1 Square Symmetric Structure HOE

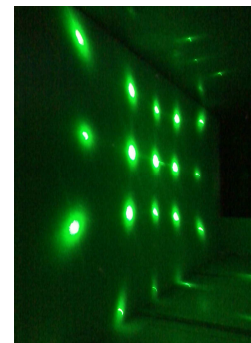


Fig -3: Laser Diffraction Pattern

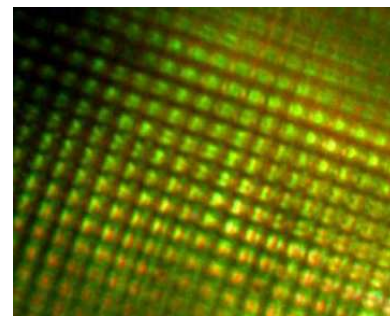


Fig -4: Optical Microscopic Image

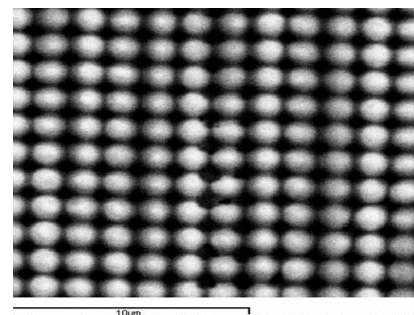


Fig -5: Scanning Electron Microscopic Image

The Hexagonal symmetric periodic structures Laser Light Diffraction Pattern, Optical Microscopic Image and Scanning Electron Microscopic Image are shown in Fig -6, Fig -7 and Fig -8 respectively.

4.2 Hexagonal symmetric structure HOE

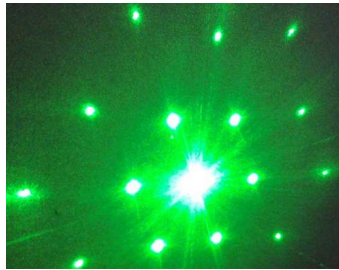


Fig -6: Laser Diffraction Pattern

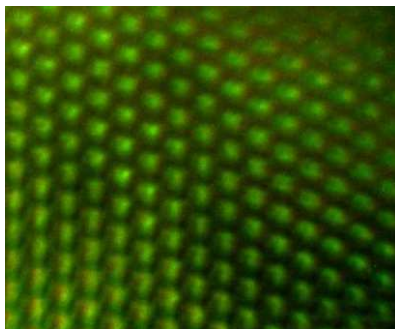


Fig -7: Optical Microscopic Image

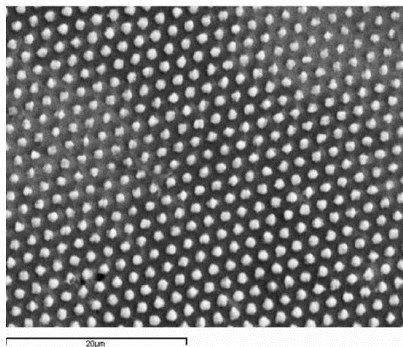


Fig -8: Scanning Electron Microscopic Image

The circular periodic symmetric patterns Laser Light Diffraction pattern, Optical Microscopic Image and Scanning Electron Microscopic image are shown in Fig -9, Fig -10 and Fig -11 respectively.

4.3 Circular symmetric structure HOE



Fig -9: Laser Diffraction Pattern

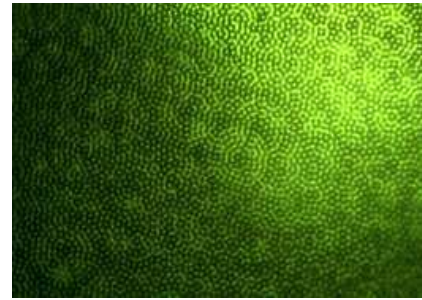


Fig -10: Optical Microscopic Image

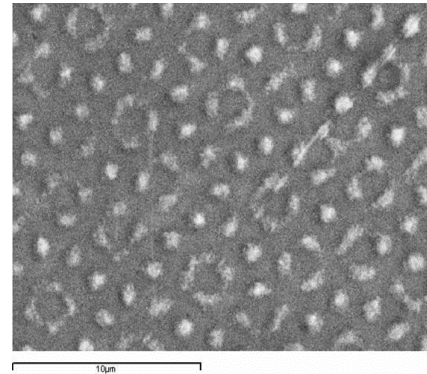


Fig -11: Scanning Electron Microscopic Image

Our HOLO-DRIZZLER and its product specification is shown in below

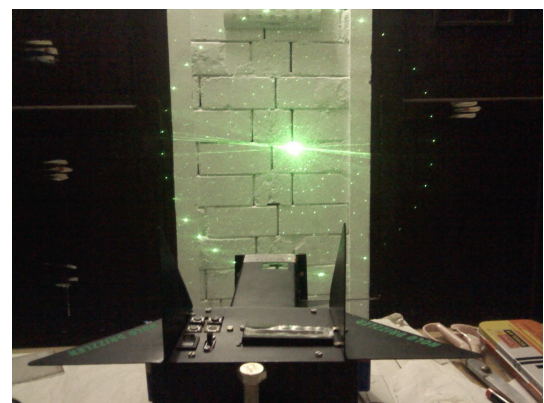
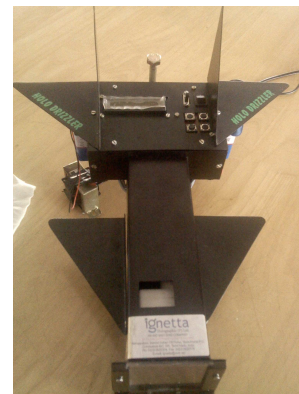


Fig -12: Proto type “HOLO-DRIZZLER” for beautification

4.4 Specifications

Dimensions: 110*mm x 65*mm x 55 mm* (Subject to change*)

Laser Type: DPSS laser

Laser Power: 100 mW - 200mW

Laser Wavelength: 532 nm, 445nm and 650nm

Holographic Elements: 3 holographic optical elements of high diffraction efficiency

Power Input: 12V AC

Operation: Indoor and main aim is for Outdoor

Effective illumination range: 5 X 6m² when holo-drizzler placed 2m away from the illumination surface.

The illumination and the rotation of the HOLO-DRIZZLER are controlled by means of a Bi-directional RPM Controller, made of a Dc motor integrated with a Programmable VFD Circuit which can be operated in both Manual and Auto modes shown in Fig - 13.

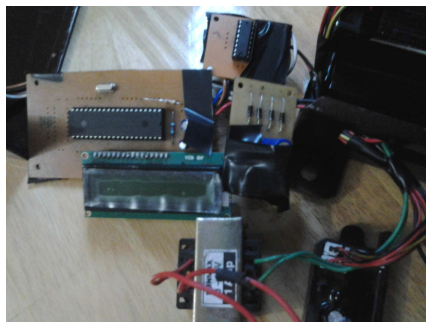


Fig -13: Bi-directional RPM controller

5. CONCLUSION

Three different symmetric structure HOEs were fabricated in photoresist material and these structures along with RPM bi-directional motor controller and DPSS laser were combined and fabricated proto-type commercial product for beautification. As a result, we commended for the best HOE application award from International Hologram Manufacturer Association's (IHMA) Holography Awards 2013 holography Conference 2013". In the future, we have a plan to illuminate large area by periodic symmetric illumination with high power laser by introducing metal holograms.

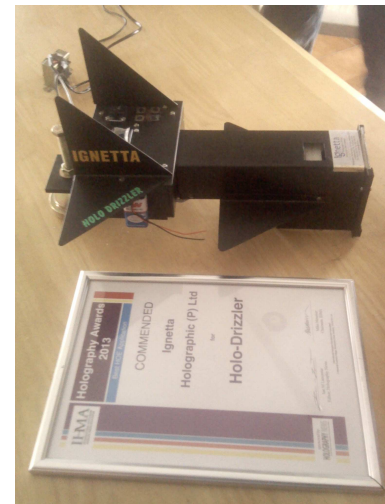


Fig -14: HOLO-DRIZZLER with its Holography award 2013

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REFERENCES

- [1]. S.R.J.Brueck," Optical and Interferometric Lithography Nanotechnology Enablers", Proc. IEEE **93**, 1704 (2005)
- [2]. A. Fernandez, J.Y. Decker, S.M. Heran, D.W. Phillion, D.W. Sweeney and M.D. Perry, "Methods for fabricating arrays of holes using interference lithography," J. Vac. Sci. Technol. B15, 2439-2443(1997)
- [3]. M. Campbel, D.N Sharp, M.T. Harrison, R.G. Denning and A.J. Tuberfield," Fabrication of photonic crystals for the visible spectrum by holographic lithography," Nature 404, 53-56 (2000)
- [4].N. D. Lai, W. P. Liang, J. H. Lin, C. C. Hsu, and C. H. Lin, "Fabrication of two- and three- dimensional periodic structures by multiple – exposure of two beam intgerference technique" Optics Express Vol. 13, No.23, 2005
- [5]. S.c. KKitson, W.L. Barnes, J.R. Sambles, "The fabrication of submicron hexagonal arrays using multiple – exposure optical interferometry," IEEE Photon. Technol. Lett. 8, 1662-1664(1996)
- [6]. L.Pang, W. Nakagawa, Y. Fainman,"Fabrication of two – dimensional photonic crystals with controlled defects by use of multiple exposures and direct write," Appl. Opt. 42, 5450-5456 (2003)
- [7]. N.D. Lai, W.P. Liang, J.H. Lin, C.C. Hsu, " Rapid fabrication of large- area periodic structures containing well-defined defects by combining holography and mask techniques." Opt. Express 13, 5331-5337 (2005)
- [8]. Saxby, "Practical Holography" Third edition, Institute of Physics Publication, Chapter 16, p 241- 250, 2004
- [9]. www.ihma.org

BIOGRAPHIES

Age 34, born in Ooty, Under and Post graduation in Physics, M.Phil in Physics with Solar Energy specialization. At present functioning as a part-time research scholar and working as a research scientist in Igetta Holographics (P) Ltd, India. Having 7 years of experience in holography mainly HOEs, 2D/3D mastering, Display and transmission hologram recording. More than 20 research papers published in journals/conferences.



Born in 1967, Mid 2009 onwards functioning as an Assistant Professor in Konguandu Arts & Science College, Coimbatore, India. Awarded Ph.D in Physics in 1999 from Bharathiar University and subsequently worked as scientist in USA and South Korea for more than four years prior to taking up teaching position in India. 15 years Research experience in Thin film physics, Nano technology and Nanotoxicology. He has more than 35 research articles in peer-reviewed journals to his credit.