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Design and Development of New Generartion 3D Holographic Stamp for firm Authentication

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Abstract—**Holography is considered as one of the future security paradigms that may answer the constantly growing need for Anti-counterfeit and forgery of stamps. Generally stamps are used to pay for the costs involved in moving mail as well as other business necessities such as insurance and registration. Here a new generation 3D Holographic Stamp for firm authentication is proposed. Application of 2D/3D images with complex image content and micro features are effectively applied in security holography and are popular in product and personnel authentication and anti-counterfeiting. Though the VISA card has such an embossed 3D image hologram, the shooting of a 3D object for security holograms is more complex when compared to other type 2D holograms using DotMatrix Technology. The 50% of the development process of a 3D holographic stamp depends on the technical skill and set up constructed for it.**

Keywords—Holography;Master hologram; Photoresist

I. INTRODUCTION

Dennis Gabor invented holography in 1947 [1]. He dedicated it for microscopy as indicated in the article “Microscopy by Reconstructed Wave fronts” [2]. The term “holography” is a compound of the Greek words ‘Holos’-whole and ‘Graphe’- writing. These two words mean that the recorded image of the object contains whole optical information about the object – amplitude and phase information of the light scattered from the object. At the time when Gabor invented holography there was no coherent source of light developed yet. This barrier was overcome in 1960 by Russian scientists N Bassov and A Prokhorov and American scientist Charles Towns with the invention of the laser, whose pure, intense light was ideal for making holograms[3]. In 1962, J. N. Denisjuk, the soviet scientist, connected holography with the paper by Gabriel Lippmann, the Nobel laureate in 1908, about the photography of natural colors. Denisyuk’s approach utilizing white light created a reflex hologram that was possible to watch in the light of an ordinary lamp. While in the classical Gabor method both the object and reference beams is incident on the photographic plate from one direction, Denisjuk chose the opposite direction of propagation of both beams. Thus it was possible to record the hologram of non-transparent reflecting objects.

Leith’s and Upatnieks transmission holograms was viewed illuminating them with the coherent (laser) light. First transmission holograms invented by Bennton in 1968 [4] were viewable in the white light also.

Gabor’s invention was originally dedicated to microscopy a lot of holography application was in different areas such as art, decorating, packaging, advertising and entertainment. For example Benton invented transmission rainbow holograms during his research in holographic television at Polaroid Research Laboratories. The development of new holography methods made it important to various industrial and scientific applications: printing, security and authentication, sensors, data storage, particles counting and manipulation, etc.

In this paper the objective is the production of a 3D holographic stamp, which is done in a three step process. First one is the formation of master hologram , then the second one is the generation of transfer hologram in the positive photoresist and the final step was stamping.

II. BASIC PRINCIPLES OF HOLOGRAM RECORDING AND RECONSTRUCTION

The basic principle behind the hologram recording and reconstruction is the interference of two waves namely, the reference beam and the object beam and Diffraction. The set up for 3D transmission hologram is described below. Optical set up for transmission hologram recording process comprises of the source of coherent light, optical table, recording media and optical mechanical components. The necessary condition for recording a master hologram with argon ion laser or He Ne laser , the angle between the object beam and the reference beam should lie in the range from 30^0 to 60^0 , as the distance between two fringes formed will be approximately 1μm. Here Argon ion laser with 514.5 nm wavelength (Green in color) was prescribed as coherent light source, so the recording media used is silver halide emulsion sensitive to green light i.e., VRP-M is used.

In Fig. 1 the optical scheme for 3D transmission hologram recording process is presented. Here the light from the Argon ion laser is fed to the beam splitter. The beam splitter is used to split the primary laser beam into two beams i.e. the object beam and the reference beam. The spatial filtered object beam illuminates the object and the expanded and spatially filtered reference beam is directed by the mirror to thin emulsion side of the photographic plate. Light scattered from the surface of the object overlaps with the reference beam on the same side of the photographic plate. There the interference pattern of reference and scattered object beam is exposed or recorded for an appropriate time.

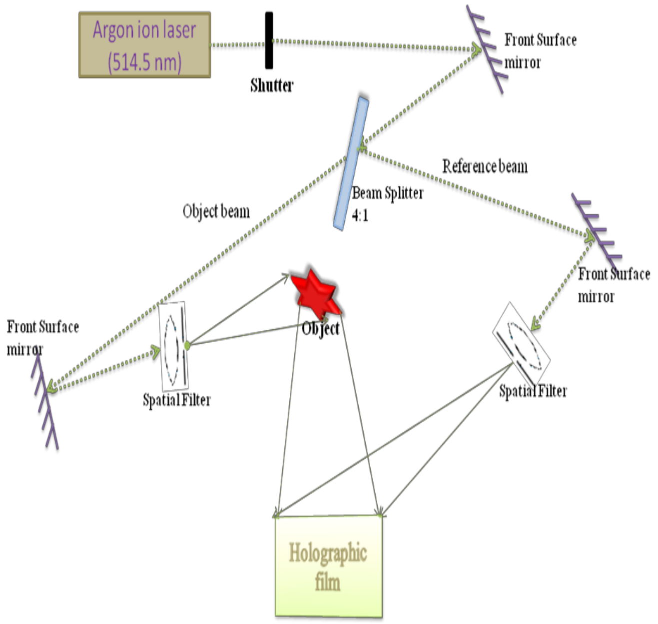

Fig.1 Optical scheme for 3D transmission hologram recording

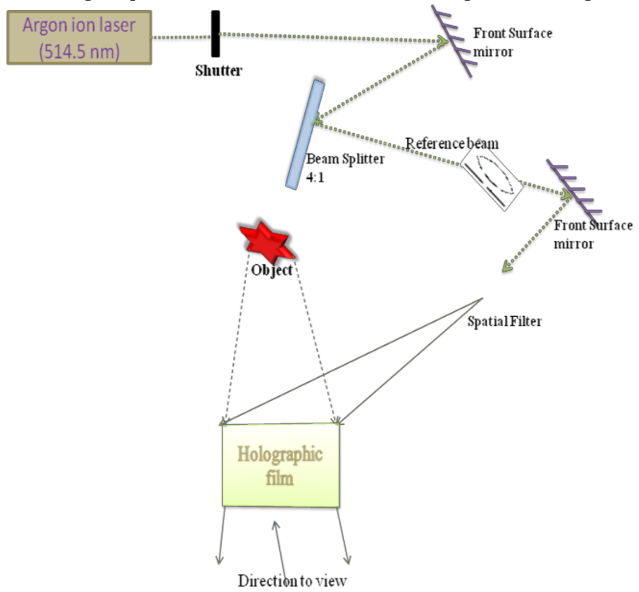

Fig.2 Optical scheme for 3D transmission hologram reconstruction

After shooting, it is needed to develop. For the developing process, CW C2 developer and PBU AMIDOL Bleach is used. After developing, the plate is dried in air for getting a finished hologram.

Fig. 2 shows the 3D transmission reconstruction process. For hologram image reconstruction the similar optical set up is used. The reference beam undergoes diffraction in recorded interference pattern in the hologram. The diffracted light creates the virtual image of the recorded object. If the hologram is turned 180^0, the reconstructing laser light comes from the opposite side of the plate and converges to the original source point of the reference beam, the image is viewed in front of the hologram. This image which is on the same side of the viewer and is seen in reverse relief is called a real image. The image can be viewed at the same direction in which scattered object beam propagated towards the plate during recording process. Different parts of the object can be viewed at different viewing angles while changing the position of the viewer creates parallax effect and a three dimensional image is perceived.

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Thus a master hologram is produced in VRP-M. The next section is transfer hologram in positive photoresist using He Cd laser.

III. GENERATION OF TRANSMISSION TRANSFER HOLOGRAM

To make a satisfactory reflection image from a transmission master hologram, the layout is as shown in Fig.3 is made. The real image obtained from the master hologram

,H1 will be the object for recording transfer hologram and it should be at least as wide as the transfer hologram , H2 and if possible wider , in order to give maximum parallax. A restriction of the master hologram to half the height of the transfer hologram is sufficient to increase the luminance of the final image by a factor of two. The beam intensity ratio for a

transmission or reflection transfer hologram will vary considerably across the H2 plane. It should not go below 1.5:1 at the brightest spot, and should not exceed about 4:1 in the neighbourhood of the image.

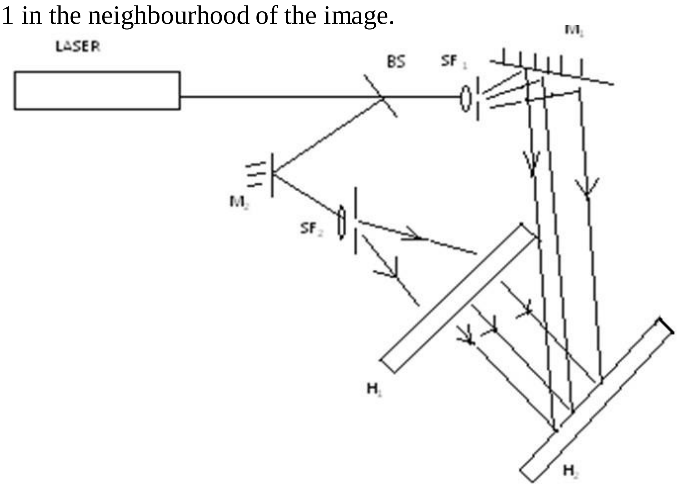

Fig.3 Layout of Transmission Transfer Hologram

In making full aperture (master) transfer holograms, avoid the directly transmitted replay light (the zero-order beam) from falling on the final hologram. This is best dealt with at the master stage; enough space between the object and the master plate, and a sufficiently large angle of incidence for the reference beam for the necessary clearances. For the successful transfer of the real image obtained from the master hologram, the angle between the object beam and reference beam should lie in the range from 25^0 to 48^0.

In this setup the master hologram produced in the Argon ion laser is transferred to the Photoresist material by using He Cd laser. The master hologram is made in the usual way , but the transfer hologram is is made on positive photoresist instead of a photographic emulsion. The interference pattern thus consists of surface ridges. Thus photoresists are used in the production of embossed hologram, as they produce fringes that consists of ridges raised above the surface of the substrate, and these can be duplicated mechanically.

Once the photoresist copy the hologram , it is put in an etching solution that etches away the areas that have not been exposed to light (the destructive interference parts of the fringes) and leaves the exposed regions of the fringes (there are some etching solutions that work opposite and remove the exposed parts and leave the unexposed parts). The hologram can now be seen in on the resist.

IV. STAMPING

Stamping process includes Electroforming, embossing, metalizing, converting and finishing. Electroforming is the process of copying holographic images. Here the hologram in the photoresist is copied to nickel. For this process to conduct, the resist is covered with an electrically conductive layer, usually silver. The silverized hologram is then then placed in an electroforming tank and a layer of nickel is deposited (grown) onto the silverized hologram. This is called the mother nickel shim. The mother nickel shim is then peeled away from the resist which degrades and destroys the resist which is no longer any good. The mother nickel shim is placed back in the electroforming tank and another layer of nickel is deposited onto the mother shim. This layer is then peeled off mother shim and is called the daughter shim. Many daughter shims can be made from a single mother shim by reintroducing the mother shim back into the electroforming tank and growing a subsequent daughter shim from it.

The next step is embossing, for which the daughter shim is then placed into an embossing printer which "stamps" the relief fringes maintained in the shim onto the surface of a plastic film using heat and pressure. This printer can print out hundreds of hologram per minute. After thousands of holograms are stamped from a single daughter shim the daughter shim starts to degrade. The printer can then be loaded with another daughter shim and the process can continue.

In the metalizing process, the roll of embossed film is loaded into a chamber from which the air is removed to create a vacuum. The chamber also contains aluminum wire, which is vaporized by heating it to 2,000°F (1,093°C). The sheet is exposed to the vaporized aluminum as it is rewound onto another roll, and in the process it becomes coated with aluminum. After being removed from the vacuum chamber, the film is treated to restore moisture lost under the hot vacuum condition. A top coating of lacquer is applied to the film to create a surface that can be imprinted with ink. The roll of film, which may be as wide as 92 in (2.3 m), is sliced into narrower rolls.

After metalizing, depending on the end product, embossed foil gets through some additional operations: laminating, die cutting, adhesive coating, slitting, rewinding. Holograms can be applied to a product as an adhesive label, hot-stamped onto an item, used as a thread or tape, or used as an over-laminate of a product. Finally the finished 3D holographic stamp is generated.

V. RESULTS AND DISCUSSION

Master hologram is generated in Argon ion laser with maximum efficiency and clarity in VRP-M photographic emulsion. To view the image, expose it to the same laser radiation. Below figure, Fig. 4 shows the set up used for its generation.

Fig.4 Master hologram set up using Argon ion laser

The master hologram is transferred to photoresist using HeCd laser for the production of surface relief pattern. Fig. 5 shows the transmission transfer hologram set up.

Fig. 5 Transfer hologram set up using He Cd laser

The optimum conditions for recording high efficient holograms are

i. Proper Spatial Filtering
ii. The large profile of object and reference beam iii. Sufficient Exposure time
iv. Small path length difference between reference beam and object beam
v. Proper Developing process

By providing all the optimum conditions an image was recorded in the VRP-M using Argon ion laser and obtained a clear virtual image in the reconstructed beam using the same Argon ion laser. Then Hologram recorded on the VRP-M material is transferred it into photoresist material by transmission transfer method using He Cd laser source.

VI CONCLUSION

Application of 2D/3D images with complex image content and micro features are effectively applied in security holography and are popular in product and personal authentication and anti-counterfeiting. Though the visa card has such an embossed 3D image hologram, the shooting of a

3D object for security hologram is more complex when compared to other type 2D holograms using dot-matrix technology. The 50% of the development process of a 3D holographic stamp depends on the expertise of the person and set up constructed for the same. Besides technical skill precision is what we require for making a 3D holographic stamp. The 3D object shooting with helium cadmium laser directly on photoresist plate as per the design was successful, and obtained a surface relief pattern with better efficiency. As stamping is only a mechanical part of the project, the successful transfer of the master hologram to the photoresist plate will enable us for mass production of the 3D image.

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