Manufacturing of Diffraction Grating Using Hologram Technique

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Abstract

In this paper the manufacturing of diffraction grating is done using (dichromate gelatin) which is sensitive to wavelength 532.5nm, by using two ways, the first one is the (in-line) way and the other is the (off-axis) way. The effect of both concentration of (dichromate) and the interference angle between the body wave and reference beam on the orders of diffraction and the number of fringes was studied. Where the second method with increase the interference angle is better than from the first one because clarity and increase the number of fringes.
Keyword: Optical Hologram

الخلاصة

في هذا البحث تم انجاز عملية تصنيع محزز الحيود باستخدام الهُلام (الجلاتين) ثنائي اللون والتي يكون حساس للطول الموجي 532.5 nm بواسطة اتباع طريقتين الاولى هي طريقة (in-line) والاخرى طريقة (off-axis).تم دراسة تاثير كل من تركيز الهلام الثنائي اللون و زاوية التداخل مابين الحزمة الضوئية للجسم و حزمة المصدر على مراتب الحيود وعدد الاهداب . حيث وجد ان الطريقة الثانية وبزيادة زاوية الحيود هي افضل بكثير من الطريقة الاولى بسبب وضوح وزيادة مراتب الحيود.

Introduction

One of the very important optical hologram elements is the sensitive film to light, which is manufactured and tested successfully in this work **[Coupland 2007and Sdymar 1981]**. There are many of materials sensitive to light and some of these are (silver halides), the phtochromatio materials , photo crosslink materials and the polymer materials, and one of the most important materials is the dichromatic gelatin. The bare gelatin can not be considered sensitive to light but will be of high recording efficiency if we add to it a another sensitive materials **[Chang 1979, Sjolinder 1981, Bolte 1994 and Mengjia 1995]**, for example the (salts of dichromate) especially the ammonium dichromate $(NH_4)_2\ Cr_2\ O_7$, which is more sensitive than potassium dichromate $K_2\ Cr_2\ O_7$ and sodium dichromate $Na\ Cr_2\ O_7$, the sensitivity increases with using $Cr_2\ O_7\ H_2\ C_5\ H_5\ Na\ H_2O$.

Adding of ammonium dichromate to gelatin in specific rates will cause many properties as follows:

1-High resolution more than 5000line /mm.
2-The ratio of signal to the noise will be high.
3-Will be sensitive to the wavelength (355-540) nm and it is possible to make it sensitive to the wavelength 632.8nm (Laser Helium-Neon) if we add appropriate dye.
4- Low scattering.
5- Development process is simple **[Stojanoff 1989]**.
6- Has high diffraction efficiency might reach theoretical value 100%.

There are two techniques for photographing: first, the in-line technique and this way was used for first time by Cabo in 1948, who considered that the wave of body and source are one wave as considered in figure (1).

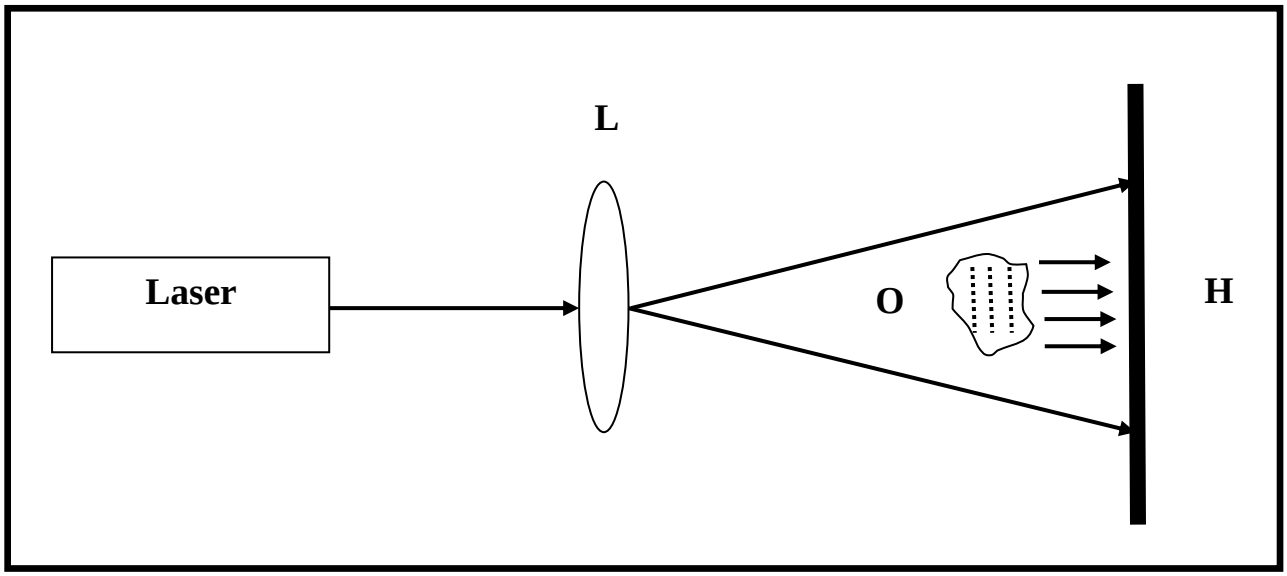


Fig (1): illustrates the process of building the hologram by using the in-line technique.

Where L represents the lens, H is the photographing plate and O is the body. The limitation of this way is the impossibility of separating the real picture from the imaginary one during the process of rebuilding. The second technique is the off-axis way which was used by Laith and Obatinic and based on the separating the body wave from the source wave in specific angle [Besle, 1987and L. Xu 2001]. As described in figure (2). The idiom off-axis means that the body and source beam do not come in same direction and therefore we can get two pictures one is real and the other is imaginary.

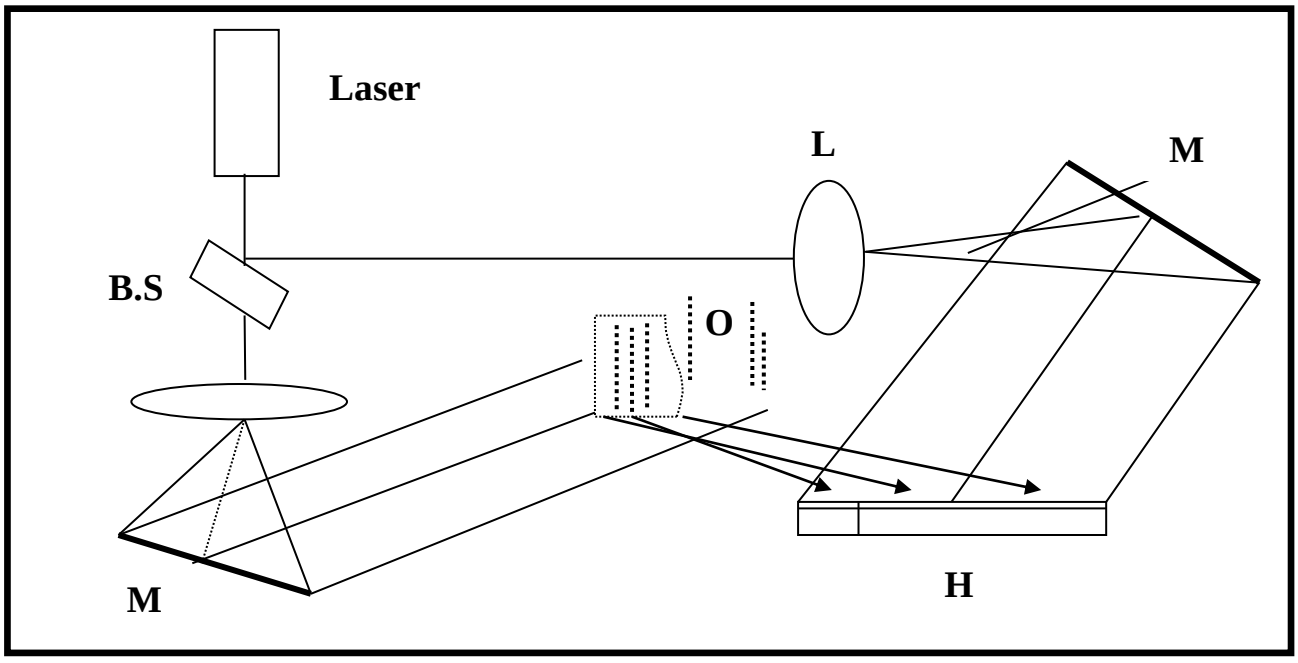


Fig (2): illustrates the building process of the hologram by using the off-axis technique.

Where M is the plane mirror and B.S. is the beam splitter[xu .L ,2001,ect].

Method

The manufacturing of grating is done as follows:

1- Solve 3% of gelatin in distilled water and coating the glass slide by this solution and let it dry.
2- Solve 4% of amunium dichromate.
3- Put the glass slide in the dichromate solution and keep it out of light for five minutes and then let it dry during night.
4- Exposure, The exposure was done by two ways:

First: In-line way is clarified in figure (3)

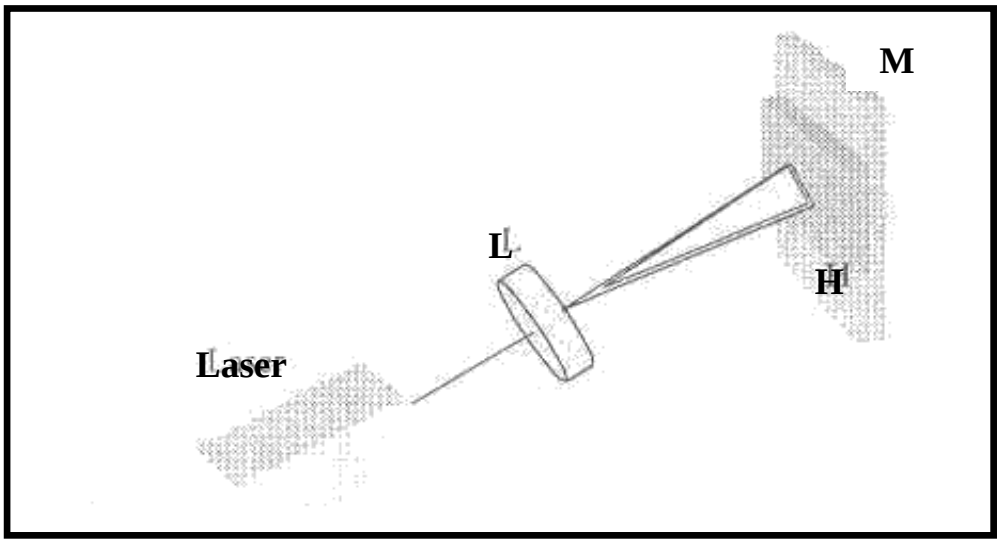


Fig (3): illustrates the in-line method for producing hologram grating.

Where M is the plane mirror, H the sensitive film and L is the convex Lens.

Second: Off-axis way as in fig (4).

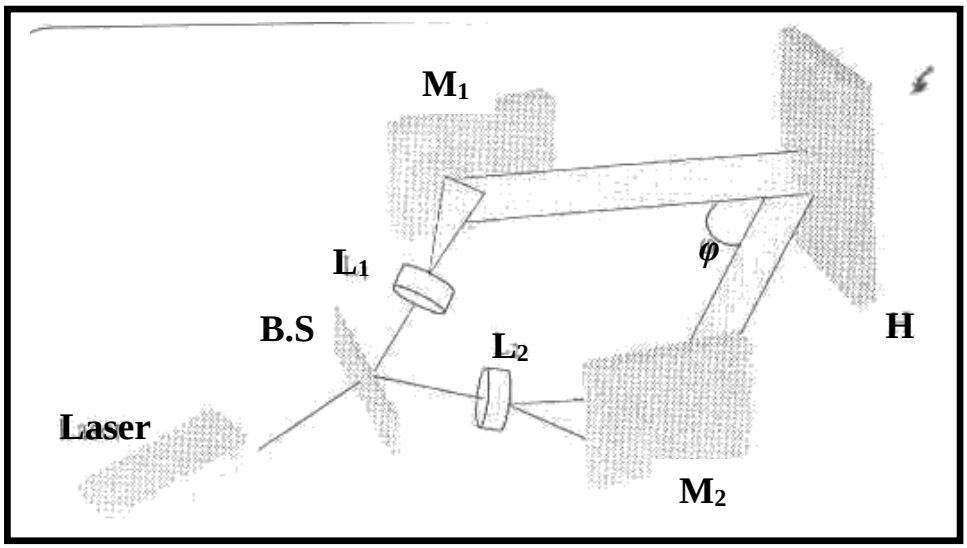


Fig (4): illustrates the diagram of off-axis method used for producing grating.

Where φ is the angle between the two interfered beams.

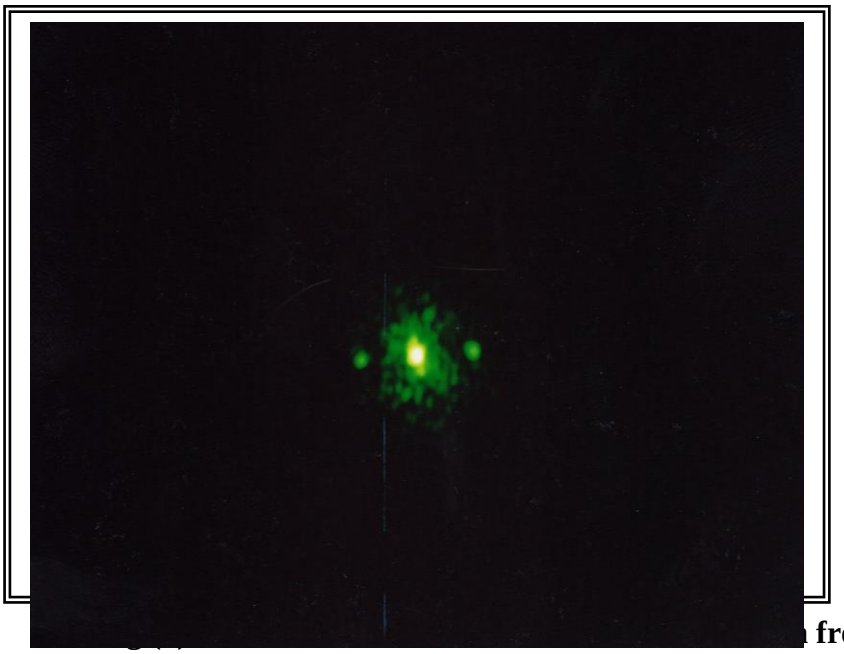
5-Development and washing the hologram film.

This process begins after finishing from exposure and as follows:

a. Putting the film in water for ten minutes.
b. Putting the film in isopropanol diluted to 50% for three minutes.
c. Putting the film in isopropanol at ratio 100% for two minutes.

Result and discussion

After completing development we rebuild the film, the orders of resultant diffraction was after putting film in figure (3) as in figure (5).



from *the in-line method at concentration 4% of dichromate.*

It is noticed that increasing the concentration of dichromate from 4% to 6% and photographing it in the same way we can conclude that the orders of resultant diffraction become as in figure(6).

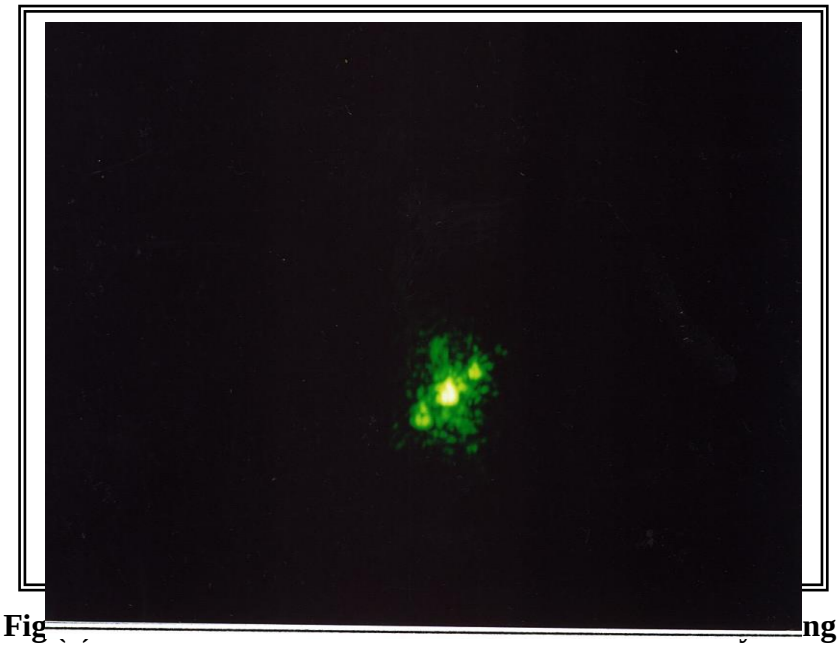


Fig ng the in-line method at concentration 6% of dichromate.

From noticing the two figures we can see that the orders of diffraction become more close to each others with increasing the concentration of dichromate and this coincide with. The distance between fringes was:

$$d = \frac{\lambda}{2} = 0.266\,\mu m$$

Where the wavelength (λ)=0.5325 μm and the number of fringes (lines) per millimeter was 3755 line/mm. When we use the off-axis technique the interfered angle between two beams was 25^0, and the orders of resultant diffraction were illustrated in figure (7).

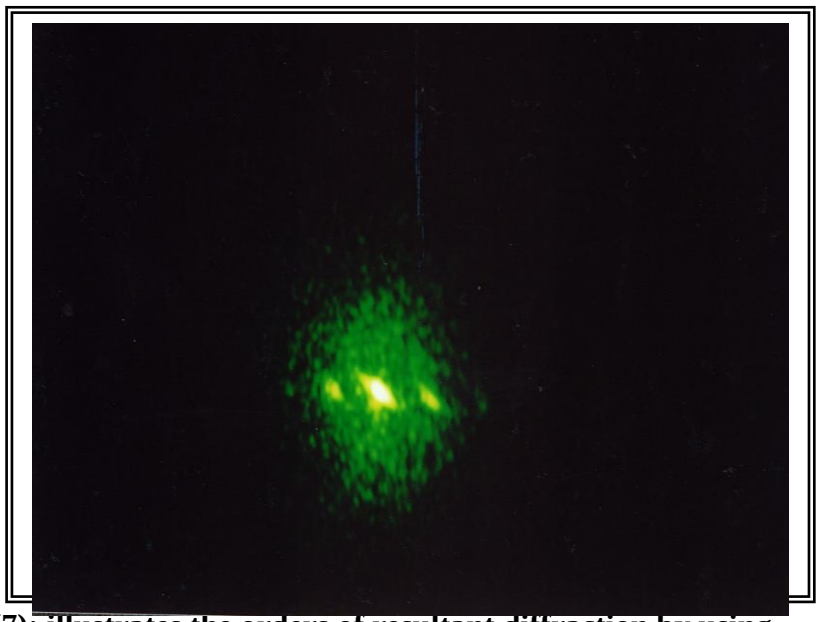


Fig (7): illustrates the orders of resultant diffraction by using the off-axis method at interfered angle 25^0.

Increasing the angle to 40^0 the shape of orders of resultant diffraction was as in figure (8) and the number of fringes at angle 25^0 was 807 line/mm. At angle 40^0 the number of fringes was 1277 line/mm, therefore, the number of fringes increases with increasing the interfered angle between the body and source beams.

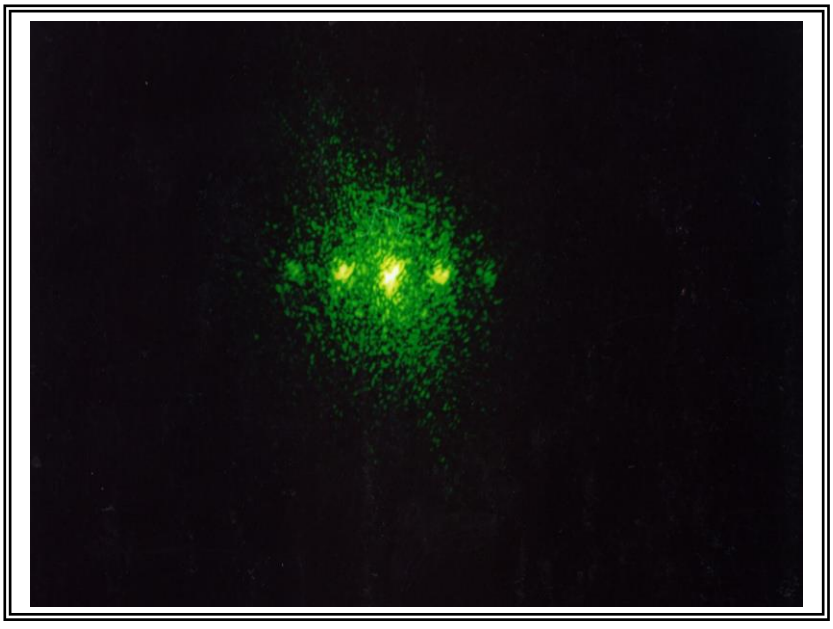


Fig (8): illustrates the orders of resultant diffraction by using the off-axis method at interfered angle 40^0.

Through this research found that the second method with increase the interference angle is better than from the first one, because clarity and increase the number of

fringes. In other side found the clarity of fringes increasing with decreasing of concentration of dichromatic.

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