DESIGN AND FABRICATION OF A TWO DIMENTIONAL GRATING LIGHT VALVE USING TEMPERATURE DEPENDENCE OF THE REFRACTIVE INDEX OF LIQUIDS

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Abstract:. *Design and fabrication of a two dimensional tuneable grating has been proposed. A transmissive 2D square well grating is fabricated. The holes of the grating then is filled with a liquid which it's refractive index is depend on the temperature. By changing the temperature the efficiency of the diffraction patterns is changed.*

1. Introduction

Tuneable gratings have lots of application. Several actuation methods have been done before by researchers. Mechanical actuation in MEMS based devices [1] and thermal actuation for optical modulation [2] are some of the tuning mechanisms. Thermal actuation using the dependence of the refractive index of water to the temperature, has also been investigated before [3].

In this article a 2D tuneable grating is proposed. first a 2D grating is designed by computer simulation and is then fabricated. The holes of such a grating is then filled with a liquid which it's refractive index is depend on temperature. By changing the temperature, such a grating can be tuned.

2. concept and design

Suppose a 2D square well grating as shown in figure 1. when a light is incident on it, a portion is passed through the lands and a portion is passed through the holes. After passing through the grating, the phase difference between these two portions will be as follow

$$\gamma = \frac{2\pi}{\lambda}(n1 - n2)d \qquad (1)$$

Where λ is the wavelength of light, d is thickness of the grating and n1 and n2 are the refractive indices of the lands and holes respectively.

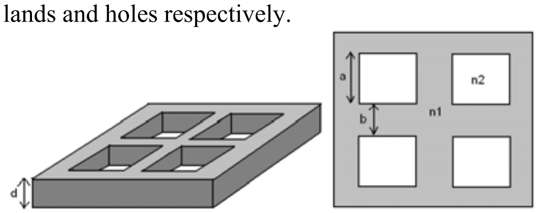

Fig. 1. a 2D square well grating with refractive indices n1 and n2 in lands and holes. The with of the land and holes are a and b respectively

A simple calculation shows that if the width of the holes, a, and the with of the lands, b, are set as follow

$$a = (\sqrt{2} + 1)b \qquad (2)$$

Then in one period of the grating, the area of each hole will be equal to the area of the land. In this manner, the amount of light which pass through the lands and holes will be equal. Now suppose that the holes of such a grating is filled with a material which it's refractive index can be changed. By changing the refractive index, the phase difference as it is seen in equation 1, is changed. Figure 2 shows the computer simulation of the diffraction efficiency for phase differences, 0, $\pi/2$, π. As it is seen, when the phase difference is equal to π, the zero order, completely is suppressed and the efficiency of diffraction, reaches to 100%

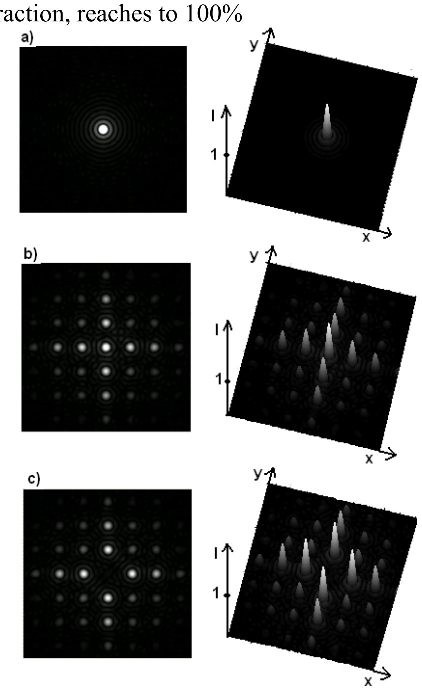

Fig. 2. simulation of the diffraction efficiency for phase differences, a)0, b)$\pi/2$, c)π. The maximum intensity in the diagrams is normalized to unity.

3. fabrication method

First, a 2D grating is made by laser direct write lithography technique on about 20micron thick ormoclear photoresist. The fabricated grating is shown in figure3.

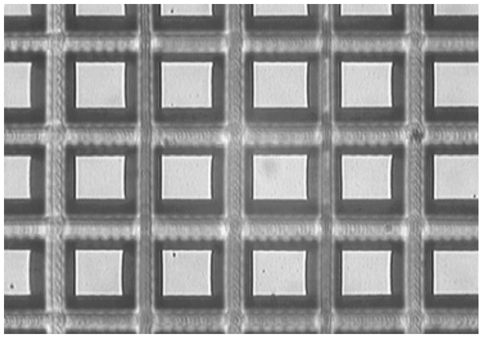

Fig. 3. fabricated grating on 20 microns ormoclear photoresist

The holes of the fabricated grating is then filled with nitrobenzene liquid which has large dependence of the refractive index on temperature (dn/dT $= -4.6 \times 10^{-4} K^{-1}$ at 626.58 at T=288°K). this structure is then sandwiched by a supporting glass as shown in figure 4.

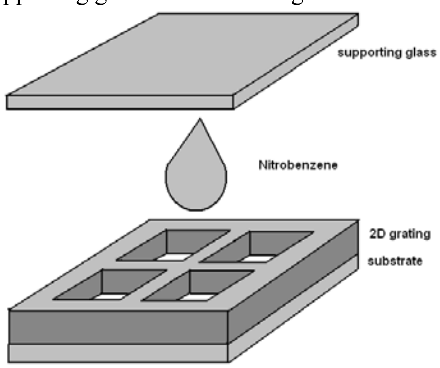

Fig. 4. filling the holes of the grating with nitrobenzene and a supporting glass is used on it

To investigate the relation between temperature and intensity of diffraction orders, we used a set up which is shown in figure5. A heat gun warms up the grating, and diffraction pattern is captured by a CCD camera

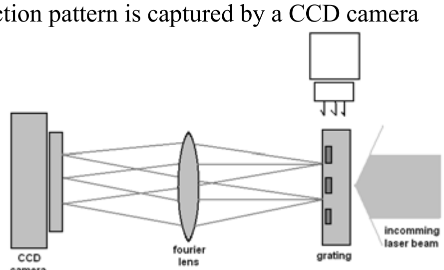

Fig. 5. the set up for investigation of the relation between diffraction pattern an temperature.

Figure 6, shows 3 diffraction patterns in three different temperatures. As it is seen, the diffraction pattern is different in different temperatures, T=25°C, 100°C and 170°C

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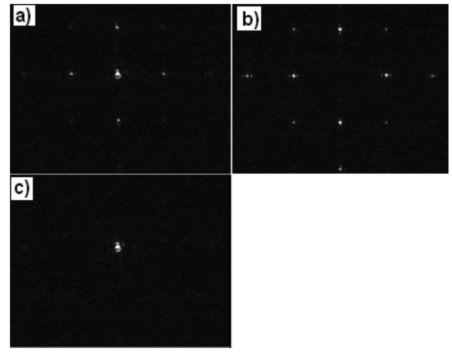

Fig. 6. the diffraction pattern at a) T=25°C, b)T=100°C and c) T=170°C

By changing the temperature from 25°C to 200°C, intensity of the 1st order of diffraction has also been plotted in figure 7.

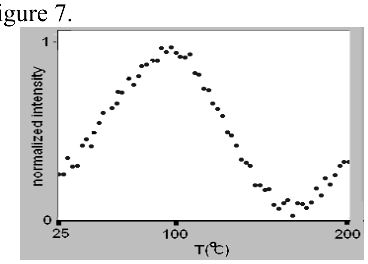

Fig. 7. intensity of the 1st order of diffraction versus temperature

4. Conclusions

In this article, the relation between the intensity of the first order of diffraction versus temperature in a 2D grating was investigated. The phenamena was first described by computer simulation. A 2D grating was built and it's holes were filled with nitrobenzene. By changing the temperature, the intensity in diffraction patterns was investigated.

References

[1] Jahja I. Trisnadi, Clinton B. Carlisle and Robert Monteverde, Silicon Light Machines, Sunnyvale, CA 94089 "Overview and applications of Grating Light ValveTM based optical write engines for high-speed digital imaging",PhotonicsWest2004 – Micromachining and Microfabrication Symposium, January 26, 2004, San Jose, CA, USA

[2] D. E. Sene, J. W. Grantham, V. M. Bright, and J. H.Comtois, "Development and characterization of micromechanicalgratings for optical modulation," in Proceedings of the ninth Annual International IEEE MicroElectroMechanical Systems Workshop _Institute of Electrical and Electronics Engineers, Piscataway, N.J., 1996_, pp. 222–227..

[3] Mohammadreza Riahi, Hamid Latifi, "Design of thermally actuated grating light valve, using temperature dependent refractive index of water", ODF'08, 9-11 june 2008, Taipei, Taiwan