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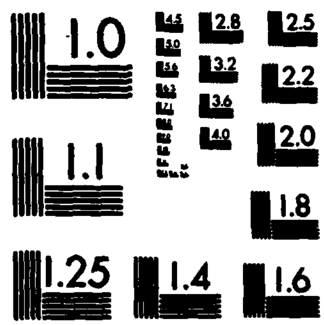

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Semiannual Report

Switchable Zero Order Diffraction Gratings as Light Valves

Office of Naval Research
Contract N00014-82-K-0522

covering the period
1 July 1982 - 31 December 1982

Submitted by
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December 29, 1982

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Introduction

The goal of this project is to build a light valve based on a switchable zero order diffraction grating. The grating is made switchable by fabricating it on two facing surfaces and then displacing one surface with respect to the other by half of one period. One way of producing the displacement is to use the strong piezoelectric properties of polyvinylidine fluoride (PVF$_2$). An alternate scheme using electrostatic forces is also being investigated. Ultimately the light switches need to be mass producible, inexpensive, and capable of being fabricated into matrix addressable arrays. If the arrays are made with 525 by 700 elements, they could be used as flat back lighted TV screens. Smaller arrays might be useful for simpler displays. Another, potentially important use of the arrays would be in optical signal processing to convert electronic information into spatial light modulation.

Progress

A) Optical Properties:

So far our efforts have been focused on building a single working light valve element. To understand the optical properties of the bigrates (two facing gratings which constitute the light valve) some gratings of 3.8μm period where fabricated in quartz and tested in a spectrometer. Their transmission properties showed the expected behavior. Single gratings varied as a function of wavelength from 5% transmitting to 85% transmitting. When the gratings were put face to face to form a bigrate, the change from 4% transmission to 50% transmission could be observed. However, because the original mask was made on a pattern generator, rather than holographically, the bigrate had a patchwork appearance. This is due to the stitching error in the pattern generator, i.e., each line in the grating is exposed in segments.

A) PVF_2 Properties and Fabrication:

Since strong piezoelectricity and light transmission is combined in one material in PVF_2, this is the material we expect to use to fabricate the bigrates. PVF_2 samples have been obtained, techniques for applying metal have been developed, and lateral motion produced by applying a voltage have been observed. The piezoelectric coefficient d31, which determines the amounts of motion per applied electric field, has been measured. Sufficient motion to operate a bigrate can be obtained. A technique for producing a sinusoidal grating (used for black-white contrast) of 1.5μm period in nickel has been developed. It consists of holographically exposing and developing a sinusoidal profile grating in photoresist, plating thick nickel over it and then dissolving the resist. The resulting nickel template has been used to emboss PVF_2 at 20,000 psi. The gratings thus embossed appear to be stable, i.e., they do not relax. PVF_2 was found to be 90% transmitting in the visible spectrum and its index of refraction was measured to be 1.46.

A very rudimentary bigrate has been successfully demonstrated by attaching a PVF_2 strip with metal on two faces to one of two facing quartz gratings. Applying a voltage to the PVF_2 caused the grating to translate and to switch the optical transmission of the bigrate. Our next immediate goal is to build this same structure entirely in PVF_2 using the embossing technique described above.

Our ability to emboss PVF_2 and to produce motion in the same material indicates inexpensive mass production may be possible.

C) Electrostatic Motion:

The electrostatic motion scheme may involve somewhat more complicated fabrication but may present advantages of guaranteed alignment and large flexibility in choice of materials. In this scheme interdigitated electrodes which run parallel to the gratings are fabricated on both facing elements and covered with a thin insulating film. Changing the sign of the voltage on the electrodes causes alternate attraction and repulsion and produces a relative movement of the elements. Simple calculations indicate that the forces are large enough to produce the desired motion. A set of masks with appropriate interdigital electrodes has been designed and fabricated in order to demonstrate this method of producing micromotion.

Conclusions

At this halfway point in the research program we have gained a good understanding of the optical principles of the bigrate, developed fabrication techniques for PVF_2, built a rudimentary electrically switchable light valve, and begun investigation of electrostatic motion. The participants in the project look forward with enthusiasm to the challenges ahead.

Fiscal Status

For the current year (July 1, 1982 - June 30, 1983) $85,000 has been spent and commited out of the $120,000 appropriated by DARPA.

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