MODULAR OPTICS INTERFEROMETER *

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A waveguide interferometer is assembled using holographically formed optical elements that are constructed as individual components and can be selectively attached to an optical waveguide. The interferometer is very rugged and easy to align.

1. Modular optical elements

We describe modular optical elements as miniature optical components that are individually constructed and can be selectively attached to the surface of an optical waveguide [1–3]. These components can be individually adjusted to optimize system performance. In this paper, we describe the construction and use of modular optical elements to form a waveguide interferometer.

Our optical modules consist of holographic optical elements constructed in dichromated gelatin films that are coated on glass substrates. Each element serves as both a grating waveguide-coupler and a beam splitter, as shown in fig. 1. The modular gratings are constructed by incoherently superimposing two thick gratings within a dichromated gelatin film such that the two gratings have a common Bragg angle, A [1]. Readout at the angle A will produce two diffracted waves each of which contains half of the incident energy [4]. The two diffracted waves are at angles such that they will both be trapped within the guide G.

* Work performed at the University of Michigan.

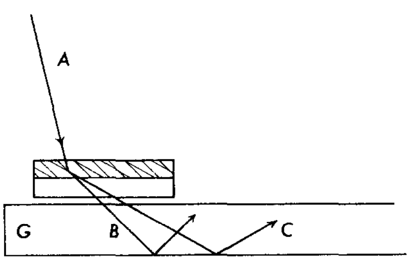

Fig. 1. Operation of the modular coupler. Beam A is split and coupled into guided waves B and C. Xylene is used as an index matching liquid between the coupler and the guide G.

2. The interferometer

Having constructed our grating modules, we assemble our in-line interferometer by placing two of these modular gratings on the surface of the thick glass optical waveguide as shown in fig. 2. Xylene is used as an index matching liquid between the modules and the guide. The first element (on the left) is used as the wave guide coupler and beam splitter while the second element acts as a beam-combiner and decoupler.

The interferometer is used by illuminating the coupler module with a coherent beam of light from the upper left in fig. 2. Since the incident wave (A in fig. 1) has a finite cross sectional area ($\approx$ 1 cm^2), the waveguide is thick ($\approx$ 6 mm) and the waves B and C propagate at greatly different angles ($\approx 20^\circ$ difference), the areas at which the guided waves strike the surface of the guide are physically separated. Thus, we can insert a sample into the interferometer by laying it on the surface of the waveguide at a position where only one of

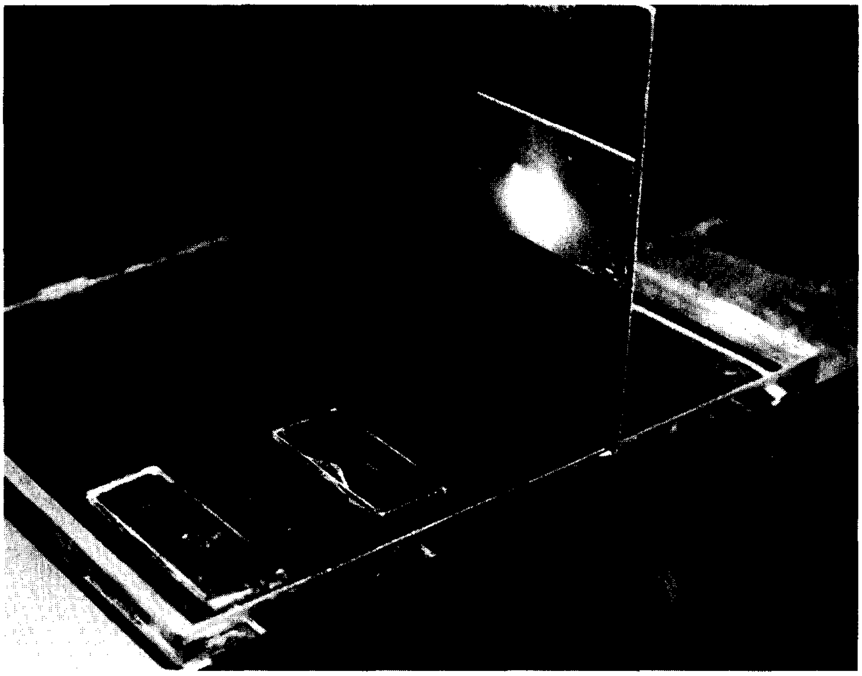

Fig. 2. The waveguid interferometer. Proceeding from left to right, one can see the coupler module, the test object, the decoupler module and the output beam which strikes the white card.

the guided waves (e.g. wave C) strikes the surface. An index matching liquid (in this case xylene) is placed between the sample and the guide. Thus, guided wave C leaves the guide, passes through the sample, and re-enters the guide as a modulated wave. A short distance later, where waves B and C again overlap, the beam combiner has been placed on the surface of the guide. This modular element is identical in construction to the beam splitter element and is merely rotated by 180° (about a vertical axis in fig. 1) before being placed on the guide. The two guided waves simultaneously enter the final grating, are combined, and are diffracted out of the guide [4]. The combined waves leave the guide at approximately 45° as can be seen in fig. 2 where they strike a white card after leaving the interferometer.

3. Experimental results

The output of the interferometer is photographed by placing a camera in place of the white card in fig. 2. With no sample in the interferometer, we see straight fringes present on the output (fig. 3). The fringe frequency in fig. 3 can easily be varied by small rotations of the final grating (about a vertical axis in fig. 1). Because the angles between guided waves B and C are fixed during grating construction and cannot get out

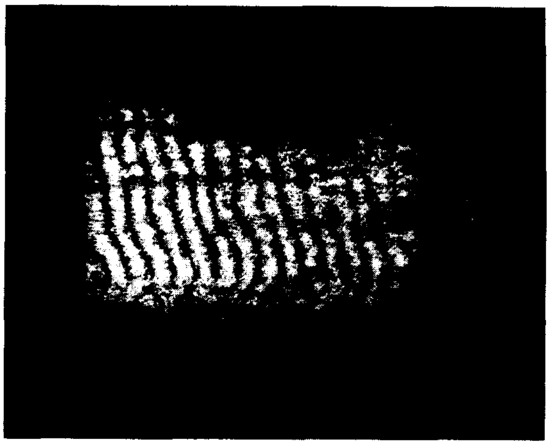

Fig. 3. The interferometer output showing straight fringes when no test object is in the interferometer.

Fig. 4. Interferometer output when a piece of thin glass with a deep scratch is used as a test object.

of alignment, the only adjustment that ever needs to be done is a slight rotation of the gratings.

In fig. 4, we see the output when an object has been inserted into the interferometer. The test object is a small piece of glass (microscope slide cover-glass) in which we have put a deep scratch with a glass cutter. The scratch extends half way across our test object and shows up as dislocated fringes on the left side of the output.

4. Conclusions

The modular interferometer we have demonstrated is easy to adjust and is very rugged. Rapid changes in air temperature or air currents have little effect on the device.

The modular coupler elements can easily and quickly be placed on any piece of glass which we would like to interferometrically test for flatness or other optical properties.

Acknowledgement

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