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Polymeric Waveguide Optical Switch Using Rotary Drive Mechanism

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Abstract

We propose a polymeric waveguide optical switch using a novel drive mechanism. A trench formed at a cross-point in the flexible polymeric waveguides is gated by rotating the near-trench arm and switching operation is demonstrated.

1 Introduction

Optical switches are key devices for optical fiber communication systems because they can change light paths without optical/electrical conversion. The important features of optical switches are not only the performance but also the cost saving.

In our past works [1-3], we proposed and demonstrated the bascule structure optical switch using polymeric waveguides, suitable for low-cost mass production. The switch also has good optical properties such as low-loss transmission and relatively fast switching speed. Fig. 1 shows the schematic of the optical switch.

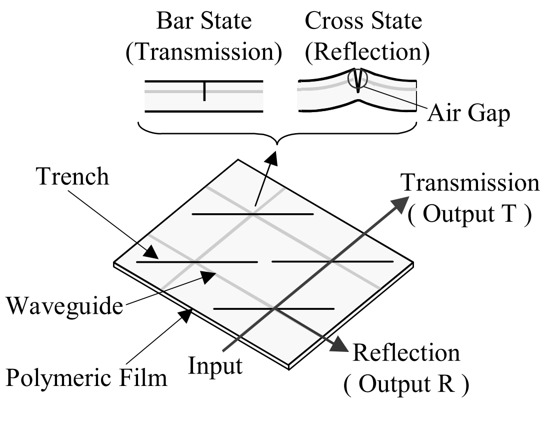

Fig. 1: Schematic of the optical switch.

The switch uses a flexible polymeric waveguide film where trenches are formed at cross-points of the waveguides. When the trench opens, light path changes by total internal reflection between the air gap and the polymeric waveguide. Previously, piezo actuators just below the cross-points were used to push up and open the trenches. However, such drive mechanism requires precise horizontal alignment between the individual actuators and the trenches, and micrometer-scale flatness of both the polymeric waveguide film and the actuators over the large film area in order to overcome the limitation of the actuators' strokes. In this paper, we propose a novel drive mechanism to solve the abovementioned problem and demonstrate the switching operation.

2 Switching mechanism

Instead of the vertical drive described above, we adopt a rotary drive mechanism shown in Fig. 2.

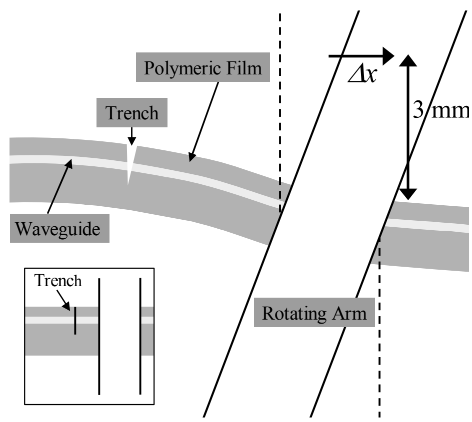

Fig. 2: Principle of rotary drive in a cross state (cross section). Inset: In a bar state.

A vertically inserted rotating arm into the film is set near the trench. By rotating the arm in the direction normal to the trench (the direction of an arrow with Δx in Fig. 2), the trench changes from bar (transmission) to cross (reflection) state. This rotary drive mechanism does not require precise alignment or flatness between the film (trenches) and the drive units. Therefore, it will be more cost-effective than the previous vertical drive mechanism especially for N x N matrix switches.

3 Design

Due to the flexibility of the polymeric film, the distance between the rotating arm and the trench in the film affects the force and the amount of rotation required for switching operation. If the arm is set far away from the trench, the rotational force necessary for switching operation will become large because it dose not directly act on the trench. Using structural analysis, we found that when the arm is set 500 μm away from the trench in the normal direction, the required rotational force at the drive unit becomes 5 times larger than that when the arm is set 150 μm away. According to the structural analysis with the appropriate arm size, we chose the distance between the rotating arm and the trench to be 250 μm.

4 Experimental Results

The rotating arm of 125 μm diameter was set 250 μm away from the trench in the normal direction in the film. We observed the intensity change of the transmission light (Output T in Fig. 1) and the reflection light (Output R in Fig. 1) with the change of a horizontal displacement Δx at the level of 3 mm high from the film surface (see Fig. 2). When Δx = 1 mm, the attenuation of the transmission light reached 21 dB and the reflection light intensity increased by 27 dB as shown in Fig. 3. Switching operation with the rotary drive mechanism was successfully demonstrated. As the mechanism uses rotary force, the required displacement Δx can be reduced by lowering the height level of the force.

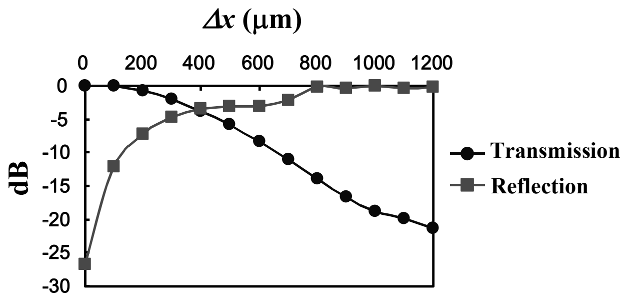

Fig. 3: Switching operation using rotary drive.

5 Conclusion

We proposed and demonstrated the polymeric waveguide optical switch based on the bascule structure with the novel rotary drive mechanism. We observed 21 dB attenuation of the transmission light and 27 dB increase of the reflection light intensity when the trench at the cross-point of the waveguides was switched from bar to cross state by the rotary drive. This drive mechanism will offer the polymeric waveguide optical switch with both high productivity and low cost.

Acknowledgements

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