Topics

Integrated-Optical Voltage Sensor - Decrease in Polarization-Dependence of Sensitivity

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1. Introduction

The sensitivity of the integrated-optical voltage sensor reported in the Topics column of this issue (p.65) depends on the polarization direction of the incident light (+/-56%) because the waveguide is fabricated on a Z-cut substrate. If polarization-independent sensitivity is attained, then a single-mode optical fiber (¥200/m) can be used in lieu of a polarization-maintaining optical fiber (¥3,600/m), sharply reducing costs, particularly in remote sensing applications.

As one of the methods to attain polarization-independent sensitivity, a λ/4 plate is provided on the reflecting end to rotate the polarization direction of the reflected light. With this method, however, it is difficult to attach the λ/4 plate on the very small reflecting end surface. Therefore, we formed the λ/4 plate directly on the end surface [1] with an oblique-deposition technique, utilizing the fact that an obliquely deposited film of metal-oxide has birefringence for normally incident light [2].

2. Fabrication of Samples

Fig. 1 shows the schematic diagram of the voltage sensor we developed. It is basically the same as the one reported in the Topic column of this issue (p.65) except for the λ/4 plate. Here the size (23mm x 6mm) of the conventional type was used. After fabricating the waveguide, the electrodes and the V-groove for optical fiber alignment, Ta_2O_5 was deposited onto the reflecting end from two opposite oblique directions alternately as shown in **Fig. 2** so that the direction of the principal optical axes of the λ/4 plate make an angle of 45°with the z-axis. The total thickness was 8.1μm. Next, a heat treatment for oxidation of the obliquely deposited film was carried out for 1 hour at 250°C in a dry oxygen atmosphere, followed by depositing the reflecting film (Au) onto the obliquely deposited film.

3. Evaluation

The polarization dependence of the voltage sensor was evaluated by using an optical setup shown in Fig. 3. The polarization state of the incident light to the sensor was varied by changing the optical principal axes of the polarizer and the λ/4 plate. The variation of the sensitivity at that time was within +/- 5.5% [due to the fact that the retardation of the obliquely deposited film was λ/4 x 1.04 (measured value)].

Next, the voltage sensor was connected to a light source with a single-mode optical fiber 30m-long. The fluctuation of the sensitivity was within +/- 6% when the optical fiber was subjected to temperature change (20°C to 40°C), bending and vibration. This value was small enough for practical use, and the use of a single-mode optical fiber was confirmed to be possible.

References

1) Takeda, Y., Ichikawa, T., Motohiro, T. and Ito, H. : SPIE Proc., 3740 (1999), 428

2) Motohiro, T. and Taga, Y. : Appl. Opt., 28 (1989), 2466

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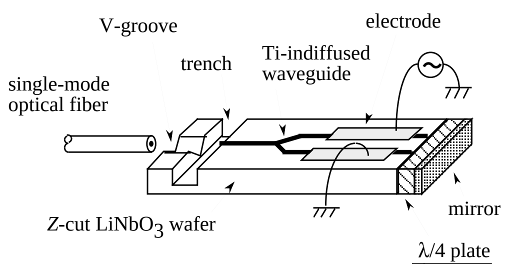

Fig. 1 Schematic diagram of polarization-independent optical voltage sensor.

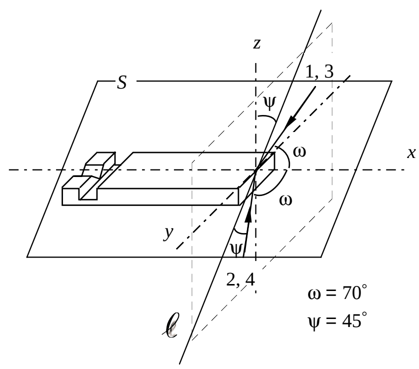

Fig. 2 Deposition directions of Ta_2O_5 onto the reflecting end. Line ℓ is on *yz* plane and makes an angle of 45° with *z* axis. Plane *S* includes *x* axis and Line ℓ. The two deposition directions indicated by arrows are on Plane *S* and make angles of 70° with *x* axis. Numbers indicate the deposition order.

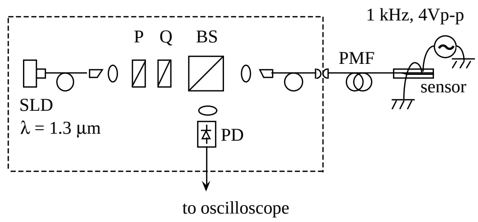

Fig. 3 Schematic diagram of the test setup for evaluating polarization dependence of the sensitivity.
SLD: super luminescent diode, PD: photodiode,
P: polarizer, Q:λ/4 plate, BS: beam splitter,
PMF: polarization-maintaining optical fiber.