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Band-pass Optical Filter in Light-induced Self-written Waveguide

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1. Introduction

The demand to realization of the optical interconnection is increasing along improving the communication and the processing capacity in recent years. However, a delay of the development becomes the obstruction of the practical use though a technique to connect individual devices to high efficiency is important. Therefore, the self-formation of optical waveguides is expected to play an equivalent role in the optical circuit as the solder in electric circuit.

In this paper, we report the processing technique to give not only the connection but also the function of the wavelength splitting filter. Furthermore, we confirmed stability more than one week of the function.

2. LISW Technology

Principle and fabrication process

Figure 1 shows the formation principle of the light-induced self-written (LISW) waveguide [1-4]. First, the tip of an optical fiber is immersed in a vessel containing a liquid mixture of two photo-polymerizable resins, A and B. The refractive index of resin-A is somewhat larger than that of resin-B. The fiber is then excited by a blue laser (457 nm wavelength), and the emitted beam photopolymerizes only the resin-A monomer. On the other hand, the resin-B monomer is not photopolymerized by the blue laser light. The resin-A monomer hardens into a cylindrical shape and becomes the core of the waveguide by the self-trapping effect. Next, the sample is irradiated with ultraviolet (UV) light, and resin-B and the remaining resin-A are cured. In this way, the cladding is formed and the LISW waveguide fabricated.

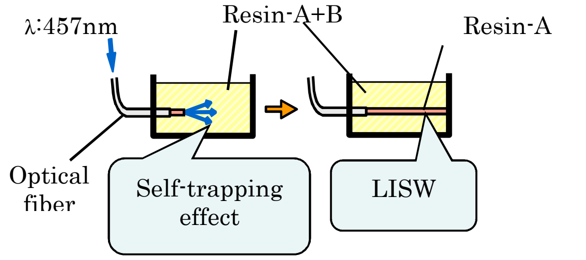

Fig. 1 Formation principle of the LISW waveguide.

Grating

We adopted a phase mask to form a grating. Figure 2 shows the formation principle used to fabricate the grating using the phase mask. The phase mask is optimized to diffract light equally and maximally into the positive and negative first orders, whereas, the zero order is suppressed. Self-interference between these +1/-1 orders creates an interference pattern with half the pitch of the phase mask. In this study, the phase mask pitch is 1040 nm, therefore, the interference pitch is 520 nm. A laser diode with a wavelength of 401 nm was used for the irradiation light source, because the phase mask was optimized at 400 nm. A waveguide type filter can be formed by exposure to light with the phase mask after forming the LISW waveguide.

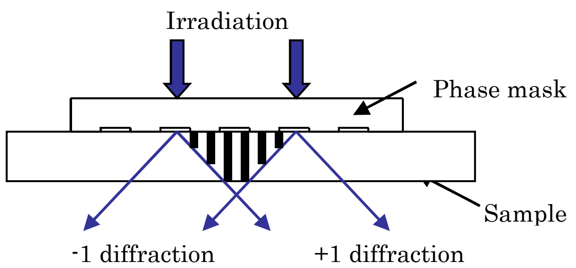

Fig. 2 Formation principle of the grating using a phase mask.

3. Result and discussion

Figure 3 shows a schema of the band-pass filter which consists of a LISW and the grating. This filter works as well as a fiber Bragg grating. The grating period was confirmed to be 520 nm from measurements and from calculating the diffraction angle for an incident He-Ne laser. The first order Bragg reflection wavelength of this filter was calculated to be 1560 nm, when the effective refractive index of the waveguide was 1.50 [5].

Figure 4 shows a schema of the set up used for measuring the band-pass filter characteristics. Light from the amplified spontaneous emission (ASE) light source (λ:1528 ~ 1608 nm) is directed to the sample through an optical circulator. The spectrum of light reflected from the sample is measured by an optical spectrum analyzer (OSA) through the optical circulator.

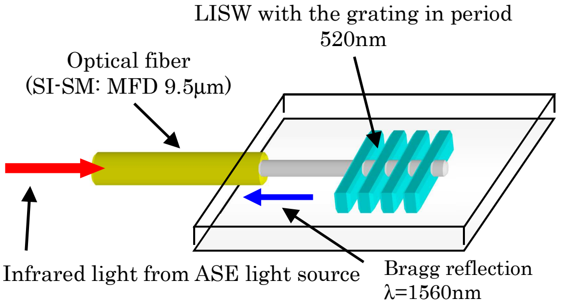

Fig. 3 Schema of the band-pass filter which consists of a LISW waveguide and the grating.

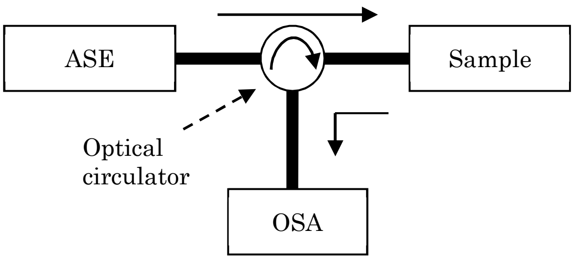

Fig. 4. Schema of the set up used for measuring the band-pass filter characteristics.

Figure 5 shows the reflection spectra from the sample with/without the band-pass filter to a LISW waveguide. The spectrum with the filter (solid line) clearly shows a resonance at 1557 nm compared to that without the filter (broken line). This resonance wavelength agrees with the calculated first order Bragg reflection wavelength when setting the refractive index of the LISW waveguide to 1.497.

Figure 6 shows the stability of filter after fabrication, 2 days and 8 days. These results show little variation was found to be stable filter characteristics.

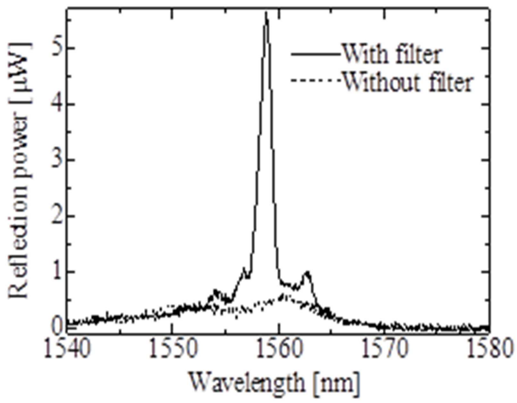

Fig. 5 Reflection spectra from the sample with/without the band-pass filter to a LISW waveguide.

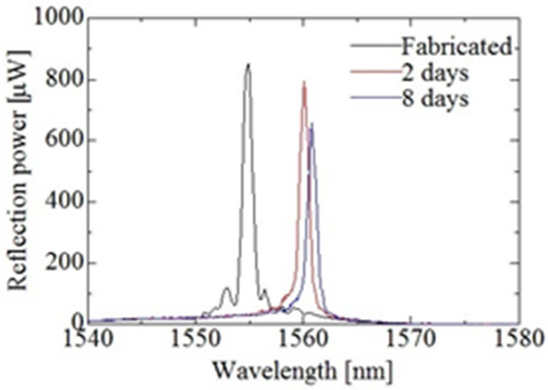

Fig. 6 Spectra of the filter function after just-fabricated, 2 days and 8 days, respectively. This graph shows the stability of fabricated filter.

4. Conclusions

In this paper, a grating was fabricated by irradiating a LISW waveguide with violet light from a LD through a phase mask. The spectrum reflected from the grating clearly indicates the characteristics of a band-pass filter. This fabrication method is a promising technology for simply and cheaply fabricating waveguides with band-pass filters such as fiber Bragg gratings.

Acknowledgements

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