Extended Abstracts of the 2003 International Conference on Solid State Devices and Materials, Tokyo, 2003, pp. 894-895

F-10-4

Optical Component Coupling using Self-Written Waveguides

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1. Introduction

Difficulties in optical alignment adjustment are one of the major problems to construct low cost optical components. Self-written waveguides technology [1-17; Fig. 1] is one of the possible solutions; introducing light from an optical fiber edge to photosensitive medium, an optical waveguide (= self-written waveguide) easily forms when refractive index of the exposed medium increases. The resulting hybrid optical component, composed of a fiber and a waveguide, can be obtained without any alignment adjustment. We have been studying [11 -17] an easy optical coupling method using this technique. Effectiveness of this method is described here throughout coupling experiment of optical fibers and polymer waveguides.

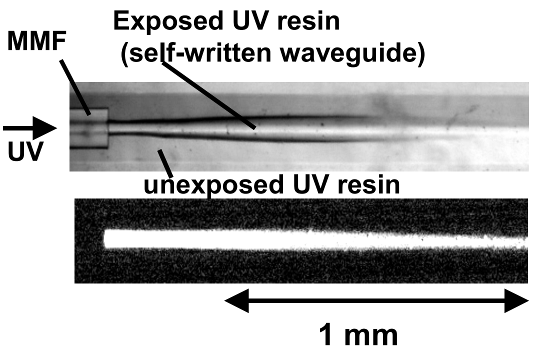

Fig. 1. Top: an example of self-written waveguide. Bottom: the light guiding behavior.

2. Optical Fiber Coupling

Yoshimura et al. [9, 10] firstly reported concept of the coupling method using self-written waveguide. Using the waveguide formation principle, introducing light from two faced optical fiber edges would result in efficient coupling with formed self-written waveguides even if significant gap and misalignment exist between the fibers. If such phenomenon actually occurs, self-written waveguide relax conventional tight control restriction of optical fiber/device alignment.

Based on the proposed concept, we tried to couple GI-type multimode fibers (MMF; core diameter = 50 μm). The waveguide material is acrylate-type UV curable resin. After exposing UV light from both fiber edges (UV intensity: < 1mW/cm^2), self-written waveguides form from the two-faced MMFs. Fig. 2 shows the coupling behavior of MMFs under 1 mm gap and 40 μm offset. Two MMFs

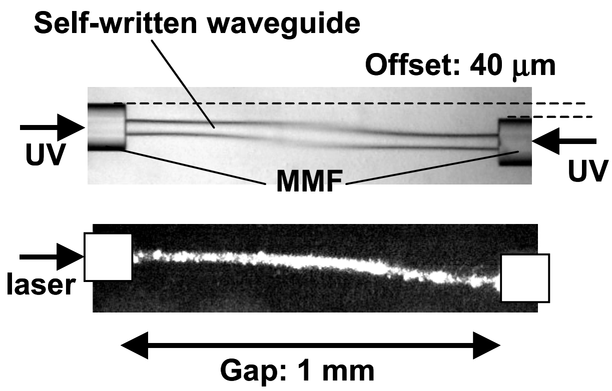

Fig. 2. Top: optical coupling behavior of two MMFs using self-written waveguides under 1 mm gap and 40 um offset. Bottom: the red laser guiding behavior.

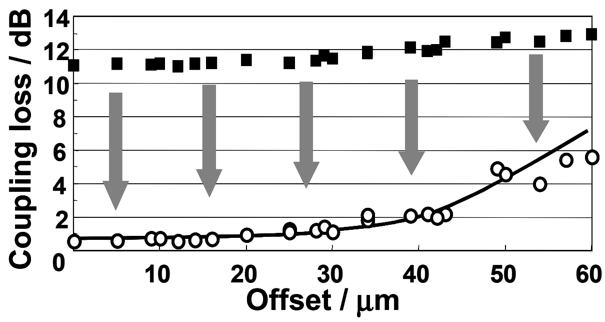

Fig. 3. Coupling loss variation as a function of offset values. The gap value is fixed as 1mm. Square: before self-written waveguide formation. Circle: after self-written waveguide formation.

are successfully coupled by the formed self-written waveguides; the red laser is also effectively guided in the waveguide under significant gap and offset existence.

Coupling loss was measured with various offset values. Fig. 3 shows the coupling loss variation at 850 nm; gap value is fixed as 1 mm. The coupling loss is drastically decreased after the waveguide formation over the measured offset range. The loss is less than 1 dB up to 30 μm offset, and about 2 dB even at 40 μm offset; these values are considerably lower than those before waveguide formation, > 10 dB.

3. Fractured Optical Fiber Coupling

This coupling technology uses a resin material as coupling medium; its refractive index is similar to optical

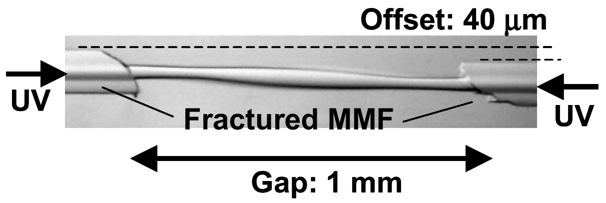

Fig. 4. Optical coupling behavior of two fractured MMFs using self-written waveguides

fiber core. We are thus investigating one more interesting feature of this coupling technology, fractured fiber coupling. Fig. 4 shows coupling behavior of fractured MMFs coupling under 1 mm gap and 40 μm offset. The waveguides nicely form irrespective of the fractured fiber edges and successfully connect two MMFs. The measured coupling loss is about 2 dB, which is well-comparable to edge-treated MMFs coupling described in the previous section, edge treatment of optical circuits which is usually essential for conventional coupling procedure such as fusion or mechanical splice is not required using this coupling technology. Recent work also suggests that buffer-coated optical fiber can also be connected with the same experiment procedure.

4. Polymer waveguide coupling

In an optical component system, various optical species are to be coupled in addition to conventional optical fibers; different optical circuit coupling is a typical example because the coupling frequently appears in optical fiber pigtailed PLCs. To make effectiveness of the coupling clear, this section describes coupling study of polymer waveguide, one of the well-known PLCs. One difficulty to apply the same coupling process mentioned so far is the UV curable resin used as a self-written waveguide material. Because of strong UV absorption of a polymer waveguide, self-written waveguides hardly form from a polymer waveguide edge. Thus, to overcome the material issue, visible light curable resin is employed here. The used polymer waveguide is film-type and has epoxy based core and clad. Fig. 5 and Fig.6 respectively show coupling behavior of two polymer waveguides, and optical fiber and polymer waveguide. The waveguides easily form in the photosensitive medium. The resulting coupling loss at 850 nm is roughly 1 dB for 500 um gap in both cases. Further investigation is now underway to decrease the loss values and to confirm the coupling capability under various gap and offset values.

3. Conclusions

The technology has a potential to provide easy and convenient optical component coupling; the coupling is successfully achieved even when significant gap/offset is created in optical components to be coupled. Additionally, as another remarkable feature, edge treatment of optical circuits may not be required using this coupling technology. Self-written waveguide acts as “optical solder” in the coupling medium; low cost optical component fabrication

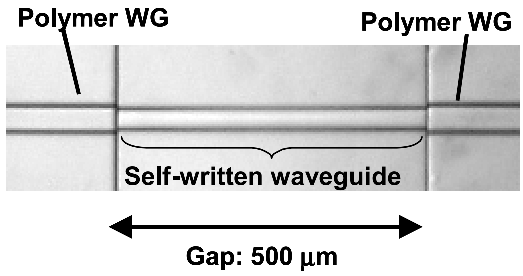

Fig. 5. Optical coupling behavior of two polymer waveguides using self-written waveguides.

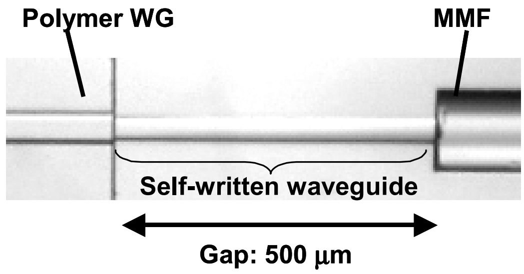

Fig. 6. Optical coupling behavior of a polymer waveguide and a MMF using self-written waveguides.

could be expected using this technology. Further systematic study is now underway for practical use.

Acknowledgements

This work was performed under the management of Association of Super-Advanced Electronics Technologies (ASET) in the basic plan of Research and Development on Ultra High-Density Electronics System Integration supported by New Energy and Industrial Technology Development Organization (NEDO).

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