Facet polishing technique for polymer on glass optical waveguide

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A new technique of end facet polishing for polymer on glass optical waveguide is presented. The technique is based on the combination of mechanical and chemical polishing and the process is worked on the grinding and polishing machine. The process starts with the waveguide cutting followed by the facet's grinding. Three sizes of silicon carbide (SiC) were used; 240 grit, 800 grit and 1200 grit. The process ends with the three steps of chemical polishing which is based on diamond paste compound. Based on the said processes, the waveguide samples are shown to produce excellent facets quality when physically inspected under the high power microscope and scanning electron microscope.

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1. Introduction

Optical waveguide can be considered as one of the most important component in the integrated optics as it plays a vital role as light connector. Thus, the major performance of integrated optics is specifically determined by the waveguide quality. Polymer material has been regarded as one of the preferred material in integrated optics due to its significant advantages which include rapid processing and cost-effective [1]. Previously, we have successfully developed a single mode structure of photodefinable based polymer, BenzoCyclobutene (BCB 4024-40) on BK7 glass substrate with thin layer of SiO_2 as cover [2]. In order to characterize the propagation loss for the fabricated optical waveguide, the waveguide's facets need to be smoothly cleaved or polished as this will prevent any reflected light as a result of facet roughness. In larger scale of photonics integrated circuit, these polished facets are needed to provide interface to fiber optics as well as within the circuit as interface to other device components [3]. Due to the molecules structure of both polymer and glass which are not crystalline in nature, the best preparation technique to be applied is polishing instead of facet's cleaving, such as demonstrated by Ibrahim, *et al.* [4].

In this paper, we report on a new facet polishing technique for polymer on glass optical waveguide. The technique comprises of three important steps which are samples cutting, mechanical grinding and chemical polishing. Although the combination of mechanical grinding and chemical polishing in dielectric surface treatment has been revealed in high voltage application [5], the presented technique in this paper is considered new for optical waveguide application. From our reading, it is found out that there is no specific literature discussing on this specific issue of waveguide facet treatment, particularly for polymer on glass waveguide structure. Hence, the motivation of this paper is to visualize the possibility of combining mechanical grinding and chemical polishing in optical waveguide facet treatment and it can be further investigated for future improvement.

2. Facet polishing technique

The developed polishing technique of BCB 4024-40 waveguide's facet requires careful and skilful handling as the polymer and glass materials are of different hardness. This technique is a combination of mechanical and chemical polishing and maneuvered on the standard grinding and polishing machine.

The process starts with waveguide cutting using the diamond cutter. The purpose of this waveguide cutting is to ensure the waveguide length is about the needed size. Following that, a waveguide facet grinding is next where three sizes of silicon carbide (SiC) abrasive paper were used in this process namely, 240 grit, 800 grit and 1200 grit. The purpose of this waveguide grinding is to ensure that the facet is uniformly planarized. Prior to grinding, the abrasive paper was stuck on a rotating plate and the sample was held in a position against the direction of moving plate. During grinding, the sample was consistently flushed with water and air was blown from time to time over the grinded area in order to keep the sample clean and minimize any crack to the waveguide structure. Due to different hardness of waveguide material; polymer and glass, the held sample need to be initially grinded at approximate 45^0 of holding angle before slowly rotated to 90^0. This technique is shown in Fig. 1. The purpose of having this initial grinding angle is to prevent any occurrence of stripped polymer. The sample was first grinded with abrasive paper size of 240 grit, followed by 800 grit and 1200 grit, subsequently.

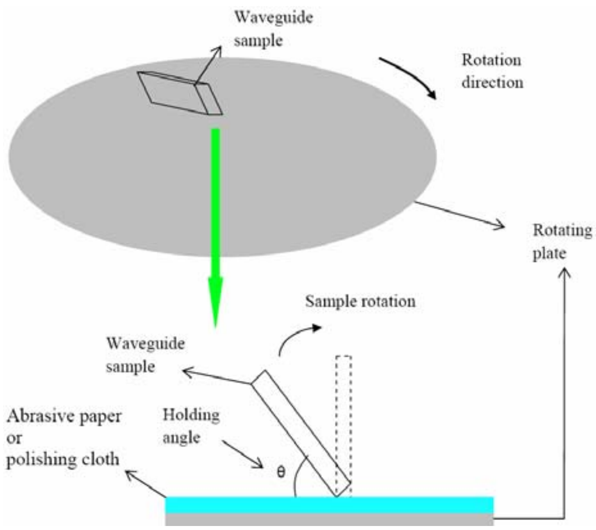
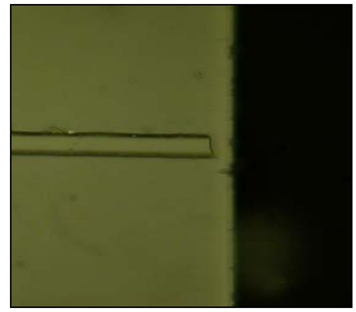


Fig. 1. Sample's position during grinding and polishing stages.

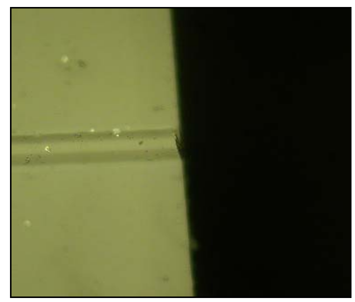
After grinding, a chemical polishing took place where three sizes of diamond compound syringe or diamond paste were used; 15 µm, 6 µm and 1 µm. During the facet polishing stage, a diamond paste was dispensed on the wet polishing cloth which was mounted on a rotating plate. Again, the sample was held in a position against the direction of moving plate and water was flushed from time to time over the polishing cloth to keep it wet. Note that the polishing technique used is according to the developed grinding technique, previously mentioned in this paper. The sample was first polished with biggest size of 15 µm, followed by 6 µm and 1 µm. Finally, the sample was flushed with small amount of water followed by air blowing to dry it.

3. Results and discussion

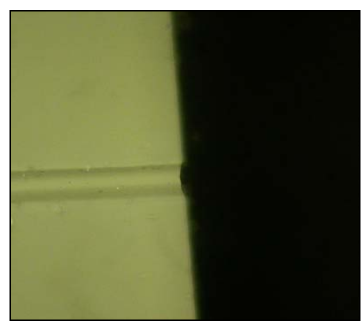
In order to inspect for the polishing quality, the sample was frequently observed under high power microscope (HPM). For clarity, the difference of facet condition during these crucial stages as observed under HPM is shown in Fig. 2. Fig. 2(a) shows the facet condition after the cutting process while Fig. 2(b) and Fig. 2(c) depict the results of facet grinding and polishing, respectively. It was visually observed that the facet quality was significantly improved at the end of the polishing stage.



(a)



(b)



(c)

Fig. 2. Facet condition: (a) cut; (b) grinded; (c) polished.

In order to investigate the facet uniformity, the scanning electron microscope (SEM) is used. The captured figure is shown in Fig. 3 which clearly exhibits smooth polished end facet of the fabricated waveguide.

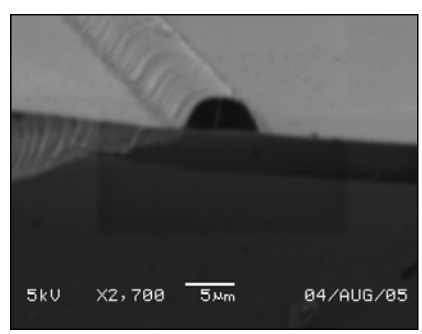


Fig. 3. Facet condition under SEM observation.

Evidently, this shows that the proposed combination of mechanical grinding and chemical polishing in polymer on glass waveguide's facet treatment is suitable and this can be further investigated for future improvement.

4. Conclusions

A new facet polishing technique that caters for polymer on glass optical waveguide structure has been demonstrated. The technique is based on the combination of mechanical grinding and chemical polishing phases in which suitable size of grit paper and diamond paste have been employed throughout the process. It is observed that by precautious handling of the waveguide in terms of initial and subsequent rotation angle, sample's position, systematic usage of grit paper/ diamond paste and consistent flushing of water, excellent quality of waveguide facet can then be realized. Evidently, this shows that the proposed technique is suitable for practical implementation and yet, it is able for future improvement.

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