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Replication of Multimode Polymer Optical Waveguides from Flexible Film Stamps

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Abstract

A low cost replication method of multimode polymer optical waveguides using flexible film stamps is presented, which achieved a low propagation loss of 0.06 dB/cm. Mirrors and ridge waveguides are simultaneously replicated with high fidelity.

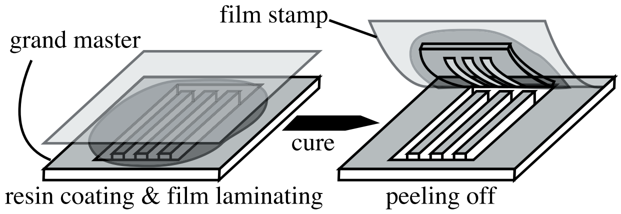

Fig.1 Fabrication of the film stamp

1. Introduction

As the bandwidth of data transmission soars in high-end routers, servers and mobile phones, optical interconnections is getting attractive aiming at the replacement of metal wiring. A flexible polymer optical waveguide film can be applied to it as an optical flexible circuit sheet as long as the fabrication cost is enough low. Therefore, some simple replication methods have been studied elsewhere[1,2].

This paper reports on a new replication method using a flexible film stamp, namely, the flexible stamping method, which has several features that previous methods do not have, and also reports on the fabricated waveguides.

2. Flexible stamping method

2.1 Replication

Figure 1 illustrates the flexible stamping method. First, a grand master is prepared by engraving designated waveguide patterns on a PMMA plate with a dicing saw or a machining center, so that it is much economical than conventional grand masters. Then, a flexible film stamp is replicated from the master. Next, a liquid resin coats over the grand master, and then a flexible film covers it. After curing the resin, it sticks to the film, which is then peeled off from the master.

The replicating processes from the film stamp to a waveguide are illustrated in Fig.2. Although the

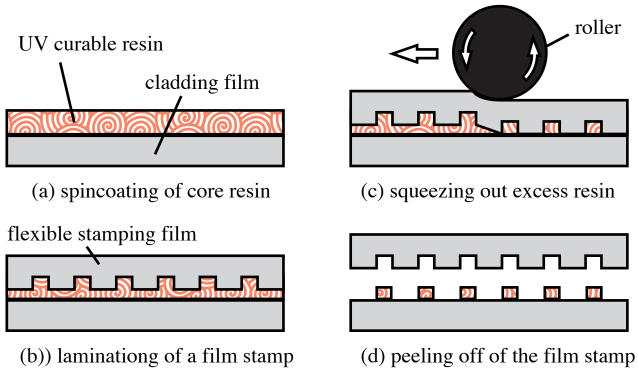

Fig.2 Replication of the waveguides

conventional methods need temporary substrates with hard and flat surfaces such as Si wafer, the cores are directly formed over the cladding films without hard substrate in this method. (a) UV curable epoxy, which will form the core, is coated on the cladding film. (b) Then the film stamp is carefully laminated on it so that they do not include air bubbles. (c) Excess epoxy fluid is squeezed out by pushing a roller. (d) The epoxy is cured and the film stamp is peeled off. Finally the over cladding is formed if necessary.

As long as the ridge waveguides are concerned, it is a remarkable feature that mirrors can be simultaneously formed in this method because the cores are directly replicated on the under-cladding surface.

2.2 Optical properties

Figure 3 is the waveguide length dependence of the insertion loss, where the core size is 50 x 50 μm square and 850 nm laser light is coupled with the waveguide via a mode scrambler and 50 μm core GI fiber. A receiving fiber is 200 μm core PCF.

Its slope gives us the propagation loss as small as 0.06 dB/cm, which is fairly small in spite that the economical mastering and replication processes are employed.

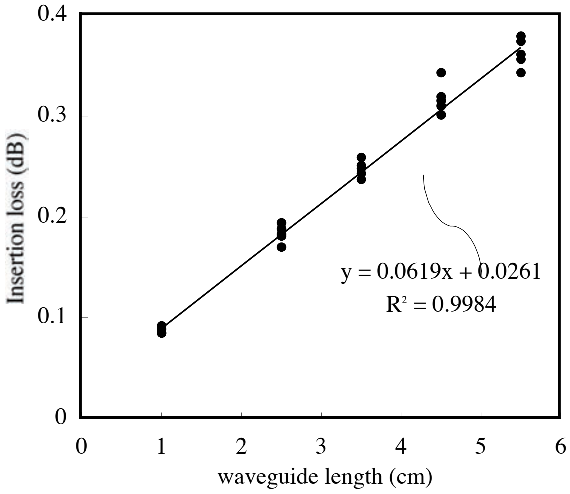

Fig.3 Insertion loss of cutback waveguides

The fidelity of the replication and the removal of the excess core resin are confirmed by Fig. 4. Since the guided wave dissipates by micro-bumps at the core-cladding interface and the residual core resin between over and under claddings, Fig. 4 agrees with the obtained low propagation loss.

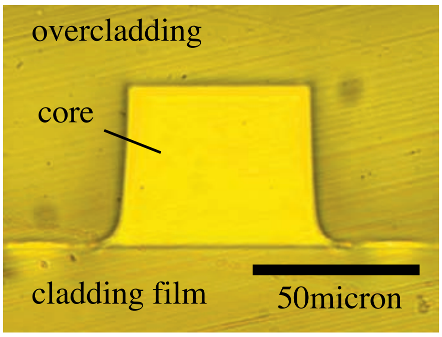

Fig.4 Cross-section of the fabricated waveguide

2.3 Simultaneous mirror fabrication

Figure 5 shows a SEM micrograph of multi-channeled ridge waveguides with 45 degree mirror end faces. The faces of mirrors and the core ceilings are flat. Every corner is very sharp. They are also special features of this method.

2.4 Possibility of wide area waveguide films

It is easy to enlarge a waveguide film because

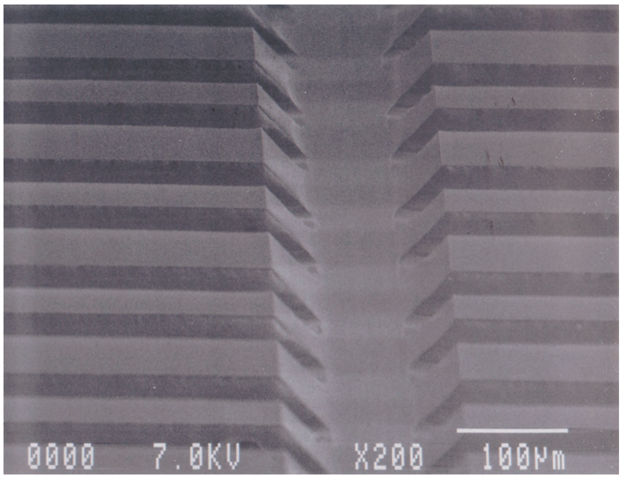

Fig.5 SEM micrograph of mirror-end waveguides

the film stamp is flexible which gives good transfer uniformities in large area. We successfully fabricated an A4 size waveguide film as shown in Fig. 6.

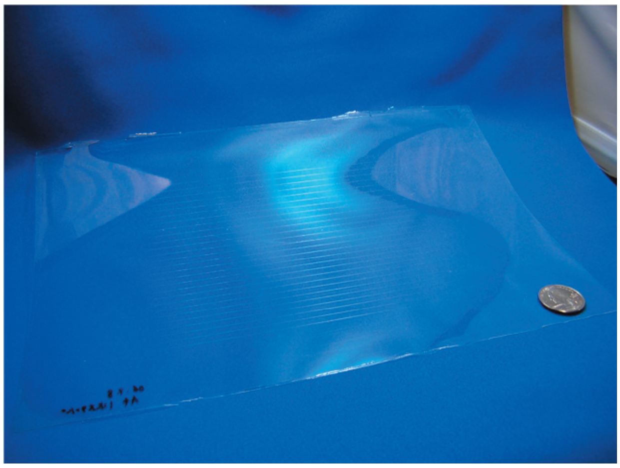

Fig.6 Replicated A4 size waveguide film

3. Conclusion

A low cost replication method of multimode polymer optical waveguide films using flexible film stamps is proposed. The propagation loss of fabricated waveguide film is fairly low of 0.06 dB/cm. This result shows that application to the inter-shelf connection with this waveguide film is in the target scope.

References

1) Sugihara et. al., C-13-7, Gen.Conf. of IEICE2004.

2) Terakawa et. al., C-3-29, Gen.Conf. of IEICE2003.