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Taper Optical Fiber for Distributed Light-driven Soft Robots

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Introduction

We have proposed and demonstrated that the taper fiber-enabled motion of soft robots. A thin film with a high refractive index is encapsulated on the top of the taper fiber as well as soft robot. By controlling power of light along the taper fiber, the soft robot can realize a grasping action. Our results may contribute to the effort of exploring distributed light field to drive soft robots.

Background

Light-driven Soft robots have broad application prospects [1]. Current photo-controlled soft robot using free-space light source requires bulky components, and influenced external environment [2]. Light from the taper fiber end experiences diffraction and is attenuated quickly, which induces a limited working distance [3]. Therefore, a distributed light source from tapered fiber to drive soft robots is worth of investigation

Method

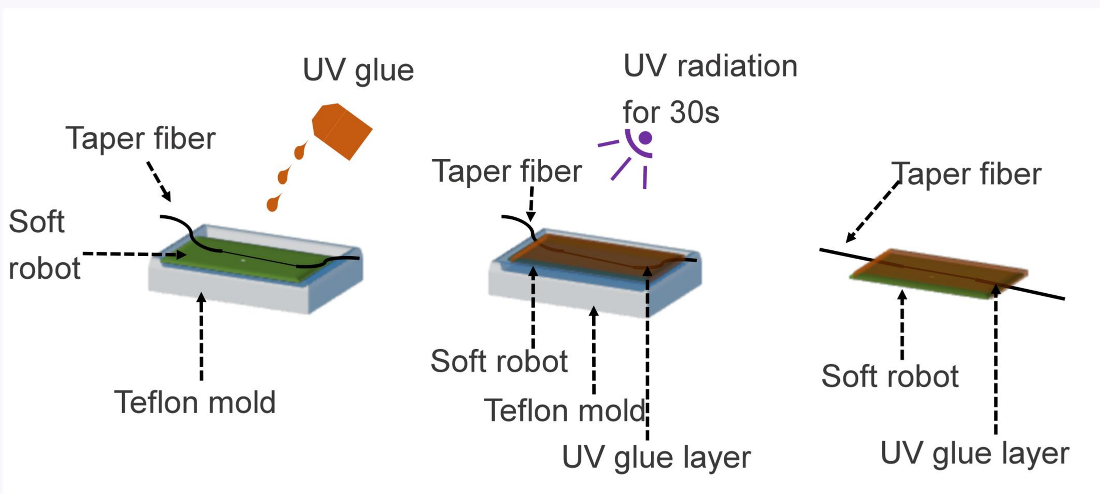

Figure 1. Schematic diagram of making taper fiber driving soft robot

As shown in Fig. 1, We package the liquid crystal elastomer and taper fiber by UV glue adhesive film with a thickness of 1 mm and refraction index of 1.8 in a Teflon mold which is well design for making certain thickness UV glue layer. We put the soft robots into the Teflon mold and put a taper fiber with taper waist around 12-μm on the soft robot and drop the UV glue on the soft robots to form a film, and irradiate it with UV for 30s, then we take the soft robot out of mold. The chosen 12-μm taper waist is due to that the taper fiber is not fragile and also has a large energy leakage. The length of taper region is 5 mm, and the embedded position is in the middle position of the soft robot.

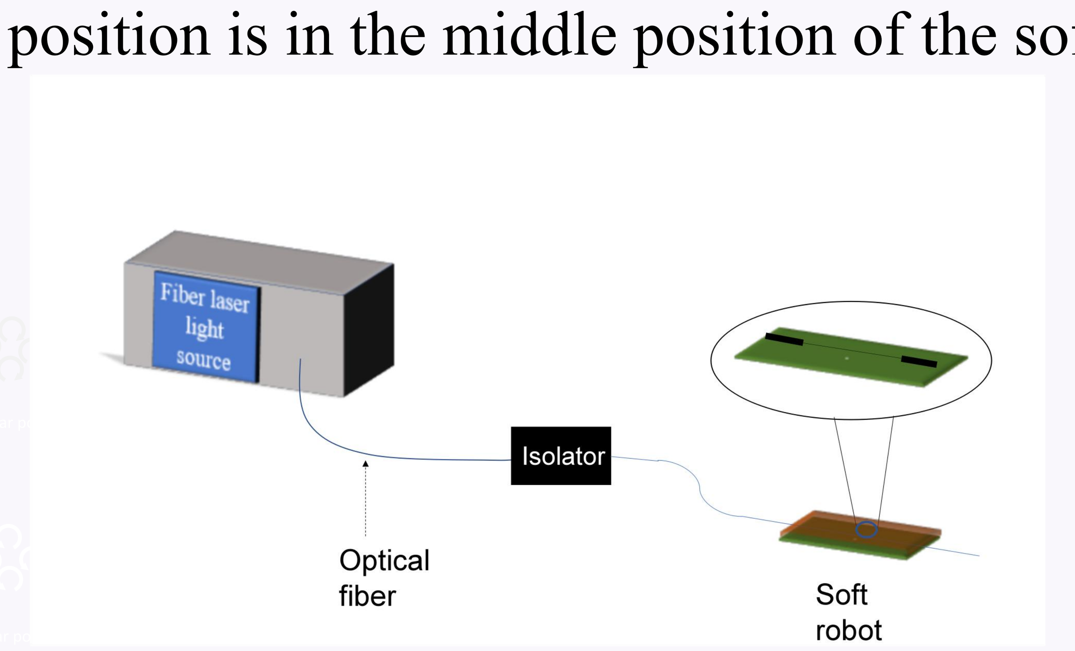

Figure 2. Schematic diagram of optical path of driving soft robot

Optical path of driving soft robot is shown in Fig. 2. The output power of the laser is 350 mW, and the wavelength of laser is 976nm. The soft robot is based on liquid crystal elastomer, with a length of 5 cm, a width of 1 cm and a thickness of 1 mm.

Result

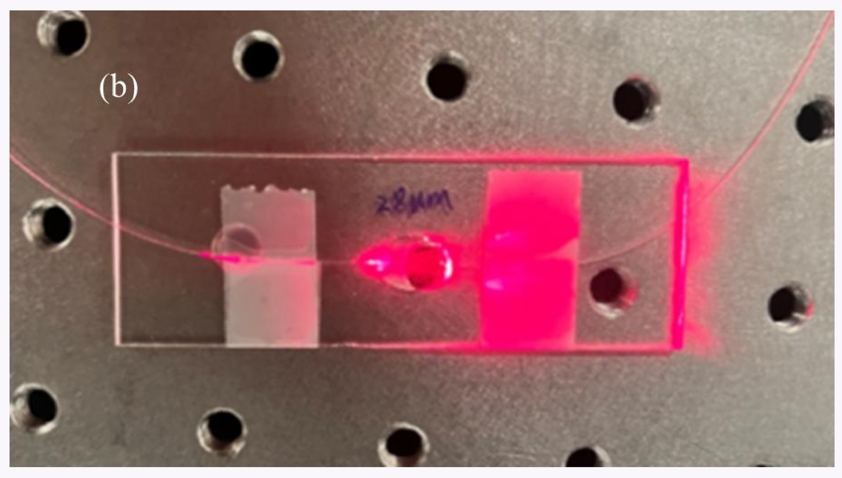

Figure 3. Diagram of taper fiber covered by UV glue

Figure 3 shows that light from a 650 nm laser is launched into a taper fiber coated by a drop of UV glue. We can clear see that the light leak from the taper region and form a divergent beam.

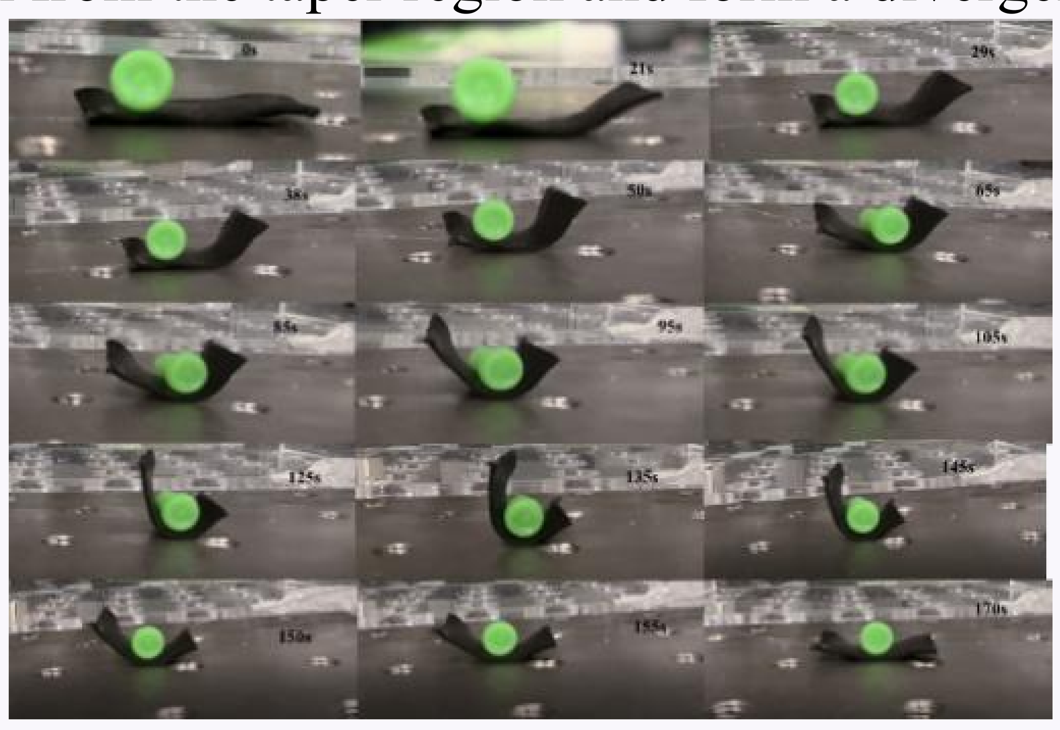

Figure 4. Diagram of taper fiber driving soft robot

As is shown in Fig. 4, the middle part of the soft robot begins to twist, the curved area is the area where the taper fiber is embedded which is proved distributed energy area. And in this case, the soft robot can realize a grasping action. When the laser turns off, the soft robot returns to the origin status.

Conclusion

Contrast to the single light spot driven soft robots, the taper fiber with distributed energy to drive soft robots in this paper have the following advantages:

(1) taper fiber driven soft robot can twist from the middle, causing bending at both sides, which enables taper fiber to realize the grasping action;

(2) taper fiber can achieve a relatively long distance for light-matter interaction, which can be applied in large size soft robots.

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