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Polymer and tapered silica fiber connection for polymer fiber sensor application

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ABSTRACT

A new type of polymer and silica connection is proposed. A tapered SMF-28 silica optical fiber tip is fabricated using a CO_2 laser by focusing and stretching the fiber. The tapered silica tip is inserted in one of the holes of a microstructured polymer optical fiber using a 3D alignment system. Using a supercontinuum source, the spectrum is observed after one and after two connections. The polymer fiber is characterized in curvature while using the previous connection.

Keywords: Microstructured polymer optical fiber, silica fiber taper, polymer to silica fiber connections, curvature sensor.

1. INTRODUCTION

Polymer optical fibers (POFs) have shown interesting results in the field of optical sensors[1–4]. The elastic properties of these fibers[5] allow different applications where standard silica fibers cannot be applied.

To work with POF different methods are required. Commercial cutting machines do not cut the fiber properly and regular connections such as splicing and commercial connectors do not work. Instead, the use of a hot blade[1] to cut the fiber is required and precise manual alignment is needed to couple the light into and out of the POF. This alignment is performed by using a 3D translation platform and matching gel[6] or by focusing the light using lenses[7]. Microstructured polymer optical fibers (MPOFs) not always have their core centered, increasing the difficulty of the alignment.

Silica fiber tapers can be obtained by decreasing the diameter of a standard silica fiber and they can either be in-line tapers or tapered tips. Methods of fabrication include stretching and heating the fiber using, for example, a focused CO_2 laser[8], or etching[9–12].

In this work, a connection between an MPOF and tapered silica fiber is presented, including a curvature test to determine the viability of this connection for characterizing sensors.

2. EXPERIMENT

2.1 Tapered tips

The MPOF used in this experiment had their core surrounded by a hexagonal shaped array of holes (Figure 1). The MPOF was fabricated in Maria Curie Sklodowska University. The diameter of the holes was of the order of a few micrometers. In order to fit a silica fiber into the holes of an MPOF, the diameter of the fiber had to be decreased.

By creating a taper, it is possible to obtain a tapered tip. Most tips were made using a CO_2 laser technique (Figure 2), but some made by etching[9–12] were tested as well. A CO_2 laser was focused on the silica fiber while the fiber was being

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stretched with programmed moving platforms. The process decreased the diameter of the fiber forming a taper and eventually breaking it, creating a tapered tip.

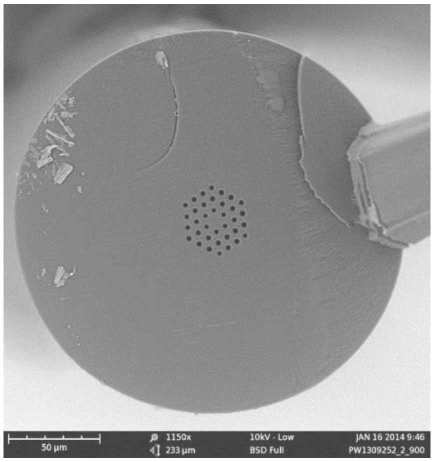

Figure 1. Electron microscope picture of an MPOF.

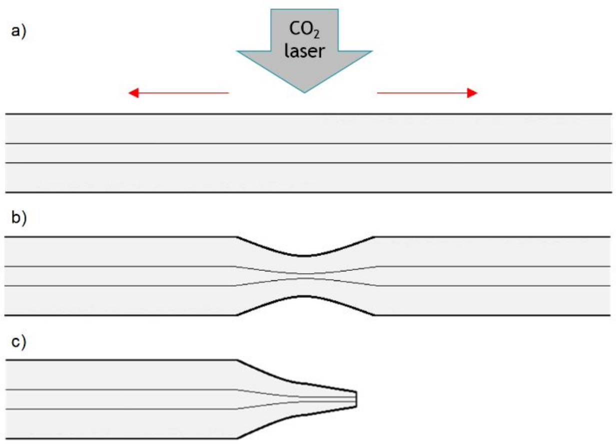

Figure 2. a) CO_2 laser focused on the fiber while the fiber is being stretched, b) Taper starts to form, c) Tapered tip.

2.2 Connections

Figure 3 presents the connection process. Splicing machines were used to make the connections, their electrodes were removed to avoid evaporating the MPOF with an electric arc. With a very rough aim at the middle of the fiber, the tapered tip was inserted into the MPOF creating the connection.

The test included a single connection (Figure 4 a)) and double connections (Figure 4 b)), where the first was from silica to polymer fiber and the second from polymer to silica fiber. The first tests were made using a He-Ne laser as a light source and both tests had light output (Figure 5).

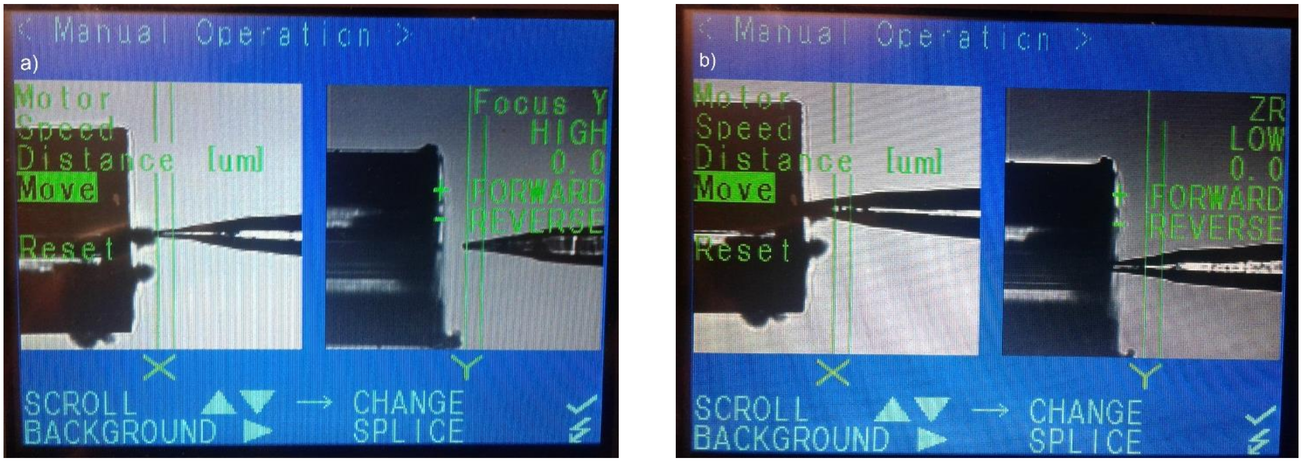

Figure 3. a) Process before and b) after the connection in a splicing machine.

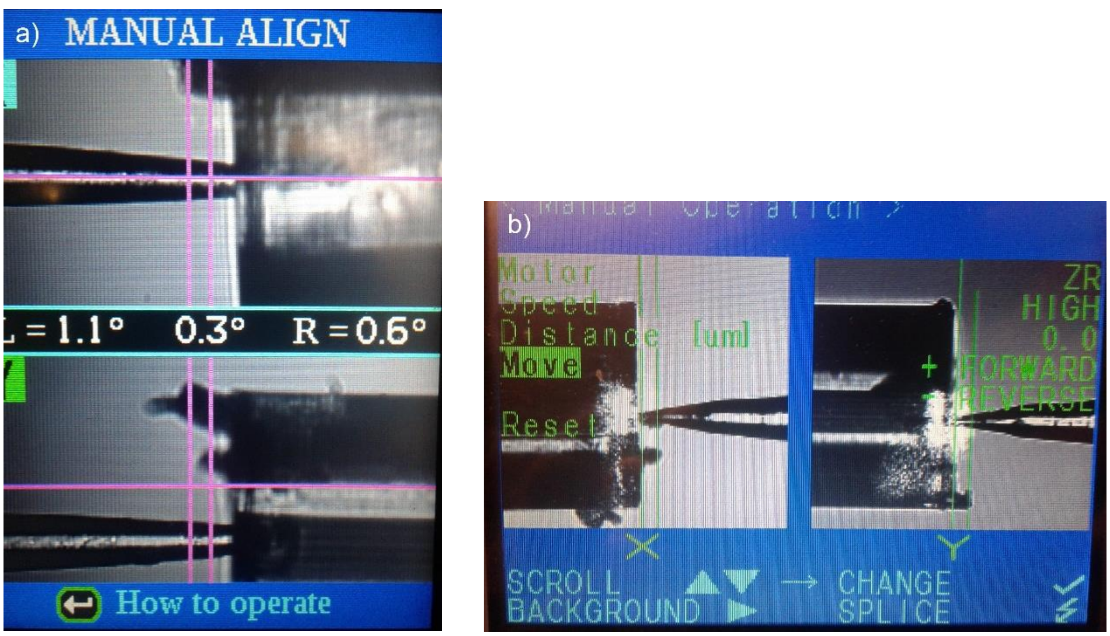

Figure 4. a) Silica to polymer fiber connection, b) Polymer to silica connection.

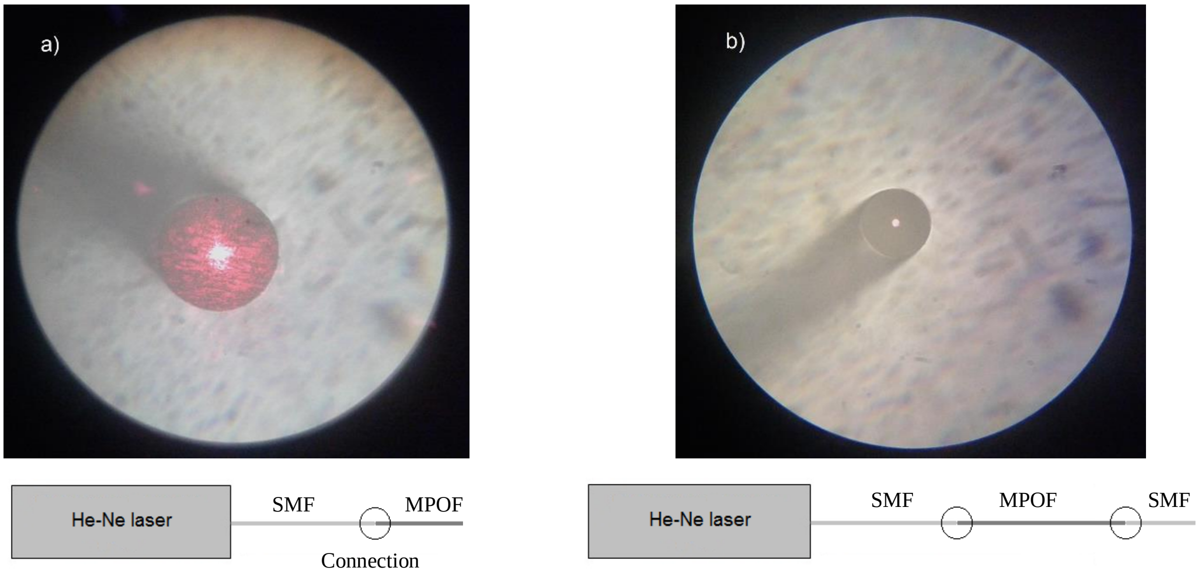

Figure 5. a) Microscope image of the MPOF output after one connection and b) after two connections using a He-Ne laser as a light source, and their respective setups.

The light source was then changed to a supercontinuum to obtain the spectral behavior of the connections. The spectra of the setups were acquired using an Optical Spectrum Analyzer (OSA) (Figure 6). The MPOF was connected to the OSA with a commercial connector that allowed enough precision to insert light into the OSA.

In Figure 7, it is shown the face of the fiber before and after a connection is made. The tapered tip pierces several holes and allows light to be transmitted from one fiber to the other without aiming into the core.

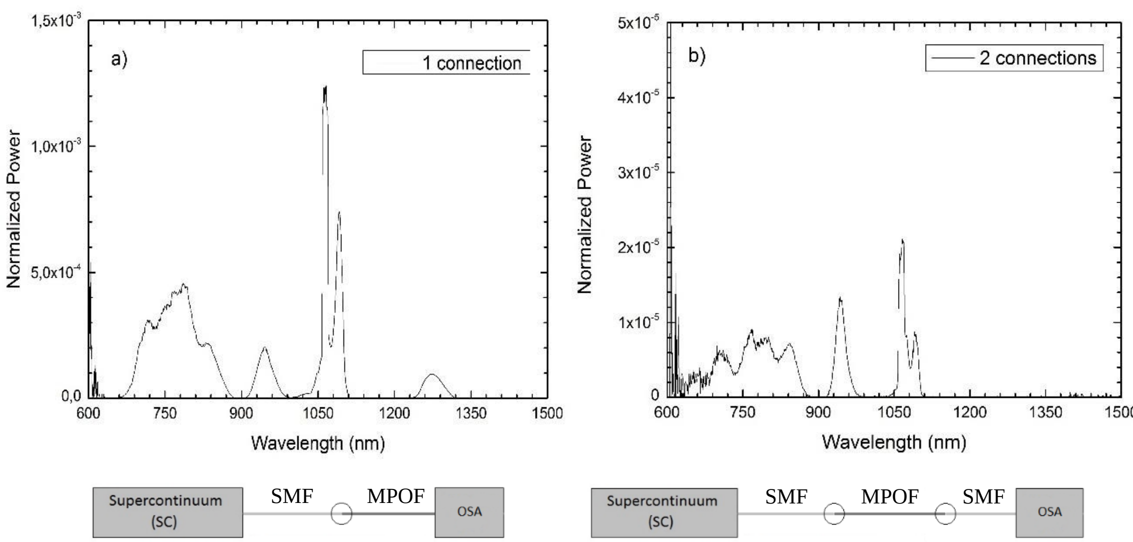

Figure 6. a) Spectra after one connection and b) after two connections using a supercontinuum as light source and monitoring the transmission signal with an OSA.

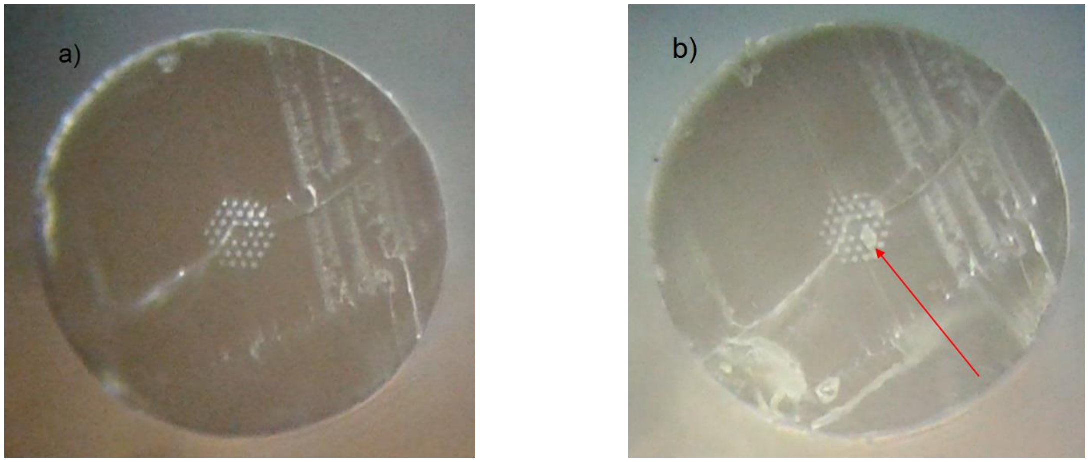

Figure 7. a) Face of the MPOF before the connection, b) Face of the MPOF after the connection.

3. CURVATURE SENSOR

Using a single connection, a curvature test was made in the polymer fiber. Figure 8 presents the setup used in the characterization. A knot was made with a diameter *d* and the spectra were acquired using an OSA.

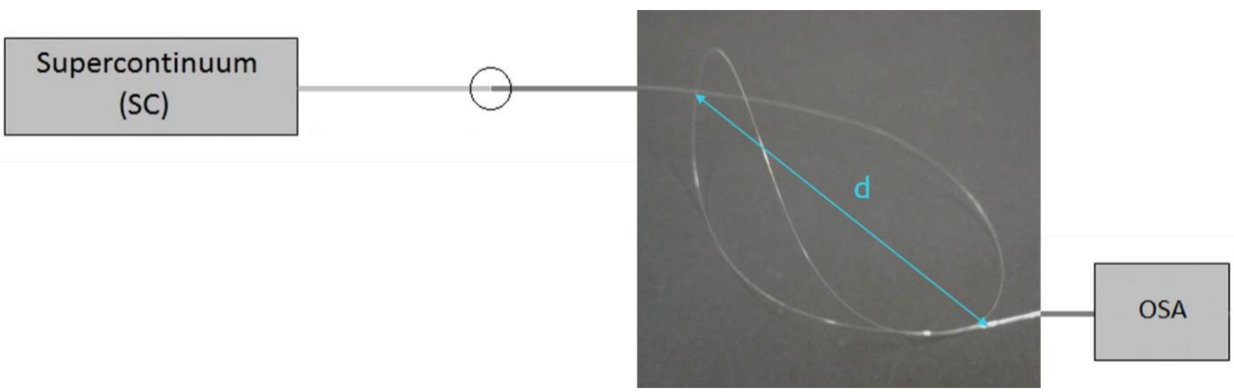

Figure 8. Experimental setup for curvature characterization.

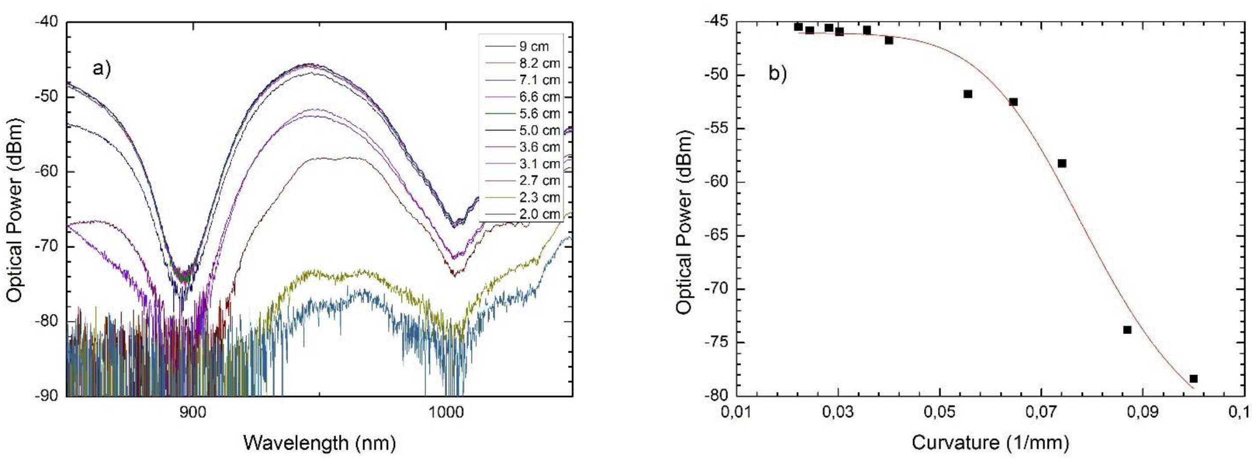

Figure 9. a) Spectra variation with the decreasing diameter of the knot (the signal drops with the decreasing diameter), b) Peak power variation with curvature.

Figure 9 a) presents the spectra centered in 950 nm. The power of the transmitted signal drops as the diameter decreases. By tracking the power of the maximum, the sensor was characterized in curvature proving that the connection allows for sensor characterization.

4. CONCLUSION AND FUTURE WORK

In this experiment, a new fiber connection is shown. The insertion of a tapered silica fiber tip into the holes of an MPOF allowed light transmission from one fiber to another without the need of a very precise alignment. This connection proved to work in both directions. A curvature characterization of the polymer fiber was made using a single fiber connection, showing that the connection allows sensor characterization.

Future work can be done to improve the losses of the connection. A study on the geometry of the tapered tip might lead to better results. Also, the connection itself can be study as a possible sensor.

ACKNOWLEDGMENTS

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