Experiment 6:

Preparing and inspecting Optical fibers

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Abstract

Contents

1 Experiments

1.1 Fiber Preparation

Task:

Remove 1-1/2 inches of fiber jacket from a 30 cm segment of F-MLD (100/140 µm) fiber, by dipping the fiber end in sulfuric acid and letting it soak for $\tilde{3}$ minutes. You could use a single-edge razor blade held at a low angle to do the stripping of the fiber jacket. This requires some practice, but goes much faster once you are used to it. Also, you could use the fiber coating stripper to remove the jacket. This will be the preferred method for the rest of the semester. But it is important that you become familiar and skilled with different methods of removing the fiber buffer coating. Therefore, you need to use the three methods mentioned above. Finally, clean the bare fiber surface with tissue paper dampened with alcohol.

Task:

Use the F-CLl Fiber Cleaver to cleave the stripped end of the fiber. The cleaver should be placed on the top of the table with the blade pointing up. Draw the fiber over the blade with a light motion. Be sure that the fiber is normal to the blade. You should not attempt to cut the fiber with the cleaver. You are only starting a small nick which will propagate through the fiber when you pull it. Gently, but firmly, pull the fiber to cleave it.

Another way

Tape the exposed fiber end onto a flat surface and apply tension by pulling on the fiber. While the fiber is still under tension, nick it with the cleaver gently and perpendicularly to the fiber axis. Do not saw back and forth or allow the fiber to rotate. The purpose is to scribe the fiber without breaking it in one single smooth stroke. Then, pull straight on the fiber with more tension until it snaps at the cleavage point. Now, examine the fiber end with a microscope or a magnifier. ***NOTE: The F-CL1 (Hand-held) Fiber Cleaver is highly dependent on your skill.***

The method used for cleaving was using the stripper method. An apparatus was used to remove the plastic coating that the provided fiber had, so as to be able to use it experimentally. After that, an alcohol cloth was used to ensure that all the small bits of plastic remaining were no longer stuck to the fiber.

The exterior coloring was removed with the use of a razor blade and tensing the fiber against the blade.

To ensure a good cleave, the F-CL1 apparatus was used, ensuring that no bits of glass were remaining on the machine or on the floor, so as to prevent any accident that this spare glass could provoke

Task:

Check the quality of the cleave by examining it under a high-power microscope. Carefully examine the end face of the fiber. The end face should appear flat and should be free of defects. However, chips or cracks which appear near the periphery of the fiber are acceptable if they do not extend into the central region of the fiber. Some good and poorly cleaved fiber ends are illustrated below. The problems associated with the poor cleaves are discussed in Step 4.

Task:

If the inspection of the fiber end face in Step 3 does not show that the end face has been properly cleaved, you should consider the following common sources of error: There are two principal reasons for obtaining a bad cleave.

a. poor scribe

b. non-uniform pull of the fiber

A scribe which is too deep may cause an irregular cleave and may cause multiple cracks to propagate through the fiber (as shown above). A scribe which is too shallow will be the same as no scribe at all and the fiber will break randomly.

If the pull which propagates the crack through the fiber is not uniform, and especially if it includes twisting of the fiber, irregularities may show up on the fiber end face or a lip may be formed on the end of the fiber, as shown above.

If the fiber end is cleaved at an angle, the fiber was probably scribed at an angle other than 90° across the fiber axis, although this, too, can be caused by a non-uniform pull of the fiber

On this picture we can see how the light is leaking before the end of the fiber. For this picture, the light of the microscope was removed, and a flashlight was aimed at the other end of the fiber. After focusing properly the microscope, we can see how the light leaks. This is due to the fiber being broken at that point probably at the stage of cleaving.

Another way of ruining a fiber end is just by having a bad procedure and not cutting the fiber cleanly. This leads to a similar issue at which the light shined at one end can be seen from angles that shouldn't be possible at the other end. On the bottom photo there is some glass debris on the end that ruins the cleavage.

Task:

Once you have a fiber segment with two well-cleaved ends, you may look at the geometry of the fiber, as it was described in the introduction. View a fiber end as you did in Step 3. Use an incandescent lamp or fluorescent light to illuminate the far end of the fiber. You will be able to see the light shining through the central portion of the fiber. This is the fiber core. The region surrounding the core is the fiber cladding. You will not be able to see the fiber jacket, because you have stripped that away from the end of the fiber.

With a proper cleave, when light shines from one end of the fiber, the other end only emits light perpendicular to the fiber end. However, with a poor cleave, light leaks from the irregular surface of the fiber end and light can be observed when looking at wider angles.

1.2 Fiber Examination Using the Microscope

Task:
Place the fiber in the Fiber chuck then loaded to the fiber positioner

Task:
Adjust the height of the fiber until you see a clear image while at $10X$ magnification. Increase the magnification to $60X$ and get a clear image. Then use the $200X$ to obtain the largest image.

Task:
Examine the quality of the cleave by rotating the fiber so you can see the different sides.

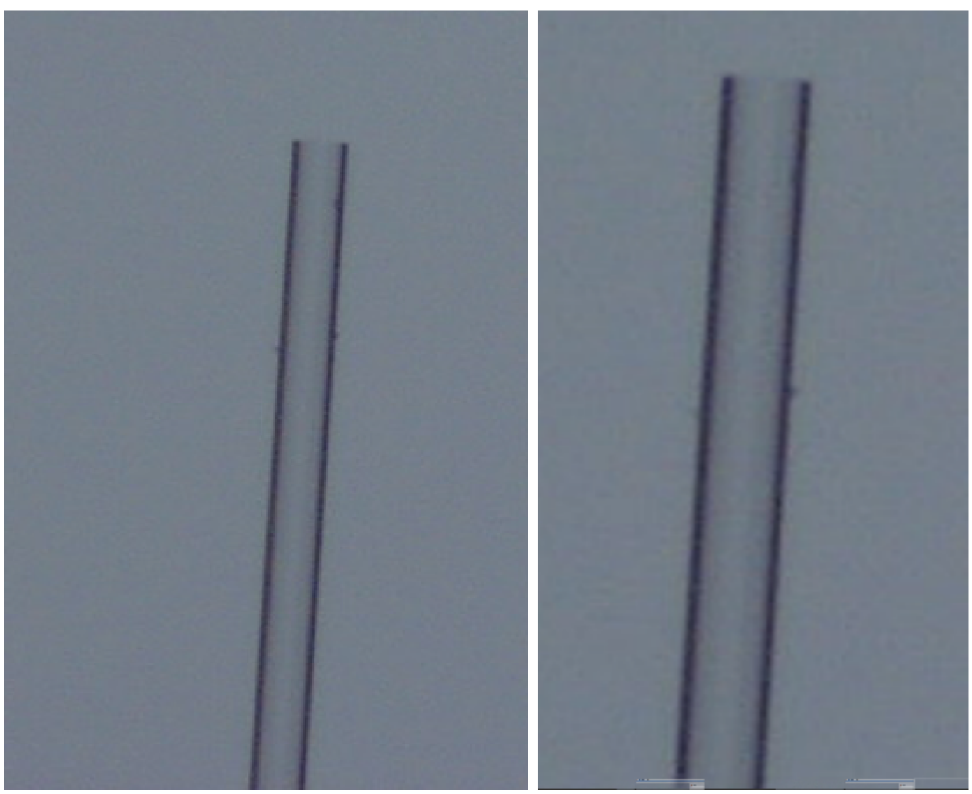
Rotation made some defects that were not visible at first glance appear. This ensured that the cleavage was done properly and that there were no leakages or plastic debris on the fiber.

Task:
Use a flashlight or any reasonable source of light to help you determine whether the cleave is flat or not. ***How?***

Again, the precedent was ensuring that no light leakages appeared on the fiber end or body.

Task:
Obtain several images of the fiber for different sides and include them in your report

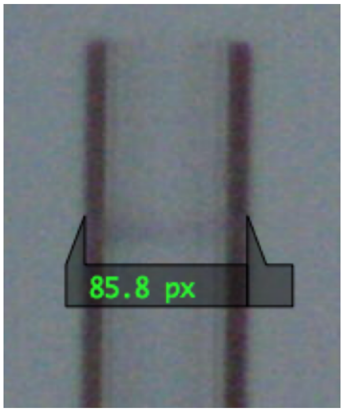
The bottom light of the microscope was used so as to illuminate evenly all the surface of the fiber. We can see how the cleave was quite good as very few amounts of plastic can be seen on the surface of the fiber, and the end does not show any light although it is being lit on the other end.



1.3 Fiber Diameter Using Translation Stage and the Microscope

Task:

While you have a clear image at the $200X$ use one of the markers on the computer screen as a reference. Use the micrometer on the translational stage to determine the diameter of the fiber before and after stripping. Report you results with diagrams.



The microscope was set to its maximum augment (200X) and by calibrating the microscope computer program with a known measure object (a clip), we could measure electronically the width of our fiber. To do so, proper vertical alignment of the fiber was needed as the computer tool only allowed measurements on fixed axis.

The clip was measured with a vernier and the measurement was of 0.62 mm or 444.5 px. This means that the fiber was 85.8 $px = 121.2\mu m$.

1.4 Fiber Diameter Using Diffraction

Task:

Determine the width of the Fiber with and without the Jacket. Tape the fiber across the front of the laser beam. From the diffraction pattern calculate the diameter of the fiber. You may need to place a stop at the center of the pattern to block the bright central spot and make the secondary ones clearly visible. The Diameter of the fiber D is relater to the wavelength of the laser by

$$\frac{D}{4}\sin(\theta) = m\lambda \qquad \text{for the } m^{\text{th}} \text{ minimum}$$

Find D using at least 4 different values of m.

The fiber was illuminated wit a He-Ne laser and the pattern of diffraction was observed in the far field. By using the small angle approximation, we can approximate the sine function with the tangent. By doing so we get:

$$\frac{Dx_m}{4L} = m\lambda \Longleftrightarrow \boxed{D = \frac{4Lm\lambda}{x_m}}$$

L is the measured distance of 157.5 cm, and x_m is the distance from the center to the minimums. After getting an average from the five datapoints that were taken, we found a value of $D = 133.2 \pm 9.3\ \mu m$. The specific datapoints can be found on the python script in the addenda.

Task:

Compare your results for the diameter with that of the manufacturer. Find the percent error. Determine the uncertainty in the fiber diameter using your data. Express you result for the diameter on the following form $D = \overline{D} \pm \Delta D$ where $\overline{D}$ is the average diameter and ΔD is the uncertainty in D. Compare you results to those of the previous method. Discuss any discrepancies. Which one of the methods is more accurate and why?

Comparing to the previous method we got a difference of 13.2 μm, which I think is quite good as the claim from the manufacturer is 120 μm, which is the same as the microscope method. The error on the second method is greater because of the eyeballing when measuring the distances, which were made with a ruler. Human error is greater in this method and that shows in the results. The error for the microscope method was of 1% whereas the error on the diffraction method was of 11%.

2 Addenda

LaTeX code that generates this document

PHOTONICS-LabRep6:fibers.tex

Python code that generates the plots and contains the data

PHOT-E6.py