

# Etching Fiber Optics

## From Bwiki

This page describes in detail the method for producing chemically sharpened fiber optic implants as used in Hanks and Kopec et al. Nature 2015. Questions about this protocol can be directed to Charles Kopec ( [http://brodywiki.princeton.edu/wiki/index.php/Charles\\_Kopec](http://brodywiki.princeton.edu/wiki/index.php/Charles_Kopec) ). Please cite Hanks and Kopec et al. if you use this method in your work:

Hanks TD, Kopec CD, Brunton BW, Duan CA, Erlich JC, Brody CD. Distinct relationships of parietal and prefrontal cortices to evidence accumulation. Nature. 2015 Apr 9;520(7546):220-3

## Fiber Preparation

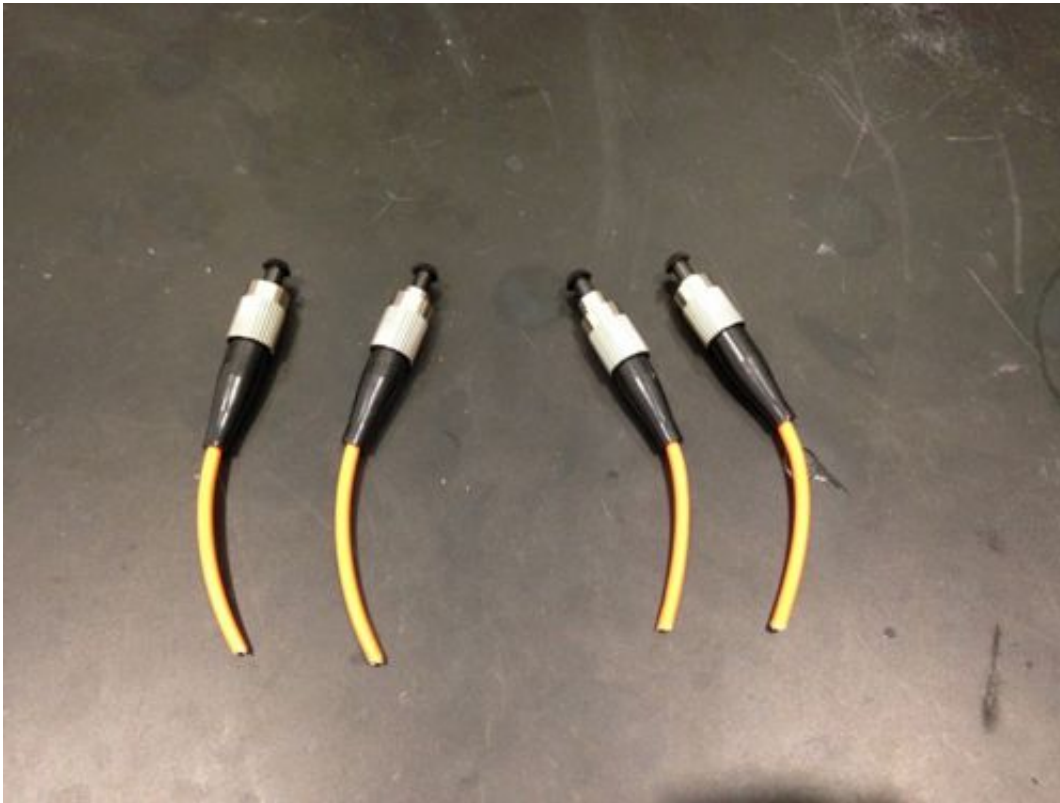
**For plastic LC fibers see note at the end of this page.**

[http://brodywiki.princeton.edu/wiki/index.php/Etching\\_Fiber\\_Optics#Plastic\\_LC\\_Connectors](http://brodywiki.princeton.edu/wiki/index.php/Etching_Fiber_Optics#Plastic_LC_Connectors)

- Begin with a 1m FC-FC duplex fiber (50um core, 125um cladding) from fibercables.com (item #FCC2433).



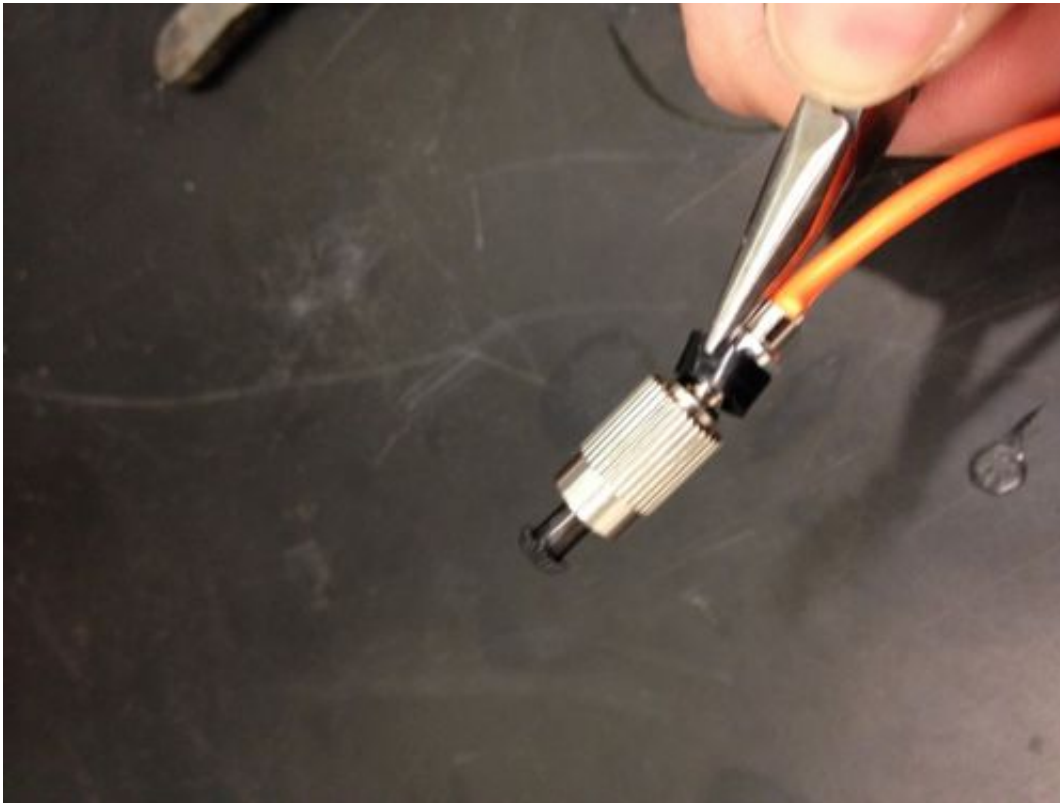
- Cut the four ends off.



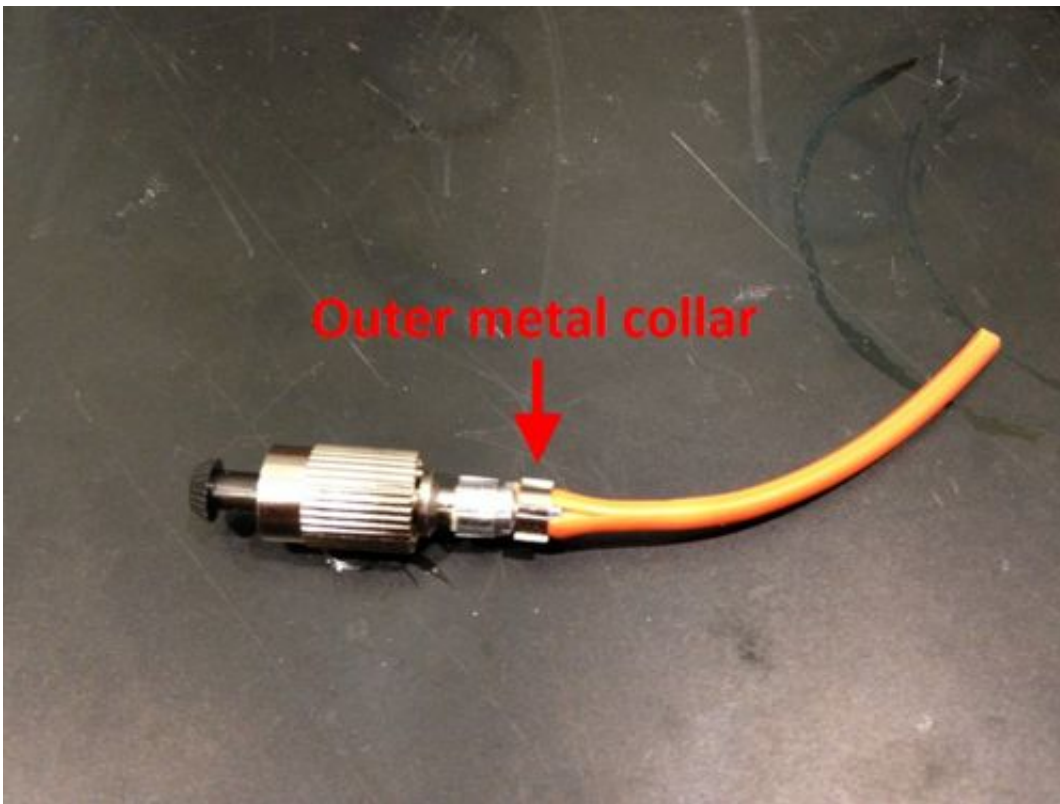
- Make a cut in the outer plastic collar and remove it.



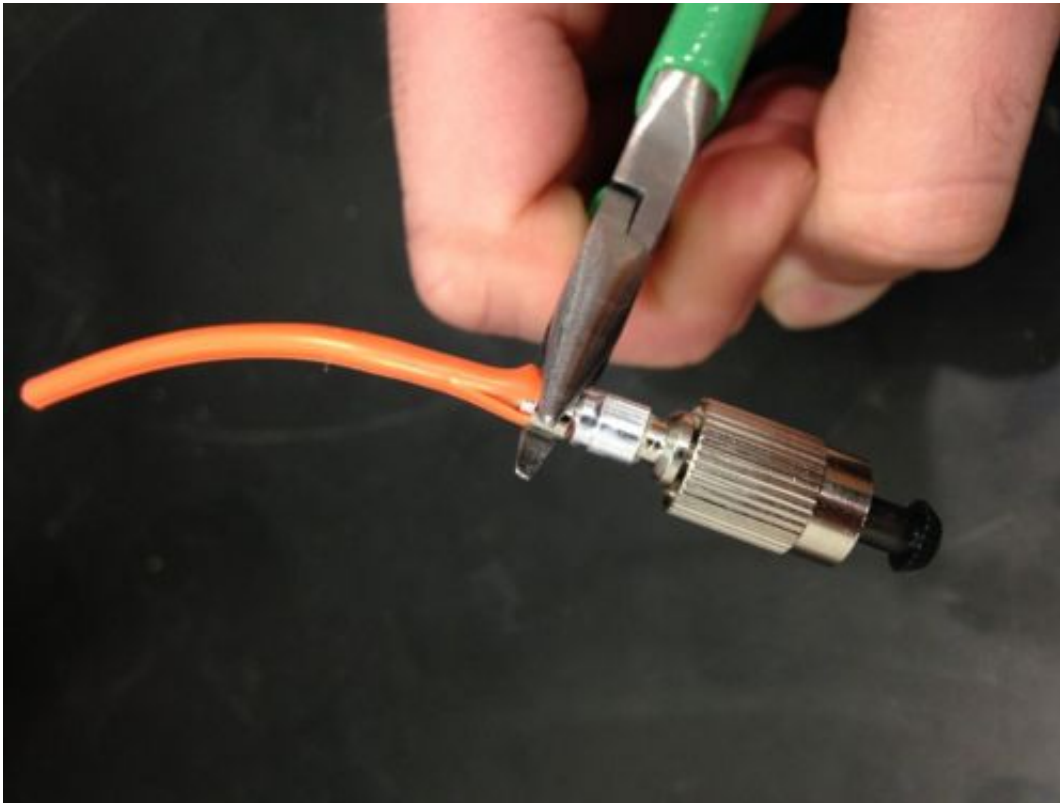
- With a pair of pliers remove the remainder of the plastic collar.



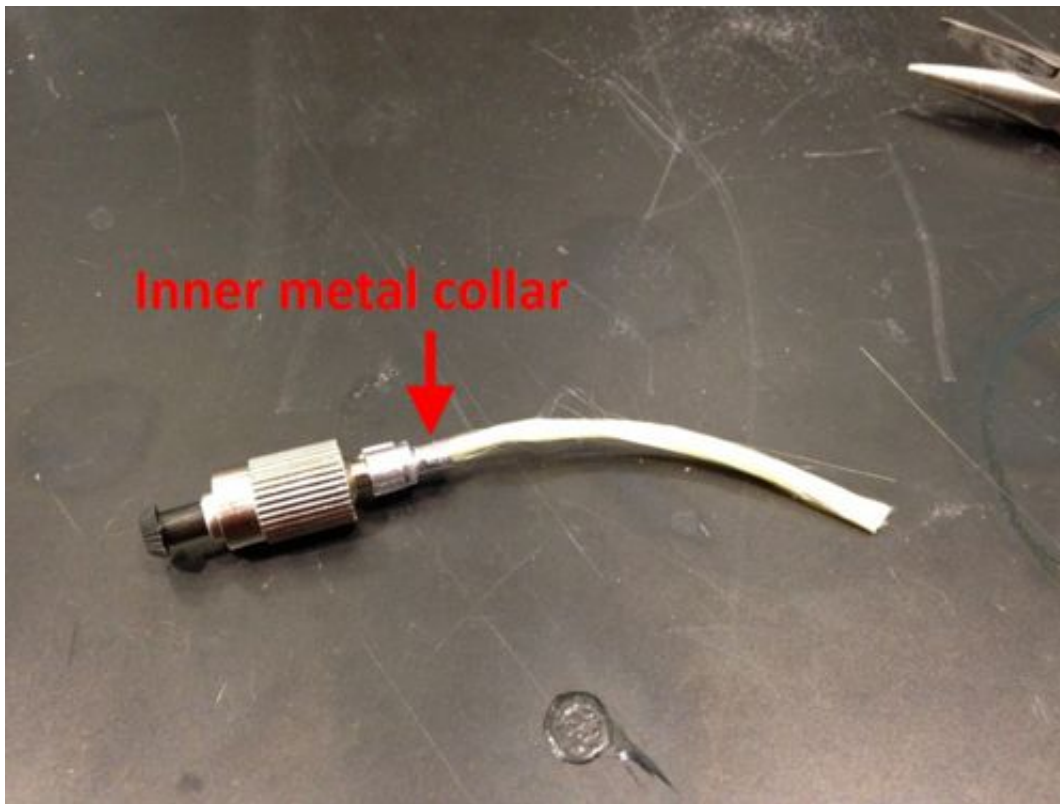
- The outer metal collar holds the orange outer plastic jacket in place.



- Remove it by gently squeezing it with pliers until it deforms slightly from circular. Then rotate 90 degrees and bend it back to circular. Repeat this process until the metal fatigues and breaks off.

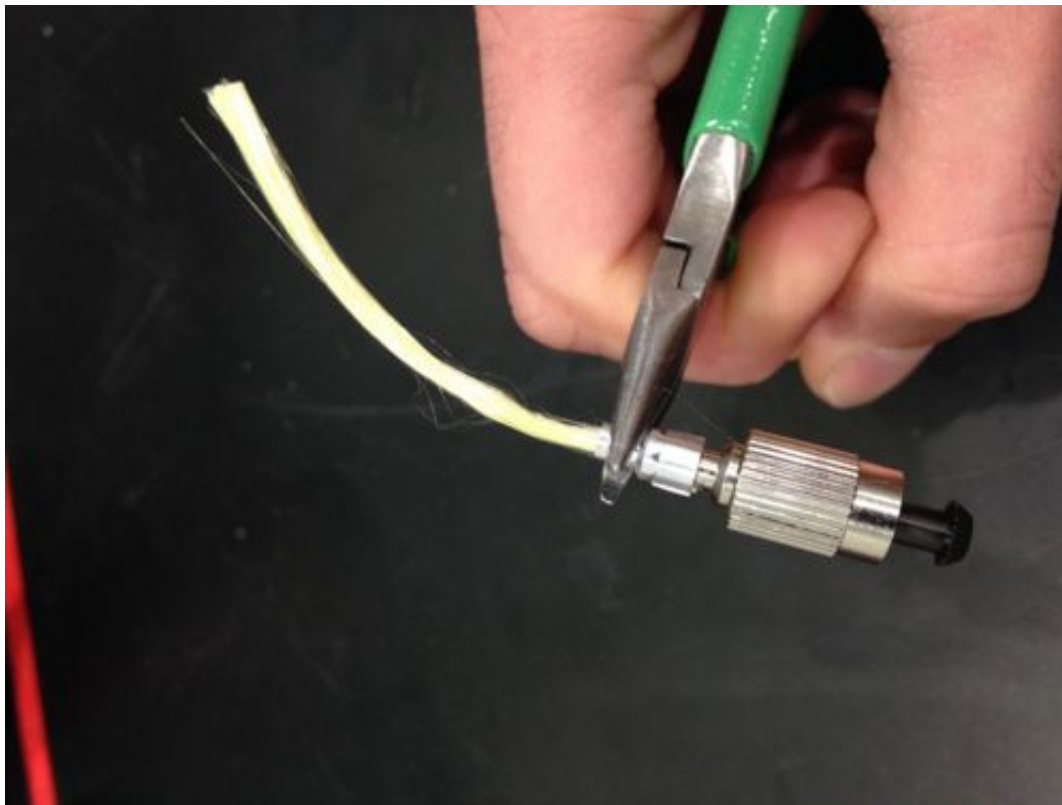


- Some fiber optics have an inner metal collar

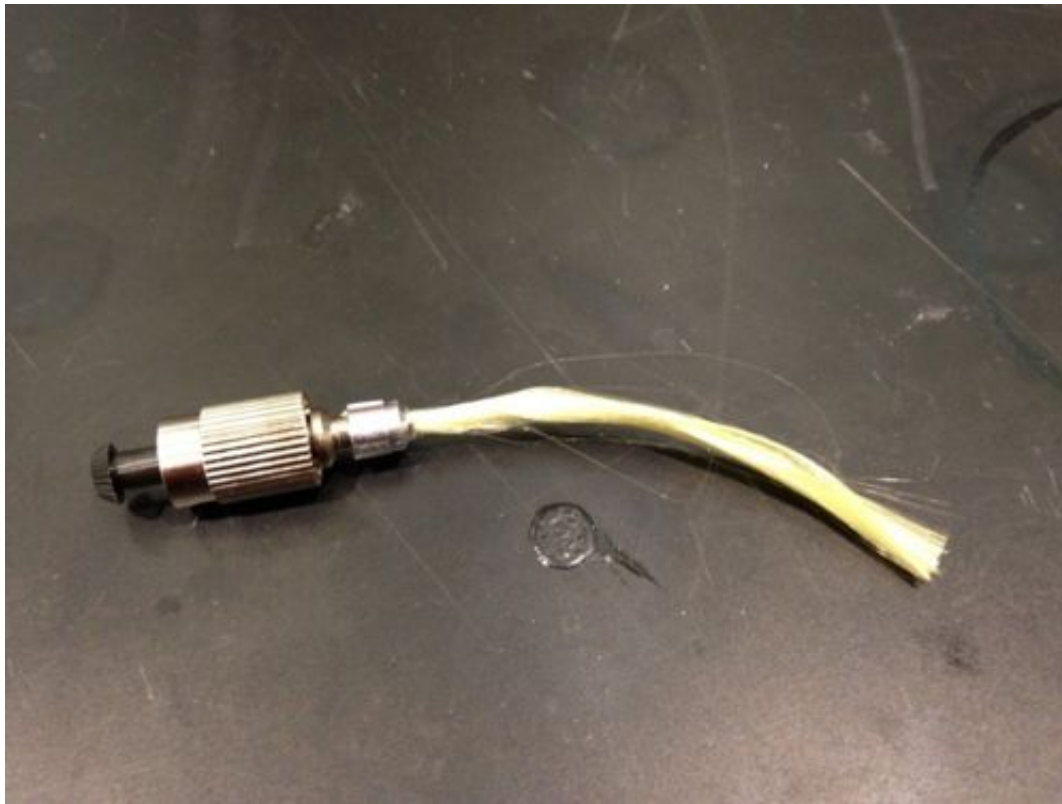


- Remove it the same way you did the outer metal collar by gently squeezing the metal until it fatigues and breaks.

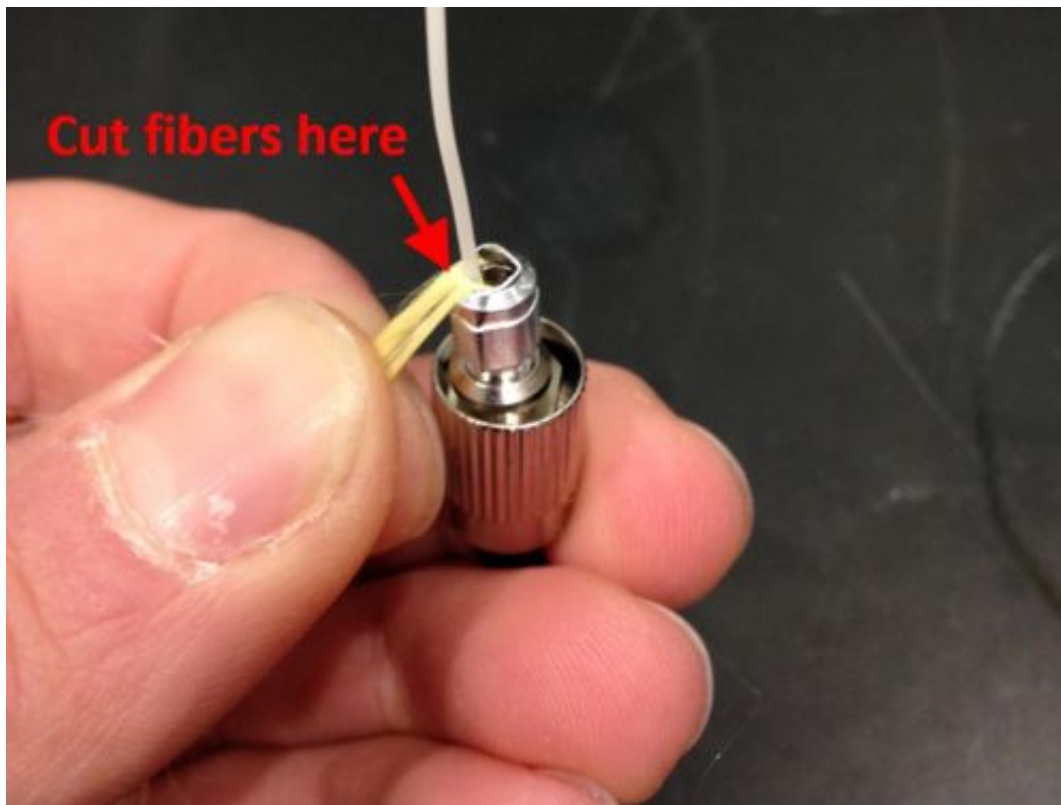




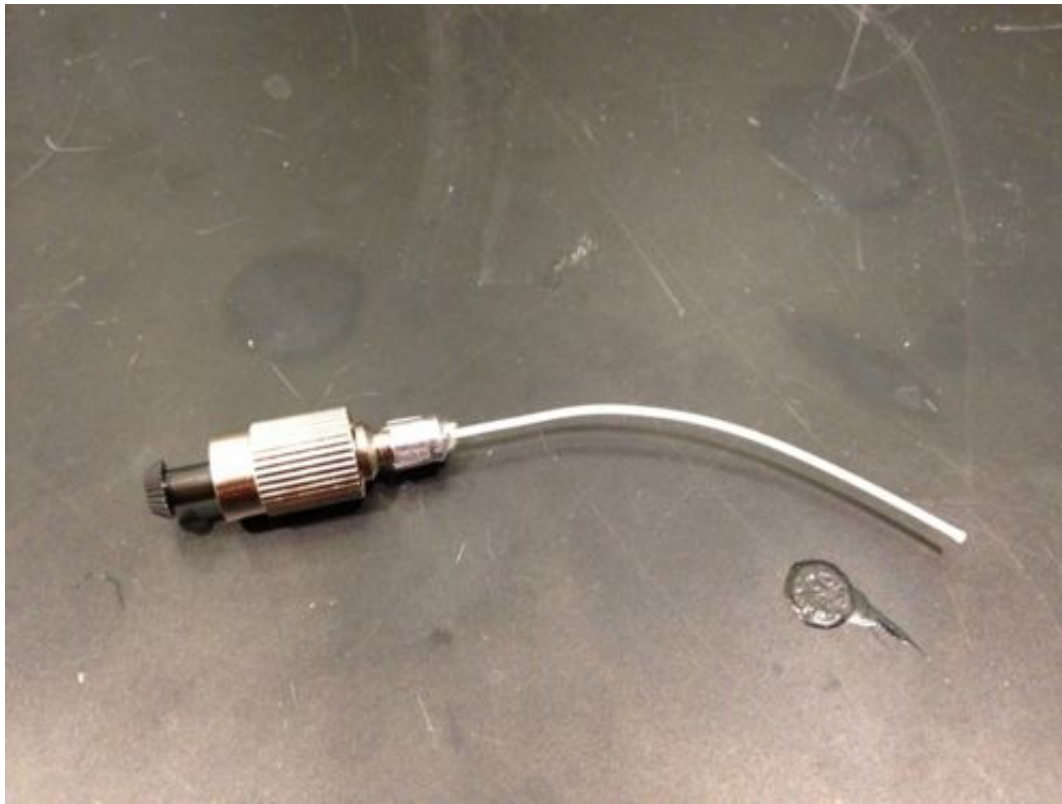
- The fiber should now look like this



- Fold the strengthening fibers back and cut them as close to the metal connector as possible. The clearer the opening the easier a later step will be.



- The fiber should now look like this.



- Cut the fiber using a new sharp razor to a length typically 5mm longer than the depth you plan to insert the fiber.



- Strip away the inner plastic jacket. To avoid breaking the fiber, strip off the jacket in segments no longer than 7mm each.



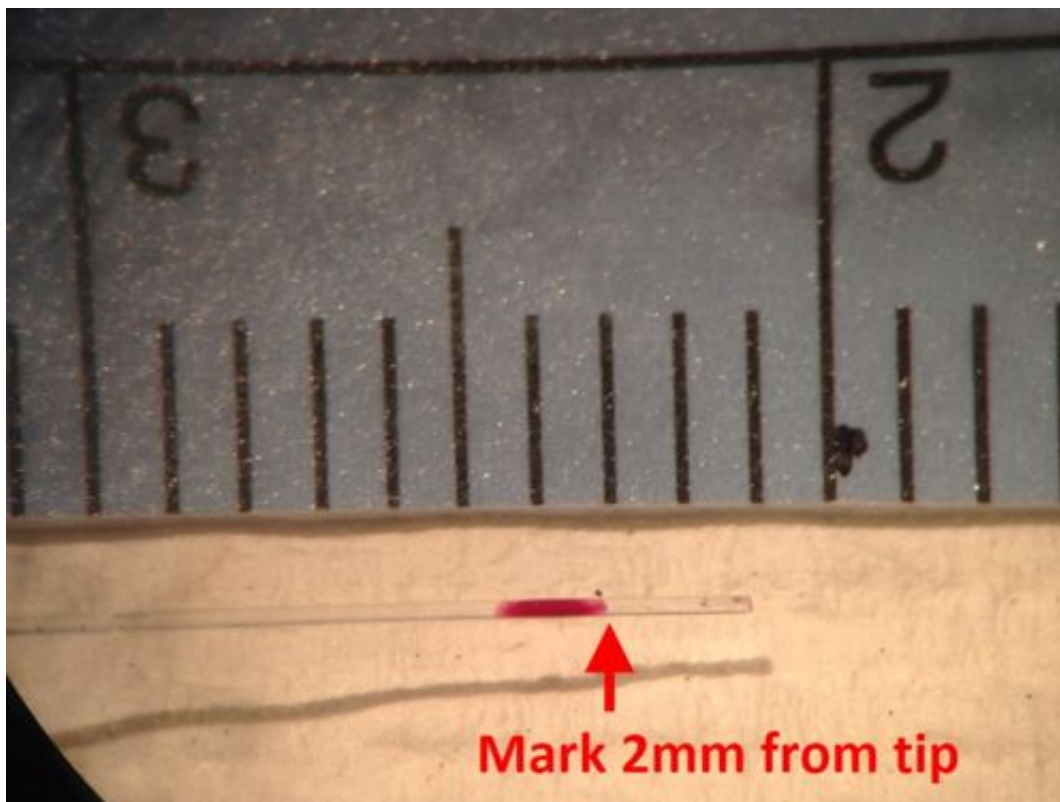
- At each point where you cut the inner plastic jacket for stripping, you will likely nick the innermost clear plastic jacket. This is okay as long as no nicks occur within 3mm of the fiber tip.





## Etching the fiber

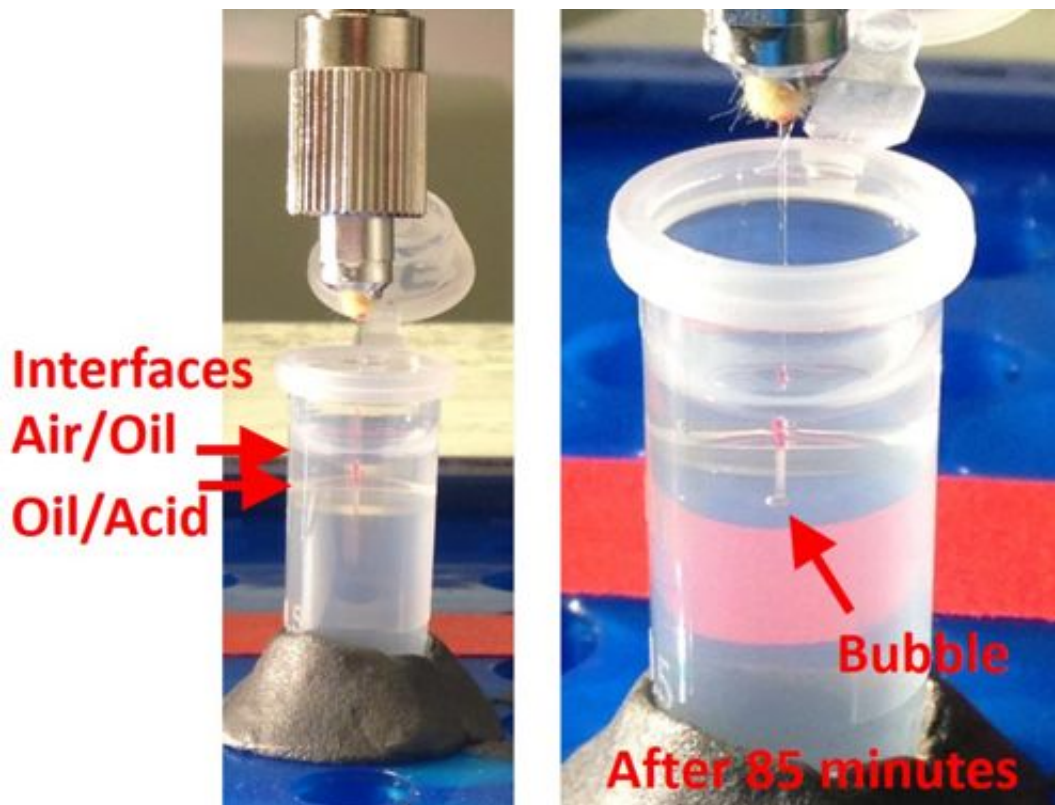
- Mark a point 2mm from the tip of the fiber using a paint pen. It is critical that you get NO paint in the first 2mm as the etching will not occur symmetrically



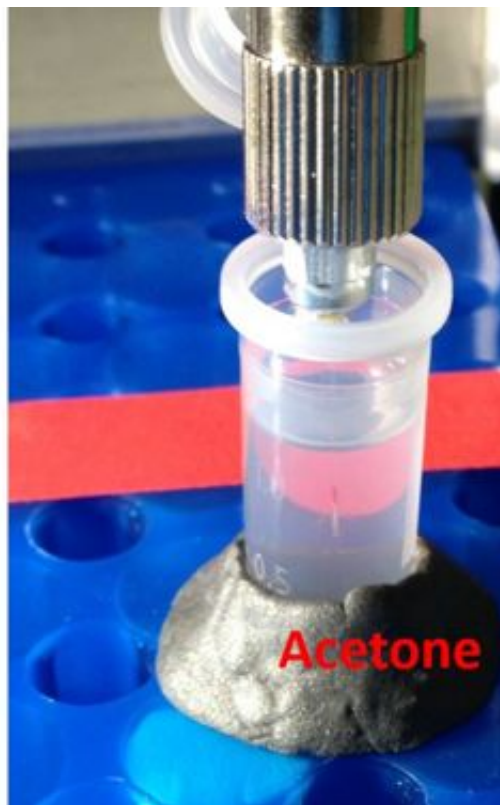
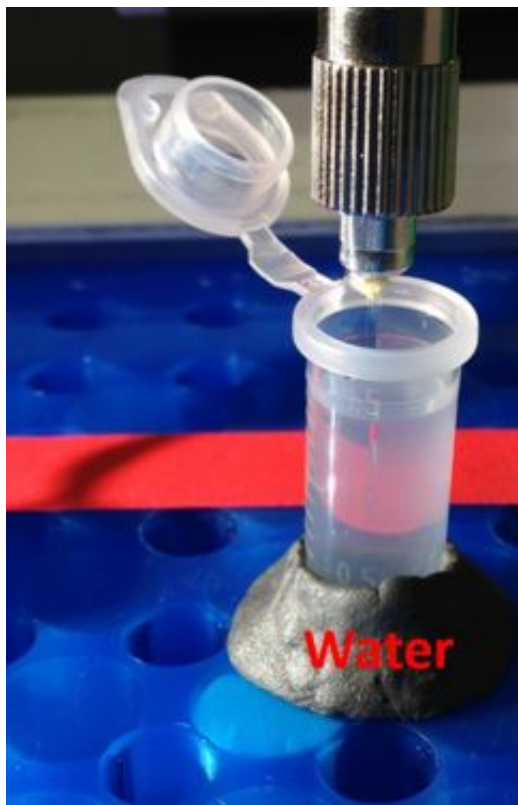
- Lower the fiber tip 2mm into 48% hydrofluoric acid capped with a layer of mineral oil. The red paint



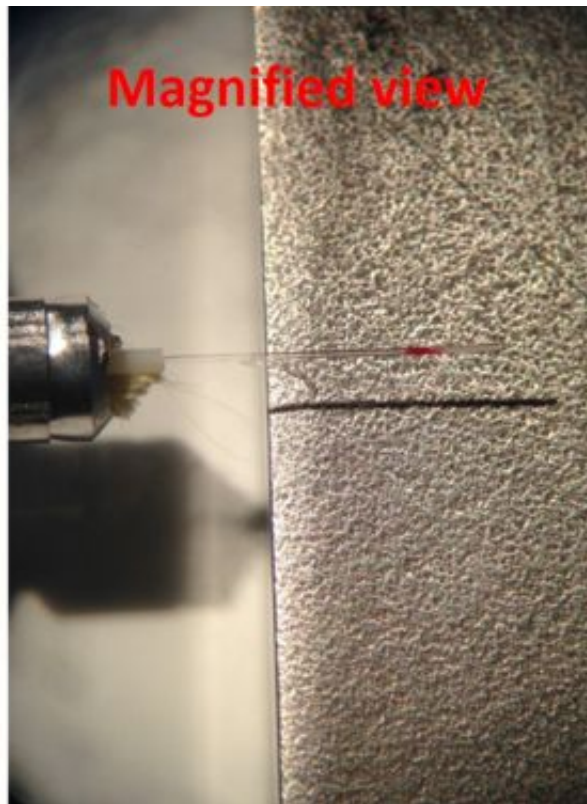
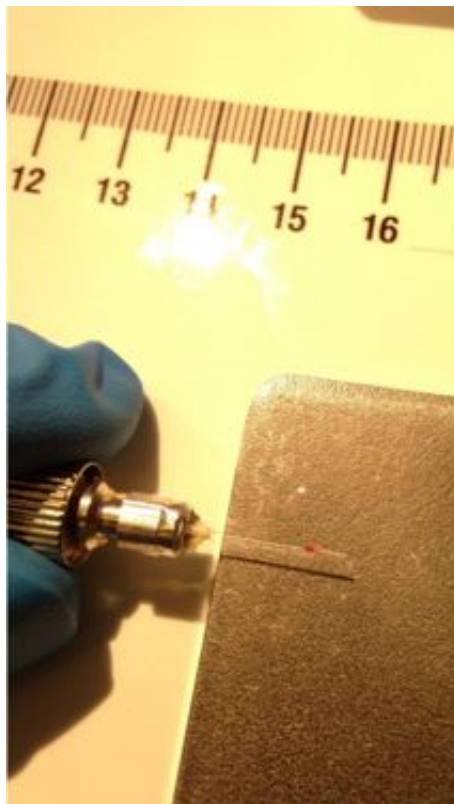
dot should be entirely in the oil, right at the oil/acid interface, thus ensuring 2mm of fiber is in the acid. Let stand for 85 minutes. During the etching a bubble may appear at the tip of the fiber, this is normal.



- Remove the fiber from the acid and immediately submerge 5mm in deionized water for 5 minutes. Then remove from the water and submerge in acetone for at most 30 seconds. This will soften the clear plastic jacket making it easier to remove. Submerge 2mm more than the depth you plan to insert the fiber to and remove all of that plastic in the next step. Watch the fiber tip closely while in the acetone. If the tip begins to bend remove it immediately.

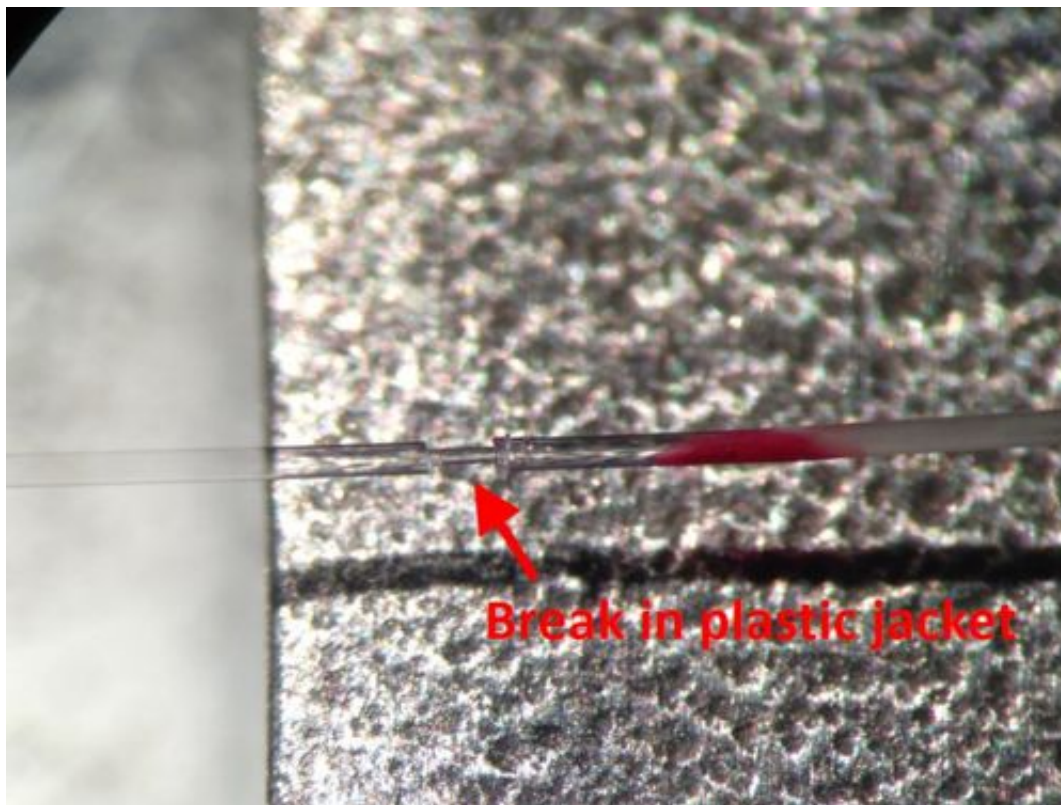


- Position the fiber tip flat along a raised smooth surface.

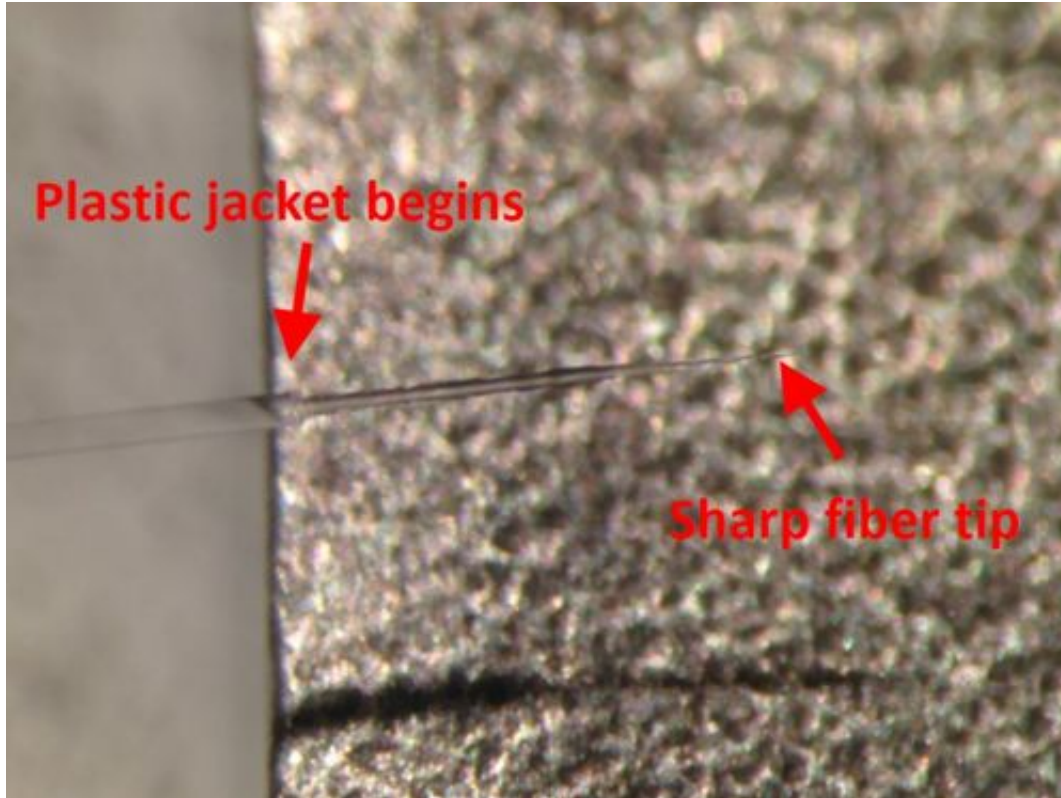


- With a fresh sharp utility razor gently make a small nick in the plastic jacket. Use very little downward force to avoid damaging the glass fiber. The plastic has been softened and should easily cut. Once you are through the plastic jacket with the blade resting on the glass fiber, gently push sideways towards the fiber tip. The plastic jacket should tear at the nick completely around. Continue pushing the jacket until you've opened a 0.5mm gap.





- With a pair of sharp forceps grab the plastic jacket at the tip (where there is no glass fiber now) and carefully remove it by pulling it straight off. You should now have exposed the chemically sharpened glass fiber optic.

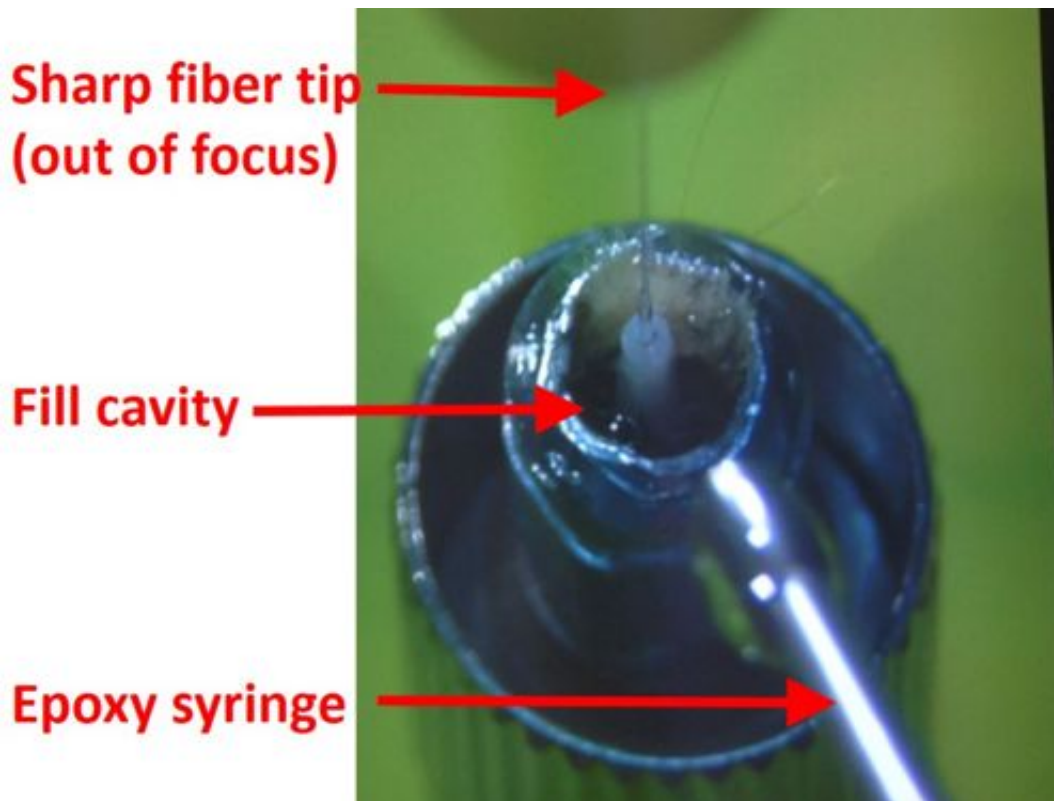


- If you need to remove more of the plastic jacket you can peel it off with the razor by holding the blade at a 45 degree angle relative to the glass fiber and cutting towards the metal connector. Remove the peeled portion of jacket with forceps and repeat with the other half of the jacket.

- Prepare a tiny batch of 5 minute 2-part epoxy and load into the back of a 3ml syringe with straight metal tip.

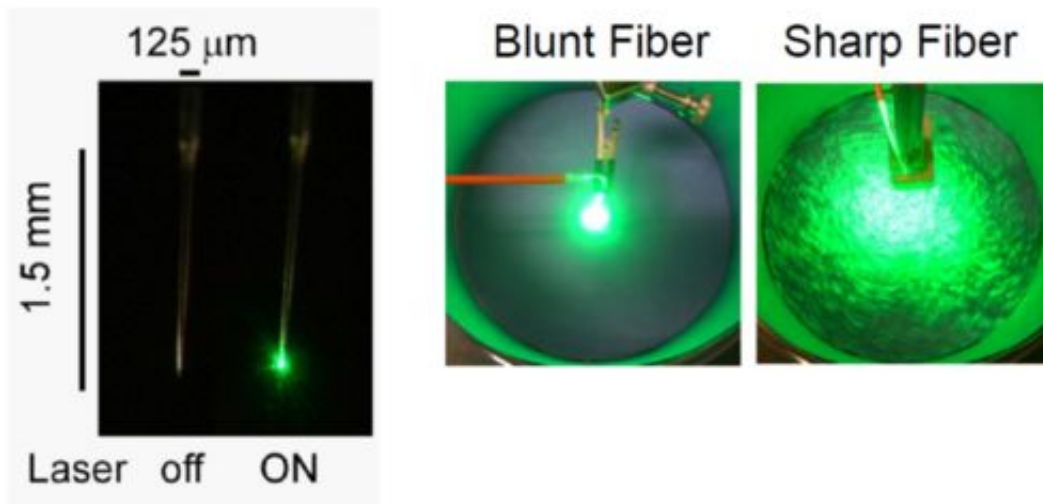


- With the fiber tip pointing up, fill the cavity inside the FC connector with epoxy. This step is made easier if the yellow strengthening fibers were cleanly removed. It is essential that that fiber is surrounded by epoxy and immobilized.





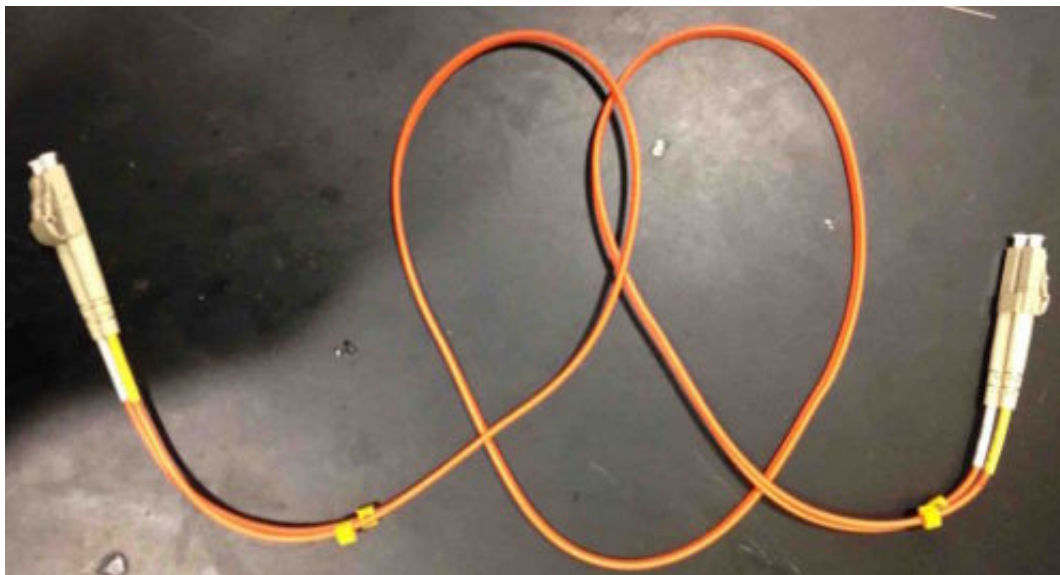
- Test the fiber by connecting it to a laser. The illumination should be broad and uniform.



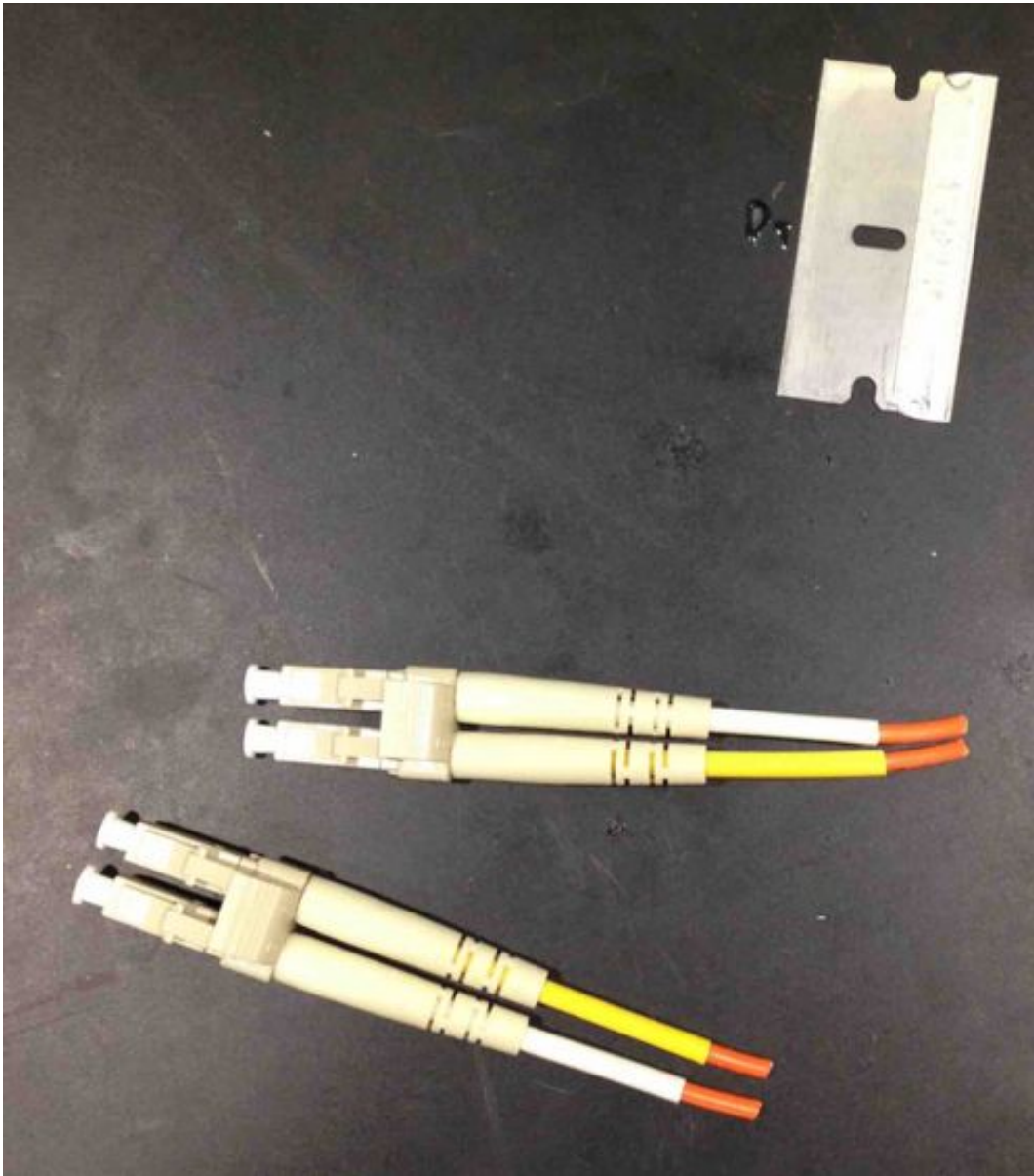
## Plastic LC Connectors

Essentially the instructions for preparing and etching a fiber attached to a plastic LC connector are the same, however we've noticed that regardless of the duration in the acid we cannot get some batches of fibers to etch to a point. The following steps have been found to achieve high quality etched LC fibers:

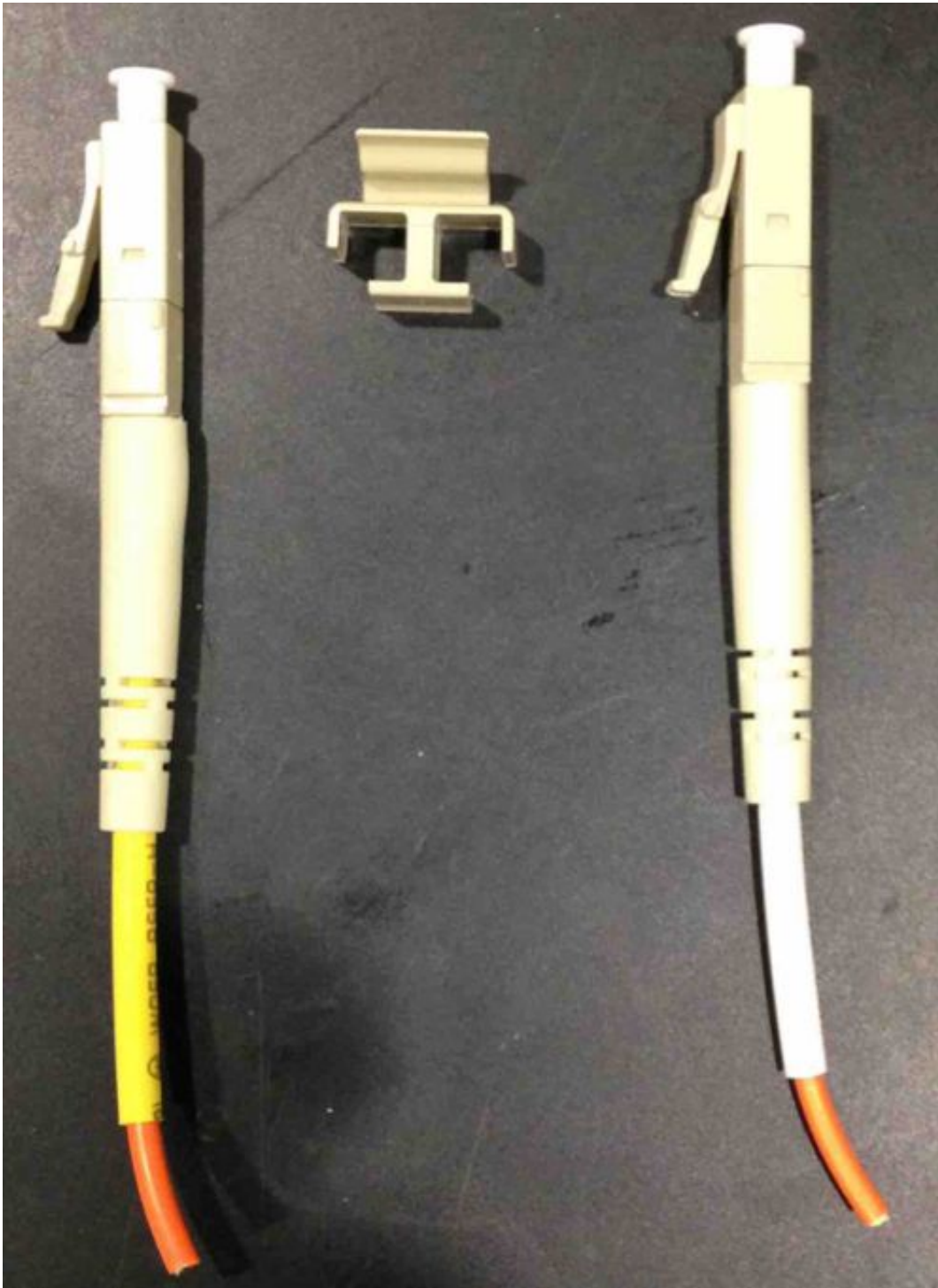
- Initial fiber.



- Cut the two pairs of ends off.

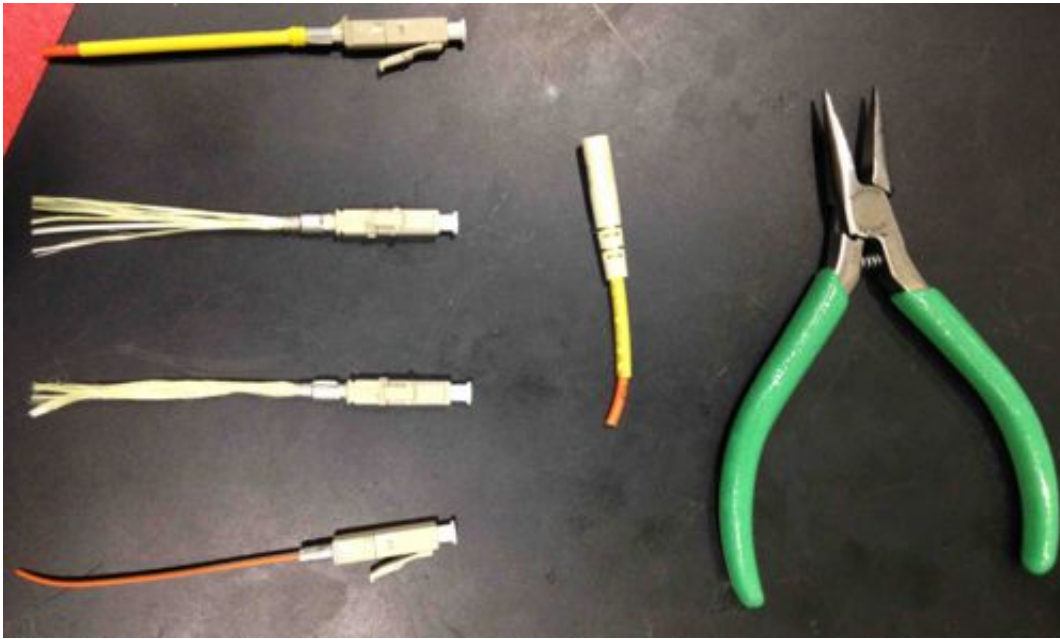


- Separate the two fibers in each pair

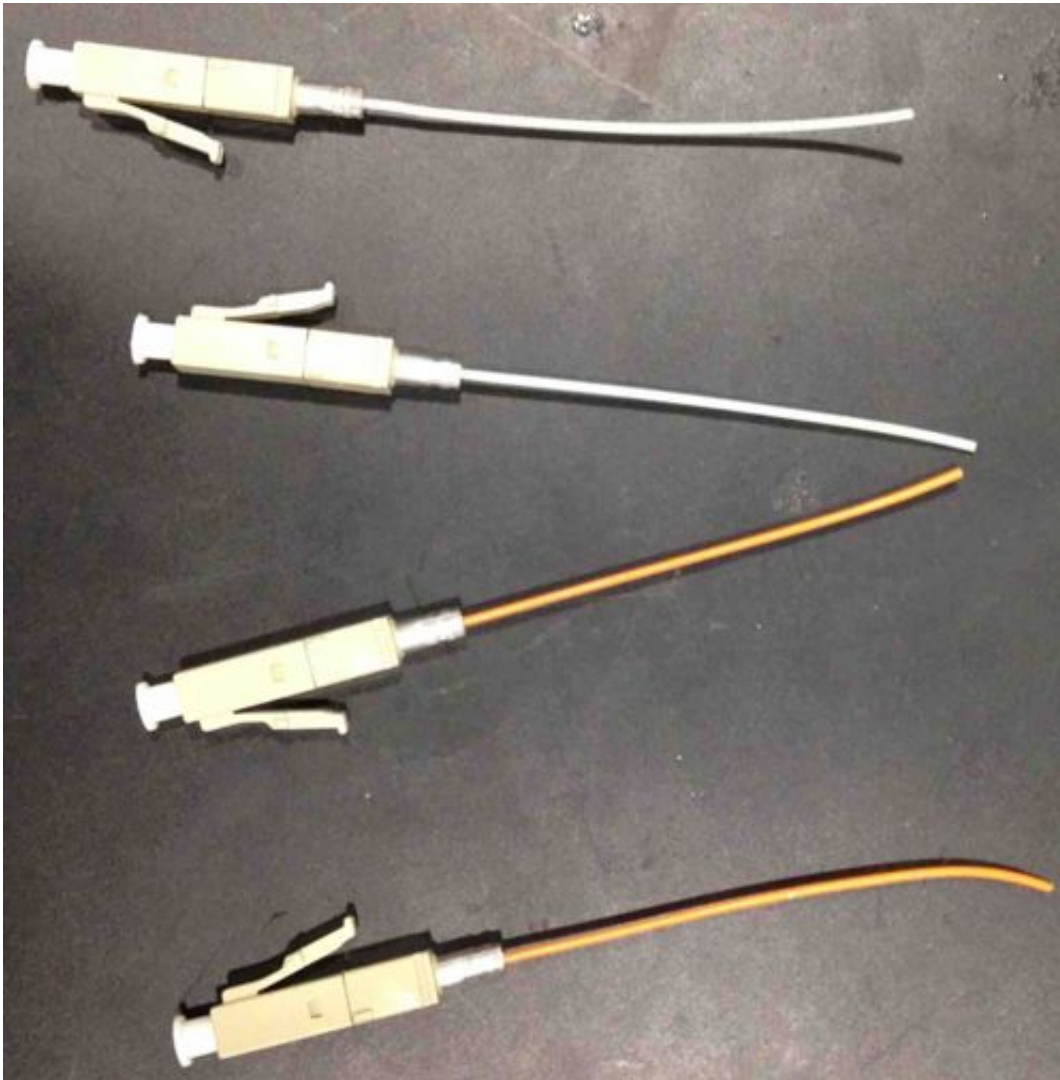


- With a pair of pliers remove the plastic collar. Sometimes the external plastic and the kevlar will come off with the collar (see bottom one). Other times it is necessary to gently squeeze the metal until it fatigues to remove these parts





- The fibers should look like this now

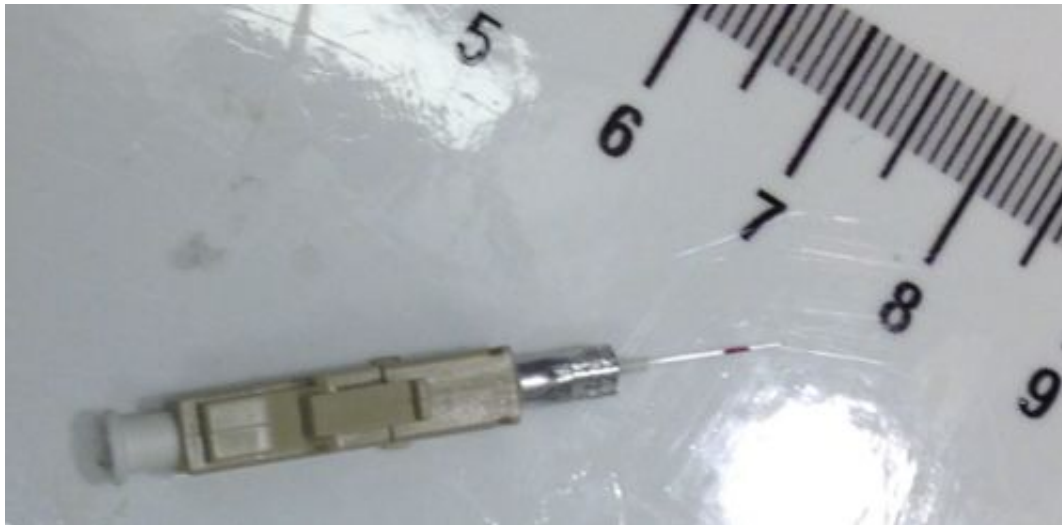


- Take fiber optic stripper, and use middle hole to strip the plastic (don't strip more than 7mm at a time!)



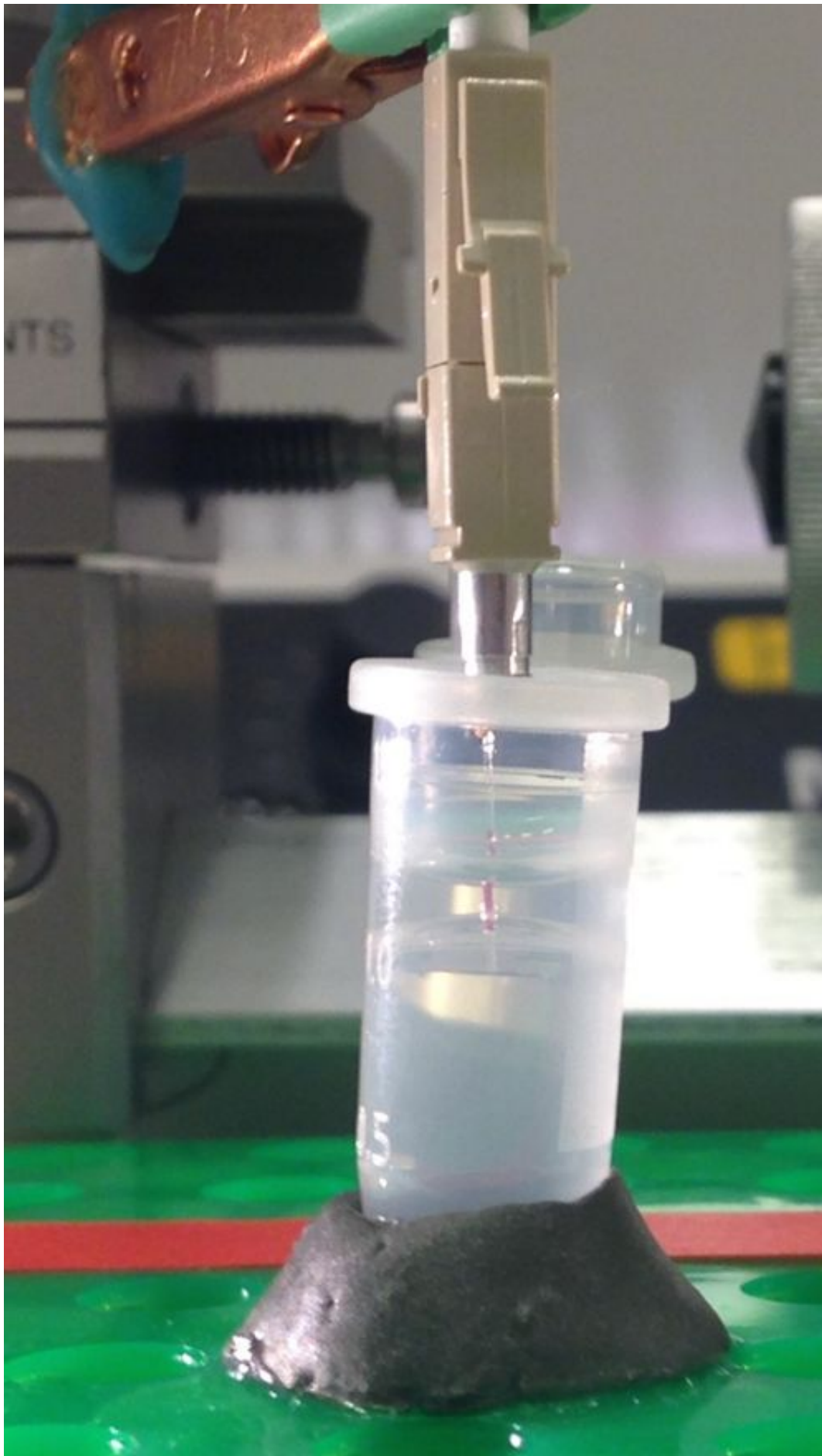


- Mark with paint 2mm away from tip of the fiber



- Soak 2mm of plastic coated fiber in concentrated HF for 48 minutes.





- Soak in water, then acetone, and remove the clear plastic jacket as described above.

- This should reveal a partially etched fiber. Most of the outer glass cladding will be etched away but the fiber will not taper to a point.
- Re-submerge the tip (only 100um or so) in the acid. Under a microscope you should be able to see the acid pull up the sides of the fiber in creating a tiny meniscus.
- Allow the tip of the fiber to soak in the acid until it is completely dissolved (the meniscus will disappear), approximately 20 minutes.
- Remove the fiber from the oil and inspect. Under 6x magnification you should be able to notice the tip of the tapered fiber now has a point. Epoxy and test the fiber as described above.

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- This page was last modified 04:30, 23 December 2015.