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Tapered Hollow Silica Waveguides for Improved 10.6µm Power Delivery

Authors: John Shannon, David Richardson, Ph.D. and Richard Timmerman

Recently, a new Hollow Silica Waveguide (HSW) was developed at Polymicro Technologies which has a tapered section at the input end to improve the light launch and power handling capability in the mid-infrared region. While large bore (750 – 1000µm ID) waveguides have been shown to transmit over 1000 watts of power, the smaller bores, such as 300µm ID, are limited to significantly lower power levels due in part to the difficulty of launching into the smaller bore. The taper design, shown in Figure 1, allows the user to couple greater power into the smaller bore size than would normally be possible. This cuts down the power density at the proximal end and funnels the light to a smaller, higher intensity output pattern.

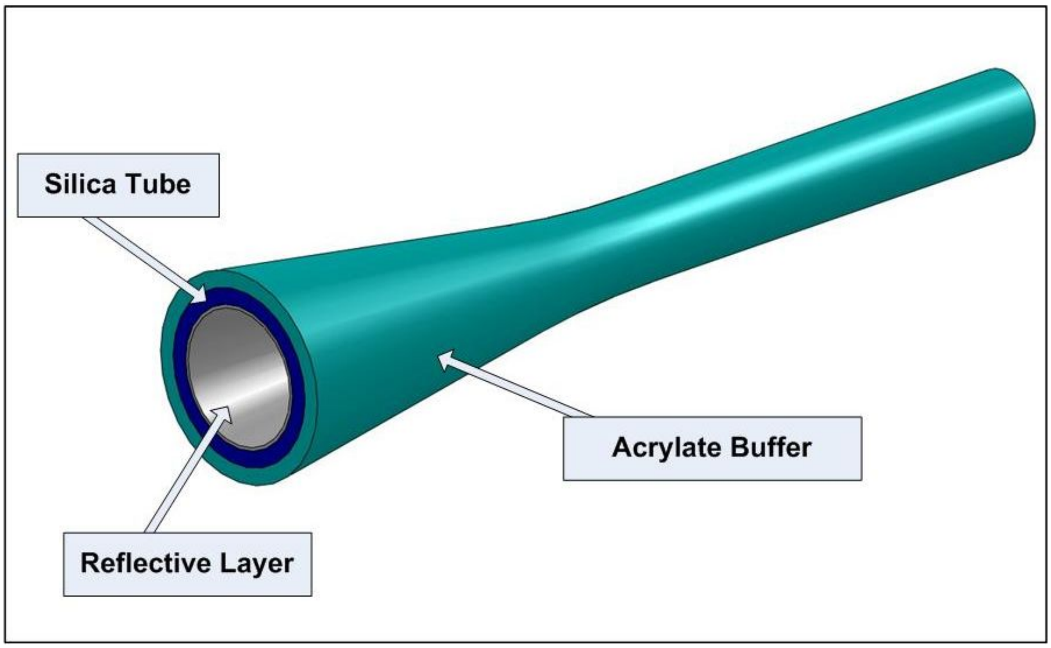

Figure 1. Waveguide Taper Schematic (not to scale)

Tapered Tube Fabrication

The input taper was formed by modifying the draw tower process used to form the base silica tubing so that the input end tapers from a large size down to a smaller bore size. By automating the tower draw controls, a smooth linear transition in the tubing bore is possible. Figure 2 below shows the linear profile of the bore and outer glass diameters of the drawn tubing taper. The waveguides were built with a 300µm ID tube which tapered to 700µm over a 1.5 meter length.

Figure 2. Tapered Tubing Dimensional Profile

Coating process
After the individual tapers were drawn at the tubing draw tower, the internal reflective coating was applied. The process used for coating straight tubing was modified for the tapered geometry.

Optical Test Results
Once the waveguides were completed they were subjected to a series of optical characterization tests. First, the attenuation of the waveguide was determined using a CO_2 laser coupled into the tapered end and measuring the output power. The waveguide was then cut back to a short length and the attenuation over the length of the waveguide calculated, in this case an average of .8dB per meter over the 6.5m length. This is a reasonable result for a 300µm ID straight waveguide, even without a taper.

Next, the attenuation was measured using an FT-IR spectrometer over the infrared range of 2.5 to 12µm. The results, averaged over the 6.5 meters of the waveguide, are shown below in Figure 3.

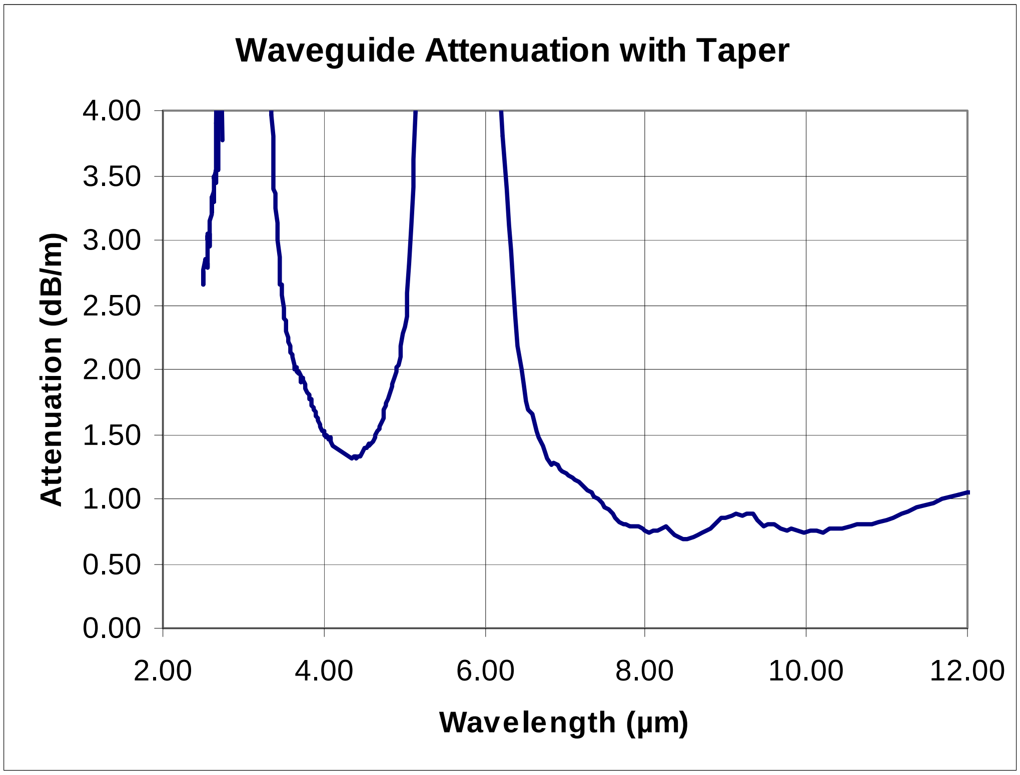

Figure 3. Spectral Attenuation Per Meter Chart

The final step was to evaluate the ability of the tapered waveguide to handle high powers. A 100W CW CO_2 laser was coupled into the tapered end and the power level incremented in ~10W steps, dwelling for a minimum of one minute at each step. The waveguide survived up to the full available 100W of laser power, finally failing after five minutes with 100W input. After the failure, the same test was applied to the non-tapered 300µm ID section with the taper removed. In comparison, the straight waveguide failed at approximately 30W input power.

Conclusions

The power test results verified a significant improvement in the ability to launch and transmit 10.6µm infrared power using the tapered input. This suggests the tapered waveguide has potential for improving the performance in applications where small output size and high power are required.

Polymicro Technologies,
A subsidiary of Molex Incorporated
18019 N 25th Ave., Phoenix
AZ 85023-1200
Ph: 602.375.4100
Fax: 602.375.4110

Media Contact:
Lyn Akers
602.375.4100