Hemispherical Thermal lensing of fiber

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ABSTRACT

Lensing optical fiber is an important for collecting efficiently the optical power from the light source and reducing the back reflection. It improves the coupling efficiency at the input of the single mode fiber. In this article S153A FitelSplicer electric arc discharge is used to thermally lens an SMF-28 fiber in hemispherical shape. The effect of the fusion program parameters on the output lensed fiber is studied. Time and arc power of the fusion are modified and the output radius of the lensed fiber is monitored. The calibration curves for this fiber between the resulted lensed fiber radius and the fusion parameters are generated. Accurate degree of repeatability of the process is achieved in the experiment at high arc power.

Keywords: Optical fiber, Optical fiber lensing, optical power coupling, optical communication

1.INTRODUCTION

Lensed optical fiber is used in coupling optical light from the source to fiber to ensure that the maximum amount of light emitted from the source get into the fiber with minimum losses [1,2,3,4,5]. It improves the mode matching between the laser diode and the optical fiber. Fiber brag gratings (FBGs) are in-fiber band-rejection filters used in the laser pigtail to stabilize the output wavelength [6]. Lensing these FBGs achieve both stabilizing the wavelength and improve the coupling efficiency. Lensed fiber is also used in biomedical imaging to achieve high resolution images [7,8].

Lensing the head of the fiber can be fabricated by different ways like, chemical etching, grinding and polishing, fused tapering, and laser micromachining. In chemical etching, it is difficult to control the area of the fiber affected in addition to weakening of the fiber beyond the processing area. Polishing and laser micromachining are precise but complicated and expensive. Thermal tapering of the fiber is a simple method and produces the required lensed fiber with a limitation to some symmetrical shapes.

In this paper, we generate a calibration curves for fabricating a hemispherical lensed fiber. It is important to be able to fabricate lensed fiber at different hemispherical diameters to get the best coupling efficiency for a specific system with a specific wavelength and laser parameters. Hemispherical lensed fiber is fabricated with different diameter by controlling the time and voltage of the arc in Fitel splicer S153A. The effect of each design parameter is characterized and analyzed separately. The repeatability of this process is found using the same parameters to fabricate the same diameter lensed fiber few times.

2.EXPERIMENTAL RESULTS AND DISCUSSION

Hemispherical lensed fiber is made using SMF-28 standard telecommunication fiber. The acrylate plastic jacket has been removed from 1 cm in the middle of a fiber. Then the fiber is laterally fusedusing the arc discharge of Fitel splicer S153A.The power and time of the arc used was enough to cut the fiber into 2 pieces and make the hemispherical end shape. It is noted that the diameter of the hemispherical shape depends on the arc time and voltage. The fiber absorbs the arc heat, fused until it becomes two pieces, and make a hemispherical shape on both ends of the broken fiber. The test is repeated many times at different values of arc time and voltage to find the calibration curves of lensing standard single mode fiber SMF-28. The maximum arc voltage of the Fitel splicer S153A is 200 Volt, and maximum arc duration is 32767ms.The cleaning arc power offset was fixed to default without change during the fabrication of all samples.

Figure 1 shows the relation between the diameter of the hemisphere of the lensed fiber and the arc voltage that represent the arc power at three different arc durations. The Figure shows that after some threshold value, increasing the arc voltage reduces the diameter of the lensed fiber. This threshold value depends on the arc duration. It is only 40 Volts for the arc duration of 2500ms, while it is 120 Volt for an arc duration of 1000ms. Longer arc duration gives smooth curve at low voltage because it soften the material even at low voltage value. It is concluded that the arc duration should be higher to have a smooth relation from a small voltage.

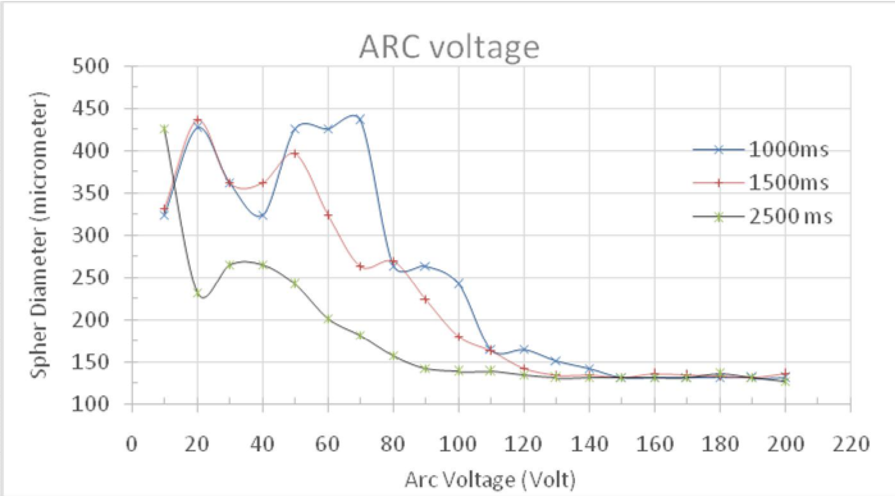

Figure 1 Voltage calibration curves at three different arc durations

Figure 2 shows the relation between the diameter of the hemisphere of the lensed fiber and the arc duration at two different arc voltages. The results show that the diameter of the lensed fiber is the same regardless of the voltage after some value. This value is 3000 ms when comparing the 70 volt and 100 volt curves. The range of diameters possible is from almost 130 to 320 micrometers at the voltage of 100, but the changes are very sharp and difficult to tune. It is advised not to use the arc duration for tuning the diameter of the hemispherical lensed fiber.

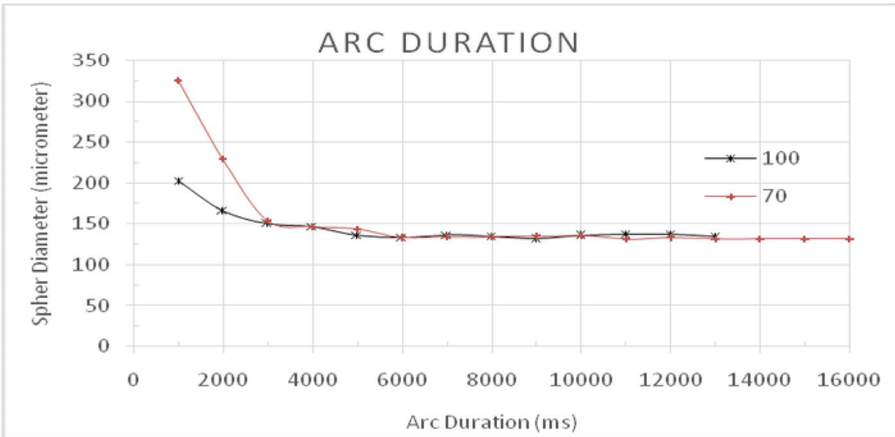

Figure 2 Duration calibration curves at two different arc voltages

Repeatability of this process is testedto make sure the lensed fiber can be reproduced using the same arc duration and voltage. The lensed fibersis fabricatedtwo times at the same arc duration of 2500ms and the diameter-duration curve is regenerated. The maximum difference between the curves is shows in Figure 3. The results show that at higher arc duration, the difference is very small and the repeatability is better. The highest difference between the two curves is 66 micrometer at 30 Volt.

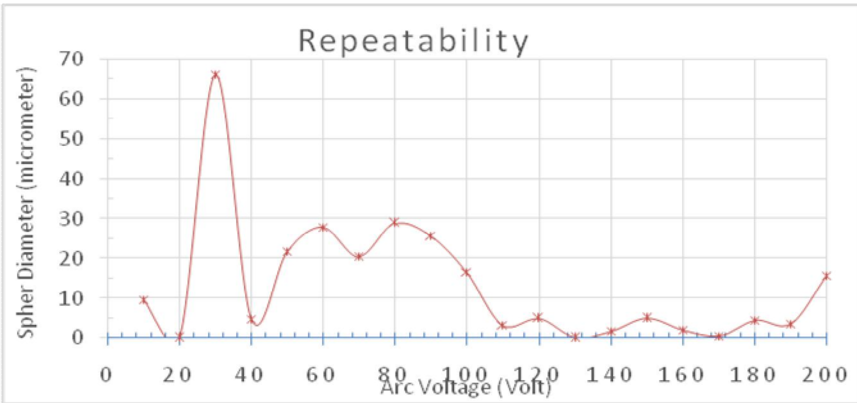

Figure 3 Repeatability of the voltage calibration curve

3. CONCLUSION

Fabrication of hemispherical thermal lensed fiber using SMF-28 communication standard fiber with arc discharge is a simple and reliable method. The fabrication process is more stable at high arc duration. 2500ms is found to be suitable discharge timeat a voltages of 100 and 70. Changing the arc voltage gives a wide range of diameters of lensed fiber up to 430 micrometer. The repeatability is acceptable at low arc voltages and excellent at high voltages.

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