OPTICAL FIBER SPLICER REVIEW

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1. PURPOSE

The purpose of this experiment is to analyze and identify the process parameters for using wet etching and vapor etching to taper a single mode optical fiber. I has been shown in previous experiment that using vapor etch processes, optical fiber tapers of approximately 600 nm can be achieved.

2. SCOPE

The Scope of this document includes an overview of the splicing process, tools, brands, prices, capabilities and the required parameters for projects at the IBIS Laboratory.

3. FUSION SPLICING

3.1. OVERVIEW

The goal of splicing is to join together two cleaved optical fibers into a single continuous fiber. The difficulty of this process lies in the fact that optical fibers often have cladding diameters of 1/10mm approximately equivalent to the width of a human hair. Furthermore they also contain cores as small as 1/100mm that may not be located in the geometric center of the fiber. This has resulted in an entire industry being created to facilitate this process.

Historically, in the optical fiber industry this was achieved manually; a process that entailed using a scribe to cleave the fiber and a polishing kit to create a flat-smooth surface so the fiber could be joined in a mechanical couple. There were many inherent consistency issues with this method of splicing that had to be overcome for the optics industry to flourish. These issues included; the dependence on the skill of the technician; high dB loss results from misaligned cores; un-even or rough fiber faces; and high cleave angles; resulting in work that was time consuming and inefficient.

The mechanical fiber cleaver was developed to help solve many of the problems with consistency. The industry no longer had to depend on the skill of individual technicians to create a smooth-flat optical fiber face for splicing fibers together and further reduced the time consuming cleave and polish process to a matter of a few seconds. While this was a large step forward there remained two major issues with the process. The first problem being that there was still a high dB loss due to the poor quality of manufacturing of the optical fibers that resulted in fiber cores that were offset from the geometric center of the cladding. This created a misalignment of the core when two fibers were mechanically spliced together. The second problem was that the process was still time consuming limiting the amount of work that could be completed.

A resolution to these problems came in the form of the fusion splicer; A tool that fuses two cleaved optical fibers into a single fiber using an electric arc. Along with the development of this tool was the invention of an automated stage alignment system that could identify and align the fiber cores resulting in loss measurements that now made it possible to use these machines to splice fiber for laboratory applications including the construction of optics based sensors.

3.2.PROCEDURE

3.2.1. Stripping & Cleaning

Manufactured optical fibers are coated with several layers of protective plastics such as polypropylene and Kevlar; to splice fibers these layers must be removed using an optical fiber stripper. When the fiber has been stripped it must be cleaned using alcohol such as isopropanol and lint-free wipes so the cladding and face should be free of any debris.

3.2.2. Cleaving

A cleave is performed on both optical fibers using a mechanical cleaving device. The cleave is achieved by sliding a diamond blade across the very edge of the cladding , then applying tension through the longitudinal axis. The end result should be a smooth fiber face with a cleave angle of less than one degree.

3.2.3. Fusion Splicing

The fibers are place into separate fiber holders and set in the machine. A fiber dependent fusion splicing program is selected. Alignment is completed by the machine if it is a core alignment type. An electric arc then fuses the fiber according to the program parameters. A heat shrink protection sleeve is automatically attached to the splice area and heated in the machines internal oven.

3.3.MAINTENANCE

Cleanliness and maintenance is the key to keeping the fusion splicing device in operating condition. The following outlines basic maintenance requirements for a fusion splicing tool.

3.3.1. Electrodes

The electrodes have a limited lifetime of approximately 1000- 3000 splices and will eventually need to be replaced.

3.3.2. Cleaning

All components of the fusion splicer machine require consistent cleaning with the use of isopropanol and a lint-free wipe. This includes mirrors and lenses for core alignment machines and “V grooves” for cladding alignment tools.”

4. EQUIPMENT TYPE

4.1.CLEAVING

4.1.1. Scribes

The crudest from of cleave possible depends on technique and is not an legitimate option for a laboratory setting.

4.1.2. Mechanical

Mechanical cleavers are the industry standard they provide high quality cleaves and are extremely durable. They also give the ability to cleave multiple fibers at once. **(Figure 1)**

Figure 1

4.1.3. Ultrasonic

Ultrasonic cleavers are used almost exclusively in the laboratory setting. They produce the most consistent results and give complete control of fiber cleave angles from 0 to 15 degrees. They are best for polarization sensitive applications. **(Figure 2)**

Figure 2

4.2.FUSION SPLICE ALIGNMENT

Currently there are three types of alignment methods for fusion splicer tools; Cladding Alignment or “Fixed V-Groove alignment”; Core Alignment; and Polarization maintaining alignment; each associated with a different machine cost.

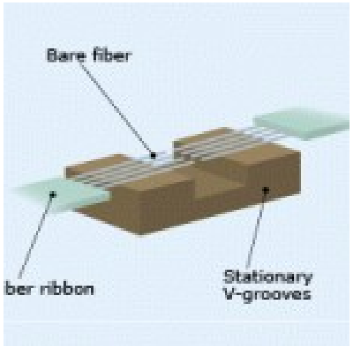

Figure 3

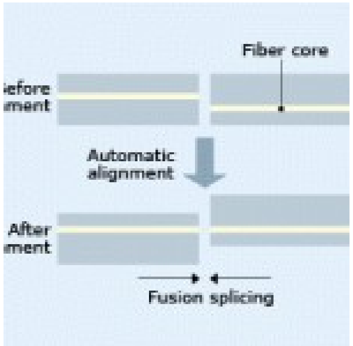

Figure 4

4.2.1. Cladding Alignment

Cladding alignment is associated with the least expensive fusion splicing devises and is commonly referred to as “V-Groove” alignment. This method consists of placing the two optical fibers to be spliced into stationary grooves that have been precisely cut into an alignment block permanently attached to the machine. Due to the increasing quality in the production of optical fibers, when comparing loss measurements, cladding alignment is able to compete with the other two automated alignment methods but is completely dependent on the cleanliness of the fibers and requires high quality or “new” optical fibers.(Fig 1)

4.2.2. Core Alignment

Core Alignment is an automated alignment process that requires the placement of the two fibers on separate x,y,z, stages. The machine uses light to identify the location of the fiber core for both of the fibers being spliced and moves the stages as to align the fiber cores in the x,y,z axis. The advantage of this technique is that it allows the use of low quality fibers, also, the structural integrity and cleanliness of the cladding are no longer critical to the splicing process. This is widely accepted as the industry standard.(Fig 2)

4.2.3. Polarization Alignment

Polarization Alignment uses the same automated alignment system as core alignment with the added capabilities of being polarization sensitive and rotation axis alignment.

5. IBIS LABORATY ANALYSIS

5.1.MECHANICAL VS. ULTRASONIC CLEAVER

	Mechanical	Ultrasonic
Estimated Cost NEW	~$1200	~$3000
Estimated Cost USED	$200-1000	$1000-3000
Polarization	OK	Optimal
Angle (Degrees)	<1(80%)	<0.35(95%)
Durability	Best	OK
Consistency	OK	Best
Face damage	Some	None

5.2.FUJIKURA

	12S		19S		70S	
Alignment	Cladding	Loss (dB)	Cladding	Loss	Core	Loss (dB)
Estimated Cost NEW	$6000 w/ cleaver		N/A		N/A	
Estimated Cost USED	N/A		N/A		N/A	
Single Mode G.652	Y	0.05	Y	0.05	Y	0.02
Single Mode G.657	Y	0.05	Y	0.05	Y	0.02
Multimode G.651	Y	0.02	Y	0.02	Y	0.01
DSF G.653	Y	0.08	Y	0.08	Y	0.04
NZDS G.655	Y	0.08	Y	0.08	Y	0.04
Amount of fibers	1		1		1	
Cladding Diameter	125/160um		125/160um		80-150um	
Cleave Length	5-16mm		5-16mm		5-16mm	
Splice Time	15 sec		9		7 sec	
Splice Result Storage	2000		2000		2000	
Electrode Life	3000		3000		3000	
Magnification	100x		320x		320x	