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MANUFACTURING GROUP, LTD

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A DURABLE FIBER OPTIC END-FACE

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INTRODUCTION

The basic transmission premise is the ability to transmit a signal at point A and receive the same signal at point B. The transmission capability across a fiber far exceeds that of a copper line. The use of fiber optic technology, however, is far more technical. In today's world, the fiber optic end-user is required to possess cleaning techniques, maintenance procedures, handling and trouble-shooting skills to address interconnect issues. It can seem, at times, the technology does not work. Achieving repeatability can be a nightmare. Techniques and products need to be developed to alleviate the issues that prevent the end-user's success.

The techniques used to terminate and polish fiber optic assemblies and interconnects have changed very little over the past ten years. Automated polishers and visual inspection equipment have been introduced to aid in the repeatability of the manufacturing process. Also, interferometers and end-face geometry criteria were introduced to develop interconnect standards in the industry. These enhancements, however, have not solved many of the obstacles that are inherent with the use of fiber optic technology.

These obstacles are encountered by the end-user on a daily basis. They include end-face scratching, dust and other airborne contaminants, films and residues, and alignment issues. All of the mentioned obstacles lead to increased loss, return loss and performance degradation. At the system level, repeatability is compromised. What works today may not work tomorrow. The industry needs a **durable** interconnect that eases the use of fiber optic transmission.

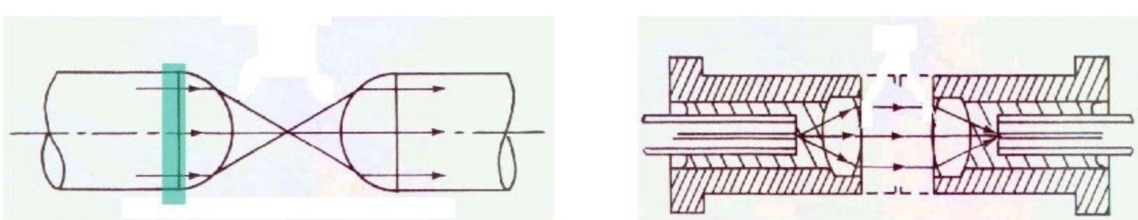
MEGLADON'S HARDENED-LENS CONTACT (HLC®) TERMINATION PROCESS

The method of producing the **HLC** (lensed fiber ends via laser action) fiber optic assembly offers many advantages, the most prominent of which are **durability** (long-term, repeated ease of use in real-world environments with consistent performance) and manufacturing repeatability with reduced processing sensitivity.

The HLC assemblies produced provide a combined hardness (resistance to scratch and dig) and surface roughness (typical 3 or more times) that exceeds that which can be achieved with traditional polishing processes. In our HLC process, the end of the fiber as well as the immediately surrounding epoxy and ferrule surface, go through a rapid thermally driven and controlled recrystalization process that results in several well-known and well-established benefits. The most important of these from the practical use and **durability** aspects include the generation of an **integral lens** structure, **surface passivation**, and the **"healing" of micro-defects** residing in the volume of the materials below the surface.

BENEFITS OF USING A LENS STRUCTURE

The benefits of using a lens structure on the end of an optical waveguide such as a fiber have been well known and publicized for more than 20 years [1, 2] as illustrated below in Figure 1 from the "Designers Guide To Fiber Optics" by AMP Incorporated (1981). While most splices and connectors in use today use strictly mechanical measures to control and connect the propagation of light from one component or waveguide to another, the lens approach is an optical approach which greatly reduces many of the alignment and loss issues that are faced with the all mechanical approach to coupling and alignment. However, until the development of the HLC structure which automatically and routinely generates an appropriate lens that is an **<u>integral</u>** part of the fiber termination itself, most uses of the pure optical coupling (lens) procedure were rarely utilized because of the costs and complexities of implementation involved in commercial applications.



(a) (b)

Figure 1 – Diagram of Lens Coupling.

BENEFITS OF PASSIVATION, REFLOW AND DEFECT HEALING

The benefits of passivation, reflow, and subsurface micro-defect healing via the use of a rapid thermal process such as with a laser beam are also known and now established within the micro-electronics arena [3, 4]. Likewise, laser annealing is now having a tremendous impact in both the micro-machining and high energy/micro-optics arenas as well [5].

In the HLC process, the end-face goes through a rapid melt and reflow process at the surface, which acts to **"harden"**, **smooth** and **passivate** (reduce dangling bonds) the surface. Tests conducted by Micro Photonics Inc. with a diamond micro-tip stylus [6] have demonstrated that not only is the fiber itself harder or less prone to scratching than a fiber end using standard polishing/finishing processes, but the surrounding epoxy and ferrule surfaces were hardened as well. These tests alone, however, do not tell the whole impact of the HLC process.

The same structures used in the scratch tests also show a surface smoothness that is typically 3-6 or more times better than assemblies manufactured using a standard UPC polishing procedure. These observations are even more striking in the surrounding regions of the end surface including the epoxy and ferrule regions. Tests have also been performed using ion etching of the surface that show a reduction of dangling oxygen atoms by more than 10x over traditional preparation and polishing procedures.

DURABILITY

Now to the issue of durability and the enhancements offered by the HLC process. The overwhelming issues within today's fiber optics arena are termination and connectivity or coupling from one component to another. Further examination reveals that contamination and cleaning issues and implementation in other than clean room environments primarily cause these issues.

The HLC process (US Patent 6,413,450 and others) addresses all of these issues head-on and provides an **INTEGRATED** single step process that works reliably and repeatedly within real-world environments. Contaminants of any type enjoy dangling bonds and particularly those relating to the gaseous elements. Dangling bonds are a stellar feature of groove or rough surface features and micro-features such as dislocations, contaminants, cracks, etc. within the main body of a material and will tend to migrate towards the surface over a period of time due to thermal variances [3, 4]. Therefore, something other than a slow bake-out process or standard cleaning process is required in order to provide a long term, and repeatable solution to practical implementation and usage.

An example of the "Hardened-Lens" is shown below in Figure 2 for a single sub-millisecond laser exposure. During this time, the lens is formed, the surface is both passivated and smoothed (reflow), and the fiber-lens interface as highlighted in Figure 1 eliminated or greatly reduced and replaced with a graded index and structural change. This latter feature can be observed in terms of lower back reflections, etc.

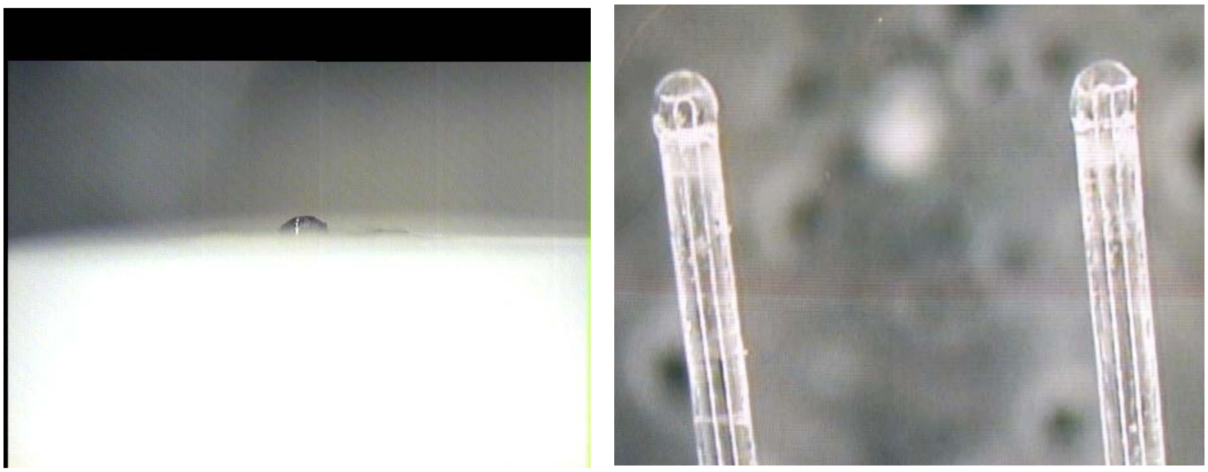
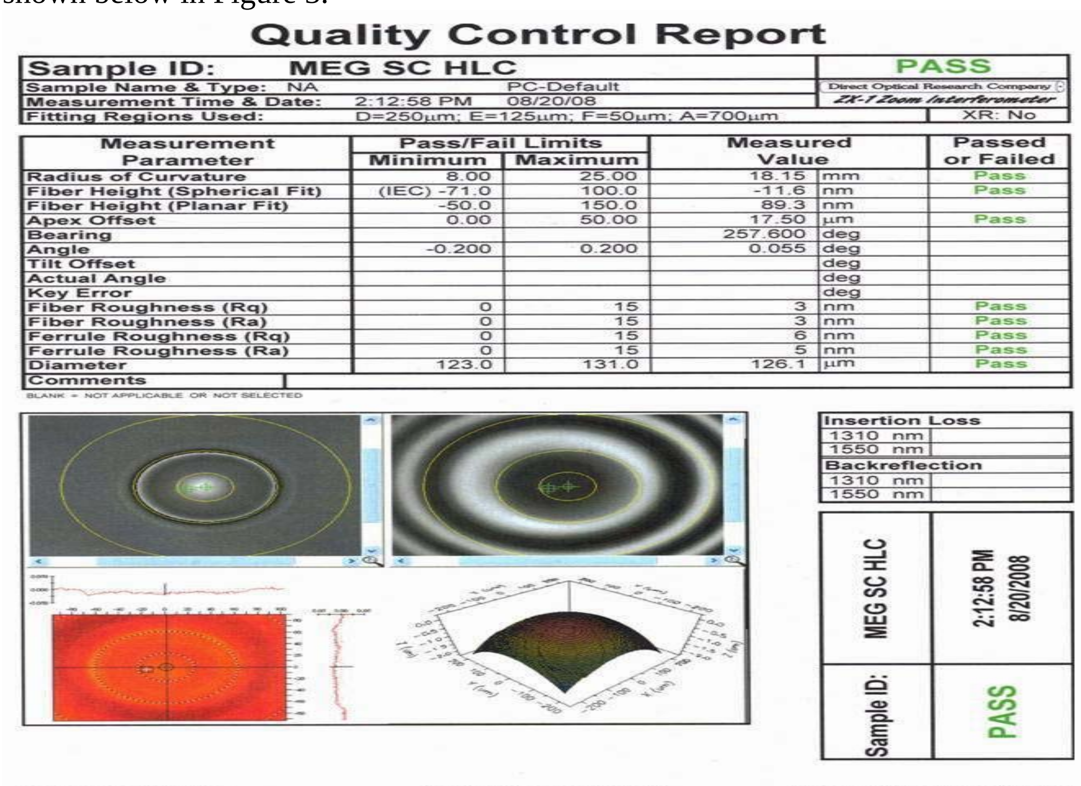


Figure 2 - Pictures of lens taken with laser camera/microscope (terminated fiber within a ceramic ferrule and bare fiber).

The resulting HLC termination process exceeds all UPC end-face geometry parameters as shown below in Figure 3.



Quality Control Report

Sample ID:	MEG SC HLC	PASS
Sample Name & Type:	NA PC-Default	Direct Optical Research Company
Measurement Time & Date:	2:12:58 PM 08/20/08	ZX-1 Zoom Interferometer
Fitting Regions Used:	D=250µm; E=125µm; F=50µm; A=700µm	XR: No

Measurement Parameter	Pass/Fail Limits Minimum	Maximum	Measured Value		Passed or Failed
Radius of Curvature	8.00	25.00	18.15	mm	Pass
Fiber Height (Spherical Fit)	(IEC) -71.0	100.0	-11.6	nm	Pass
Fiber Height (Planar Fit)	-50.0	150.0	89.3	nm	
Apex Offset	0.00	50.00	17.50	µm	Pass
Bearing			257.600	deg	
Angle	-0.200	0.200	0.055	deg	
Tilt Offset				deg	
Actual Angle				deg	
Key Error				deg	
Fiber Roughness (Rq)	0	15	3	nm	Pass
Fiber Roughness (Ra)	0	15	3	nm	Pass
Ferrule Roughness (Rq)	0	15	6	nm	Pass
Ferrule Roughness (Ra)	0	15	5	nm	Pass
Diameter	123.0	131.0	126.1	µm	Pass
Comments					

BLANK = NOT APPLICABLE OR NOT SELECTED

Insertion Loss	
1310 nm	
1550 nm	
Backreflection	
1310 nm	
1550 nm	

MEG SC HLC	2:12:58 PM 8/20/2008
Sample ID:	PASS

DORC: ZX-1 mini PMS Serial Number: 2365246-01 Printed at 2:16 PM on 8/20/2008

Figure 3 – Typical Interferometer data of a HLC with smoothness.

SUMMARY

Megladon's Hardened-Lens Contact (HLC) termination process (US Patent 6,143,450 and others) provides the durable interconnect that the fiber optic industry is seeking. The method of producing HLC (lensed fiber ends via laser action) fiber optic assemblies offers many advantages over a conventional polishing/finishing process.

The process subjects the end-face to a rapid melt and reflow. The fiber as well as the surrounding ceramic ferrule and epoxy regions becomes a hard, smooth surface that resists scratching, films and residues, and the accumulation of airborne particles. The process also prevents leaching of contaminants from below the surface. These benefits provide a durable fiber optic end-face that is easy to clean and produces repeatable results in a real world environment.

Another benefit is the integrated lens that is automatically formed during the termination process. The lens is an optical approach that is well known and greatly reduces many of the alignment and loss issues that are faced by the industry today.

Megladon's HLC process provides end-face geometry characteristics with less than 50% of the tolerance of off-the-shelf UPC assemblies. The result is a reference grade assembly that is compatible with all PC and UPC interconnects.

While the industry has continued to provide cost reductions based on more efficient manufacturing methods, the real issues have not been addressed. Fiber optic assemblies manufactured in Asia have become so inexpensive that they are considered disposable. This is not what the majority of end-users require. They want something that will work. Megladon listened to these end-users and developed a better assembly and interconnect that provides real value to its customers.

REFERENCES

[1] Designer's Guide To Fiber Optics, AMP Incorporated, Harrisburg, Pa., 1981.

[2] Fiber Optics, CRC Press Inc., James C. Daly, Editor, 1984.

[3] D. Crosthwait, R. Shah, G. Brown and R. Mays, Teaxas Instruments Inc. (SRDL), "Effects Of Pulsed Laser Irradiation On Thermal Oxides Of Silicon", (1980); and R. Shah, R. Mays and D. Croswait, Texas Instruments Inc. (SRDL), "Characterization Of Thermal Oxides Of Laser Annealed Silicon", (1981). Papers presented to The Materials Research Society, Boston, Mass. In 1980 and 1981.

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[6] Analytical Reports NST-020715 and NST-020802 for Megladon, Micro Ohotonics Inc., Ethel Poire, Jully, 2002.

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