High density, low cost, no-polish optical ferrule

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ABSTRACT - A monolithic, multi-fiber ferule with integrated collimating lenses with the same overall footprint as a traditional MT-type ferrule was tested for insertion loss and return loss, before and after durability testing without cleaning.

1. Background: Embedded Parallel Optic Active Devices + High Fiber Count Interconnects

Today, low-cost miniature optic embedded modules are available and being installed into many equipment [1]. Architectures which utilize multiple embedded parallel optic modules facilitate the need for dense optical interconnect technology at the card edge demarcation point.

Currently, this parallel optic demarcation occurs via multi-fiber bulkhead feed through or blind-mateable connectors which utilize traditional MT ferrules for the precision alignment. In order to obtain a low, stable, insertion loss, the optical fiber tip, mated pairs must come into physical contact with each other. This physical contact requires very tightly controlled termination, polishing and metrology procedures which drive the cost of traditional multi-fiber interconnects. For interconnect densities beyond 24F, obtaining and maintaining physical contact of the fiber tips becomes unobtainable with state of the art polishing and termination technology. As a result, the mated fiber tip interface of high fiber count MT ferrules (>24 fiber) becomes unstable which can result in optical interference and amplifying return loss values higher than a simple unmated connector will generate (i.e., unstable RL values can oscillate and peak at values below 10dB.)

2. US Conec PRIZM MT™ Design Overview

The PRIZM MT™ was designed with the same overall outer dimensions as a traditional MT ferrule. This aspect of the ferrule design allows for use with existing MT based connector solutions like the MTP® brand MPO connector or other ganged MT ferrule based connector solutions. As shown in Figure 1, the hermaphroditic design in the PRIZM MT™ with a single precision alignment post and precision alignment hole eliminates the need for the costly stainless steel guide pin sub-assembly. By increasing the alignment hole/pin pitch to 5.3 mm and changing the nominal alignment post size to 550 microns, the PRIZM MT™ can accommodate up to 16 fibers per row. The PRIZM MT™ was designed with the same low-cost, no polish termination methodology developed for the PRIZM® LightTurn® connector [2]. By utilizing a similar dual window design, a cleave-only fiber array is aligned to an optical stop plane and bonded into the ferrule via an index matched light cure or thermal cure epoxy. Utilization of micro-holes for precision alignment allows for scaling to multiple rows in the same ferrule. The 50 micron multimode PRIZM MT™ ferrules of this study use a collimated, expanded beam approximately 180 microns in diameter. One of the advantages of an expanded beam connection is very low sensitivity to debris as compared to a traditional fiber to fiber interface.

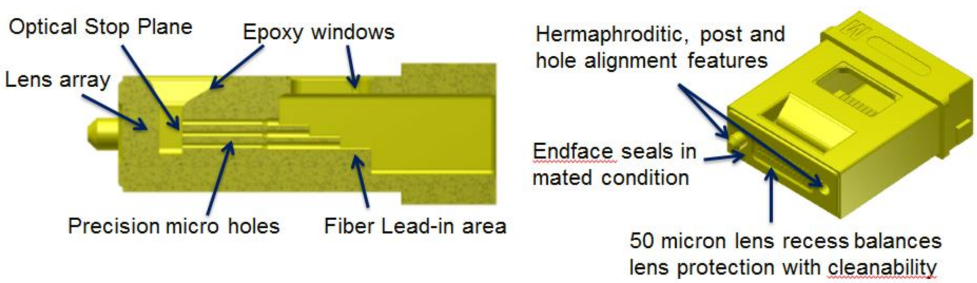

Figure 1: PRIZM MT™ Design

Consider a 16µm diameter, opaque, dust particle that has contaminated the endface of a connector with a uniform power distribution across the emission area. The effect of the blocked light would be nearly 0.5dB of insertion loss for a traditional MT ferrule compared with only 0.035dB for the PRIZM MT™.

Because the PRIZM MT™ design does not require physical contact, the ferrule mating force can be reduced from 2 pounds to ½ pound. The reduction in force is conducive to large connector arrays with closely packed ferrules. The design of the lens improves the optical return loss (ORL) of potentially less than 10 dB with a traditional MT ferrule without physical contact due to the Fabry–Pérot cavitational effects to a stable ORL of greater than 20 dB for the PRIZM MT™.

3. Empirical results

Testing consisted of an initial insertion loss on six mated PRIZM MT™ ferrule pairs. The optical ferrules were mated within an MTP® brand MPO type connector embodiment. The connector pairs were then subjected to 200 durability cycles prior to a second insertion loss test on the same six mated pairs.

Common industry practice for traditional, physical-contact, multi-fiber connectors is to inspect and clean the ferrule endface before every mating cycle. Failure to remove contamination before a mating cycle can lead to performance degradation resulting from signal occlusion, loss of physical contact and/or fiber tip damage. Industry performance standards dictate that cleaning should occur on every fifth mating cycle during durability qualification. For this investigation, an extreme approach was taken to examine the debris insensitivity of expanded beam, non-physical contact, multi-fiber interconnects.

A second set of insertion loss data was collected after the durability cycles but without any cleaning. Subsequently, the ferrule endfaces were cleaned prior to the collection of a third and final set of insertion loss data. A histogram for the three insertion loss data sets is shown in Figure 2. There was no significant difference noted in the three data sets. In addition, images of a typical ferrule endface at each stage of the test is shown in Figure 2. ORL for all mated pairs at each testing stage was greater than 22 dB.

Figure 2: Insertion Loss Histogram for Initial, Post Durability without cleaning, and after a cleaning iteration.

4. Conclusion

Expanded beam, non-contact, multi-fiber ferrules were tested for insertion loss after severe durability testing and prior to cleaning. This loss data was compare to the initial insertion loss data in addition to a final insertion loss data after a cleaning iteration. The PRIZM MT™ ferrule exhibited unprecedented loss stability for multi-fiber connectors without careful attention to endface cleanliness. This multi-fiber optical interconnect technology is suitable for applications and environments when careful cleaning and inspection of fiber tips is not possible.

5. Future Work

Development is underway on an expanded beam, singlemode version of the PRIZM MT™ ferrule. Due to the nature of expanded beam, non-physical contact interconnects; the SM version will be similarly debris insensitive. In addition, formal performance qualification to Telcordia GR-1435, “Generic Requirements for Multi-fiber Optical Connectors” will be conducted which includes testing at environmental and mechanical extremes within a connector embodiment.

6. References

[1] Fields, Mitch., “Optical Interconnects for Chip-to-Chip Communications”, ECOC 2010, Turin, Italy.
[2] Hughes, G., Graham, J., Schoellner, D., Childers, D., Childers, E., and Ugolini, A., "Miniature Detachable Photonic Turn Connector for Parallel Optic Transceiver Interface," Optical Fiber Communication Conference and Exposition (OFC/NFOEC), Los Angeles, 2011.
[3] Hughes, M., Childers, D., Graham, J., “Next-generation high-density low-cost multimode optical interconnect,” SPIE Photonics West, San Francisco, 2012.