Ultra Low Loss (ULL) MPO connector

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The rapid growth of the optical network traffic has dramatically increased and the demands for high bandwidth and multi-fiber optical connection needs are increasing. We have developed an Ultra Low Loss (ULL) MPO connector equipped with an MT ferrule with a low fiber core eccentricity, a lower loss of connection than conventional MPO connectors, a good track record as multi-fiber optical connectors, excellent insertion loss and mating repeatability. The 12 fiber single mode 12 ULL MPO connector and the 24 fiber single-mode 24 ULL MPO connector have been confirmed to have a maximum insertion loss of less than 0.20 dB after 50 repetitions of insertion and removal, resulting in a stable ultra low loss connection. Also, this ULL MPO can be manufactured at almost the same cost as the conventional MPO.

1. Introduction

Recently, optical fiber communication has spread widely due to the exponential increase of data transmission by the diversification of internet service. The demand for multi-fiber optical connector which enables high-density optical fiber connection of multiple optical fibers in a configuration is increasing. Our company has developed and commercialized MPO connectors as multi-fiber optical connectors[1)-3)]. Under such background, in order to facilitate for higher speed transmission, a demand for MPO connector equipped with single mode optical fibers and capable of obtaining stable low loss characteristics is increasing.

We have developed an Ultra Low Loss (ULL) MPO connector for single mode optical fibers, which has high insertion and mating repeatability and ultra low loss characteristics for repeated insertion and removal of the connector.

2. Structure

2.1 Interface structure of connector

Fig. 1 shows the external structure of the 24 core ULL MT connector. Both 12 core ULL MT connector and 24 core ULL MT connectors use MT ferrules made of PPS (polyphenylene sulphide) resin. Fig. 2 shows the external structure of the ULL MPO connector with housing parts assembled on the MT connector. The 12 core ULL MPO connector has an interface structure conforming to IEC 61754-7-1 ed.1, and the 24 core ULL MPO connector has an interface structure conforming to IEC 61754-7-2 ed.1. Therefore, they have mating compatibility with existing MPO connector.

2.2 Structure of MT ferrule

Fig. 3 shows a schematic diagram of fiber core eccentricity in an MT connector. The fiber core eccentricity is the deviation of the optical fiber core position from the design value. The displacement of

Fig. 1. Structure of 24-fiber ULL MT connector.

Fig. 2. Structure of ULL MPO connector.

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Panel 1. Abbreviations, Acronyms, and Terms.

MT—Mechanically Transferable
A connector, using the mentioned technology, which connects multi-fibers in a batch is called MT connector. The key part is the MT ferrule.

MPO—Multi-fiber Push-On
A technology that enables MT to be connected easily. The connector using this technology is called MPO connector.

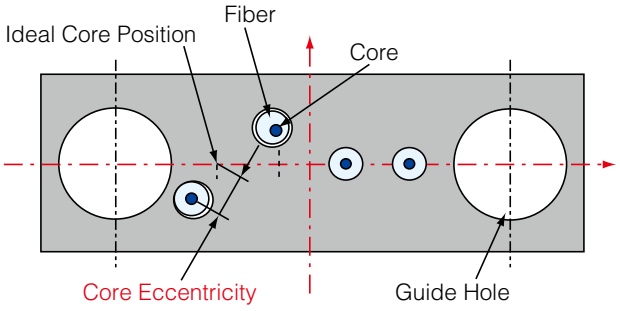

Fig. 3. Illustration of fiber core eccentricity of MT connector.

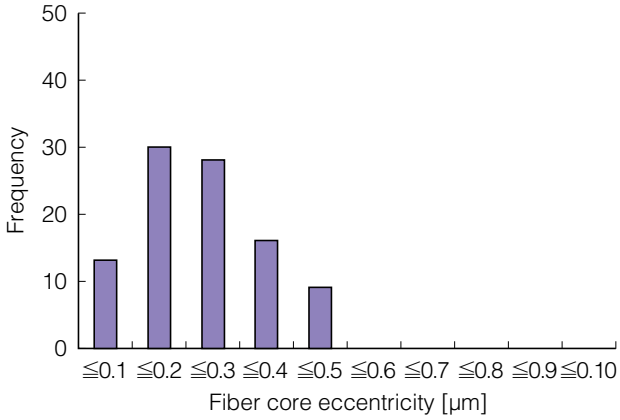

Fig. 4. Fiber core eccentricity of 12-fiber ULL MPO connector.

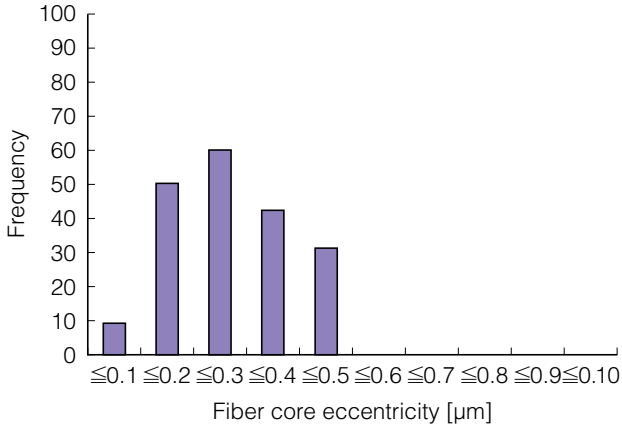

Fig. 5. Fiber core eccentricity of 24-fiber ULL MPO connector.

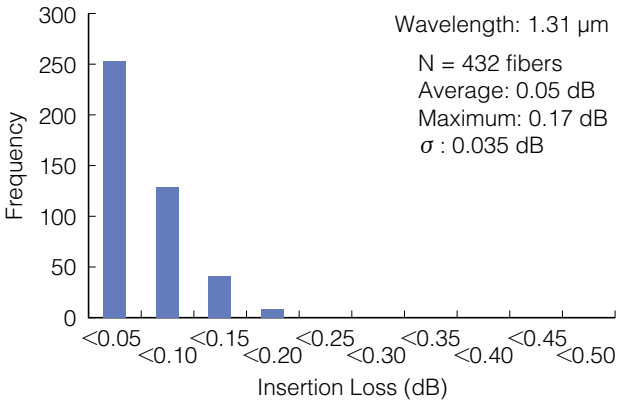

Fig. 6. Insertion loss of 12-fiber ULL MPO connector.

the optical fiber core depends on the connection parameters including the optical fiber insertion hole position; the outer diameter of the optical fiber cladding; the clearance of the optical fiber insertion hole; the concentricity of the optical fiber core and the optical fiber cladding. The insertion loss of the MPO connector largely depends on the fiber core eccentricity of the optical fiber assembled on the MT ferrule. Therefore, minimizing the fiber hole eccentricity of the MT ferrule, greatly contributes to the low loss of the MPO connector. As for the assembled fiber, we use a type of high-precision fiber of high-precision outer diameter dimension and core eccentricity. We have developed ULL MPO connector with ultra low loss characteristics by controlling the fiber core eccentricity of the MT connector to a small value using this high-precision MT ferrule molding technology and highly dimensionally controlled optical fiber.

3. Evaluation result

3.1 Fiber core eccentricity

Fig. 4 shows the measurement result of fiber core eccentricity for the 12 core ULL MPO connector, and Fig. 5 shows the measurement result of fiber core eccentricity for the 24 core ULL MPO connector. The fiber core eccentricity of the 12 core ULL MPO connector was 0.23 μm in average and 0.46 μm maximum. The fiber core eccentricity of the 24 core ULL MPO connector was 0.27 μm in average and 0.49 μm maximum. It was confirmed that the eccentricity of the fiber core could be controlled to be low by our high-precision MT ferrule molding technology.

3.2 Insertion loss

Fig. 6 shows the evaluation result of insertion loss of

the 12 core ULL MPO connector, and Fig. 7 shows the evaluation result of insertion loss of the 24 core ULL MPO connector. The optical fiber used for the evaluation was a single mode type optical fiber, and plugs of ULL MPO connector were randomly connected without using refractive index matching agent. The measurement wavelength was 1.31 μm.

The insertion loss of the 12 core ULL MPO connector was 0.05 dB in average and 0.17 dB maximum. The insertion loss of the 24 core ULL MPO connector was 0.05 dB in average and 0.18 dB maximum. The performance of conventional low loss MPO is about 0.25 dB at maximum. The performance of ULL MPO developed this time is 0.20 dB at maximum, and it is confirmed that the low loss characteristics is better than the conventional type.

3.3 Return loss

Fig. 8 shows the evaluation result of the return loss of the 12 core ULL MPO connector, and Fig. 9 shows the evaluation result of the return loss of the 24 core ULL MPO connector. The optical fiber used for the evaluation was a single mode type optical fiber, and plugs of ULL MPO connector were randomly connected without using refractive index matching agent. The measurement wavelength was 1.31 μm. Also, the return loss was measured by a measuring method using an optical coupler.

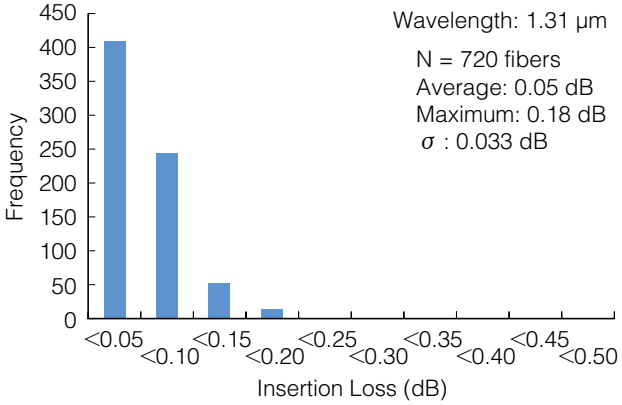

Fig. 7. Insertion loss of 24-fiber ULL MPO connector.

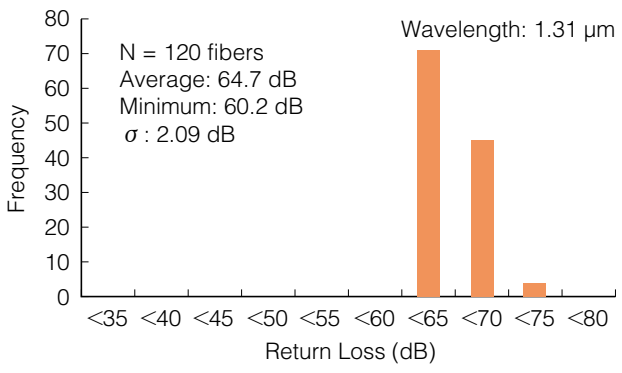

Fig. 8. Return loss of 12-fiber ULL MPO connector.

The return loss of the 12 core ULL MPO connector is 64.7 dB in average and 60.2 dB minimum. The return loss of the 24 core ULL MPO connector was 63.7 dB in average and 55.7 dB minimum. Both of them complies with Telcordia standard (GR -1435 - CORE Issue 2) which is 55 dB and above.

3.4 Repeatability of connector insertion loss by connector re-mating

Figure 10 shows the evaluation result of the repeatability of connector insertion loss by connector re-mating for the 12-fiber ULL MPO connector, and Figure 11 shows the evaluation result of the

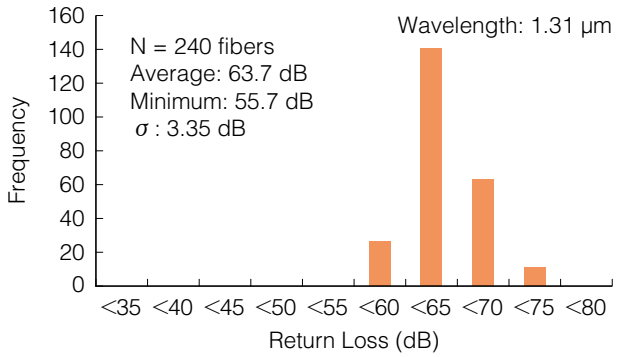

Fig. 9. Return loss of 24-fiber ULL MPO connector.

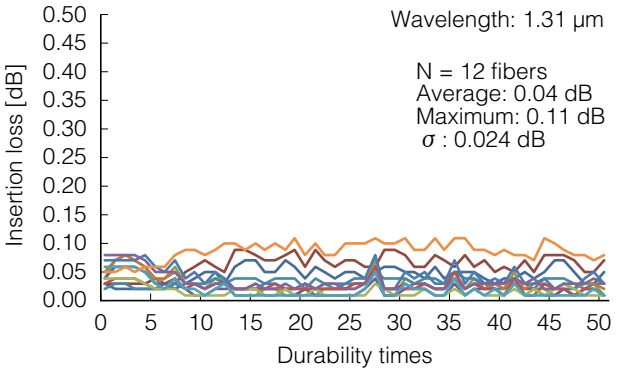

Fig. 10. Mating repeatability test result of 12-fiber ULL MPO connector.

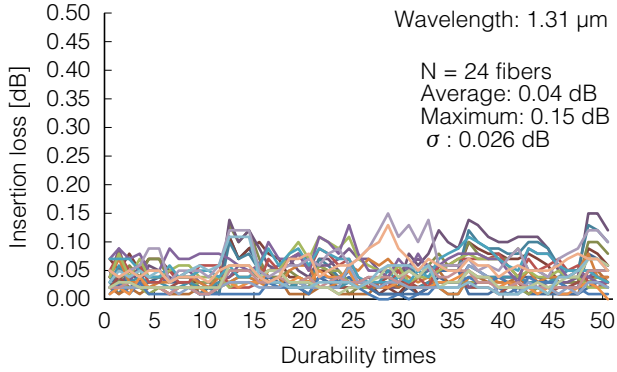

Fig. 11. Mating repeatability test result of 24-fiber ULL MPO connector.

repeatability of connector insertion loss by connector re-mating for the 24-fiber ULL MPO connector. In the test of the repeatability of connector insertion loss by connector re-mating, MPO connectors were mated and removed 50 times in total through the MPO adapter, and the insertion loss was measured each time of re-mating. The end face of the MPO connector was not cleaned during 50 times of re-mating. The applied optical fiber for this evaluation was a single mode type optical fiber, and plugs of ULL MPO connector were randomly connected without using refractive index matching agent. The measurement wavelength was 1.31 μm.

The insertion loss of the 12-fiber ULL MPO connector during 50 times of re-mating was 0.04 dB in average and 0.11 dB maximum. The insertion loss of the 24-fiber ULL MPO connector during 50 times of re-mating was 0.04 dB in average and 0.15 dB maximum. In both cases, it was confirmed that low loss characteristics of 0.20 dB or less at maximum were stably retained in repeated re-mating of the MPO connector. It can be said that the ULL MPO developed this time maintains stability of connector insertion loss by connector re-mating which is better than the conventional low loss MPO, because the insertion loss in the case in which similar repeated re-mating of the connector are carried out in the conventional low loss MPO is about 0.35 dB maximum.

Table 1. Environmental test conditions (Telcordia GR-1435-CORE Issue 2) and results of 12-fiber ULL MPO connector and 24-fiber ULL MPO connector.

Test item	Test condition	Specification	Result	
			12-fiber ULL MPO	24-fiber ULL MPO
Thermal Aging Test	Temperature: 85 °C 7 days	Insertion loss increase: ≦0.3 dB	≦0.12 dB	≦0.14 dB
Humidity Test	Temperature: 75 °C Humidity 95% 7 days		≦0.08 dB	≦0.11 dB
Thermal Cycle Test	Temperature: −40～75 °C 21 cycles		≦0.24 dB	≦0.20 dB
Humidity/ Condensation Cycling Test	Temperature: −10～65 °C Humidity: 95% 14 cycles		≦0.06 dB	≦0.13 dB
Dry Out Test	Temperature: 75 °C 1 day		≦0.02 dB	≦0.07 dB

3.5 Environmental test result

For the developed 12-fiber ULL MPO connector and 24-fiber ULL MPO connector, the environmental test, the Telcordia standard (GR-1435-CORE Issue 2) was carried out. Table 1 shows the test conditions (Thermal Aging Test, Humidity Test, Thermal Cycle Test, Humidity/Condensation Cycling Test, Dry Out Test) and the result, and Fig.12～16 shows the result of the insertion loss increase of the 12-fiber ULL MPO connector during the environmental test. The insertion loss increase during the test was less than 0.3 dB in all tests, which complies with the Telcordia standard.

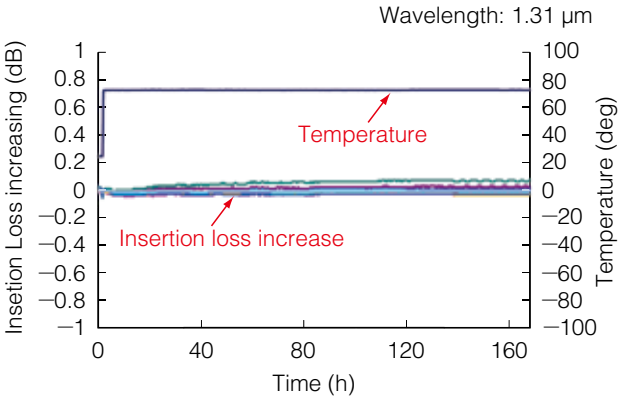

Fig. 13. Results of Humidity Test for 12-fiber ULL MPO connector.

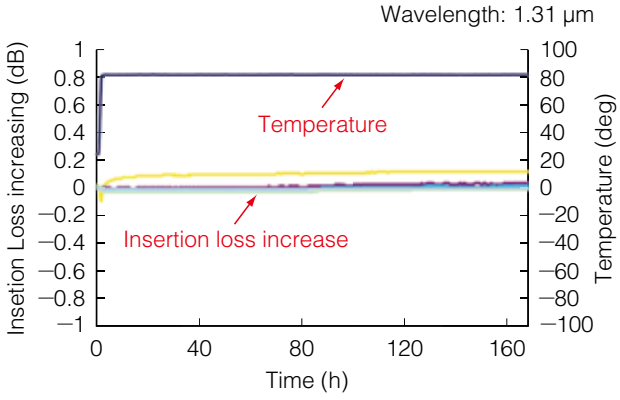

Fig. 12. Results of Thermal Aging Test for 12-fiber ULL MPO connector.

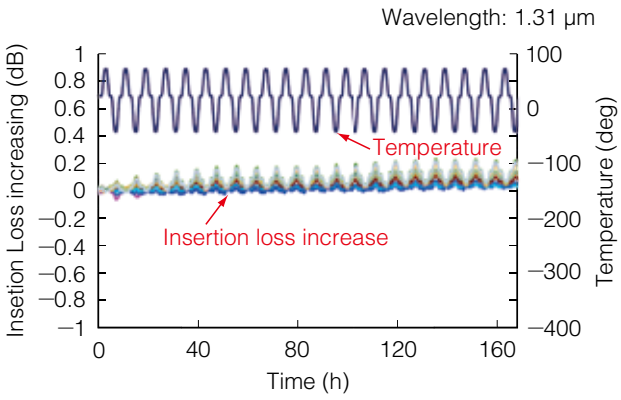

Fig. 14. Results of Thermal Cycle Test for 12-fiber ULL MPO connector.

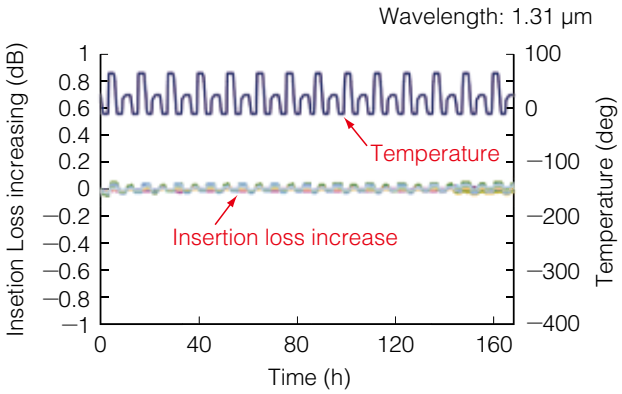

Fig. 15. Results of Humidity/Condensation Cycling Test for 12-fiber ULL MPO connector.

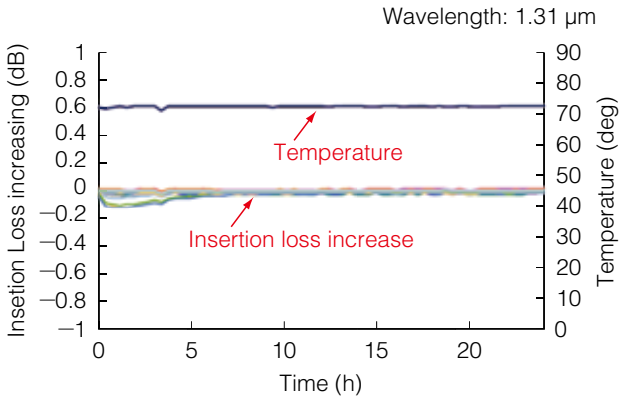

Fig. 16. Results of Dry-out Test for 12-fiber ULL MPO connector.

3.6 Mechanical test result

Mechanical test conforming to Telcordia standard (GR -1435 - CORE Issue 2) was carried out. Table 2 shows the test conditions (Vibration Test, Flex Test, Twist Test, Transmission w/load Test, Impact Test, Durability Test) and result. The insertion loss increase was less than 0.3 dB in all tests, which complies with the Telcordia standard.

Table 2. Mechanical test conditions (Telcordia GR-1435-CORE Issue 2) and results of 12-fiber ULL MPO connector and 24-fiber ULL MPO connector.

Item	Test condition	Specification	Result	
			12-fiber ULL MPO	24-fiber ULL MPO
Vibration Test	10-55 Hz, 3-axis 2 h	Insertion loss increase: ≦0.3 dB	≦0.05 dB	≦0.08 dB
Flex Test	2.2 N, 100 cycles		≦0.07 dB	≦0.12 dB
Twist Test	2.2 N, 10 cycles (±1 revolutions)		≦0.03 dB	≦0.08 dB
Transmission w/load Test	0 °: 2.2 N 90 °: 2.2 N	Insertion loss increase: ≦0.5 dB	≦0.08 dB	≦0.18 dB
Impact Test	1.5 m, 8 times	Insertion loss increase: ≦0.3 dB	≦0.05 dB	≦0.06 dB
Durability Test	50 times		≦0.11 dB	≦0.14 dB

4. Conclusion

We have developed an Ultra Low Loss (ULL) MPO connector for single-mode optical fiber, which has high repeatability of connector insertion loss by connector mating and removing, and ultra-low loss characteristics in repeated mating and removing of the connector, and confirmed its excellent characteristics. On the basis of the technology of this optical connector, further development to the ultra-low loss multicore optical connector with multi-core and high-density can be expected.

References

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2) S. Kanno et al., "Short size and Low-loss MPO Connector for High-Density Optical Interconnection Applications," 66th IWCS (2017).
3) T. Otomitsu et al., "Ultra Low loss (ULL) MT Connector for High Density Optical Connector," 67th IWCS (2018).