High Durability Molded Lens Connector for SMFs

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Abstract: We have achieved IL of <0.7dB and RL of >50dB in molded lens connector for single-mode fibers and confirmed its excellent durability, the maximum IL change is 0.06dB without cleaning during mating 250 times.

1. Introduction

In recent years, data traffic is increasing with increase in the information communication using the Internet. To realize higher data traffics, optical wiring between the electronic devices installed in data centers has to be studied. High density of these optical wires is an important factor that requires attention. For this purpose, multi-fiber push-on (MPO) connectors [1] and backplane connectors [2], that can connect multiple optical fibers simultaneously using the mechanical transfer (MT) ferrules, have been developed. In addition, we have developed the ultra-low loss MT ferrules [3]. For optical interconnections in the data centers, multi-mode fibers (MMFs) are majorly used for short-distance communication. On the contrary, to process higher data traffic, scale of the data center is increased. Therefore, long-distance communication within or between the buildings is indispensable in the deta center. In addition, application of single-mode fibers (SMFs) capable of long-distance optical wiring has progressed and demand for SMF components is expected to increase.

Optical backplane connectors used in the data centers connect a large number of optical fibers simultaniously due to which the communication quality is frequently degraded because of dust. It therefore requires frequent cleaing of the conector end face. However, it is tedious to clean because the optical connection point is a recessed portion in the rack. Therefore, communication quality degradation due to dust is an urgent issue in optical wiring in the data centers. Furthermore, this issue becomes serious in a system constructed with SMF where expansion is expected in the future. To solve this problem, attention has been drawn to lens connectors with anti-dust properties, by enlarging the optical path at the connector end face. We have developed molded lens connectors for MMF [4] and SMF [5]. This study highlights the improved optical performance of the molded lens connector developed for SMF and confirmed its durability.

2. Ferrule design

2.1. Ferrule Structure

Fig. 1 shows the appearance of the molded lens ferrule and a MT ferrule. The molded lens ferrules can be replaced with MT ferrules without changing the housing design, because they have the same outer shape and external dimensions as the MT ferrules. In addition, the Molded Lens ferrules are aligned with high-precision pins during connector mating, similar to the MT ferrules. Hence, the repeated positional accuracy between ferrules is high. Furthermore, lens connectors are insensitive to connector misalignment because of their expanded beam. Therefore, mating and de-mating repeatability of the molded lens connectors is expected to be high. On the contrary, unlike MT ferrules, it does not need physical contact during mating of the connectors. Thus, the mating force of the molded lens connectors can be reduced.

Lens and fiber positions of lens connectors are particularly important for achieving a low loss. The precision was improved by bifurcating into the lens parts and the fiber-hole parts. In addition, the insertion loss (IL) improved owing to the high precision of these parts [5].

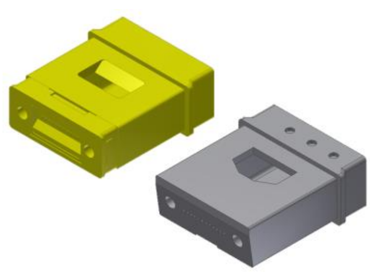

Fig. 1. Appearance of Lens ferrule (left) and MT ferrule (right)

2.2. Optical design

The lens parameters of the lens connectors are optimized so that the light emitted from the fiber is converted to a collimated beam. If the mode field diameter (MFD) of the collimated beam is large, the influence of IL due to inclination of the connectors becomes large. Contrarily, if the MFD is small, the influence on IL due to the dust becomes large. Considering these balances, the MFD is designed to be 100μm. By applying an AR coating on the lens surface, the reflection loss due to difference in the refractive index between air and resin is suppressed.

2.3. Structure change for low reflection

Table 1 shows the comparison of the calculation results of return loss (RL) of the conventional [5] and the new structure of the molded lens connector. The RL of one pair of lens connectors is calculated as the total value of RL factors A, B, and C, as shown in Table 1. The factor A, B, and C, result from the Fresnel reflection due to the difference in refractive indices of the materials. In the conventional structure, the RL due to the factors A and B was less than 50dB, and the total RL was 35dB. In the new structure, the RL of the factor A and B improved after changing the angles of the fiber end face and the fiber stop plane of the lens ferrule. The calculation result was higher than 50dB.

Table. 1. Comparison of RL calculation results between the conventional and the new structure

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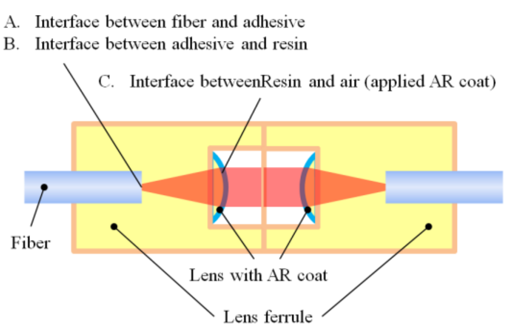
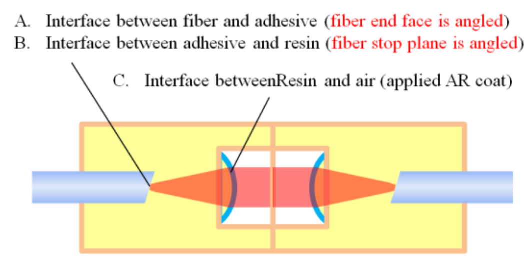
<tr><th></th><th colspan="2">Conventional Structure [5]</th><th colspan="2">New structure</th></tr>
<tr><td>Structure</td><td colspan="2">
</td><td colspan="2">
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<tr><td rowspan="3">RL factor due to refractive index mismatch</td><td>A. Fiber and adhesive</td><td>49dB</td><td>A. Fiber and adhesive</td><td>79dB</td></tr>
<tr><td>B. Adhesive and resin</td><td>38dB</td><td>B. Adhesive and resin</td><td>63dB</td></tr>
<tr><td>C. Resin and air</td><td>54dB</td><td>C. Resin and air</td><td>54dB</td></tr>
<tr><td>Estimated RL</td><td>Total (1 pair)</td><td>35dB</td><td>Total (1 pair)</td><td>50dB</td></tr>
</table>

3. Experimental result

A 12-fiber lens MPO connector with molded lens ferrule was evaluated. The optical performance was evaluated at a communication wavelength of 1550 nm, which is mainly used in long-distance transmission systems.

3.1. Insertion Loss

Fig. 2 shows the measurement results of IL in the 12-fiber lens MPO connector. For the measurement wavelength of 1550 nm, the average of 792 fibers is 0.33 dB and maximum is 0.68 dB.

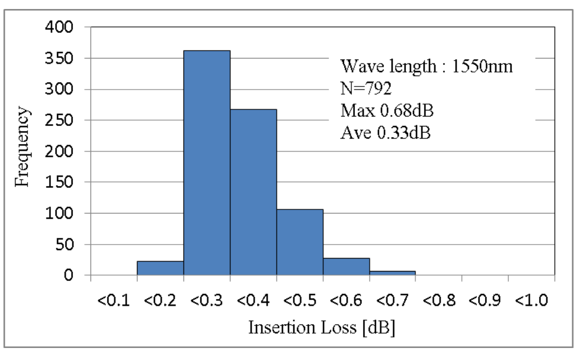

Fig. 2. Insertion loss measurement result of 12-fibers Lens MPO Connectors

3.2. Return Loss

Fig. 3 shows the measurement results of RL for a 12-fiber lens MPO connector with the conventional and the new structure ferrule. In the conventional structure, the average of 504 fibers is 39.3dB and the minimum is 36.1 dB for a measurement wavelength of 1550 nm. On the contrary, the new structure has an improved average of 52.4 dB and a minimum of 50.0 dB.

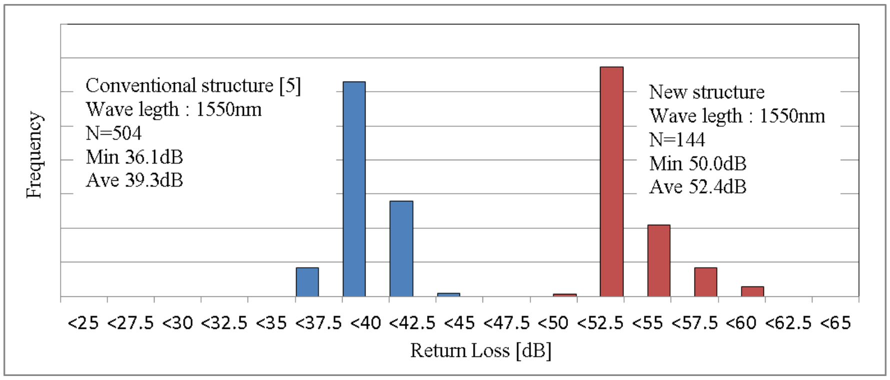

Fig. 3. IL measurement result of 12-fibers Lens MPO Connectors

3.3. Durability

Fig. 4 shows the results of the durability test repeated 250 times on a 12-fiber lens MPO connector. The test conditions were assumed to be applied to places where end face cleaning is tedious; the connector end face was not cleaned during the test. The IL was measured after every 10 matings. For a measurement wavelength of 1550 nm, the maximum IL change was 0.06 dB.

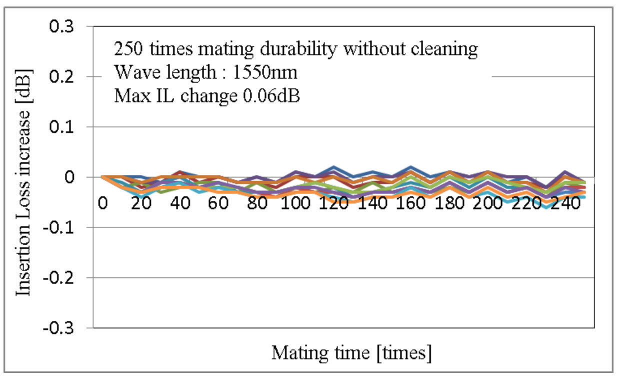

Fig. 4. Mating durability test result of a 12-fiber lens MPO connector repeated 250 times

4. References

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