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10-year reliability test results for SC connector installed on outside plant

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Abstract: Optical connectors are used both indoors and outdoors. To confirm the durability of optical connectors employing PC connection in actual outdoor environments, since 1997 we have been performing a reliability test on an SC connector installed in a high temperature and high humidity location. We confirmed that SC connectors with optimized ferrule end dimensions, which are designed to provide physical contact connection with long-term reliability, have maintained good levels of optical performance in an actual outdoor environment for 10 years.

Keywords: optical connector, SC connector, optical fiber connection, reliability

Classification: Fiber optics, Microwave photonics, Optical interconnection, Photonic signal processing, Photonic integration and systems

References

[1] H. Shinohara, "Broadband Access in Japan: Rapidly growing FTTH market," *IEEE Com. Mag.*, vol. 43, pp. 72–78, 2005.
[2] E. Sugita, R. Nagase, K. Kanayama, and T. Shintaku, "SC-type single-mode optical fiber connector," *J. Lightw. Technol.*, vol. 7, no. 11, pp. 1689–1696, Nov. 1989.
[3] R. Nagase, E. Sugita, S. Iwano, K. Kanayama, and Y. Ando, "Design for MU-type single-mode miniature optical connector" *IEICE Trans. Electron.*, vol. E81-C, no. 3, pp. 408–415, March 1998.
[4] T. Nakajima, K. Terakawa, M. Toyonaga, and M. Kama, "Development of optical connector to achieve large-scale optical network construction," *Proc. 55th IWCS/Focus*, pp. 439–443, 2006.
[5] T. Shintaku, E. Sugita, and R. Nagase, "Highly stable physical-contact optical fiber connectors with spherical convex ends," *J. Lightw. Technol.*, vol. 11, no. 2, pp. 241–243, Feb. 1993.

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1 Introduction

The optical connector is an essential component of optical network systems. In fiber to the home (FTTH) systems, optical connectors are used in both indoor environments such as buildings and in outdoor equipment such as aerial closures [1]. For example, the SC connector [2] and the MU connector [3] are used in buildings, and the FAS connector [4] is used in aerial closures. These optical connectors are designed for single-fiber coupling and employ a physical contact (PC) connection, which realizes full-face contact between two mated fiber cores. The PC connection enables us to eliminate Fresnel reflection at the connection point and achieve stable optical performance. In order to maintain reliable optical network systems, it is important that the optical connector as well as the other optical components used in the systems provide long-term reliability. The results have been reported of environmental durability tests on optical connectors employing a PC connection and undertaken using an indoor environmental test chamber [2, 3].

To confirm the durability of an optical connector employing a PC connection in an actual outdoor environment, since 1997 we have been undertaking a reliability test on an SC connector installed outdoors. In this letter, we report the changes in the ferrule end dimensions and optical performance of an SC connector exposed outdoors for 10 years.

2 Structure and ferrule parameters for realizing PC connection

In an optical connector employing PC connection such as an SC connector, the ferrule houses an optical fiber fixed in place with adhesive, and whose endface is polished. The polished endface has a spherical convex surface. However, it is difficult to maintain the initial shape of the ferrule endface. Namely, the fiber end protrudes or withdraws slightly from a virtual sphere on the ferrule endface. Figure 1 shows a cross-sectional view of the ferrule housing the optical fiber. The fiber end withdraws from the ferrule endface. This displacement of the fiber ends is the result of environmental factors such as temperature change. The fiber withdrawal from the ferrule endface causes a gap between the mated fibers, which induces a high return loss. To overcome this fiber end separation from the ferrule endface, the ferrule is deformed by the application of axial compressive force, as shown in Fig. 1. However, the optical connectors are connected for a long time, and so this axial compression force causes an increase in the fiber withdrawal because of the creep of the adhesive used to fix the fiber to the ferrule. When the temperature increases, the difference between the expansion ratios of the fiber and the ferrule materials causes an increase in the fiber withdrawal. To overcome these problems and maintain the initial optical performance, it is important to optimize the fiber end dimensions as shown in Fig. 1. The optimized ferrule end dimensions for realizing a stable PC connection have already been reported [5]. The optimized dimensions after polishing the ferrule ends are a spherical radius of 10 to 25 mm, a fiber withdrawal of less

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than 0.05 μm and a convex vertex eccentricity from the ferrule center of less than 50 μm. An optical connector with these parameters satisfied various reliability tests conducted in an environmental test chamber. To confirm the outdoor environmental durability of an optical connector employing the PC connection, we carried out a reliability test using SC connectors installed outdoors.

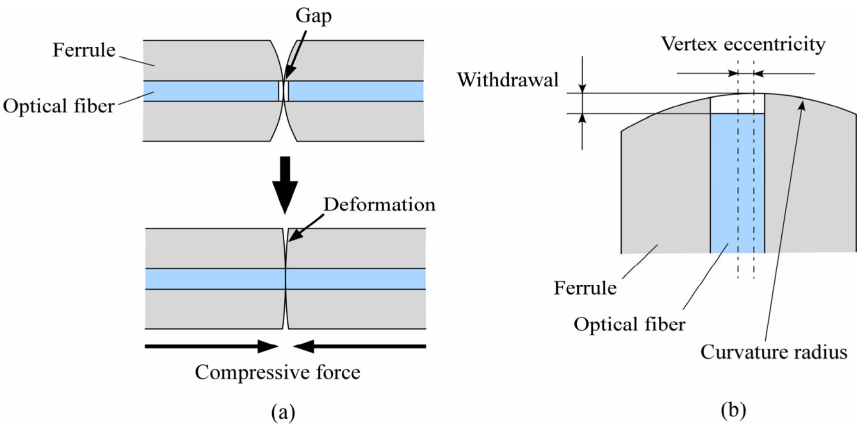

Fig. 1. Cross-sectional view of ferrule housing fiber (a) ferrule enface deformation when mated the ferrule ends (b) ferrule end dimensions.

3 Reliability test results

We began our reliability test of SC connectors on outside plant in 1997. We chose a region of high temperature and high humidity as the test site. The exact test location is Miyako Island in Okinawa Prefecture, Japan, which is located at latitude 24°N and longitude 125°E. The test samples are SC connectors, which consist of a plug–adapter and have a simplified receptacle-plug configuration, as shown in Fig. 2. In the SC connector, two ferrules

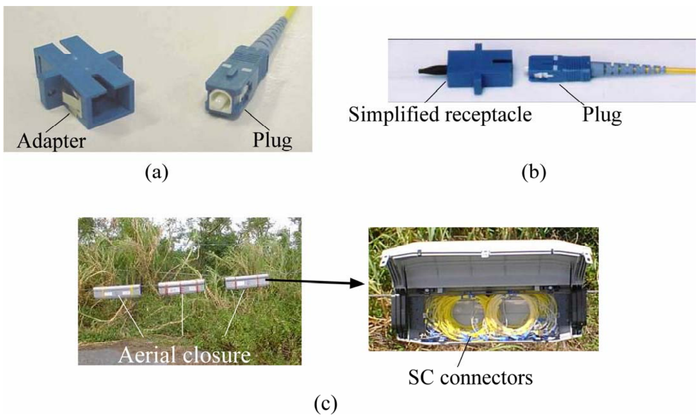

Fig. 2. (a) SC connector plug and adapter (b) SC plug and simplified receptacle (c) aerial closure set on outdoor plant and SC connectors inside the aerial closure.

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are butted together inside a split sleeve and compressed with coil springs to maintain a PC connection. In the reliability test, the ferrule material is a zirconia ceramic, and the split sleeve material is a zirconia ceramic or phosphor bronze. We installed 35 pairs of connected SC connectors in an aerial closure exposed outdoors, as shown in Fig. 2 (c). We placed a thermometer and a hygrometer in the aerial closure. The measured annual temperature and humidity ranges were 9 to 50°C and 25 to 99%, respectively.

We measured the ferrule end dimensions of 70 SC connectors and the optical performance of 35 pairs of SC connectors annually except in 2003, 2004 and 2006. The ferrule end dimensions are the fiber withdrawal from the ferrule endface, the curvature radius of the ferrule and the convex vertex eccentricity from the ferrule's central axis, as shown in Fig. 1. With the exception of a few samples, we used SC connectors with the optimized ferrule end dimensions described in section 2. The deterioration of the adhesive that fixed the optical fiber to the ferrule and the deformation of the ferrule endface from spherical convex ends to flat ends can degrade the optical performance. We can estimate the deterioration of the adhesive and the deformation of the ferrule endface by measuring the fiber withdrawal and the curvature radius of the ferrule, respectively. Figure 3 (a) and (b), respectively, show the changes in the minimum, maximum and average values of the fiber withdrawal and the ferrule curvature radius of the 70 SC connectors over a period of 10 years. Figure 3 (c) and (d), respectively, show the changes in the insertion and return losses in 2007 from the initial measured values in 1997. The insertion and return losses were measured at a wavelength of 1.31 μm. The maximum change in the fiber withdrawal was 0.03 μm from the initial value, which can be compensated by the applied axial compression force. The ferrules main-

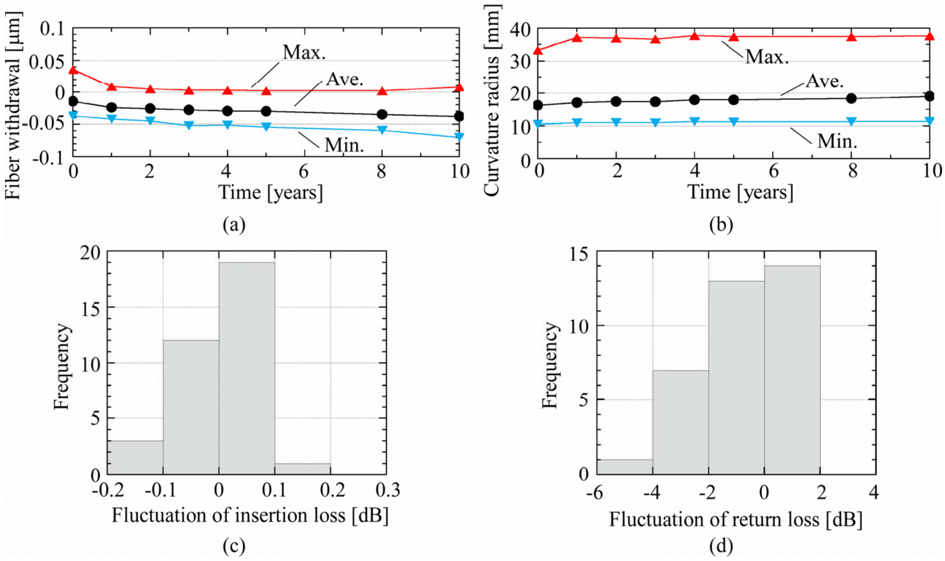

Fig. 3. Reliability test results (a) Fluctuation of fiber withdrawal from ferrule endface for 10 years (b) Fluctuation of curvature radius of ferrule for 10 years (c) Insertion loss fluctuation (d) Return loss fluctuation.

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tained their spherical convex ends and provided PC connection for 10 years. The changes in the fiber end dimensions that lead to optical performance degradation did not occur during this period. The results reveal that the optimized ferrule end dimensions are useful as regards maintaining a stable PC connection in an actual outdoor environment for long periods. The maximum fluctuation in the insertion loss was 0.2 dB, which indicates that good optical performance was maintained for 10 years. The maximum fluctuation in the return loss was 5 dB and the return losses of the SC connectors stayed at over 44 dB. We confirmed that the SC connector maintained a PC connection in an exposed environment on outdoor plant.

4 Conclusion

We tested the environmental durability of an SC connector installed on outside plant under high temperature and humidity conditions. We measured the ferrule end dimensions and optical performance of the SC connectors for 10 years. There was no degradation in the optical performance during the test period. We confirmed that an SC connector employing a PC connection has good durability in both indoor and outdoor environments.

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